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Technology Solutions for Supply Chain Traceability in the Brazilian Amazon:

Opportunities for the Financial Sector

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Executive Summary

The 2019 Amazon fires brought unprecedented attention to the issue of deforestation in Brazil, which is currently at its worst levels since 2007. The Brazilian National Institute of Space Studies (INPE) reported an 85% increase in deforestation in the Amazon from 2018 to 2019, and by June 15, 2020, deforestation had already risen a further 34% over 2019 levels. In response to last year's fires, 251 global investors with $17.7 trillion in assets issued a demand for companies to meet their commodity supply chain deforestation commitments or risk losing access to international markets. Later, in December 2019, 87 UK companies and asset managers called for an extension of the Amazon Soy Moratorium, while this past June, an additional 29 state financial institutions responsible for over $4 trillion in assets expressed their grave concern over increasing systemic risks.

The widespread international reaction to the fires underlines the urgency for companies and investors to manage the various reputational, operational, legal, and regulatory risks posed by natural capital degradation in commodity supply chains. However, companies and investors seeking to comply with ESG requirements typically navigate a patchwork of certifications and standards for which data has often been unavailable or unreliable. This lack of clarity has had a direct impact on the quality and depth of individual disclosures and hinders their industry-wide adoption. Existing forestry and land use metrics, specifically, are insufficient to address the issue given the additional element of legal complexities that distinguish deforestation dynamics across multiple sectors and jurisdictions.

A variety of new technologies are helping to meet this challenge by revolutionizing transparency and traceability in commodity supply chains and allowing for real-time tracking of ESG metrics, rather than static post-event reporting. In this paper, we review the challenges and opportunities around illegal deforestation and propose ways in which the financial sector in particular can leverage data and emerging technologies to

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transform the way that companies measure, monitor, and manage their deforestation and land use ESG exposure, thereby substantially improving transparency, reliability of credit-risk analyses and integration with existing reporting standards.

1. Introduction

The Amazon fire season, while attracting significant attention through the years, saw an unprecedented engagement of financial, private and public stakeholders in 2019, demanding greater transparency, scrutiny and protection for the Amazon biome. While farmers have always used burning during Brazil's dry season (August to November) to clear forest for agriculture and livestock, the events of 2019 represented an alarming spike in an already concerning trend. Satellites that detect heat signatures issued more than 109,000 fire alerts in the single week from August 13-20. This nearly two-fold increase in fires over the prior year, combined with the proliferation of high-resolution satellite, drone, and other imagery of the fires on social media, triggered widespread protests around the globe. U.S. National Oceanic and Atmospheric Administration (NOAA) data on temperature and moisture levels in the Amazon suggest that this year's burning season will be even worse (NOAA, 2020).

In addition to the public outcry from sovereign heads of state and activists alike, investors worth $17.7 trillion immediately called for action for greater transparency, risk assessments and reporting standards. The ongoing situation threatens to affect Brazil's narrow trade surplus and hinder foreign direct investment, of which Brazil is the 9th largest recipient globally in terms of inflows. In May of 2020, 40 supermarkets and financial institutions wrote an open letter to the National Congress of Brazil declaring their deep concern for Provisional Measure 910 (changed to PL 2633/2020) and how it would put at risk the ability of organizations such as theirs to continue sourcing products from Brazil. The movement went from global to local in July of 2020 with 38 Brazilian business owners writing a joint-letter to Vice President, General Morao, imploring for sustainable development and a halt to illegal deforestation in the Amazon.

Failure to address the issue of deforestation has already compromised Brazil's ability to meet its Paris Agreement commitments (UNCTAD, 2020). Nearly half (46 percent) of Brazilian greenhouse gas emissions result from deforestation (SEEG, 2020). Under the Paris Agreement, Brazil committed to reduce *illegal* deforestation in the Amazon to zero by 2030. Decree No. 7,390 of 2010 established the National Policy on Climate Change and set a target for 2020 consisting of an 85% reduction of annual deforestation rates in the Legal Amazon in relation to the verified average from 1996 to 2005. Yet by September of 2019, it was clear to many scientists that Brazil was already too far behind to achieve its Paris Agreement's goals for 2030 (Artaxo, 2019).

2. Natural Capital Risks and Opportunities

The year 2020 marked the first time in the 15 year history of the annual Global Risks Report published by the World Economic Forum (WEF) that each of the five most alarming global risks were directly related to natural capital, specifically: i) extreme weather, ii) climate action failure, iii) natural disasters, iv) biodiversity loss, and v) human-made environmental disasters (WEF, 2020). Deforestation and forest degradation associated with soft commodity supply

chains have a disproportionately large overall environmental impact since they lead to large-scale biodiversity loss and regional weather effects as well as greenhouse gas (GHG) emissions that affect the global climate.

In fact, the conversion of native forest for agriculture and livestock in the Amazon is one of the most destructive practices globally in terms of its adverse environmental impacts. A 2013 study by Trucost (now part of S&P Global) found that the land use impact from cattle ranching and farming in South America was second only to coal power generation in Eastern Asia in terms of the overall environmental impact in monetary terms (generating US$354 billion of negative externalities on only $16.6 billion of revenue, an impact ratio of 18.7). The extent to which agricultural sectors globally fail to produce enough revenue to cover their environmental damage is particularly striking from a risk perspective (Trucost, 2013).

Similarly, a report by the Principles of Responsible of Investment (PRI), in partnership with UNEP Finance Initiative and UN Global Compact, placed the Amazon at the heart of climate risks: "In response to the rising human pressures on the Amazon biome, efforts to halt deforestation and forest degradation, preserve and regenerate remaining patches of primary forests, as well as reforestation efforts, are paramount. Forest management will increasingly play a critical role in the stability and resilience of the Amazon, as well as for the Earth's climate system as a whole." (PRI, 2019).

Data from the Carbon Disclosure Project indicates that as much as US$906 billion in annual corporate turnover is at risk because of inadequate risk pricing and risk mitigation for commodities linked to deforestation alone (CDP, 2016). This does not take into account Brazil's export revenue of at least US$36.4 billion (US$26.1 billion for soy, US$7.4 billion for beef, and US$ 2.9 billion for hardwood in 2019) at risk as international pressures continue to rise.

Equally, a white paper by the Tropical Forest Alliance highlights the way in which stranded assets will affect financial institutions along the forest risk commodity supply chain. An example from Indonesia's palm oil concessions suggests that 29% of these concessions cannot be developed without violating buyers 'No Deforestation, No Peat, No Exploitation' policies. Translated, this means that as many as 95 Indonesian palm oil companies have at least 1,000 hectares of stranded assets on their books (Tropical Forest Alliance, 2018). Moreover, investment opportunities in these same commodities, in favor of climate-transition, are expected to total US$200 billion on an annual basis, according to a report by the Tropical Forest Alliance (2017). Investors equipped to support this transition can benefit from the opportunity to deepen their involvement across supply-chain financing, those that fail to walk in-step with new regulations and innovations, risk becoming less competitive from a reputational and risk-analysis perspective.

The private sector, and the finance industry in particular, have the power to effect rapid, positive change. In 2014, the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) found that the stabilization of GHG emissions will require significant shifts in global capital. Since then, the finance sector has demonstrated commitment to the WEF Climate Initiatives, including the Natural Climate Solutions (NCS) Alliance, and shown leadership on topics including low carbon financing, emissions-reducing financing, adaptation financing, measurement and transparency, and engagement with the private sector and policymakers. Global green bond issuance reached a record US$270 billion in 2019 (IRENA, 2020), while market-driven efforts such as the Task Force on Climate-related Financial Disclosures have promoted climate-related financial risk disclosures in mainstream filings.

Nonetheless, these efforts have been incomplete and gradual - unable to keep pace with the dramatic and urgent acceleration of climate-related events taking place. An S&P Report on physical risks estimated that 60% of the companies in the S&P 500, representing a market capitalization of US$18 trillion, hold assets at high risk of physical climate change impacts. Equally, Forest 500's 2019 Annual Assessment demonstrates that 40% of the most influential companies in forest-risk supply chains still do not have deforestation commitments. Of the 210 companies with commitments, 48% do not report on progress of implementation. Meanwhile, in the finance sector, 68% of 102 institutions assessed do not have deforestation policies (Thomas and Rogerson, 2020). This speaks to the existing gap between policy and risk-analysis efforts, implementation and effectiveness.

Nonetheless, important shifts are currently underway. Itaú, Santander and Banco Bradesco (all signatories of the collective letter to Vice President Mourao) notably presented a proposal to the Brazilian government on July 22, 2020 including a series of investment proposals to support sustainable initiatives and infrastructure, with the aim of protecting the Amazon from further deforestation. This, we argue, is only the beginning.

3. Standards and Benchmarks for Deforestation Risk

Despite an abundance of initiatives and standards (see Annex 1) and a rapid increase in corporate pledges and government efforts to reduce deforestation in recent years, there is little evidence that initiatives have had their intended impacts. A 2019 report on progress by the signatories of the New York Declaration on Forests (NYDF), a 2014 multi-stakeholder initiative committed to ending natural forest loss by 2030 (with a 50% reduction by 2020), found a disturbing lack of results, and concluded that achieving the 2020 NYDF targets was essentially impossible (NYDF, 2019). In 2020, the landscape in terms of certifications and standards for natural capital remains fragmented, with efforts focusing on GHG reporting and sector-specific commitments around deforestation.

Moreover, those standards which do include natural capital suffer from limited participation by the most important companies and sectors. According to 2017 data from Forest Trends' Supply Change Initiative, just over half of the nearly 900 companies with exposure in the cattle, palm, soy, or timber and pulp supply chains had made at least one public commitment. However, the majority of companies that made forest-related supply chain commitments were not among the 250 most influential companies as identified by the Global Canopy Program's Forest 500 initiative, and only about one-fifth of this group made zero- or zero-net deforestation commitments. Of the companies with existing commitments to reduce or eliminate deforestation from their supply chains, only 8% had a zero-deforestation commitment covering their entire supply chain and operations (Haupt et al., 2018; Supply Change, 2020). Being able to influence the largest companies in the most active sectors with deforestation risk is therefore imperative.

While an increasing number of companies are publicly reporting on commitments and progress, they lack a standardized approach in terms of their types of commitments,

clarity, timelines, measuring, and monitoring. Companies have been slow to implement commitments due to lack of agreement on priority actions, limited understanding of risks, and hesitation to invest in sustainable activities without clear financial incentives. Furthermore, company reporting on actions taken and progress made toward achieving these commitments is generally inadequate to assess the efficacy of supply chain based zero-deforestation approaches (Garrett et al., 2019).

While the financial sector has begun to adopt policies that address deforestation risks, few institutions make those policies mandatory to loan-agreements or monitor them. Data for 2016 from Forest 500 indicate that only a limited number of the 150 financial institutions linked to the 250 companies in the big four commodity supply chains are actively addressing deforestation risks in their portfolios. Only one-third of financial institutions had made forest-related commitments for at least one commodity, and few publicly report against these policies. While half of commitments go as far as to refer to the protection of priority forest types, including primary, intact, natural, and/or HCV tropical forests, most do not set specific requirements but only encourage their clients to consider the protection of these ecosystems.

A number of roadmaps exist to help guide financial institutions incorporate natural capital considerations into their products and services. In 2012, the UNEP Finance Initiative (UNEP-FI) and the Global Canopy Programme, launched the Natural Capital Finance Alliance, a public-private partnership aimed at integrating natural capital awareness into financial services and products. In 2016, a dozen banks – with a combined US$10 trillion in assets – committed to the Soft Commodities Compact, an initiative of the Banking Environment Initiative and the Consumer Goods Forum (CGF) that aims to achieve greater supply chain transparency in the financial sector. More recently, the Accountability Framework and the WEF IBC ESG metrics aim to provide a core set of global metrics for reporting non-financial information, the latter of which includes indicators on ecological sensitivity and land use adapted from the GRI and CDP frameworks (WEF, 2020; Fleck, 2020).

National legislation around land tenure and land use is a critical component of supply chain traceability and one of the key missing pieces to existing ESG deforestation metrics. Studies suggest that 80-99% of deforestation in the Amazon is illegal, yet many types of environmental crime aren't addressed by existing standards (Forest Trends, 2018; MapBiomas, 2020). The Soft Commodities Compact prohibits signatories from providing financial services to companies that illegally deforest, yet offers no way to measure this objectively. Likewise, the Soy Moratorium monitors deforestation in terms of new farms in recently deforested areas, but disregards new land clearings on existing farms in violation of the Forest Code (Gibbs et al., 2015). Despite the promise of tools such as Global Forest Watch (GFW, 2020) and Trase (Trase, 2020) for enhancing traceability, tracking compliance with laws, policies, and targets depends on the quality and availability of government data. Insufficient transparency around land registries (CAR), land tenure, licenses, and concessions not only poses significant challenges to the implementation of supply-chain commitments, but also deters companies from investing in agricultural production and forest protection (Webb et al. 2017).

In the following sections, we review current practices in standards and benchmarking for the three commodities most associated with deforestation and land degradation in the Brazilian Amazon: soybean farming, cattle ranching, and timber. There are a variety of old and new technologies available for companies to responsibly and objectively trace their supply chains to the farm level in a far more effective and transparent way than current deforestation metrics and coalitions. Their adoption must be a central priority for companies as well as the financial sector.

4. Challenges and Technology Solutions in Key Sectors

Monitoring and traceability technologies are dramatically changing the type of data available to companies, investors, and civil society as well as how that data is gathered and reported. In a context in which historically deforestation-related data has been fixed, self-declared and state-controlled, this is significant progress. At the same time, these same technologies are shaping consumer preferences by providing investors and the public with greater visibility into the ESG impacts of the products and services they consume. Specifically, technology drives greater transparency and traceability in commodity supply chains by 1) decreasing the cost of data collection and ESG reporting, 2) enabling more widespread monitoring of ESG impacts by third parties and other stakeholders (e.g. civil society groups), 3) reducing bias associated with self-reporting since monitoring can now be conducted and/or verified by other actors, 4) increasing the frequency of reporting, and 5) decreasing the time lag in reporting (in many cases approaching real-time).

4.1 Soy

Brazil recently surpassed the United States to become the world's largest producer of soy, growing more than 122 million tons of soybeans in 2019. Exports made up about 60% of total production, representing a value of US$26 billion. About 75% of total exports went to China, making Brazil the single largest supplier of soy products to China. At the same time, the rapid growth of the Brazilian soy industry has had a tremendous negative impact on the Amazon and Cerrado biomes. Soy production is the second-largest cause of deforestation in Brazil after cattle ranching, and continues to receive ample international attention (WWF, 2016; Trase, 2020).

While soy certifications schemes can add a price premium of about $3 per ton of soybeans (FEBRABAN, 2017), leading initiatives such as the Roundtable on Responsible Soy (RTRS, 2006), the ProTerra Standard (ProTerra Foundation, 2014), the Sustainable Agriculture Standard (Sustainable Agriculture Network, 2010) have experienced little commercial uptake. In response to pressure from retailers and nongovernmental organizations (NGOs), major soybean traders signed the Soy Moratorium, agreeing not to purchase soy grown on lands deforested after July 2006 in the Brazilian Amazon. The Soy Moratorium was the first voluntary zero-deforestation agreement implemented in the tropics and set the stage for supply-chain governance of other commodities, such as beef and palm oil (Gibbs et al., 2015).

Originally, it was planned that the Soy Moratorium would be phased out as Brazil's environmental governance, including increased enforcement through the national implementation of the Rural Environmental Registry (CAR), became robust enough to justify ending the agreement. However, fourteen years after the adoption of the agreement, only 59% of Brazilian soy production is covered by zero-deforestation commitments, and soy producers have increasingly called to scale it back (Trase, 2020). Vasconcelos et al. (2020) note that 12% of soy plantations in the Amazon and the Cerrado are on properties that are not registered in the CAR, representing 2.6 million hectares of farms. The CAR, a self-declared land-registry document, suffers from lack of

transparency and verification of information, as it is not public. As such, if the geographic registry of a property is not reliable, satellite imagery demonstrating deforested lands can only go so far in linking illegal or irregular activity, to a given perpetrator (or supplier).

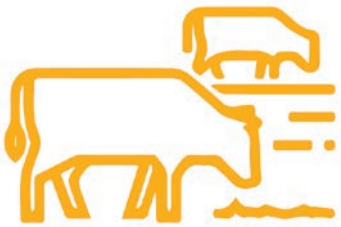
Almost 40% of the soy produced on unregistered CAR properties is exported to China, while only 12% is destined for the European Union (Vasconcelos, 2020). Brazilian soy makes up roughly 41% of EU's soy imports, equivalent to 13.6 million metric tons per year (Rajao, 2020). Although it is impossible to trace soy imports to individual properties, Rajao and colleagues (2020) analyze municipal soy export shares and estimate a total of 1.9 million metric tons of soy grown on properties with illegal deforestation may have reached EU markets annually during the period of analysis, of which 26% (0.5 million metric tons) came from the Amazon. In sum, 18 to 22% of all soy exported from the region to the EU is potentially contaminated. Trase data indicates that in 2018, about 15% (1.95 out of 12.83 million tons) of soy exported from Brazil by Cargill went to the EU. Cargill's footprint that year was a total of 3,258,27 hectares, of which 5,087 were linked to deforestation (4,351 ha in the Cerrado, 82 ha in the Mata Atlantica, and 654 ha in Amazonia). This is equivalent to a CO_2 emissions risk of 1,004,399 tCO2e for Cargill's Brazilian soy exports in 2018 (Trase, 2020).

Soy producers are more likely to comply with the Soy Moratorium than with legislation such as the Forest Code (Azevedo et al., 2015) owing to the fact that the Soy Moratorium monitoring mechanism suffers from substantial limitations in recognizing deforestation at the farm level. Trase (2020) notes that the Soy Moratorium neither publishes blacklisted farms, nor does it consider new deforestation on existing farms in violation of the Legal Reserve. As a result, it is not possible to verify that soy exported under the Moratorium is legal. In an assessment of the standards compliant with the European Feed Manufacturers' Federation (FEFAC) soy sourcing guidelines, a study by Profundo (2019) found that 10 out of 17 standards surveyed rely on national legislation by prohibiting illegal deforestation, while only the minority (7) prohibit deforestation of any kind, whether legal or not. Despite weak legislation permitting up to 80% deforestation on farms in the Cerrado biome, soy investment funds are increasingly choosing to exceed legal requirements in order to meet the more stringent ESG expectations of international investors (Granito Group, 2020).

A public and audited CAR would therefore enable existing technologies, specifically MapBiomas' satellite verification program to link deforestation alerts with specific private and commercial land-owners, greatly reducing the margin for irregular suppliers to enter regular and monitored supply chains. Blockchain, equally, represents a promising solution for soy traceability despite the complexities of the soy supply chain. An Accenture study notes that a blockchain solution could cover transactions from farm to wholesaler, although it would have difficulty tracing data further down the supply chain as the product gets further mixed and refined. Tracing whole beans until they reach the wholesaler is technically feasible and would allow processors to confirm they are purchasing whole beans from a sustainable source (Leong et al., 2018). Using blockchain to trace soy with valid proof of proper CAR registration from farms to storage silos and beyond could create an incentive for purchasers to confirm that their soy is compliant, regardless of the form it takes after processing (Proforest, 2020; Leong et al., 2018).

Table 4.1: Supply Chain Traceability Technology in the Soy Sector

Technology	Use Case(s)	Example(s)
Remote sensing	Monitoring of soybean planting and associated deforestation	Orbital Insight, Trase, Sourcemap, INPE, GFW Pro, Asner Lab, Planet Inc., DroneDeploy, PrecisionHawk
Genomics	Verifying soy genotype, which can be used to trace	DNA barcoding (ETH Zurich); Oritain
Big data and machine learning (AI)	Estimation of soy crop yields	Descartes Labs soy forecast
Blockchain	Transparency and governance for supply chain traceability, taxation, and import/export documentation; "Smart contracts" which execute automatically when certain criteria are fulfilled	IBM Food Trust traceability system
Devices (IoT)	Tracking of grains stored in warehouses for quality assurance	CropMetrics



4.2 Cattle ranching

With an estimated 232 million head of cattle, Brazil has the world's second-largest herd and its production is largely based on grass (USDA, 2019). Cattle ranching represents 8.5% of Brazilian GDP. While three quarters of the meat produced is directed to the domestic market, 24% is sent to key export partners such as China, the United States, the EU, and Hong Kong among others. This 24% represents 2,483 1000 MT CWE, making Brazil the largest beef exporter in the world. This comes as a direct consequence of the expansion of cattle activity in the Amazon where, since 1988, the number of cattle has almost quadrupled to 86 million in 2018, accounting for 40% of the national total (Amnesty International, 2020).

Beef, unlike soy and timber, has an additional dimension of climate vulnerability due to the disproportionately high GHG emissions per ton of protein. Beef requires more than 20 times the area of land and emits 20 times more GHG emissions per gram of edible protein than common plant proteins such as beans (Ranganathan, J. et al. 2016). When compared to fish or poultry, beef emits 10-12 times greater GHG emissions. Estimates from the Food and Agriculture Organization of the United Nations indicate that beef consumption in 2027 is expected to be 21% higher in developing countries and 8% higher in developed countries than it was over the period 2015-2017 (OECD, 2018). As such, the cattle industry plays a central role in the fight against deforestation and climate change.

Of the 157 active meat-packing plants in the Amazon that are SIF and SIE registered (which is required to sell both within and out-of-state), Imazon data identified that JBS, Marfrig and

Minerva control 42% of the slaughter capacity, and another six firms help form a total of 60% of slaughter capacity (Barreto et al., 2017). Moreover, it is estimated that half of the supply ranches procure cattle from other smaller farms where transparency and control is limited. This indicates that the potential reach of key companies in the region is much larger than currently quantified, leading some to put the percentage of legal and illegal slaughter by JBS, Marfrig and Minerva as high as 70% (Amazon Watch, 2019).

It is critical that these firms participate in and adhere to deep supply-chain transparency standards in order to make any meaningful progress in combating illegal deforestation. A series of cases levied against these and other firms by the Public Prosecutor's Office resulted in the signing of 'TAC Carne' in 2009, a term of conduct seeking to condition non-prosecution on compliance with environmental law, greater transparency and reporting on supply-chain irregularities. The term's impact on supply-chain sustainability has been underwhelming, in large part due to lack of political will from offenders and lack of transparent tracking and land-registry data. While JBS continues to report high incidence of beef procured from deforested areas, Minerva has yet to sign the agreement (Mengardo, 2018).

A report released by Imazon analyzed the overlay of meat-packing plants of large companies on incidents of deforestation, risk of deforestation and embargos, and identified significant risks that are not being adequately analysed, priced and mitigated. JBS, for example, with 21 active plants in the Amazon region (out of 37 total active plants in Brazil) has 4.6 million hectares (an area larger than Switzerland) exposed to risk: 1.7 million hectares under embargo, 1.6 million hectares illegally deforested, and 1.2 million hectares at high risk of deforestation (Barreto et al., 2017). The scale of production that takes place in the Amazon region demonstrates the level of turnover-risk at stake.

Adherence to voluntary standards lags far behind other sectors such as timber, soy, and palm oil. Leading standards such as the Brazilian Roundtable for Sustainable Livestock (GTPS), the Multi-stakeholder Initiative for Sustainable Beef Production Standards, and the Standard for Sustainable Cattle Production Systems of the Sustainable Agriculture Network (SAN) have seen relatively little uptake (GTPS, 2007; Multi-stakeholder Initiative, 2009; SAN, 1997). Other coalitions like the FAIRR initiative, with US$ 23 trillion in assets under management affiliated with the platform, still lack the critical on-the-ground transparent and audited data to deepen their analysis and reach.

Similarly, the Brazilian Identification System for the Certification and Origin of Cattle and Buffalos (SISBOV), which was developed in 2002 as a tracking system for individual cattle as a condition to European export agreements, is used only for specific European export countries. SISBOV requires that the registration and tagging of cattle (and buffalo) must be conducted within ten months after birth and always before any transfer off the farm. As of June 2020, 1,654 farms (about 1.3% of the total) were using SISBOV tagging systems.

According to Trase data, three firms were responsible for 63% of beef exports in 2017: JBS, Minerva and Marfrig, demonstrating the potential progress SISBOV requirements to these firms, abroad, could generate. In July of 2020, Marfrig, acutely conscious of these trends, adopted a technology-driven solution and announced that it was investing R$500 million to trace *all* cattle within its direct and indirect supply chain (from birth to slaughter) by 2030. According to their "Marfrig Verde +" report, a combination of ear-tags, chips, landscape monitoring and blockchain will be used. Only time will tell the quality and efficacy of these efforts, but it proves as a useful indicator for how transparency of supply chains have become a necessary ESG policy as well as necessary commercial decision.

The lack of widespread adherence to cattle-tracking systems such as SISBOV has meant tracking and transparency methods have remained rooted in non-dynamic registries, thereby creating space for the widespread practice of cattle-registry fraud. Environmental audits today are based on the Rural Environmental Registry (CAR), the cattle-movement permit (GTA-e), and the bill of sale (NF), each providing a fixed, land-based registry, rather than dynamic tracking. The result is that many producers raise cattle on deforested lands, and then send them for fattening and GTA-e and CAR registration on legal, registered lands, making the links between legal and illegal activity difficult to identify, prove, and mitigate.

The CAR, therefore, represents a central piece of this puzzle - the excessive use of false names and overlapping registries (as the CAR is self-declared and not audited) means that irregular activity of a certain geographical region can be identified by satellite, but cannot be traced to the companies or individuals responsible. This represents the greatest hurdle from the perspective of quality of data of supply chains as well as ability to prosecute illegal actors. Lack of adoption of a public and audited CAR, as well as better cattle monitoring systems, has almost exclusively been a consequence of lack of political will.

Equally, the GTA-e has become a hurdle to greater transparency and auditing of suppliers. Initially conceived as a document to verify health and sanitary requirements of cattle (such as vaccines), it has great potential to be used in environmental audits as well. If made public, the GTA-e could be used to cross-check satellite imagery with supplier ranches and the movement of cattle. The proposal, repeatedly made to government by Marfrig, JBS and other meat-producers alike, has been met with lack of political will.

Remote sensing has also been critical in enabling academic and civil society researchers to better understand and monitor the irregular/illegal dimensions of cattle-ranching activity. An Imazon 2018 report demonstrated that “the potential buying zones for the meat-packing plants affect regions that contain the majority of problems associated with deforestation in the Brazilian Amazon: 88% of the total of embargoed areas by Ibama, 88% of the area deforested from 2010-2015 that was not embargoed (although a large share may be illegal) and about 90% of the areas at greater risk for deforestation from 2016-2018” (Barreto et al., 2017). More recently, Vale et al. (2019) mapped the expansion of beef slaughterhouses in Mato Grosso by triangulating across multiple data sources, including a registry of 21 million companies, government records of three million slaughter transactions (GTA), and high resolution satellite imagery. Studies of this kind greatly alter the quality and quantity of data available to financial institutions in terms of ESG and credit risk.

Table 4.2: Supply Chain Traceability Technology in the Ranching Sector

Technology	Use Case(s)	Example(s)
Remote sensing	Satellite data analysis for agriculture census and deforestation monitoring	MapBiomas
Genomics	Verification of beef samples along the supply chain against databases of individual animals that have been DNA profiled	Eurofins Genomic Meat Sourcing service
Big data and machine learning (AI)	Pattern recognition in imagery acquired by satellite or drone; triangulation and cross-validation of government records	Fire detection (PRODES); Estimation of cattle herd size (Picterra)
Blockchain	GTA chain of custody, taxation, and import/export documentation; "Smart contracts" which execute automatically when certain criteria are fulfilled	Beefchain: Blockchain verified beef and sheep in Wyoming, USA
Devices (IoT)	Radio-frequency tracking devices for livestock; Wearable dynamic tags from birth	SISBOV; Proposed USDA regulations for ear tags on cattle by Jan 1, 2023

4.3 Timber

The Brazilian tropical timber sector today is responsible for the extraction of more than 13 million cubic meters of hardwood logs from Amazonian forests, generating around US$3 billion in annual revenue (less than 10% of the global hardwood market). While small in comparison to the beef and soy industries, the sector nonetheless provides employment for over 200,000 people (BVRio, 2016). Yet, there has been negligible progress in terms of the adoption of sustainability standards. Forest Stewardship Council (FSC) certified operations account for less than 3% of the total log production in the Brazilian Amazon, and is diminishing as a result of unfair competition from illegal sources (FSC, 1993; NYDF, 2019). Operations certified by the Programme for the Endorsement of Forest Certification (PEFC) such as the Brazilian Forest Certification Program (CERFLOR) account for even less (PEFC, 1999; CERFLOR, 2002; Ranganathan et al. 2016).

Brazil ranks amongst the highest-risk countries in terms of the risk of illegality in its timber industry. Imazon (2013) estimated that over 70 percent of timber products from the Amazon come from illegal operations, which may involve theft of wood from conservation areas and indigenous reserves, use of slave labor, and laundering of stolen timber. A 2016 analysis by BVRio found that more than 40 percent of the forest management operations in the Brazilian states of Pará and Mato Grosso between 2007 and 2015 were at medium to high risk of having involved severe legal violations. Only 10 percent of the cases examined by BVRio showed no indications of irregularities (BVRio, 2016).

The difficulty of sourcing legal wood as required by legislation such as the U.S. Lacey Act, the EU Timber Regulation (EUTR), and Australia's Illegal Logging Prohibition Act (ILPA) has led many foreign companies to refrain from buying timber products from the

Amazon. These frameworks require traders and operators to conduct their own due diligence on the timber they import into these markets. The ability to conduct due diligence, however, is hindered by the fact that the state timber control systems (e.g., Mato Grosso and Pará) restrict the public availability of their data, making it difficult for third parties to conduct their own independent due diligence (BVRio, 2016). Even when documents are available, they are often characterized by various types of fraud (Brancalion et al., 2018).

A number of approaches have been used for tracing timber products' origins and screening them for legality (BVRio, 2016). The classic approach consists of field audits and spot checks by independent auditors to verify whether operations conform to expected rules, regulations or standards - such as the CAR. More recently, remote sensing data from satellites (MapBiomas) and drones is being combined with traceability systems and technologies, including bar codes, computer chips, radio frequency identifiers, GPS, and DNA identification. Supply chain information platforms, such as BVRio's Timber Due Diligence System, are using novel blockchain approaches to help buyers identify the sources of products. Machine learning algorithms are being applied to the resulting large volumes of data in order to detect potential illegalities. Table 4.1 provides a brief overview of how these technologies are being used.

Table 4.3: Supply Chain Traceability Technology in the Timber Sector

Technology	Use Case(s)	Example(s)
Remote sensing	LiDAR-based assessment of forest degradation	Rainforest Connection (RFCx); MapBiomas alerts
Genomics	DNA fingerprinting	British Columbia Ministry of Forests microsatellite markers for red cedar
Big data and machine learning (AI)	Cross-validation and triangulation of georeferenced records	Xylotron identifies over 150 species of wood more accurately than trained law enforcement personnel
Blockchain	Highly-transparent, decentralized digital smart contracts to prevent fraud	BVRio's Timber Due Diligence System and Trading Platform
Devices (IoT)	Bar codes, computer chips, and RFID applied to timber shipments; GPS tracking of trucks	Greenpeace Brazil covert GPS surveillance of timber trucks

5. Recommendations

Financial institutions are uniquely positioned to incentivize public and private sector action and have a fiduciary responsibility to their shareholders to mitigate increasing credit risks arising from natural capital degradation and carbon-intensive industries. As such, financial actors should extend their central role in improving transparency by leading a multi-stakeholder approach on environmental crime, deforestation, and thereby, climate change. There are at least three measures that, when adopted and advocated for as priorities by financial institutions, could have a rapid, effective and large-scale impact on limiting illegal deforestation in the Brazilian Amazon.

5.1 Legislation and Policy

First, the financial sector should advocate for greater market transparency through a public and audited Rural Environmental Registry (Cadastro Ambiental Rural - CAR) and a public GTA-e:

- The CAR and GTA-e data serve as critical pieces in linking individual and/or commercial actors to specific, geographically defined, plots of land and/or herds of cattle that, in turn, can be monitored with satellites to detect illegal deforestation. These two databases need to be made public, and need to be audited and validated by their respective environmental authorities.

- To date, prosecutors estimate that as many as 30% of existing CAR registries are fraudulent as a result of this lack of transparency, further complicating the ability of public prosecutors to identify the perpetrators of illegal activity, and policy makers to create more fitting legislation to tackle these crimes.

- Moreover, as many as 10,000 properties registered under the CAR also overlap with indigenous territories, infringing upon their legal and human rights, with little recourse until this data becomes publicly accessible.

- Equally, the GTA-e could be used to cross-check satellite imagery with supplier ranches and the movement of cattle, making significant progress towards eliminating cattle fraud.

Therefore, it is imperative that:

- Financial institutions directly appeal to FEBRABAN to make CAR data, that is *already* available to FEBRABAN, available to individual institutions on a rolling-basis; and,

- Financial institutions make a public appeal, in line with public written appeals made by private enterprises on deforestation (e.g., the letter from 38 Brazilian business-owners to General Mourao) to make CAR and GTA-e data publicly available and audited through validation of an environmental authority.

5.2 Credit Conditionality

Second, it is critical that the financial sector condition credit approval on robust land registry information (e.g., CAR) and SISBOV and GTA-e information (in the case of cattle) that is triangulated and verified by satellite data (among other technologies):

- Incorporating land registries (CAR) and satellite data (PRODES, MapBiomas alerts) into compliance and ESG metrics has been proven possible from a technical perspective. However, progress has been limited due to issues of governance. The Public Prosecutor's Office has repeatedly appealed to the Brazilian Federation of Banks (FEBREBAN) to integrate deforestation and embargo data into credit approvals in an effort to curb financing of illegal projects.

- Multinational company loans' use of proceeds are predominantly for "general working capital purposes" – a catch-all term that does not distinguish activities in a suburb of Sao Paulo from those in high-risk environmental crime areas.

- Equally, commercial loans made to small local operators (that are often directly or indirectly supplying the larger corporations) in deforestation-risk regions are approved on the basis of personal or commercial entity credit scores, rather than an analysis of the use – or geographical location - of proceeds (usually for a plot of land, equipment or cattle/crops). This creates significant risks for local bank branches as they knowingly or unknowingly lend to entities operating irregularly or illegally.

- Some institutions are already moving in this direction: Rabobank, the largest bank in the food and agribusiness sector and 2nd highest-ranked Forest 500 financial institution, has integrated the use of MapBiomas (cross-validating the CAR, embargo, and satellite data) into its credit approval process that is monitored on an annual basis (Rabobank, 2020).

- Meanwhile, Banco do Brasil removed a credit guideline related to minimizing damage on protected forest areas in 2018, reducing its ESG score and further exposing it to un-mapped credit risks (Thomson and Rogerson, 2020).

Therefore it is imperative that:

- More stringent compliance checks in the form of the land registry (CAR) and satellite triangulation (MapBiomas) be adopted for *all* credit agreements for *all* entities exposed to any deforestation risk. In other words, in doing business with firms that operate in climate-vulnerable sectors, *any* modality of credit, should be made conditional upon deforestation metrics;

- SISBOV and GTA-e requirements be adopted for cattle-industry loan-agreements, such that cattle movement can be actively tracked, avoiding fraud and providing additional data to triangulate CAR and satellite data;

- Small-scale commercial loan applicants be required to present a verified land registry (CAR) that can be triangulated with satellite imagery (see, for example, MapBiomas and the Terras app), as well as tracking verification for the cattle (GTA-e and SISBOV) or crop to be purchased. This would prevent financing of small-to-medium scale operations that operate in at-risk or embargoed areas, greatly limiting the unintentional exposure many large buyers have from small producers; and,

- Proper adherence to the Program for Environmental Regularization (PRA) be made an additional conditionality to credit agreements for those that have exceeded the legal limits for deforestation on their properties.

5.3 Physical and Transitional De-Risking Instruments

Third, financial institutions must fully integrate deforestation and land-use indicators into their existing ESG evaluation and reporting metrics to more accurately measure physical and transitional risks throughout companies' supply chains:

- Financial institutions, by requiring the routine reporting of company suppliers that are involved in regular, irregular, or illegal activity, would be able to more accurately measure deforestation risk across their investment portfolios and thereby, systemic risk to climate-vulnerability.

- International ESG reporting standards, foreign-direct investment conditionality, international carbon trading markets, and traditional trade agreements with Brazil are likely to create ever more relevant transitional risks for companies that fail to adopt deforestation metrics. In April of 2020, the European Commission confirmed that voluntary measures had not been effective in identifying, accounting, and mitigating human rights and environmental impacts in commodity supply chains and signaled an EU-wide mandatory legislation for 2021.

Financial institutions must understand, account for, and monitor the risks associated with these changes, specifically by:

- assessing and monitoring the transitional risks associated with portfolio companies shifting to more rigorous international reporting standards and any potential impacts this may have (depending on length of uptake) on foreign direct investment and trade agreements;

- identifying clear adhesion plans to these deforestation metrics with portfolio companies over a specific time-frame; and,

- incentivizing financing agreements with companies that are already working to meet deforestation and land-use metrics.

Adoption of these priorities will significantly improve the transparency of supply chains, raise credit approval standards, and bolster financial institutions' capacity to de-risk portfolios in climate-vulnerable sectors. From an environmental standpoint, these three priorities have the potential to drive transparency and thereby hold public and private actors more accountable in terms of supply chain impacts on natural capital, while reducing the frequency and scale of financing of irregular projects.

We have limited time to act. The Amazon is nearing its critical 'tipping point', beyond which both the Amazon biome and our global climate will suffer irreversible damages, negatively impacting not only local communities but also entire industries in the Amazon and Cerrado regions that depend on natural capital and represent a significant portion of Brazilian GDP. By taking action on the concrete steps proposed herein, the financial sector is uniquely positioned to shape the agenda and drive the change needed in order to avoid this outcome.

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7. Annexes

Annex 1: Leading Sustainability Initiatives for Amazon Commodities

Initiative	Approach
Carbon Disclosure Project (CDP)	Reporting Framework
Forest Trends' Supply Change Initiative	Framework
The Sustainability Consortium	Framework
Global Canopy Programme Forest 500	Ratings Body
TFA Commodities and Forest Agenda 2020	Network/Coalition
New York Declaration on Forests (NYDF)	Commitment
Principles for Responsible Investment (PRI)	Commitment
Coller Foundation FAIRR Initiative	Network/Coalition
Principles for Responsible Investment (PRI) - Ceres Investor Initiative for Sustainable Forests	Network/Coalition
The Accountability Framework	Reporting Framework
World Business Council for Sustainable Development (WBCSD)	Network/Coalition
Global Reporting Initiative (GRI)	Reporting Framework
Sustainability Accounting Standards Board (SASB)	Reporting Framework
Task Force on Climate-related Financial Disclosures (TCFD)	Reporting Framework
WEF Task Force	Reporting Framework
Brazilian Coalition on Climate, Forests, and Agriculture	Network/Coalition
EU Multi-Stakeholder Platform on Deforestation, Forest Degradation and Forest Generation	Network/Coalition

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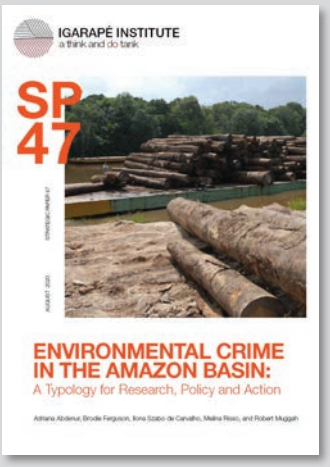

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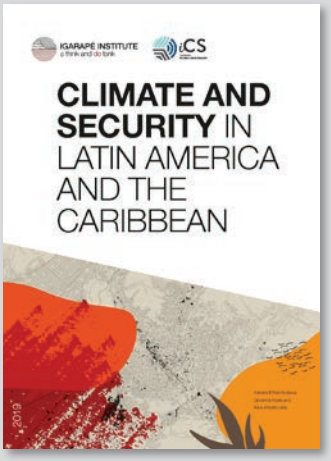

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