

Research Project

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Project Title: “Brazil in 2050” (BR2050+)

Period: 2018-2020 (3 years)

Abstract

The “**Brazil in 2050**” Project” (**BR2050+**) will establish a network of social, natural and health scientists, engineers, practitioners, policy makers and representatives of civil society organizations with the aim of providing analysis and construction of sustainable development pathways for Brazil in 2050 and beyond to meet the Sustainable Development Goals while remaining within planetary limits. The project will describe the overarching narrative and target indicators for Brazil in 2050 which are consistent with those for the world in 2050, providing the first step to allow modeling and other communities to begin analyses of ‘*backcasting*’ to Sustainable Development Pathways (SDP) that attain the Sustainable Development Goals by 2030. The objective is to transform Brazil towards a just, inclusive and sustainable future for all within planetary boundaries. The analysis goes beyond 2030 towards 2050, and in some cases 2100, to take into account the long-term Earth system processes and transformational socio-economic dynamics. This project is linked to the international initiative The World in 2050 (TWI2050). Part of the work will be to downscale global perspectives to national level by developing complementary sustainable development pathways applicable to Brazil, including a regionalization of SDPs. Two critical regions for sustainable development challenges will receive special attention, namely Amazonia and Northeast Brazil.

Resumo

O projeto de pesquisa “**Brasil em 2050**” (**BR2050+**) estabelecerá uma rede de pesquisa com cientistas sociais, naturais e da saúde, engenheiros, profissionais, tomadores de decisão e representantes das organizações da sociedade civil, com o objetivo de analisar e construir trajetórias de desenvolvimento sustentável para o Brasil em 2050 e além para o atingimento dos Objetivos de Desenvolvimento Sustentável, permanecendo dentro de limites planetários. O projeto descreverá uma narrativa abrangente e os principais indicadores para o Brasil em 2050, que são consistentes com os do mundo em 2050, fornecendo o primeiro passo para permitir que a comunidade de modelagem e outras iniciem análises utilizando o método de “*backcasting*” para atingir Trajetórias de Desenvolvimento Sustentável (TDS) que alcancem os Objetivos de Desenvolvimento Sustentável até 2030. O objetivo é transformar o Brasil em direção a um futuro justo, inclusivo e sustentável para todos dentro dos limites planetários. A análise ultrapassa 2030 até 2050 e, em alguns casos, 2100, para levar em consideração os processos a longo prazo do sistema terrestre e a dinâmica socioeconômica transformacional. Este projeto se associa com a Iniciativa internacional “The World in 2050”(TWI2050). Parte

do trabalho será uma visão global das perspectivas globais ao nível nacional através do desenvolvimento de trajetórias complementares de desenvolvimento sustentável aplicáveis ao Brasil, incluindo uma regionalização de TDS. Duas regiões críticas para o desenvolvimento sustentável receberão atenção especial: Amazônia e Nordeste do Brasil.

Knowledge Areas

Sustainable Development; Sustainable Development Goals; Integrated Assessment Modeling; Earth System Modeling; Regional Development.

The Problem to Be Addressed

What future do we want for humanity? What future do we want for the planet? In the trajectory of *Homo sapiens* for several hundred thousand years, it was only in the twentieth century that it seemed possible that a species could ask such questions. That one out of millions of living organisms could have become—by developing a unique characteristic of life over 3.6 billion years of biological evolution, that is, the intelligence of the human brain—a force of global transformation of the Earth, reaching such magnitude that is generating a new geological epoch, the Anthropocene. This new epoch is characterized by the so-called "Great Acceleration", especially since the 1950s, with the recent population explosion, the intensive use of natural resources and the global environmental transformations unprecedented in millions of years. For example, the rapid increase in the atmospheric concentration of greenhouse gases, a dangerous decrease in the stratospheric ozone layer over Antarctica, the disappearance of forests and extinction of species.

The risks we face are real and science increasingly scrutinizes them and seeks to assess their probability of occurrence and the scale of time involved, in addition to their impacts. The concept of "planetary boundaries", that is, boundaries that should not be exceeded if we are to maintain the stability of the Earth System, implies the construction of a safe operating space for human well-being and planetary health. Some of these planetary boundaries are: climate change, ozone layer depletion, ocean acidification, biosphere integrity, land use, atmospheric aerosol load, freshwater, biogeochemical flows (N and P), novel elements introduced into the biosphere.

Nature probably does not know any absolute limits, since our planet has already undergone gargantuan transformations in the geological time scale, although Nature never produced tens of thousands of novel substances that are part of the modern world, such as plastics. Thus, planetary boundaries involve a judgment of value, that is, of our human desire not to allow the planet to move to *terra incognita*. Subjectively, it is estimated that we have already transgressed two of these planetary limits: the extinction rate of living species is 100 times greater in relation to the natural flow of disappearance and appearance of biological species; and the nitrogen and phosphorus flows due to human actions (mainly intensive agriculture) are already superior to the natural biogeochemical flows of these elements. On the other hand, with the Montreal Protocol's ban of CFCs, we are reducing the risk of catastrophic ozone layer depletion.

And what about global warming? Have we already surpassed any critical, irreversible threshold, considering that the planet has already warmed about 1 °C at the surface in

relation to the pre-industrial era? The historic Paris Accord, signed in December 2015 by 195 countries, states that we should not by any means exceed the 2 C guardrail and, in fact, the greater risks of global warming will be avoided if the temperature increase is limited to 1.5 C. This commitment brings us to an unprecedented challenge for humankind: virtually net zero greenhouse gas emissions by mid-century and effectively removing carbon dioxide from the atmosphere in the second half of the century and the next one to bring back concentration of carbon dioxide to 360 parts per million (ppm), keeping in mind that we have already exceeded 410 ppm in 2017.

The sense of urgency allows no more hesitation, lack of clear goals, procrastination, inaction. It is time for concatenated, just, supportive, effective and urgent global action. Action that track us down to long-term sustainability pathways for humanity and the planet, but at the same time are just socially just and economically inclusive, reducing stark inequalities and inequities.

It is time to seek solutions firmly grounded in the best science to pursue technically sound and economically feasible ways sustainable development pathways, but, at the same time, ensuring food, water and energy security for all, protection of life on land and in the oceans, smart and resilient cities, and a more just, educated and equal society, including reducing gender inequality. We need to develop a comprehensive and creative 'manual for planetary sustainability' geared to the pursuit of sustainable development pathways that serves all countries and each country can find its role within the global effort.

Brazil should play a leading role. On the one hand, it is the seventh largest emitter of greenhouse gases, although it ranks 25th to 30th in per capita emissions—a just and equitable way of computing each country's responsibility for global warming. Unique to Brazil and a few other countries, almost 70% of Brazilian emissions originate in the agricultural sector through direct emissions from agriculture and indirect emissions due to deforestation of tropical biomes to expand the commodity frontier for grains and livestock.

The country has already demonstrated that it can rapidly and significantly reduce deforestation of the tropical rainforest. It cut down Amazon annual deforestation rate by 80% between 2005 and 2012, without reducing agricultural production. We must use the best science to search for a model of tropical development that does not exist today, a model that produces food in increasingly productive ways, using smaller areas, releasing large extensions of previously pasture land--unparalleled in any other country--for forest restoration. That can become an efficient mechanism for carbon dioxide removal from the atmosphere and the provision of important ecosystem services such as water quality, pollinators, erosion reduction and biodiversity protection.

It should also seek to harness the biological and biomimetic assets of tropical biodiversity, a new standing forest economic paradigm that will serve as a model for all tropical countries, providing inputs for the necessary diet diversification, new materials and substances for pharmaceuticals, food and cosmetics industries, generating bio-industries and real local development.

In terms of energy, there is an enormous potential for renewable and inexhaustible clean energy, mostly solar and wind, which, interlinked to the hydroelectric potential already

installed, would overcome almost completely the difficulties inherent to the intermittency of those clean energy options.

The UN 2030 Agenda, including the Sustainable Development Goals (SDG), presents an aspirational and ambitious target for the world. SDGs are the pillars of an integrated foundation: *protect the Planet; leave no one behind; prosperity for all*. The adoption of the 2030 Agenda was a landmark achievement for the United Nations, providing for a shared global vision on sustainable development. The UN 2030 Agenda is the most comprehensive search of remedies for planetary health and for the well-being of humanity in the present and future. It should be a great catalyst to unite humanity's majority desire to bequeath a decent and sustainable future for future generations.

The scale and ambition of the 2030 Agenda and the Sustainable Development Goals are unprecedented and require creative and innovative approaches. An inherent property of the Anthropocene epoch that humanity has entered is the realization that there are planetary boundaries that we should not cross to avoid moving into *terra incognita* (Crutzen and Stoermer, 2000; Steffen et al., 2007; Steffen et al., 2015). We might have already crossed some of the safe operating space in two such boundaries, namely biosphere integrity and interference in the natural biogeochemical cycles of N and P (Rockstrom et al., 2009; Steffen et al., 2015).

Currently, there has been no comprehensive analysis of the pathways towards a defined, desired target space: meeting the development goals while remaining within planetary boundaries. A major international research collaboration “The World in 2050” (TWI2050) has been established to provide the framework for the scientific community to explore sustainable development pathways (SDPs). The framework is designed to allow modeling and analytical groups (Integrated Assessment Modelers, Earth system modelers and other scientific communities) to identify and explore a portfolio of measures needed to achieve all SDGs jointly, accounting for synergies and trade-offs and allowing comparison of results (Nakicenovic et al., 2017).

The TWI2050 was initially proposed by the International Institute for Applied System Analysis (IIASA), The Earth Institute of Columbia University and the Stockholm Resilience Center. Currently, there is a large number of institutions engaged in many parts of the world, including in Brazil.

The need for regional perspectives has been identified within the project. Several sectoral and integrated global models exist, but they often lack appropriate downscaling to the major regions. TWI2050 will downscale and interpret its integrated analysis to provide a better understanding of how every major world region can achieve sustainable development. Exemplary country studies will complement the regional perspective. That is the context of proposing a case study for Brazil, the “**Brazil in 2050**” Project or “**BR2050+**”. This project will develop a normative vision of the sustainable future we want for Brazil in 2050 and beyond. Then, we seek likely sustainable pathways to reach that vision, assessing also major obstacles for Brazil to achieve the SDGs in 2030.

BR2050+ will describe an overarching narrative and target indicators for Brazil in 2050 which are consistent with those for the world in 2050, providing the first step to allow modeling and other communities to begin analyses of back-casting to Sustainable Development Pathways that attain the SDGs by 2030. The objective is to transform

Brazil towards a just, inclusive and sustainable future for all within planetary boundaries. The analysis goes beyond 2030 towards 2050, and in some cases 2100, to take into account the long-term Earth system processes and transformational socio-economic dynamics. Part of the work will be to downscale global perspectives to national level by developing complementary sustainable development pathways applicable to Brazil. Two critical regions for sustainable development challenges will receive special attention: Amazonia and Northeast Brazil. One of the initial objectives of BR2050+ will be a rigorous assessment of SDG metrics for Brazil and the establishment of data requirements and consensus methodologies for monitoring SDGs in Brazil (See Box 1 and Figure 1).

Box 1

The Brazil In 2050 Narrative (BR2050+) and Sustainable Development Pathways

The BR2050+ Initiative, a regional contribution to The World In 2050 (TWI2050) Initiative, aims at developing integrated sustainable development pathways that meet the SDGs within the planetary boundaries for Brazil in parallel with similar initiatives for all regions of the world. It integrates new quantitative analysis by world-class models of key sectors such as energy, food, population, education, macro-economics, biodiversity, climate, and combine these with global assessments and national scenarios. Sustainable Development Pathways (SDP) are scenarios that include that the world, and in particular Brazil, reaches all the SDGs within the Planetary Boundaries. This is in line with the framing narrative that is being developed within TWI2050. The ultimate objective of the narrative is to identify a portfolio of measures that are needed to achieve all SDGs jointly, accounting for synergies and trade-offs across the goals. The initiative goes beyond 2030 towards 2050 in order to account for Earth system processes in response to human activity in the longer run.

BRAZIL IN 2050 (BR2050+) FRAMEWORK

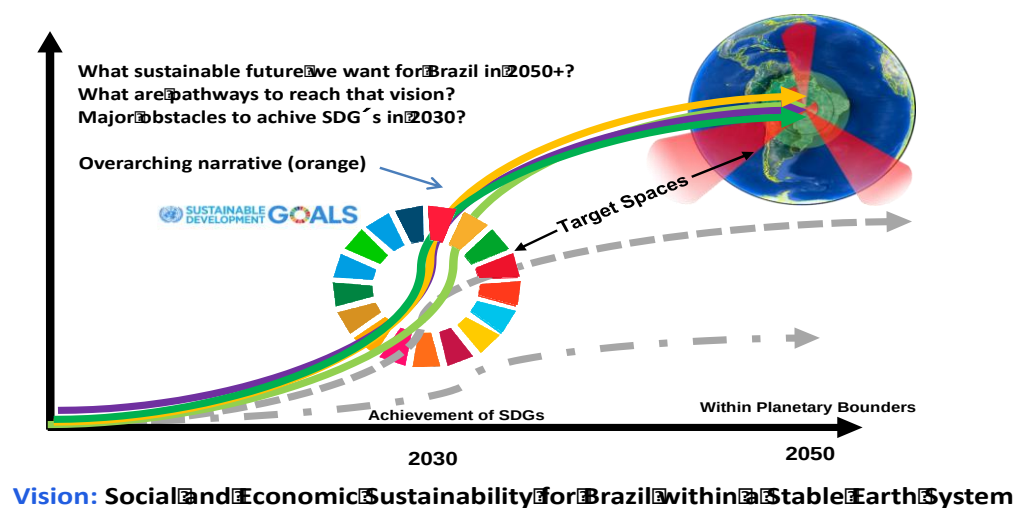


Figure 1: TWI2050 and BR2050+ Framework: The illustrative graphic shows alternative sustainable development pathways (SDPs) that reach the two defined target spaces: all 17 SDGs and the transformation toward sustainability within planetary boundaries beyond 2050. An overarching narrative (orange) on sustainability transformation motivates the TWI2050 framework. Alternative pathways (gray) may achieve SDGs in 2030, but not within Planetary Boundaries in 2050 (gray, dashed line) or miss the SDGs by 2030 altogether (gray, dash-dot line). Source: based on WBGU (2011).

The UN Agenda 2030 has been argued to be technically feasible, but there is still not yet any fact-based integrated pathway in which all SDGs are reached within the Planetary Boundaries. The World in 2050 (TWI2050) is a newly formed global research initiative designed with the aim to provide such pathways. For TWI2050 to be relevant in the Agenda 2030 processes, it needs to reflect a diversity of regional perspectives. To achieve such inclusion of perspectives, BR2050+ will have to engage in a number of multi-actor, cross-sector and sub-regional dialogues in order to bring a multitude of Brazilian Perspectives on potential *Sustainable Development Pathways* and define relevant research agendas.

Initial steps for the development of BR2050+ call for engaging a suite of research institutions and universities and assemble a team of specialists covering the diversity and all-encompassing nature of SDGs. This group will define the scope and direction of research and prepare a proposal. Additionally, an overarching coordinating structure at national level will be required to facilitate the implementation of BRA2050, support the work of fund-raising and provide linkages and connectivity to ongoing programs and to the TWI2050 project.

This project will be built upon previous GEF-sponsored MCITC-led projects, especially the Third National Communication to the UNFCCC (Brasil, 2016) and the Project “Mitigation Options” (Rathmann et al., 2017). Although these studies were directly relevant to SDG 13 Climate Action, they helped to develop a conceptual framework for developing scenarios and development pathways to achieve Brazil’s NDC by 2030 and dealt in-depth with development of integrated assessment models to support quantitative implications in the national economy and in social indicators for a family of mitigation pathways. BR2010+ will benefit from these earlier projects and extends considerably to many more dimensions since it deals with 17 SDGs and covers much more broadly social, economic and environmental aspects.

The challenges to achieving sustainable development in Brazil can be broadly categorized in three categories, similarly to a conceptual framework laid out for planetary health (Whitmire et al., 2015):

- conceptual failures (imagination challenges), such as the vision of Brazil as only a source of commodities for the world and the lack of imagination to create alternative, less socially and environmentally damaging development pathways based on the country’s rich biodiversity and renewable natural resources, with value added via technological innovations for an inclusive ‘bio-industrial’ model of development, generating higher income jobs;
- knowledge failures (research and information challenges), such as reduced amount of funding to research institutions, insufficient R&D investments by the private sector, and lack of innovative research, for instance, to unveil the hidden economic and societal value of biological assets, that is, a ‘tropical model of development’;
- implementation failures (governance and policy challenges & entrepreneurial capacity failures), such as the failure of government to recognize the risks of current and past development policies and the inefficient implementation of a diversified economy by public and private actors and even the failure to share more equitably the benefits of the current resource-intensive economy, reducing social and income inequities.

Why TWI2050 and BR2050+ are needed¹

The Sustainable Development Goals (SDGs), unanimously adopted by the United Nations in September 2015, provide an aspirational narrative for the desired future for human development with an actionable agenda. The aspiration is for a world free from hunger, injustice and absolute poverty, of universal education, health and employment with inclusive economic growth, based on transparency, dignity and equity, all achieved within the boundaries of the planet. The urgent question now is how to act on this aspirational agenda and to have a clear understanding of the full consequences and cost of inaction and the benefits of achieving SDGs in every major region of the world. The World in 2050 (TWI2050) is an initiative designed to help answer these questions and Brazil in 2050 (BR2050+) is a regional contribution to the global project.

TWI2050 aims not only to contribute to this understanding but also develop science-based transformational and equitable pathways to sustainable development that can provide much needed information and guidance for policy makers responsible for the implementation of the SDGs. These advances in understanding acquire many regional variations to take into considerations national aspects that may depart considerably from global patterns and BR2050+ will delve into those aspects.

While the SDGs provide normative guidance on the direction of change that should be pursued, the exact pathways how to get there are far from clear and even more difficult to tackle at a regional, national scale. There are several challenges associated with identifying pathways that achieve the goals. One is that the targets associated with the SDGs have been set mostly without considering their interaction but progress towards one SDG will inevitably create trade-offs and synergies in the progress towards other SDGs. Another one is that the SDGs in a way extrapolate the present to the future, i.e. they assume that preferences and trends to not change substantially and no major unforeseen hurdles or tipping points occur over the before 2030; in reality, the SDGs will be more a moving target, since the only thing certain is that the future is uncertain. Therefore, successful identification of pathways requires a comprehensive, robust approach that spans across disciplines and methodologies, and that is capable to deal with non-linearity.

BR2050+ will build a consortium to reflect these competences. A core strength will set the BR2050+ consortium apart from other initiatives contributing to the scientific knowledge creation for the SDGs is its capacity in integrated assessment modeling and scenario development. However, in order to best tackle sustainable development challenges in the 2030 timeframe and beyond for Brazil, BR2050+ seeks to further deepen (modeling) expertise in non-resource based sectors and to better integrate knowledge and analytical capacity across social, political, technical and Earth systems. This is particularly important for Brazil since the major challenges to achieve SDGs by 2030 are in non-resource based sectors such as how to reduce significantly levels of violence.

Objective

¹ Based on the justifications of TWI2050 Initiative.

Analysis and construction of sustainable development pathways for Brazil in 2050 and beyond to meet the Sustainable Development Goals while remaining within planetary limits.

Justifications

UN Sustainable Development Goals (SDG) represent the most aspirational, comprehensive and ambitious set of development goals by the UN and they were adopted unanimously by the UN in 2015. They go much further and deeper in relation to the UN Millennium Goals (MDG) and are holistic in nature: not one issue of development was left behind and it encompasses all the dimensions of human development while seeking to maintain Earth system stability. The first timeline for the SDG is set by the Agenda 2030 and is quite ambitious to seek clear signs in progress in all SDG indicators in short 15 years. However, that is the same timeframe for the MDG and evaluation of that program showed significant progress everywhere except perhaps in sub-Saharan Africa. Brazil met or exceeded all MDG.

What is the role of science for the SDGs? It is clear that science can develop, test and validate metrics and indications to monitor the attainment of SDGs globally, regionally, nationally, etc., and it is already moving steadily in that direction. But, it can do much more. In fact, it should also be aspirational in supporting a normative vision of sustainable development pathways in the future and developing methods to ‘backcast’ such pathways backwards to the present (Vergragt and Quist, 2011).. That is quite a departure from the more traditional field of scenarios development, in which scientists gather and propose families of future scenarios for the world, some sustainable, some very unsustainable and do not attempt to set likelihoods for a particular scenario.

In this project, by design a series of sustainable development pathways will be proposed for Brazil and studied in great detail by a network of scientists, policy makers, practitioners and others. The main justification for this course of action is the urgency that the planet faces to find sustainable trajectories of development, including the use of natural resources, to avoid taking humanity and the living planet to ‘terra incognita’, transgressing planetary boundaries and social systems boundaries of no return.

Scientific and Social Impacts

The BR2050+ is planned to be a regional contribution to the larger project The World in 2050 under implementation by a consortium of research institutions from many parts of the world. It will be a contribution bringing the regional perspective of a tropical developing country to the fore. BR2050+ will also support the establishment of a network of scientists, policy makers and civil society representatives on the themes of sustainability science, an interdisciplinary science gaining importance and respectability. Such network of social, natural and health scientists, engineers, practitioners, policy makers, etc. dedicated to advance an agenda on Sustainable Development Goals does not exist at the moment in Brazil. Therefore, a relevant contribution is the creation of such scientific capacity in Brazil and a knowledge network that could grow and last long enough to keep track of Brazil’s SDG for a decade or more. The project will also have the impact of producing quality data sets and metrics for SDGs.

The exercise of developing a vision for Sustainable Development Pathways for 2050 and beyond for Brazil in itself will bring a positive impact for society in terms of providing scientific underpinning to the political actions under UN’s Agenda 2030 such as “The Future

We Want’’, the motto of the Rio+20 Summit, in Rio de Janeiro, in 2012. Rigorous scenario setting for SDPs and ample validation of potential sustainable trajectories in the hands of an influential network of scientists and policy makers could become reference to policy making in all corners of Brazil’s development needs. This exercise will also help in developing an in-depth understanding on the three challenges laid out above, that is to imagine an authentic Brazilian model of tropical development, and to address the information required and the implementation policies to achieve it.

Data and Methods

- Sustainable Development Goals (SDGs). Some thematic areas of SDGs are well connected with one another, whereas other parts of the network of targets have weaker connections with the rest of the system (Le Blanc, 2015). Therefore, it may simplify the analysis to group the SDGs in few categories to depict more easily the connections. One such proposal is present in Figure 2: Social&Economic Development; Basic Human Needs; Earth Pre-Conditions; Universal Values; Sustainable Resource Use; and Governance&Partnership.
- The overarching methodological approach is the use of the tools of quantitative reasoning for making sense of enormously complex development and environmental problems of the Anthropocene, including biophysical forces that shape our planet and our lives directly and also focused on the rising threats to the survival of civilization and of living species.

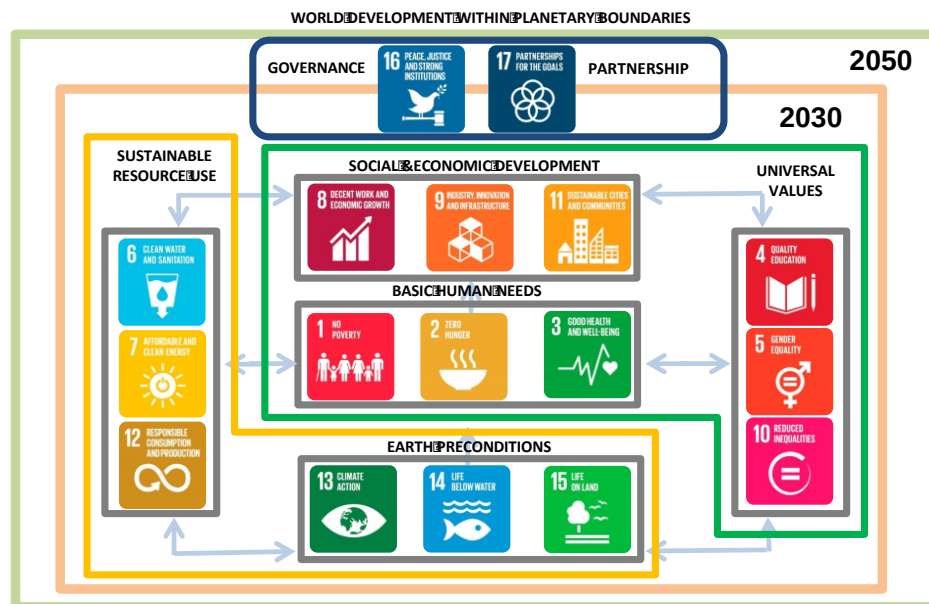


Figure 2. Grouping of UN Sustainable Development Goals for the goals of the BRA2050 (and TWI2050) Project in 6 categories: Social&Economic Development; Basic Human Needs; Earth Pre-Conditions; Universal Values; Sustainable Resource Use; and Governance&Partnership. Time scales for achievement of such goals within planetary boundaries are indicates: 2030, 2050 and beyond.

- Planetary boundaries.** One paradigmatic innovation of this project is to seek SDPs, but within planetary limits for Earth's stability over the long run. It will take as planetary boundaries the conceptual and empirical work depicted in Figure 3 drawing from the definition of 9 planetary boundaries: climate change; ocean acidification; stratospheric ozone depletion; biogeochemical flows (N&P); freshwater use; biosphere integrity; land system change; atmosphere aerosol loading; novel entities (Rockström et al., 2009; Steffen et al., 2015). Those boundaries are strongly interconnected with one another in the Earth system and a very precision definition of the safe operating space is difficult. Scientific advances allow better inferences on the level of safety in the operating space. For instance, until the Paris Accord, it was thought that 2 C global warming was the safer boundary to set. However, the aim now is to attempt to limit warming at 1.5 C to reduce long term risks. Another way of looking into planetary boundaries is to add a social dimension to it, which may be directly relevant to the work of linking to SDGs and SDPs. Figure 4 presents the concept of “the doughnut of social and planetary boundaries” (Leach et al., 2013) that extends the concept of a ‘*safe operating space for humanity*’ to a grander ‘*safe and just space for humanity*’ along with a ‘*regenerative and distributive economy*’. Annex 1 shows the matrix of interaction between the nine planetary boundaries and with 65 SDG targets. This matrix was mostly derived through a consultation process within the TWI2050 project. For the case of BR2050+, we suggest additional interactions between planetary boundaries and SDG targets (highlighted with the target in blue letters on Annex 1).

Planetary Boundaries

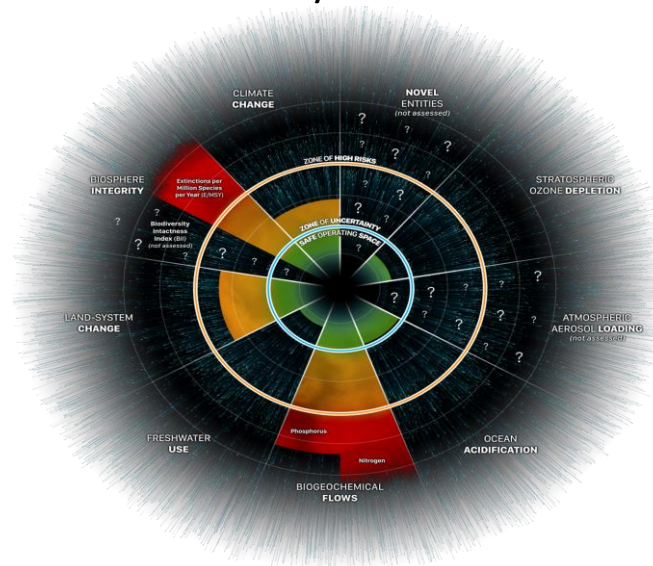


Figure 3. Schematic depiction of the 9 Planetary Boundaries (Rockström et al., 2009; Steffen et al., 2015) to guide development of Sustainable Development Trajectories.

The Doughnut of social and planetary boundaries (2017)

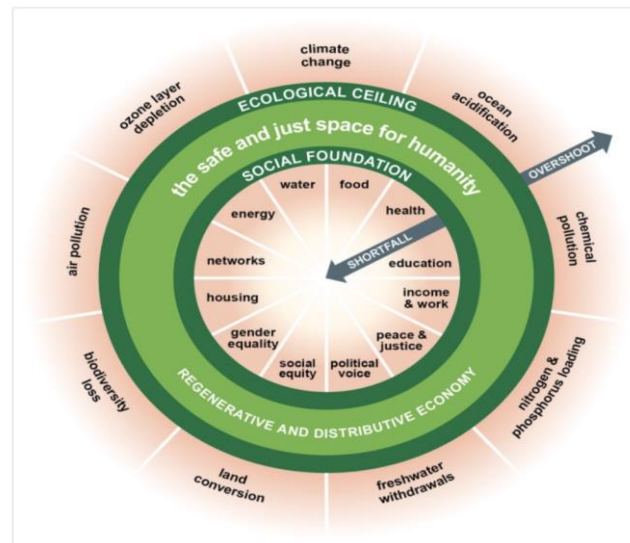


Figure 4. Schematic representation of the social doughnut of social and planetary boundaries (Leach et al, 2013).

- SDG metrics. Assemblage of metrics of SDG indicators, starting with the products of the SDGindex.org (Sachs et al., 2016; SDSN, 2016; Schmidt-Traub et al., 2017). This research project led by UN's SDSN, compiled metrics of indicators for all 17 SDGs for almost 150 countries in the world, including Brazil.

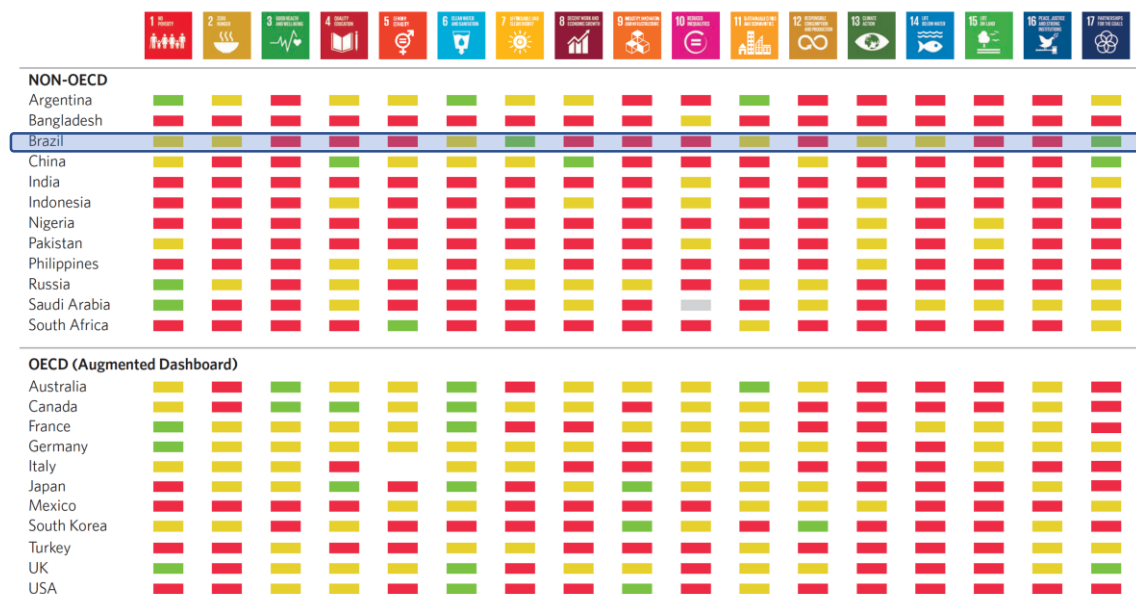


Figure 3. SDG Dashboards 2016. SDG Dashboard for members of the G20 and other countries with a population greater than 100 million. Dashboards for OECD countries calculated using an augmented set of 77 indicators, compared to 63 global indicators for non-OECD countries. Green signifies that the country has achieved the goal, yellow points to significant challenges that remain and red warns that major challenges must be overcome to meet the goal. Grey indicates an SDG for which there is no data. Icon images courtesy of United Nations (Schmidt-Traub et al., 2017).

- An example of such indicators for Brazil is presented in Figure 4. It will serve as a starting point for refinement of indicators for Brazil and proposal of a set of metrics to be used in the development of the Sustainable Development Pathway construction. For comparability purposes among all nations, some metrics necessarily have to be simplified. Let us take the example of SDG 6 Clean Water and Sanitation where Brazil scores high at 92.12 based on 98.1% of the population having access to not contaminated water sources (universal access) and 82.8% have access to ‘improved’ sanitation. However, less than 55% of Brazilian households have sewage collection and less than 40% of the sewage receives any type of treatment. Therefore, on a Brazilian perspective, sanitation is one of our most serious environmental and health issues and a Brazilian specific metric for sanitation would put Brazil as very far from middle-level grades as the SDGindex.org has done it. Another comparison can be made for SDG 13 Climate Action. SDGindex places Brazil’s vulnerability to climate change as very low. However, a national account of the impact of recent climate extremes on agriculture, water resources and natural disasters would very likely raise the perception of vulnerability. In sum, an important element of this project is to improve the representativeness of SDG metrics for all 17 SDGs, maintaining a subset for comparability to other nations, but constructing such metrics with regional and national specificities as to allow the Brazilian metrics to be in tandem with the overarching SDPs to be developed. For this particular example of sanitation, a target would be universal access to sewage collection and treatment for urban populations and adequate sanitation facilities for rural population. The methodology for defining and refining SDG metrics for Brazil will rely on the participation of a large number of experts on the various aspects directly linked to each one of the SDGs to assess existing metrics (e.g., SDGindex.org) and propose improvements. It will equally seek to assemble existing data sources, primarily the IBGE census statistics and derived metrics as illustrated in Figure 5. A series of interdisciplinary workshops will validate and further improve the proposed indicators or sets of indicators. A final phase will be to test the metrics for 3-5 years to attest to its adequacy. The importance of measuring progress towards SDGs is acquiring strategic importance and it is being called a ‘new vital science’ (Maurice, 2016). In fact, BR2050+ has an overarching goal of putting the Brazilian scientific community on track for this new science.

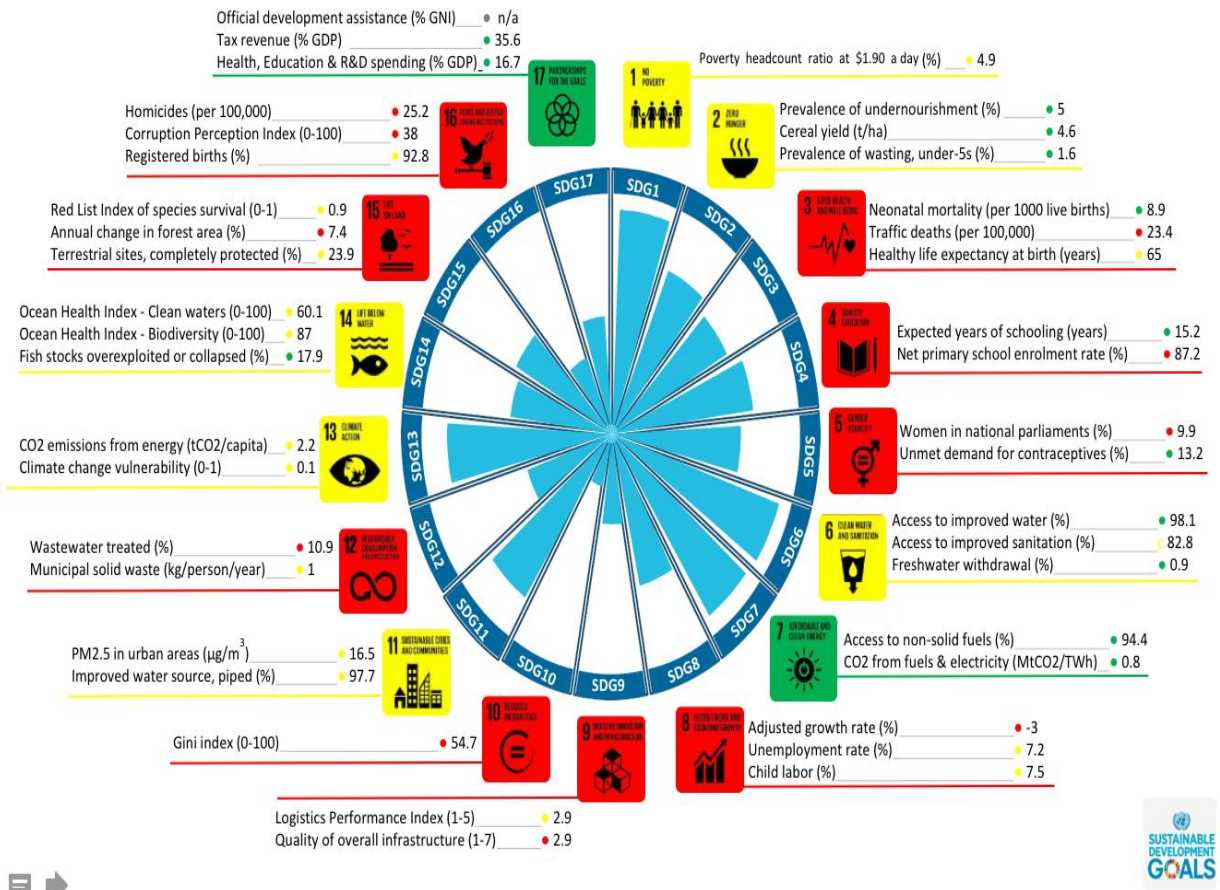


Figure 4. Illustration of an assessment of the present status of Sustainable Development Goals for Brazil as calculated by the SDG Index.org. For each of the 17 SDGs there are examples of some of the metrics used in the calculation. The size of the blue bar is a relative indication on how Brazil performs for a particular SDG.

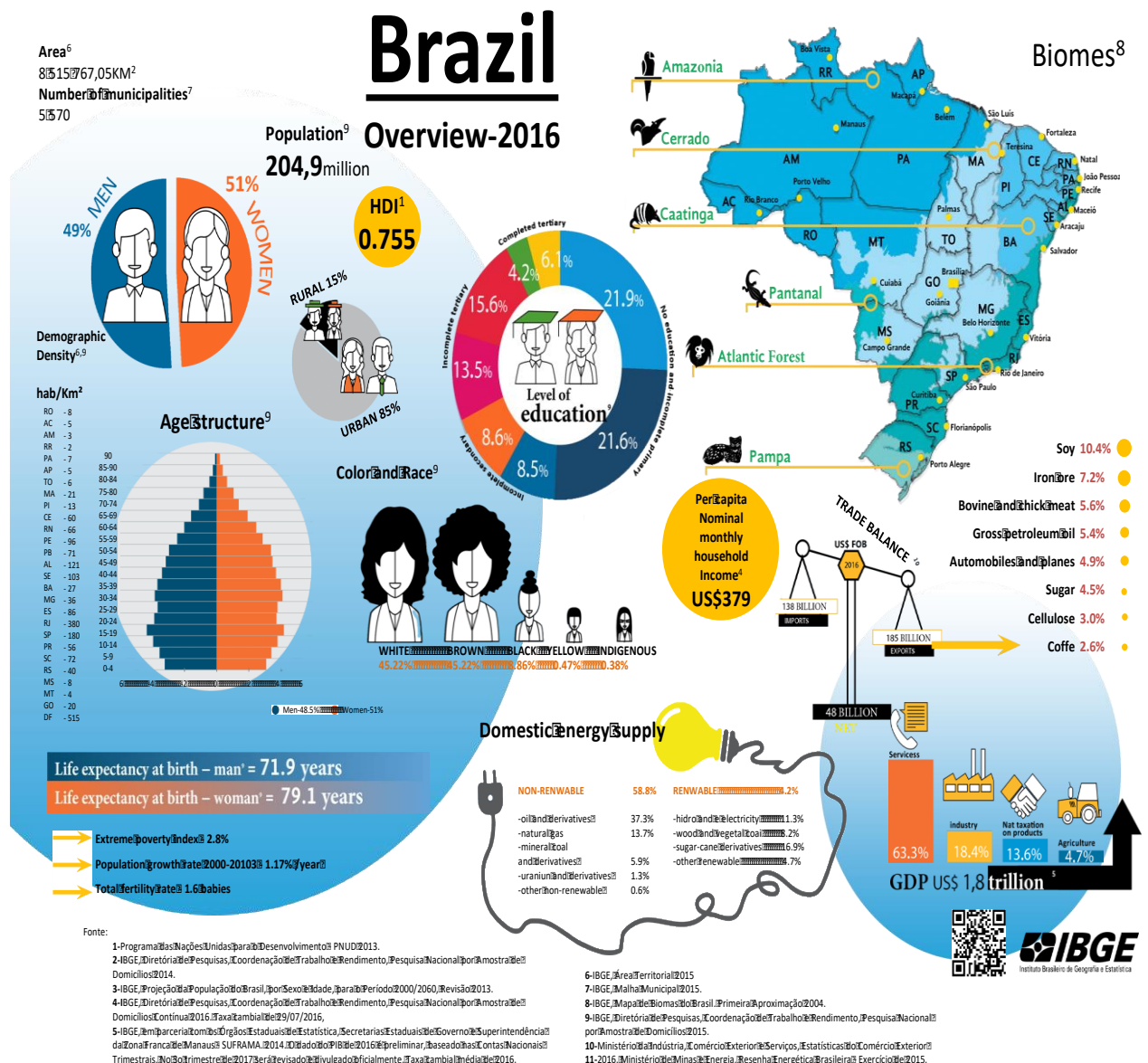


Figure 5. Overview of socioeconomic indicators for Brazil (2106) from IBGE data base (Brasil, 2017).

- SDGs Synergies and trade-offs matrix.** There are many co-benefits and some trade-offs among SDG (Nilsson et al., 2016; Pradhan et al., 2017; Spaiser et al., 2017; Wackernagel et al., 2017). A few examples of trade-offs applicable to Brazil follows. Energy security for all can be achieved, for instance, with intensive exploitation of pre-salt oil reserves that can last over 100 years. That would impede Brazil to reach the goal of SDG 14 on climate stabilization and would bring dangerous climate change and ocean acidification. Food production is a necessary condition for food security. It may be reached by continued expansion of animal and vegetable protein commodity expansion, with serious impacts on water resources and the preservation of life on land, in addition to increased emissions due to deforestation. However, there are many more synergies among SDGs than trade-offs. For instance, reducing deforestation and increasing efficiency of agriculture and livestock is a key climate mitigation strategy for Brazil and directly reduces emissions and threats to land biodiversity, ocean acidification, at the same time that it addresses issues of food security and rural development. A number of

studies have produced diagrams of such complex relationships such as the one depicted in Figure 6. We need to study in detail co-benefits and trade-offs for Brazil [check if there are studies mentioning specifically Brazil].

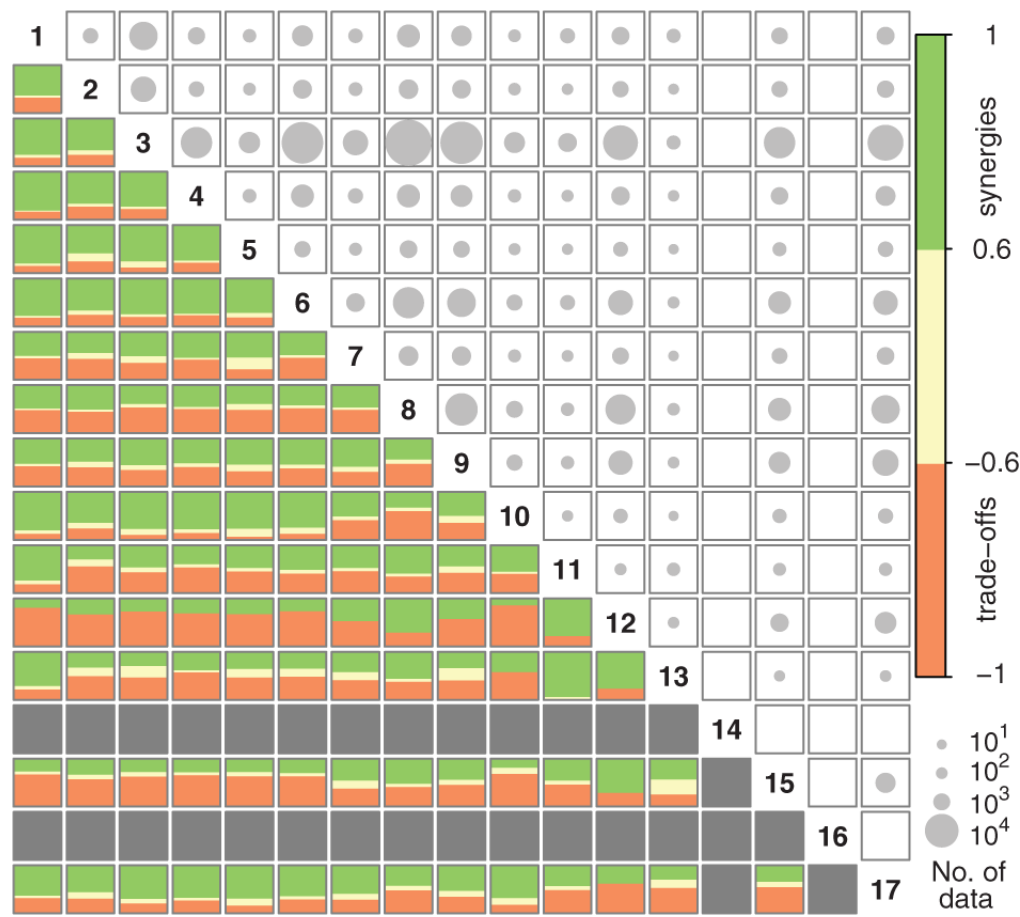
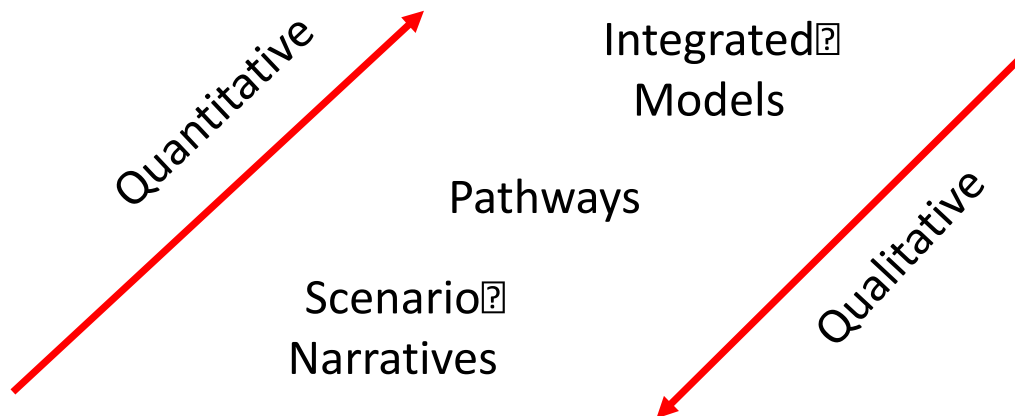


Figure 6. Observed synergies and trade-offs between the SDGs. The color bars represent the shares of synergies (green), nonclassifieds (yellow), and trade-offs (orange) observed between the SDG pairs for the entire dataset. The gray bar depicts insufficient data. The area of the circle in the boxes indicates the number of data pairs (see the legend for comparison). The SDGs are represented by the numbers in the diagonal. Both positive and negative correlations are observed among the SDG pairs with SDG 1 (*No poverty*) expressing synergies among most other SDGs. SDGs 12 (*Responsible consumption and production*) and 15 (*Life on land*) have mostly shown trade-offs with most other SDGs. (Pradhan et al., 2017).

- **Sustainable Development Pathways (SDPs).** The main method of the proposed work is the development of Sustainable Development Pathways for Brazil (see Box 1). [explain SDP; references]. Their construction depends on development methodologies for merging quantitative scenarios with qualitative scenario narratives (“storytelling”) (Nakicenovic et al., 2000), shown schematically in Figure 6. Some of the SDGs render themselves for quantitative analysis (e.g., the nexus water-energy-agriculture), whereas other SDGs analysis are still carried out through narratives. We will rely mostly in the analysis on the recently developed Shared Socio-Ecological Pathways – SSPs (O’Neil

et al., 2014; van Vuuren et al., 2014). The SSPs are five distinct global pathways describing the future evolution of key aspects of society that together imply a range of challenges for mitigating and adapting to climate change (O'Neill et al., 2014). This family of scenarios have been elaborated into storylines and quantitative scenarios using various tools (Riahi et al., 2017).

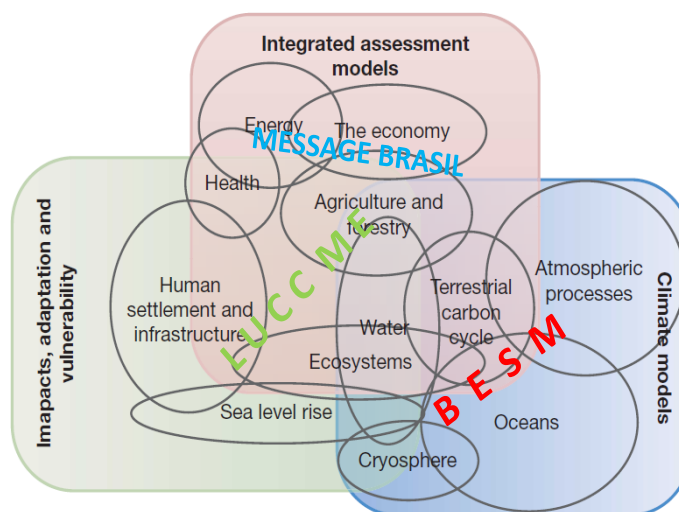
Possible Unified Analytical Approach



Source: Nakicenovic et.al., 2000

Figure 7. Possible unified analytical approach to derive the Sustainable Development Pathways (SDP) through the combination of quantitative modeling with scenario narratives (adapted from Nakicenovic et al., 2000).

- Quantitative modeling approaches. A key element for SDP construction is the use of a suite of modeling approaches (reference). The main type of quantitative models is the Integrated Assessment Models (reference of their use in sustainability research). For this project, we plan on using IAM developed for different applications by Brazilian research institutions, namely the MESSAGE-Brazil model and the LUCC modeling framework.



Moss et al., (2010)

Figure 8. Modeling framework for this study through integration of complementary modelling approaches: Integrated Assessment Models, Earth System Models and Assessment Models for Impact, Adaptation and Vulnerability (based on Moss et al., 2010). Three classes of Brazilian models are depicted in the future: MESSAGE-Brazil (Lucena et al., 2016; Lima et al., 2015), Lucena et al. 2010; Nogueira et al., 2014), LUCC, DINAMICA-EGO (Soares-Filho, 2009) and BESM.

- MESSAGE-Brazil modelling framework

Integrated Assessment Modelling (IAM) is the part of integrated assessment that relies on the use of numerical models. IAM are a type of scientific model often used by the environmental sciences and environmental modeling policy analysis. The modeling is integrated because the environmental problems do not respect the borders between academic disciplines. Integrated assessment models, therefore, integrate knowledge from two or more domains into a single framework. Integrated modelling is referred to as assessment because the activity aims to generate useful information for policy making, rather than to advance knowledge for knowledge's sake. In BR2050+ we will use one of the family of IAMs being used extensively, derived from the MESSAGE (*Model for Energy Supply Strategy Alternatives and their General Environmental impact*) IAM (Riahi et al., 2007), the MESSAGE-Brazil IAM. This model has been used to assess energy-emissions nexus (Lucena et al., 2016; Lima et al., 2015) and will be used primarily to address quantitatively the water-energy-agriculture nexus.

- LUCC modeling framework

LuccME, (Aguiar et al. 2016) developed by INPE / CCST (<http://luccme.ccst.inpe.br/>), is a spatially explicit land use modeling framework that allows for easy construction of models of deforestation, agricultural expansion, desertification, forest degradation, urban growth and other land use change processes at different scales and areas of study. The platform is an open-source framework built as an extension to the TerraME

programming environment (Carneiro et al., 2013) and can quantify in time and space the relationships between spatial and temporal patterns of land use changes and their drivers, combining different components of demand, potential and allocation of land use, which are generally needed in most land-use and land-cover models (Verburg et al. 2006). Using LuccME, models are organized so that each year the demand for change is spatially allocated according to the potential of the cell and the user can combine several components available on it.

Considering that changes in land use are influenced by local, regional and global factors (such as global demand for food and national policies), LUCC-ME will be implemented in BR2050+ covering the national territory, with input from global economic models projecting the demand for different uses, and will produce spatially explicit land use projections linked to possible visions of the future and support production indicators in different dimensions (social, economic, institutional and environmental), as well as the identification and selection of more meaningful indicators for "sustainable" or "unsustainable" trajectories.

- BESM modeling framework

The investigation of planetary limits also calls for the need to use quantitative models of the Earth System (references). These models have been used both to provide boundary conditions to constrain IAM and also to project future global environmental change scenarios once scenarios based on narratives (e.g., SSPs narratives) have been defined (reference).

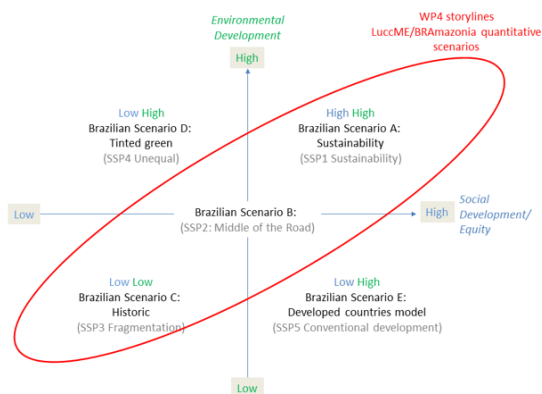
One way of considering the consequences of human activities on the Earth system consists of the development of mathematical models to describe the interactions of the oceans, the atmosphere, the biosphere and the cryosphere, among themselves and with the energy and matter fluxes originated from human activities. This is a class of model called 'Earth System Models'.

In Brazil, such an effort of mathematical modeling of the biophysical environments of the Earth System has resulted in the creation of the Brazilian Earth System Model – BESM (Nobre et al. 2013; Giarolla et al. 2015; Capistrano et al. 2017; Veiga et al. 2017). Such a class of models is a must to study climate phenomena on time scales varying from weeks to centuries and millennia. Several early studies have shown the impacts of tropical deforestation on climate using atmospheric global models Shukla et al. 1990; Nobre et al. 1991) or the more recent calculation on the risk to the Amazon forests from the synergistic effects of deforestation, climate change and forest fires (Nobre et al., 2016). Yet, only with the use of a coupled ocean-atmosphere-biosphere model it was possible to gauge the combined effects of Amazon deforestation on atmospheric and oceanic circulation changes, and their combined effects on rainfall reduction over the Amazon (Nobre et al. 2009). Also the explanation of the thermally indirect atmospheric circulation associated with the formation of the South Atlantic Convergence Zone (SACZ), with augmented rainfall over cooler Sea Surface Temperatures (SST) was only possible with the use of an early coupled ocean-atmosphere version of BESM (Nobre et al. 2012). The study of global climate variability and change was also subject of study using BESM, like in the study of the current climate simulation (Veiga et al. 2017), in the study of climate sensitivity to Greenhouse Gases (GHG) increase (Capistrano et al. 2017), as well as in the study of centennial scale ocean circulation changes due to GHG increase (Nobre et al. 2017).

With the most recently implemented land use and forest fires effects on BESM, a next level of flexibility for the study of the human intervention on the global climate system shall soon be available as a potent research tool for the community as a whole.

Therefore, BESM will be the main Earth system model for BR2050+ in terms of producing quantitative scenarios of the evolution of the global Earth system on timeframes of 2050 to 2100, providing necessary boundary conditions to Integrated Assessment Models. BESM will be forced in such simulations with scenarios of emissions and land use change that are compatible with the normative sustainable pathway for 2050 and beyond, that is the approximation given for the Shared Socio-ecological Scenario SSP1 (reference?).

- Overarching Narratives for SDPs. Qualitative narratives require also carrying out a number of dialogues with diverse stakeholders to obtain regional perspectives (references). For instance, future scenarios for the Brazilian Amazon were obtained by a combination of quantitative and qualitative methods as shown in Figure 9. (Folhes et al., 2015; Aguiar et al., 2016). A series of stakeholder consultation/scenario co-development workshops/dialogues will be carried out regionally and by sector before modeling their impacts.



Ana Aguiar (INPE/CCST)

Figure 9. Mapping out the Shared Socioeconomic Pathways to development pathways for the Brazilian Amazon (Aguiar et al., 2016; Folhes et al., 2015).

- Developing the vision of a Sustainable Brazil by 2050 and beyond. Next, the exercise of deriving a family of SDPs, that is, the exercise of first normatively defining a vision of sustainable development for Brazil for 2050 within planetary limits and by using the ‘backcasting’ method (reference) to arrive at a family SDPs from present to 2050 to 2100, under the constraint that they should abide by the 2030 Agenda of meeting SDG by 2030. We start with the SS1 shared socioeconomic scenario (maximum resource efficiency combined with rapid and equitable development) because this is the scenario

that most closely resembles the normative vision of a just and safe operating space for humanity within planetary boundaries by 2050 and beyond.



Backcasting analysis, working back from a sustainable end point to determine actions for today

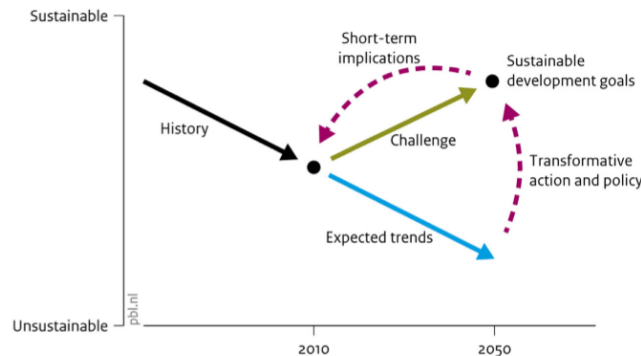


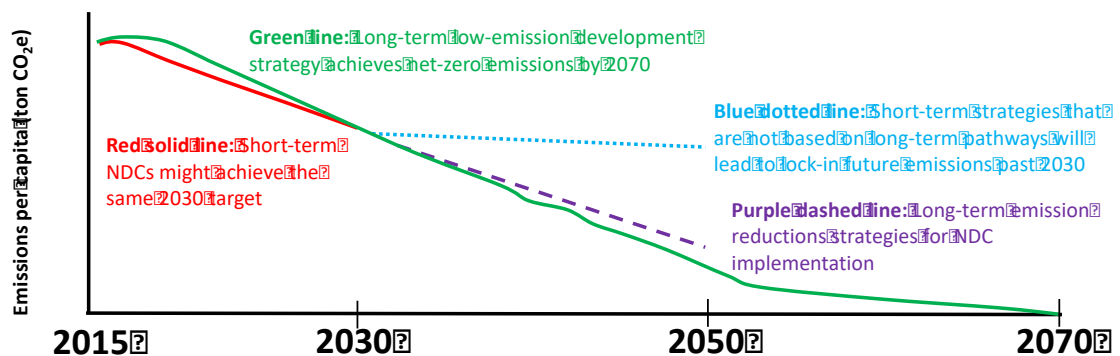
Fig. 1. Main study design. First, a set of Sustainable development goals has been derived from existing international treaties. The Trend Scenario explores expected trends. The Challenge Scenarios or Sustainable Development Scenarios in contrast explore the transformative action and policies that are needed to meet these goals compared to the Trend Scenario. Finally, the study looked into the implication for decisions in the short-term.

Please cite this article as: van Vuuren, D.P., et al., Pathways to achieve a set of ambitious global sustainability objectives by 2050: Explorations using the IMAGE ..., Technol. Forecast. Soc. Change (2015), <http://dx.doi.org/10.1016/j.techfore.2015.03.005>

Ana Aguiar (INPE/CCST)

Figure 10. Schematic diagram of backcasting analysis to be used in BR2010+ applied to Brazil.

- Downscaling of the Shared Socioeconomic Pathway SSP1 for Brazil. In many respects, the drivers for the global SSP socioeconomic scenarios vary widely across regions and have to be downscaled for a regional application (Absar and Preston, 2015). For example, indigenous children in Brazil are more than twice as likely to die in their first year of life than other Brazilian children (You et al., 2015:2284). That is the case, of projections of population growth, life expectancy, urbanization, mortality and aging rates, child mortality ...
- SDPs for Brazil. Obtaining SDPs will be achieved by combining the results of quantitative scenario generation with narratives for the SDGs. For instance, Figures 11 and 12 illustrates what could be such exercise for SDG 13 Climate Action for sustainable mitigation trajectories for Brazil (Pathway 2) and one example of a not-sustainable trajectory (Pathway 1), using as indicator metrics the per capita emission of CO₂e during this century and narratives of what would be policies to adhere to those pathways. Notice that this figure illustrates the ‘back-casting’ method, that is, Pathway 2 is a normative vision of where we desire to be in 2050 and beyond in terms of climate change mitigation and the sectoral targets described for Pathway 2 form a narrative for its accomplishment. Whenever feasible, quantitative sustainable pathways will be proposed through the use of a suite of IAMs. For example, MESSAGE-Brazil has well calibrated sub-models for the Brazilian and the world energy sector and can quantify trajectories for energy. It also is developing an agricultural sub-model to link it up to land use change and emissions. On the other hand, LUCC models can be used to obtain quantitative trajectories of land use change in response to sustainability policies. The Annex A contains a first analysis of the interactions of the targets for each of the 17 SDGs of relevance to Brazil with the 8 planetary boundaries. BR2050+ will explore these interactions in great detail for the construction of SDPs.



Source: Adapted from Sachs et al., 2016

Figure 11. Illustration of possible long-term low-emission development pathways consistent with limiting warming to 2 C and short-term NDCs. Long-term low-emission development strategy to achieve zero net emissions by 2070 (green line). Short-term NDCs might achieve the same 2030 target (red line). Short-term strategies that are not based on long-term pathways will lead to lock-in future emissions past 2030 (blue dotted line). Long-term emission reductions strategies for NDC implementation (purple dashed line). Source: Adapted from Sachs et al., 2016.

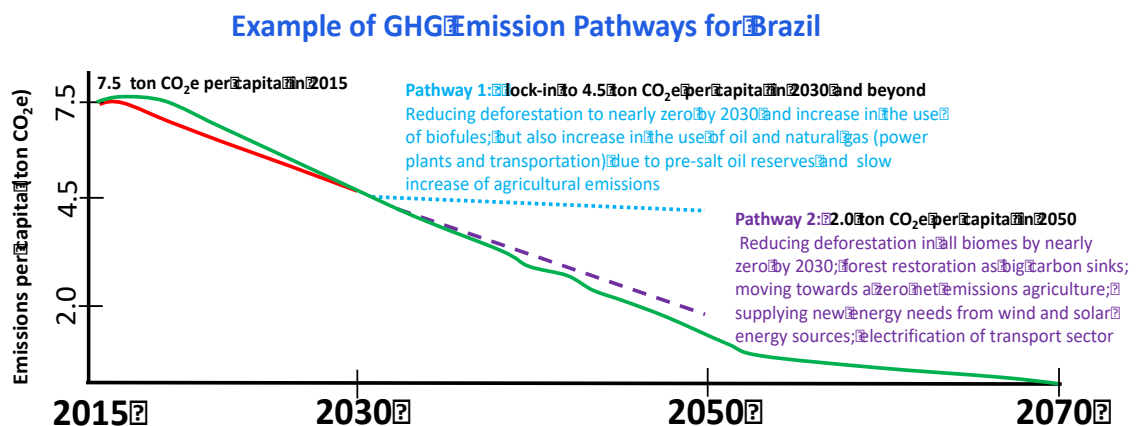


Figure 12. Same as Figure 3, but for the Brazilian contribution to SDG 14 goals (Climate Action). Diagram was adapted from Sachs et al., 2016, but Pathways are actual representations of possible sustainable development pathways for Brazil over the long range (Pathway 2) or pathways that will meet the 2030 Agenda, but will fall short to meet the long-term goals (Pathway 1).

- This type of exercise will be accomplished through a series of focused workshops for a particular set of SDGs and a final workshop gathering all participants to devise the final selection of SDPs for Brazil.
- Finally, there will be two validation exercises. One would be an open consultation process via web on the reach and suitability of the proposed SDPs for Brazil. Concurrently, there will be at least three stakeholder consultation process/meetings to validate the final products.

Number of hours of dedication per week

12 hours

Timeline²

Three Year Project: 2018-2020 (36-month duration)

Summary of Proposed Activities

BR2050+ is planned to be a 3-year project. The initial contract with PNUD will support the preparation of a Project Information Form (PIF) for the full project, assemblage of some data sources and establishment of a network of research institutions and individuals willing to take part in the project.

Phase I: Initial Activities

Preparation of conceptual white paper to disseminate the main goals of the project; creation of a website for the initiative to facilitate dissemination of project ideas; engagement of interested research institutions and individuals; establishment of the basis for a research network on Sustainable Development Goals (SDG) in Brazil; preparation of the Project Information Form (PIF), as part of the contract with PNUD; preparation of research proposals for funding agencies.

Timeline: months 01 to 06.

Phase II: Data Assemblage and Methodological Development

Development of SGD metrics appropriate for Brazil; definition of target spaces for 2050 and 2030 for Brazil-specific SDGs and interaction of selected SDG targets with planetary boundaries applicable to Brazil; development of a matrix of synergies/co-benefits and trade-off among SDGs for Brazil; selection of Integrated Assessment Models and Earth System Models to be part of the study; downscaling of shared socioeconomic scenario SSP1 for Brazil; implementation of a series of participatory research multi-actor, cross-sectoral dialogues to bring regional perspectives, particularly of less developed regions, namely Northeast Brazil and Amazonia; methodological development to merge quantitative scenarios with qualitative narratives for designing Sustainable Development Pathways through the “backcasting” methodologies.

Timeline: months 3 to 30.

Phase III: Production, Validation and Dissemination of Sustainable Development Pathways

Elaboration of a number of Sustainable Development Pathways (SDP) for Brazil for 2050 and beyond encompassing all SDGs, addressing co-benefits and trade-offs among SDPs with respect to regional specificities, particularly for Amazonia and Northeast Brazil; wider

² See detailed Timeline for Components and Activities in the Work Plan for BR2050+ Project.

validation of the proposed SDP results; dissemination of SDPs via scientific articles, a book and website.

Timeline: months 19 to 36

Plan for production of scientific articles, books, book chapters, other.

The project plans to produce diversified outcomes, particularly of five kinds:

1. Website “BR2050+” containing all the information about the project, project development and products, including an interactive tool to allow how policies interact with the SDPs and their outcomes.
2. Materials for allowing writing of research proposals for funding to national and international funding sources.
3. A book containing chapters pedagogically describing all phases of the project, all methodological developments, modeling and qualitative narrative scenarios results and the family of SDPs and pre-conditions, conditions and likelihood of implementation in Brazil.
4. A series of scientific papers published in international, interdisciplinary journals reporting scientific methodological advances and main results.
5. Materials for wider dissemination and outreach to influence policy making, such as O-Ed articles.

Financial Resources

1. The initial development of this research project has been given a small ‘seed money’ grant by the UNDP Office in Brasília of about R\$ 180 thousand. That grant will cover development of a detailed research proposal to be used by MCTIC to seek for GEF funding of a major project related to Brazil and Sustainable Development Goals. This grant will also allow for a number of visits to key Brazilian institutions and researchers to discuss potential interest and participation in the project. Not only a detailed research plan will be an outcome of this initial phase, but equally it will facilitate the dissemination of the central scientific ideas underpinning this research and the formation of a network of Brazilian and international researchers to carry out this line of interdisciplinary and transdisciplinary research.
2. Part of this very research project will be submitted to CAPES in the category of individual research project applications (“Fluxo Contínuo”). That will aim at full time engagement of two or three post-doctoral fellows for supporting development of the project throughout its duration and also doctoral students to be allocated to a number of PhD programs of the participating institutions.
3. A full-fledged research proposal will be written in the first 6 months to be submitted to FAPESP as a thematic project to fund doctoral students and post-doctoral fellows, resources for mobility, computer equipment, technical support, data acquisition, development of new data sets, supporting modeling studies, supporting cross-disciplinary and sectoral dialogues and participatory research, and dissemination of results.

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Annex A: Table of Potential Interactions of Targets of SDGs of Relevance to Brazil with Planetary Boundaries

[illegible]

SDG TARGET	Climate Change Ocean Acidification Stratospheric Ozone Depletion Biogeochemical Flows (N & P) Freshwater Use Biosphere Integrity Land System Change Atmospheric Aerosols No. Entities								
	1	2	3	4	5	6	7	8	9
1) End poverty in all its forms everywhere	✓								
1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than \$1.25 a day	✓								
1.2 By 2030, reduce at least by half the proportion of men, women and children living in poverty in all its dimensions according to national definitions	✓								
1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial	✓								
1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and their economic, social and environmental shocks and disasters	✓								
2) End hunger, achieve food security and improved nutrition and promote sustainable agriculture	✓								
2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	✓								
2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	✓								
2.4 Ensure sustainable food production systems	✓								
2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as well as internationally agreed									
3) Ensure healthy lives and promote well-being for all at all ages	✓								
3.1 Reduce global maternal mortality to below 70/100,000 live births									
3.2 Reduce infant mortality to max. 12/1,000 live births, under-5 mortality to max. 25/1,000 live births									
3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases									
3.9 Reduce the number of deaths and illnesses from chemicals, pollution and contamination									
4) Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	✓								
4.1 100% completion of secondary education	✓								
4.4 Eliminate gender disparities in education	✓								
4.6 Full literacy and numeracy	✓								
5) Achieve gender equality and empower all women and girls	✓								
5.5 Equal opportunities and participation	✓								
6) Ensure availability and sustainable management of water and sanitation for all	✓								
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all									
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations									
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally									
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity									
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	✓								
7) Ensure access to affordable, reliable, sustainable and modern energy for all	✓								
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	✓								
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	✓								
7.3 By 2030, double the global rate of improvement in energy efficiency	✓								
8) Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	✓								
8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 percent gross domestic product growth per annum in the least developed countries	✓								
8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead	✓								
8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value	✓								
9) Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	✓								
9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	✓								
9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	✓								
9.5 Enhance scientific research, upgrade technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	✓								
	✓								

[illegible]

WORK PLAN

Description of Activities

The Project Preparation and Implementation process has been structured in several components and activities, divided as follows:

Component A: Engagement of research institutions to ensure Brazil-wide participation, full coverage of necessary themes and interdisciplinary methodological approaches

Activity A1: Production of dissemination materials (brief project description and short video)

Activity A2: Preparation of a project concept note (“white paper”)

Activity A3: Initial web-based survey of interested institutions

Activity A4: Definition of institutions to participate in the project, ensuring Brazil-wide participation, coverage of relevant themes and interdisciplinary participation and individual researchers and institutional engagement

Activity A5: Preparation of Project Concept Note (5-pager document main project ideas)

Activity A6: Preparation of Project Identification Form (PIF), following GEF criteria, for submission of a funding request by MCTIC to GEF for funds for implementation of BRA2050

Output A1: Website with project description, short video describing the project’s main goals and questionnaire for surveying interested institutions

Output A2: Analysis of web-based survey and definition of interested institutions to participate in the project

Output A3: Project Concept Note

Output A4: GEF-criteria Project Identification Form (PIF) completed and submitted to MCTIC

Component B: Establishment of a matrix of co-benefits and trade-offs of the 17 SDGs (including its 169 targets) for Brazil

Activity B1: Survey of existing studies on co-benefits and trade-offs among all of the 17 SDGs and 169 targets

Activity B2: Define the key elements of co-benefits and trade-offs among all of the 17 SDGs and 169 targets specifically for Brazil

Output B: Review article of co-benefits and trade-off among the 17 SDGs (including 169 targets) specifically for Brazil

Component C: Review of existing and proposal of a set of metrics to monitor implementation of SDGs for Brazil

Activity C1: Assessment of existing metrics for monitoring SDGs for Brazil (e.g., SDGindex.org)

Activity C2: Proposal of a set of metrics for monitoring SDGs tailored for Brazil

Output C1: Critical review article of existing metrics and indicators of SDGs for Brazil
Output C2: Scientific article with proposals for a new set of metrics and indicators for Brazil

Component D: Implementation of a series of multi-actor, cross-sector and sub-regional dialogues in order to bring a multitude of Brazilian Perspectives on potential *Sustainable Development Pathways* and define relevant research agendas

Activity D1: Define the methodology for participatory research via dialogues
Activity D2: Define critical themes and sectors to undertake the dialogues to obtain Brazilian Perspectives
Activity D3: Carry out a finite number of dialogues in different parts of Brazil

Output D1: Workshop reports of every one of the dialogues
Output D2: Scientific article with the outcome of the dialogues in terms of Brazilian Perspectives for SDPs.

Component E: Definition of a process for establishing Sustainable Development Pathways for Brazil, that will start with a vision for 2050 and “backcasting” pathways to meet SDGs in 2030

Activity E1: Review of existing methods for defining Sustainable Development Pathways globally and regionally
Activity E2: Downscale shared socioeconomic scenario SSP1 for Brazil, with adjustments
Activity E3: Definition of a methodological process for establishing Sustainable Development Pathways tailored for Brazil

Output E: A methodological technical paper describing the backcasting methods to be applied to backcast SDPs for Brazil

Component F: Engagement of modeling communities (Integrated Assessment Models - such as LUCC, MESSAGE-Brasil; Earth System Models – such as BESM) and definition of models and methodologies to be used to merge quantitative modeling results with qualitative narratives of scenarios

Activity F1: Survey of modeling groups in Brazil and existing models to be used in the project (Integrated Assessment Models, Earth System Models, etc.)
Activity F2: Definition of modeling groups to participate in the project
Activity F3: Discussion with interested modeling groups on modeling advances to better incorporated SDGs in the models and necessary model simulations for the producing Sustainable Development Pathways
Activity F4: Define methodologies to merge quantitative modeling results with qualitative narratives of scenarios
Activity F5: Propose and carry out a number of modeling experiments to the project’s modeling groups to provide the quantitative projections to underpin the merging of quantitative and qualitative narratives of scenarios

Output F1: A methodological technical paper on methods to merge quantitative modeling results and qualitative narratives for scenarios construction for Brazil

Output F2: Series of scientific papers describing Brazilian IAM and ESM improvements and results

Component G: Establishment of a set of sustainable development pathways (SDP) for three spatial scales: Brazil-wide and two key regions (Amazonia and Northeast Brazil) validation and dissemination of SDPs

Activity G1: Convene a series of focused workshops to propose SDPs at national scale for Brazil, a regionalization of SDPs, particularly for the two selected regions (Amazonia and Northeast Brazil)

Activity G2: Convene a series of workshops to validate the SDPs proposed in Activity G1

Activity G3: Carry out wider dissemination and validation of SDPs via an internet-based consultation process

Activity G4: Dissemination of validated SDPs via the internet and through academic products (scientific articles and a book)

Output G1: Website to disseminate the SDPs generated by the project for Brazil

Output G2: Scientific papers with the main results of the project, that is, a family of SDPs for Brazil

Component H: Analysis of institutional arrangements, monitoring and evaluation, knowledge management, financial planning for project continuation and sustainability

Activity H1: Final report of the project and containing elements to qualify for its continuation

Activity H2: Dissemination via publication of a scientific book

Output H: Final report of the project and publishing of a book describing all the project's phases, developments, research network construction and results

Justifications

This is not a totally funded project as yet. It has obtained a small 'seed money' grant to allow development of a conceptual white paper to support fund raising for a longer-term research project.

In addition to search for funding in the initial stages, a *sine qua non* element is to generate interest within the Brazilian scientific community, since an integrated vision on Sustainable Development Goals is, by principle, interdisciplinary and transdisciplinary and must engage a score of social scientists, natural scientists, health scientists and engineers. It equally must draw policy makers and practitioners and attempt to follow an innovative way to carry out sustainability research, that is the so-called '*co-design, co-production and co-delivery*' of new knowledge collectively by scientists, science funders, policy makers and other stakeholders from the very beginning. This follows an approach championed by the Future Earth project. If successful, the project will create a new network for interdisciplinary science, as, for instance, we have seen with 'Observatório das Metrópolis' created for urban

environment science, or 'Rede CLIMA' established for climate change science, among others. Let us call it tentatively 'SDG Research Network' or 'SDG Brazil Network'.

Housing such an interdisciplinary project at university or research institution of excellence presents clear advantages in terms of provision of institutional support within campus and outside due to the institution's national and international reach.

Establishment of the 'SDG Research Network' (SDG Brazil Network) is expected to be a multi-year process and BRA2050 will form the supporting pillar for its formation. Initially, it is necessary to have a small group of researchers to lead the main elements of this proposal. By nature, it must have natural, social and health scientists to be able to assess the implication and application of SDGs in Brazil.

The project will also serve as a conduit to put together analysis of subsets of SDG by individual research groups and to provide a platform for integration. It will serve to align efforts of a number of quite diverse data collection institutions (e.g., IGBP) providing scientific background to developing SDG metrics for Brazil.

The project will support further development of Integrated Assessment Models and the Brazilian Earth System Model in Brazil, particularly by enlarging the scope of such models and allowing for validation experiments to be carried out.

Timeline

Detailed Timeline for Components and Activities of Project BR2050+												
Year	2018				2019				2020			
Trimester	1	2	3	4	1	2	3	4	1	2	3	4
Component A: Engagement												
Activity A1												
Activity A2												
Activity A3												
Activity A4												
Activity A5												
Activity A6												
Component B: SDG 13 - Climate Change												
Activity B1												
Activity B2												
Component C: SDG 14 - Life Below Water												
Activity C1												
Activity C2												
Component D: SDG 15 - Life on Land												
Activity D1												
Activity D2												
Activity D3												
Component E: SDG 16 - Peace, Justice and Strong Institutions												
Activity E1												
Activity E2												
Activity E3												
Component F: SDG 17 - Partnerships for the Goals												
Activity F1												
Activity F2												
Activity F3												
Activity F4												
Activity F5												
Component G: SDG 18 - Local Governance for Sustainable Development												
Activity G1												
Activity G2												
Activity G3												
Activity G4												
Component H: SDG 19 - Industry, Innovation and Infrastructure												
Activity H1												
Activity H2												