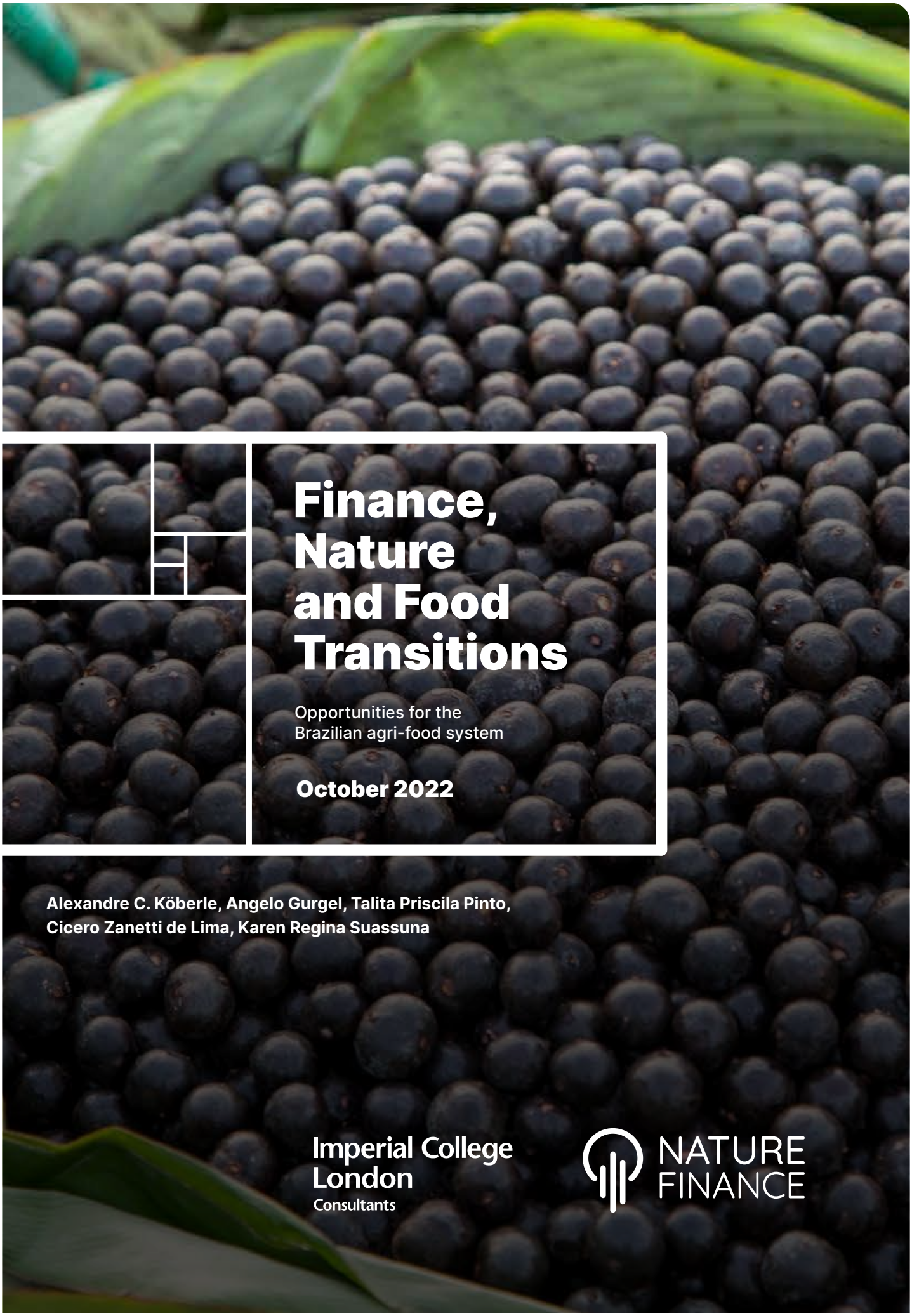

Finance, Nature and Food Transitions

Opportunities for the Brazilian agri-food system

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Our use of Fibonacci sequence imagery is inspired by the association of this unique ratio with the maintenance of balance, and its appearance everywhere in nature- from the arrangement of leaves on a stem to atoms, uncurling ferns, hurricanes and celestial bodies.

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Executive Sumary

Agricultural and food systems are facing increasing challenges due to contemporary environmental, societal and economic changes. The transition towards sustainability and lower greenhouse gas (GHG) emissions is imposing profound transformations in agri-food supply chains globally. The war resulting from the Russian invasion of Ukraine has elevated food security to the top of the political agenda and hunger is rising around the world. Such physical and transition risks will challenge current business models. The financial sector is aware of these challenges and is busy implementing practices that integrate nature and climate risks into decision making in order to reduce exposure to them. At the same time, however, new challenges may create new opportunities.

In particular, the outcomes may be positive for society if relevant knowledge and coordinated action can be used to assess and internalise nature and climate risks in a way that minimises adverse impact on incomes, assets, supplies and food security. Conversely, if financial institutions price nature and climate risks in an uncoordinated and isolated way, there is a high risk of disruption in global food systems; this will lead to higher food insecurity and employment losses, especially in the case of an abrupt transition led by financial risk avoidance.

A well-planned policy-led transition starting now can create enabling conditions that will shape financial institutions' engagement with food systems in a fair and sustainable way. Policy-led financial system engagement can facilitate a smoother transition through purposeful directed policy packages (e.g., redistribution of carbon tax revenues, payment for ecosystem services and a redirection of existing agricultural subsidies towards sustainability and resilience of food systems) that soften the adverse side effects of the transition (e.g., policies that counteract food prices and agricultural job losses) (F4B, 2021). Transforming the way food production is financed is key since financing is both a driver of inefficiencies and a key ingredient to food production (World Bank, 2021a).

Properly navigating the agri-food system's transition requires well-prepared public and private agents who understand what is at stake. In addition, as food production systems vary drastically from place to place, local contexts must be considered. To this end, the current study examines Brazil as its real economy jurisdiction. Brazil is the fourth-largest food producer and the largest net exporter of food products in the world, and is expected to continue playing an important role in the global agri-food transition. It is also home to large areas of native vegetation and rich biodiversity, which face increasing pressure from agriculture expansion. While Brazil's agri-food sector is taking steps to reduce its environmental footprint, it is exposed to considerable transition risk in the form of foregone revenues. It is also vulnerable to climate change impacts from, for example, droughts and heatwaves, especially as Brazilian agriculture is mainly rainfed (only 10% of agriculture area is irrigated) (Rattis et al., 2021).

Major challenges faced by the Brazilian agri-food system are related to environmental and social risks. Although Brazil still has large areas of its territory covered by natural vegetation, deforestation rates have been increasing in the last decade, threatening biodiversity and reducing the provision of ecosystem services, as well as exacerbating the climate change crisis by releasing large volumes of GHGs into the atmosphere. There are many drivers of land use change in the country, such as land grabbing, illegal logging and mining activities, new roads and large hydropower projects; however, satellite images show most of the deforested areas being replaced by cattle ranching and crop expansion (MapBiomas, 2022). Social conflicts and human rights violations associated with land use changes and related illegal activities, including assassinations, are also on the rise (Comissão Pastoral da Terra – CPT, 2022). These facts impact the risk perception of the financial sector and present a real threat for disruption of finance mechanisms and flows. Indeed, this reality has already caused some disruption, such as the hold on the ratification process of the EU-Mercosur Trade Agreement (European Parliamentary Research Service – EPRS, 2020), with implications for finance flows and investments in Brazil.

As such, it is essential to assess risks and opportunities arising from the food system transition in Brazil – and even more so since the country will face elections in October 2022 for presidency, state governors and parliament. Accordingly, this report builds on current and past work to explore the role that Brazil can play in this transition, as well as its exposure to risks and opportunities resulting from global and national trends. It then proposes policies to help smooth the transition towards a sustainable agri-food system in the country. The aim is to provide guidance on the above-mentioned risks and opportunities and to highlight the main aspects that will prepare public and private representatives to deal with the emerging food system transition. Two recent studies provide the basis for the recommendations offered here. The first is an ongoing study by the Food Systems Economics Commission (FSEC) that explores the role of Brazil in a global transition to a sustainable development pathway (SDP); this study focuses on the agriculture, forestry and other land use (AFOLU) sectors, with particular emphasis on the ruminant meat livestock sector.

The second is a report commissioned by NatureFinance (previously the Finance for Biodiversity Initiative – F4B) that examines global impacts on socioeconomic and environmental indicators arising from two possible future scenarios (NatureFinance, 2022): (i) a disorderly transition driven by the global financial sector's pricing of nature and climate risks in an uncoordinated manner, and (ii) an orderly scenario led by forward-looking policy packages starting now and designed to provide a supporting environment that reduces the adverse consequences of a transition. These two studies are complemented by a thorough literature review and expert judgement on current trends and conditions affecting the Brazilian agri-food sector.

The main messages emerging from our analyses are:

- Brazil faces strong challenges in the transition to a sustainable agri-food system, but can create conditions to turn these into promising opportunities.

- Environmental problems, such as increasing deforestation rates, GHG emissions from agriculture and high vulnerability to climate change, pose non-negligible risks to agri-food chains. These include potential negative impacts on yields, trade barriers and consumer rejection, decrease in market share and losses on comparative advantage, higher financial costs and disruptions in financial flows.

- Brazil holds environmental assets of high quality and in large quantities, is a major producer of agricultural, livestock and food products, has several potential technologies and pathways to sustainably increase productivity, and has some experience with environmental and agricultural policies aligned with a sustainable transition.

- However, the country still needs to incorporate new approaches and trends associated with sustainable production systems, develop systems to measure and monitor environmental services, improve and coordinate its efforts and policies, and create conditions for new markets and products to emerge related to sustainable and alternative proteins.

Based on these points, this report makes the following key recommendations, which must be part of a broader strategic development plan for Brazil and must be coordinated and integrated with that plan's other actions and policies. Some recommendations can be implemented in the first few months of a new administration to promote potential benefits for the agri-food sector, including higher resilience, competitiveness, investment opportunities, and societal acceptance. A more detailed and complete set of recommendations is presented in Section 5 of this document.

• Promote intensification (increasing food output in current farmland while preserving the future production capability of those areas) and improve efficiency in agriculture and livestock activities, while enforcing the policies to protect natural vegetation, nature reserves and traditional communities' land. To this end, improve and expand existing policies and programmes to achieve higher yields in agriculture—for example, the Low-Carbon Agriculture Plan (Plano Setorial de Mitigação e de Adaptação às Mudanças Climáticas para a Consolidação de uma Economia de Baixa Emissão de Carbono na Agricultura – ABC Plan), rural extension and technical assistance quality and coverage, and research, development and demonstration at agri-food research institutions. Improve and reactivate policies to combat deforestation, such as the plans to prevent and control deforestation in the Amazon and Cerrado areas, the PPCDAm (Action Plan for the Prevention and Control of Deforestation in the Legal Amazon) and PPCerrado (Action Plan for the Prevention and Control of Deforestation and Forest Fires in the Cerrado) and accelerate the enforcement and implementation of the Forest Code.

• Encourage and advance the development of the knowledge-based alternative protein production chain – from the promotion of diverse agricultural systems and use of bio-based raw materials to (primarily) the processing, industrialisation and production of the final good and incorporation of environmental and/or geographic attributes. Promote alternative proteins – such as plant-based foods, microbial protein (also called mycoprotein), insects and cultivated meat – due to their potential to mitigate GHG emissions and lower land and water resource usage. To this purpose, we recommend the creation of new funding programmes (and the strengthening of existing ones) at institutions such as BNDES, FINEP, EMBRAPII, Embrapa and CNPq, targeting farmers, cooperatives of family farmers, companies, start-ups and research institutions in all stages of the production chain.

• Guide and encourage the financial sector to participate in and contribute to a 'policy-facilitated' transition of the agri-food system towards a sustainable pathway, since a 'financial risk-driven' transition leads to adverse impacts on food security from higher food prices, while also implying lower yields, higher environmental damage and lower economic growth for Brazil. To achieve this aim, policymakers should work together with the financial sector in implementing policies that foster higher efficiency in the agri-food sector and protect natural ecosystems, and in establishing monitoring systems and aggregating environmental attributes to the agri-food sector in order to incorporate sustainability indicators in the sector's metrics, reports, portfolios and range of services generated by agricultural activities, which the financial sector funds.

• Encourage the adoption of 'climate smart agriculture' (CSA), 'sustainable intensification' (SI) and 'nature-based solutions' (NbS) approaches, practices and techniques, such as low carbon agriculture. Encourage adding and incorporating their concepts, practices and techniques into ongoing policies and initiatives and promoting the advantages of these practices in increasing resilience and combatting climate change (adaptation and mitigation). To achieve this goal, we suggest revising the operative plan of the ABC+ to embrace and explicitly mention internationally consolidated terminology and to

present the ABC+ practices and techniques as aligned with and included in the above concepts and approaches. In addition, improve and increase actions and activities related to dissemination and training of farmers and professionals in the ABC+ practices and engagement with management committees at the sub-national level (states and municipalities). Ensure that the ABC+ policy and practices are disseminated, promoted and recognised as being adherent and aligned to the CSA, SI and NbS concepts. We also recommend the introduction of these concepts in (i) the curriculum of agricultural sciences colleges and schools, (ii) the training of professionals providing technical assistance and rural extension providers, and (iii) the training of financial agents involved in the disbursement of rural credit to farmers. Lastly, we recommend strengthening and expanding rural credit targeting the practices and technologies of the ABC+, and indeed, expanding the budgets allocated to that plan.

• Improve food security in the country, considering the broad diversity of farmers, production systems, institutions and supply chain structures in Brazil's agri-food system; this will require policies and actions targeting improvements in human, social, physical and financial capital to those producers lagging behind in opportunities and access to markets and technologies. To this end, a broad set of actions is required, including improving the education system in rural areas, increasing and improving training of farmers and of professionals responsible for developing rural extension and technical assistance, generating and assessing quantitative and qualitative information (data gathering and dissemination) about the farmers with higher vulnerability, and creating new policies and revising/improving existing policies targeting these stakeholders on aspects such as technical assistance, financing technology transfer and commercialization, which must be aligned with the CSA, SI and NbS approaches. In that sense, the National Programme for Strengthening Family Farming (PRONAF) should be fully aligned with and given access to equitable funding for sustainable agriculture and implementation of the ABC Plan targeting smallholders. Re-equipping and urgently funding programmes such as the National Programme for Food Acquisition (PAA – Programa Aquisição de Alimentos) could be an effective strategy in the short term for increasing food security and improving environmental outcomes.

Finally, many recent studies have pointed to the role of demand-side changes in helping to achieve sustainability targets in agri-food and energy systems (IPCC, 2019; IPCC, 2022). Notably, the current study explores supply-side options only, while demand-side options were assessed in the third report of this series - Finance, Nature and Food Systems - Consumers choosing sustainable food systems in Brazil (Bataillard, D., 2022). That report made several recommendations for demand-side interventions, as follows:

• Encourage consumers to shop for food more sustainably by supporting them in making better decisions and avoiding counter-productive biases and choices. People normally use shortcuts when deciding between alternatives when they do not have all the information.

• Advance food policies by designing socioenvironmental labels that can quickly characterise a food product as less harmful to a specific socioenvironmental impact in terms of intensity (low, medium and high). Such tailored information is a powerful tool that can communicate to consumers valid cues or characteristics that can differentiate food options. The target is to facilitate understanding of socioenvironmental impact information by developing a label on the front panel of packaged foods using simple icons. Life cycle sustainability assessment may be applied to evaluating environmental, social and economic decision-making processes towards sustainability throughout the food product life cycle. The impacts should be chosen to represent the most critical ones to the environment and society based on robust scientific evidence pointing in this direction.

• Impacts should also be selected based on Brazilian consumers' concerns about them. The label must be designed to avoid biases, misleading information and repeating information already delivered by well-established official labels.

• To guarantee the effectiveness of the label implementation, (Bataillard et al., 2022) recommend employing an educational programme wherein consumers make their decisions so they can visualise the different options and recognise the label to learn how to make sustainable food choices. This programme should be developed in collaboration with all stakeholders to guarantee their support when putting it into practice.

1

Brazil faces unique risks from the emerging transition

In a world interconnected by trade, going against global trends is not a risk-free proposition. Trade rules are not as rigid as may be perceived and the risk of financial backlash due to perceived increases in country risks cannot be neglected. Brazil faces unique levels of risk due to its large-scale deforestation and reliance on agricultural products as a main export. Concerns about the deforestation risk of imported commodities are rising around the world. The failure to address and halt deforestation by national actions is fuelling a drive for trade scrutiny in Europe and the US. Similarly, banking on China to maintain its high demand for Brazilian beef exports is a risky proposition, as China can leverage price drops of the commodity caused by demand shifts to gain bargaining power. Further, the introduction of the development of lab meat in the new China's 14th Five-Year Plan clearly indicates an ambition to become less dependent on imports of animal protein. In addition to the economic risk, sovereignty issues become relevant in such a scenario, since Brazil has faced pressure to relax its rules on foreign ownership of agricultural land in the country.

Following a 'business-as-usual' approach that ignores the current reality carries major material and financial risk. The FSEC Brazil study describes the potential risks if Brazil follows a strategy which neglects negative impacts on environmental (or natural) resources while the world transitions to an SDP. The results of that study suggest Brazilian agricultural exports would be impacted by a decrease in the animal protein share in global food demand, even if both Brazil's and China's populations continue on their current trends of meat consumption. In fact, the more animal protein supply continues unchanged in the two countries, the more the Brazilian trade balance for beef tips towards imports. The reasoning is that as global demand drops, prices also drop in the international market. Competition from low-cost alternatives from abroad means importing beef becomes a more economic strategy than meeting the high national demand in Brazil through domestic production exclusively. On the other hand, alternative protein sources (e.g., plant-based proteins, microbial proteins or cultured meats) all require crop-derived inputs so global demand for crops goes up, creating opportunities for crop producers from the rise of alternative proteins (Humpenöder et al., 2022; Rubio et al., 2020).

This global co-dependency is all the more relevant since the Brazilian agri-food sector plays a key role in providing goods, income, exports and jobs, as well as in the overall land use allocation. It accounts for 27.4% of the country's GDP (CEPEA, 2022), of which 29% is provided by the primary agricultural sector. Brazil is one of the world's leading producers and suppliers of agricultural goods, food, fibre and bioenergy, and the largest net agri-food exporter in the world, achieving a trade balance of USD 75.3 billion in 2020 (FAO, 2022). According to the United Nations Food and Agriculture Organization (FAO), Brazil's farm production value in 2020 reached USD 135.8 billion, ranking it fourth in the world, behind only China, India and the US. The country is the leading producer and trader in a variety of products, such as sugar, coffee and orange juice, and one of the four largest producers and exporters of soy, soy oil and meal, beef, poultry, cellulose, maize, cotton and pork. In 2021, the Brazilian agri-industrial system accounted for 43% share of exports and its trade balance equalling 172% of the national trade balance. A total of 15 million farmers and agricultural producers are engaged in the sector (IBGE, 2017).

The agri-food system in Brazil is very diverse in terms of the farm sizes and types, agricultural goods provided, companies and firms selling to and buying from farmers, institutions and associations, and supply chain structures. These differences add complexities in dealing with economic, social and environmental aspects and designing policy. Approximately 4.4 million establishments are considered 'family farming', which includes 13.6 million people and represents 84% of Brazilian rural establishments (IBGE, 2017). These family farming establishments contribute to 38% of the gross value of agricultural production and to seven out of 10 jobs in rural areas (IBGE, 2017). Moreover, family farming is responsible for more than 50% of food items in the Brazilian basic food basket and a large share in production volume for several commodities: 87% of cassava, 70% of bean, 63.2% of horticulture, 46% of maize, 34% of rice, 58% of milk, 59% of swine, 50% of poultry and 30% of cattle (IBGE, 2017). Yet, a significant share of these producers lack access to human and physical capital, financing, technologies, commercialization systems and opportunities, bringing them more vulnerability and less resilience to economic and environmental shocks – even as they are key to the country's food security.

Current trends, challenges and opportunities

On the one hand, agri-food systems contribute to the welfare of billions of people around the world through provision of sustenance, livelihoods, culture and economic development. On the other hand, they are also a major driver of global environmental changes and simultaneously vulnerable to these same changes. The Brazilian agri-food sector is no different and, although its environmental performance had begun to improve in the first decade of this century, more recent trends have pointed to a reversal of past gains, giving rise to several risk factors that the financial sector is increasingly aware of and eager to address. The future of the Brazilian agri-food system hangs in the balance of how these risks are addressed, with consequences for millions of people who depend on it for the food they eat and the jobs that it provides. Some of the key trends, risks and opportunities facing Brazil's agri-food system are as follows.

Despite the agri-food system's contribution to the supply of nutrients to the world population, food production is a major driver of environmental degradation. The agri-food sector is responsible for over a third of global GHG emissions. Agriculture is the main driver of historical habitat loss and all the consequent impacts on biodiversity and other ecosystem services (IPCC, 2019; Köberle et al., 2021; Gibbs et al., 2010).

The financial sector is increasingly incorporating climate and nature risk assessments into decisions regarding investments in agri-food systems, which reduce its willingness to invest in farmers and businesses associated with negative environmental outcomes. Governments, consumers and companies in the food industry are all aiming for sustainable practices and goods. Consumers and the financial sector increasingly demand better environmental footprints and compliance with conservation law (Azevedo et al., 2015) and this is becoming the new norm. The environmental challenges faced by Brazilian agri-business pose relevant risks to the image of its agents, acceptance by the public and financing sources. Less capitalised farms (e.g., small or family farms) are especially vulnerable to these risks. Thus, there are growing calls for financing nature-positive – in addition to net-zero – activities (Muller and Robbins, 2022; TNFD 2022)

There is high potential for investments into Brazil's high endowment of natural capital, providing opportunities for the large areas of native vegetation in the country, which are home to high levels of biodiversity, carbon sequestration potential and water resources. Although the agri-food sector receives financial support from public sources, it is largely financed through other sources, including self-funding by farmers, family financial operations, supply chain financing from input suppliers and downstream agri-food companies (such as traders and processors), and credit from private financial institutions (Santana and Nascimento, 2012; Schreiner, 2018; IMEA, 2018). Most funding sources do not focus on improving environmental performance of agricultural practices. Concerns for inclusive production that ensures less prepared producers are not left behind are likewise not emphasised. As new markets develop – for example, markets for carbon and nature credits – Brazil's natural capital will look increasingly attractive to investors, both national and international. However, several enabling conditions must be in place for these markets to function, including enforceable land rights and contracts, equity and inclusion, clear verification and monitoring rules, and clear and ambitious targets, all of which contribute to the credibility of the environmental outcomes promised in return for investments.

High deforestation rates in Brazil have caused negative reactions from several actors, both domestically and abroad (Levis et al., 2020; Tollefson, 2019; Carvalho et al., 2019; Dobrovolsky et al., 2018). Although Brazil still has large areas of natural vegetation, totalling 563.6 million hectares (ha) (5,64 million km2)(MapBiomas, 2022), deforestation and conversion of natural areas to other uses have long been and continue to be major environmental concerns. While deforestation rates in the Legal Amazon decreased from 28,000 square kilometres (km2) in 2004 to 4,600 km2 in 2012, they have since increased almost every year, reaching 13,000 km2 in 2021 (INPE, 2022). Deforestation rates in the Cerrado biome, which were as high as 28,800 km2 in 2003 and 2004, have also decreased but remain high, between 6,300 km2 per year and 8,500 km2 per year in 2016-2021. Deforestation data from MapBiomas (MapBiomas, 2022) showed a 20% increase in deforestation rates from 2020 to 2021; 59% of the deforestation in Brazil took place in the Amazon and 30% in the Cerrado. Of all deforested areas in Brazil in 2021, 98% showed some signs of illegal deforestation activity. However, until May 2022, only 5.2% of the deforested area was subject to an embargo or assessment by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA). Such deforestation rates create reputational risks to firms involved in the financing and trading of commodities. This reality has already caused some disruption, such as the hold on the ratification process of the EU-Mercosur Trade Agreement, with implications for finance flows and investments in the country. A resolution from the European Parliament emphasised that 'the EU-Mercosur agreement cannot be ratified as it stands', referring to the increase in deforestation (EPRS, 2020) and human rights violations in the Brazilian Amazon related to agri-food and mining expansions and conflicts in the region.

The socioenvironmental risks of human rights violations associated with deforestation in Brazil, particularly in the Amazon, present a real threat for disruption of finance mechanisms and flows, since they are perceived by the financial sector as related to agricultural expansion and the agri-food system. According to historical data from the Pastoral Land Commission (CPT), there has been a steady increase in rural conflicts in the country since 2016, peaking in 2020 with 2.054 conflicts involving 77 million ha of land (770,000 km²), 915,000 people and 20 assassinations. While most of these occurred in frontier regions, actors not familiar with the Brazilian rural realities may perceive these as representative of the Brazilian agricultural system as a whole.

Deforestation contributes to climate change, threatens biodiversity and reduces the provision of ecosystem services (Gatti et al., 2021; Feng et al., 2021; Metzger et al., 2019; Prevedello et al., 2019; Esquivel-Muelbert et al., 2018; Barlow et al., 2016). These impacts can also harm future agricultural production in Brazil by potentially reducing yields and the optimal cultivation area, as well as changing precipitation patterns not only in the deforested regions, but also in the center-south part of the country (Oliveira et al., 2013; Lovejoy and Nobre, 2018; Spera et al., 2020; Rattis et al., 2021; Leite-Filho et al., 2021).

Historically, land use change has been the largest source of GHG emissions in the country, contributing to more than 50% of emissions from 1990 to 2008 (MCTI, 2022). In 2016, the last year of official estimates, net emissions from land use change achieved 403 million tonnes of CO2 equivalent (MtCO2eq), or 25.7% of total emissions (using GWP-AR5 conversion of non-CO2 gases to CO2eq), while gross emissions amounted to 801 MtCO2eq (40.6%). Net emissions include the removal of CO2 from the atmosphere by land sinks, which is calculated based on a methodology that carries uncertainties and does not capture the specific contribution of deforestation to Brazil's total GHG emissions. Gross emissions, on the other hand, show the true contribution of deforestation to the global emissions balance. The Sistema de Estimativas de Emissões e Remoções de Gases de Efeito Estufa (SEEG, 2022) reports both net and gross emissions to 2020, and is fully aligned in methodology with the national inventory. SEEG data shows gross emissions from land use change and forestry (LULUCF) in 2016 of 932 MtCO2eq (GWP-AR5), corresponding to 44.5% of the country's total emissions, and net emissions of 319.5 MtCO2eq (21.5%). In 2020, SEEG reported a volume of 998 MtCO2eq from land use changes, which is 46% of total gross emissions, and 362.2 MtCO2eq net emissions (23.8%).

Agriculture is both a driver of global climate change and a sector that is vulnerable to its effects. Brazilian agriculture and livestock contributed to 36% (567 MtCO2eq, GWP-AR5) of the country's net GHG emissions in 2016 (MCTI, 2022). In 2020, agriculture and livestock added 577 MtCO2eq (GWP-AR5) of GHG emissions to the atmosphere; this represents 37.8% of net emissions, or 27% of gross emissions of the country in 2020, with methane from enteric fermentation contributing the most (65% of all agricultural emissions) (SEEG, 2022).

Brazilian agriculture is vulnerable to environmental change and extreme climatic events, which are expected to increase in frequency and intensity due to climate change (IPCC, 2021). Brazilian crop production is mainly rainfed, making the sector highly vulnerable to more variable precipitation patterns. Since the 1960s, changes in climate patterns have been associated with lower-than-expected productivity improvements in agriculture in the order of 15% to 20% in Brazil (Ortiz-Bobea et al., 2021). Estimated net impacts of climate trends on crop yields from 1980 to 2008 suggest negative impacts of 7.5% in maize and 4% in soybeans in Brazil (Lobell et al., 2011). In the most relevant crop production region (Mato Grosso state and Cerrado biome), the optimum area for rainfed crop production has been reduced by 28% since 1980 due to regional warming and drying (Rattis et al., 2021). Other climate change impacts in Latin America and Brazil include decreases in agricultural yields since the 1980s (Prager et al., 2020), migration (Woetzel et al., 2020), social and political conflicts (ECLAC, 2019), biodiversity loss (Boit et al., 2016), deforestation (Prager et al., 2020), changes in precipitation regimes, increases in heat stress, droughts and aridity (Magrin et al., 2014), changes in livestock production (Nelson et al., 2014), shifts in biomes and ecosystems, and changes in biodiversity (Boit et al., 2016).

Land use change is also contributing to regional climatic change by reducing evapotranspiration and increasing local temperatures (Rattis et al., 2021; Coe et al., 2017). Heatwaves present threats to livestock and are increasing in both intensity and frequency, causing losses of cattle in several countries, such as Argentina and the US. These events also pose an increasing threat to livestock production in Brazil. Farms with lower access to human and financial capital will be more vulnerable to changes in historical weather patterns caused by climate change and to declines in ecosystem services from nature loss, posing a significant risk of social unrest stemming from impacted livelihoods and food insecurity.

On average, beef production in Brazil has lower productivity levels than biophysically possible in the country and below rates in the country's closest competitors, a situation which creates opportunities for improvements. Brazil has the largest cattle herd in the world – 2.3 times larger than that of the US – but produces 5-10% less meat, leading to higher methane emissions per animal and beef output. In the last 35 years, the carcass weight per hectare increased by only 10% (0.74% per year), and a slight gain in the stocking rate (from 248 to 255 kilogrammes per hectare) was observed. These figures are in sharp contrast to the considerable productivity gains experienced in maize and soybean production. Corn productivity grew by 5.3% per year, while soybean productivity rose by 3.9% per year. Both crops present productivity indicators comparable to Mercosur neighbours and even the US, while beef productivity is at least 20% less than that of Brazil's main competitors (Feltran-Barbieri and Féres, 2021). Cattle are also a source of diversification and resilience for small and family farmers so policies that aim to address the chronic inefficiency of the sector must include measures to help them prosper in a transition.

The financial sector is increasingly aware of the trends and challenges listed above and is busy developing and implementing frameworks to price the risks that emerge from them. In the absence of clear policy to address these issues, the financial sector will unilaterally price these risks in an uncoordinated manner, potentially leading to a disorderly transition. Such a finance-led transition could be disastrous for the Brazilian agri-food system, raising the possibility of disruptive consequences like higher capital cost, lack of finance and even loss of access to key markets.

Finance- versus policy-driven transition

As a process that replaces old, entrenched means of production with new, more efficient or more desirable ones, transition requires an element of disruption – what Schumpeter (1950) termed 'creative destruction'. Although disruption itself is inevitable, the form that it takes and the impacts that it will have are policy choices (F4B, 2021). A food systems transition led by financial risk aversion can lead to undesirable socioeconomic outcomes. In contrast, well-designed policies can soften the ride by providing a clear path forward and helping economic agents navigate the transition (NatureFinance, 2022; F4B, 2021).

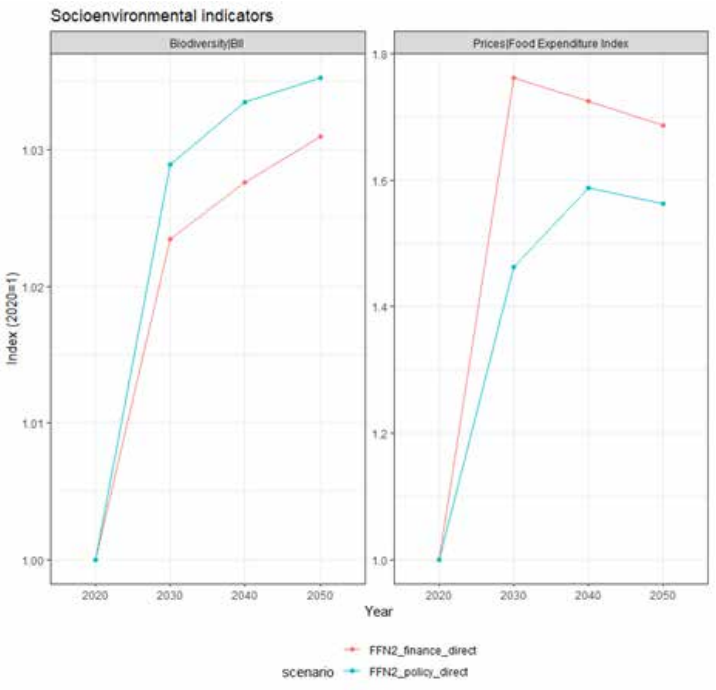
In Brazil, the fact is well established that improving the productivity of the livestock system carries many benefits for society, including many stakeholders involved in the current system. Policy approaches that align with the global rise of nature and carbon credit markets can provide viable options to improve the currently underperforming livestock sector and turn it into an engine for growth. However, this shift will require relevant stakeholders to recognize that the sector is under threat from several compounding and cascading risk drivers. Individuals, firms, and whole industries must relinquish the assumption that this sector can continue to do business along the same lines it has followed in the past.

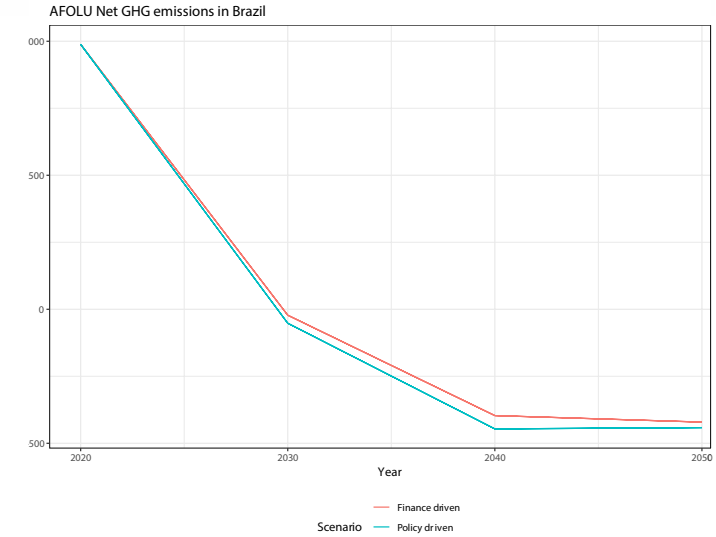
Depending on how it is implemented, a global transition to sustainable food systems can have very different outcomes on relevant socioeconomic and environmental indicators. The uncoordinated pricing of climate and nature risks by the financial sector can lead to a disorderly transition in which food prices and agricultural employment are more adversely impacted than they would be in a coordinated policy-driven transition that proactively implements measures to establish incentives, create enabling environments and de-risk new markets (NatureFinance, 2022). Conversely, a well-designed policy-driven transition can reduce or eliminate many of these adverse effects, and in some cases even turn them into opportunities.

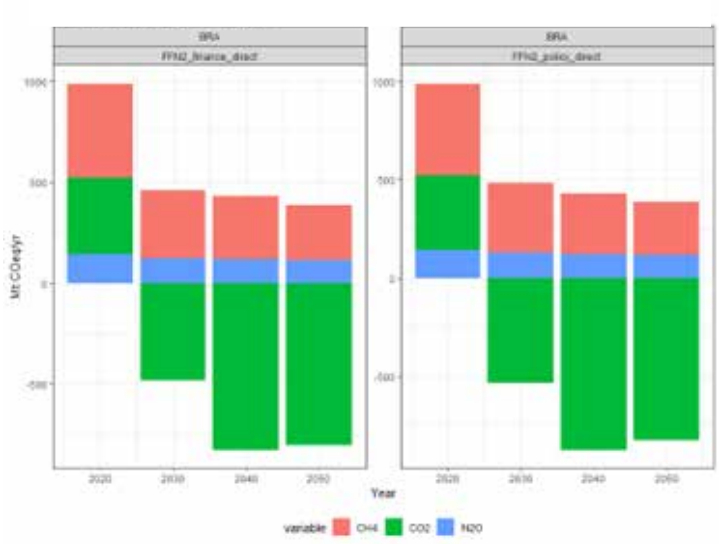
In this report, we expand on the "Finance, Nature and Food Systems - The impact of potential financial climate-nature risk repricing on normative outcomes for food systems" report on global nature-related transition risks (NatureFinance, 2022) by going deeper into a jurisdictional study. Specifically, we use Brazil as a case study of the outcomes of a finance- versus policy-driven transition. We follow the same general narrative and approach of the global study but use more Brazil-specific indicators and variables, partly enabled by a more recent release of the open-source Model of Agricultural Production and its Impact on the Environment (MAgPIE). Both the finance- and policy-driven scenarios reach similar carbon prices by 2050. However, the finance-driven scenario starts pricing emissions more abruptly in 2030 with very high carbon prices, while the increase is smoother and more gradual in the policy-driven scenario. To represent investments into research and development, technological change costs are lower in the policy-driven scenario than they are in the finance-driven one. Pricing of biodiversity loss starts earlier in the policy-driven scenario and consequently, this scenario requires lower values to deliver greater impact in restoring biodiversity (as measured by the Biodiversity Intactness Index).

While both transitions can reduce emissions and reverse nature degradation, the policy-driven approach leads to more desirable outcomes (NautureFinance, 2022). Compared to the finance-driven transition, the policy-driven transition can deliver net-zero sooner, lead to higher biodiversity restoration and lead to more people being able to afford a nutritious diet – all while also reducing the economic costs associated with required structural changes in how goods and services are produced (Figure 1). In both scenarios (but more so in the policy-driven one), enhancing carbon sinks in natural and agricultural lands creates opportunities for generation of carbon credits, which can be sold in voluntary and compliance markets and under Article 6 of the Paris Agreement to the UNFCCC (United Nations Framework Convention on Climate Change). As nature credit markets evolve, the biodiversity credits would also be a new opportunity for nature-positive revenue streams. These markets are gaining traction in the finance world and other ecosystem services will also become revenue streams as they mature.

Figure 1 Socioenvironmental indicators in a finance- vs. policy-driven scenario. Results obtained using the MAgPIE land use model v4.5.0.





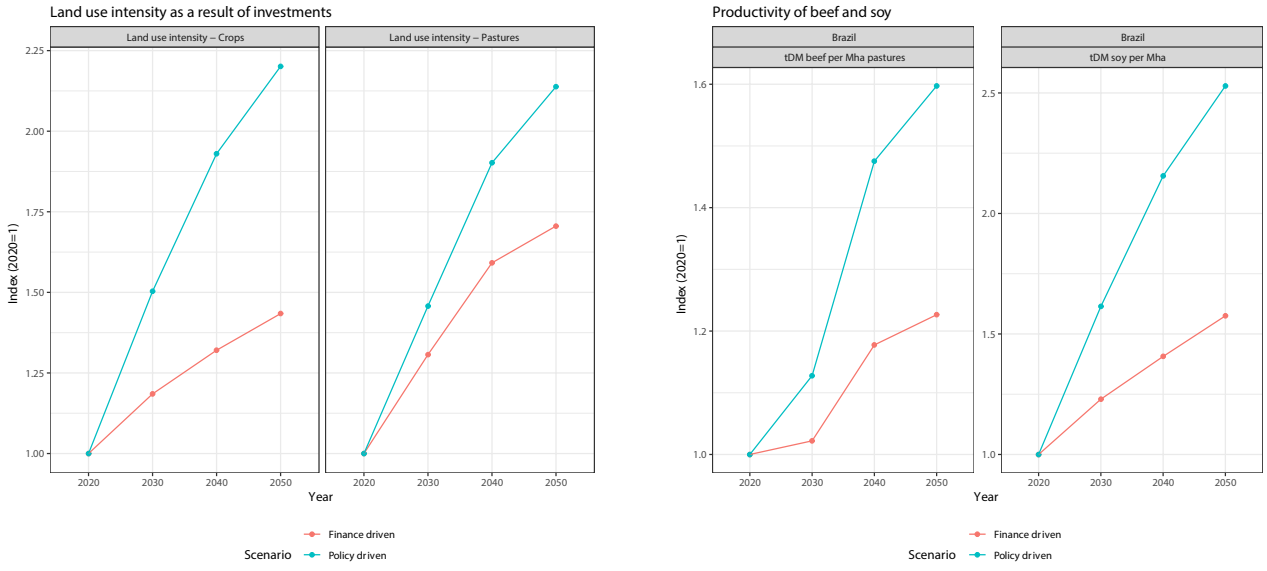


Getting the right financialisation of food involves finance levers that are efficient, directed, innovative and empowered (F4B, 2021, p. 25). Directed financing that empowers producers through innovative financial instruments and markets can drive change that reduces economic inefficiencies, minimises costs and maximises the (co-)benefits of the transition.

In Brazil, there is consensus that increasing productivity of land, especially for livestock systems, has high potential to reduce pressures on land while increasing the economic and environmental resilience of farms (Barretto et al., 2013; Cohn et al., 2014; Gurgel and Laurenzana, 2016; Garcia et al., 2017; Sá et al., 2017; Gil et al., 2018; Lima et al., 2019; Peterson et al., 2020; Silva et al., 2021). Land use intensity increases in a policy-driven scenario for both croplands and pastures, leading to increased productivity (Figure 2).

When done within environmental health constraints, the intensification of agricultural practices can lead to land sparing (higher farmland yields leading to less need for natural habitat conversion to agriculture) creating opportunities for regeneration of natural vegetation and for generation of carbon and nature credits, which can be traded in markets. Investments into research, development and demonstration of innovative technologies and processes can boost productivity through more resource efficiency, novel cultivars, better production techniques and more. Bragança et al. (2022) show how innovation and improved practices in the livestock sector represent key opportunities for yield improvements and provide evidence that extension services can promote pasture restoration in cattle ranching in Brazil.

Figure 2 Left: Land use intensity index (a measure of investment-led productivity gains); right: Brazilian land productivity for soy and beef, two major commodities in the protein supply chain. Results obtained using the MAgPIE land use model v4.5.0.



2

Turning risks into opportunities

Many of the multiple risks facing the Brazilian agri-food system can be mitigated. But doing so will require strong political leadership and buy-in from the private sector. The following three sections outline how a positive shift from risk to opportunity may occur across three categories: known solutions, new innovations (especially alternative proteins), and nature credit and carbon markets. The good news is that Brazil and Brazilian society have a history of successfully addressing environmental challenges. By leveraging past successes and its remaining vast natural capital endowment, the country can reverse existing and growing perceptions that it is moving in the wrong direction and align itself with emerging policy and technological advances to become a truly inclusive agro-ecological powerhouse.

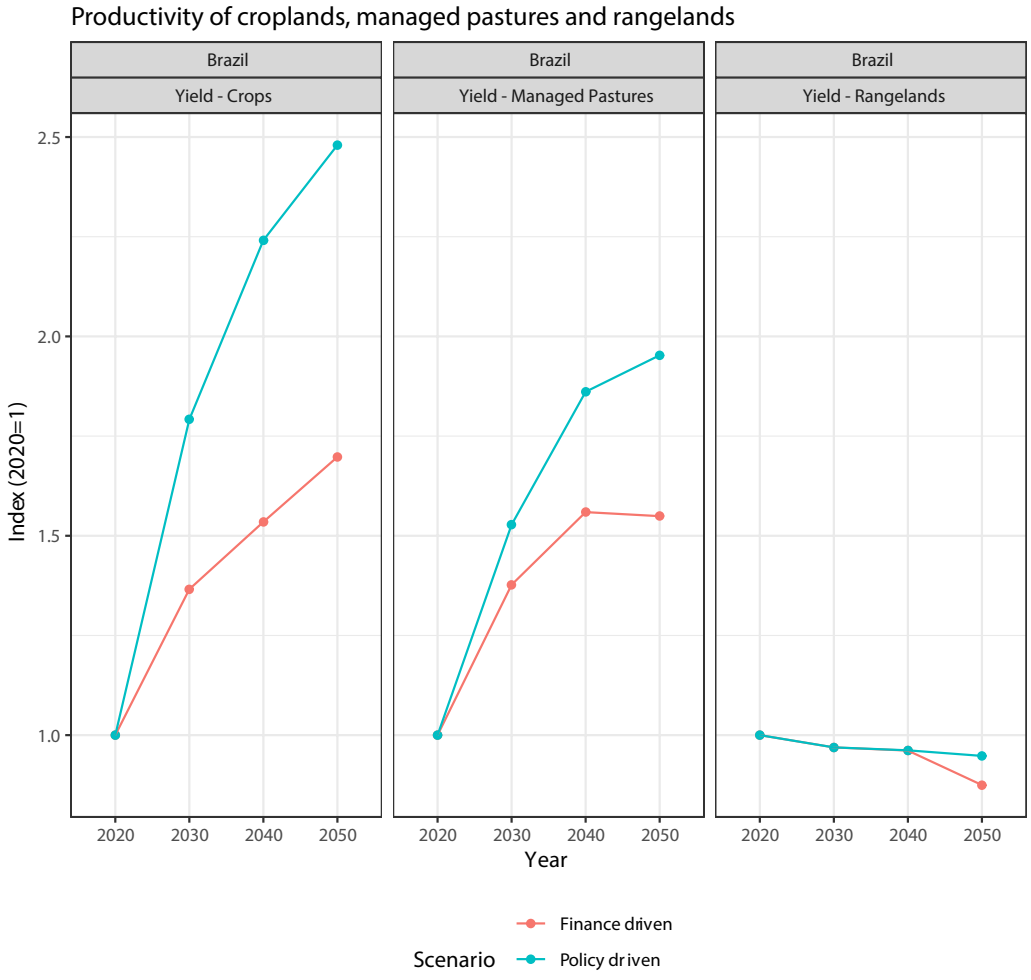
Known solutions create opportunities

Under both transition scenarios, Brazil's yield per hectare increases substantially; however, the policy-driven scenario delivers higher productivity and biodiversity gains with lower GHG emissions, all at a lower socioeconomic cost (Figures 1 and 2). Higher pasture productivity means more can be produced on less land, freeing up large areas for other purposes, such as crop or bioenergy production, forestry and carbon farming, or regeneration of natural habitats. Reaching net-zero GHG emissions effectively prices carbon stocks in standing forests, generating revenues that keep forests standing and even lead to their expansion. Proactive biodiversity implies the regeneration of natural habitats and vegetation, and leads to a reversal of biodiversity loss and an eventual gain in biodiversity indicators such as the Biodiversity Intactness Index.

Because agriculture still emits GHGs (especially methane and nitrous oxide), if the pricing of these residual emissions is passed on to consumers then the cost of food rises. A disorderly transition with higher carbon prices would mean that food prices rise faster than in an orderly transition, causing food expenditure to be higher in a finance-driven scenario than in the policy-driven one. These results align with the FSEC Brazil study (FSEC, 2022), which arrived at similar conclusions but by considering a normative scenario of a deep transformation of global food systems in a transition to an SDP (Soergel et al., 2021).

Figure 3

Productivity improvements of all croplands, managed pastures and rangelands in Brazil across scenarios. The falling yields of rangelands are explained both by climate change impacts and by conversion of the most favourable rangeland areas to croplands or managed pastures. Results obtained using the MAgPIE land use model v4.5.0.



There are several mitigation options technically available today for reducing emissions in agriculture. But they all currently face low adoption and limited potential due to costs and constraints of an economic, social and institutional nature (Herrero et al., 2016; Gil et al., 2015). In the livestock sector, for example, options include improving grazing management, improving feed digestibility, using feed additives, avoiding land use changes through intensification of ruminant systems, better animal management and genetics, rehabilitation of rangeland areas, manure management and legume sowing in pastures.

Intensifying pasture systems can be achieved through improved pasture management and reformation, better cattle breeds and more digestible grass species, all of which require investments up front to reap the benefits over several years. Implementing the structural changes on a system as large as the Brazilian agri-food system requires three broad developments: (i) coordinated public and private finance streams, (ii) capacity-building measures and policies (e.g., agricultural extension services) to provide training in novel techniques to low-skilled farmers, and (iii) widespread pilot projects to demonstrate how the proposed interventions will work for the benefit of the farmers. Moreover, public funds can help de-risk private investments and lead to a 'crowding-in' effect by attracting capital market funds.

In addition to improving environmental indicators and productivity, recuperation of degraded pastures can increase farm resilience, both financially and environmentally. A recent use case by Robeco, the Dutch asset management company, reported that farmers operating on degraded land are more vulnerable to the economic impacts of extreme events (like droughts) than those on healthy land (Robeco and CISL, 2022). Many studies on livestock systems have also shown a potential for higher returns, although upfront investments can be a barrier for less capitalised small farms (e.g., Harfuch et al., 2016).

Although SI is economically attractive in the long run, existing barriers are unlikely to be overcome without targeted public support. Further, history has shown that public and private initiatives are effective when deployed in parallel. In the case of cattle ranching in Brazil, pasture-based systems could be intensified to reduce GHG emissions by more than 50% at the farm level (Gerssen-Gondelach et al., 2017), which could be achieved through policy instruments such as taxes and subsidies targeting intensification and sparing land from deforestation (Cohn et al., 2014). Private initiatives include roundtables (Brazilian Roundtable on Sustainable Livestock, Roundtable on Sustainable Biofuels, Roundtable on Responsible Soy), the Soy Moratorium, Project SOY Plus, the Sustainable Livestock Farming Working Group (GTPS), and the Bonsucro certification programme.

New sectors and innovations: Alternative proteins

The Brazilian agri-food system has been reluctant to debate diet shifts away from animal protein consumption and towards more plant-based diets. Yet this stance leaves the sector unprepared for and more exposed to potential disruptions, while also preventing it from seizing opportunities presented by new markets. Even before the invasion of Ukraine, food supply chains were shifting to more domestic production and reliance on friendly sources ('ally sourcing'). This shift, which has only increased since the invasion, is causing a trend of rising prices in the international food market with impacts on competition for land. Alternative protein sources have thus become more competitive since their land footprint is lower than that of conventional animal-based proteins (Rubio et al., 2020).

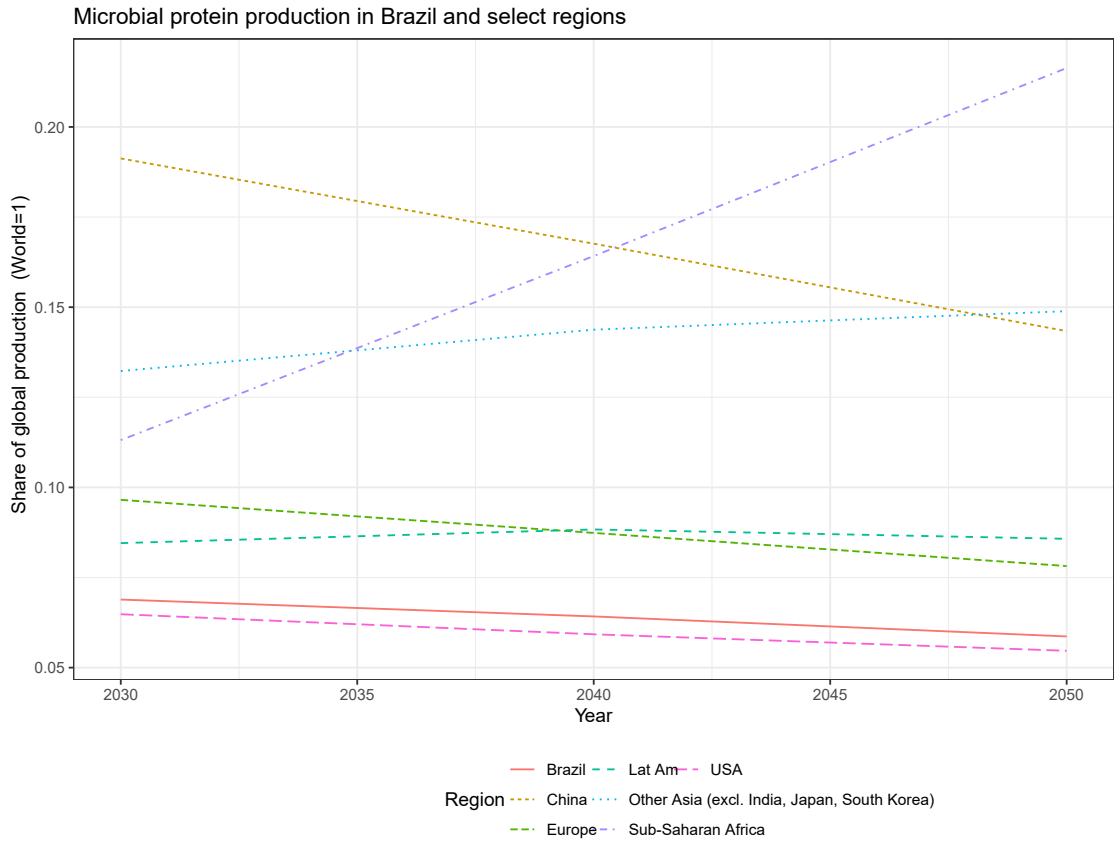
Research and development have allowed technological advancements towards new protein sources. These include plant-based proteins, cultured meat and fermentation-derived microbial protein products, which have seen fast-decreasing costs and innovative solutions applied to consumer perceptions and sensorial characteristics to mimic traditional animal-based products (Rubio et al., 2020). The manufacturing of alternative proteins creates fewer environmental externalities (e.g., lower land footprint and pollution) compared to animal-based proteins (Rubio et al., 2020). Further, although the environmental impacts from food production systems vary enormously among regions, producers and goods (Poore and Nemecek, 2018), scientific literature on both the environmental and health benefits of shifting towards more plant-based diets has grown strongly in the last decade (Hedenus et al., 2014; IFPRI, 2015; Mottet et al., 2017; Poore and Nemecek, 2018; Willett et al., 2019; Swinburn et al., 2019; Jarmul et al., 2020; Humpenöder et al., 2022)

These trends point to potential fast increases in the demand for alternative protein sources, which can generate opportunities to a new industry and novel markets. They also point to the inclusion of the diversity of existing products and ingredients from family and traditional farmers into diets and new agri-food value--chains. Given Brazil's comparative advantage in the production of crops, biomass and livestock, and the diversity of tropical plants and goods produced by traditional local and family farmers but not yet widely used, the country could take the opportunity not only to shift its current agri-food production systems towards more sustainable practices, but also to incentivise investments in the development of new supply chains based on alternative protein sources.

Targeted interventions can leverage the Brazilian agri-food sector's competitive advantages to make it not only a major supplier of the raw inputs needed, but also a producer of alternative proteins: such interventions could create the conditions for developing industrial capacity to convert the raw ingredients into protein products and keep the added value in the country. There are only a few studies exploring the consequences of the global deployment of alternative protein production at scale. Using the same implementation of microbial protein production as Humpenöder et al. (2022), we explored the effects of a normative scenario in which microbial proteins replace 50% of the global ruminant meat market, the MP50pct scenario. MAgPIE results for our scenarios (Figure 4) show that Brazil can provide 6-7% of global alternative protein production without differentiated policies. Sub-Saharan Africa emerges as the powerhouse of microbial protein production, leveraging its vast tropical areas to produce sugar from sugarcane to provide the main raw material needed for the microbial fermentation. But this scenario assumes a technological change is uniformly applied around the world and allocation of production follows a minimal cost objective. Without targeted policies elsewhere, Asia and Sub-Saharan Africa remain the lowest cost regions for alternative protein production and these regions gain market share. With early action, Brazil could in fact gain more market share through targeted policies that enable the transformation industry to be set up in the country and take advantage of its leadership position as the largest sugar exporter and producer of sugarcane in the world.

Figure 4

Global share of microbial protein production by region in the policy-driven scenario variant MP50pct. China's total production continues to grow and it only loses market share because it is currently the largest producer of microbial protein in the world. The MP50pct scenario is a normative scenario in which microbial proteins replace 50% of the global ruminant meat market by 2050. Results obtained using the MAgPIE land use model v4.5.0.

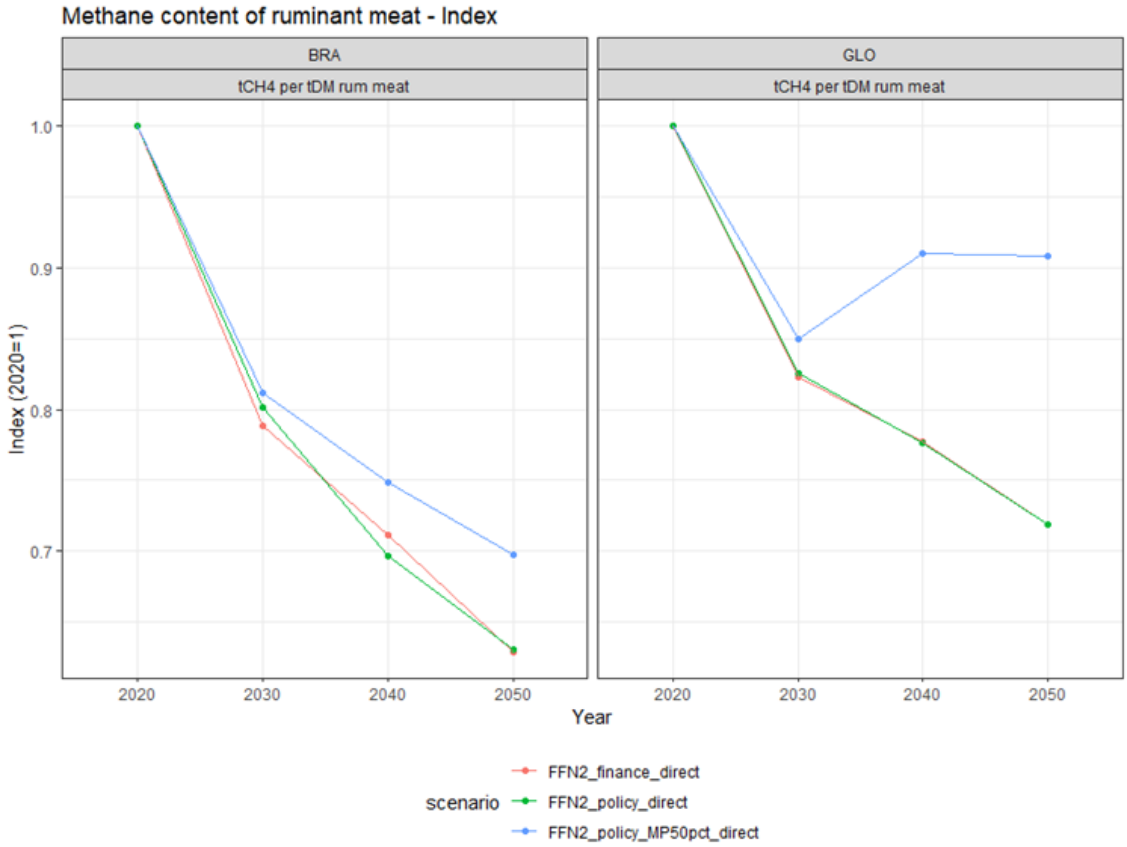


Consumers who may not shift to fully plant-based diets are still likely to demand more transparency around their food's environmental impacts, making sustainable production and its credibility an attractive risk hedging strategy. A full global shift to plant-based diets is unlikely in the coming decades. But it is quite possible that any remaining demand for animal protein will come with conditions on credible sustainability credentials. Few countries have the conditions found in Brazil that enable production of environmentally friendlier animal protein. Using the same MP50pct scenario mentioned above, we explored the methane content of ruminant meat across the two main scenarios and also when microbial proteins replace 50% of the global ruminant meat market (Figure 5). In this scenario, the methane from the enteric fermentation of ruminant meat (beef) production falls by about 30-40% by 2050 in Brazil, but much less on average globally, giving Brazil a green competitive edge in a transitioning world.

This result is even more stark in a scenario of high penetration of alternative protein consumption, in which Brazil can continue to produce beef at lower emission factors, while elsewhere, pastures are relegated to less productive lands by expanding cropland. As global consumers evolve, a decreasing share of animal protein-based products in their diets can be counterbalanced by the higher prices fetched by a premium product with strong 'green' credentials. But credibility is key: any indication that greenwashing is occurring can lead to rejection and it can be hard to undo the damages from this change in perception. In this sense, a few bad apples could spoil the bunch for everyone (Rajão et al., 2020).

Figure 5

Methane content of ruminant meat in Brazil and globally, indexed to 2020 values. The MP50pct scenario is a normative scenario in which microbial proteins replace 50% of the global ruminant meat market by 2050. Results obtained using the MAgPIE land use model v4.5.0 and calculated as tonnes of methane enteric fermentation emissions per dry matter tonne of ruminant meat produced.



Zero-deforestation cattle agreements are a recent effort to reduce deforestation linked to cattle activity. These initiatives require slaughterhouses to identify and block supplying ranches that rely on or enable deforestation or other forms of noncompliance with environmental regulations and norms. In practice, the agreements operate based on the threat of exclusion from the markets and will imply a better behaviour; however, leakages occur and they still need improvements (Alix-Garcia and Gibbs, 2017; Rajão et al., 2020).

A possible solution to leverage the effectiveness of these agreements would be the best use of complementarity policies, both public and private, to reduce deforestation in private areas (Alix-Garcia and Gibbs, 2017; Pereira et al., 2020), together with an efficient tracking system.

Carbon and nature credits:

Opportunities for Brazil from the emergence of global markets

Several concepts, techniques and approaches have evolved in recent years that leverage natural systems and processes to deliver benefits to people and nature. In particular, sustainable intensification (SI), climate-smart agriculture (CSA) and nature-based solutions (NbS) are concepts and approaches driving transformation in the use of natural resources and attracting public incentives and private investments. SI involves increasing food output in current farmland while preserving the future production capability of those areas (Garnett et al., 2013; Tilman et al., 2011). It is related and connected to the CSA approach (Campbell et al., 2014; Lipper et al., 2014), which considers landscape management of natural areas to deal with food security and climate change challenges (World Bank, 2021b). Additionally, both SI and CSA share common ground and goals with the NbS approach (IPCC, 2022), which allies environmental protection with economic and social benefits from healthy ecosystems (Griscom et al., 2017).

SI, CSA and NbS are expected to promote several environmental benefits and give basis for the development of ecosystem services markets. Since sustainable food systems must incorporate these three broad concepts and approaches in the policy strategy and practice, Brazil should engage in developing conditions to be part of these emerging markets. Recent developments in carbon markets include the agreement on the Article 6 rules of the Paris Agreement (World Bank, 2022), the rapidly expanding voluntary carbon market (Ecosystem Marketplace, 2022) and the deployment of the Jurisdictional and Nested REDD+ (JNR) framework. Notably, the Brazilian state of Acre has become a flagship example of the latter, and the scheme is leveraging early lessons to improve outcomes (Fishbein and Lee, 2015).

Carbon offsets and credits from land use and agriculture – which are intrinsically related to SI, CSA and NbS – have gained increasing attention and are under fast development. Such carbon credits and offsets are being used in voluntary carbon markets and have been evaluated to participate in regulated markets, despite the challenges related to protocols and procedures for measuring and estimating such credits (Zelikova et al., 2021; Plume, 2021; Lokuge and Anders, 2022; IPCC, 2022).

Brazil is in a privileged position to develop, expand and adopt SI, CSA and NbS in land use and agriculture, which could generate not only carbon credits but also credits related to environmental and ecosystem services. Griscom et al. (2017) estimate that Brazil may contribute at least 15% to the world carbon mitigation from NbS. The country has large stocks of natural forests (395.8 million ha, or 46.5% of the country's territory) and dedicates 63.2 million ha to crops and planted forests (MapBiomas, 2022), while pastures occupy between 154.5 and 159.5 million ha (MapBiomas, 2022 and IBGE, 2017). Cattle ranching relies on relatively low stocking rates – 1.08 animals per hectare (IBGE, 2017) – and there are considerable differences in technology and productivity within regions and farmers. Several technologies for tropical agriculture were developed in the country, including some conservation and novel practices that are well aligned with the SI, CSA and NbS approaches. For instance, no-till farming, integrated crop-livestock-forestry systems and double cropping systems combining maize and soybean are all well suited to the tropical conditions and are fast evolving and expanding in Brazil. These provide several opportunities to increase yields and productivity while preserving existing natural areas and recovering degraded ones. Such practices also help avoid deforestation and reforestation of areas with high suitability to provide environmental services. In sum, SI, CSA and NbS practices and technologies offer abundant opportunities.

Engaging in nature credit markets and carbon credit markets, and supporting other market-based mechanisms such as green bonds and sustainability-linked bonds, will require the development of monitoring, registry and verification systems that are adapted to Brazil's tropical climate and soil conditions and to its existing conservation and production practices. In this regard, the country has consolidated experience and know-how in some areas (e.g., monitoring deforestation in the Amazon and Cerrado), has been developing and improving in others (e.g., monitoring the cattle herd using SISBOV and including areas to be conserved under the Forest Code (Código Florestal) in the Rural Environmental Registry (Cadastro Ambiental Rural – CAR)), and still lacks tools and protocols in some cases (e.g., monitoring the ABC Plan practices, although there are steps and proposals to deal with this) (Perosa et al., 2020; Manzatto et al., 2020). Combination and integration of several available and foreseen methods and systems will be required, as well as incentives and partnering with private initiatives and institutions from the civil society to develop and apply new technologies and approaches.

3

Past and current policies shaping the future of agri-business in Brazil

Summary of past and current policies

There are several current policies in Brazil related to SI, CSA and NbS principles that may help the country's economy in the transition to a low carbon economy. The prime examples are the Forest Code, the ABC Plan, the National Policy on Agroecology and Organic Production (PNAPO), the National Policy on Environmental and Territorial Management of Indigenous Lands (PNGATI), the PRONAF, the PAA, the National Policy on Climate Change (PNMC) and the Nationally Determined Contribution (NDC).

The Forest Code prescribes several instruments impacting farmers' decisions towards conservation (Brancalion et al., 2016; Climate Policy Initiative and Agroicone, 2018; Santiago et al., 2018). Although it has some challenging implementation issues (Soares-Filho et al., 2014), the Forest Code can play an important role in (i) ensuring the conservation of relevant natural assets for farmers and society, and (ii) meeting the climate goals assumed by Brazil in the Paris Agreement (Climate Policy Initiative and Agroicone, 2018).

The ABC Plan and the ABC+ (an updated version of the ABC Plan launched in 2020) promote agricultural practices to reduce GHG emissions and increase efficiency and resilience of agricultural systems, such as restoration of degraded pastures and integrated crop-livestock-forest production systems (Brazil, 2012). According to Manzatto et al. (2020), from 2010 to 2017/2018, these practices have mitigated almost 170 MtCO2eq. Several estimates point to relevant contributions from the ABC Plan practices and techniques that have led directly to reduced GHG emissions in agricultural practices and indirectly to higher yields and land sparing effects, with consequential lower pressures on deforestation. However, this policy also has some bottlenecks to be addressed (Assad et al., 2013, 2015; Gurgel and Laurenzana, 2016; Lima et al., 2019).

The country had command-and-control policies in place which played a relevant role recently, such as the plans to prevent and control deforestation in the Amazon and Cerrado areas (Brazil – PPCDAm, 2004 and Brazil – PPCerrado, 2016). There is evidence establishing causal relations between the conservation activities promoted by the PPCDAm in the Brazilian Legal Amazon since 2004 and the observed reduction in deforestation rates (Alix-Garcia and Gibbs, 2017; Arima et al., 2014, 2011; Azevedo et al., 2017; Börner et al., 2015; Cisneros et al., 2015; Svahn and Brunner, 2018). Assunção et al. (2015), attribute 56% of the reduction in forest losses over the 2004–2009 period to the conservation policies implemented in the Amazon between 2004 and 2008.

The ABC Plan, PPCDAm and PPCerrado are three of the sectorial plans that form part of the PNMC. The PNMC was approved by the National Congress to fulfil the voluntary commitment made by Brazil at the 15th Conference of the Parties (COP15), held in Copenhagen in 2009. In the same year, the Congress also approved the National Climate Fund. The Amazon Fund (Fundo Amazonia) had been announced two years earlier, at COP13, in Bali. The PNMC, its funding mechanisms, and its standards define priority areas for climate mitigation and adaptation plans, financial mechanisms (such as the Amazon Fund and Brazilian Climate Fund) and the governance of this transversal and multi-sectorial development priority, as linked to an Interministerial Committee chaired by the Presidential Office (Casa Civil). The climate policy framework is also responsible for research and monitoring in the country. The ABC Plan, PPCDAm and PPCerrado were implementation mechanisms of the PNMC. The ABC Plan and the commitment to stop illegal deforestation were also included in the proposals to achieve the goals of Brazil's NDC, offered at the 21st Conference of the Parties (COP21), in 2015 (Brazil, 2015). In 2016, Brazil ratified the Paris Agreement. The most recent update of the Brazilian NDC has the absolute target of reducing GHG emissions by 37% by 2025 and 40% by 2030, relative to 2005 emissions (Brazil, 2022). The initial version of the NDC also included the recovery of 12 million ha of natural vegetation as a potential action to achieve the NDC goal, which was aligned with an expected outcome of the Forest Code implementation. As such, the PNMC already has implementation mechanisms involving and impacting the agri-food system.

Some policies have targeted the country's most vulnerable farmers and have relevance to food security but lack sufficient connection with environmental goals. The PAA has some benefits related to increasing production, diversification and income of rural families; however, it has lost resources in recent years and needs improvements (Assis et al., 2017; Sambuichi et al., 2019). The PRONAF provides credit at subsidised interest rates to encourage farmers' development. Yet its impacts on yields, income level and distribution, and poverty reduction are conditioned by farmers' characteristics and geographical specificity (Batista and Neder, 2014; Araújo and Vieira Filho, 2018). Improvements in rural extension services and farmers' human capital are needed to enhance the PRONAF's outcomes (Zeller and Schiesari, 2020), while its environmental results have not been assessed.

What will be most useful going forward?

Policies to control deforestation and incentivise SI in livestock and agriculture should be part of the same strategic development and governance framework towards a smooth transition of the agri-food system in Brazil. Developing such a governance framework requires a common vision encompassing the interlinked realms of ecosystem services (e.g., water, biodiversity, climate, etc.), finance, food security and agri-food systems.

Well-designed and coordinated policy packages and governance systems can deliver more benefits than individual policies, especially if they explore synergies across – and avoid conflicting objectives in – individual policies. For example, the National Plan for the Recovery of Native Vegetation (Planaveg) was created in 2017 to expand and strengthen public policies, financial incentives, markets, good agricultural practices and other measures necessary for the recovery of Brazilian native vegetation (Brazil, 2022). Planaveg is connected to the national commitments made in the Paris Agreement, such as those to restore, reforest and promote the natural recovery of 12 million ha of forest by 2030. Assad et al. (2020) discuss how the strategies and actions implemented by Planaveg, in combination with the ABC Plan, have created adequate and resilient conditions for agriculture and livestock. As a result, these initiatives can have positive impacts on regional environmental conditions and production systems, as well as socioeconomic and cultural benefits for farmers.

Several policies, instruments and efforts could be combined as complements to achieve similar goals and a broader objective of preparing the country to turn the existing environmental challenges into opportunities. Efforts to control deforestation may benefit not only from command-and-control policies, but also from economic incentives to intensify livestock and agricultural production, payments for environmental services and cattle traceability systems. Monitoring and traceability can be better achieved by improving and combining existing instruments and tools, such as the Brazilian System of Individual Identification of Cattle and Buffalo (SISBOV), CAR in the Forest Code, and the mandatory Animal Transit Guide (GTA) recording cattle transportation. In summary, the knowledge accumulated from current and past policies should be used to promote their integration and coordinated implementation.

4

Delivering a smooth transition through well-designed policies

Policy coordination

Turning the above-outlined agri-food and environmental challenges into opportunities requires careful and well-orchestrated policy coordination and multi-sectorial governance that links planning and execution across different ministries, ensuring coherence and integration of goals, instruments and resources. It also needs the alignment of roles and responsibilities between the different levels of government (multi-level governance from federal/-central to local), as well as synergistic instruments and actions, which could prevent and avoid conflicting outcomes and inefficiencies.

The ABC Plan, for example, implemented from 2010 to 2020, had some elements of good policy coordination, as well as some aspects of limited coordination. A positive feature was the design and elaboration of the Plan, which was done as one of the sectorial plans in the PNMC; as such, it aligned with the PNMC's principles and goals, followed a broad democratic and inclusive process aligning expectations and demands from several stakeholders and was intensively based on available scientific information (Brazil, 2012; Prado Jr., 2017). However, other coordination elements were missing, such as the alignment with policies and instruments of monitoring and control of results, the agricultural rural credit policy (ABC Programme), and the responsibility and command chain from the federal to the state level, among other elements, which limited aspects like disclosure, accountability and compliance (Prado Jr., 2017).

Well-coordinated environmental and agricultural policies must be designed and harmonised considering multiple public actors (e.g., those from the environment, agriculture, economy, infrastructure and energy sectors) and a long-term strategy for land use planning; this means policy evaluation must occur across ministries and jurisdictions to ensure no conflicting elements undermine the overarching objectives of the agri-food system's transformation in the desired direction. Economic incentives have to align at all governance levels with other instruments, such as command-and-control measures.

Financial innovation: Nature credit markets and carbon markets

What is needed to create them in Brazil?

The financial sector in Brazil faces structural barriers, such as an unstable macroeconomic environment and limited legal protection for its investments, as well as microeconomic challenges determining unfavourable risk-return ratios in environmental and low-carbon financing opportunities and instruments (Yamahaki et al., 2020). Good governance and strong institutions can enable policy-driven structural change that minimises costs and maximises benefits. Hence, Brazil needs clear land tenure rights and obligations, strong monitoring and enforcement of regulation, and efficient contractual dispute resolution. These aspects would all work together to increase the credibility of environmental outcomes and reduce risk perception of investments.

In addition to improving the effectiveness and coordination of existing financial regulations, new laws and regulations are needed to keep pace with international financial innovation for emerging nature credit markets and carbon markets. Many types of financial instruments currently exist around the world that facilitate private investment in nature, including green bonds, sustainability-linked bonds, conservation easements and blended finance using public and/or philanthropic capital to de-risk private investments (Holtedahl, Köberle and Wilkins, 2022). Some of these instruments exist in Brazil but many do not; these could help strengthen the nature asset class and make it more attractive to mainstream investors.

Holtedahl, Koberle and Wilkins (2022) identify conditions that must be in place to enable the scaling up of nature markets. These include projects that generate returns (through revenue streams or cost reductions), markets with credible exchange mechanisms, demand signals, enforceable property rights and sizeable deals that justify transaction costs. Safeguards are needed to ensure legitimacy and equity – key ingredients for a stable and lasting market, along with local stakeholder participation and profit sharing. The right level of impact metrics needs to strike a balance: it should not be overly burdensome for project managers but it must be strong enough to provide comfort for investors. Importantly, nature conservation entails opportunity costs for agriculture, which means that projects need to generate enough return to be attractive to landowners and decision makers (Koberle et al., 2021).

A growing number of frameworks provide guidance on how markets can operate to enable opportunities for investment while ensuring real change on the ground, bringing positive benefits for nature and people. Emerging nature credit markets can learn from climate initiatives. For example, the Voluntary Carbon Markets Integrity Initiative (VCMI) is developing a code of practice that advises corporations on how carbon credits can be used in a credible and impactful manner. Likewise, the Taskforce on Nature-related Financial Disclosure (TNFD) provides guidance on disclosing corporate nature-related risks to inform investors' decisions. Brazilian stakeholders need to review these resources and guidelines, and implement (or adapt) them.

A policy-driven transition can create the enabling conditions for nature markets to function as intended. This kind of transition needs to be developed in Brazil for the Brazilian context in order to realise its potential as a prime destination for future investments in nature. Notably, however, markets alone will not save nature. In fact, the results presented in this report and in the global-level report point to the dangers of leaving it to the financial sector to price nature-related risks on its own. These dangers are explored in more detail in the F4B report describing the Food Finance Nexus (F4B, 2021).

5

Policy recommendations for the new administration

These policy recommendations are proposed to all candidates for presidency, state governance and parliament as they can promote an enabling environment to deliver climate-resilient, nature-positive and equitable outcomes. The proposals may also foster the engagement of the finance community as well as civil society, academia and the private sector.

We urge the candidates to clearly signal compliance with the legislation through communication and the practice of law enforcement, indicating the non-tolerance of illegal practices in land and natural resource use. To this end, we recommend the prompt reintegration of the environmental inspection bodies' capacities and activities, including the monitoring and punishment of illegal deforestation.

Recommended Policies

• Promote intensification and improve efficiency in agriculture and livestock activities, while enforcing the policies to protect natural vegetation, nature reserves and traditional communities' land. To this end, improve and expand existing policies and programmes to achieve higher yields in agriculture (e.g., the ABC Plan, rural extension and technical assistance quality and coverage, and research, development and demonstration at the agri-food research institutions). Improve and reactivate policies to combat deforestation (e.g., PPCDAm and PPCerrado) and accelerate the enforcement and implementation of the Forest Code.

• Encourage and advance the development of the knowledge-based alternative protein production chain – from the promotion of diverse agricultural systems and use of bio-based raw materials to (primarily) the processing, industrialisation and production of the final good and incorporation of environmental and/or geographic attributes. Promote alternative proteins – such as plant-based foods, microbial protein, insects and cultivated meat – due to their potential to mitigate GHG emissions and lower land and water resource usage. To this purpose, we recommend the creation of new funding programmes (and the strengthening of existing ones) at institutions (e.g., BNDES, FINEP, EMBRAPII, Embrapa and CNPq) targeting farmers, cooperatives of family farmers, companies, start-ups and research institutions in all stages of the production chain.

• Guide and encourage the financial sector to participate in and contribute to a policy-facilitated transition of the agri-food system towards a sustainable pathway, since a financial risk-driven transition leads to adverse impacts on food security from higher food prices, while also implying lower yields, higher environmental damage and lower economic growth for Brazil. To achieve this aim, policymakers should work together with the financial sector in implementing policies that foster higher efficiency in the agri-food sector and protect of natural ecosystems, and in establishing monitoring systems and aggregating environmental attributes to the agri-food sector in order to incorporate sustainability indicators in the sector's metrics, reports, portfolios and range of services generated by agricultural activities, which the financial sector funds.

• Encourage the adoption of CSA, SI and NbS approaches, practices and techniques in agriculture, such as low carbon agriculture. Encourage adding and incorporating their concepts, practices and techniques into ongoing policies and initiatives and promoting the advantages of these practices in increasing resilience and combatting climate change (adaptation and mitigation). To achieve this goal, we suggest revising the operative plan of the ABC+ in order to embrace and explicitly mention internationally agreed terminology and to present the ABC+ practices and techniques as aligned with and included in the above concepts and approaches. In addition, improve and increase actions and activities related to dissemination and training of farmers and professionals in the ABC+ practices and engagement with management committees at the sub-national level (states and municipalities). Ensure that the ABC+ policy and practices are disseminated, promoted and recognised as being adherent and aligned to the CSA, SI and NbS concepts. We also recommend the introduction of these concepts in (i) the curriculum of agricultural sciences colleges and schools, (ii) the training of professionals providing technical assistance and rural extension providers, and (iii) the training of financial agents involved in the disbursement of rural credit to farmers. Lastly, we recommend strengthening and expanding rural credit targeting the practices and technologies of the ABC+, and indeed, expanding the budgets allocated to that plan.

• Improve food security in the country, considering the broad diversity of farmers, production systems, institutions and supply chain structures in the agri-food system in Brazil; this will require policies and actions targeting improvements in human, social, physical and financial capital to those producers lagging behind in opportunities and access to markets and technologies. To this end, a broad set of actions is required, including improving the education system in rural areas, increasing and improving training of farmers and of professionals responsible for developing rural extension and technical assistance, generating and assessing quantitative and qualitative information (data) about the most vulnerable farmers, and creating new and revising/improving existing policies targeting these stakeholders on aspects such as technical assistance, financing and food acquisition, which must be aligned with the CSA, SI and NbS approaches. In that sense, the PRONAF should be fully aligned and given access to equitable funding for sustainable agriculture and implementation of the ABC Plan targeting smallholders. Re-equipping and urgently funding programs such as the PAA would be a win-win strategy in the short term.

Finally, many recent studies have pointed to the role of demand-side changes in helping to achieve sustainability targets in agri-food and energy systems (IPCC, 2019; IPCC, 2022). Notably, the current study explores supply-side options only, while demand-side options were assessed in the third report of this series - Finance, Nature and Food Systems - Consumers choosing sustainable food systems in Brazil (Bataillard, D., 2022). That report made several recommendations for demand-side interventions, as follows:

• Encourage consumers to shop for food more sustainably by supporting them in making better decisions and avoiding counter-productive biases and choices. People normally use shortcuts when deciding between alternatives when they do not have all the information.

• Advance food policies by designing socioenvironmental labels that can quickly characterise a food product as less harmful to a specific socioenvironmental impact in terms of intensity (low, medium and high). Such tailored information is a powerful tool that can communicate to consumers valid cues or characteristics that can differentiate food options. The target is to facilitate understanding of socioenvironmental impact information by developing a label on the front panel of packaged foods using simple icons. Life cycle sustainability assessment may be applied to evaluating environmental, social and economic decision-making processes towards sustainability throughout the food product life cycle. The impacts should be chosen to represent the most critical ones to the environment and society based on robust scientific evidence pointing in this direction.

• Impacts should also be selected based on Brazilian consumers' concerns about them. The label must be designed to avoid biases, misleading information and repeating information already delivered by well-established official labels.

• To guarantee the effectiveness of the label implementation, (Bataillard et al., 2022) recommend employing an educational programme wherein consumers make their decisions so they can visualise the different options and recognise the label to learn how to make sustainable food choices. This programme should be developed in collaboration with all stakeholders to guarantee their support when putting it into practice.

• Improve and provide conditions for the development of mandatory origin control and traceability in the cattle ranching chain. To this end, we recommend (i) improving and reformulating SISBOV to achieve a mandatory system, and (ii) considering an implementation plan to disseminate and prepare rural extension professionals, cattle ranchers and other agents in the production chain to allow full coverage of the sector and informal market development, and to avoid exclusion of small farmers and less prepared producers.

• Establish systems for monitoring and measuring sustainability indicators and metrics in the agri-business chains, primarily in the animal protein and alternative protein chains. We recommend the development of a multi-institutional taskforce to map and assess all existing (public, private and non-profit) patterns, systems, certifications and efforts aiming to monitor sustainability metrics in the agri-food sector. We also recommend the elaboration or adaptation of existing criteria and rules of monitoring sustainability indicators in the agricultural sector in Brazil, and developing a centralised platform to host and coordinate monitoring efforts.

• Encourage and promote the aggregation of sustainability attributes and geographic identity to products from farmers who adopt sustainable agricultural practices, especially those associated with the Amazon and Cerrado biomes. To this end, regulate the Law of Payment for Environmental Services (PES), integrating the monitoring systems to PES, and create new programs at BNDES, FINEP, SEBRAE, Rural Credit and CNPq incentivising the integration of environmental and geographic attributes to agricultural goods.

• Encourage the financial sector to participate in and contribute to establishing monitoring systems and aggregating environmental attributes to the agri-food sector in order to align the incorporation of sustainability indicators in its metrics, reports, portfolios and range of services generated by the agricultural activities that it finances.

• Encourage and create conditions for the implementation of carbon markets and ecosystem and biodiversity services (nature credit markets) with clear rules that generate confidence for investors. To this purpose, we recommend the regulation of the PSA and the provisions outlined in the Forest Code; this will encourage synergies between agricultural production, conservation and recovery of natural resources.

• Promote the training of new workers and professionals for sustainable protein production chains, as well as the retraining and reallocation of workers to migrate from contracting chains and sectors towards sustainable chains. Implement and improve training programs and dissemination of information and sustainable and resilient practices for farmers (extension services and technical assistance). We recommend reviewing the rural extension policy with a purpose other than technical assistance. Direct the rural extension to assist in the training of producers as well as teaching them to adapt to legal norms and requirements.

• Encourage farmers to diversify primary agricultural production at the property and/or local level in order to supply raw materials for the alternative protein industry, and encourage and promote the sustainable intensification of livestock.

In addition to the above, there are past and current policies that can be reinstated or strengthened, leveraging lessons learned to improve their performance, as follows:

• Improve and reactivate policies to combat deforestation that have shown favourable results in the past (PPCDAm, PPCerrado and the Amazon Fund).

• Accelerate and guarantee the implementation of the Forest Code. To this end, we recommend (i) banning further changes to the final implementation of the Rural Environmental Registry (CAR) date and setting minimum thresholds for the share of verified and validated CAR in each state by the final CAR implementation date; (ii) providing assistance (expertise, human and public resources) to the states lagging behind in these processes; and (iii) setting firm goals and due dates for farmers' adoption of the Environmental Regularization Program (Programa de Regularização Ambiental – PRA).

• Expand rural credit resources associated with the adoption of sustainable practices in agriculture (such as the ABC+) and impose conditions to the other existing rural credit programs to require environmental good practices, such as the net decrease of GHG emissions in the financed activities (monitoring or carbon accounting systems need to be in place for verification purposes).

• Improve governance and institutional coordination of the various policies in progress in order to take advantage of the existing synergies between them and avoid overlaps and potential contradictions and conflicts. The PNMC sets the governance of this transversal and multi-sectorial development priority, as linked to an Interministerial Committee of Climate Change chaired by the Presidential Office. The actual legal framework is clear in seeking to coordinate climate policies to the highest levels of the executive power; it is preferable that those policies are aligned with decisions from legislative and judiciary power.

Finally, we recommend introducing policies and regulation to improve the operational environment of private investors to de-risk investments in environmentally friendly agriculture. Specifically,

• Engage with the financial sector to encourage the private sector's participation in financing agriculture. At the same time, expand and encourage the creation and adoption of financial instruments associated with sustainable practices (such as green bonds and climate bonds) in agriculture.

• Implement macroeconomic policies and structural reforms that improve the stability of the macroeconomic environment and reduce the uncertainties and risks of the financial sector associated with the business environment, regulatory environment and validity of contracts; this will involve reviewing and restructuring norms, rules, laws and the functioning of judicial services.

6 Discussion and closing remarks

The agri-food system contributes to human well-being through the supply of nutrients to the world population, the provision of jobs and livelihoods, and economic development. However, food production is also a major driver of environmental degradation in the form of pollution, climate change and biodiversity loss, all of which threaten the continuation of current agricultural practices. This position as both driver and victim of environmental change puts the agri-food sector in a position where 'business as usual' is no longer an option, and doing nothing carries a different, but just as material, set of risks as acting on the evidence. These pressures are driving a consensus that food production systems must be transformed; the debate is on how and how fast this should happen. Depending on how it is implemented, a global transition to sustainable food systems could have very different outcomes on relevant socioeconomic and environmental indicators.

To complicate matters, the global financial sector is increasingly incorporating climate and nature risk assessments into decisions regarding investments in all sectors, including agri-food systems. Many are hailing this shift as a revolutionary one that will unleash the power of capital to drive positive change. However, finance is driven by profits and if the global financial system begins to price nature- and climate-related risks based on maximising returns on investment or minimising risk exposure, then there is a real possibility of disruption in global food systems. Disruption tends to harm smallholders and can put existing business models at risk; this carries dangers of higher food insecurity, along with all the expected consequences. The current food crisis following the invasion of Ukraine illustrates some of these significant dangers.

One of the sectors presently facing high risk of disruption is protein production. Animal protein is the main protein source today, but its production is also a major driver of GHG emissions and land use change driving climate change and habitat loss, whether directly (through demand for pasture land) or indirectly (through demand for crops for feed). Beef cattle production has recently been likened to coal use as a major driver of GHG emissions (The Economist, 2021). Important financial institutions are reporting on the role of beef in nature loss and there are growing calls for divestment from deforestation--driving activities, of which beef production is a major example (e.g., Financial Times, 2020). But global production of poultry and pork requires crops as feed, driving up the demand for soy and maize, which are also culprits of land use change.

Alternative proteins have emerged as potential game changers in the provision of protein for human consumption. These capital- and energy-intensive technologies have lower land and natural resource footprints, but may disrupt existing supply chains and threaten the livelihood of millions of farmers who lack access to cheap capital. Scaling up these novel technologies will require capital investments, placing the financial sector at the centre of this transition. Disruptions in current food systems will likely be part of a transition that looks increasingly unavoidable. But although disruption itself is inevitable, the forms that it will take and the impacts that it will have are policy choices (F4B, 2021). Despite the fact that polarisation, self-interest and high stakes may make it difficult to forge a common path forward, the benefits of a well-managed transition make it worth exploring what is required to make it possible. There is ample potential to turn the transition challenges into opportunities, such as environmentally friendly technologies and new markets for alternative protein and nature-related credits.

As one of the world's largest producers of food in general and protein in particular, Brazil is exposed to risks resulting from a transition away from animal protein produced with a high environmental footprint. The country is also the most biodiverse in the world and home to the largest remaining tropical forest, the Amazon. On the one hand, persistently high deforestation rates in Brazil have raised concerns from financial institutions globally (e.g., S&P Global Ratings, 2021; Bloomberg, 2022), exposing the Brazilian agri-food sector to reputational risk which, once established, is difficult to undo. On the other hand, as we demonstrate in this report, Brazil's favourable climate and fertile soils mean it can turn these risks into competitive advantages in a global food systems transition, provided that well-designed and coordinated policy packages are deployed to create the key enabling conditions needed. All of these considerations make the country an interesting case study to explore how to get the financialisation of food right.

In this report we have made several policy recommendations for the first few months of the next incoming administration in Brazil. Implementing these policies will not be without its detractors. But we encourage all stakeholders in the Brazilian agri-food system to examine the evidence presented here and reconsider their positions in light of the changes that are undoubtedly coming: how resilient are those positions to these changes? What are the best investment choices that we can make right now?

Brazil is one of the few countries in the world that can clearly benefit from a global transition to sustainable food production systems. These benefits, however, are far from guaranteed. A clear vision of how to position the country for success – along with political and business leadership unified around this vision – will be needed to improve governance and strengthen institutions for a resilient, inclusive and sustainable agri-food sector that truly delivers on its potential for much-needed economic development.

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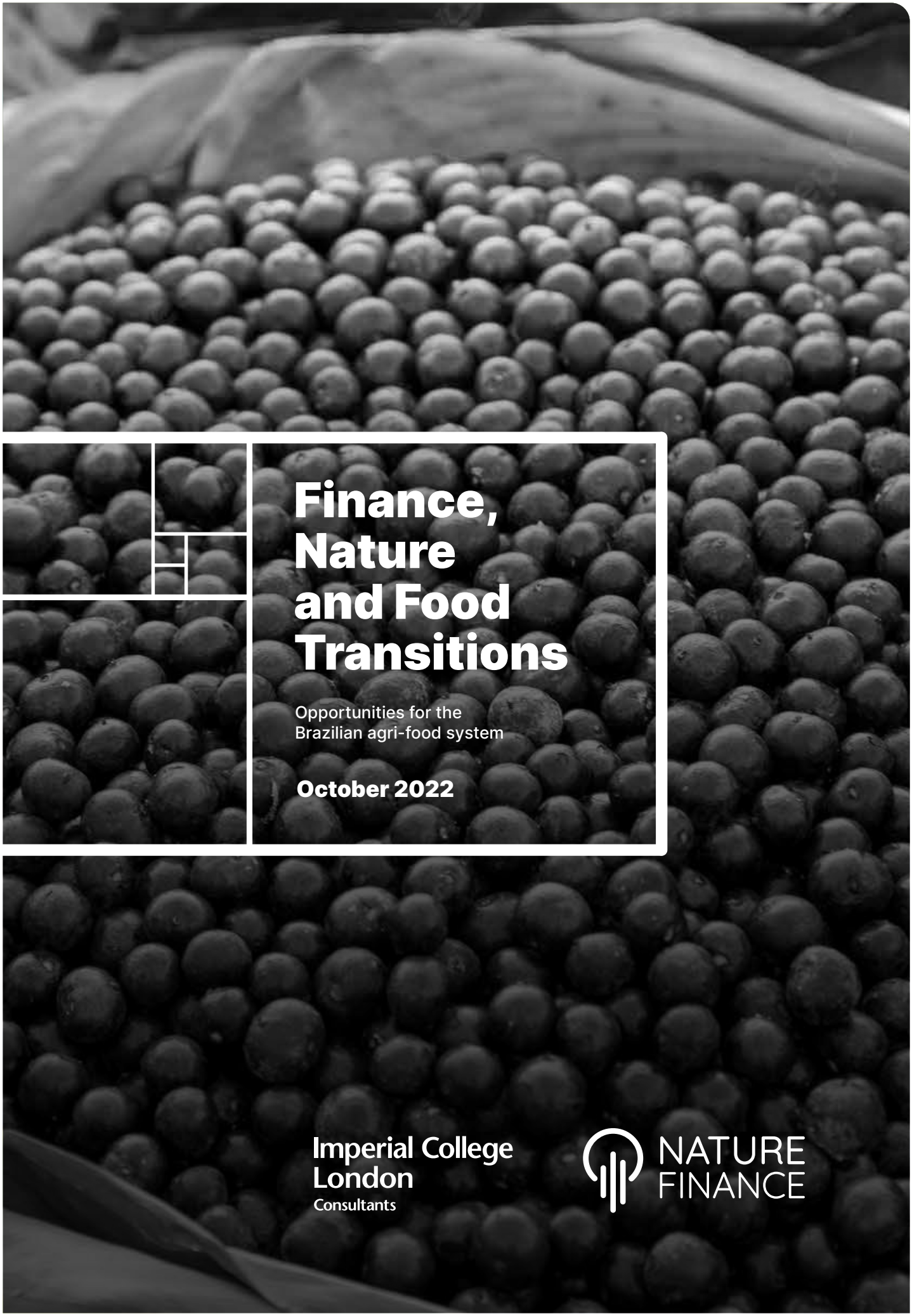

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