Environmental impact and food security: socio-ecological sustainability of soya from Brazil

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Abstract

The interdependent planetary boundaries highlight that our natural and social system limits are being exceeded. This is evidenced by scientific, ecological, and business impact assessment studies, which draw attention to how anthropogenic activities or inactivity is influencing environmental wellbeing, in particular deforestation. Humanity faces key grand challenges. Globally, 17 Sustainable Development Goals (SDGs) offer a blueprint that are most pressing issues. Removal of specific critical barriers can help to resolve local societal problems and support widespread environmental conservation. Addressing a grand challenge requires changing individual, organizational, and societal behaviors. This study focuses on food security being a priority challenge (SDG 2).

A socio-ecological framework of cosmopolitan resilience is conceptualized. Application is to produce-case of soya from Brazil. Issues identified are across different levels impacting biodiversity loss, deforestation, and freshwater sustainability at individual, firm, and government level. Cultural, moral, and governance components form recommendations towards ameliorating adverse influences and promoting integrated sustainability improvements towards systemic resilience. Case learnings have implications for better environmental, business, and policy collaborations.

Keywords: Rainforest; biodiversity; environment; food security; soya; Brazil

(Abstract - 200 words)

1. Introduction

Planetary boundaries is a helpful conceptual framework in embracing appraisal of geophysical prerequisites (i.e., collective *limits or constraints*) critical to enabling sustainable human development. This is receiving growing scrutiny from biodiversity and Earth system scientists (Ryberg et al., 2018; Folke et al., 2016). Their shared priority focuses on the preservation of age-old tropical rainforests as key temperate zones. This is fundamental to preserving life and tackling wider environmental management. In turn, better aligned engagement between public policymakers and private businesses is vital in the tropical zone countries to protect their biomes.

The largest rainforest on Earth is within the Amazon River Basin (Butler, 2020). Its land area is over 6 million km^2. The Amazon is equivalent to 70 percent of the size of the United States of America and stretches across nine countries, mainly Brazil (Pester, 2022). Environmental, societal, and business transdisciplinary Amazonia research has been calling to halt and reverse the accelerated pressure from human activities on land-based resources and natural rainforests. This underpinned the COP26 discussions in Glasgow and reset the trajectory of the United Nations' 17 SDGs for 2030 (Antonini and Larrinaga, 2017).

Planetary impacts pertain collectively to nine ecological biosphere constraints based on geological scientific evidence, within which humans live as asymmetrical societies (Rockstrom et al., 2009). Each society consists of local climatic conditions and resources, cultures, trades, and skills, with different societies impacting on each other. The less developed, resource-rich and highly populated countries are most vulnerable. Within their societies, the dominance of political and corporate actors contributes to increasing asymmetric diffusion across individuals and corporate entities, with power and authority favouring the latter (Leal Filho et al., 2019).

Inevitably, outcomes of natural and human activities have become amplified impacting on sustainability. Humans and animals face an increasingly hostile environment that manifests as interrelated and non-linear extreme events in the Earth system. These present as floods, droughts, species extinction, hurricanes, forest fires, earthquakes, health pandemics, geo-political conflicts, fauna degradation, and malnutrition. The proliferation of known risks poses major challenges (Emori et al., 2018).

Addressing a perceived grand challenge (George et al., 2016) requires the "mobilization and collaboration of multiple communities of actors with overlapping interests" (O'Mahony and Lakhani, 2011: 7). The interests can often be perceived as divergent and disparate, can be much more effectively integrated and aligned into system-wide resilience building (Holmberg et al., 1999). The Anthropocene epoch, this era in which we see the impact of humanity on the planet, is to be crucial in establishing innovative solutions such as the preservation of local and regional ecology; the development of animal and plant protection, a health conscious food chain, and less evasive technologies for energy use and production; the reduction of waste; and the development of business strategies to improve self-sufficiency. Some impacts have not so far completely emerged as geological evidence, however are trends recognized in the scientific exceedance rates in the period after the 1950s. Sustainability must be sensitive to context and requires continually reorientating the resilience trajectory (Dsouli et al., 2017; Smith et al., 2017) for stewardship of the co-evolving socio-ecological system (Whiteman et al., 2013).

This research responds to the dearth of studies for addressing the conservation of rainforest and vast tropical savannahs through multilevel integrative cosmopolitan lens (Kakabadse and Khan, 2016). As a worldview, cosmopolitanism has an established historical foundation that prioritizes achieving common solutions through social connections, viewing multi-level diversity as mutually beneficial, and ensuring respect

between divergent interest groups (Robbins and Horta, 2017). The study establishes a distinctive cosmopolitan framework for tropical forest resilience, founded upon interconnections and interdependence governance, that is sensitive to moral and cultural traits (Rekow, 2019). Social axiom theory links these together to better respond to the planetary limits.

In the framework, social axioms are ‘generalized beliefs about the world’ (Leung et al., 2004: 289). Characteristics and dimensions of entities or concepts can be bound together in relationships, i.e., as ‘intertwined, correlations or cause-effect’ modelling (Leung et al., 2004: 288) for achievement of the all-encompassing sustainability goal (Gari et al., 2009).

The next section proceeds with a food security review focusing on the research questions inclusive of agri-food resilience and cosmopolitanism. Then the investigative approach is shared using the case of soya in Brazil. The progressive sections outline key findings, debate, and conclusion.

2. Food security sustainability

The research questions are as follows: How can tropical rainforests and vast tropical savannah be better preserved and protected? And how can we overcome the obstacles to change necessary for sustainable land usage and tropical climate vulnerabilities? Responses to these questions pertain to food security as the primary challenge (Food and Agriculture Organisation (FAO), 2018; Lorentz Marsden and Farioli, 2015). Contribution of agriculture is 23 percent to worldwide greenhouse gas emissions (IPCC, 2019) and the ozone is contributing to a nexus of socio-economic factors affecting farmers’ incomes, soil quality, crop production, food prices, access to food, and nutritional value.

Sustainability resilience frameworks must better integrate ecological with human actions within product chains and as wider stakeholder analysis, to enable a more meaningful transition. This study uses a single product by way of exemplification: soya in Brazil.

The next section focuses on agri-food and considers how social urban growth, rainforest land usage, and worldwide food supply trade-offs are the critical concerns of socio-ecological resilience in terms of anthropogenic responsibility (Giannini et al., 2020).

3. Agri-food resilience

The ability of the agri-food supply chain and its structure to handle shocks is resilience (Bousquet et al., 2016). This depends upon the collaborative ability of the system to prepare, endure, adapt, and potentially transform. The overarching resilience agenda is collective for those facing the effects of threats to development from climate, politics, finance, conflict, and environmental disaster.

The agri-food sector is unique in that it is positioned between environmental and human societal systems (Morawicki and González, 2018). All people ingest its produce. Regional impacts include social ones, e.g., the nature or conditions of work, public health; and geographic or spatial ones, e.g., energy, water, and land-use concerns. Together these form wider societal interests and legitimate social justice.

The pace of global material consumption has continued to rise, particularly in most recent decades, and 40 percent of land use is devoted to agriculture (FAOSTAT, 2018). The combined global production of cocoa, coffee, oil palm, beans, rice, soybeans, and sugarcane has increased by more than 46 percent since 2000 (Statista, 2021). International competitive pressures contribute to a negative sustainability impact, with global greenhouse gas emissions exceeding 49.4 billion tonnes of CO2 (Millennium Ecosystem Assessment,

2005).

From the perspective of international demand and supply, recent data trends indicate that a third of food is never consumed. This highlights how business units in the agri-food sector are key agents of change in terms of environmental health and overarching sustainability. Looking at greenhouse gas emissions alone (Wright and Ryberg, 2017), multinational companies contribute between 24 percent and 29 percent of the global total; clearly the highest, among various emitters causing overshoot. The quantified reporting of issues has increased from lead companies such as Syngenta, Monsanto, Mars, Kellogg, Danone and Associated British Foods Plc. However, COP26 warns that this remains insufficient and needs to be improved at board. company, regulatory authority, and institutional levels.

Collectively, the sustainability issues and their resolutions relating to food have for a long time been regularly conceptualized through a globalized authoritarian vision, representing one-size-fits-all solutions (Liu and Jones, 2014). This often is without taking account of local context and diversified interests at multiple levels (Dermody et al., 2018). Moreover, policies concerning agriculture and environment likely handle food rationally, secularly, and as bioeconomically; whereas socio-ecological frameworks can provide more holistic, system-wide contextual understanding that includes moral and cultural sensitivities (Xu et al., 2015).

A cosmopolitan perspective is adopted to examine the socio-ecological impact of food systems. Having sensitivity to the locality and community context, adaptability for co-ordinated and shared human activities refers to collective innovation and improving pathways for effective sustainable and financially equitable wellbeing (Folke et al., 2016).

The emergent framework proposes a unique theoretical contextual construct that combines theories of cosmopolitanism and social axioms to address planetary boundaries.

Although there are impacts on all nine planetary boundaries, the case study focuses attention on the most important factor in each level of the framework because the resilience of tropical forests and tropical savannahs is a priority. The loss of biodiversity at the individual level, deforestation at the firm level; and supplies of freshwater at the governmental level are highlighted. Addressing these collectively can promote environmental protection and better economic governance and stewardship.

4. Cosmopolitanism

Cosmopolitanism, represented as ‘I am a citizen of the world’ (Diogenes, 404–423 BC), seeks to promote shared communities through a dynamic respect of varied beliefs and local diversity (Woodward et al., 2008; Lu, 2000). As a mindset, this approach harnesses a broad awareness of interdependence and mutual benefit (Pieterse, 2006). Cosmopolitan leadership and communities therefore align well for enabling transdisciplinary sustainable resilience and equitable wellbeing within overarching planetary boundaries (Steffen et al., 2015).

Moreover, cosmopolitanism transcends distant protectionist views of ‘self versus other’ or notions of geographic boundaries, such as the nation-state (Selles, 2013; Jazeel, 2011). It proposes collaborative open approaches to address critiques of sustainable development (Hopwood et al., 2005) as a triple bottom line that has not yet achieved systemic integration (Le Blanc, 2015).

Previous research (Khan et al., 2021) has established characteristics of cosmopolitanism as a worldview that consists of particular cultural, moral, and political traits and behaviours. Cosmopolitanism is different and distinct from globalization. Political characteristics can be understood in agendas and practice, within broader dynamic

governance setting (Banerjee, 2017). Figure 1 illustrates the cosmopolitan conceptualization formed from moral, cultural, and governance characteristics.

Figure 1: Socio-ecological resilience

Dimensions	Components
Cosmopolitanism	• Moral • Cultural • Governance (political and corporate)
Planetary boundaries	• Individual/local • Firm • Government (institutional) • Anthropogenic duty of care responsibility towards natural resource

Source: Compiled by the authors.

These triple helix characteristics (Etzkowitz and Leydesdorff, 2000) are correlated using social axioms theory (Leung et al., 2002). This enables us a view of cosmopolitan resilience as interconnected across levels and as sensitive to multi-level contextual impacts on the planetary boundaries (Hui and Hui, 2009; Rockstrom, et al., 2009). Social axioms theory represents a bind that connects each part of the conceptual framework.

5. Investigative research approach

Qualitative case studies and an inductive logic approach (Langley, 1999; Yin, 1994) provide an appropriate lens for the holistic study of phenomena to capture rich real-life contextual settings (Barratt et al., 2011). Particularly, this is beneficial for exploration and better understanding of emergent in-depth contextual research.

A qualitative thematic analysis is carried out on a collection of materials from secondary published sources. This study uses archival sources – i.e., documentation, available records, relevant reports – to construct a broader and more in-depth multi-level case study (Stagl, 2007; Eisenhardt and Graebner, 2007). This includes allowing process traceability for validity and reliability cross-checking by experienced expert peers (Sandelowski, 1993).

The focus and unit of analysis is soya grown in Brazil (Mintzberg, 1979). A commodity case is explained, with emerging tiered constructs and relationships that form theoretical connections to enhance system-wide resilience. The next section presents a narrative of Brazil, where soya is grown.

6. Brazil in South America

The Federal Republic of Brazil (*Brasil* in Portuguese) is 8.5 million km^2. It is the fifth largest country by size and, with 211 million people, is the sixth most populous country in the world. Brazil has more than 7,000km of coastline, borders the Atlantic Ocean and many other countries on the continent including Venezuela, Colombia, Peru, Bolivia, and Paraguay (Dominguez, 2006). The land and climate of Brazil form the Amazon Basin, confirming its unique ecological significance for rich biodiversity. Brazil contains 25 percent of planetary biodiversity and hosts the biggest tropical rainforest on Earth (Ruiz-Vasquez, et al., 2020). The biodiversity is critically dependent upon the preservation of land surface characteristics: the historical, irreplaceable Amazon rainforests (Woodwell and Houghton, 2020). Importantly, the rainforest is drained by the Amazon River – the lifeline of the forest. Evaluative and scientific studies have raised concerns regarding the pace of deforestation, highlighting the change from natural vegetation to cropland usages. According to images gathered by Landsat satellites and published by the Projeto de

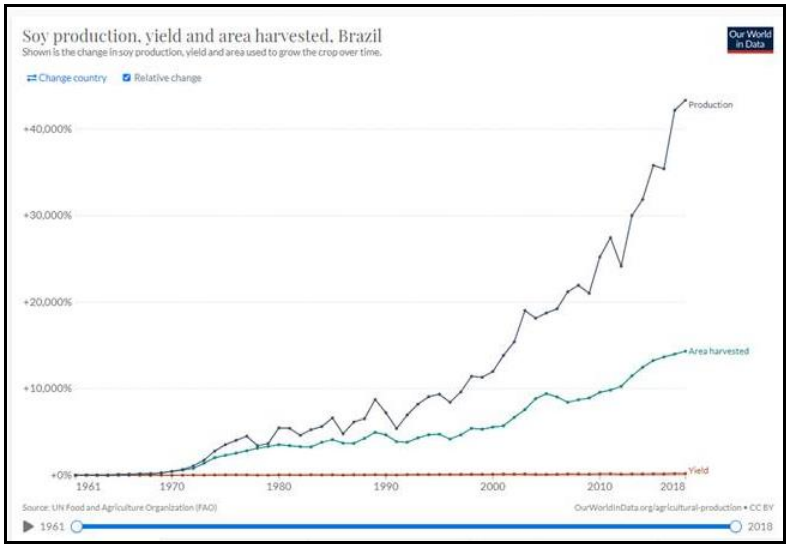
Monitoramento do Desmatamento na Amazonia Legal, PRODES (2021), deforestation reached 10,851 km^2 between August 2019 and July 2020, representing an annual growth of 7 percent. Consequently, 57 percent of Amazon trees are now considered globally under threat (Carrington, 2015). This in turn impacts eco-services including carbon sequestration, water cleanliness, and water cycle – the very foundations needed for humans to flourish.

Europeans arrived in Brazil in the 15th Century (1467/68). Between the 16th and 19th centuries, Brazil was a colony of the Portuguese Empire. In 1822, Brazil declared its independence and in 1891 became a Republic. Modern day Brazil has transited from military dictatorships (1964–1985) to democratized government (1985–present). Socially, there remain high inequalities in wealth distribution. Brazil is ranked 94/180 on the corruption perception index (Transparency International, 2020). Approximately 15 percent of the population live in rural areas and are primarily dependent on agricultural incomes. There are 21 UNESCO World Heritage Sites, of which seven are natural conservation sites.

6.1 Soya sustainability

Extensive natural areas in tropical countries are being irrevocably devasted to allow for soya beans (*Glycine max)* cultivation. During the last two decades, most of this increase in soya production has been in Brazil (WWF, 2020). In 2019, 37 percent of all soya beans in the world were planted in Brazil, now the world's largest soya bean producer. Soya constitutes 49 percent of Brazilian cropland area and 41 percent of agricultural revenues. Between 1990 and 2019, Brazilian farmers expanded plantation land from 11.5 to 35.8 million ha and increased crop yields from 1.7 to 3.2 tons/ha (IBGE, 2021) (see Figure 2).

Figure 2: Soya production, yield, and area in Brazil

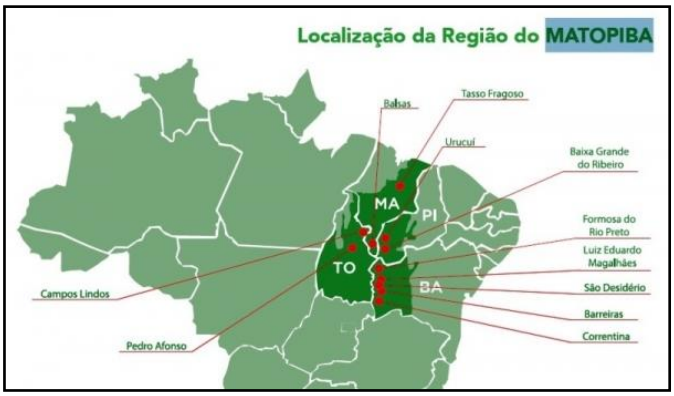


Source: Collated by authors from Our World in Data (2021), accessible at: https://ourworldindata.org/about

Soya production in Brazil has contributed to the deforestation of important biodiversity hotspots. As a result, Brazil's half-a-billion-acre, forest-savannah mosaic known as the Cerrado has been intensely deforested (Bonfim et al., 2019). The Cerrado biome, covering over 20 percent of Brazil's terrain, is a savannah region with irreplaceable biodiversity and serves as an important water system in Brazil.

Cargill, Bunge, and other leading soya traders have participated in the Amazon Soya Moratorium in Brazil since 2009 – a commitment to cease sourcing from suppliers engaged in deforestation. This has resulted in the drastic reduction of deforestation in existing areas. However, local soya traders, supported by international players, continue to drive deforestation of the wider Brazilian forests. Production and deforestation have transited to expanded land zones such as the Cerrado (Magalhães, et al., 2020). The projection is to grow soya in the MATOPIBA region (Figure 3) which in 2020 represented 10 percent of the total Brazilian soya production (CPI, 2020).

Figure 3: Map of Brazil: Amazon and MATOPIBA region



Source: courtesy of © Piaui Negocios (2021) accessible at: https://www.pinegocios.com.br/noticia/342-Area-plantada-do-Matopiba-alcancara-8-9-milhoes-de-hectares-ate-2030

The MATOPIBA region, comprising the states of Maranhão, Tocantins, Piauí, and Bahia, is expected to expand the soya area by 15 percent over the next ten years, reaching 8.9 million ha (MAPA, 2020). Production is expected to double, reaching 33 million tons by 2030 suggests the study "Agribusiness Projections 2019/20 to 2029/30", carried out by the Ministry of Agriculture, Livestock and Supply in agreement with the Brazilian Agricultural Research Corporation-Embrapa (MAPA, 2020; Bragança, 2018).

In 2018, the newly elected Brazilian government led by Bolsonaro openly stated their policy for opening commercial exploitation of Brazil's protected lands for economic growth. By July 2019, Brazil's area of the Amazon had 'lost more than 1,330 square miles' (Casado and Londoño, 2019: 1). Moreover, Brazil's environmental agency had curtailed enforcement measures such as warnings, fines and destruction or seizure of illegal equipment in protected areas (Casado and Londoño, 2019). In the 2022 election, Lula's left-wing party is leading against Bolsonaro conservative liberal party in round one of the elections with the future of the Amazon at stake (Frost, 2022).

Recently, discussion of an extended soya moratorium in the Cerrado has gained support from a group of multinational companies. Tesco, Walmart, Unilever, and McDonald's are amongst 163 fast-moving consumer goods companies demanding international traders to cease direct or indirect purchasing of soya cultivated in illegal deforestation areas, by signing the Cerrado Manifesto (Reuters, 2020). However, the international traders Archer Daniels Midland (ADM), Bunge, Louis Dreyfus, Cargill, and Glencore do not agree with the manifesto.

The fast growth of soya bean cultivation is eroding the natural lands of central Brazil, which is of increasing concern. The smallholders who have been growing crops for subsistence are being displaced due to the expansion of soya bean plantations (WWF, 2021).

The environmental consequences are threefold: soil erosion, degradation, and compactions; water quality degradation and use; and raised greenhouse gas emissions (Pailler, 2018). Not to mention the human societal impact (Pailler, 2018).

Although the practice of monocropping in agriculture for crops such as soya allows farmers to increase overall profitability – i.e., consistency of single seed, pest control, machinery, and growing method – there are longer term negative consequences (Rekow, 2019). Agricultural monoculture disrupts the natural soils balance, as excessive population of the same plant species in one field area deprives soil of important nutrients, reducing the varieties of microorganisms and bacteria required to maintain fertility and quality of soil and its natural ability for water flow and retention.

Brazil is the largest consumer of agrochemicals in the world (Ecodebate, 2021). In 2019 and 2020, the Brazilian government approved a record of more than one thousand

different agrochemicals. Such chemicals and fertilizers are increasingly used to manage soya bean farms to boost size and efficiency, and reduce labour costs. However, this then has a considerable impact on nutrient pollution in lakes, rivers and estuaries.

The Brazilian congress are discussing more flexible regulations to facilitate the usage of new agrochemicals, pesticides, and fertilizers. Most contradictory is the bill PL 6299/2002 that recommends flexibilizations in the oversight usage of agrochemicals by Brazilian agencies. This will transfer the responsibility and management of new pesticide registration from two regulatory agencies (ANVISA and IBAMA) to the Ministry of Agriculture. Specialists claim that this alteration in the law will facilitate the registration and adoption of potentially harmful products by reducing the length of approval from eight years to twenty-four months. Interestingly, the author of the bill is the owner of the world's largest private soya bean producer, the Amaggi Group, whose personal fortune exceeds U$1.15 billion (Forbes, 2021).

In Brazil, farmland concentration is in the hands of a few powerful elites and has a negative impact on small farmers and communities. They are pushed off the land and, in turn, encouraged to exploit workers (WWF, 2011; 2021). The Brazilian company Bom Futuro (owned by family members of the Amaggi Group) is the biggest soya producer in the world, exceeding US$52 million turnover in 2020 (Gazeta Digital, 2021). This is followed by SLC Agricola with US$470 million turnover and Grupo Amaggi with US$3.46 billion (Embrapa, 2021).

Survival International (2021) warns that the expansion of agricultural and grazing land threatens the lives of 650,000 Brazilian Indians representing 200 of the 305 tribes. Indigenous tribes mostly live entirely off savannahs, forests, and riverways through a

mixture of gathering, hunting, and fishing. Using satellite imagery with CAR's rural environmental land registry data and official databases, Ruiz-Vásquez (2020) estimates that 99 percent of deforestation in Brazil in 2019 was illegal. Of the 12,000km^2 of destroyed native forest, most was in the Cerrado and Amazon biomes. This situation is exacerbated due to Brazil being a young democracy with weak institutions and heightened corruption.

The next section presents the emergent responsibility and accountability factor findings, focusing on the case of soya in Brazil.

7. Sustainable accountabilities

For soya beans in Brazil, secondary materials such as reports from researchers, practitioners, and organizations, scientific reports, practitioner and societal research, and newspaper and online articles have been selected from trustworthy reliable sources that have been published publicly. From these, multiple themes have been developed. The materials are for the 2016–2020 period. An understanding of morality, governance, and culture underlies the evolution of cosmopolitan themes in response to the research questions.

The emergent themes were categorized as governance, moral, or cultural across different levels – individual, firm, government (Table 1). This was framed for each planetary boundary.

Table 1: Categorization of themes for each planetary boundary

Cosmopolitan dimensions for planetary boundary 1	**Individual**	**Firm**	**Government**
Moral	Unfair and exclusionary land allocation	Big players against moratorium agreement Lack of board accountability Unbalanced power of usage of water and land	Vague national mandatory ecological targets Weak promotion of biosphere farming opportunities Opaque programmes to ensure respect and social inclusion of local communities and individuals
Governance	Absence of policies to support small farmers Relaxation of pesticide production and usage Excluded communities exposed to nutrition challenges	Lack of governance action to prevent illegal deforestation Lack of action to counteract negative effects on biodiversity	Unclear or flexible regulation for land and water reallocation and usage Short-term vision and strategy for approval to use new pesticides and fertilizers
Cultural	Local habits and culture displaced	Focus on short-term strategies and investments to improve land productivity	Absence of public-private programmes to sustainable development

Source: Compiled by the authors, with reference to Rockstrom et al. (2009).

Anthropogenic responsibility affects all nine planetary boundaries. The emergent nine tables (each planetary boundary having a table) were analyzed collectively and evaluated together in a holistic way, as interconnected relational structures. The theory of social axioms (Leung et al., 2002) is concerned with conceptualizing, explaining, and justifying the cosmopolitan relationships between each of the planetary boundaries and between different levels to establish the structure. Issues that answer the research questions

were prioritized as themes, with focus on improving resilience and sustainability. Each planetary boundary analysis and overarching integrated framework was verified independently by highly experienced colleagues.

At the individual level, the great concern is for basic human rights. Historic cooperatives in the field of communal land systems suffered from the wave of 1990s reforms. Furthermore, sustained and increasing biodiversity degradation from fertilizers, accessibility to and purification of water and yield per acre, and the controlling of pests make it more difficult for the smallholder farmers to stay on their land due to competitive pressures from economies of scale and increasing costs. The individual farmer faces an erosion of self-determining power and ability to influence labourers' motivations and wellbeing. This emerges as cosmopolitan contraction of diversity and mutual respect of individuals (Pieterse, 2006).

Moreover, while soya and grain production reached record highs in 2020, the price of food and level of unemployment in Brazil increased. Consequently, 9 percent of the Brazilian population is facing its highest level of food insecurity (Consea, 2020). Another issue is institutional representatives having high control, low expertise and / or multiple agendas. This emerges as a weak formal voice that contributes to few dominant players pressing, through soft power, the informal geographic and cosmopolitan outcomes (Jazeel, 2011).

The major concern at firm level is about land usage, in particular the pace and effects of deforestation. Increasingly larger and more powerful firms emerge as the mechanism dominating and controlling land-based resources, which harvest greater returns for their demanding wealthy investors (Blas and Farchy, 2021). Related ethical, ecological, and sustainability concerns must address more robustly the illegal land and forest

degradation including control of the land for crop growing. Firms with political connections have been able to afford to pay for access and permits; however, this in turn erodes the rights and capacity of small farmers (Rekow, 2019).

There is a major concern pertaining to freshwater usage at the government level. Continued excessive deforestation of the Amazon, the Cerrado including MATOPIBA, has replaced native vegetation and biodiversity. Native Amazon and Cerrado vegetation is vital for Brazil's waster systems, supporting rainfall through evapotranspiration. Moreover, deforestation increases droughts and erratic river behaviour (Chain Reduction Research, 2018). To embed and enforce policies more effectively and stringently, the need is for wide-spread and long-term research with reliable impact over time.

The individual, corporate, and governmental levels have varied issues within each tier that impact overall sustainability, but upon which collective resilience at multiple levels depends (Smith et al., 2017; Stagl 2007; Leung. et. al., 2002). Table 2 highlights, among the main results, that the most important impacts at different levels were biodiversity loss, deforestation, and freshwater (Magalhães et al., 2020).

Table 2: Soya bean impacts on planetary boundaries findings

PB level	Key issues	Priority impact
Individual	human freedoms and rights pest and chemical additives unfair and exclusionary land allocation	**Biodiversity loss**
Firm	control over resources illegitimate unlawful deforestation lack of accountability	**Deforestation**
Government	resources accessibility preservation of elements political control and power play for financial incentives ignores ecological wellbeing.	**Global freshwater**

Source: Compiled by the authors.

In Table 2, the cosmopolitan levels of government, firm, and individual are related and impact as intra and inter factors. Together these manifest as cause and effect to co-evolving sustainability. An aspiration is to retract degradation and build resilience of the systemic cosmopolitan framework. The next section of recommendations addresses enhancing resilience ass the priority issues (Table 2) emerging from the research questions, to ensure planetary boundary resilience.

8. Socio-ecological cosmopolitan resilience

During the last 30 years, agriculture has been the key driver of 92 million ha of deforestation in Latin America, and 88 percent of this is within South America (Willaarts et al., 2014). The state in Brazil has promoted soya development in the Amazon and Cerrado regions (Lopes et al., 2021) with politically incentivized policies. There has been land titling, government funding schemes for soya bean cultivation, subsidized credit, along with research and development grants. There has been criticism of government regarding the poor and misuse of public funding. Global organizations that support trade neo-liberalization agendas, such as the World Bank (WB) and International Monetary Fund (IMF), have approved such incentivized programmes in developing nations for access to a wealth of natural resources (Knyght et al., 2011). The entry of foreign-funded multinationals into and competition with local markets has intensified competition (firm level).

The effects of globalization serve as a warning that when competitiveness leads to local regional interference, the deterioration of indigenous culture, and pressures reminiscent of colonialism, governments become more and more reliant on outside organizations and colonial-style approaches to meet their resource demands.

In this consideration, the cosmopolitan framework (Kakabadse and Khan, 2016) draws attention towards the urgent need for accountable innovations and transparent reforms necessary to rebalance resilience. When vested firm interests are the government's priority, as in a globalized perspective, the system is less sustainably resilient and more vulnerable to collapse. The framework notes that the case of soya has unique moral, governance, and cultural dimensions in Brazil (Table 2). The dimensions' influence on each other, negatively impacting that cosmopolitan sustainable resilience, is not achievable (Figure 4 offers opportunities for advancement). Moreover, the challenges and their prioritization at each level are currently acting as blockages and perceptions of threat to overarching socio-ecological systemic (SES) balance and harmony (Folke, et al., 2016; Xu et al., 2015).

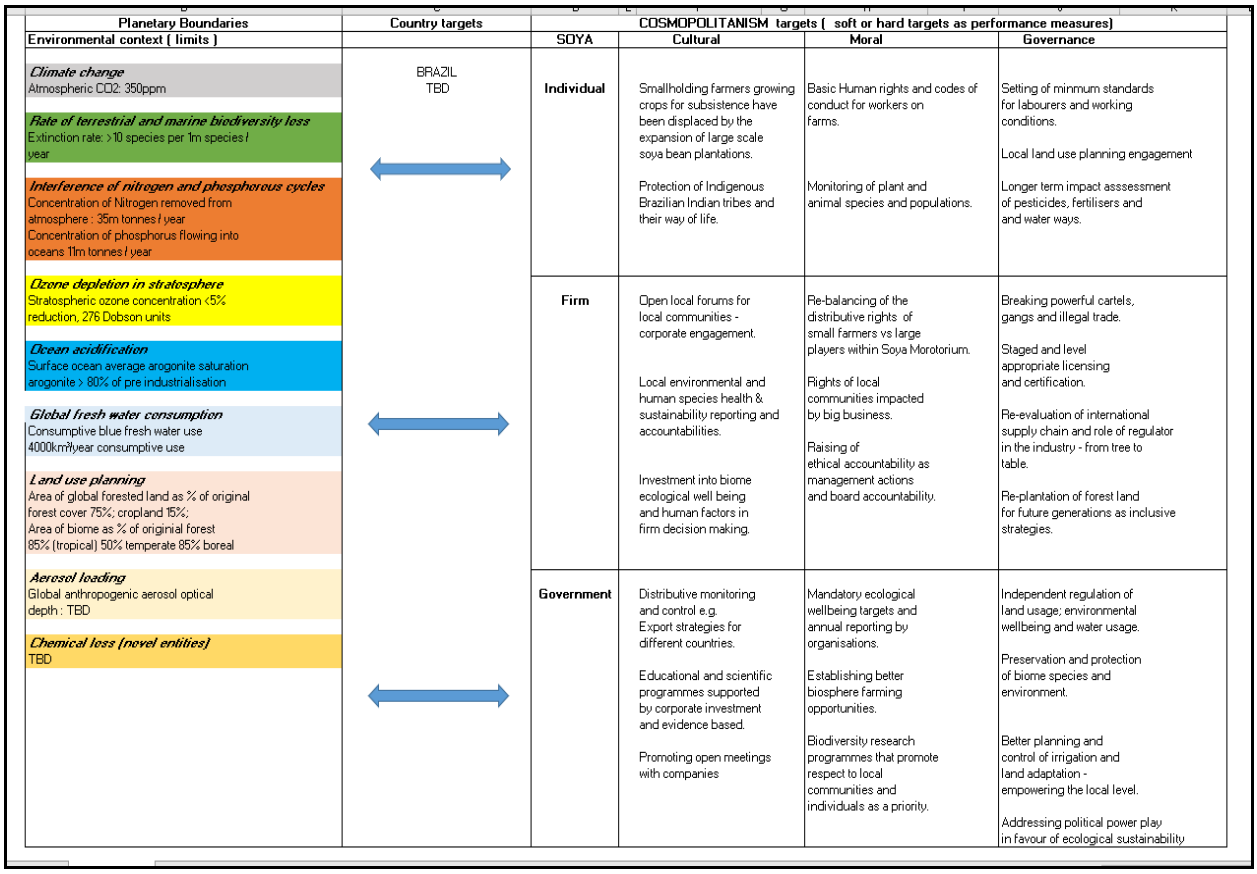
The problems pertaining to equitable environmental, social, and economic outcomes, in that order, are addressed by the SES approach in this study. In contrast, performance appears to follow more economic, social, and environmental concerns via the lens of globalization. Ecosystems (The Economics of Ecosystems and Biodiversity Report TEEB, 2018) must take into account and include eco-services in order to promote the advantages of welfare and sustainability, according to Costanza et al. (2014).

According to socio-ecological frameworks, eco-services give human society advantages from the ecosystem, and human actions in turn have an impact on the eco-system, constituting the link between nature and human civilization. The multilevel and interwoven relationships that can increase the overall sustainable resilience are highlighted by the cosmopolitanism framework.

In the case of soya within the socio-ecological framework, Figure 4 shows the prospects for cosmopolitan resilience at the human, corporate, and governmental levels to

improve the cultural, moral, and governance features. In this way, the cosmopolitan approach gives priority to the sustainability impact and mediates the more limited and alienating effects of globalization on the economy.

Figure 4: Cosmopolitan resilience: Case of soya in Brazil



Planetary Boundaries	Country targets	COSMOPOLITANISM targets (soft or hard targets as performance measures)			
Environmental context (limits)		SOYA	Cultural	Moral	Governance
Climate change Atmospheric CO2: 350ppm	BRAZIL TBD	**Individual**	Smallholding farmers growing crops for subsistence have been displaced by the expansion of large scale soya bean plantations. Protection of Indigenous Brazilian Indian tribes and their way of life.	Basic Human rights and codes of conduct for workers on farms. Monitoring of plant and animal species and populations.	Setting of minmum standards for labourers and working conditions. Local land use planning engagement Longer term impact asssessment of pesticides, fertilisers and and water ways.
Rate of terrestrial and marine biodiversity loss Extinction rate: >10 species per 1m species / year					
Interference of nitrogen and phosphorous cycles Concentration of Nitrogen removed from atmosphere : 35m tonnes / year Concentration of phosphorus flowing into oceans 11m tonnes / year					
Ozone depletion in stratosphere Stratospheric ozone concentration <5% reduction, 276 Dobson units		**Firm**	Open local forums for local communities - corporate engagement. Local environmental and human species health & sustainability reporting and accountabilities. Investment into biome ecological well being and human factors in firm decision making.	Re-balancing of the distributive rights of small farmers vs large players within Soya Morotorium. Rights of local communities impacted by big business. Raising of ethical accountability as management actions and board accountability.	Breaking powerful cartels, gangs and illegal trade. Staged and level appropriate licensing and certification. Re-evaluation of international supply chain and role of regulator in the industry - from tree to table. Re-plantation of forest land for future generations as inclusive strategies.
Ocean acidification Surface ocean average arogonite saturation arogonite > 80% of pre industrialisation					
Global fresh water consumption Consumptive blue fresh water use 4000km³/year consumptive use					
Land use planning Area of global forested land as % of original forest cover 75%; cropland 15%; Area of biome as % of originial forest 85% (tropical) 50% temperate 85% boreal					
Aerosol loading Global anthropogenic aerosol optical depth : TBD		**Government**	Distributive monitoring and control e.g. Export strategies for different countries. Educational and scientific programmes supported by corporate investment and evidence based. Promoting open meetings with companies	Mandatory ecological wellbeing targets and annual reporting by organisations. Establishing better biosphere farming opportunities. Biodiversity research programmes that promote respect to local communities and individuals as a priority.	Independent regulation of land usage; environmental wellbeing and water usage. Preservation and protection of biome species and environment. Better planning and control of irrigation and land adaptation - empowering the local level. Addressing political power play in favour of ecological sustainability
Chemical loss (novel entities) TBD					

Source: Developed by the authors with reference to Leal-Filho et al. (2019); Kakabadse and Khan (2016), and Rockstrom et al. (2009).

The commodity case of soya in Brazil exemplifies the adoption of the cosmopolitan framework. It draws to attention opportunities for better communication across the levels along with more coordination between ground-up and top-down efforts. This may facilitate collaborative relationships for achieving impact on sustainability (Dsouli et al., 2017). Between government and firm levels, businesses need to focus on a broad policy design and aligned environmental performance indicators as part of integrated reporting. To achieve

this, greater local discretionary capacity to enable communities and stakeholders with their initiatives will be beneficial. In the framework, a re-orientation of government–firm relationship and firm incentives are critical.

The managerial ramifications are directed at encouraging actions towards farming wellbeing at individual and organizational levels. This includes improving human and animal welfare, locality working conditions, and raising awareness of pesticides and fertilizers as factors in quality and longer term economic wellbeing.

Typically, there are many individual farmers and smallholders. The large corporations are more dominant, yet less engaged in local areas. This has implications for the development of local rent increases, entry barriers, value of land, price and quality of property, which all impact local life. The framework highlights an overarching problem that Brazil's institutional and regulatory governance structures have not yet fully embraced philosophical changes in their reform of infrastructure, industry regulation, supply chain or labour training through its transition from state control to market liberalization.

Recommendations draw attention contemporary sustainability endeavors that require enhanced integration assessments and to the setting of future goals with better accountability at all levels. Furthermore, scientific global ecological limits are historical and need to be translated into meaningful projected strategic commitments, set at country level (Selles, 2013). There remain opportunities for enabling multi-directional application and feedback mechanisms as dynamic capability within the framework.

9. Conclusion

For effectively attending to planetary boundaries (Rockstrom et al., 2009), the case of soya beans demonstrates how interdependence and adaptive relationships (Leung et al., 2002) are key to improving collective resilience as socio-environmental sustainability. Collective

food sourcing, production, distribution and supply chain improvements will lead to enhanced resilience. This study calls that multi-level integrated bottom-up and top-down collaborative stakeholder engagements can contribute to addressing sustainability development goals. This research contributes particularly to SDG2. Sustainable Development Goal 2 aims to achieve a world free of hunger. Some 700 million people worldwide are suffering from hunger and 30 percent of the planet faces food security concerns. This has increased during 2020-2022 due to geo-political effects on food availability and prices. Globally, it is of concern that children below age 5 are suffering from malnutrition, low mortality rates and countries such as Central Africa Republic and Yemen consistently remain high on the Hunger Index (2022). Within Brazil itself, since 2020 the number of people facing hunger has doubled to 133million and 60% of families in 2022 are facing some form of food insecurity. To date, a globalized lens has encouraged top-down economic innovation as a priority. The associated social and environmental problems have persisted. The conceptual application of a cosmopolitan framework highlights systemic integrative opportunities across different levels as a transdisciplinary contribution (Xu et al., 2015).

A theoretical conceptualization of the framework is extended through incorporating novel relational dimensions into the mechanism (Khan et al., 2021; Leung et al., 2002). This offers unique case-study application as moral, governance, and cultural cosmopolitan factors (Yin, 1994). Responding to the research questions, outcomes offer contributions towards addressing food security as a main grand challenge. Indeed, the historical foundation of food has always been the forest that must be protected and preserved for future generations.

To impact environment, social, and then economic wellbeing, personal worldviews, behaviors, aligned actions, and institutional structures have to evolve ensuring

environmental impact has equitably embedded prioritization. The Halocene epoch (extinction) is dependent on Anthropogenic (human) influences at government, firm, and individual levels for treating the range of issues as critical to socio-ecological sustainability. Only through diverse cosmopolitan policies and engagement can government and business agendas be more collaborative to restore and preserve the resilience of global planetary boundaries. Areas such as the Pantanal (Junk et al., 2006), the world's largest wet-land and flooded grassland in Mato Grosso State, and across the border in Bolivia, the Uyuni Salt Flat (Sanchez-Lopez. 2019), are lands that are resource rich and urgently need protection against potential exploitation.

Transferability of the framework to a range of political systems (authoritarian to democratic) and different industry sectors (travel, energy, construction) is important. This includes ensuring the response is relevant to communities and citizens. Proactive efforts instead of reactive responses are the call from the recommendations.

In conclusion, organizations and institutional attention is on better embedding environmental linkages between international and local entities and structures, along with broadening the accountability of leadership. Alignment between COP26-type agreements, policy formation, and business execution must account for meaningful sustainability impact at different levels. Bottom-up engagement and more responsive collective decision-making will be critical to systemic socio-ecological outcomes.

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