Chapter 3. Brazil

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Background report

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FABLE CONSORTIUM

Authors
Alexandre Koberle (1)*, Wanderson Costa (2)

(1) Instituto Dom Luiz, Faculty of Sciences, University of Lisbon, Portugal
(2) National Institute for Space Research (INPE)

***Corresponding author: ackoberle@ciencias.ulisboa.pt**

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Highlights

- In this study, we assessed the evolution of hidden costs for Brazil's agrifood system as presented in the SOFA 2023 report and analyzed strategies for reducing them through stakeholder consultation and modeling using the FABLE approach.

- The scenarios were developed using FABLE-Calculator, a tool that computes land use, emissions, and food system projections over 2000–2050. The hidden costs were analyzed by integrating the TCA methodology with the FABLE Calculator outcomes, exploring three alternative pathways to achieve sustainability.

- Results indicate that over half of the hidden costs are linked to dietary choices, followed by nitrogen flows and climate components. However, these results are driven by methodological and data choices that were questioned by the stakeholders consulted. They suggested national datasets should be used instead and methods should be adjusted to reflect national context.

- Strategies from different actors from the public and private sectors are needed to reduce the hidden costs in Brazil. National and local actions to shift towards healthier diets and to reduce GHG emissions can be important to diminish these costs, such as government subsidies and incentives for sustainable agricultural practices and organic food production.

- The findings highlight the importance of enhancing analytical capacity through stronger collaboration between Brazilian institutions and the FAO, as well as the need for additional national datasets that reflect Brazil's diversity and complexity.

Contents

3.1 Introduction

The aim of this chapter is to provide country-specific feedback for the improvement and further development of the estimates of the hidden costs of agrifood systems in Brazil. Brazil-specific scenarios were developed with the FABLE Calculator to provide inputs for the evolution of hidden costs by 2030 and 2050. The feedback presented here was collected and produced via literature review and expert consultation with stakeholders in civil society, government, and academia. The consulted experts have expertise spanning the areas of economics, social sciences, agricultural sciences, food and land use systems, low carbon and climate resilient development, and sustainability transformations.

Brazil is the largest net exporter of food products in the world, the largest producer of soybeans, and the second largest beef producer. It is also the most biodiverse country in the world, home to large swathes of remaining Amazon rainforest, home to native plants, animals and Indigenous communities. The country's high suitability for agricultural production at industrial scales has enabled a thriving agricultural sector with large contributions to GDP and employment. This has come at the expense of natural habitats and ecosystems causing greenhouse gas emissions, soil degradation, biodiversity loss and pollution of air, land and water. While productivity increases have contributed substantially to increasing production, expansion of agricultural land over native vegetation has continued to this day, and chronic inefficiencies remain.

Our results show there is high potential for improving yields, adopting conservation agriculture, increasing inclusivity, incentivizing more healthy diets, and capturing revenues from carbon sequestration in land sinks, and this is in line with a large literature (e.g., see Köberle et al., 2020; de Oliveira et al., 2017; Assad et al., 2018). However, this literature also shows that challenges that need to be overcome to fully grasp the opportunities include increasing access to finance, strengthening enforcement of existing environmental and land regulation, and creating robust carbon and nature markets that properly value climate and biodiversity stocks (see e.g., NatureFinance 2022; Rochedo et al., 2018). While industrial agriculture dominates commodity production for export markets, smallholders and family farmers make a sizable contribution to supplying domestic food markets. Yet, unhealthy diets increasingly contribute to health issues, and the widespread use of biocides undermines both human and environmental health. In both grain and beef sectors, market power by a handful of companies is both a cause of current externalities and an opportunity to transform agricultural value chains through active engagement of a limited number of actors. Technological and process innovation can deliver both environmental and economic benefits and facilitate a transformation that maximizes well-being in a country that still needs to bring a large share of its population out of poverty and low-income traps.

Still, while science points to the high potential for a sustainable transformation of food systems in Brazil which would have many benefits, there would still be an uneven distribution of benefits and trade-offs, which imply the results can elicit strong reactions and can be perceived as politically charged.

Feedback was requested via email from key stakeholders of the agricultural sector, including from academia, government, and civil society. To provide respondents with relevant information, a slide deck was prepared with key messages and figures from the hidden costs analysis. Respondents were then asked to provide their feedback via an online form in which they could provide i) their personal information such as sector, affiliation, and anonymity preferences; ii) responses to prepared questions about specific topics; and iii) their opinions regarding results as well as suggestions for improvements to the analysis or alternative datasets (cf. Annex).

The emails were sent out in mid-February and respondents were given a period of two weeks to respond. While a longer period would have been desirable to elicit the largest possible number of responses, the tight production timeline of the report plus the summer holiday season in Brazil constrained our options in that regard. In a second round, requests were sent to the 32 respondents to participate in a virtual meeting set in early April. Only nine responses were obtained from the online survey, all with expertise in disciplines of economics and agriculture. The virtual meeting in April was attended by nine participants, with five of them being stakeholders who responded to the online survey. Based on the limited number of responses, it is already evident that the results will elicit a broad range of responses from different stakeholders.

When asked "How well do you think the analysis reflects hidden costs in Brazil?", two stakeholders had diametrically opposite responses to the size of the hidden costs' estimates, one suggesting they were overestimated while the other saying they were underestimated. A third responded by saying "Not very well" and said it was "Probably due to the high uncertainty associated to the data used for such analyses."

The personal views of respondents also seem to be influenced by respondents' disciplines, suggesting this exercise may trigger subjective reactions. For example, the respondent who thought the hidden costs were underestimated works in an economic thinktank and is active in the rural development field, while the one who thought they were overestimated is tied to an agronomic research facility. These responses suggest that stakeholders may respond subjectively in the face of uncertainty or perceived lack of clarity about the assessment, raising the possibility that the results may trigger politically charged debates. This is useful in preparing for broader engagement with society through a proper framing of the questions posed and the insights highlighted.

3.2 SOFA 2023 hidden costs analysis

3.2.1 Main cost components and explanations of the results

In 2020, the hidden costs from food production in Brazil totaled around 500 billion 2020 PPP dollars. This is roughly equivalent to 16% of Brazil's GDP on a PPP basis, implying that Brazil's GDP PPP would be roughly 16% lower if the hidden costs were to be accounted for in 2020. The main cost components for Brazil's TCA are the burden of disease, nitrogen flows and climate, accounting for 270 billion (54%), 231 billion (30%) and 2.2 billion (15%) 2020 PPP dollars respectively of the total hidden costs (FAO, 2023).

SOFA 2023 TCA analysis shows the cost of unhealthy diets has been steadily increasing from 2016 to 2023 (Figure 3-1), in line with Brazilian studies showing increasing costs from diets rich in processed meat (Rocha et al., 2023) and increasing overweight and obesity rates (Ferrari et al., 2022). Rocha et al. (2023) used national data to estimate an increasing burden of non-communicable diseases (NCDs) from hospitalizations and outpatient procedures of around USD 9 million in 2019, and age-standardized DALYs estimated at around 35/100,000 for 2019. (Ferrari et al., 2022) estimated direct healthcare costs related to NCDs attributable to high body mass index (BMI) of USD 654 million. Both these studies results are in market exchange rate (MER), not PPP, making direct comparisons to SOFA 2023 TCA more challenging.

The estimated 2023 costs of agrifood work poverty and blue water use are much smaller, at 3.5 billion and 34 million 2020 PPP dollars, respectively (Figure 3-2), and the cost of undernourishment is shown as being zero.

Figure 3-1: *Burden of disease costs for Brazil as estimated in SOFA 2023 TCA*

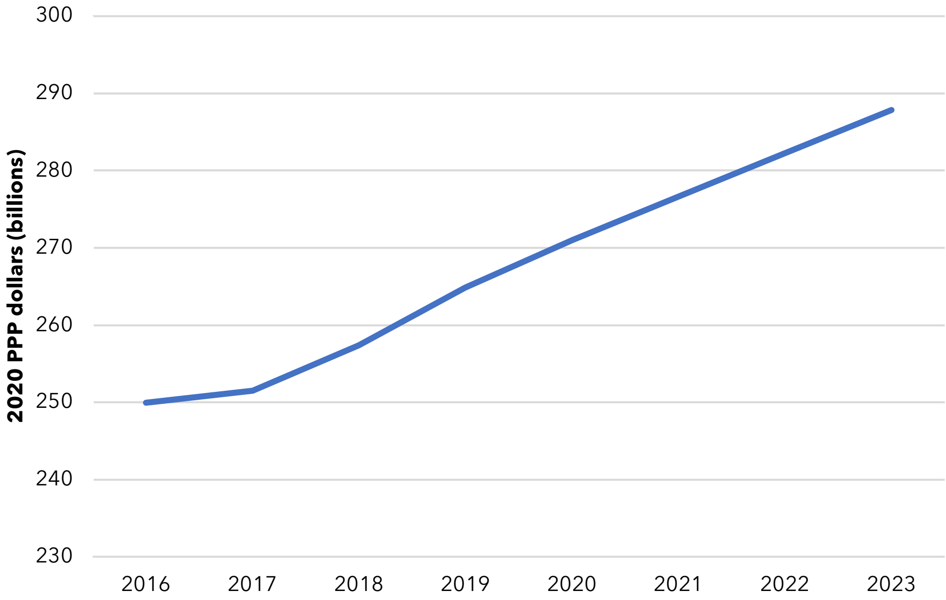
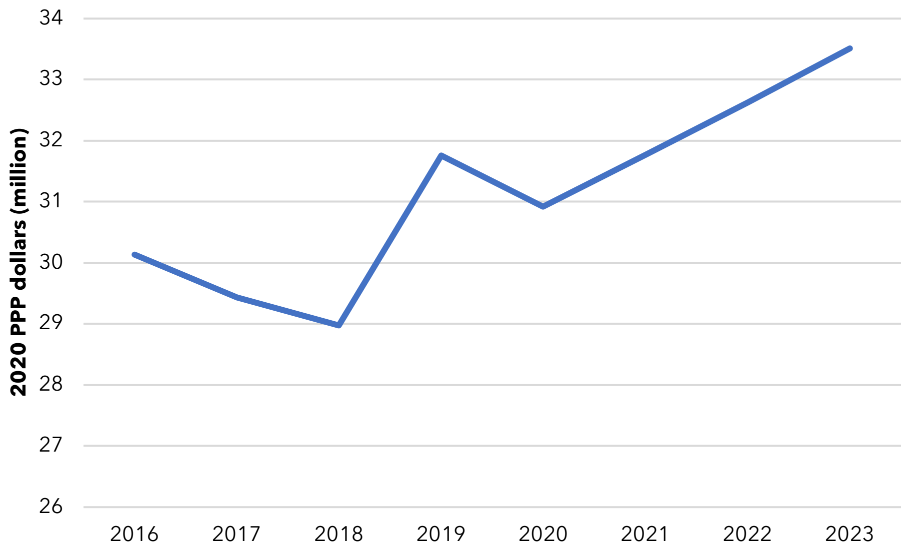


Figure 3-2*: Blue water costs for Brazil as estimated in SOFA 2023 TCA*



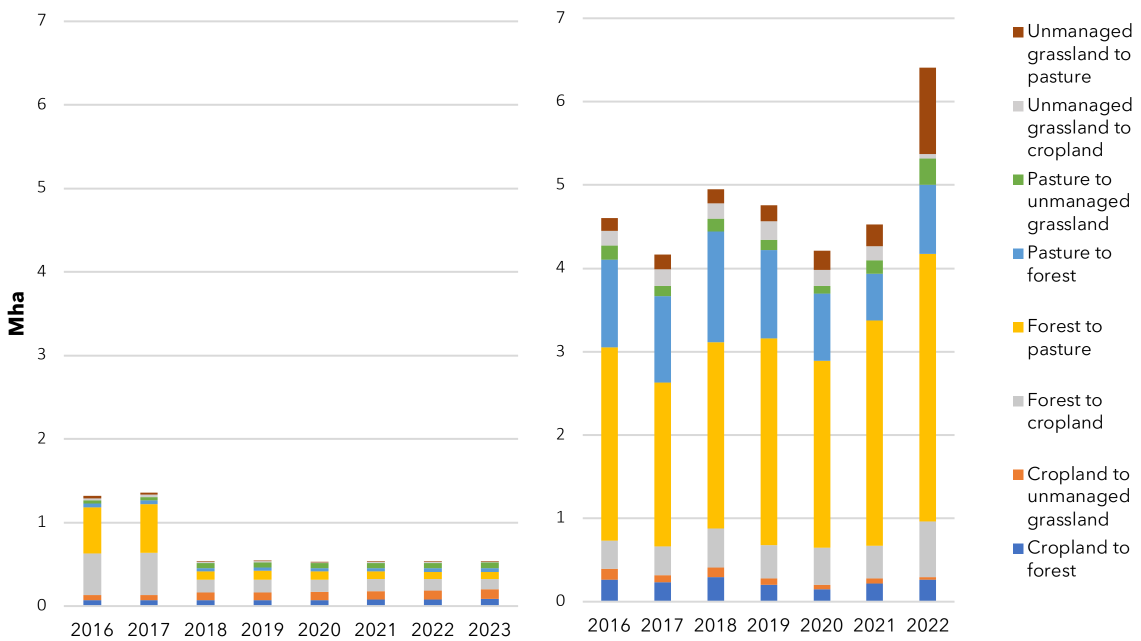
The increasing costs of unhealthy diets are in line with rising obesity and overweight in Brazil. Land use data needs to be checked against Brazilian datasets as it does not match observed trends in the last decade (see Section 3.3.1). As an agricultural powerhouse and one of the main exporters of commodity food items in the world, it is expected that agriculture would play a large role in the costs estimated. Indeed, this does show up through the sizeable contributions of climate and nitrogen run-off costs, which are driven by CO_2 emissions from deforestation (associated with expansion of agricultural areas), CH_4 emissions (mainly from enteric fermentation) and N_2O emissions (mainly from synthetic fertilizer application but also from manure). Nitrogen run-off is associated with increasing use of fertilizer application associated with robust growth in agricultural production in recent decades, and with nitrogen use efficiency not visibly improving, even showing signs of worsening according to a few studies (Pires et al., 2015; Santos et al., 2023). Finally, the increase in the use of irrigation in agriculture signals a rise in the cost associated with blue water withdrawals, although Brazilian agriculture is mainly rainfed (only about 10% of the agricultural area is irrigated).

3.2.2 Comparison of SPIQ data with national datasets

Brazil is one of the largest food exporters globally and as such, has a high share of its anthropic land surface used for agriculture, including crops and livestock. Land use transitions are extracted from the HILDA+ dataset, a yearly worldwide dataset obtained at a resolution of 1 km by satellite data. The trend smooths out after 2020 because data was extrapolated beyond that period. The data indicates a drop in forest conversion to agricultural land between 2017 and 2018, with a reduction of 77% in forest loss in a single year and staying roughly constant until 2023. This is not corroborated by national data such as the MapBiomas land use transition datasets, which shows an increasing trend in the natural vegetation loss in the period 2018–2022 (MapBiomas in Souza et al., 2020), as shown in Figure 3-3.

Additionally, a 3–6 million hectares disparity exists in the total land use transition area when comparing the two datasets over the years. On the one hand, this may imply that the TCA for land use is likely to be underestimated based on land conversion alone. However, TCA only considers a limited set of land use changes, and further analysis is necessary to account for the full range of land use transitions. Importantly, there is much uncertainty in the marginal costs of land use change, so combining the land use flux with this uncertainty leads to a high range of land use related hidden costs.

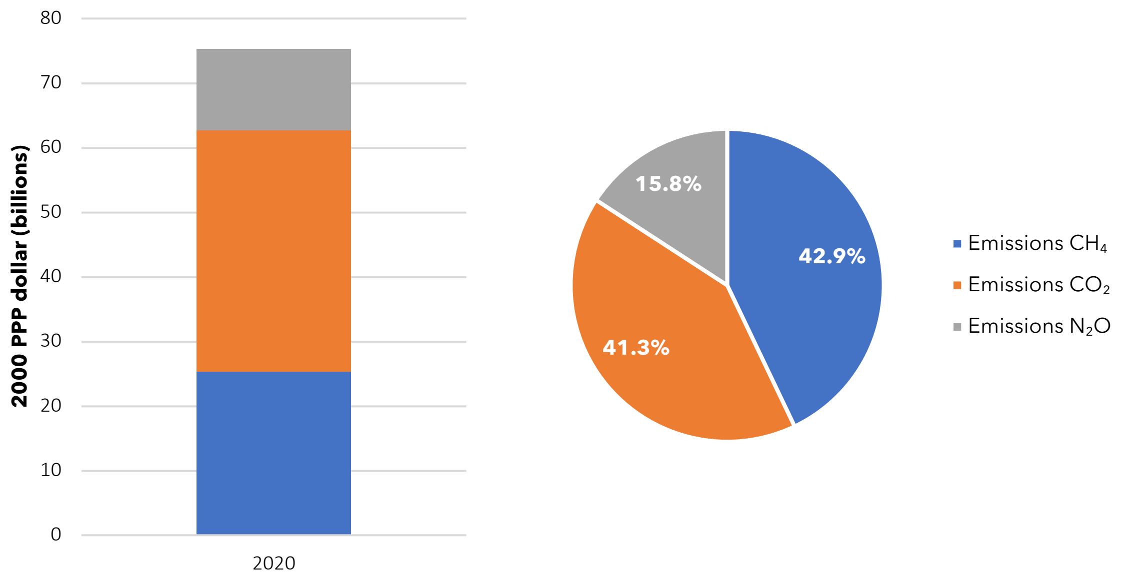
Figure 3-3: *Comparison of HILDA+ land use change dataset for Brazil used in TCA results (a) and land use transitions based on MapBiomas (b) for land use transitions. MapBiomas Collection 8 has information up to 2022.*



Regarding greenhouse gas (GHG) emissions, the TCA considers three types of gas when calculating the hidden costs: CO_2, CH_4 and N_2O. CO_2 corresponds to 50% of the total hidden costs from emissions in the TCA results for the year 2020 (Figure 3-4a). Emissions from CH_4 and from N_2O cause 33% and 17% of the hidden costs, respectively.

This breakdown aligns with the emissions profile for the agriculture, forestry and other land use (AFOLU) sectors in the same year according to national data from SEEG (SEEG, 2023). Agricultural non-CO_2 emissions account for more than half of total AFOLU emissions (Figure 3-4b).

Figure 3-4: *Comparison of hidden costs from GHG emissions decomposed by gas in the SOFA 2023 analysis (left) and the percentages of emissions based on SEEG emissions (right) for the agricultural and LULUCF sectors in 2020.*



3.2.3 Recommendations for tailored country hidden costs analysis

An essential measure for tailoring the analysis quality is to include national datasets that are more precise for the Brazilian context. Respondents suggested improvements using national databases, such as those provided by the Ministry of Agriculture and Embrapa. Suggestions for specific data included food security in rural populations, carbon sequestration in agricultural lands, but also new datasets that fill existing gaps. For example, global datasets could be replaced using land use/cover data from the MapBiomas platform; social and agricultural data from the Brazilian Institute of Geography and Statistics (IBGE); environmental data from the National Emissions Registry System (SIRENE/MCTI), and the Greenhouse Gas Emissions and Removals Estimation System (SEEG); and agricultural productivity data from the Ministry of Agriculture, Livestock, and Supply (MAPA). For the undernourishment analysis, data from The Brazilian Research Network on Food and Nutrition Sovereignty and Security could be used. Additionally, improving the nitrogen and water analysis is crucial, given their importance in the agricultural context, direct implications in food production, and the high share of nitrogen-related costs represented in the Brazilian case. Stakeholders also emphasized the importance of future analyses that consider the different Brazilian regions and biomes. Recognizing the diversity and complexity across different regions and ecosystems is essential for meeting equitably the specific needs of each locality. They also suggested closer collaboration between Brazilian institutions and FAO to strengthen analytical capacity.

Methodologically, suggestions ranged from including poverty costs of unequal land distribution, use of pesticides on health and biodiversity, differentiation between types of agricultural systems, and revising water usage parameters. The full allocation of hidden costs to producing countries was seen as unbalanced and singles out Brazil, a major exporter of agricultural products. Including the hidden costs to consumer countries would reveal an alternative view that would emphasize the role played by importing nations in driving the hidden costs from Brazilian production systems. However, this may reduce the ability for the analysis to reveal entry points for reducing the hidden costs through policy interventions. As a corollary of this, it may be useful to frame this analysis as seeking to reveal the entry points for policy action, which would support a production-based assessment.

3.3 Evolution of hidden costs by 2030 and 2050

3.3.1 FABLE Calculator for Brazil

The FABLE Calculator (Mosnier et al., 2020) for Brazil included several adjustments to adapt to the national context. Historical land cover maps have been updated with information from MapBiomas (Souza et al. 2020) and from the Brazilian Institute of Geography and Statistics (IBGE) (PAM/IBGE, 2023). Data from IBGE replaced the area and production for soybeans, corn, sugarcane, beans, rice, cassava, and wheat. Adjustments were also made to the export calculations for soybeans and corn to align with historical data from the FAO (FAOSTAT, 2023) and forecasts by the Brazilian Ministry of Agriculture, Livestock, and Food Supply.

Furthermore, GHG emissions calculations incorporate Brazil's average carbon content (418.4 tCO_2e/ha) as reported in Brazil's Third Emissions Inventory, used in the official documents of the United Nations Framework Convention on Climate Change in 2016 (MCTI, 2016). The analysis also integrates the data by de Andrade Junior et al. (2019), which describes potential ethanol demand scenarios in Brazil through 2030 and replaces the biofuel feedstock use for sugarcane in the model.

3.3.2 Scenathon 2023 pathways assumptions

We present three alternative pathways for reaching sustainable objectives for Brazil's food and land use systems. The Current Trends (CT) pathway is characterized by medium population growth, no constraints on agricultural expansion, no deforestation control, and a business-as-usual (BAU) scenario regarding diets and biofuel feedstock used for ethanol. This translates into a future that, given current policies and past trends, would also result in a low growth in agricultural productivity and a significant increase in the volume of exports of the major commodities.

A future in which national policies and activities are aligned with Brazil’s commitments is represented by the National Commitments (NC) pathway. We assume that this future considers the restoration of 12 million hectares of forest by 2030, the expansion of protected areas, and no deforestation beyond 2030, reflecting Brazil's international commitments. Also, we assume that this future would lead to higher livestock productivity growth and medium crop productivity growth. This future also considers food waste and post-harvest loss reductions, and a renewable fuel-oriented scenario.

The Global Sustainability (GS) pathway represents a future in which national actions/policies are aligned with global sustainability targets. Assumptions on population growth, agricultural productivity, diets and reforestation targets differ from the NC pathway. We assume this future would lead to low population growth, higher crop productivity growth, and an evolution towards a healthier diet (EAT-*Lancet* recommended diet). Additionally, we considered a restoration target of approximately 27 million hectares by 2050 to go beyond Brazil's NDC commitment of restoring 12 million hectares of forests by 2030. This restoration target considers the amount of environmental debt from the Rural Environmental Cadastre (CAR) for all biomes but the Atlantic Forest, where we take into account the Atlantic Forest Pact target of restoring 15 million hectares.

3.3.3 Results across the three pathways

Land use change and afforestation/restoration targets

The main changes in the agricultural land cover led to increased cropland and decreased grassland areas in the three pathways by 2050 (Figure 3-5). The results suggest that cattle ranching intensification is sparing land for cropland expansion, which is in line with other Brazilian studies (Strassburg et al., 2014; de Oliveira et al., 2017, Köberle et al., 2020; NatureFinance 2022, Orbitas 2024). Under the CT pathway, we estimated a decrease of forest from 558 to 534 million hectares between 2020 and 2050 but assumptions on agricultural land expansion, reforestation targets, and the creation of protected areas differ under NC and GS. In these scenarios, Brazil will have no deforestation after 2030, and the restoration goals will align with Brazil's commitments. However, there was a significant increase in land abandonment in the GS pathway compared to CT, mainly driven by improved agricultural productivity and dietary change assumptions.

Food consumption

Two dietary changes were implemented to evaluate their impact on land use change and GHG emissions for the three pathways. These two diets represent specific targets for the calorie consumption of each food group, intended to be achieved by 2050 (Figure 3-6). The diet scenario used in the CT and NC pathways is based on projections of food consumption in 2050 given by the FAO (2018), built upon the narratives of the shared socioeconomic pathways SSP2 and SSP3. The diet contains a high share of cereals, animal-based products, and sugars, with a net calorie intake of 3,480 kcal/cap/day by 2050. Under the GS pathway, the diet is based on the recommendation of the EAT-Lancet Commission, providing a net calorie intake of 2699 kcal/cap/day. This diet is characterized by significantly reducing animal-sources food consumption compared to the diet scenario used in the other pathways. The three pathways indicate a daily consumption higher than MDER (minimum dietary energy requirement) for all years (Figure 3-7).

Figure 3-5: *Evolution of area by land cover type under each pathway*

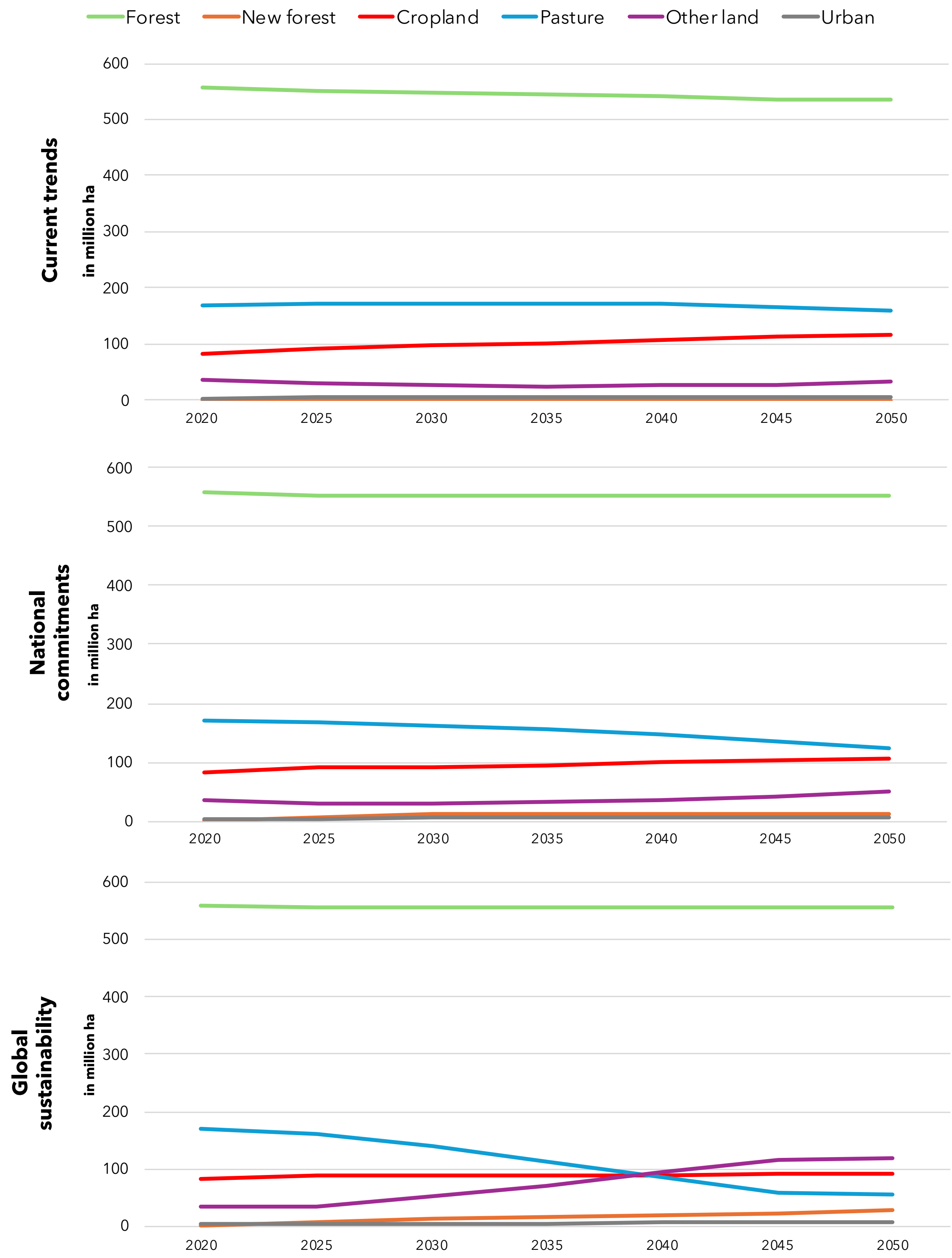


Figure 3-6: *Food consumption (kcal/cap/day) by food group by 2050 for the three pathways for Brazil.*

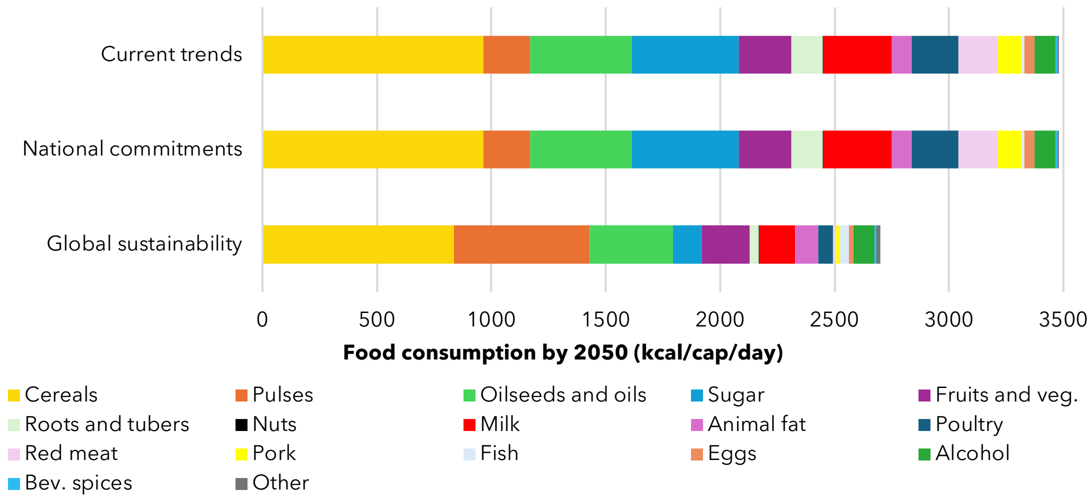
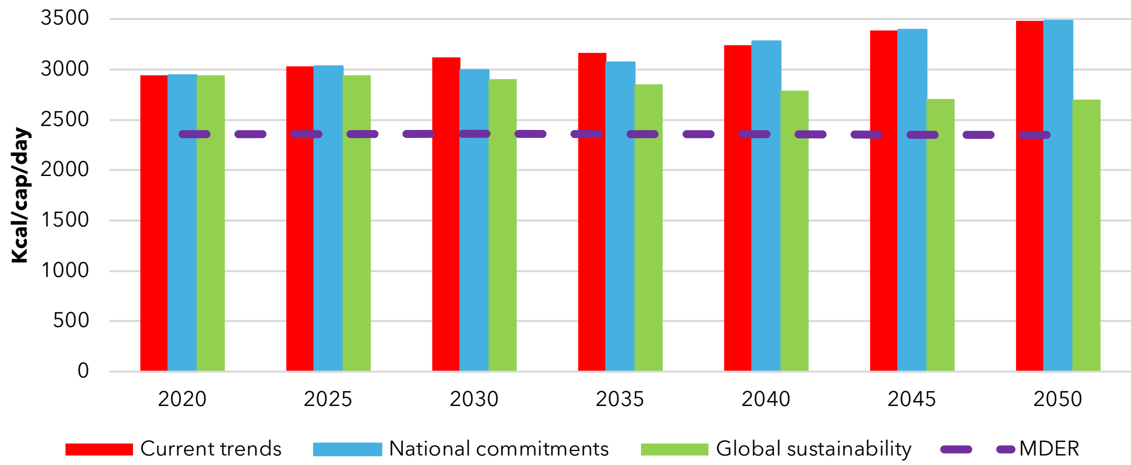


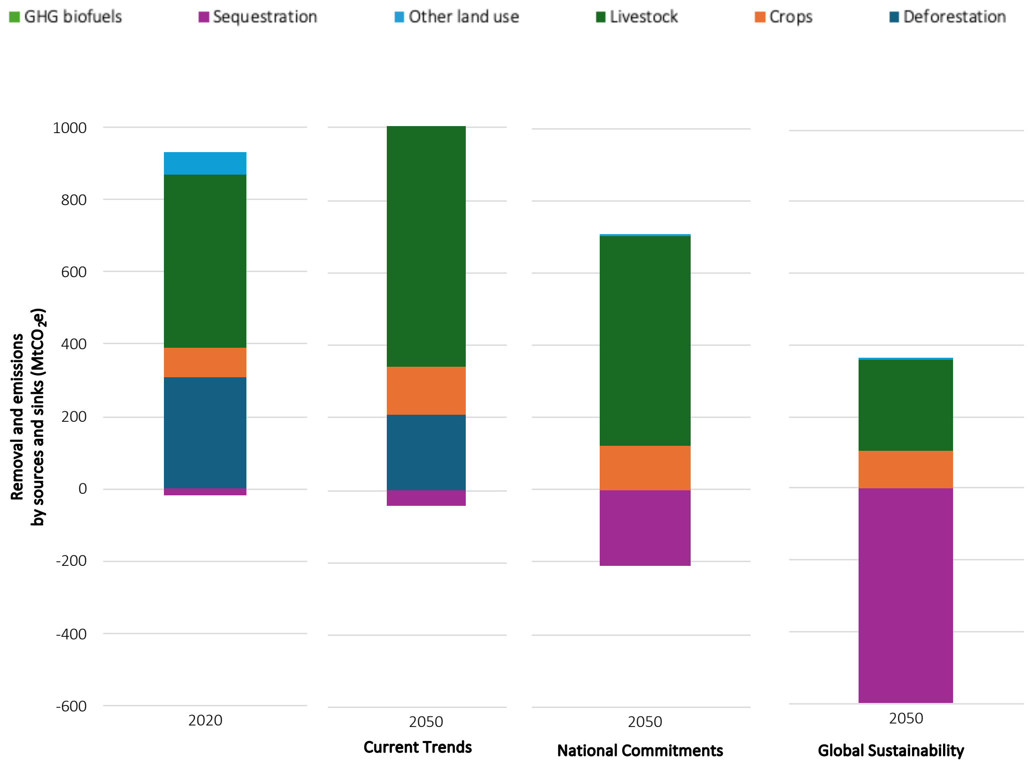
Figure 3-7: *Evolution of the food consumption for the three pathways during 2020–2050. The results indicate a consumption above the MDER (purple dotted lines) for all years.*



GHG emissions

The potential emissions reductions under the NC pathway are dominated by the CO_2 sequestration from the forestry and land use change sector if compared with the CT results (Figure 3-8). The most important drivers of this reduction are the ban on deforestation by 2030, and the carbon uptake from natural vegetation regrowth and afforestation. Under the GS pathway, GHG emissions from CO_2 sequestration from the forestry and land use change sector, enteric fermentation, and manure management are further reduced when compared to the NC pathway due to the ambitious afforestation/reforestation targets and the healthier diet assumption, with low consumption of red meat.

Figure 3-8*: Removal and emissions decomposed by the primary sources for three pathways by 2020 and 2050.*



Water

The blue water footprint in agriculture is projected to reach 5,337 to 6,890 Mm^3/yr under the CT pathway between 2020 and 2050 (Figure 3-9). In contrast, the results indicated a rise in blue water use in the NC pathway (8,690 Mm^3/yr in 2050). Under the GS pathway, the blue water footprint decreases more when compared with the NC pathway, reaching 6,451 Mm^3/yr in 2050. Both the NC and GS pathways were based on a higher expansion of irrigated areas compared to CT. The reduction observed in the GS pathway was primarily due to the huge decrease in agricultural land driven by dietary changes.

Figure 3-9: *Evolution of blue water footprint in the three pathways (top) and decomposition of the main drivers of the changes of water related hidden costs across scenarios (bottom)*

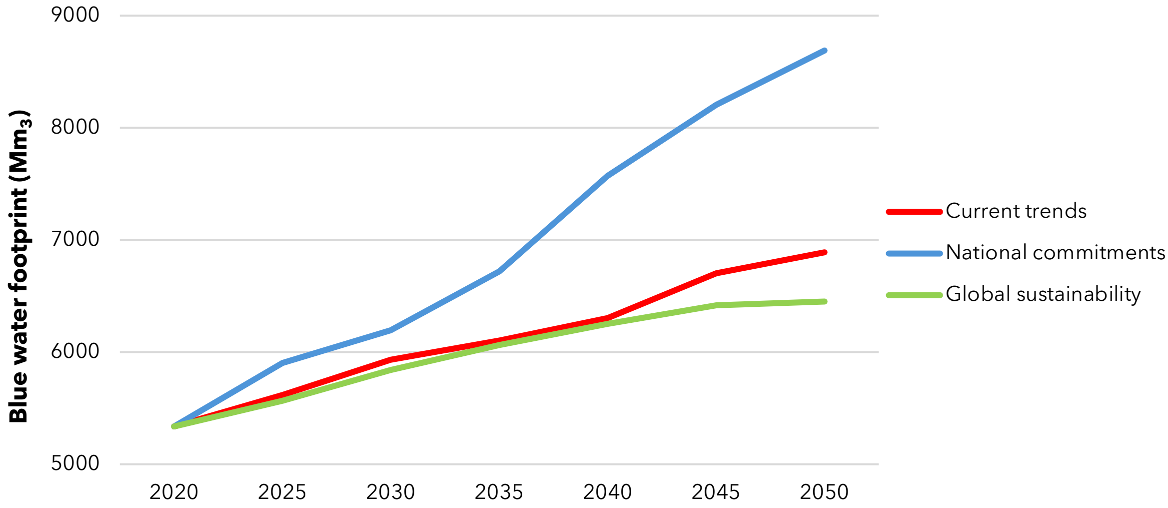
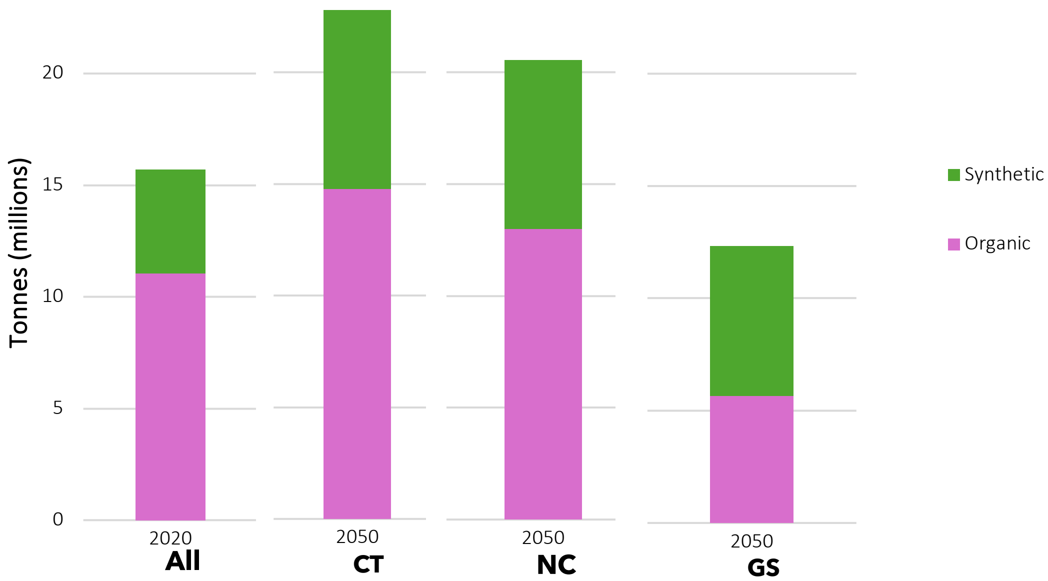


Figure 3-10: *Organic and synthetic nitrogen use in cropland areas in 2020 and 2050.*



Notes: CT = Current Trends pathway, NC = National Commitments pathway, and GS = Global Sustainability pathway.

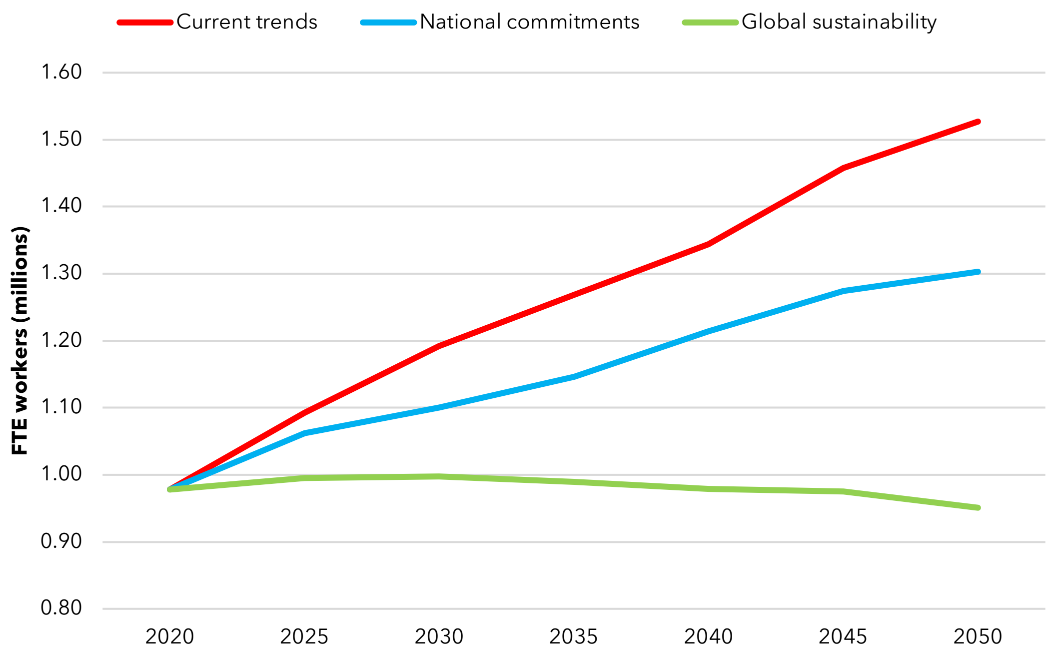
Nitrogen use

Organic and synthetic nitrogen use gradually increased in the three pathways during 2020–2050 (Figure 3-10). The results indicate a reduction of 10% in the National Commitments pathway by 2050 if compared with the current trends projections (12.3 Mt), mainly attributed to the combined effects of crop productivity, population growth and food consumption changes.

Farm labor

The Current Trends pathway shows a steady increase in the full time equivalent (FTE) farm labor workforce from 2020 to 2050. Conversely, the National Commitments pathway also indicates but with a notable reduction of 0.24 million FTE workers compared to the CT scenario by 2050. Notably, the global sustainability pathway stands out as the pathway where the number of workers experiences a significant decline from 2020 to 2050, reducing 38% of the workforce compared to CT (Figure 3-11). This reduction can be primarily attributed to the substantial decrease in livestock due to reduced consumption of animal-source foods imposed by the chosen diet.

Figure 3-11: *Evolution of the farm labor workforce in the three pathways during 2020–2050*



3.3.4 What are the most influential factors to reduce the hidden costs by 2030 and 2050?

Figure 3-12 shows the decomposition of the differences between the two transition pathways (National Commitments and Global Sustainability) and the current trends. The figures represent the contribution of each component to the reduction in hidden costs for the years 2030 and 2050, with the left panel showing NC vs CT, and the right GS vs CT.

It shows that dietary changes provide the largest driver for reducing CH_4 and N_2O emissions. Crop and livestock productivity gains, and food waste reduction also contribute significantly to GHG emissions reduction by 2050. Increases in irrigation contribute the most to the hidden costs associated with water withdrawals, which in fact increase in both transition scenarios relative to CT, while increases in crop productivity and diet changes contribute the most to reduce these costs.

Dietary changes were also projected to be the main contributor in reducing the pasture area and increasing land abandonment in the GS pathway. Other factors, such as ruminant density, livestock productivity and food waste, had a smaller contribution in both land use change projections (Figure 3-13). Crop yield improvements and dietary changes were the main contributors of cropland reduction in GS. The key factors for forest increase in GS pathway were the constraints on agricultural area expansion regarding zero deforestation, crop yield gains and changes in international demand and diets.

Figure 3-12*: Decomposition analysis for feasible kcal consumption, total nitrogen, CH_4 emissions and blue water used for irrigation*

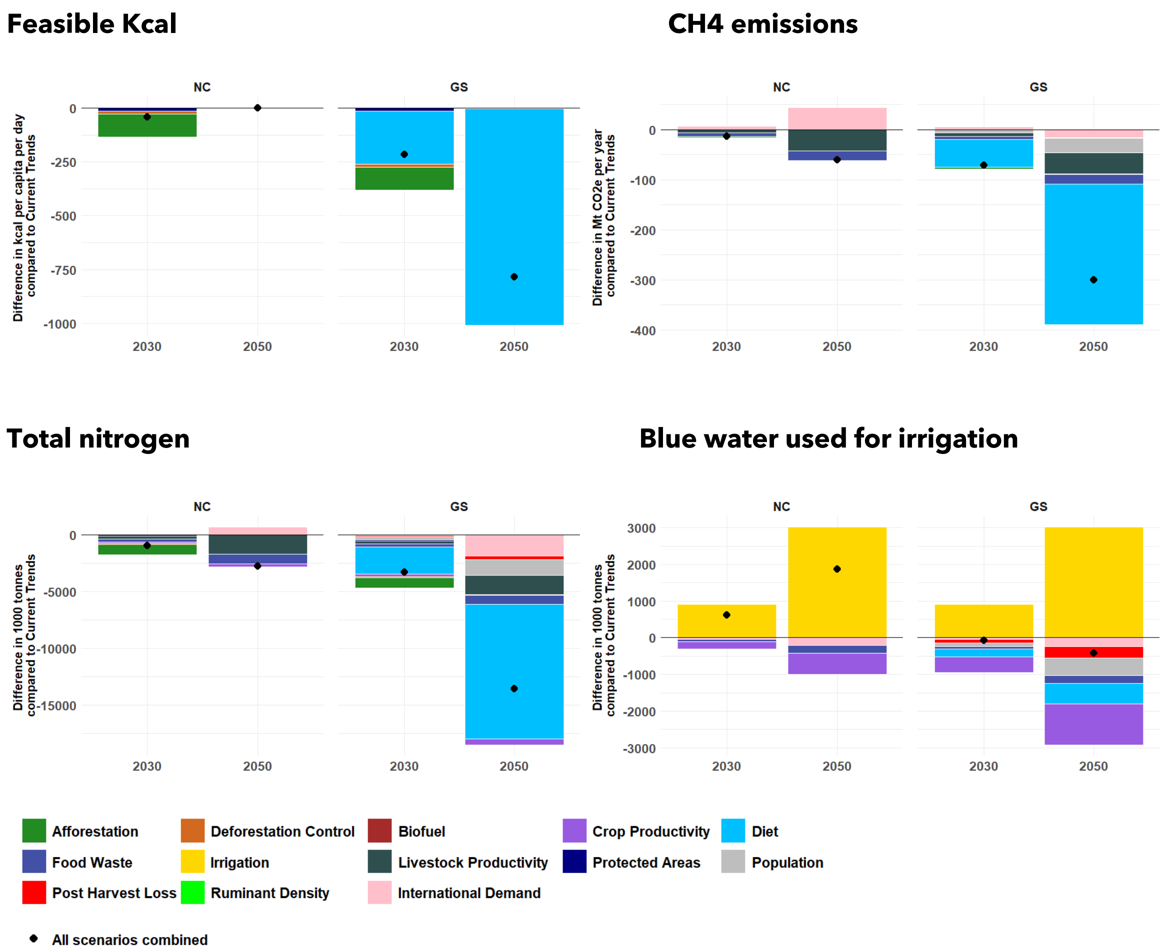
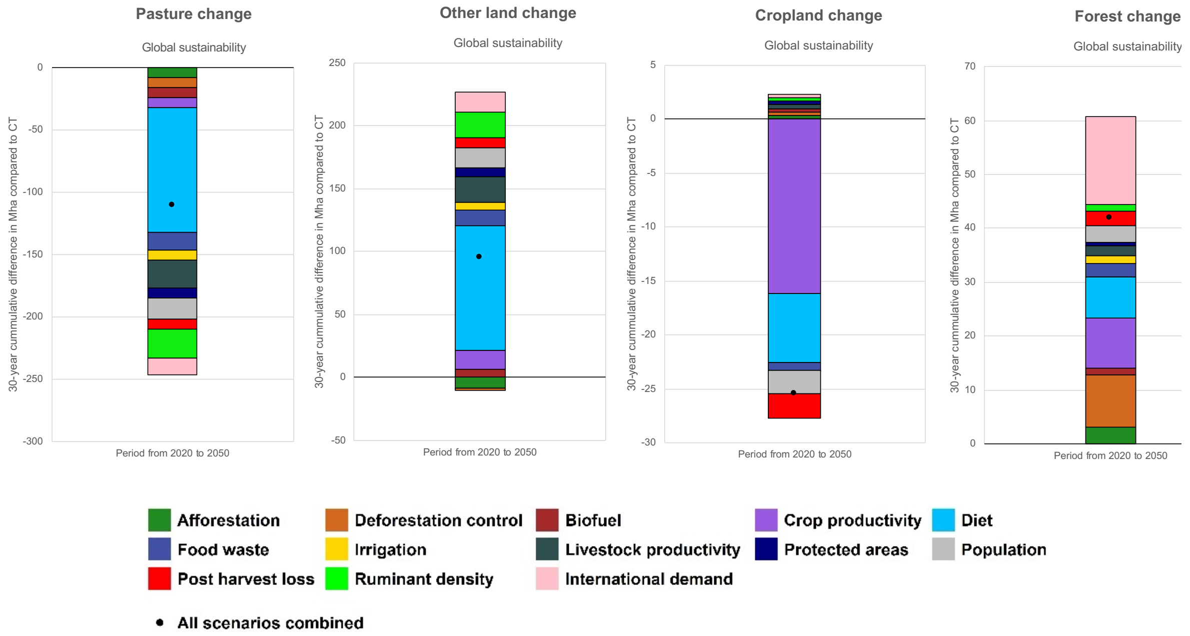


Figure 3-13 *– Cumulated impact over 2021-2050 of each scenario change between the Global Sustainability and Current Trends pathways on land cover*

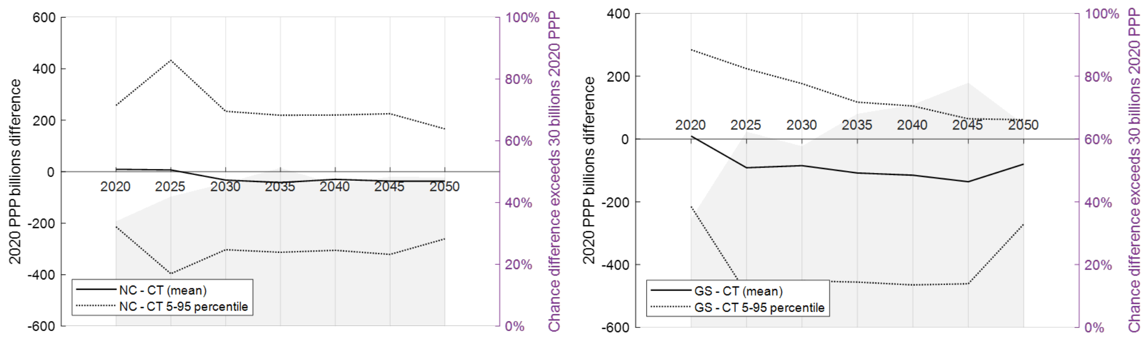


3.3.5 Impacts on the agrifood system's hidden costs

A new study of the hidden costs was produced by Lord (2024) in the FABLE context, with a specific analysis for Brazil. The updated analysis estimated the hidden costs for Brazil as 340 billion 2020 PPP in 2023. GDP would be roughly 11% lower if the hidden costs were to be accounted for in 2020. It is important to note that estimates from other analyses, such as SOFA 2023, reported slightly higher costs of 350 billion 2020 PPP by incorporating obesity and poverty costs, which FABLE does not consider.

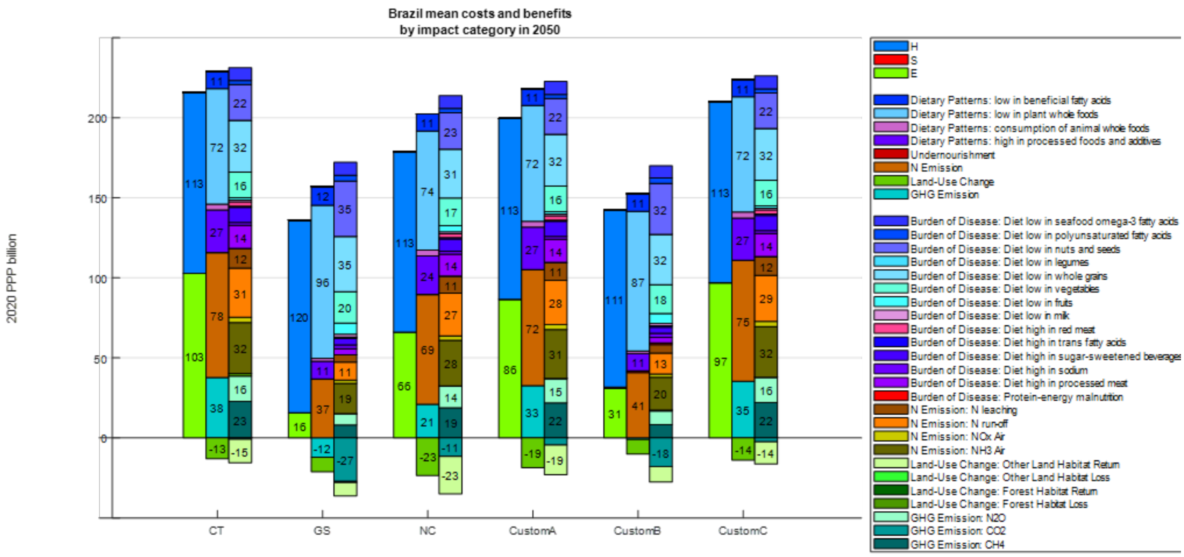
The NC pathway projected a reduction of the accumulated hidden costs by 8% compared to CT, averaging 25 billion 2020 PPP per year. Meanwhile, the GS pathway suggests significant changes in food production and consumption between 2020 and 2050, potentially reducing these hidden costs by 32% compared to CT.

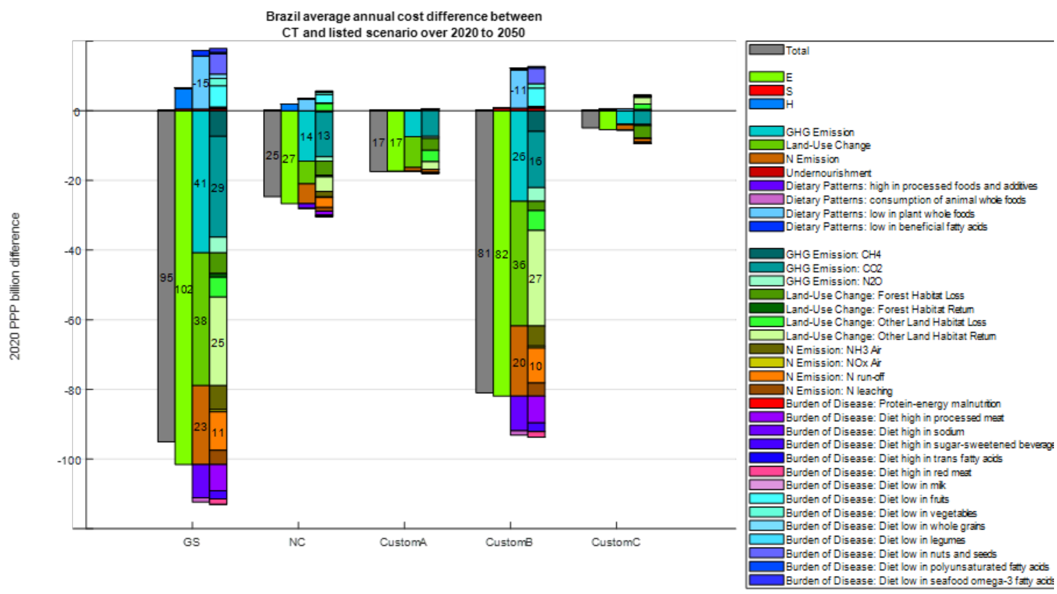
Figure 3-14: *Brazil annual cost trajectory between CT and NC (left), and between CT and GS (right) with uncertainty estimate.*



In addition to the CT, NC, and GS pathways, three new scenarios highlighting the most impactful factors have been created to explore their contributions to the reduction in hidden costs (Figure 3-15 top). For Brazil, the three scenarios are crop productivity (Custom A), dietary change (Custom B) and the constraint of zero deforestation after 2030 (Custom C). As seen in Figure 3-15, the key factor for the most savings is the dietary change component, specifically reducing red meat consumption in favor of plant-based proteins, which would lead to decreased agricultural land use, reduced greenhouse gas emissions, and less nitrogen pollution. According to the new analysis, the GS pathway projects to avoid 38 billion 2020 PPP from preventing land use changes. Additionally, 41 billion 2020 PPP can be avoided from changes in GHG emissions and 23 billion 2020 PPP from reducing nitrogen run-off and human productivity losses from ammonia air pollution (Figure 3-15 bottom).

Figure 3-15: *Breakdown of Brazil hidden costs in 2050 (top) and annual average hidden cost reduction under alternative pathways compared to CT (bottom) in 2020 PPP. The breakdown is illustrated in different levels of detail separating the cost categories.*





Source: Lord (2024)

3.4 Entry points for action and foreseen implementation challenges

The results show that more than half of the hidden costs are related to dietary choices. Shifting dietary behaviors is crucial, yet further investigation is needed to determine effective implementation strategies. Furthermore, national and local actions hinge upon the choices made by policymakers, landowners, and consumers. Measures such as decreases in loss and waste distribution, subsidies for organic food production, and policies that provide the public with essential health information and encourage healthy behaviors can increase the availability and access to nutritious foods. Government procurement policies (e.g., for public school meals) can serve as catalysts to boost demand for products that make up healthy diets, providing opportunities for raising awareness of their benefits. The Dietary Guidelines for the Brazilian Population, published in 2014, contains a full set of recommendations to promote the health and well-being of the whole Brazilian population, now and in future. The guidelines were elaborated in a participatory manner and in consultation with multiple sectors of society, the Ministry of Health and academia but lack a comprehensive implementation plan (FAO, 2024). Nevertheless, many initiatives exist to promote healthy diets, including schools programs (WFP, 2024), and a framework that highlights two main implementation pathways, namely educational materials and public policies (Gabe et al., 2021)

Another entry point is adopting agroecological practices, such as economic incentives for low carbon emission techniques and implementing integrated crops, livestock and forest systems. The recuperation of degraded areas, especially pastures, has high potential to spare land that can be dedicated to other uses such as crop production, bioenergy or afforestation. This is reflected in the Brazilian NDC and several national studies (de Oliveira et al., 2017; Köberle et al., 2020). Healthy pastures provide more nutritious grazing for livestock, which can also reduce emissions of CH_4 from enteric fermentation. National policies and programs towards those practices have the potential to uphold and improve soil quality, conserve water, sequester carbon, enhance animal yield and welfare by providing thermal comfort, mitigate greenhouse gas effects, and aid in the recovery of degraded areas. Realizing this potential requires investments, a challenge to about two thirds of Brazilian farmers who lack technical skills and access to finance, and interventions to address this can improve environmental performance and farm profitability (NatureFinance 2022). Extension services already exist (e.g., through Embrapa and ANATER[6]), but they need to be expanded to effect change at the scale and pace needed.

It is important to note that, as hidden costs are likely underestimated for land use change in Brazil (see Section 2.3.2), efforts to reduce deforestation could have a higher impact than would follow from the current hidden cost estimates. Ending illegal deforestation and incentivizing preservation of natural vegetation to prevent legal deforestation would effectively prevent conversion of natural vegetation and reduce (or ideally, eliminate) losses of ecosystem services.

When asked to suggest specific entry points for different actors or potential challenges, respondents mentioned the following:

- Subsidies for organic food production.
- Land governance aiming at land redistribution in territories with high land concentration.
- Incentives for the implementation of agroforestry systems.
- Support for the establishment of short supply chains for food production and consumption.
- Economic incentives for low carbon emission agricultural techniques.

[6] Embrapa - Empresa Brasileira de Pesquisa Agropecuária (https://www.embrapa.br/); ANATER - Agência Nacional de Assistência Técnica e Extensão Rural (https://www.anater.org/)

In final considerations, one respondent emphasized the need to adopt a TCA approach, but sounded a note of caution in that "one needs to be completely sure about the approach, otherwise is going to considerably impact some countries' economy (such as Brazil) using data with a huge uncertainty".

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3.6 Annex

Questionnaire of the online survey

<table>
<tr><th>Question</th></tr>
<tr><td>1. How well do you think the analysis reflects hidden costs in Brazil?</td></tr>
<tr><td>2. Please provide any suggestions on how the analysis of hidden costs could be improved by using national datasets instead of the global data used for the SOFA 2023 analysis.</td></tr>
<tr><td>3. Please provide any suggestions on how the methodology of the SOFA 2023 analysis could be improved to give a more accurate estimate of hidden costs for Brazil, e.g. by including additional cost categories (where data is available), or through new research to fill data gaps.</td></tr>
<tr><td>4. Please provide any comments or feedback on the FABLE model assumptions and baseline projection to 2050, and the implications for biodiversity, climate, food security and health.</td></tr>
<tr><td>5. Please suggest:
- potential levers for reducing the hidden costs of agrifood systems;
- specific entry points for different actors;
- any potential challenges associated with these levers.</td></tr>
<tr><td>6. If there are any other updates you would like to share that are not covered by the previous questions, please let us know.</td></tr>
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