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INVESTING IN NATIVE TREE SPECIES AND AGROFORESTRY SYSTEMS IN BRAZIL: AN ECONOMIC VALUATION

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Design and layout by:
Néktar Design
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ACKNOWLEDGMENTS

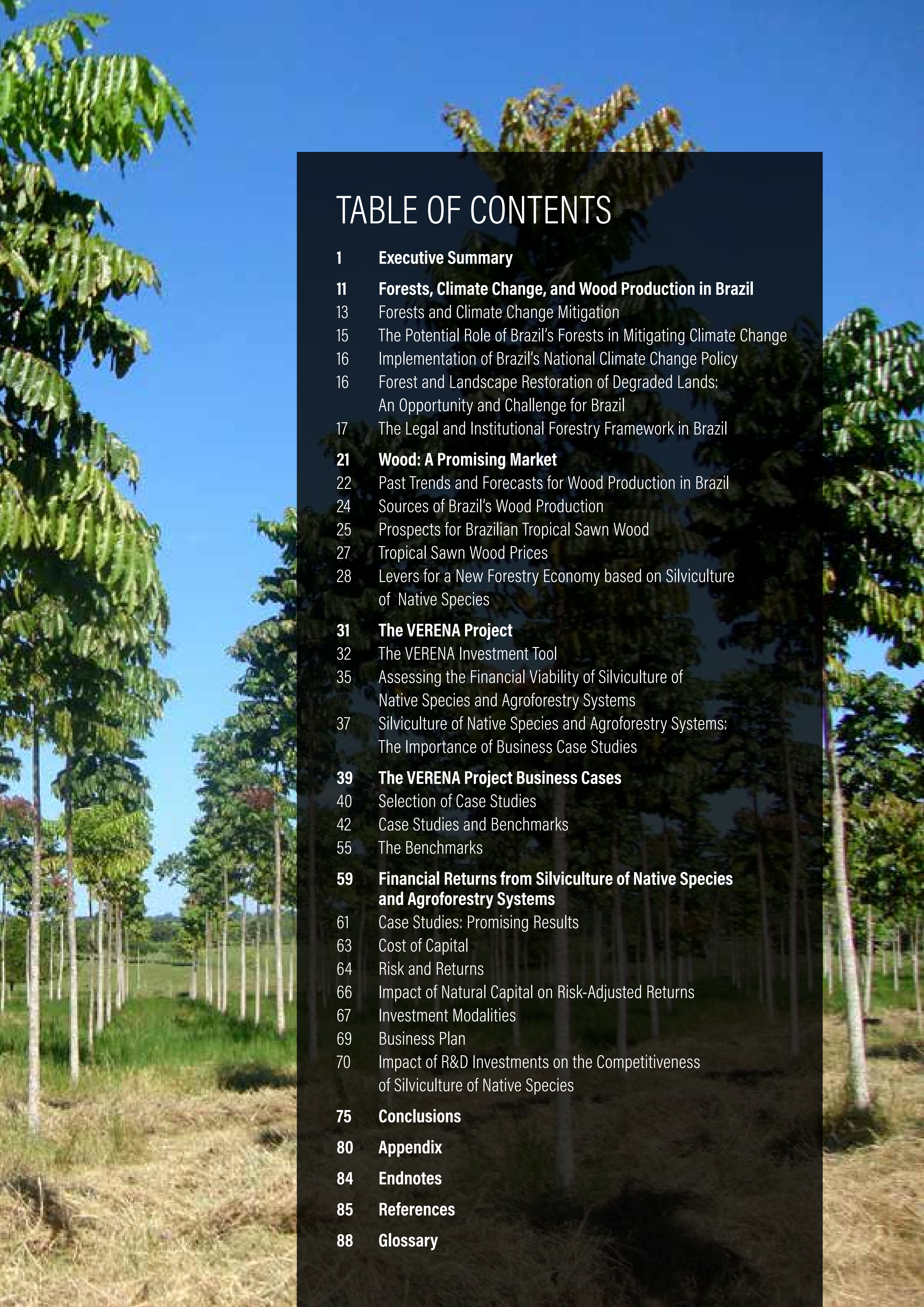
The authors would like to thank CIFF (Children's Investment Fund Foundation), Good Energies Foundation, and the World Bank though the PROFOR program for providing technical and financial support to this project.

We also appreciate the partnership and provision of data by the companies and organizations Amata, Symbiosis, Agro Itubera, TNC, C.A.M.T.A., Futuro Florestal, Sucupira Agroflorestal, and Fazendas Jaíba, Santo Antônio, and Toca.

The authors would like to thank and recognize the reviewers of this document, who shared their knowledge to make the study more robust: Achille Djeagou (Coordinator, WRI DRC), Haijun Zhao (Coordinator, Food and Land Use Coalition China), Rene Zamora (Associate, Initiative 20x20), Sofia Faruqi (For WRI Global), Daniel Piotto (Professor, UFSB), Pedro Brancalion (Professor, ESALQ-USP), Marcio Macedo (Manager, BNDES), and Bruno Mariani (CEO and Founder, Symbiosis Investment).

A special thanks to Ana Yang, Mireille Perrin, and Roberto Waack for their inspiration, leadership, and commitment to the VERENA project and to Emily Mathew and Gregory Taff for their patience, dedication, and hard work to make this report more polished and impactful. Also thank to Christine Plugeo for her excellent work on the final review.

We extend our sincere gratitude to Joana Oliveira and the communication team at WRI Brasil for the graphic intelligence and visual art that simplified the messages without changing their technical and scientific content.



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EXECUTIVE SUMMARY

Silviculture of native species and agroforestry systems have an enormous potential for tropical wood markets, in Brazil and globally. Their economic viability is shown in this report.

This results also demonstrate that the main market risk variables can be included in the valuation of forest assets, including exchange rates, inflation, production volumes, and price volatility.

HIGHLIGHTS

- More than 70 million hectares (Mha) of degraded pastures in Brazil could benefit from forest and landscape restoration, afforestation, and reforestation.
- Brazil's laws and policies support the restoration and reforestation of degraded lands with native tree species for economic use, which is an opportunity to establish a viable forest economy based on silviculture of native species and agroforestry systems (AFS).
- The VERENA Project conducted 12 case studies in the Amazon Forest, Atlantic Forest, and Brazilian Savanna (*Cerrado*) to assess the economic viability of silviculture using native species and AFS.
- The project found risk-adjusted returns on silviculture of native species and AFS comparable to those obtained from commercial plantations of exotic tree species commonly used in Brazil's forestry sector today, while sensitivity analysis showed a lower market risk. However, capital requirements are higher, and the payback period is longer, which are important barriers to scale up silviculture of native species in Brazil.
- Increased investment in research, development, and innovation (RDI) is necessary to support the competitiveness of native species in commercial forestry and AFS and move from pilot projects to landscape scale.
- It will be critical to develop business models for native species and AFS to attract private investors and farmers.

Exploring the Business Potential of Native Tree Species in Brazil

This report presents the findings of a project that set out to demonstrate the economic viability of investments in silviculture of native species and AFS. The aim is to promote large-scale recovery of degraded pastures and deforested lands through planting native tree species. Commercially oriented restoration and reforestation activities could form an important part of Brazil's contribution to international commitments to mitigate climate change impacts. Such activities would also contribute to expanding Brazil's role as a major supplier of tropical wood.

The report presents 12 business cases of silviculture of native species and AFS and compares them to eucalyptus plantations and permanent crops (referred to in this report as benchmarks), in order to assess the risk and return characteristics of the two kinds of investments. Initially, the VERENA Project focused on silviculture of native species but was expanded to include AFS because of their important socioeconomic and environmental role in several regions of Brazil.

About This Report

WRI Brasil led the VERENA project in partnership with the International Union for Conservation of Nature (IUCN). Leadership and technical support support was provided by the entrepreneur Roberto Waack, and financial support came from the Children's Investment Fund Foundation (CIFF) and Good Energies Foundation (GEF). The first phase of the project was undertaken between 2016 and 2019. We analyzed the technical and financial performance of innovative silviculture and AFS businesses based on 12 projects implemented between 2007 and 2016 and interviews and field research re-conducted in 2016 and 2017 (Batista et al. 2017a). The analyses confirmed the 12 cases as business opportunities that could attract farmers and private investors who invest in sustainable forestry and agriculture. These businesses offer risk-adjusted returns comparable to mainstream investments in land use.

The report introduces the VERENA Investment Tool (Batista et al. 2017b), which was developed and used to assess risks and returns on investment in silviculture of native species and agroforestry systems underway in Brazil. It is a framework model developed by WRI Brasil with contributions from organizations and experts from private companies and finance and investment institutions. It is intended for use by investors, landowners, stakeholders, and policymakers involved in making investment decisions. The tool requires reasonable accounting and finance skills and good knowledge of the business world.

The Global Wood Market

National and global demand for wood indicates opportunities to develop sustainable wood businesses, including businesses based on native species, in commercial plantations. During the period 1961–2016, global wood production increased an average of 0.7 percent per year, while Brazilian wood production increase 1.6 percent annually. These trends resulted in a cumulative increase of 48 percent over the period at the global level and 140 percent in Brazil.

Demand projections point toward global wood consumption of 5.4–6.7 billion cubic meters (m^3) by 2050. In the context of a business-as-usual economy, Brazil would produce around 500 million m^3 by 2050 and be responsible for 8 percent of the global wood supply. But if wood production were to become more attractive, for example, in an economy that encourages silviculture of native species for wood production, Brazil could become one of the main players in the world and produce more than 1 billion m^3 of wood.

Brazil is currently a minor player in the global tropical wood market, relative to its potential. Some of the reasons for Brazil's relatively small contribution to the global wood supply are corruption, an inefficient manufacturing process, a complex system for determining the legality of wood, and unfair competition from illegally harvested wood. The United States, the main importer of Brazilian wood, supports Brazil's legal market via the Lacey Act which bans the import of illegally harvested, possessed, transported, or sold plants and wood.

The VERENA Project

Conceived in 2015, the VERENA project aims to contribute and boost a sustainable forestry economy, providing knowledge, tools, and information from leading initiatives underway in Brazil on silviculture of native species and AFS.

Led by economists, forest engineers, biologists, geographers, lawyers, and agronomists, the VERENA Project is fundamental to engage and mobilize private investments, financial institutions, companies, and farmers to assess risk and return, taking advantage of market opportunities based on credible economic models and robust business plans.

A forest continuum embraces different land typologies across landscapes, ranging from primary forests to low-carbon agriculture, with different associated benefits. Within the forest continuum, different forms of land use that offer different products, services, and potentials to meet the demands of society were considered as part of possible typologies studied by VERENA Project (Figure ES1).

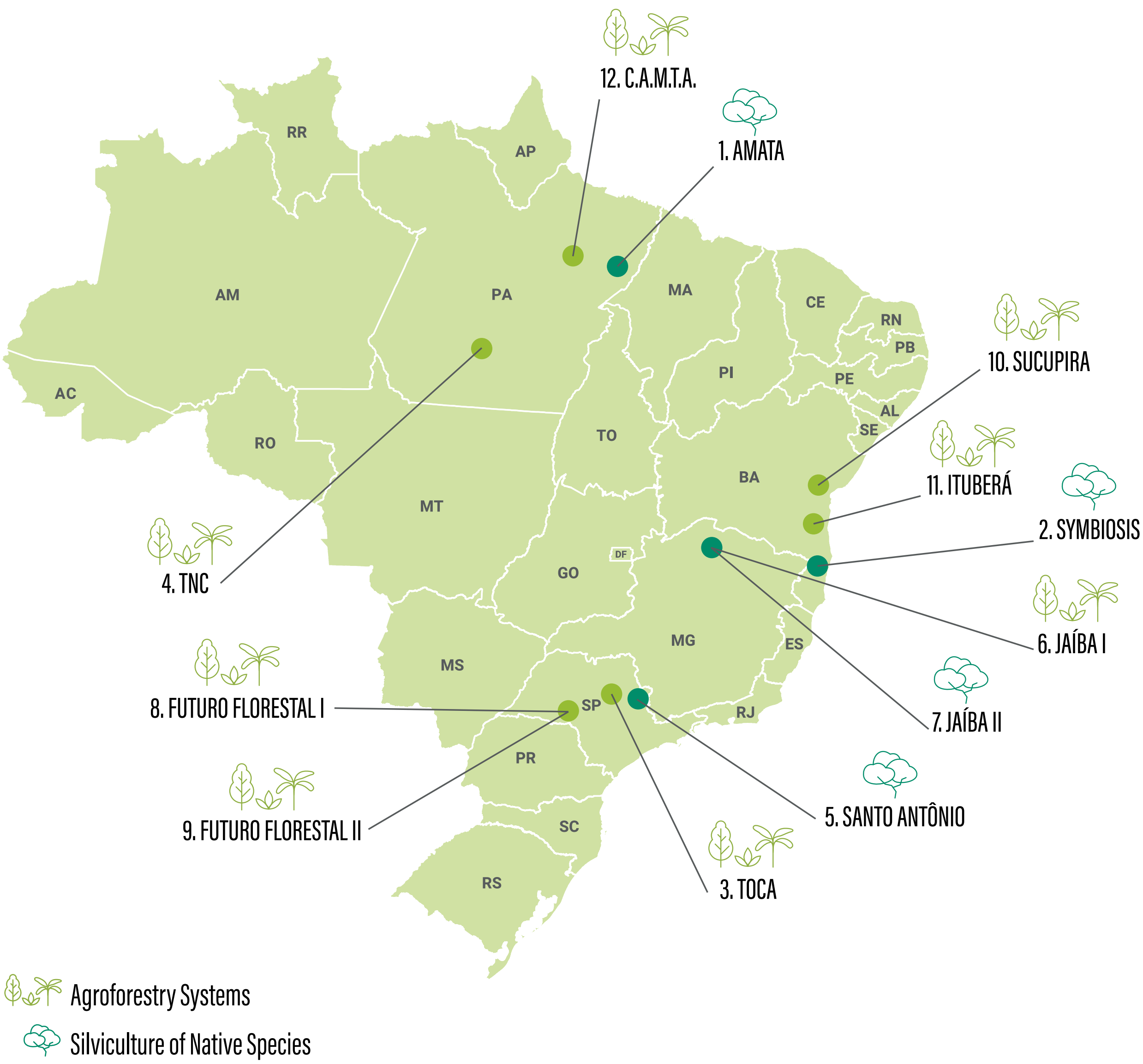
Figure ES1 | Land-Use Typologies Studied by the VERENA Project

Source: Batista et al. 2017b.

The Study Approach: 12 Business Case Studies

The VERENA Project first identified more than 30 potential cases and later made a deeper analysis of 12 business cases in different regions of Brazil. The project examines business opportunities for silviculture of native species and AFS in at least four asset classes categorized by production system: mixed plantings of native species, monocultures of native species, mixed plantings of native and exotic species, and agroforestry systems. Located in three biomes—Amazon Forest, Atlantic Forest, and *Cerrado* (Figure ES2)—the 12 business cases were compared to the financial performance of eucalyptus plantations and permanent crops in monoculture, traditional forms of forestry and agriculture which were used as benchmarks.

Figure ES2 | Locations of the 12 Business Case Studied by the VERENA Project



Source: Batista et al. 2017b.

Financial Analysis

Investment risk and return profiles differed for each forestry asset class, which increases the importance of developing solid and robust business cases for the different asset classes.

Due to the long-time horizon of the assets studied and their different characteristics, we used the discounted cash flow method for valuation. The discount rate was used to measure risk-adjusted return. Besides these analyses, economic viability depends on the risk characteristics, unique circumstances, time horizon, and capital needs of the investor and farmer.

The return on assets, given the investment risks, was adjusted using the capital asset pricing model (CAPM) and the weighted average cost of capital (WACC) models. In addition, we compared these results with those that might be expected if ecosystem services such as carbon storage and improved water quality were incorporated into market prices. We used and compared discount rates that public companies normally use to report the fair value of their biological assets.

Return estimates considered the value of the asset and were based on the net present value (NPV) and the internal rate of return (IRR). The 12 business cases were analyzed in two categories, one comprising silviculture of native species and the second comprising AFS involving native and exotic tree species and agricultural crops. The business cases were compared to traditional agriculture (major crops) and silviculture with exotic species.

The IRR found for silviculture of native species and agroforestry systems were comparable to those for traditional agriculture and silviculture plantation. However, we found a statistical difference between capital-needs requirements and the payback period among the asset classes. The payback and capital needs were greater for AFS and silviculture of native species because they require more investment, and a longer rotation period. This barrier can be overcome by developing long-term financing mechanisms aligned with the investment and tenure requirement of those types of asset classes.

Key Findings

Silviculture of native species and agroforestry systems has risk-adjusted returns comparable to traditional enterprises in the forestry and agriculture sector, with an internal rate of return of approximately 12 percent. However, the capital needs and payback period for silviculture of native species and AFS are statistically greater when compared to the benchmark enterprises, which is an important barrier to scaling up silviculture of native species and AFS in Brazil. The returns from the business cases were risk-adjusted differently from the benchmarks to consider uncertainty, given the early phase of these projects. Therefore, one of the major opportunities for silviculture of native species and AFS is to move from pilot projects to landscape scale; with scale, much of the actual perception of risk can be reduced.

Sensitivity analysis showed that silviculture of native species has the lowest variation of returns among all the case studies and benchmarks, in terms of response to changes in product prices. The benchmarks – traditional monocultures such as coffee and cocoa, and plantations of pine and eucalyptus – produce only one revenue stream, whereas mixed native-species plantations offer a diversity of revenue streams. Sensitivity analysis also showed a lower market-risk profile for silviculture of native species when compared to monocultures and AFS.

This report reinforces the importance of Research and Development (R&D) in establishing a feasible, competitive, and scalable economy based on silviculture of native species and agroforestry systems. Within the scope of a pre-competitive R&D program for native tree species, the gains in terms of environmental benefits and financial returns to the business models may be significant. This array of benefits, along with the opportunity to scale up silviculture of native species and AFS, led the Brazilian Coalition on Climate, Forests and Agriculture to prioritize the establishment of a pre-competitive R&D program for silviculture of Brazilian native tree species.

Intelligent investments in R&D will allow Brazil to become a major supplier in the global tropical timber market. The country is well-suited to forestry and has a large area of degraded pastureland with low suitability for agriculture that would benefit from tree planting. Brazil offers both the biophysical conditions and potential cutting-edge technologies for a successful program. Although most wood-processing technologies have been developed for exotic species such as pine and eucalyptus, native species can benefit from this previous R&D investment.

There is potential to increase competitiveness of silviculture of native species and agroforestry systems through the monetization of natural capital. Ecosystem services such as carbon storage and improved water quality are currently not priced in the market. Reforestation with native species offers several non-monetized positive externalities. Although marginal, based on our analysis, the monetization of natural capital could increase the internal rate of return by 0.4 percent. However, the greater potential for increasing the competitiveness of the sector comes from investments in R&D.

The country has the legal framework favorable to establish a viable and competitive forest economy based on silviculture of native species, which may help Brazil to fulfill its national and international climate targets and commitments and increase its rural and industrial economic competitiveness. However, the country still lacks an industrial policy with all the necessary elements to establish and scale up a competitive forest economy using native species comparable to the highly successful industry developed for plantations with exotic species. Brazil's forestry and agroforestry economies can thrive if a competitive industry is established as nature-based solutions for climate mitigation and adaptation are at the forefront of international debate. The authors offer some recommendations, such as mixed planting of native and exotic species and developing new markets, to help policymakers support and incentivize silviculture of native species and AFS.

FORESTS, CLIMATE CHANGE, AND WOOD PRODUCTION IN BRAZIL

This report presents the methodology, activities, outputs, and outcomes of the first phase of the Economic Valuation of Reforestation with Native Species and Agroforestry System (VERENA) Project undertaken in Brazil between 2016 and mid-2019.

From the beginning, this project was intended to demonstrate whether silviculture of native species and agroforestry systems (AFS) could contribute to a viable investment asset class. The broader context for the VERENA project is that these investments would contribute to forest and landscape restoration and the reforestation of degraded lands, mainly pastures, and thus contribute more broadly to Brazil's climate change commitments.

The following main issues are presented and discussed in this report:

- Global context of forests and their role in climate change mitigation;
- Opportunities for forest and landscape restoration and reforestation in Brazil;
- Importance of the wood market;
- Basis for building the VERENA Project;
- Characteristics of the business cases in the VERENA Project;
- Economic viability of investments in silviculture of native species and AFS;
- Conclusions regarding the economic viability of silviculture of native species and AFS.

Forests and Climate Change Mitigation

The Paris Agreement on Climate Change, approved in 2015, set a goal to limit the average annual increase in global temperatures to 2°C or less by the end of this century. To achieve this target, it is now more important than ever to reduce deforestation and forest degradation, which contributes to the reduction of carbon emissions and increases carbon sequestration through forest and landscape restoration and reforestation. Global human-caused greenhouse gas (GHG) emissions in 2010 totaled 49 gigatons of carbon dioxide equivalent (Gt CO_2e) (IPCC 2014), with about 24 percent coming from agriculture, forestry, and other land uses (AFOLU). At the same time, land acts as an important carbon sink.

Forests play an important role in capturing CO_2 from the atmosphere, acting as a carbon sink for a portion of anthropogenic GHG emissions and thereby contributing to climate change mitigation goals. When planted for economic purposes, trees provide a source of long-term income, increase the supply of wood for industrial purposes (cellulose, paper, furniture, and wood panels), energy (charcoal and firewood), and construction. The utilization of planted trees also reduces pressure on native forests. Long-lived wood products, such as construction timber and furniture, have a positive balance in capturing CO_2, but this may not be true of wood produced for energy or pulp and paper. It should be noted that wood is currently considered one of the priority products for financing green bonds (Knoch and Van der Plasken 2020).

Several studies show that forest and landscape restoration and reforestation are cost-efficient ways to mitigate global warming (McKinsey 2007; NCE 2014) and simultaneously ensure the conservation of biodiversity, the provision of environmental services, and employment and income opportunities. Some of the terms associated with forestry and land-use change used throughout this report are presented in Box 1.

Natural climate solutions (NCS) in the tropics, where the potential for additional land carbon storage is greatest, are being widely studied. According to Griscom et al. (2020), cost-effective tropical NCS offer globally significant climate

mitigation in the coming decades (6.56 billion tons CO2e per year at less than US$100 per ton of CO2e). It is in this context that we present the findings of the VERENA project, as they point to business models that may allow scaling up NCS in a key tropical country like Brazil. As pointed out by Griscom et al. (2020), in half of the tropical countries, cost-effective NCS could mitigate over half of national emissions. They consider that one-fifth of cost-effective NCS involves the restoration of native forest and wetland totaling 1.4 million tons of CO2e per year. The authors argue that with international financing and political will, NCS can cost-effectively deliver most national commitments under the Paris Agreement while transforming national economies and contributing to sustainable development goals. Brazil is among the countries identified with the majority of tropical NCS opportunities, high governance indicators, and strong-to-intermediate financial capacity.

The land-use sector, especially forestry, is a key component in the implementation plans of the Nationally Determined Contributions (NDCs) prepared by countries under the Paris Climate Agreement (Grassi et al. 2017). Realizing and tracking this mitigation potential requires more transparency regarding countries' pledges and enhanced science-policy cooperation to increase confidence in the numbers presented in country reports and scientific studies (Grassi et al. 2017).

BOX 1 | TERMS RELATED TO FORESTS AND LAND-USE CHANGES

Afforestation. The conversion to forest of land that historically has not been forested.

Agroforestry systems (AFS). The ecological management system based on natural resources that, through the integration of trees in farm and pastures, diversifies and sustains smallholder production using a large diversity of plants and animals to provide vital community needs (food, health, clothing, and building materials), with social, economic, and environmental benefits (Castro et al. 2009; Leakey 2017).

Deforestation. The permanent removal of tree cover resulting in conversion of forest to non-forest.

Forest. A vegetation type dominated by trees. Many definitions of the term forest are in use throughout the world, reflecting wide differences in bio-geophysical conditions, social structure, and economics.

Forest management. The process of planning and implementing practices for the stewardship and use of forests to meet specific environmental, economic, social, and cultural objectives (FAO n.d.).

Land degradation. A negative trend in land condition, caused directly or indirectly by human-induced processes including anthropogenic climate change, expressed as long-term reduction in or loss of at least one of the following: biological productivity, ecological integrity, or value to humans. This definition applies to forest and non-forest land. Changes in land condition resulting solely from natural processes (such as volcanic eruptions) are not considered to be land degradation.

Land use. The sum of the arrangements, activities, and inputs applied to a parcel of land. The term "land use" is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, conservation, and city-dwelling).

Land-use change. The change from one land-use category to another. The change can be direct (e.g., a parcel of land is converted from agriculture to urban settlement) or indirect, when the cause of change is outside the area of focus. For example, if agricultural land is diverted from food crops to biofuel production, forest clearance may occur elsewhere to replace the former food production.

Land restoration. The process of assisting the recovery of land from a degraded state.

Reforestation. The conversion to forest of land that was previously forested but has been converted to some other use.

Silviculture. The art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society such as wildlife habitat, timber, water resources, restoration, and recreation on a sustainable basis (U.S. Forest Service 2020).

Sustainable forest management. The stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality, and their potential to fulfill, now and in the future, relevant ecological, economic, and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems (IPCC 2019a).

The Potential Role of Brazil's Forests in Mitigating Climate Change

Reducing deforestation and forest degradation is a powerful option for climate change mitigation (Table 1), with enormous mitigation benefits, mainly in the tropics (IPCC 2019b). According to SEEG data (Albuquerque et al. 2020), Brazil emitted 2.17 billion tons of CO2e in 2019, an increase of 9.6 percent compared to 2018. Almost half (44 percent) of Brazilian emissions resulted from land-use changes, followed by 28 percent from agricultural activities.

Table 1 | Mitigation Effects of Land Management Options Based on Land Management in Forests

MANAGEMENT OPTION	POTENTIAL ($GTCO_2e$/YEAR)
Forest management	0.4 to 2.1
Reduced deforestation and forest degradation	0.4 to 5.8
Reforestation and forest restoration	1.5 to 10.1
Afforestation	0.5 to 8.9

Source: IPCC 2019b, Table 6.14.

Reducing emissions from deforestation and agriculture could account for 85 percent of Brazil's mitigation potential by 2030. At the 15th Conference of the Parties (COP15) to the United Nations Convention on Climate Change (UNFCCC) in Copenhagen, Brazil presented voluntary actions to reduce GHG emissions through the recovery of 15 Mha of degraded pastures and the implementation of 4 Mha of integrated systems (crops, livestock, forests) and 3 Mha of planted forests (Brasil 2012). This challenge would represent a mitigation potential of more than 100 million tons of CO2e.

Brazil's NDC target also includes the reforestation and restoration of 12 Mha of degraded lands and forests. However, contrary to claims by government officials, currently Brazil is not on track to meet any of its climate change commitments or develop or implement robust policies that would deliver Brazil's obligations under its own national legal framework or international agreements (Ângelo and Rittl 2019).

One way of scaling up NCS is through increased production of wood and other forestry and agroforestry products. In practice, carbon benefits depend on what land use the forestry and agroforestry system is replacing. The rationale of the VERENA project is to replace degraded pasture lands and lands that are poorly suited to agriculture with AFS and silviculture of native species.

Implementation of Brazil's National Climate Change Policy

Several strategies within the National Climate Change Policy (PNMC, from its initials in Portuguese) that can contribute toward Brazil's NDC targets have been developed and implemented since 2009. One of the sectoral plans within the PNMC is the National Plan for Low Carbon Emission in Agriculture (ABC Plan, from its initials in Portuguese). The ABC Plan establishes guidelines to increase sustainable agricultural practices, restore degraded pasture lands, expand forest plantations (with native and/or exotic trees), and reduce deforestation, especially in the Amazon region.

Despite the lack of progress in national Congress, regional governments have been successfully forging local plans and actions for Reducing Emissions from Deforestation and Forest Degradation (REDD+).

The legal framework for the forestry supply chain includes several fiscal measures and taxes at all levels of government, in accordance with the 1988 Federal Constitution. Many incentives for the sector have been successfully tested over decades, enabling growth in this field. Such incentives include a review of the Tax Levied on Products and Services (ICMS, from its initials in Portuguese), according to their means of forestry production. Other incentives include tax exemptions that range from long-term to short-term and across jurisdictions. Building an incentive framework that can lead to a robust forest economy requires an in-depth analysis of the complex tax system in Brazil, which is one of the barriers to development.

To this end, the Brazilian Coalition on Climate, Forest, and Agriculture defined as one if its main goals to support government efforts to deliver the NDC targets, implement the NVPA, and collaborate in developing a competitive market based on sustainable agriculture, AFS, and silviculture.

Forest and Landscape Restoration of Degraded Lands: an Opportunity and Challenge for Brazil

Under the Bonn Challenge, countries agreed to restore or reforest 150 Mha of degraded lands by 2020, with an additional commitment of 200 Mha by 2030 added through the 2014 New York Declaration on Forests.

In Brazil, more than 99 Mha of pastureland are degraded to some degree (LAPIG 2020), of which more than 27.5 Mha are moderately degraded and about 42 Mha are severely degraded (Figure 1). Land that is in violation of the Native Vegetation Protection Act (NVPA), meaning that it has been deforested beyond the legal limit, covers between 19 Mha (Guidotti et al. 2017) and 21 Mha (Soares-Filho et al. 2014). This land is concentrated mainly on the on the southern and eastern edges of the Amazon and includes nearly the entire Atlantic Forest and *Cerrado* (Soares-Filho et al. 2014). Some of this land can only be restored with active planting, as the land will not naturally regenerate, at least not in a timeframe that will contribute meaningfully to climate goals. Moreover, the degraded areas are so large that restoration for conservation purposes alone is not viable financially and would require economic incentive. Therefore, planting and sustainably managing native tree species for timber production is an environmentally and economically viable option to help farmers recover degraded land and restore natural vegetation to comply with the NVPA.

One strategy to overcome the funding gap is to demonstrate the economic viability of a new forestry economy using native tree species. Moreover, to realize Brazil's international forest and landscape restoration commitments, a pre-competitive R&D program for native species will be needed. Even though this strategy must take into account the enormous challenges of the tropical forest economy, growing native tree species in silvicultural systems may represent an excellent business opportunity. To make this possible, it is necessary to combat illegal timber trade, effectively regulate and enforce the laws, develop reliable data to support decision-making, and create incentives for a competitive market.

Figure 1 | Characterization of Degradation of Brazilian Pastures

Level 1

Light Degradation

Pasture still productive but already with bare soil areas and weed infestation. After grazing, regrowth is slow. Support capacity is about 20% less than that of undegraded pasture.

Photo: Moacyr Dias-Filho

Level 2

Moderate Degradation

Increase in weed infestation or in the percentage of soil discovered in relation to Level 1. Support capacity is about 30 to 50% less than that of undegraded pasture.

Photo: Roberto Reis

Level 3

Strong Degradation

Excessive increase in weed infestation or in the percentage of soil uncovered in relation to Level 2. Support capacity is about 20 to 40% less than that of undegraded pasture.

Photo: Roberto Reis

Level 4

Very Strong Degradation

Predominance of uncovered soil, with evident signs of erosion. Proportion of forage very low or nonexistent. Support capacity is less than 20% compared to undegraded pasture.

Photo: Mailada Lyra

Source: Adapted from Dias-Filho 2017.

The Legal and Institutional Forestry Framework in Brazil

A comprehensive international legal and institutional framework enables action for avoiding and reducing land degradation, promoting restoration of ecosystems, and reducing carbon emissions. Several multilateral agreements within the United Nations (UN) have provisions to avoid, reduce, and reverse land degradation, including:

- Convention to Combat Desertification (UNCCD), acting mainly in those countries experiencing serious drought and/or desertification, particularly in Africa;
- Framework Convention on Climate Change (UNFCCC), with the goal of stabilizing GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system;
- Convention on Biological Diversity (CBD), with the goals of biological diversity conservation, sustainable use of the components of biological diversity, and fair and equitable sharing of the benefits arising out of the utilization of genetic resources;

- Convention on Wetlands (Ramsar Convention), an intergovernmental treaty, provides a framework for the conservation and wise use of wetlands and their resources, and

- 2030 Agenda for Sustainable Development, and its 17 sustainable development goals (SDG).

Brazil is a signatory to all relevant treaties and agreements that address forests, biodiversity, and climate protection. Other governmental initiatives include bilateral agreements, programs, and transnational alliances with non-state actors. For instance, Brazil committed to the Bonn Challenge and Initiative 20x20 and has adopted the Forest and Landscape Restoration strategy to meet its 12 Mha of restoration and reforestation targets by 2030 (PLANAVEG 2017). The Atlantic Forest Restoration Pact (PACT), established in 2009 as a multi-stakeholder movement to restore 15 Mha of degraded/deforested lands in the Atlantic Forest biome by 2050, pledged 1 Mha towards the 2020 Bonn Challenge (Crouzeilles et al. 2019). From 2011 to 2015, an estimated 700,000 ha of native forests in the Atlantic Forest was mapped under natural regeneration, and a total area 1.35–1.48 Mha should be under natural regeneration by 2020 (Crouzeilles et al. 2019).

Environmental regulation has focused on curbing deforestation and protecting biodiversity. The legal framework relevant to the forest sector that allows planting of trees for economic purpose using both native and exotic species includes the following:

- Law 12,651 passed in 2012 to alter the Forest Code of 1965 and establish NVPA, also known as the New Forest Code, and

- The National Agricultural Policy on Planted Forests (Decree 8,375/2014).

Even though there are numerous and detailed forest regulations in Brazil, several gaps and uncertainties persist. There are many barriers to compliance with the NVPA, including lack of enforcement and incentives, land tenure issues, legal insecurity, and repeated efforts by interest groups to reduce the effectiveness of the law through Congress. Although the NVPA addressed some of these issues, it remains controversial and uncertain because of the need for regulation at a subnational level to secure its enforcement and implementation. Several attempts by the federal government and the national Congress to modify the NVPA in 2019 may create more uncertainty over the effectiveness of this law.

This situation encourages illegal and unsustainable exploration of natural forest resources, resulting in unfair competition with landowners, entrepreneurs, and investors who follow the rules. Illegal timber is sold in the market as legal timber (Brancalion et al. 2018) at lower prices that do not internalize costs such as labor and taxes. In general, illegal timber production does not provide formal employment, avoids payment of taxes and fees, and has high social and environmental impact. In the current situation, lawbreaking loggers are rewarded for not complying with legal requirements.

The NVPA demands that all farmers register their rural properties in the Rural Environmental Registry (CAR, from its initials in Portuguese), with all information and environmental data georeferenced (Box 2). As of July, 2021, there were almost 6.3 million properties registered in the National Rural Environmental Registry System (SICAR, from its initials in Portuguese),[1] comprising more than 630 Mha. Another requirement is the adherence of landowners to the Environmental Regulation Program (PRA, from its initials in Portuguese), a state-level instrument that rules how the landowner with liability (e.g., land deforested beyond the legal limits) can restore native vegetation *in situ* or through trading schemes, such as the Environmental Reserve Quota (CRA, from its initials in Portuguese).

The NVPA is potentially the most effective instrument to address climate change mitigation and adaptation in the land-use sector in Brazil, but its implementation is still lagging. Moreover, it is crucial to improve the legal framework at the federal and state level to reduce the economic and regulatory burden on farmers who want to reforest degraded lands with native species for economic use (Valle et al. 2020).

Nonetheless, the NVPA provides the enabling framework for large-scale forest and landscape restoration using native species, not only as a policy requirement but also as a viable business opportunity. If the NVPA's requirements are met, forest and landscape restoration and reforestation with native species could reach up to 11.4 Mha (Walter et al. 2018).

BOX 2 | THE BRAZILIAN RURAL ENVIRONMENTAL REGISTRY

The Native Vegetation Protection Act (NVPA) of 2012 (Law 12,651/2012) established the Brazilian Rural Environmental Registry (CAR, from its initials in Portuguese) as an instrument for environmental monitoring. CAR registration is mandatory and self-declared for all rural properties. Landowners need to provide georeferenced delimitation of property boundaries and of all legally protected areas, such as Permanent Preservation Areas (APPs, from its initials in Portuguese) and Legal Reserves (RL, from its initials in Portuguese). The CAR system already plays a major role in the implementation of the Law 12,651/2012, known as the New Forest Code. Recent studies, such as Azevedo et al. 2017, found that credit and market restrictions provided strong incentives for producers to join the CAR system. However, according to the authors' findings, its implementation did not contribute significantly to reducing deforestation from 2008 to 2012. The instrument still needs further regulation to prevent deforestation and ensure full compliance with the NVPA restoration requirements (Azevedo et al. 2017). Registered producers have little incentive to stop deforestation, due to inconsistent monitoring and lax CAR enforcement, and minimal risk of detection or penalties. To date, the incentives for full compliance with the code remain weak, whereas costs remain substantial.

WOOD: A PROMISING MARKET

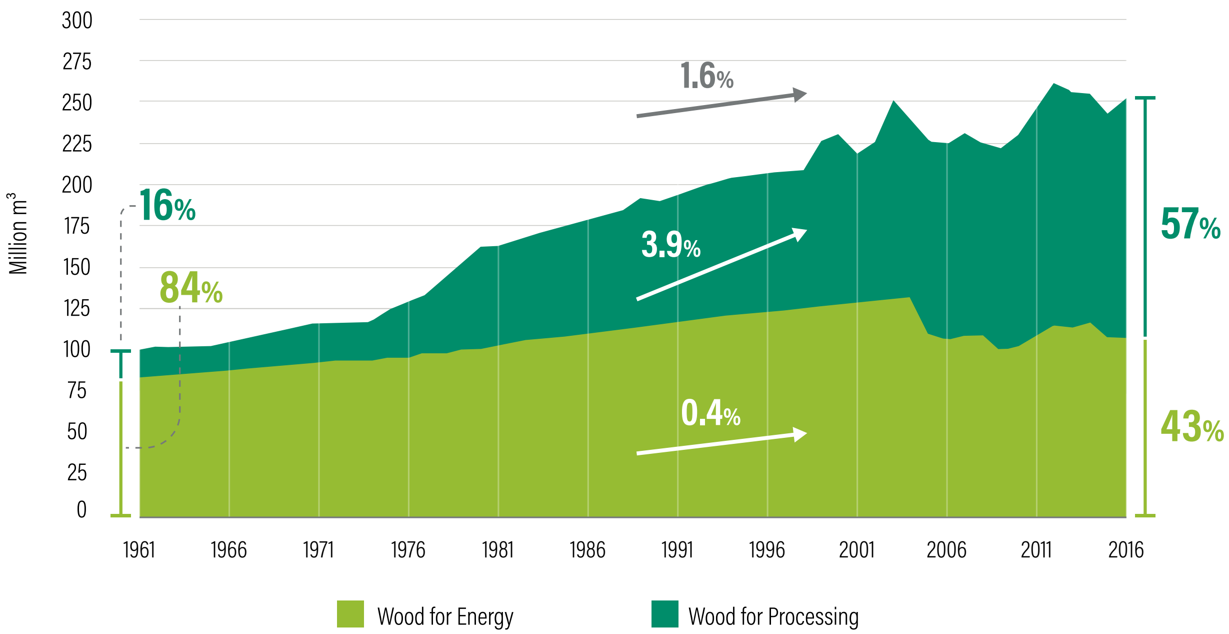
Global wood consumption has been rising in the last decades, representing a cumulative 48 percent increase in global consumption between 1961 and 2016. Under a business-as-usual scenario, Brazil could double its current wood production, reaching around 500 million m^3 by 2050, when global wood consumption could reach 5.4 billion m^3 to 6.7 billion m^3. However, a low-carbon scenario projects that Brazil could also become one of the main players in the world, producing 1 billion m^3 by 2050.

Past Trends and Forecasts for Wood Production in Brazil

Between 1961 and 2016, wood production in Brazil rose by 150 percent, from 100 million m^3 to 250 million m^3 per year (Figure 2). Rolim et al. (2019) pointed out that timber production in Brazil has shifted in recent years away from wood for energy toward industrial roundwood, used for bridge girders, utility service poles, building poles, retaining walls, or as raw material to be processed into industrial products such as sawn wood, panel products, or pulp (Figure 2).

As a result, the source of wood has shifted somewhat from natural forests to planted forests. Many factors could explain this shift, but perhaps the most important is the increased profitability of planted forests, mostly due to silviculture research and development and fiscal incentives (Rolim et al. 2019).

Figure 2 | Production and Uses of Wood in Brazil, 1961–2016

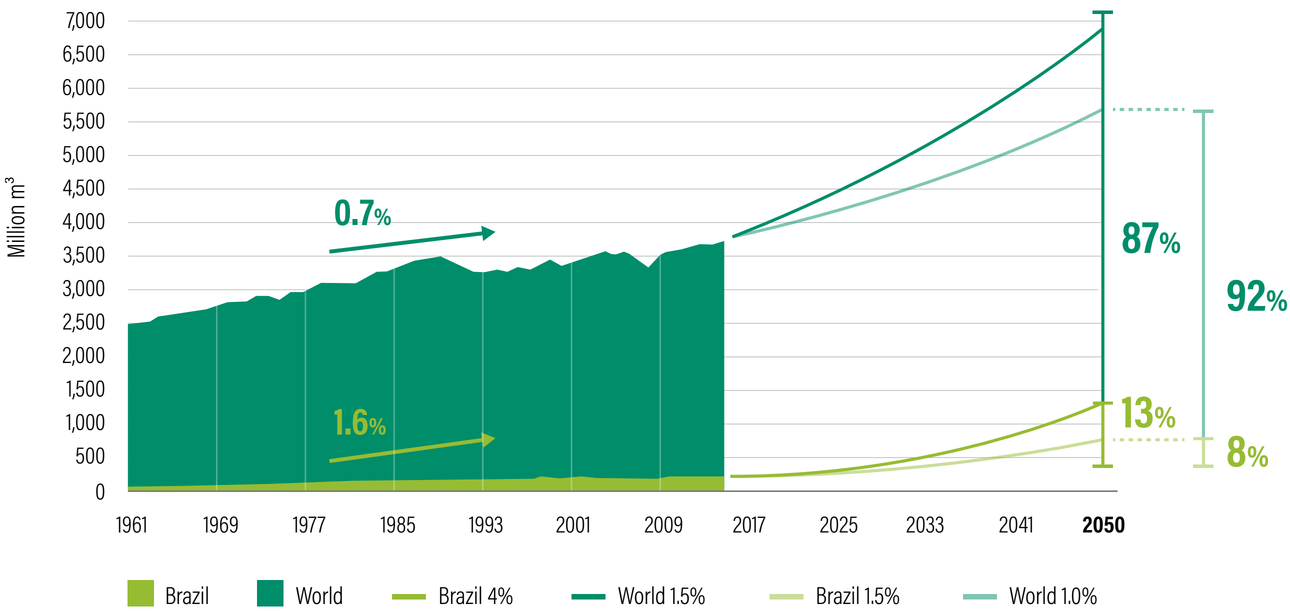


Notes: Growth rates in compound annual growth rate (CAGR). Overall, compound annual growth rate was 1.6% per year over the last 55 years. Arrows represent CAGR over the period, and percentages on the y axis represent the share of wood use.

Source: Rolim et al. 2019.

Domestic and international demand can drive the development of sustainable businesses using planted native tree species. Between 1961 and 2016, global wood consumption rose by a historic 0.7 percent annually (FAO 2017), and by 1.6 percent annually in Brazil (IBGE 2017), representing a cumulative 48 percent increase in global consumption over the period (Figure 3). Based on scenarios from WWF (2014), New Forests (2017), WBCSD (2015), and FSC and Indufor (2012), global wood consumption in 2050 could reach 5.4 billion m^3 to 6.7 billion m^3. Under a business-as-usual scenario (assuming a compound annual growth rate, that is, a CAGR of 1.5 percent), Brazil would produce around 500 million m^3 by 2050 – double its current 250 million m^3 per year for fuel and manufacturing (industry supply) – and be responsible for 8 percent of the global wood supply (Figure 3). Brazil's domestic wood consumption has been growing at least twice as fast as the global average. Moreover, if policy incentives were in place to increase the sequestration of carbon, silviculture might greatly expand in many areas of Brazil, leading, among other benefits, to increased wood production. Brazil could become one of the main players in the world by 2050, producing 1 billion m^3 of wood and supplying 13 percent of the world's timber. This assumes a CAGR of 4 percent in Brazil compared to BAU (business-as-usual) growth rate of 1.6 percent (Rolim et al. 2019).

Figure 3 | Historic and Projected Wood Production in Brazil and the World, 1961–2050



Notes:

0.7% - historical annual increase in global wood consumption during the period from 1961 to 2016

1.6% - historical annual increase in Brazilian wood consumption during the period from 1961 to 2016

4% - projected annual increase in Brazilian wood consumption, 2016 to 2050, under a scenario of greater incentives for carbon sequestration

1.5% - projected annual increase in world wood consumption, 2016 to 2050, under a business-as-usual (BAU) economy scenario

1.5% - projected annual increase in Brazilian wood consumption, 2016 to 2050, under a BAU economy

1.0% - projected annual increase in world wood consumption, 2016 to 2050, under a BAU economy

8% - Share of Brazilian wood in world supply under a BAU economy (1.5% CAGR)

13% - Share of Brazilian wood in world supply under a scenario of greater incentives for carbon sequestration

CAGR = compound annual growth rate.

Sources: Rolim et al. 2019, using historical data from FAOSTAT (2017) and ITTO (2018). Projections based on scenarios from WWF (2014); New Forests (2017); WBCSD (2015); FSC and Indufor (2012).

Sources of Brazil's Wood Production

In 2019, 539 Mha of Brazilian lands were covered by forests (Souza Jr. et al. 2020) and approximately 310.5 Mha (or 58 percent) were registered public forests (federal, state, and municipal forests). However, only 1.02 Mha or 0.32 percent are federal forest concessions (MAPA/SFB 2019). Forest concessions are a form of public forest management – legally stipulated in 2006 – that allow the federal government, states, and municipalities to grant, through bidding, the legal right for a private entity to manage public forests in order to obtain products and services (MAPA/SFB 2019). Currently, Brazil has 67 National Forest Areas (FLONA, from its initials in Portuguese), covering an area of 17.8 Mha (ICMBIO, 2019) and 17 federal concession contracts in operation (MAPA/SFB 2019).

Two states in the Amazon region – Amapá and Pará – also have state forests. According to MAPA/SFB (2019), the State of Pará has already eight concession contracts in two places (Mamur-Arapiuns Lands with three contracts, and Paru State Forest with five contracts), totaling approximately 433,000 ha, and the State of Amapá has an area of 67,500 ha under forest concession in the Amapá State Forest.

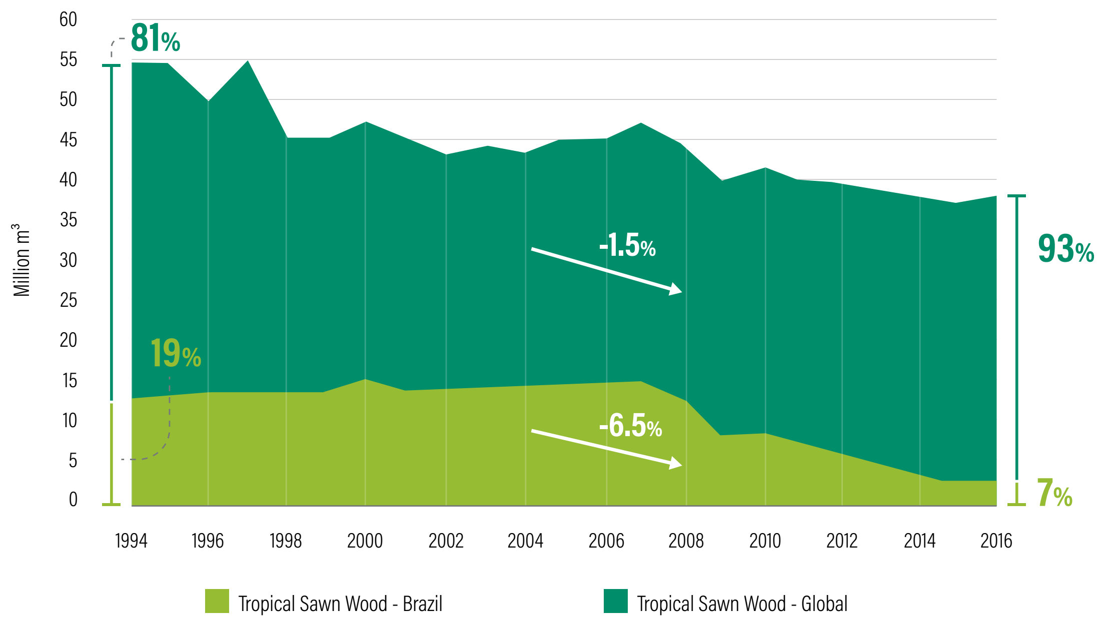
In 2018, the total volume of timber production from forest concessions was only 221,657 m^3 (MAPA/SFB 2019). All concessions were located in a FLONA. All activities permitted in a concession must be expressly mentioned in the contract and, in general, involve ecotourism (including visitation, accommodation, and sports); production of wood and residual woody material from logging of different species; and exploration of products of plant origin, such as fruits, oils, medicinal and ornamental plants, resins, etc.).[2]

The production of tropical sawn wood from silviculture of tropical native species is virtually zero to date (Rolim et al. 2019). The tiny production from native species plantations illustrates the immense pressure on natural tropical forests but represents a great opportunity to produce wood in a responsible manner using native tree species in silvicultural systems and forestry concessions. Based on past production trends and future drivers of wood production, the sustainable management of natural forests under concession and silviculture using native tropical tree species could meet the demand for tropical sawn wood (Rolim et al. 2019).

Prospects for Brazilian Tropical Sawn Wood

Demand for tropical tree species faces great uncertainty because of the illegal wood trade. It is estimated that 50 percent of all traded tropical wood in the world comes from illegal origins, a rate that may reach up to 70 percent in the Brazilian Amazon rainforest (BVRio Institute 2016). Legal production of sawn wood from the Brazilian Amazon rainforest fell by 77 percent from 1994 to 2016 (Figure 4). Globally, tropical sawn wood production also decreased 28 percent in the same period. Tropical wood production has been falling ever since the economic crisis of November 2008. However, on the demand side, relatively stable prices indicate that demand persists. This paradox may be explained by stable or rising demand being met in part by illegal unrecorded supply.

Figure 4 | Legal Production of Tropical Sawn Wood, Globally and in Brazil, 1994–2016



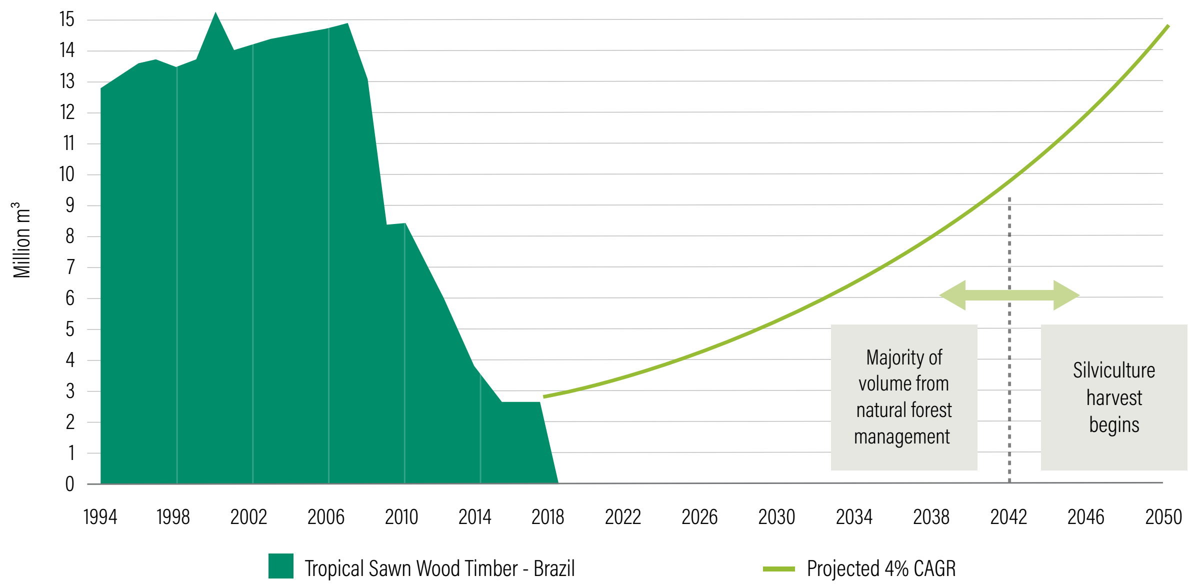
Source: Rolim et al. 2019.

The decline in Brazil's production and its small contribution to global supply relative to its potential can be explained by the following factors:

- Complexity of the due diligence system required to determine the legality of wood;
- Low efficiency of the manufacturing process. In Brazil, data from wood conversion – also called processing yield – are relatively scarce and variable. On average, they indicate 20 percent efficiency for hardwood timber conversion to lumber, and 50 percent for softwood lumber conversion. In the Amazon, processing yield is traditionally between 30 percent and 40 percent (Consufor n.d.);
- Unfair competition with illegally harvested wood, which undercuts the price of legal wood, and;
- Substitution of wood by other materials such as plastic.

Figure 5 presents our scenario for tropical sawn wood production in Brazil in 2050. We assumed conservatively that by 2050 the demand for sawn wood could reach the same volume registered in 2000, that is, 15 million m³. By spreading this increase within the time period, we projected a 5.1 percent CAGR in supplies from natural forest concessions and forestry plantations with native tropical species.

Figure 5 | Historic Trends and Projection for Tropical Sawn Wood Production in Brazil, 1994–2050



Notes: Assumes Brazilian demand for sawn wood rises by an average CAGR of 5.1% by 2050. The dotted line indicates when timber from silviculture of native species will start production, assuming trees are planted today and considering their production cycle. Until then, natural forest management and concessions will be the main source of tropical sawn wood. Under this scenario, with a conversion rate from timber to lumber of 35%, production of roundwood could reach 43 million m³ per year by 2050.

CAGR = compound annual growth rate.

Source: Rolim et al. 2019.

In line with the rotations and maturity cycle of silviculture of native species, we assumed that the largest volume of wood from this source would be supplied within 25 to 35 years of planting when the trees reach a diameter of 30 to 40 centimeters. Based on our assumptions on the demand and yield and production cycle, we estimated the potential sawn wood supply (based on the assessed demand above) from forestry with native tropical species in Brazil at 5 million m³ per year by 2042. We also assumed a conversion rate of 35 percent applied to production of sawn wood, which results in a volume of 14 million m³ of logs a year. Rolim et al. (2019) estimated that forestry with native tree species may generate an average annual increment of 10 m³/ha/year of wood logs in rotation cycles of 25 to 35 years. In our scenario, based on the yield curves described by Rolim and Piotto (2018), the scale of forestry with native species to meet this production level would be 1.4 Mha.

It is important to highlight that the estimated area is highly sensitive to the assumptions in the above scenario, such as conversion rates of roundwood to timber, yields, ratio of wood production between natural forestry management and silviculture of native species, substitution of wood products, and incentives for carbon sequestration via tree planting (Rolim et al. 2019).

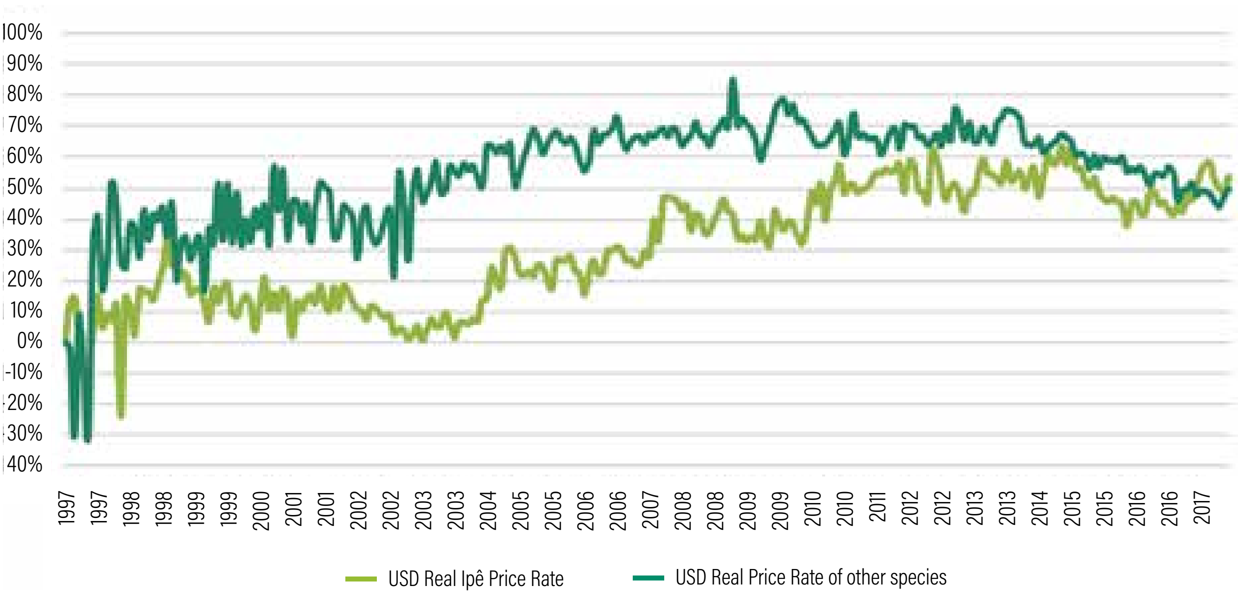
This scenario may be considered conservative, and depends on the future development of forestry concessions and management in Brazil. However, it indicates that silviculture of native species for wood production could account for at least 10 percent of targeted forest and landscape restoration and reforestation for Brazil's NDC, without disrupting the balance of the global tropical wood market.

Tropical Sawn Wood Prices

The exports market for sawn wood showed real increases in prices in USD deflated by the Consumer Price Index (CPI) (Figure 6).

The price index for sawn wood is particularly important to understand the demand for this product. The inflation measured by CPI in the United States during the period, was approximately 88 percent.

Figure 6 | Index of Real Increase Export Prices of Tropical Sawn Wood, 1997-2017



Note: Based on figures from ComexStat (2018).[3]

Source: Calculations and graph developed by authors.

All species had price appreciation in real terms of between 2.0 percent and 2.2 percent per year (Table 2). Therefore, the increasing export price index of export wood reflects favorably on the economic viability of silviculture of native species. In order to define the value of the forestry assets, an understanding of the market's size and the relationship between trade prices and volume, exchange rates, and volatility is needed.

Table 2 | Appreciation of the International Market for Ipê Wood (*Handroanthus* sp.) and Other Species, in USD

SPECIES	IPÊ	OTHER SPECIES
Real Increase in Prices from 1997 to 2017	53.7%	49.9%
CAGR	2.2%	2.0%

Note: Ipê is one of the most valuable native-tree species in Brazil. Based on data from ComexStat (2018)[3] and the Central Bank of Brazil (2018).[4]

CAGR = compound annual growth rate.

Sources: Developed by authors based on ComexStat (2018)[3]; Central Bank of Brazil (2018)[4]; and IBGE (2017).

Those variables shed light on the risks of investments in forestry with native species. There is great discussion concerning the different sources of risks to forestry with high-value commercial species and rotation period longer than 25 years. Here, we focused on the commercial and financial aspects of projects. Prices collected from the international market showed a greater volatility in Brazilian *Real* (BRL) than in USD. This was due to exchange volatility (Table 3).

Volatility is the most important component in the analysis of return sensitivity. Since the main variables that affect return are price, productivity, and cost, the lower the volatility, the lower the risk of having returns below the cost of capital.

Table 3 | International Market Volatility Rates in BRL and USD

CURRENCY	USD		BRL	
SPECIES	Ipê	Others	Ipê	Others
ANNUALIZED VOLATILITY	28.0%	37.9%	36.5%	41.5%

Notes: Based on figures from ComexStat (2018).[3]

Source: Developed by authors.

Levers for a New Forestry Economy based on Silviculture of Native Species

Every real asset may be valued and monetized, so understanding the source of value is essential when investing and managing assets. Although there is a well-recognized methodology developed by The Economics of Ecosystem and Biodiversity (TEEB) initiative to assess ecosystem services, the value of natural capital is one of the greatest limitations in asset valuation methodology (TEEB 2010).

Among the main return drivers, productivity and prices are the most influential variables. The key determinants of risk and return on investments in silviculture of native species are:

- Land assets
- Liquidity
- Wood supply and demand
- Wood price
- Biological growth
- Climate catastrophes
- Fires
- Pests and diseases

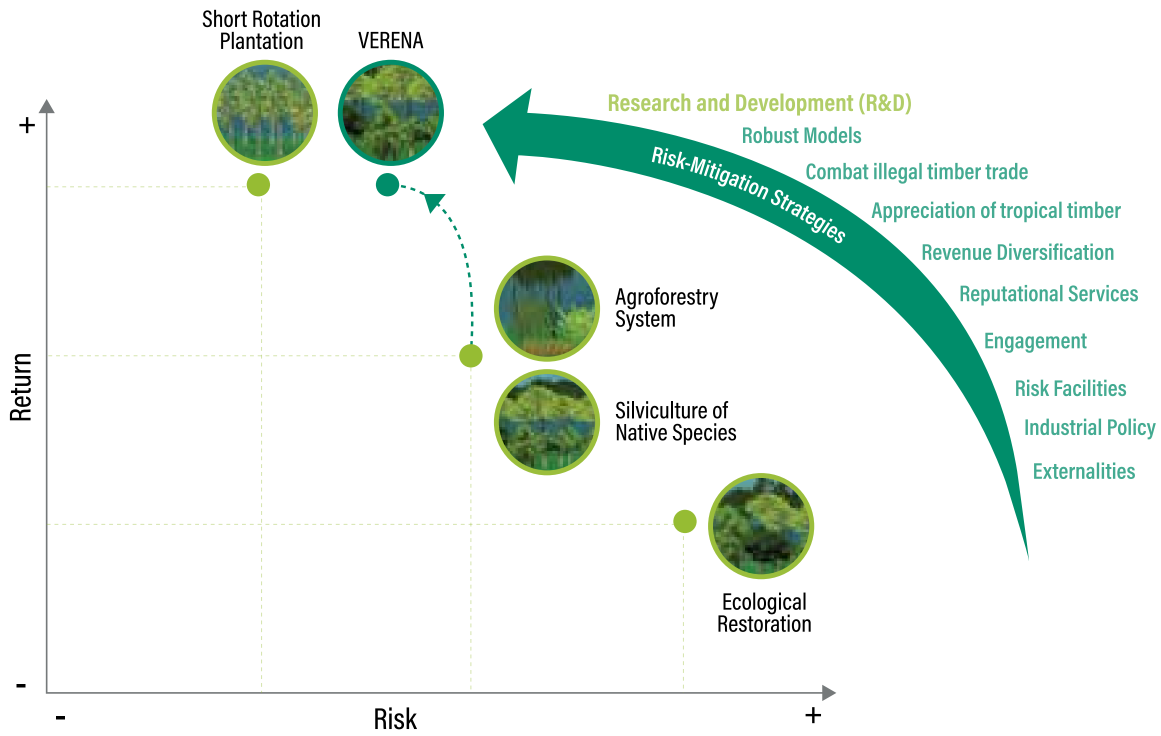
Because the price variable is defined by the market, investing in research and development to increase productivity is fundamental to maintaining returns over the medium and long terms. The great success of Brazilian agriculture and forestry sectors has always been linked to public and private investments in R&D, and the expectation is that the same dynamic will work with native tree species.

Capital is remunerated in two ways: for the time value of money and the risk. Thus, there is a correlation between risk and return. Therefore, projects with different typologies, periods, and risks can be compared. For example, it is possible to compare mainstream silviculture (eucalyptus), ecological forest and landscape restoration, and silviculture of native species.

Figure 7 represents the general perception of risks and returns related to different forestry asset classes. Currently, short-rotation plantations (used for pulp and paper) are perceived to have high returns and low risks. Ecological forest and landscape restoration and the assets studied by the VERENA Project (i.e., silviculture of native species and agroforestry systems) are perceived as having lower returns and higher risks.

To improve this risk and return perception, it is necessary to invest in risk-mitigation strategies. For example, the importance of R&D must be emphasized for investment in technologies to increase productivity and reduce the rotation period, creating more value per unit of produced biomass and helping to increase the future supply of wood. R&D for adapting productive systems to climate change is another example.

Figure 7 | Perceived Risks and Returns of Several Forestry Asset Classes and 10 Risk-Mitigation Strategies to Increase Returns on Silviculture of Native Species and Agroforestry System



Note: R&D is highlighted because it one of the most important risk-mitigation strategies.

Source: Developed by authors.

THE VERENA PROJECT

This section presents the VERENA Project and emphasizes activities carried out from 2016 to June 2019, with data from 2016 to 17.

Conceived in 2015 by WRI Brasil, the International Union for Conservation of Nature (IUCN), and the entrepreneur Roberto Waack, the VERENA Project was initially supported by the Children's Investment Fund Foundation (CIFF) and later by Good Energies Foundation (GEF).

The VERENA Project focuses on the financial and sustainability aspects of silviculture of native species and AFS in Brazil. It aims to foster private and public investments that will accelerate and scale up forest and landscape restoration and create sustainable business opportunities for investors and landowners. The project analyzes business opportunities to create a portfolio of attractive economic models for private investors and public funding, and to build a track record for this type of asset class.

The VERENA Project also aims to promote silviculture of native species and AFS as one of the most cost-effective natural climate solutions to address both climate change mitigation and adaptation (Batista et al. 2017b). It is an initiative that supports the implementation of forest and landscape restoration of degraded lands and forests at scale, as a contribution to the Bonn Challenge, Initiative 20x20, and AFR100 (Box 3).

BOX 3 | GLOBAL RESTORATION INITIATIVES

WRI supports forest and landscape restoration initiatives and fosters the New Restoration Economy by providing an international program framework for the development of strategies and tools to overcome knowledge gaps.

The **Bonn Challenge** (bonnchallenge.org) is a global effort to bring 150 Mha of the world's deforested and degraded lands into restoration by 2020, and an additional 200 Mha by 2030. What "counts" under the Bonn Challenge are non-binding pledges toward forest and landscape restoration. "Forest and landscape restoration" is the process of leveraging trees (e.g., allowing them to naturally regrow, actively planting them) to regain ecological functionality and enhancing human well-being across deforested or degraded landscapes. Currently, the Challenge has surpassed the 150-million-hectare milestone for pledges in 2017. More than 70 pledgers from more than 60 countries and regional initiatives committed to restore 210 Mha of degraded and deforested lands and will generate significant additional benefits in addition to reduction of greenhouse gas emissions.

Initiative 20x20 (initiative20x20.org), launched in Lima at the 2014 COP 20, calls upon Latin American countries to restore 20 Mha of degraded land in the region by 2020. At COP 25 in Madrid, member countries increased the pledges to bring under restoration 50 Mha of degraded land by 2030. Its goals include a reduction of 4.8 $GTCO_2e$ over 50 years and storing 0.23 $GTCO_2e$ in the first 20 years. The initiative has earmarked US$2.6 billion of private sector capital to invest in restoration projects in Latin America. Key stakeholders participate in the initiative as governments, technical partners, and impact investment funds.

AFR100 (www.afr100.org) is a country-led effort to bring 100 Mha of deforested and degraded landscapes across Africa into restoration by 2030. The initiative connects political partners in participating African nations with technical and financial support to scale up restoration on the ground and capture associated benefits for food security, climate change resilience, and poverty alleviation.

The VERENA Investment Tool

The project team, with the contribution from several organizations and experts, developed a business model framework (Batista et al. 2017c) to inform and guide investors, policymakers, and analysts interested in adopting silviculture of native species and AFS. The VERENA Investment Tool is like a calculator that can be used to assess the return on investments of any biological asset, such as silviculture, agrilculture, and/or agroforestry systems. The tool and its technical note (Batista et al. 2017b, 2017c) take the form of a spreadsheet that can be used to assess risk and returns from biological assets.

Aiming to help investors, WRI Brasil developed a series of five Portuguese-language videos, subtitled in English, demonstrating how to use the VERENA Investment Tool (Batista et al. 2017c). The tutorial shows how to use the tool, based on discounted cash-flow approach, to calculate the economic viability of silviculture projects with native species. The user is guided on how to complete the information cells on different screens (general information, cost/revenues, externalities, simulation, and reports).

Many publicly available valuation tools allow users to assess financial capital, but the VERENA tool goes further by allowing users the option of undertaking a complete valuation of the financial and natural capital of a wide range of asset classes. Natural capital is defined as the environmental goods and services provided by natural resources that make economic production possible yet are not currently priced in financial markets (OECD 2020).

Examples of natural capital included in the VERENA Investment Tool are carbon sequestration or removal and water services such as infiltration or erosion control. In addition, the tool allows users to factor in CRA easement, and sustainable management and economic use of the Legal Reserve. Carbon and water are the most commonly acknowledged assets, and some financial mechanisms exist to pay or compensate for them through voluntary markets or as part of companies' Corporate Social Responsibility programs.

In sum, the VERENA tool allows users to model situations when the production of goods and services imposes costs or benefits on others, which are not currently reflected in the market prices charged for the goods and services being provided. However, policies must be in place in order to monetize the benefits.

The tool uses an income statement approach (revenues – costs – opportunity costs) and enables users to apply the same income statement treatment to conventional (market) and natural (nonmarket) sources of revenue streams. Until policies are in place that monetize environmental goods and services such as carbon storage, these revenue streams cannot be fully realized. However, the assessment of natural capital is critical to encourage new markets, and to mobilize policymakers and investors to engage in forest and landscape restoration and reforestation (Batista et al. 2017b).

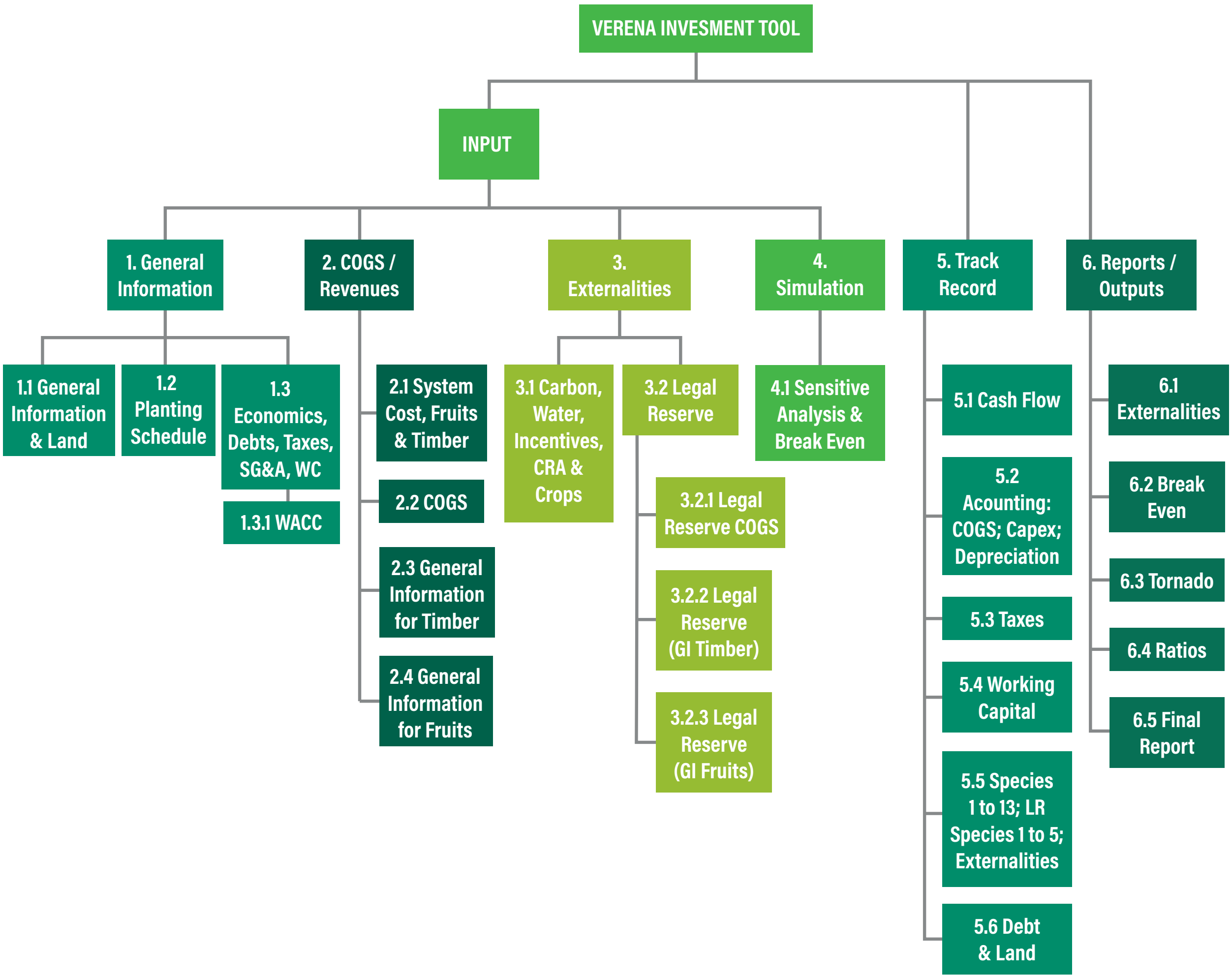
The VERENA Investment Tool can produce the following outputs:

- Assessment of risks and returns on investment in the main types of silviculture of native species and AFS underway in Brazil.
- Demonstration of the importance of tools and knowledge to farmers and investors who need to reduce risks and optimize return on their investment.

The VERENA Investment Tool can provide different insights tailored to different stakeholders. However, its use requires reasonable accounting and financial skills and a good knowledge of business.

The general inputs in the model are parameterized for the valuation of investment cases (Batista et al. 2017b). The model has an input section that feeds information to the income and cash flow statements. In the track record section, which is linked to the input, it is possible to see every calculation and the financial methods used, and the results are shown. Users must enter the variables at the input section to run the sensitivity analysis; the user then runs the simulation, and the results of the simulation are found in the output/report section. The information flow in the tool is shown in Figure 8.

Figure 8 | Flow of Information Used in the Discounted Cash Flow Model of the VERENA Investment Tool



Notes: 1. General Information and the Cost of Capital to Use as Discount Rate; 2. Inputs of Costs and Revenues; 3. Inputs of the Positive Externalities of the Natural Capital; 4. Simulations; 5. Track Record [all calculation records from inputs to reports]; and 6. Reports.

SG&A – selling, general, and administrative expense; WC – working capital; WACC – weighted average cost of capital; COGS - cost of goods sold; CRA - Environmental Reserve Quotas; GI Timber – general information for timber; GI Fruits – general information for fruits; CAPEX - Capital Expenditure; LR Species – Legal Reserve species.

Source: Batista et al. 2017b.

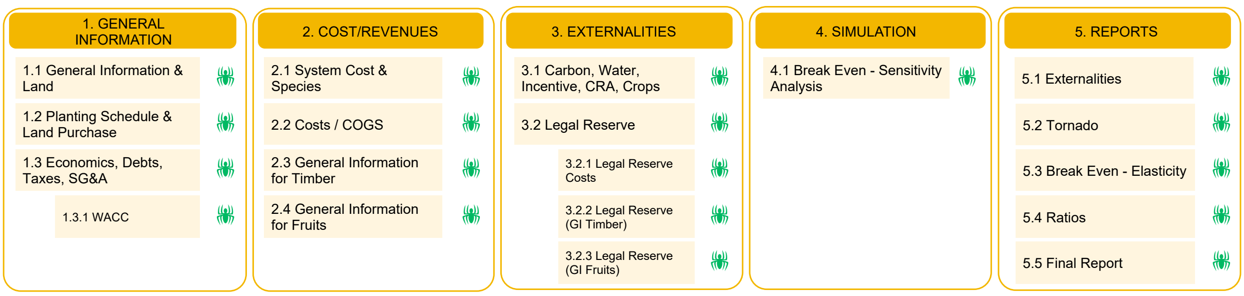
Assessing the Financial Viability of Silviculture of Native Species and Agroforestry Systems

Due to the timeframe and differing characteristics of biological assets, we analyzed the financial viability and risk-adjusted returns using a discounted cash-flow methodology (Damodaran 2012), as proposed by Batista et al. (2017b).

In addition, the value of assets derived from real economy (i.e., market) products with risk to return can be adjusted by the discount rate on revenues from natural capital. Such an adjustment to account for externalities is helpful to assess the potential impacts of higher prices for wood products that would be encouraged by policy and markets that support enhanced climate action, characterized by land-use activities that reduce emissions of greenhouse gases to the atmosphere or remove greenhouse gases from the atmosphere (Mountford et al. 2018). However, in this study we assumed conservative, low values for natural capital, and found only a small effect on risk-adjusted returns of the project. The VERENA business cases proved to be economically viable at current market valuations and the returns on natural capital did not influence the results and conclusions of this report.

The interactive tool has an input interface (Figure 9) with four sections of inputs and one section for reports and results (Batista et al. 2017b). The screen shot from the valuation model shows how to find the value of an asset with products in the real economy and, additionally, the income from natural capital—an externality. The economic viability of assets depends on the investor's characteristics, circumstances, timeframe, and needs.

Figure 9 | Interface of the VERENA Investment Tool with Asset Values Based on Risk-Adjusted Return (screenshot)



Source: Batista et al. 2017b.

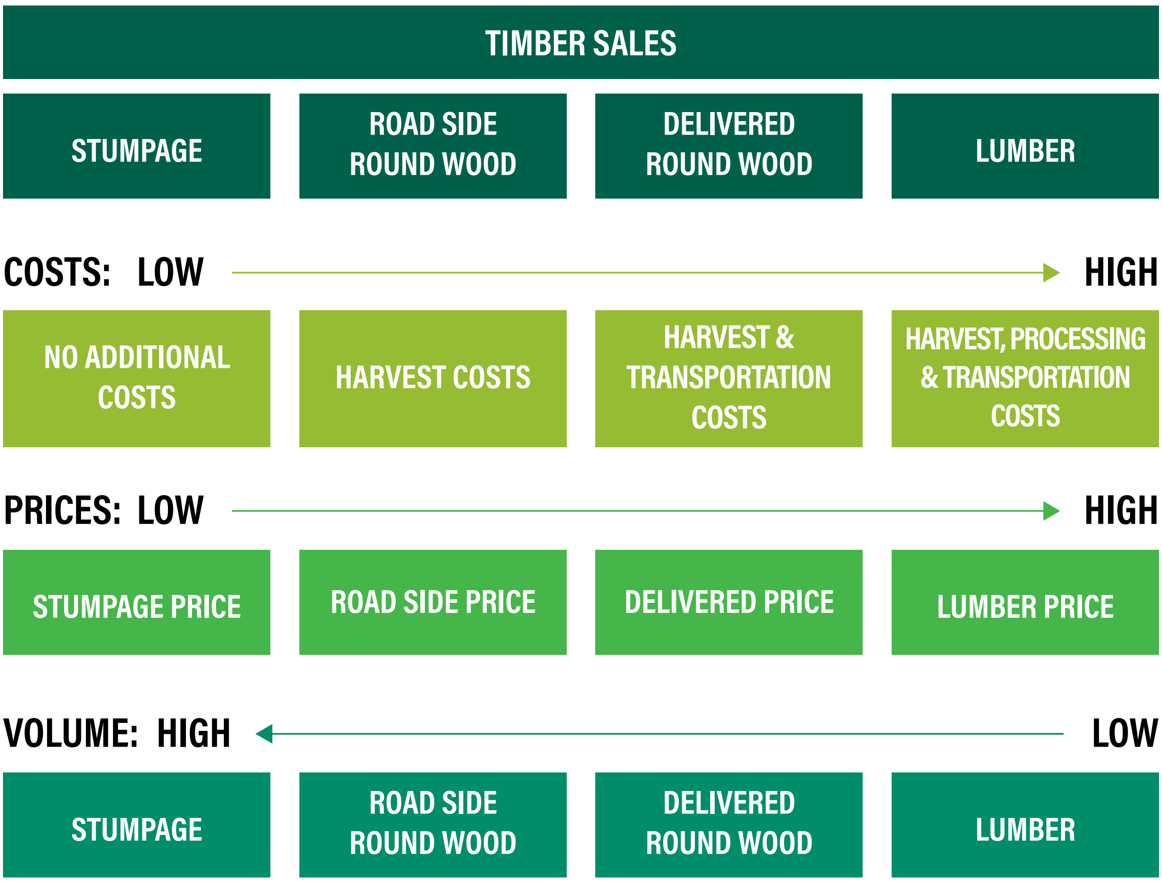
The externalities section (Figure 9) refers to the valuation of externalities from natural capital, which could create new streams of revenues. The valuation of ecosystem services proposed by TEEB, for example, could trigger investments in forest restoration and reforestation by adding new streams of revenues and increasing diversification for landowners. The VERENA Investment Tool allows the inclusion of carbon sequestration or removal, water services, CRA, easement, and sustainable management and economic use of the Legal Reserve. Different models and approaches were used to assess the externalities, which are described in the investment tool.

To conduct risk-return adjustments, we used the capital asset pricing model (CAPM) and the weighted average cost of capital model (WACC) as proposed by Markowitz (1952), Sharpe (1964), and Lintner (1965). We compared results to rates used by listed companies that report the fair value of their biological assets using International Financial Reporting Standards (IFRS 13[5] and IAS 41[6]). The natural capital externalities were assessed using other models of volume measurement, such as carbon storage, water infiltration, and avoided sedimentation, and were considered in the financial model from the standpoint of economic profit. Details of the methodology and assumptions used to calculate the cost of capital and the value of natural capital can be found in Batista et al. (2017b).

For valuation purposes, the modality of timber sales (i.e., the form in which timber is sold), costs, revenues, and the conversion rate of logs to sawn wood must be carefully considered (Table 4).

A summary of assumptions for data entry in the economic model for assessing the financial viability of silviculture of native species and agroforestry systems is presented in Table A1.

Table 4 | Relationship between Volume, Price and Costs, According to Modality of Wood Sale



Notes: Volume 100% - whole tree is sold; Assorted Volume – logs are set aside in the forest stand cut to certain lengths; Assorted 100% – logs are delivered in different assortment classes of product; Volume Converted to Lumber – the finished lumber product is sold.

Source: Developed by authors.

Silviculture of Native Species and Agroforestry Systems: The Importance of Business Case Studies

In the global capital market, there is a 100-year history of risk and return for different asset classes and openly traded companies (Batista 2018). There exists information on how these different asset classes relate to one another, to the economy, and to inflation. In other words, there is sufficient information for investment decision-making in terms of risk and return profile. There exist hundreds of years of records on Brazilian native tree species (D'Agostini et al. 2013; Dias 2018) and there have been some successful commercial examples (Oliveira and Andrade 2015; Moretti 2018). However, from a capital market perspective, there is no track record for this type of asset.

Identifying current business cases for native tree species and AFS in Brazil and other countries is essential to mobilize private and public investments and scale up the sector. In addition to analyzing the native species and AFS case studies, we used other references and proxies drawn from similar asset classes that have a long track record, such as reforestation with exotic species and natural forest management (typical in the Northern Hemisphere). In this report, the source was the S&P Global Timber & Forestry Index.[7]

The different assets analyzed by the VERENA project fall within the *forest continuum* (Batista et al. 2017b). The forest continuum (Figure 10) represents different types of land use involving trees, from primary forests to low-carbon agriculture, and provides a range of other environmental and ecosystem benefits (Norse 2012). Even if it is not possible to precisely differentiate the category of land use, it is important to understand that each one comprises a set of products and services with different potential to meet society's needs and demands. For example, a primary forest in the Amazon can contribute to the amount of rainfall in the main agriculture production areas in the mid-west and southeast regions in Brazil, which are important centers of food and fiber production. Agroforestry systems promote the management of native or exotic trees that maintain ecological function and forest structure, as part of an integrated system with annual or perennial crops. Low-carbon agriculture involves a crop-livestock-forest system, that combines, on the same property, different production systems such as those for grains, fibers, meat, milk, and bioenergy.

The assumptions used for data entry in the economic model for silviculture of native species, AFS, and benchmarks are found in Table A2. More details are in Batista et al. 2017b.

Figure 10 | Land-Use Typologies Studied by the VERENA Project

Source: Batista et al. 2017b.

THE VERENA PROJECT BUSINESS CASES

This section describes the 12 projects and investments that were selected as business case studies for the VERENA Project. The studies focus on cases of silviculture of native species and AFS; they include projects using a mix of different native species, a mix of native and exotic species, and monoculture of a native species. The project results are compared with benchmarks drawn from long-established cases of forestry and agriculture, for example, eucalyptus plantations and monocultures of cocoa, coffee, peach palm, citrus, banana, and manioc.

Selection of Case Studies

A series of three assessment workshops on "Silviculture of Native Species: Challenges and Opportunities for a New Forest Economy"[8] was held in Pará, Bahia, and São Paulo states between February and May 2016. The goals of the workshops were to share knowledge and experiences, gather information, and promote a debate on the main enabling factors necessary to promote a new forest economy using native species and AFS. A wide range of participants with different skills and experience attended the workshops, including investors, public banks, businesses, academics, government agencies, civil society, and multilateral agencies. At the end of the three workshops, 11 enabling factors were identified as underpinning a new forest economy based on native species and AFS.

1. Investment in R&D to improve the performance of native species is critical to increase the returns and reduce the risk to farmers and investors.

2. The economic modeling of existing and new business cases using credible and robust valuation tools under different conditions is crucial for building a track record of a new asset class such as native species and agroforestry systems.

3. The generation, dissemination, and uptake of knowledge and results through a network of partners and actors are critical actions in the process of promoting a new economy based on native species.

4. One of the benefits of native species, when compared with traditional exotic plantations, is the positive externalities (e.g., water quality and availability, biodiversity conservation, reduction of soil erosion, etc.). The ability to estimate and monetize those externalities can increase the returns and attractiveness to farmers and investors.

5. One of the challenges to accelerating and increasing the scale of forest and landscape restoration has been the quality and quantity of seeds and seedlings available. This issue becomes more critical when promoting silviculture of native species, which require high-quality genetic material for seed and seedling production.

6. As with any other economic activity, the development of the value chain and markets are critical to increase the value and return of the products and services and encourage farmers and investors from investing in native species.

7. Public policies are crucial to incentivize and support farmers and investors who make long-term investments in the silviculture of native species.

8. One of the main barriers to the viability of native species plantations has been competition from illegal logging of native species in natural forests and the consequent downward pressure on the price of timber. Reducing the level of illegal timber harvesting is crucial to establish a fair market for timber produced from silviculture of native species, as well as to protect natural forests and the biodiversity they contain.

9. Understanding the behavior of a wide diversity of native species in different regional contexts and edaphoclimatic conditions is critical for selecting the most suitable species and maximizing performance when establishing a silviculture project.

10. In order to establish and develop a new type of business, it is necessary to mobilize and allocate public and private finance. Because silviculture of native species is a new asset class, funding in the form of grants, investments, and loans is critical to overcome barriers, reduce risks, and support implementation on the ground.

11. Training, capacity building, education, and awareness-building on the important role of native species in generating economic, environmental, and social benefits at the local, national, and global levels are critical to obtaining the necessary political and financial support.

For the first phase of the VERENA Project, the priorities were R&D, economic modeling, and the valuation and monetization of positive externalities (water, carbon sequestration, biodiversity, soil health, etc.).

The 12 investment case studies were selected from a preliminary list of more than 30 potential cases from several regions of Brazil that were identified and mapped through our partner network, the Internet, reports, and articles. Selection criteria were developed in response to questions about commercial purpose, scalability of the project, possibility of replication, and positive externalities from natural capital:

- Is there a clear commercial purpose in terms of selling products to an established market?
- Are the cases scalable?
- Could they be replicated on degraded lands in other regions of Brazil?
- Do they have positive externalities from natural capital?
- Do we have access to credible input data to run the model?

Although all projects contribute to employment and income generation for members of local communities, social and economic gains were not evaluated in the first phase of the VERENA Project.

Expert participants at the workshop also made several recommendations to decision-makers to ensure the presence of the 11 enabling factors needed to increase the scale of silviculture of native species and agroforestry systems. The recommendations are summarized in Box 4.

BOX 4 | THEMES AND ACTION POINTS FOR DECISION-MAKERS TO PROMOTE AND INCENTIVIZE SILVICULTURE OF NATIVE SPECIES AND AGROFORESTRY SYSTEMS

1. Policy and Incentives:

- Improve and develop new markets for timber and non-timber products from native species
- Allow tax exemption for long-term rotation plantation
- Allow the economic use and management of native species in the recovery of Legal Reserves
- Incentivize the use of small watersheds as a reference unit for land management to guarantee the ecosystem's environmental functions and services, especially water resource conservation
- Employ ecosystem service models to estimate the correlation between forest growth and wood production, and soil quality and climate variables
- Adopt public and private sustainable procurement policies, for sourcing, negotiation, and strategic selection of goods and services from tropical silviculture
- Promote innovation within the forest supply chain to improve the economic and financial viability of forest management enterprises that go beyond primary product commercialization
- Exclude silviculture of native species from the current provisions that consider silviculture of exotic species a potentially polluting activity under the Environmental Licensing Law and National Environmental Policy regulations
- Provide incentives to encourage silviculture using native species, including longer grace periods and payment terms compatible with the production cycles of native species
- Implement policies and increase public and private finance, both domestic and international, that encourage low-carbon economic and social activities
- Ensure an R&D program for native species, including genetic improvement, production systems, and database and monitoring systems

2. Management:

- Use multifunctional planted forests with native and exotic species integrated with agriculture and/or livestock farming systems
- Develop and adopt criteria and indicators for sustainable forest management
- Improve wood harvest and transport systems by adapting machines to operate safely on lands with steep slopes and/or rocky terrain to minimize hydrological impacts and soil erosion

3. Design and Planning:

- Identify and select priority sites for silviculture of native species
- Conduct planning and study regional suitability for the implementation of agroforestry systems
- Support the development of seed and seedling supply to ensure the supply for large-scale forestry projects
- Prioritize local production hubs and cooperatives
- Promote collection and systematization of data and monitoring of results and performance
- Create an information management system that contains essential data on the market (prices, stocks, forecasts, etc.), climate, research, diseases and pests, products, and inputs for native species, impacts of climate change, etc.

Case Studies and Benchmarks

This section presents key data on the 12 business case studies, detailing the planting model followed and silvicultural information. Following the business case profiles, we set out the "traditional" forestry and agricultural systems that we use as benchmarks to compare the performance of silviculture of native species and AFS. The systems are listed in Table 5, and a summary of all data is presented in Table 6. The assumptions for the VERENA modeling and the data used in this report from the case studies and benchmark systems can be found in Appendix A (Table A1 and Table A2, respectively).

CASE 1 | AMATA

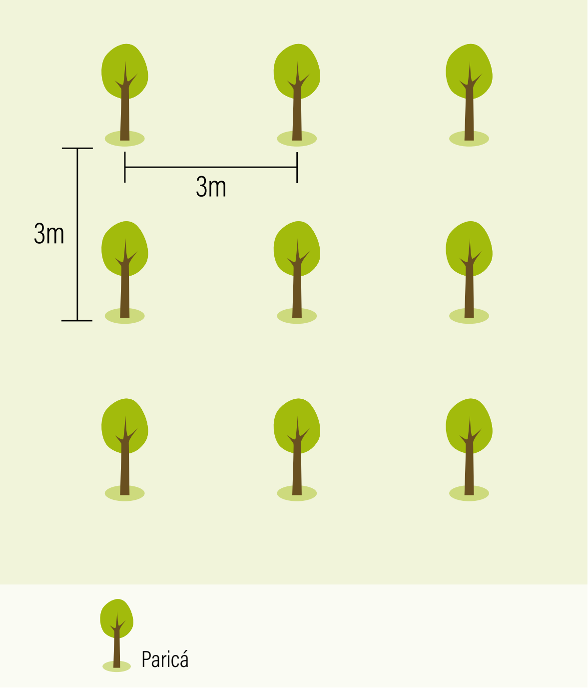
Amata is a company that supplies and sells certified wood of guaranteed origin, providing round wood, sawn wood, and wood for processing through low-impact management and forestry plantations.

Silvicultural information

- **Year of implementation:** 2008
- **Location:** Paragominas – Pará State
- **Forest type:** Monoculture reforestation with native species aiming to restore degraded areas
- **Planted area:** 3,991 ha
- **Species:** Paricá (*Schizolobium amazonicum*)
- **Planning horizon:** 7 years

Planting model

- Trees/ha: 1,111
- Even-aged stand evaluated
- Manually planted trees
- It has 76 operational activities, aiming at seedling preparation, planting, soil preparation, soil fertilization and liming, pest, and disease control, thinning, and harvest.
- Seedlings supplied by third-party, seed-germinated nurseries.
- Paricá wood has a density of 0.311 g/cm³ and is used in the plywood industry, sold in layer sheets of high-aggregated value to the plywood industry and the inner layer to the laminate industry in southern Brazil.



Environment: Paragominas (PA) has a tropical climate (Am – tropical monsoon climate).[9] Significant rainfall occurs during most months of the year, with only a short dry period. The average annual temperature is 26.6ºC, and annual average rainfall is 1,805 mm.

CASE 2 | SYMBIOSIS

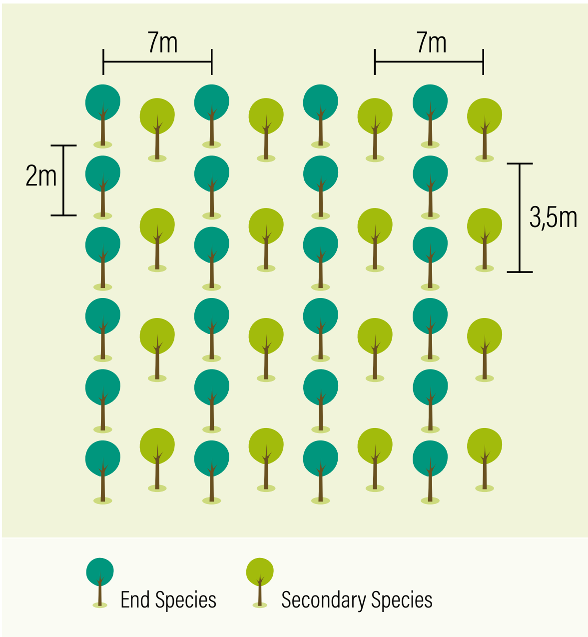
Symbiosis is a Brazilian company active in the forestry industry and focused on investments and operation. It transforms degraded areas into forest production stands, with species from the local biome.

Silvicultural information

- **Year of implementation:** 2011
- **Location:** Porto Seguro – Bahia State
- **Forest type:** Reforestation with 26 different native species
- **Planted area:** 803 ha
- **Planning horizon:** 36 years for main species and 24 years for secondary species.

Planting model

- Accessory species: for wood production of high aggregated value.
- End species: for wood production of higher aggregated value.
- All seedlings are obtained from a self-owned nursery.
- Forest cycles: 36 years for end species, manually planted in a density of 833 plants/ha, and 24 years for secondary species, manually planted in a density of 555 plants/ha.
- Plantations combine four to six species per plot, separated in rows.
- Forestry management includes thinning and enrichment, and 52 operational activities.
- Its production is for trade in the industry of valuable sawn wood and furniture production.



End Species

Jacarandá da Bahia (*Dalbergia nigra*)	Gonçalo Alves (*Astronium concinnum*)
Yellow peroba (*Paratecoma peroba*)	Vinhático (*Plathymenia foliolosa*)
Aderne (*Astronium graveolens*)	Louro pardo (*Cordia trichotoma*)
Jenipapo (*Genipa americana*)	Pink jequitibá (*Cariniana legalis*)
Red angico (*Parapiptadenia pterosperma*)	Ipê amarelo (*Handroanthus serratifolius*)
Angico curtidor (*Anadenanthera peregrina*)	Peroba-rosa (*Aspidosperma polyneurum*)
Sucupira (*Bowdichia virgilioides*)	Pau-brasil (*Caesalpinia echinata*)
Ipê-Amarelo (Handroanthus serratifolius)	

Secondary Species

Red cedar (*Toona ciliata*)	African mahogany (*Khaya grandifoliola*)

Environment: Local climate is tropical (Af – tropical rainforest climate)[9] with significant rainfall throughout the year. Average annual temperature is 24.4°C and average annual rainfall is 1,624 mm.

CASE 3 | FAZENDA DA TOCA

Fazenda da Toca is a Brazilian company focused on organic production, including fruit, eggs, milk, and grains, and it is located on 2,300 ha. Its core principals are experimentation/innovation in agroecological practices and regenerative, diverse, and integrated production. Its pioneering spirit is emphasized, as well as its innovative use of tractors implemented to specifically develop large-scale agroforestry activities.

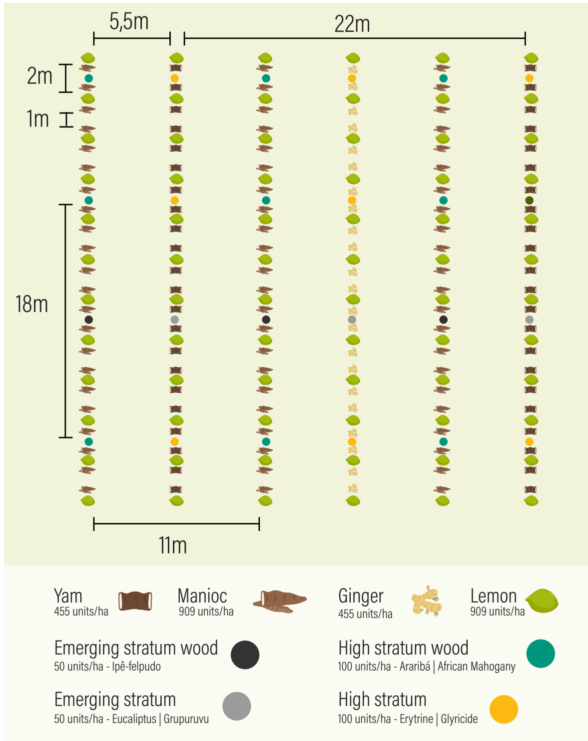
Silvicultural information

- **Year of implementation:** 2012
- **Location:** Itirapina – São Paulo State
- **Forest type:** Agroforestry system
- **Planted area:** 5 ha (2012) and 260 ha (2018)
- **Planning horizon:** 20 years

Planting model

- Manually plants citrus (lime) in mix with five timber species, three agricultural crops, and two fertilizing species.
- There are 84 operational activities, and they are managed by the principles of syntrophic agriculture with regenerative agroforestry practices of the soil-plant-water system.
- Production system for the food industry.
- Annual agricultural plantations remain in the system until year one, while short-cycle timber species remain until year eight and medium-cycle remain until the end of the planning timeframe.

Species	Plant/ha
African mahogany (*Khaya senegalensis*)	100
Araribá (*Centrolobium tomentosum*)	100
Tahiti lime (*Citrus latifolia*)	909
Eucalypt (*Eucalyptus urograndis)*	50
Guapuruvu (*Schizolobium parahyba*)	50
Ginger (*Zingiber officinale*)	455
Ipê-felpudo (*Zeyheria tuberculosa*)	50
Manioc (*Manihot esculenta*)	909
Yam (*Dioscorea spp.*)	455



Environment: The local climate is hot and temperate (Cwa – humid subtropical climate)[9] and has an average annual temperature of 19.6°C and average annual rainfall of 1,367 mm.

CASE 4 | TNC – CACAU MAIS FLORESTA

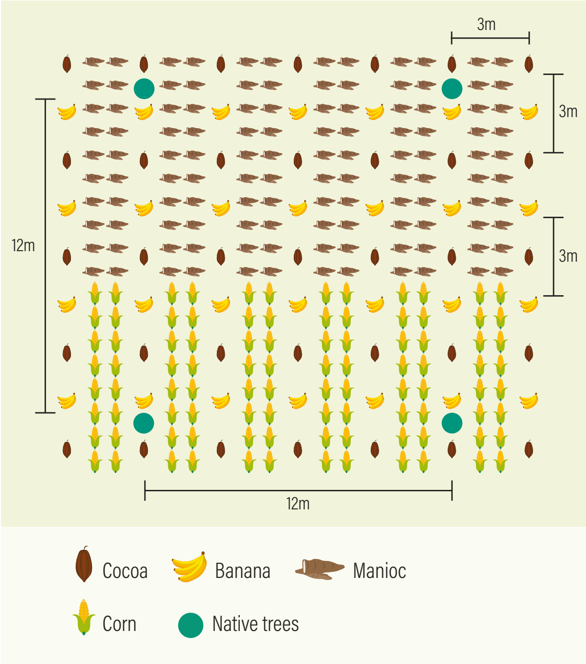
TNC is an international non-profit organization in the environmental sector. In Brazil, TNC focuses mainly on water security, sustainable agriculture and livestock farming, and infrastructure. One of its projects in Brazil is the Cacau Floresta Initiative.

Silvicultural information

- **Year of implementation:** 2014
- **Location:** São Félix do Xingu – Pará State
- **Forest type:** Agroforestry system
- **Planted area:** 312 ha
- **Planning horizon:** 20 years

Planting model

- Family production of cocoa in agroforestry systems as an alternative to deforestation and to forest reforestation in the south and southeast of Pará State.
- The plantation is manual and has 35 operational activities.
- Forestry management includes the introduction of annual crops for family subsistence and trade of the surplus.
- Maize and manioc stay in the system up to the first year and banana up to the seventh.
- Timber is planted for the harvesting of seeds and fruit, so wood is not considered a product.
- Fifty-two native trees are also planted for aesthetic reasons, and without economic valuation.



Species	Plant/ha
Cocoa (*Theobroma cacao*)	1,111
Banana (*Musa sp.*)	111
Manioc (*Manihot esculenta*)	3,300
Maize (*Zea mays*)	3,300
Andiroba (*Carapa guianensis*)	4
Amazonian mahogany (*Swietenia macrophylla*)	2
African mahogany (*Khaya ivorensis*)	5
Pequi (*Caryocar brasiliense*)	1
Brazilian nut (*Bertholletia excelsa*)	1

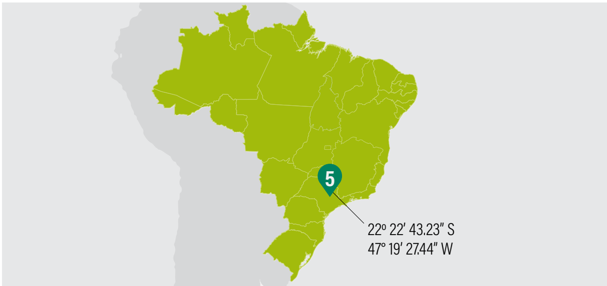
Environment: The local climate is tropical (Am – tropical monsoon climate)[9] and in most months, there is a significant amount of rainfall. Average annual rainfall is 2,035mm and average annual temperature is 25.2°C.

CASE 5 | FAZENDA SANTO ANTÔNIO

Fazenda Santo Antônio is a traditional coffee producer in the countryside of São Paulo State, innovating by planting native trees for trade under the guidance of experts from ESALQ/University of São Paulo and Bioflora.

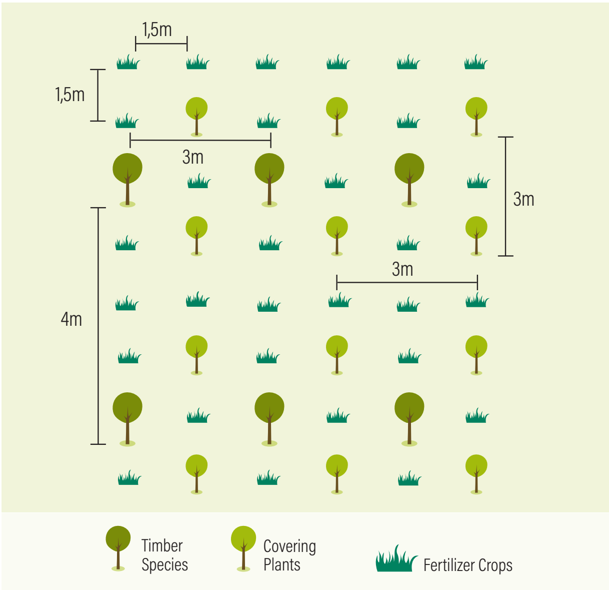
Silvicultural information

- **Year of implementation:** 2013
- **Location:** Araras – São Paulo State
- **Forest type:** Reforestation with multiple native species
- **Planted area:** 13 ha
- **Planning horizon:** 40 years



Planting model

- Its forest cycle is 40 years and has 37 operational activities.
- 1,111 plants/ha are manually planted; fertilizer crops are seeded and in the following year, timber trees are planted.
- The logic of this model follows the principles of forest succession used for ecological succession, which allows introduction of other native species and increases the resilience and success of the production system.
- The goal is to produce timber, and short-cycle trees are harvested from years 11 to 18, while long-cycle trees stay in the system for up to 40 years.



Valuable Timber Species

Red Angico (*Anadenanthera colubrina*)	Guaritá (*Astronium graveolens*)
Araribá (*Centrolobium tomentosum*)	Ipê-felpudo (*Zeyheria tuberculosa*)
Canafístula (*Peltophorum dubium*)	Purple ipe (*Handroanthus heptaphyllus*)
White jequitibá (*Cariniana estrellensis*)	Pink jequitibá (*Cariniana legalis*)
Louro-pardo (*Cordia trichotoma*)	Pau-marfim (*Gliricidia sepium*)
Pau-marfim (*Balfourodendron riedelianum*)	

Timber Species

Algodoeiro (*Heliocarpus popayanensis*)	Capixingui (*Croton floribundus*)
Crindiúva (*Trema micranta*)	Fruto-de-sabiá (*Acnistus arborescens*)
Fumo bravo (*Solanum granulosoleprosum*)	Ingá-banana (*Inga vera*)
Mata-pasto (*Senna alata*)	Mutambo (*Guazuma ulmifolia*)
Pau cigarra (*Senna multijuga*)	Pente de Macaco (*Apeiba tibourbou*)
Sangra D'água (*Croton urucurana*)	

Fertilizer Crops

Crotalária (*Crotalária sp.*)	Guandu anão (*Cajanus cajan*)
Milheto (*Pennisetum sp.*)	Nabo forrageiro (*Raphanus sativus*)

Environment: The local temperature is hot and temperate (Cwa – humid subtropical climate)[9] with much more rainfall in the summer than in winter. Average annual temperature is 20.3°C and average annual rainfall is 1,312 mm.

CASE 6 | FAZENDA JAÍBA I

Fazenda Jaíba I is a family company located in Jaíba's irrigation project, which is under concession of the Development Company of São Francisco and Parnaíba Valleys (CODEVASF, from its initials in Portuguese). The irrigated banana is typical to the region.

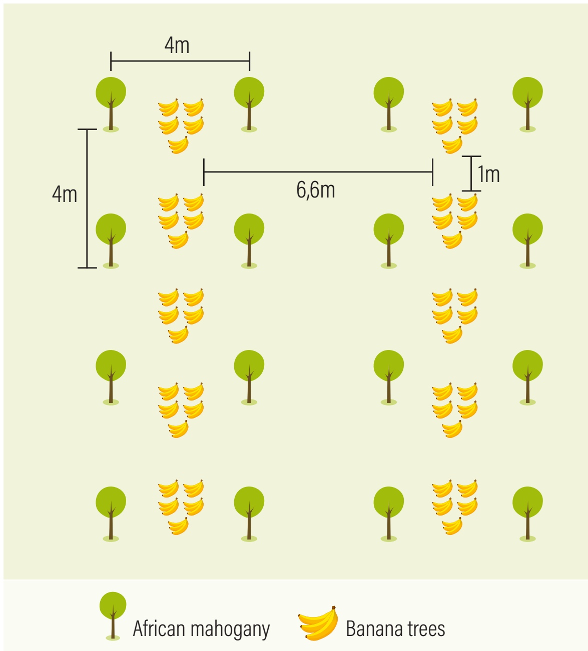
Silvicultural information

- **Year of implementation:** 2007
- **Location:** Jaíba – Minas Gerais State
- **Forest type:** Agroforestry system
- **Planted area:** 15 ha
- **Planning horizon:** 20 years
- Business model based on the distribution of quotas among the members of the family; a portion is destined for production of mahogany and banana

Planting model

- Planting is manual and irrigated, then water is not a restrictive factor.
- There are 39 operational activities.
- It is necessary to control the mahogany shoot borer (*Hypsipyla grandella*).
- Strategies of forestry management and the use of chemical insecticides is adopted.

Species	Plant/ha
African mahogany (*Swietenia macrophylla*)	625
Banana trees (*Musa sp*)	1,651



Environment: Local climate is tropical (Aw – tropical savanna climate)[9], with much more rainfall in the Brazilian summer than during winter. It does not rain in July, which is the driest month of the year. The greatest rainfall is in December, registering an average of 197 mm. Average annual temperature is 24.5°C and average annual rainfall is 834 mm.

CASE 7 | FAZENDA JAÍBA II

Fazenda Jaíba II is a family company located in Jaíba's irrigation project, which is under concession of the Development Company of São Francisco and Parnaíba Valleys (CODEVASF, from its initials in Portuguese). Irrigated banana production is typical to the region.

Silvicultural information

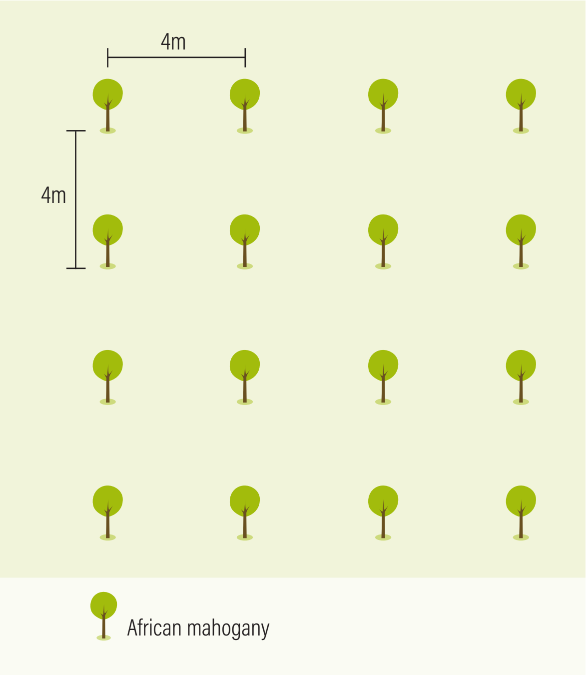
- **Year of implementation:** 2007
- **Location:** Jaíba – Minas Gerais State
- **Forest type:** Monoculture reforestation with native species
- **Planted area:** 5 ha
- **Planning horizon:** 20 years

Planting model

- Planting is manual and irrigated; water is not a restrictive factor.
- There are 39 operational activities.
- The mahogany shoot borer (*Hypsipyla grandella*) requires control using silvicultural management and chemical insecticides.

Species	Plant/ha
African mahogany (*Swietenia macrophylla*)	625

Environment: Local climate is tropical (Aw – tropical savanna climate)[9], with much more rainfall in the Brazilian summer than during winter. It does not rain in July, which is the driest month of the year. The greatest rainfall is in December, registering an average of 197 mm. Average annual temperature is 24.5°C and average annual rainfall is 834 mm.



CASE 8 | FUTURO FLORESTAL I

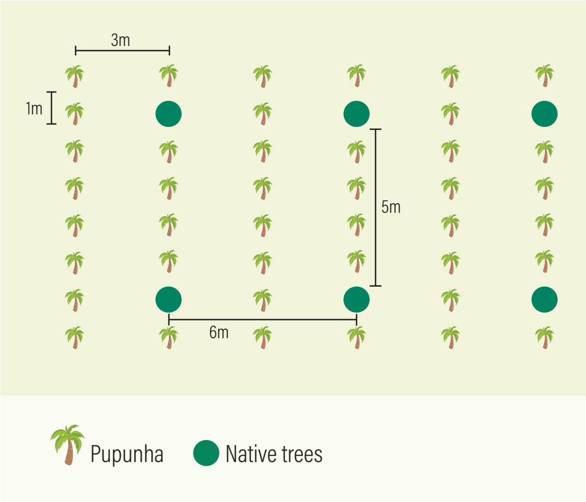
Futuro Florestal I is a Brazilian company that implements and manages plantations and also offers consultancy and assistance for plantations with native and exotic species, seeking sustainable commercial production of tropical hardwoods.

Silvicultural information

- **Year of implementation:** 2009
- **Location:** Garça – São Paulo State
- **Forest type:** Agroforestry system
- **Planted area:** 5 ha
- **Planning horizon:** 20 years

Planting model

- The introduction of peach palm (pupunha) consorted with native trees is a pioneering activity in the area.
- The harvest of pupunha begins midway through the second year and, from then on, it occurs four times per year.
- Timber species are thinned in years 7 and 14 and harvested at the end of the planning timeframe.
- Forty operational activities were mapped in this model.



Species	Plant/ha
Pupunha (*Bactris gasipaes*)	3013
Pink jequitibá (*Cariniana legalis*)	80
Guanandi (*Calophyllum brasiliense*)	80
Louro pardo (*Cordia trichotoma*)	80
African mahogany (*Khaya senegalensis*)	80

Environment: Local climate is tropical (Cfa – humid tropical climate).[9] Garça, has an average temperature of 19.9°C and average annual rainfall of 1,306 mm.

CASE 9 | FUTURO FLORESTAL II

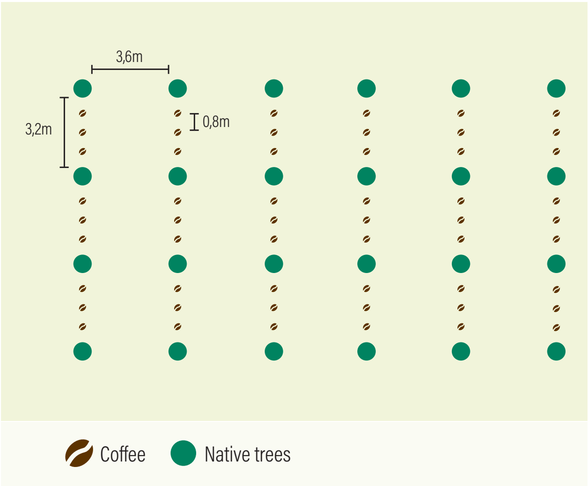
Futuro Florestal II is a Brazilian company that implements and manages plantations and offers consultancy and assistance for plantations with native and exotic species, seeking sustainable commercial production of tropical hardwoods.

Silvicultural information

- **Year of implementation:** 2010
- **Location:** Garça – São Paulo State
- Garça is a traditional region that produces coffee
- **Forest type:** Agroforestry system
- **Planted area:** 8 ha
- **Planning horizon:** 20 years

Planting model

- The mechanized model is viable for a mixed system with native trees and coffee.
- From year 2 on, it is already possible to harvest the coffee, but its full production only occurs in year four.
- Timber species are thinned in year 10 and harvested in the end of the planning horizon (20 years).
- This model has 46 operational activities.



Species	Plant/ha
Coffee (*Coffea arábica*)	2,604
Pink jequitibá (*Cariniana legalis*)	162
Guanandi (*Calophyllum brasiliense*)	89
African mahogany (*Khaya ivorensis*)	54
African mahogany (*Khaya senegalensis*)	163

Environment: Local climate is tropical (Cfa – humid tropical climate).[9] Garça has an average temperature of 19.9°C and average annual rainfall of 1,306 mm.

CASE 10 | SUCUPIRA AGROFLORESTAS

Sucupira Agroflorestas is a company that produces hard woods and organic food in high-biodiversity successional agroforests systems.

Silvicultural information

- **Year of implementation:** 2015
- **Location:** Valença – Bahia State
- **Forest type:** Agroforestry system
- **Planted area:** 45 ha
- **Planning horizon:** 33 years

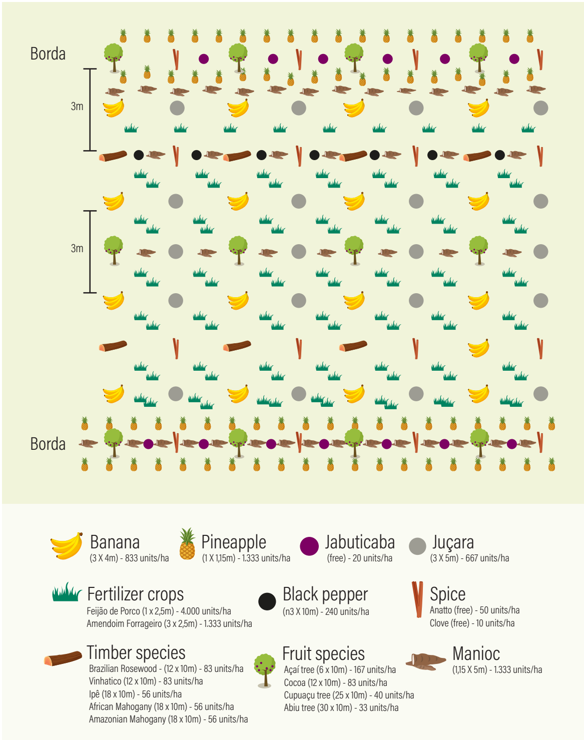
Planting model

- Plantation started on a degraded pasture, with deep soils, very drained, acid, and dystrophic, aiming at the production of wood, spices, heart-of-palm, and fruit.
- Wood production takes places in a forestry system of unequal mixed stands, with three cycles scaled during the planning timeframe.
- Harvests concentrated in cycles of 17, 25, and 30 years.
- There are 59 operational activities.

Fruit/Spice species	
Pineapple (*Ananas comosus*)	Banana (*Musa sp.*)
Juçara (*Euterpe edulis*)	Açaí (*Euterpe oleracea*)
Cocoa (*Theobroma cacao*)	Cupuaçu (*Theobroma grandiflorum*)
Yellow abiu (*Polteria caimito*)	Jabuticaba (*Plinia jaboticaba*)
Jaboticaba (*Plinia trunciflora*)	Black pepper (*Piper nigrum*)
Urucum (*Bixa orellana*)	Clove (*Sygygium aromaticum*)
Manioc (*Manihot sculenta*)	

Green manure species	
Jack bean (*Cannavalia ensiformes*)	Pinto peanut (*Arachis pintoi*).

Timber species	
Jacarandá (*Dalbergia nigra*)	Vinhático (*Plathymenea foliolosa*)
Ipê amarelo (*Handroanthus serratifolius*)	African mahogany (*Khaya ivorensis*)
Amazonian mahogany (*Swietenia macrophylla*)	



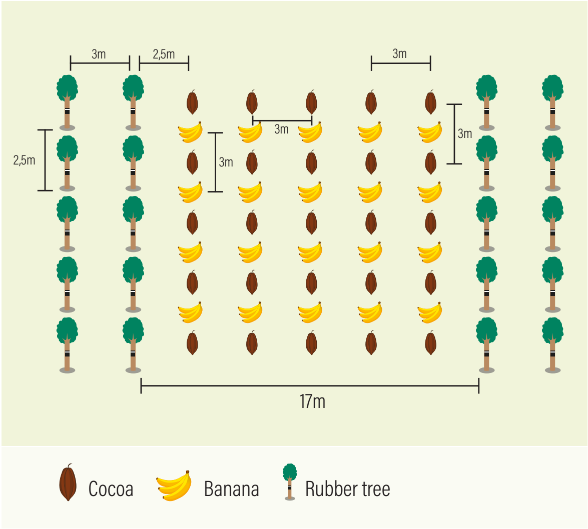
Environment: Valença has a significant amount of rainfall during the year, even during the driest month. The climate is Af (tropical rainforest climate).[9] The average annual temperature is 24.6°C, and the average annual rainfall is 2,109 mm.

CASE 11 | AGROINDUSTRIAL ITUBERÁ

Agroindustrial Ituberá is a pioneering rubber tree company in Bahia, with its main activity benefitting natural rubber. It is currently diversifying its production with new plantations.

Silvicultural information

- **Year of implementation:** 2015
- **Location:** Ituberá – Bahia State
- **Forest type:** Agroforestry system
- **Planted area:** 60 ha
- **Planning horizon:** 30 years
- Mixed model of cocoa/rubber tree/banana developed by the Executive Cocoa Planning Commission (CEPLAC), from its initials in Portuguese.



Planting model

- Rubber trees are planted in double stands with cocoa in the intermediary zone.
- This ensures full sunlight for cocoa crops in the first years and shade when crops reach a young-tree stage, which is a requirement of the species.
- Cocoa trees start full production after four years, and rubber trees take up to seven.
- Banana crops are planted between the cocoa rows, producing from year one to four and providing short-term economic return.

Species	Tree/ha
Cocoa (*Theobroma cacao*)	833
Banana (*Musa sp.*)	833
Rubber tree (*Hevea brasiliensis*)	400

Environment: Ituberá has a tropical climate classified as Af (tropical rainforest climate).[9] Rainfall is significant throughout the year, with an annual average of 2,095 mm. Average annual temperature is 24.6°C with variations of 3.4°C.

CASE 12 | C.A.M.T.A.

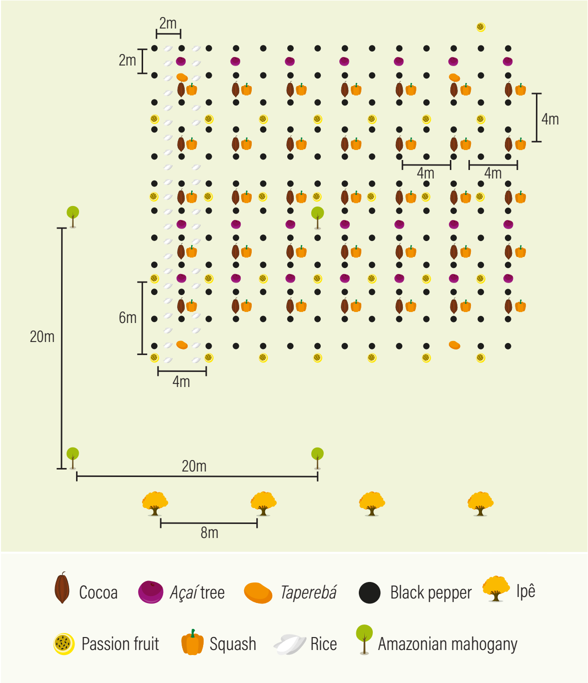
***The Cooperativa de Agricultura Mista de Tome-Açú* – C.A.M.T.A.** was officially founded by a colony of Japanese immigrants in 1949. It produces and trades agricultural crops suited to Amazonian conditions, utilizing AFS to produce processed fruit pulp, cocoa, black pepper, and timber.

Silvicultural information

- **Year of implementation:** 2008
- **Location:** Tomé-Açu – Pará State
- **Forest type:** Agroforestry system
- **Planted area:** 39 ha
- **Planning horizon:** 30 years

Planting model

- The model is the Agroforestry System of Tomé-Açú (SAFTA, from its intials in Portuguese) and is used by different farmers in the region.
- Its crops favor the coverage of the biomass above the primary forest's soil, preserving water resources and protecting the Amazon's soil and biodiversity.
- SAFTA's sustainability results in the permanence of different crops that generate income in a determined area, forming a successive production chain with short-, medium-, and long-term cycles.
- Its prioritized crops are cocoa, açaí, and andiroba, from which a valuable oil for the cosmetics industry is extracted.



Species	Plant/ha
Cocoa (*Theobroma cacao*)	625
Açaí (*Euterpe oleraceae*)	400
Taperebá (*Spondias mombin*)	25
Andiroba (*Carapa guianensis*)	15
Ipê (*Handroanthus avellanedae*)	13
Amazonian mahogany (*Swietenia macrophylla*)	10
Black pepper (*Piper nigrum*)	2,500
Squash (*Curcubita moschata*)	625
Passion fruit (*Passiflora sp.*)	416.

Environment: Tome-Açu's climate is Af (tropical rainforest climate),[9] with significant rainfall throughout the year. Average annual rainfall is 2,438 mm and the average annual temperature is 26.8°C, with little variation throughout the year.

The Benchmarks

The benchmarks were chosen for comparison with the investments assessed by the VERENA Project. From a portfolio management perspective, every asset risk and return should be tracked through a benchmark. Metrics for alternative investments, compared to some readily available benchmarks, are very difficult to track and, in the case of biological assets, are especially difficult to access (Box 5).

For this reason, the assets assessed by the VERENA Project were compared to eucalyptus, a mainstream forestry plantation, and other agricultural investments such as cocoa and coffee that are included in traditional agroforestry systems (Table 5). In this way, we have attempted to compare similar assets in terms of investment viability and risk and return characteristics.

BOX 5 | DEFINITIONS AND METRICS USED TO EVALUATE BIOLOGICAL ASSETS

Biological assets. Living assets, such as trees, animals, or grains. The International Accounting Standard 41 (IAS 41)[5] states that a biological asset is any living plant or animal owned by the business, and it is typically measured at fair value minus selling costs. Biological assets also include crops grown by farmers, such as corn, tomatoes, grapevines, trees, or any produce coming from planting trees, such as wood or fruits. Some industries, like food and beverages, biofuels, natural rubber products, and paper and cellulose products, are known for involving large amounts of biological assets. As all economic assets, biological assets have value and can be traded on the financial market. They generate substantial revenue and income for businesses in industries such as silviculture, wineries, and paper products. Biological products are the equivalent of goods produced by other companies manufacturing, for example, items made of plastic, paper, or other materials. All of them generate revenue for the seller and losses if the goods are damaged or stolen. The difference is that biological assets are living. Thus, they change and depreciate naturally and more rapidly than other types of goods, and can be in high or low demand, depending on the season. However, in general, the longer the production cycle of the biological asset, the lower its depreciation. In other words, the depreciation of an asset such as corn (normal cycle of 110 to 180 days) is faster than the depreciation of mahogany (shallow cut after 17 to 25 years). Some metrics are important to evaluate biological assets:

Compound annual growth rate (CAGR). The constant rate of return that would be required for an investment to grow from its beginning balance to its ending balance, assuming the profits were reinvested at the end of each year of the investment's lifespan.

Cost of capital. The cost that a firm pays to access funds. It can be a combination of the cost of accessing loans and using equity. If the returns of an investment are greater than the cost of accessing the funds for that investment, the firm will increase its value by investing.

Internal rate of return (IRR). The discounted rate at which the present value of cash inflows equals the present value of cash outflows. In other words, the IRR is the interest rate at which the Net Present Value (NPV) equals 0. Firms can compare the IRR to the return on alternative investments or to a minimum required return.

Net present value (NPV). Equals the sum of present values of all cash flows (inflows and outflows) in a project. It is the fundamental measure of profitability of investment projects. If the NPV is greater than zero, the project is profitable. If the NPV is less than zero, one should not invest in the project.

Risk-adjusted return. A risk-adjusted return explicitly includes the risk of an investment in the return assessment, adjusted to the cost of capital. A riskier investment has its return adjusted at a higher discount rate, for example, compared to a less risky investment, in which the adjustment has a lower discount rate.

Table 5 | Traditional Forest and Agricultural Systems Used as Benchmarks for Comparison with the Investments Assessed by the VERENA Project

Benchmarks	Main Characteristics
	**Eucalypt (*Eucalyptus*)**. In 2019, the eucalypt crop (*E. grandis, E. urophylla, E. urograndis*) occupied about 7 million hectares in Brazil, from a total of 9 million hectares of trees planted for industrial purposes (wood, charcoal, lumber, and oil).[10]
	**Cocoa (*Theobroma cacao*)**. Brazil is seventh in world production. In 2019, Brazilian production was 260,000 tons. The largest producers in 2019 were Pará and Bahia, which together accounted for 93% of Brazilian cocoa production.[11]
	**Coffee (*Coffea arabica* and *C. canephora* var. robusta)**. In 2019, the Brazilian grain coffee production (arabic and conilon species) was 3 million tons.[11] The largest producer was Minas Gerais, responsible for approximately 50% of national production.
	**Tahiti lime (*Citrus latifolia*)**. In 2019, the state of São Paulo accounted for 74% of the more than 1.5 million tons of lemons produced in Brazil. It is estimated that about 90% of the area is planted with Tahiti lemon plantations.[11]
	**Heart of palm**. In Brazil, the most planted species is peach palm (*Bactris gasipaes*). São Paulo is the main producer with 35% of the total production in 2019 (39,749 tons), followed by Santa Catarina (28,434 tons) and Goiás (15,128 tons).[11]
	**Banana (*Musa sp*)**. The banana tree is cultivated in all Brazilian states, from the coast to the interior plateaus. In 2019, the main producer states were São Paulo (1,088,877 bunches), Bahia (828,284 bunches), and Minas Gerais (825,124 bunches).[11]
	**Manioc (*Manihot esculenta*).** Manioc is produced in all Brazilian states and in the Federal District. The three largest producers are Pará (3,711,214 tons), Paraná (3,176,368 tons), and São Paulo (1,358,067 tons), which together account for 47% of Brazilian manioc production.[11]

Source: Iba Report 2020[10] and IBGE 2019.[11]

Table 6 | List of Case Studies, Divided by Forestry and Agroforestry Systems, and the Benchmarks (Monoculture Forestry or Agricultural Systems)

CASE	YEAR	AREA (ha)	SPECIES	LOCATION	BIOME
FORESTRY					
Amata	2008	3,991	Paricá	Paragominas, Pará State	Amazon Rainforest
Symbiosis	2011	803	Native species (15)	Porto Seguro, Bahia State	Atlantic Forest
Fazenda Santo Antônio	2013	13	Native species (11)	Araras, São Paulo State	
Fazenda Jaíba II	2007	5	Mahogany	Jaíba, Minas Gerais State	Brazilian Savanna
AGROFORESTRY SYSTEM					
Cacau Mais Floresta –TNC	2014	312	Cocoa + banana + native species (5) + agricultural crops (2)	São Félix do Xingu, Pará State	Amazon Rainforest
C.A.M.T.A.	2008	39	Cocoa + açaí + native species (4) + agricultural crops (4)	Tomé-Açu, Pará State	
Agro Industrial Ituberá	2015	60	Cocoa + rubber tree + banana	Ituberá, Bahia State	Atlantic Forest
Fazenda da Toca	2012	5 (2012) + 260 (2018)	Citrus + native species (5) + agricultural crops (3)	Itirapina, São Paulo State	
Futuro Florestal I	2009	5	Peach palm + native species (4)	Garça, São Paulo State	
Futuro Florestal II	2010	8	Coffee + native species (4)	Garça, São Paulo State	
Sucupira Agroflorestas	2015	45	Native species (5) + agricultural crops (13)	Valença, Bahia State	
Fazenda Jaíba I	2007	15	Brazilian mahogany + banana	Jaíba, Minas Gerais State	Brazilian Savanna
MONOCULTURE					
Benchmark	Forestry		Eucalypt 1	São Paulo State	Atlantic Forest
			Eucalypt 2	Bahia State	
			Eucalypt 3	IHS Markit	
	Agroforestry System		Coffee arabica	São Paulo State	Brazilian Savanna
			Cocoa	Bahia State	Atlantic Forest
			Banana	São Paulo State	
			Heart of palm		
			Tahiti lime		
			Manioc	Paraná State	

Note: Numbers in parentheses following species indicate the number of species considered.

Source: Developed by authors.

FINANCIAL RETURNS FROM SILVICULTURE OF NATIVE SPECIES AND AGROFORESTRY SYSTEMS

This section discusses the key components of risk and return on investments in silviculture of native species and AFS. The main variables discussed are price, productivity, cost of capital, and return. It also discusses the importance of valuing natural capital.

The efficiency ranking between silviculture of native species and AFS was defined based on key variables, such as investment needs, payback period, NPV, and IRR. However, a project with a high IRR and NPV project might not be suited to some investors, depending on their risk appetite, liquidity needs, time horizon, and other variables.

We collected and analyzed data on wood production in Brazil and globally for the last 55 years (FAOSTAT 2017; IBGE 2017; ITTO 2017). Data on sawn wood since 1994 were collected from The International Tropical Timber Organization (ITTO) database on non-coniferous sawn hardwood. We analyzed production and consumption of the wood, and projected a growth scenario based on the previous compound annual growth rates.

International market prices for Ipê sawn wood and other sawn wood species were collected from Comex Stat[3] from 1997 onward. FOB (free on board) value data on exports in USD were crossed-checked against data on exported volume in m^3. Domestic market prices from 2001 to 2017 were extracted from CEPEA (2018)[12] for eucalyptus (*Eucalyptus sp.*), ipê (*Tabebuia sp.*), jatobá (*Hymenaea sp.*), peroba (*Aspidosperma sp.*), maçaranduba (*Manilkara huberi*), angelim vermelho (*Dinizia excelsa*), angelim-pedra (*Hymenolobium petraeum*), and cumaru (*Dipteryx odorata*).

Domestic market prices were analyzed in terms of:

- Real-price trend of the historical series deflated by the Extended National Consumer Price Index (IPCA, from its initials in Portuguese), base year 2002; and

- Price correlation between exchange rates (BRL/USD), using data from Brazilian Central Bank, and inflation rate and price volatility, all using monthly data.

In addition, the economic analysis of perennial crops used in AFS was carried out using price and volatility data available on stock markets, local markets, trade associations, and Brazilian government agencies. Land values and prices for the project's execution were collected from the IHS MARKIT Agrianual report (2018), because land assets are always considered at least an opportunity cost in economic viability analysis.

Then, the models were run through perpetuity to compare the different groups of species used in different projects at different scales. Terminal value is the estimated value of a business beyond the explicit forecast period and is a critical part of the financial model. The perpetual growth method of calculating a terminal value formula is the preferred method among academics because it has mathematical theory behind it. This method assumes the business will continue to generate Free Cash Flow (FCF) at a normalized state forever (e.g. perpetuity).

We calculated the NPV on a per-hectare basis. Then, we calculated the mean and the 95 percent deviation from the mean.

International market prices were analyzed in terms of:

- Historic trends in real prices, and in prices deflated by the Consumer Price Index (CPI), both in USD, from the United State Bureau of Labor and Statistics data,[13] base year 1997;

- Price correlation between exchange rates (BRL/USD), using data from the Brazilian Central Bank[4], and production volume, inflation rate, and price volatility, all using monthly data; and

- Regression analysis to predict the price of wood depending on the main variables that affect prices.

Case Studies: Promising Results

The economic viability of any asset or project depends on analysis of fundamentals such as the IRR and NPV, based on future cash flows. Beyond this, viability depends on the characteristics, circumstances, time horizon, and needs of the investor. For example, a project with a positive NPV may not be feasible for a farmer because the time horizon of return on investment may not match the liquidity of that farmer. Therefore, to interpret the viability of projects the constraints of investors and farmers must be known.

In a more carbon-conscious future, for example, the value of natural capital might be expected to appreciate, whether through a regulated (e.g., carbon pricing) or voluntary market. Investor sensitivity, defined by the WACC model, allows categorization of four types of investor profiles (Figure 11). What differentiates each of these profiles are the following variables, according to Batista et al. (2017a):

- Credit Risk: cost of debt based on specific company risk
- Premium: market-risk premium, or the difference between the market return (e.g., S&P 500[14]) and the risk-free rate (e.g., 10-year government T bond).
- Beta: the measure of risk which compares market return with the return of a specific sector
- Degree of leverage: the ratio of debt to equity
- Cost of debt: component of the cost of capital, which is based on the weighted average cost of debt and equity

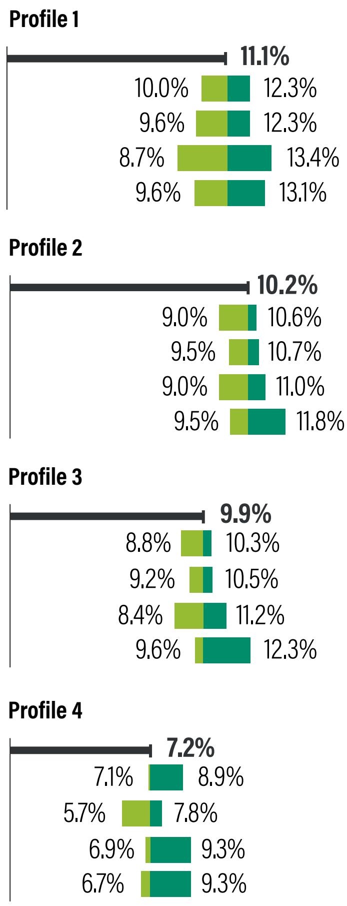
Figure 11 | Sensitivity of Investor Profiles Defined by the WACC model

Profile 1	Best →	Base	← Worse
Credit Risk	4.5%	8.5%	12.5%
Leverage	30.0%	47.0%	70.0%
Beta	0.77	1.42	2
Premium	5.0%	7.1%	9.6%

Profile 2	Best →	Base	← Worse
Credit Risk	8.5%	12.5%	13.8%
Leverage	30.0%	47.0%	70.0%
Beta	0.77	1.22	1.5
Premium	4.0%	5.0%	7.5%

Profile 3	Best →	Base	← Worse
Credit Risk	8.5%	12.5%	13.8%
Leverage	30.0%	47.0%	70.0%
Beta	0.7	1.42	2
Premium	3.5%	4.0%	7.1%

Profile 4	Best →	Base	← Worse
Credit Risk	8.5%	8.8%	12.5%
Leverage	30.0%	70.0%	80.0%
Beta	0.7	1.97	2.4
Premium	3.5%	4.0%	7.5%



Source: Batista 2018.

In summary, the characteristics of investors and rural producers are very important to interpret the viability of projects, as presented in Table 7.

Table 7 | Characteristics of Different Types of Investors

INVESTOR	RISK TOLERANCE	INVESTMENT HORIZON	NEED FOR LIQUIDITY	NEED FOR PROFITS
Rural and individual producers	Depends on producer or individual	Depends on producer or individual	Depends on producer or individual	Depends on producer or individual
Pension Funds	High	Long	Low	Depends on age
Impact Investors	High	Medium	Medium	Depends on fund
Banks	Low	Short	High	Interest payment
Foundations	High	Long	Low	Preserving capital
Insurance Companies	Low	Medium	High	Low
Mutual Funds	Depends on fund	Depends on fund	High	Depends on fund

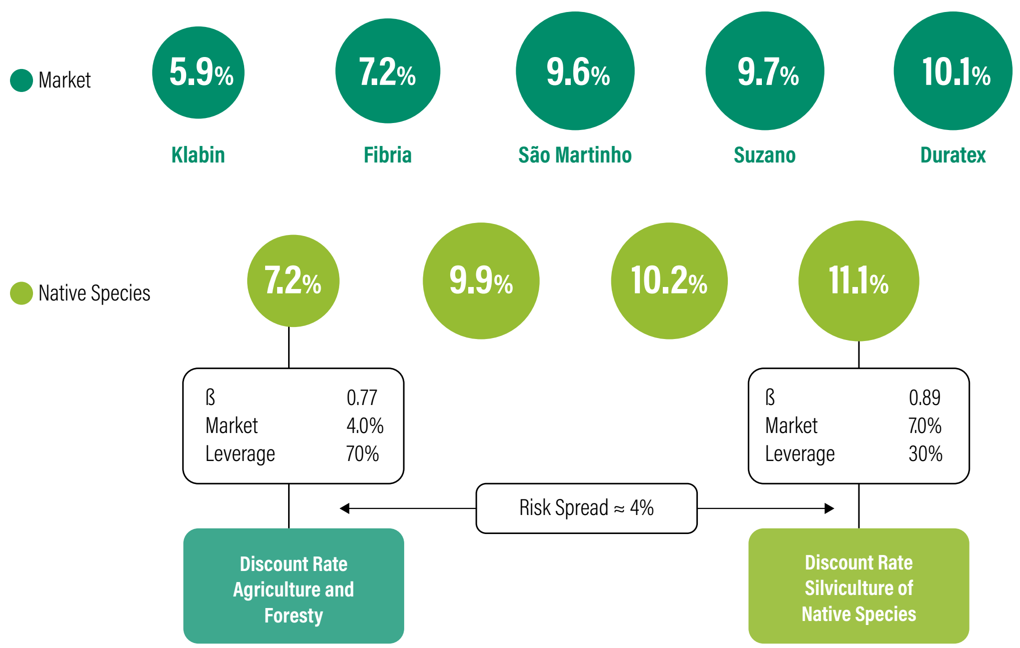
Source: Modified from Schweser (2017).

Cost of Capital

The cost of capital we used as our benchmark is the same as that used for the agribusiness sector, that is, 7.2 percent (Figure 11, Profile 4). Profile 3 (9.9 percent) is the forest-type investor that is considered patient capital. Profile 2 (10.2 percent) is the type of investor that invests in forests and any other asset class, and Profile 1 (11.1 percent) is the investor that considers silviculture of native species a high-risk business (Figure 11).

As there are no publicly traded companies in the forest-landscape restoration sector (Batista et al. 2017a, 2017b), we assumed four different cost of capital scenarios to conduct the valuation of the 12 business cases and benchmarks and to consequently estimate the risk of investing in silviculture of native species and AFS (Figure 12).

Figure 12 | Comparison of Discount Rates Used by Publicly Traded Companies to Bring Fair Value to Biological Assets (Market) and for the Profiles Defined for Present Study (Natives Species)



Notes: Market is represented by listed companies. Native species are VERENA cost of capital models. Blue circles indicate discount rates used by publicly traded Brazilian companies to bring fair value to their biological assets. Green circles indicate discount rates used for the profiles defined for this study.

Source: Developed by authors based on 2012–17 financial reports from the listed companies.

The assets of silviculture of native species and AFS were discounted at an 11.1 percent rate, but the assets of reforestation with eucalyptus and permanent crops (benchmarks) were discounted at a 7.2 percent rate to represent the different levels of risk. In general, native species assets are perceived as higher risk due to the lack of technological knowledge and track record, despite good knowledge of the tropical timber market. The average data on discount rates of public companies (in the paper, cellulose, wood panels, and sugar-ethanol industry sectors) over the last five years vary according to their cost of capital and nature of their debt, which could represent the cost of capital of assets of silviculture of native species in the future.

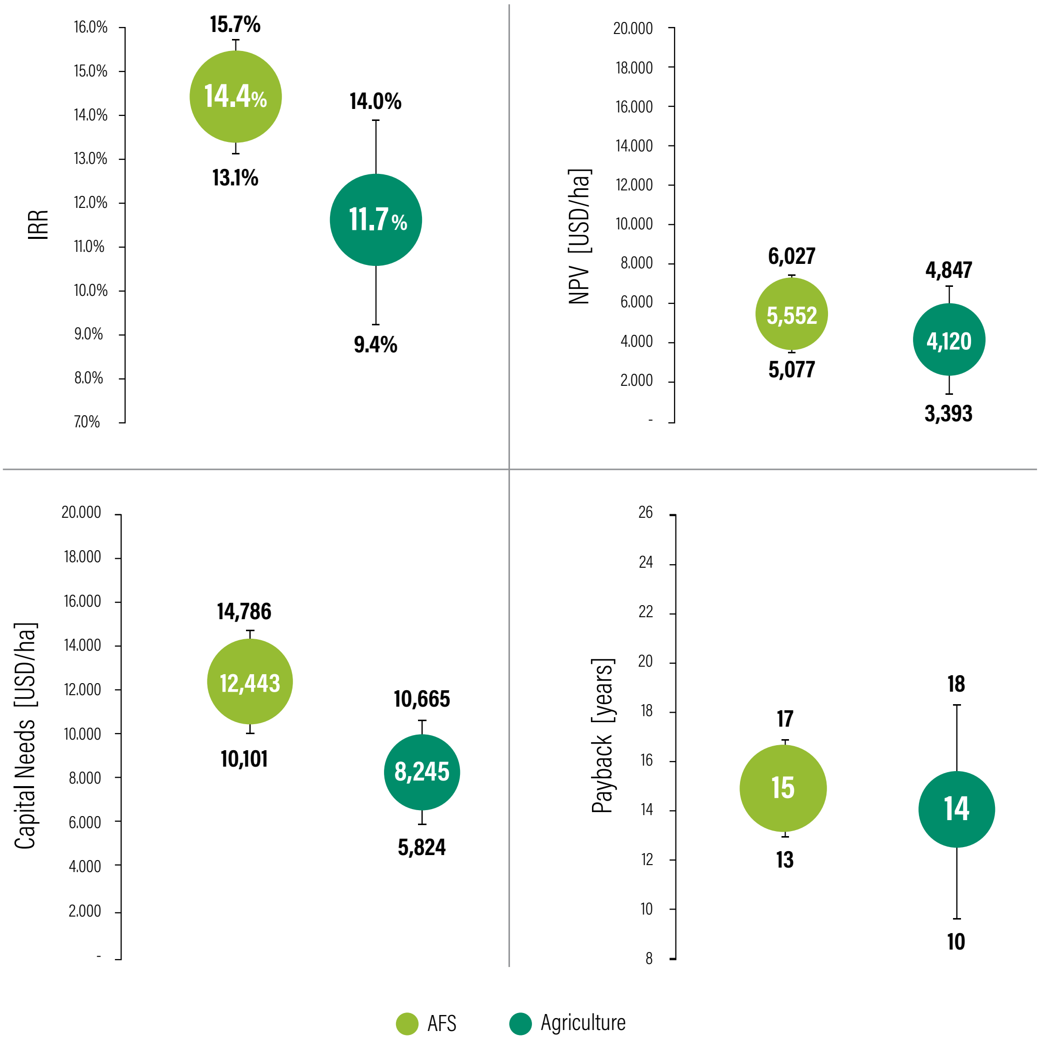
Risk and Returns

The risk and return measurements consider the asset value based on the NPV, the IRR, the capital needs, and discounted payback (Figures 13 and 14). As we have a nondisclosure agreement (NDA) with all the owners of the projects analyzed by the VERENA Project, we can only show aggregated results in this report.

Figure 13 | IRR, NPV, Capital Needs, and Payback of Case Studies of Native Species and Their Benchmarks

Notes: The upper and lower bands indicate the standard deviation of the average with 95% confidence.
Exchange rate: 1 USD = 3.85 BRL (December, 2017).
Source: Developed by authors.

Figure 14 | IRR, NPV, Capital Needs, and Payback of the Case Studies with AFS and Their Benchmarks



Notes: The lower and upper bands show the standard deviation of the average with 95% confidence. In this case, the need for capital considers the acquisition of land assets.
Exchange rate: 1 USD = 3.85 BRL (December, 2017).
Source: Developed by authors.

Results (Figure 13) show that there is no statistical difference, with 95 percent confidence between the return on eucalyptus (11 percent), considered as the benchmark, and the return on silviculture of native species (12.9 percent). However, the two important parameters to assess the viability of a project (capital needs and payback) were significantly greater in silviculture of native species when compared to the benchmark eucalyptus. On the other hand, AFS showed no statistical difference, with 95 percent confidence in any of the four variables when compared to their benchmark permanent crops (Figure 14).

These results may partially explain why silviculture of native species has not proven a popular investment, as it needs a great deal of capital and a long investment horizon for payback. The fact that the assets with native species are slightly more valuable than assets with eucalyptus, despite the greater discount rate, is because the market for tropical forestry products (sawn wood) has larger aggregated value when compared to stumpage sales of eucalyptus.

In addition to the importance of calculating the return on these assets, the sensitivity analysis that measures the sensitivity to changes in any one of the model's variables is fundamental. The higher the sensitivity and volatility, the greater the risks.

To analyze return deviations, the price of the products varied from –10 percent to +10 percent of their base value. The responses to these deviations in price were a delta of 1.4 percent in IRR for silviculture of native species, 5.6 percent for eucalyptus, 8.4 percent for AFS, and 8.8 percent for permanent crops. These results show that silviculture of native species has the lowest return-deviation in terms of price changes, which implies lower risks. Even though we recognize that forest investments have other important risks, such as pests or fires, here we consider only market risks. Although fires are considered high risk, they can be mitigated by several measures that forestry companies have already developed and implemented around the world.

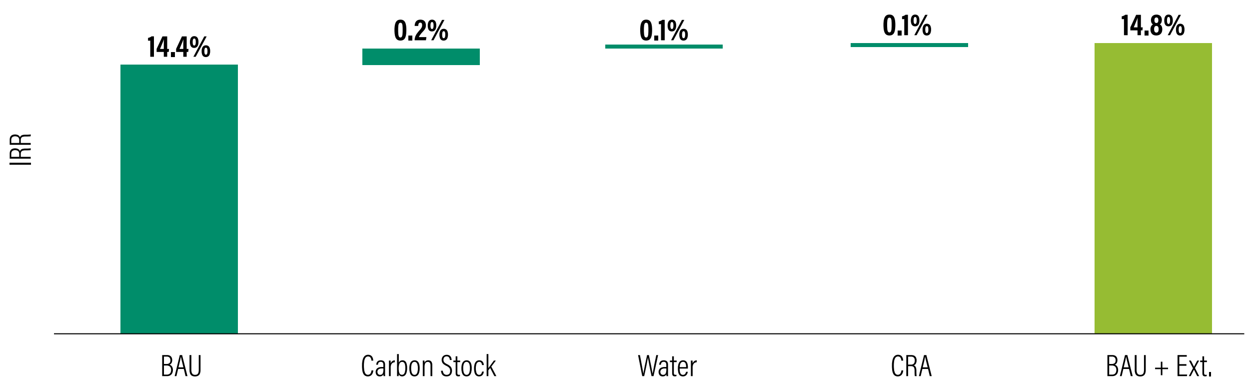
Forestry assets are known for being less volatile and less risky than soft commodity agricultural assets (Mercer et al. 2014). Just as assets of silviculture of native species show lower deviations due to price variations, tropical wood assets have consistently gained value in real terms in the last 20 years. Real price increases have a significant impact on the return of these species.

Impact of Natural Capital on Risk-Adjusted Returns

Natural capital may be expected to appreciate in future under any future scenario— whether achieved through a regulated or unregulated market—that supports enhanced carbon mitigation and adaptation activities.

Figure 15 shows the evaluation of the marginal impact of natural capital returns on the returns yielded by silviculture of native species, in terms of its contribution to mitigating global warming (carbon storage) and supporting agricultural systems through increased water infiltration and availability.

Figure 15 | Marginal Impact of Natural Capital on IRR of the Case Studies and the Consolidated Result



Notes: BAU = Business-as-usual; CRA = Environmental Reserve Quotas; BAU + Ext. = Business-as-usual + Externalities (i.e., positive benefits of natural capital).

Source: Developed by authors.

Both public policy and private sector actions can introduce mechanisms that value and monetize natural capital and would act as drivers of a new economy for silviculture of native species. The IRR shown in Figure 15 reflect the marginal impact of new costs and revenue streams in the business; natural capital assets are analyzed in an integrated manner with the business and not as a separate asset.

Investment Modalities

By understanding the characteristics of investors, it is possible to apply portfolio theory, where asset diversification reduces investment risk without necessarily reducing portfolio return.

Historically, forest investments have low correlation with macroeconomic development and high correlation with inflation (IWC 2013; Agri-investor 2016). Those two characteristics offer risk diversification when this asset is placed within the portfolio. Several vehicles for forest investments are available, suited to the needs of different investors. They include direct investments, club deals, private equity, funds, and mutual funds (Box 6).

BOX 6 | VEHICLES FOR FOREST INVESTMENTS

Direct Ownership (https://www.crowdstreet.com/resources/investing/) – Investing involves buying a stake in a specific property. For equity investments, this means acquiring an ownership interest in an entity that directly owns an asset, such as a forest concession or plantation. Real assets tend to be more stable than financial assets. Inflation shifts in currency values, and other macroeconomic factors affect real assets less than financial assets. Real assets, however, have lower liquidity than financial assets, as they take longer to sell and generally have higher transaction fees. Real assets also have higher carrying and storage costs than financial assets.

Real Estate Investment Trusts (REITs) (https://www.investopedia.com/terms/r/reit.asp) – A real estate investment trust (REIT) is a company owning and typically operating real estate, which generates income. Properties included in a REIT portfolio may include plantations, for example.

Exchange Traded Funds (ETFs) (http://www.mysmartrend.com/ETFS) – Exchange Traded Funds (ETFs) are funds that track indices. The shares of an ETF are shares of a portfolio that track the yield and return of its original index. The main difference between ETFs and other types of index funds is that ETFs do not try to outperform their corresponding index, but simply seek to replicate its performance. Examples of ETFs include: S&P Global Timber & Forestry Index;[7] Guggenheim Timber ETF.

Private Equity (https://www.investopedia.com/terms/p/privateequity.asp) – Private equity is an alternative investment class and consists of capital that is not listed on a public exchange. Private equity is composed of funds and investors that directly invest in private companies.

Funds – The Limited Partners (LPs) that typically invest funds in timber-producing land are Pension Plans, Family Offices, Endowments, Foundations, High-Net-Worth Individuals, Sovereign Wealth Funds, and Development Finance Institutions (DFIs).

Each of these vehicles requires different levels of investor knowledge in terms of both technical knowledge and financial understanding of the operation and how to balance the benefits and risks that each investment vehicle creates. Funnel logic provides a standardized framework for looking at evaluation criteria in the four areas of market, project, financing, and management that are most relevant to the investor seeking to assess an investment's prospects (Credit Suisse and McKinsey 2016) (Table 8).

VERENA is supporting market studies by assessing the global and national markets, understanding the impact of planted and managed native forests on timber quality, and assessing markets for different wood products.

Table 8 | Consolidated Evaluation Strategy (Funnel Logic) of Projects and Investments in Silviculture of Native Species

MARKET	PROJECT	FINANCING	MANAGEMENT
▪ Regulatory Framework and Legal - Transparency; need for public policies ▪ Size of market - clients; growth rate ▪ Maturity - market volatility; global trade; future markets; *hedging* ▪ Regionality - local agricultural potential; potential for areas for restoration; technical assistance; R&D and increase in productivity	▪ Strategies for Risk Mitigation and Revenue Flows of Future Capital ▪ Maturity of Business Cases; Project developed on proven concept ▪ Certifications, standards and license to operate ▪ Identification of impacts of project externalities. Disruptive designs vs. Business-as-usual	▪ Recognized cash flows as well as return on investment ▪ Need for capital to invest in the project ▪ Guarantee structure on invested capital or minimum return. Loan guarantees (collateral) ▪ Investor, Development Banks and rural producer	▪ Qualification of the management team to manage the project ▪ Cases with historical data that can be reported

Source: Adapted by the authors from Credit Suisse and McKinsey (2016).

The major challenge confronting silviculture of native species and AFS is advancing from pilot to larger-scale projects. The path to new markets and new asset classes begins with one-off projects with dedicated funding and broadens as the projects become a proven concept with liquidity and potential for replication and scale (Batista et al. 2017a).

Table 9 shows different investment arrangements for two corporations and one cooperative that disclosed their information because of their status. The companies included in other analyzed cases are not required to publicly disclose their numbers; an NDA was signed allowing for the use of their information in the analyses.

Table 9 | Characteristics of Investment Arrangements in Three Business Cases Analyzed by the VERENA Project

CASES	AMATA	SYMBIOSIS	C.A.M.T.A.
Investment mechanisms	Equity and Debt	Equity	Grants, Equity, and Debt
Revenues (millions BRL, 2017)	16	Pre Commercial	58
Arrangement type	S.A.	S.A.	Cooperative (172 producers)
Products	Wood	Wood	Soft commodities, fruit pulp, and vegetable oils

Notes: 3.85 BRL = 1 USD. Relies on data from Amata[15] and Alimi Impact Ventures[16].
Sources: Amata Annual Report 2017; [15]Alimi Impact Ventures 2019; [16]Faruqi et al. 2018.
Adapted by WRI authors.

Business Plan

Preparation of a business plan is an important step in securing investment. Plans will differ depending on whether the objective is to aggregate rural producers, or to attract the interest of large corporations or medium-sized companies seeking investment opportunities. The business cases analyzed by VERENA showed that the arrangements are diverse in order to address the different situations and challenges of Brazil. According to Batista et al. (2017a), a business plan requires several risk mitigation considerations:

- R&D promotes an improved business environment for silviculture of native species by reducing costs and increasing the productivity of the main species with commercial value.

- Financing and guarantees are necessary to introduce public and private financial institutions to the risk and return characteristics of silviculture of native species and agroforestry systems. They are necessary if institutions are to leverage projects. Bilateral and multilateral funds (mainly those related to the climate agenda) need to be mobilized to serve as drivers for silviculture of native species.

- The revenue stream should be adjusted, and consequently securitized, to the present value. Another option would be to enter into a structured operation, that is, any operation different from ordinary common debt, to finance the project. However, the restriction would be the absence of a domestic market in Brazil.

- Recognized and stable cash flows, that is, cash flows with low volatility are fundamental for attracting investors and farmers.

- Understanding of the insurers' concerns regarding forestry activity with native species, which involves a long maturation process and forest species lesser known than pine or eucalyptus. Understanding of risk and premiums in relation to insurance coverage (for fire, meteorological phenomena, pests, and diseases) is fundamental, and this market should be supported with some public assistance, as is the case for agricultural insurance.

- Guaranteed funds can increase investor interest in projects. Multilateral agencies can play a key role in stimulating silviculture of native species by using existing mechanisms for sector financing. Other funding agencies might then become more interested in investing with public guarantees.

Impact of R&D Investments on the Competitiveness of Silviculture of Native Species

Investing in research and development to increase productivity is fundamental to maintaining returns on investment over the medium and long term. The world as a whole and individual countries have benefited enormously from the productivity growth in agriculture that has resulted from public and private investments in agricultural R&D. The benefits have far outweighed the costs (Alston 2010; Ulvenblad et al. 2019). The level of investment in agricultural R&D in Brazil is comparable to that of developed countries, albeit at the lower end of the range (Beintema et al. 2006). The great success of Brazilian agriculture and forestry has always been linked to public and private investments in R&D programs, and our expectation is that the same success can be achieved from R&D programs for native tree species.

The Brazilian Coalition on Climate, Forests and Agriculture—which supports a low-carbon economy in Brazil—defined as one of its top priorities the implementation of a pre-competitive R&D program for native tree species (Brazilian Coalition on Climate, Forests and Agriculture n.d.). The decision was based on the successful experience of investment in R&D for the forestry sector by public and private partnerships (Rolim et al. 2019). According to McKinsey (2007), reducing deforestation and increasing reforestation – in other words, keeping forests standing and increasing their extent – is currently the most effective and cost-competitive means of mitigating global warming.

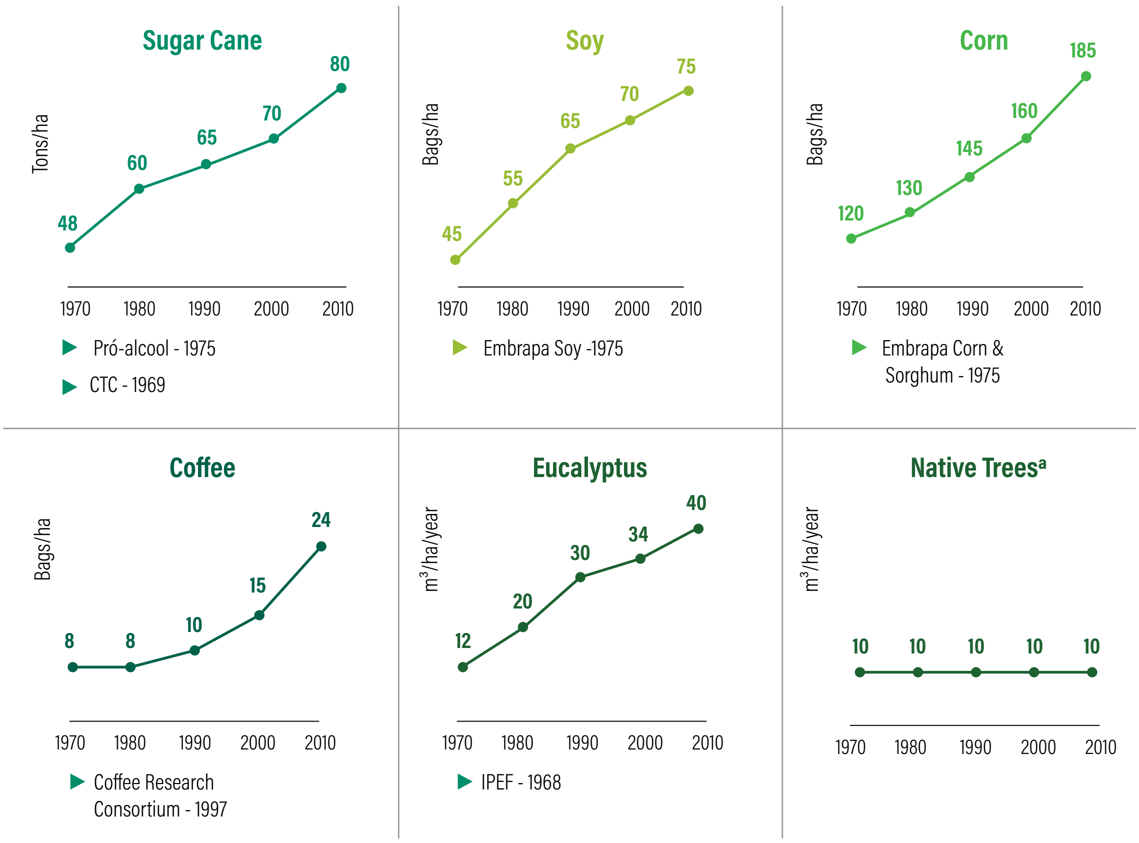
Within the scope of an R&D program for developing native species, tree planting not only benefits the climate and the local and regional environment, but also represents an excellent investment opportunity from both a financial and social standpoint (Rolim et al. 2019).
A cost-benefit analysis of a hypothetical investment in an R&D program in the Brazilian Atlantic Forest, assuming a silviculture project with native species of 10,000 ha, found that the investment could expect to earn $2.39 for each dollar invested (7 percent CAPEX in R&D and 93 percent forestry CAPEX at outlay) (Rolim et al. 2019).

Realizing this kind of return requires investment and discipline to ensure a robust and viable R&D platform for native tree species, as has occurred in recent decades to consolidate the well-established industries for eucalyptus and pine silviculture. The high degree of development involving these species enhanced techniques both for the production system and for genetic improvement.

However, promoting silviculture of native species requires more information on many aspects of production, such as best source and quality for seed harvesting, seed, and seedling production, planting density, planting conditions (shade-tollerant or light-demanding), growth rates, arrangement of species, management activities (thinning, pruning), insect and disease control, cutting cycle length, and timber quality of planted species, among others (Rolim et al. 2019).

In Brazil, the agriculture and forestry industries, especially silviculture and agribusiness, have developed in part by increasing productivity through R&D. The effect can be seen in Figure 17, where the productivity of sugarcane, soybean, maize, eucalyptus, and coffee, after public and private investments in R&D, is contrasted with the productivity of silviculture using native species, with very low investments in R&D (Figure 16).

Figure 16 | The Effect of Public and Private Investment in R&D on Productivity of Commercial Crops versus Native Trees without R&D Investment



Notes: a. The data are an average of all native species in silvicultural systems. Research centers corresponding to each crop and their respective year of creation are indicated below each graph.
Research centers in Brazil: Pró-álcool (National Alcohol Program) established during the military government, the Sugarcane Technology Center (CTC), a research center created by the private sector, Embrapa Soy and Embrapa Corn & Sorghum, the Coffee Research Consortium, currently composed of government and the private sector and 36 leading R&D institutions, and the Institute of Forestry Research and Studies (IPEF).
Sources: Embrapa 2002; Consórcio Pesquisa Café & Embrapa Café n.d.; Cortez 2016; New Forests 2015; FSC and Indufor 2012.

In the period 1970–2010, the productivity increase of eucalyptus and coffee, both perennial crops, was greater than that of annual crops such as soybean, corn, and sugar cane, with significant gains over 40 years (Table 10). Investments in R&D for native forest species could have the same effect, taking advantage of the Brazilian experience in R&D programs with eucalyptus and pine (Rolim et al. 2019).

Table 10 | Performance of Selected Traditional Crops Following Public and Private Investments in Brazilian Research & Development Programs

CROPS	CAGR	GAIN IN 40 YEARS
Sugar cane	1.3%	66.7%
Soybean	1.3%	66.7%
Corn	1.1%	54.2%
Eucalypt	3.1%	233.3%
Coffee	2.8%	200%

Note: CAGR = compound annual growth rate.

Source: Rolim et al. 2019.

The leading variables that comprise the return from native forest assets are price and productivity. In terms of genetic improvement, native species are still considered *wild species*. Gains from genetic improvement in the first generation might increase productivity by 25 percent in the short term, for example, which would be enough to increase the attractiveness of silviculture of native species to mitigate climate change. The development and improvement of production systems may also have a significant impact on cost reduction in the implementation and management phases of silviculture of native species.

Silviculture of native species is a relevant strategy to increase wood production and help Brazil achieve its NDC targets. It is an important part of agriculture and livestock production in integrated systems and can increase the resilience of the agriculture sector and farmers. Native species silviculture can contribute to job creation, increased or diversified income, carbon storage, and many other positive social and economic benefits (Rolim et al. 2019).

CONCLUSIONS

The first phase of the VERENA Project during the period 2016–2019 demonstrated the economic viability of silviculture of native species and AFS, assessed the potential for tropical wood markets (national and international), and showed the competitiveness of this sector through investments in research and development and valuation of natural capital.

The main goal – to make the business case for silviculture of native species and agroforestry systems in Brazil – was achieved. Additionally, key barriers and risks, as well as strategies to overcome them were identified to create a new forest economy in Brazil. Investment in research and development is key to improve the return on investment and performance of business models at the landscape level.

The project results showed the potential contribution of native species to the enormous wood market, in Brazil and globally. Native species can drive a new forestry economy, comprising both silviculture and the management of natural forests through concessions. Additionally, the results demonstrated that the main market risk variables can be included in the valuation of forest assets, including exchange rates, inflation, production volumes, and price volatility.

Silviculture of native species and AFS have risk-adjusted returns similar to their benchmarks in forestry and agriculture (silviculture of eucalyptus and permanent crops in monoculture), with an IRR of approximately 12 percent. However, the capital needs and payback period are statistically higher, and are thus among the barriers that must be overcome to scale silviculture of native species in Brazil. Our analysis and results did not include other risks, such as forest fires and pest/diseases because they are complex to predict. However, it would be important to include them in future work.

The cost of capital analysis allows the adjustment of returns given its risk and is an important starting point for discussions of a still-unknown asset class such as silviculture of native species and AFS. The returns from the business cases were risk-adjusted differently from the benchmarks to translate their uncertainty, given the early phase of these projects.

Investment tenure, and liquidity can prevent investors from allocating their investments. The lack of liquidity of sustainable investments in wood in the private market has been pointed out as one of the main barriers to the allocation

of resources in the wood market. Mixing native trees with shorter rotation exotic species can mitigate liquidity issues for new investment vehicles with different liquidity requirements. The business models analyzed in this study are often complex and long-term, which can be perceived as another barrier for investors. The real risk of investing in sustainable forests tends to occur when investing a relatively small set of funds that have a limited history or track record. The sensitivity analysis showed that silviculture of native species has the lowest variation of returns among all the case studies and benchmarks in relation to the same percentage change in product prices. It showed a lower market risk profile when compared to monocultures and AFS.

The real increase in tropical timber prices had a significant impact on the return of silviculture assets with native species, but many native species with enormous potential are not yet known to the markets. For this reason, it is necessary to increase the portfolio of cases to build a track record of risk and return from the perspective of capital markets, as well as identify more species with market potential, thus reducing the cost of capital, increasing the use of tropical timber, and increasing the scale of these investments. There is potential to increase the competitiveness of silviculture of native species through the monetization of natural capital, which currently represents an unpriced positive externality, and investments in research and development. Although marginal, natural capital could increase the internal rate of return by up to 0.4 percent, due to the new streams of revenues from carbon for example. The greater possibility of increasing the competitiveness of the sector, however, comes from R&D investments.

An R&D program for silviculture of native species will ensure an improved business environment by reducing costs and increasing productivity of the main species with commercial value. Investment in technology and innovation for lesser-known species and management systems not only is a de-risking strategy but also a great upside opportunity to enhance return. An R&D program can help to reduce the cost of forest operations for managing, harvesting, transporting, and processing the products. Efficiency gains must be sustainable in the long term.

The major challenge for silviculture of native species and AFS is to move from pilot projects to landscape scale. The paths to new markets and new asset classes begin with occasional projects with specific funding that become a proof-of-concept with liquidity and potential for replication and scale. With this, it can become attractive to investors.

An alternative is blended finance, combining capital with different levels of risk tolerance and the market rate for impact investments. This financing does not need to be used only for risk reduction purposes, but capital can also be used to leverage new funds and strategies.
Another important aspect is the size of the operation, which must be large in order to become cost-effective and generate operational efficiencies that improve the return and allow better risk management.

Intercropping soft commodities with trees can play an important role because it matches asset characteristics improves liquidity, and provides an exit strategy.

Brazil has a legal framework conducive to making silviculture of native species a viable forest economy, which may assist the country in fulfilling its international commitments, increasing its rural and industrial economic competitiveness, and promoting an internal market for timber. However, the country still lacks an industrial policy with all the elements necessary to establish and scale up a competitive forest economy using native species.

The authors emphasize that all the assumptions may be used in discounted cash flow models, and that the quality of the results depends on the quality of the data entry regardless of the complexity of the models used. Authors encourage readers of this publication to run the VERENA Investment Tool (Batista et al. 2017b).

APPENDIX

Table A1 | Assumptions and Benchmarks for the VERENA Modeling

	ASSUMPTION	UNIT	BC1	BC2	BC3	BC4	EUCALYPTUS 1	EUCALYPTUS 2	EUCALYPTUS 3	BC5	BC6	BC7	BC8
1	Rotation	years	7	35	40	20	7	6	6	30	20	30	20
2	CAPEX	USD / ha	2,130	9,610	5,455	17,614	1,922	1,652	2,182	4,595	5,309	11,653	25,659
		BRL / ha	8,200	37,000	21,000	67,813	7,400	6,359	8,400	17,692	20,441	44,863	98,786
3	Land Asset or Land Lease	USD / ha	1,299	1,558	4,675	8,312	143	143	130	1,818	17	1,169	8,312
		BRL / ha	5,000	6,000	18,000	32,000	550	550	500	7,000	66	4,500	32,000
4	Administrative Costs (SG&A)	USD / ha	78.1	242.1	419.6	623.4	97.4	39.0	97.4	415.6	1,137.7	142.2	623.4
		BRL / ha	300.7	932.1	1,615.4	2,400.0	375.0	150.0	375.0	1,600.0	4,380.0	547.5	2,400.0
5	Taxes on Profit	%	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
6	Cost of Capital	%	11.1	11.1	11.1	11.1	7.2	7.2	7.2	11.1	11.1	11.1	11.1
7	Harvest and Transportation to Sawmill	USD / m^3	-	11.9	9.1	9.9	-	-	-	-	-	-	9.9
		BRL / m^3		46.0	35.0	38.0							38.0
8	Conversion Cost from Log to Rough Sawn Wood	USD / m^3		39.0	-	39.0	-	-	-	-	-	-	39.0
		BRL / m^3		150.0		150.0							150.0
9	Shipping and Customs Costs	USD / m^3 / Km	-	0.04	-	0.03	-	-	-	-	-	-	0.03
		BRL / m^3 / Km		0.14		0.13							0.13
10	Average Shipping Distance	Atlantic Rainforest Km		150		300							300
11	MAI	m^3 / ha / ano	27,0	13.8	16.2	11.0	47.1	38.0	45.0			0.6	11.0
12	Production Volume in Logs	m^3 @ year	189,0	60	63	47	330	228	270			17	47
		m^3 @ year		87.5	140	173							173
		m^3 @ year		161.5	443								
		m^3 @ year		174.5									
13	Conversion Rate from Log to Rough Sawn Wood	% in thinning		20		20							20
		% in final cut		40		40							40
14	Prices of Native Wood Species FOB	USD / m^3	25	649	156	909	-	-	-	-	-	156	909
		BRL / m^3	96	2,500	600	3,500						600	3,500
15	Prices of Exotic Wood Species FOB	USD / m^3	-	364	-	-	19	19	-	-	-	-	-
		BRL / m^3		1,400			75	75					
16	Wood Residue Price	USD / m^3	-	-	-	-	-	-	-	-	-	-	-
		BRL / m^3											
17	Weighted Price [conversion x volume x price]	USD / m^3	25	468	156	325	19	19	19	-	-	156	325
		BRL / m^3	96	1,800	600	1,250	75	75	75			600	1,250
18	Real Increase in Sawn Wood Price	% CAGR		1.5	1.5	1.5						1.5	1.5
		Period in years		30	30	30						30	30
		Gain over period %		56	56	56						56	56
19	Flagship Species	Name								Cocoa	Cocoa	Cocoa	Banana
	Productivity	Kg/ha								1,182	933	725	21,463
	Price	USD / Kg								1.77	2.14	1.82	0.18
		BRL / Kg								6.80	8.25	7.00	0.70
20	Venture Species	Name								Rubber Tree	Banana	Black Pepper	
	Productivity	Kg/ha								344	12,377	3,740	
	Price	USD / Kg								0.55	0.26	1.30	
		BRL / Kg								2.10	1.00	5.00	
21	Carbon	Ton / ha	90	140	140	150				110	80	110	150
		Price / ton USD	9.9	9.9	9.9	9.9				9.9	9.9	9.9	9.9
		Price / ton BRL	38.1	38.1	38.1	38.1				38.1	38.1	38.1	38.1
22	Water	Benefit m^3 / ha	600	421	180					180	700	700	
		BRL / m^3	0.02	0.11	0.06					0.08	0.02	0.02	
23	CRA	BRL / ha / year	190	700	750					700		190	
		% exceeding area	30	25	30					5		30	

	ASSUMPTION	UNIT	BC9	BC10	BC11	BC12	COCOA	BANANA	COFFEE	CITRUS	PU-PUNHA	MANIOC
1	Rotation	years	33	18	20	20	30	5	18	12	15	2
2	CAPEX	USD / ha	9,105	15,668	10,968	11,184	5,225	11,075	13,408	6,245	12,311	6,435
		BRL / ha	35,055	60,321	42,228	43,059	20,117	42,637	51,619	24,042	47,399	24,774
3	Land Asset or Land Lease	USD / ha	1,818	312	5,195	5,195	1,818	5,022	5,195	312	5,195	5,195
		BRL / ha	7,000	1,200	20,000	20,000	7,000	19,333	20,000	1,200	20,000	20,000
4	Administrative Costs (SG&A)	USD / ha	448.4	649.4	222.6	222.6	249.4	284.4	142.2	805.2	142.2	568.8
		BRL / ha	1,726.4	2,500.0	857.1	857.1	960.0	1,095.0	547.5	3,100.0	547.5	2,190.0
5	Taxes on Profit	%	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
6	Cost of Capital	%	11.1	11.1	11.1	11.1	7.2	7.2	7.2	7.2	7.2	7.2
7	Harvest and Trans-portation to Sawmill	USD / m^3	-	-	7.5	7.5	-	-	-	-	-	-
		BRL / m^3			29.0	29.0						
8	Conversion Cost from Log to Rough Sawn Wood	USD / m^3					-	-	-	-	-	-
		BRL / m^3										
9	Shipping and Customs Costs	USD / m^3 / Km					-	-	-	-	-	-
		BRL / m^3 / Km										
10	Average Shipping Distance	Atlantic Rainforest Km			50	50						
		Amazon Rainforest Km										
11	MAI	m^3 / ha / year	5.4	4.4	4.8	6.1						
12	Production Volume in Logs	m^3 @ year	24	79.5	5.56	16.23						
		m^3 @ year	24		18.75	104.92						
		m^3 @ year	35		71.69							
		m^3 @ year	96									
13	Conversion Rate from Log to Rough Sawn Wood	% in thinning										
		% in final cut										
14	Prices of Native Wood Species FOB	USD / m^3	156	155	312	312	-	-	-	-	-	-
		BRL / m^3	600	598	1,200	1,200						
15	Prices of Exotic Wood Species FOB	USD / m^3	-	-	312	312	-	-	-	-	-	-
		BRL / m^3			1,200	1,200						
16	Wood Residue Price	USD / m^3	-	-	9	9	-	-	-	-	-	-
		BRL / m^3			35	35						
17	Weighted Price [conversion x volume x price]	USD / m^3	156	155	286	286	-	-	-	-	-	-
		BRL / m^3	600	598	1,100	1,100						
18	Real Increase in Sawn Wood Price	% CAGR	1.5	1.5	1.5	1.5						
		Period in years	30	30	30	30						
		Gain over period %	56	56	56	56						
19	Flagship Species	Name	Cocoa	Citrus	Pupunha	Coffee	Cocoa	Banana	Coffee	Citrus	Pupunha	Manioc
	Productivity	Kg/ha	248	26,597	4,188	1,575	1,250	39,000	2,880	22,730	3,800	32,500
	Price	USD / Kg	1.73	0.32	0.78	1.95	2.04	0.26	1.95	0.32	0.78	0.09
		BRL / Kg	6.67	1.25	3.00	7.50	7.87	1.00	7.50	1.25	3.00	0.35
20	Venture Species	Name	Juçara	Manioc								
	Productivity	Kg/ha	1,103	2,424								
	Price	USD / Kg	1.95	0.13								
		BRL / Kg	7.50	0.49								
21	Carbon	Ton / ha	110	90	90	100						
		Price / ton USD	9.9	9.9	9.9	9.9						
		Price / ton BRL	38.1	38.1	38.1	38.1						
22	Water	Benefit m^3 / ha	421	180	180	180						
		BRL / m^3	0.11	0.06	0.06	0.06						
23	CRA	BRL / ha / year	771		300	300						
		% exceeding area	1		15	15						

*BC = Business Case

Notes:

1 - Cycle based on information obtained from growth curves provided by companies and from forestry curves of native species (Rolim and Piotto, 2018).

2 - Uses standard IFRS 13[5] for biological assets. All forestry cash outflows are included in the company's asset and, when harvest occurs, this asset is included in the income statement.

3 - Based on opportunity cost for degraded areas. When the asset is bought, for modeling purposes, it is sold in the end of the forestry cycle. Field research, and IHS MARKIT (2018).

4 - Based on a corporate administration and commercial teams of the VERENA Project.

5 - Tax on profit, in presumable profit regimen for corporations. It was presumed that products are exported with exemption of Social Integration Program (PIS, from its initials in Portuguese), Contribution for the Financing of Social Security (COFINS from its initials in Portuguese) and Tax on Circulation of Goods and Services (ICMS, from its initials in Portuguese), excluding the standing timber sales.

6 - Cost of capital based on CAPM (Capital Asset Pricing Model) and WACC (Weighted Average Cost of Capital) model. For references see: www.wri.org/publication/verenainvestment-tool

7 - Based on semi-mechanized harvest system (chainsaw and forwarder), based on two VERENA experiences.

8 - Based on two VERENA experiences, costs are highly sensitive to the sawmill's scale.

9 - Average shipping distance of 300 km to harbor for areas of the Atlantic Rainforest and of 200 km for projects in the Amazon. Cost/km/m^3 of shipping plus customs was 0.14 BRL, based on two cases of project VERENA.

10 - Based on two VERENA experiences, costs are highly sensitive to the sawmill's scale.

11 - Based on information obtained from growth curves provided by companies and on forestry curves for native species by Rolim and Piotto (2018).

12 - Based on information obtained from growth curves provided by companies and on forestry curves for native species by Rolim and Piotto (2018).

13 - Based on information obtained from growth curves provided by companies and on forestry curves for native species by Rolim and Piotto (2018) and the Federal Rural University of Rio de Janeiro (UFRRJ).

14 - Values based on CEPEA (2018)[12] and Secex MDIC indices (2018)[17].

15 - Values based on CEPEA (2018)[12] and Secex MDIC indices (2018)[17].

16 - Based on local markets.

17 - Formula.

18 - Based on the history of gains and prices of noble sawn wood CEPEA (2018)[12] and Secex MDIC indices (2018)[17].

19 - Productivity assessed on the field, prices, and volatility based on markets. Source: stock market, future contracts, Supply Centers (CEASAs from its initials in Portuguese), IHS MARKIT (2018), industry associations.

20 - Productivity assessed on the field, prices, and volatility based on markets. Source: stock market, future contracts, CEASAs, IHS MARKIT Agrianual, industry associations.

21 - Volumes obtained from the growth curves by Rolim and Piotto (2018). Prices obtained from "From Forest Trends" transaction from tree planting projects. http://www.forest-trends.org/documents/files/doc_5242.pdf.

22 - Price based on the work of Young and Castro (2016) where 1.5% of the municipal rate could be reverted into Payment for Ecosystem Services (PES) quantification of water benefits, estimated using a tool from the Water Fund toolbox (TNC, personal communication) and USDA (1986), which takes into consideration precipitation and soil use.

23 - Bondage values obtained from BVRio (2016) and Biofílica platforms (https://www.biofilica.com.br/en/), prices vary per biome and state.

Table A2 | Data from Studied Cases (C) and Benchmarks (B) Used in this Report

ASSET		LAND AQUISITION	PRICE	CYCLE	SG&A (BRL/HA)	LAND SALE	LAND
BC5	C	100%	7,000	30	1,600	Yes	2.5%
BC1	C	60%	7,000	7	275	Yes	2.5%
BC7	C	100%	7,000	30	548	Yes	2.5%
BC3	C	100%	18,000	40	1,685	Yes	1.0%
BC10	C	0%	1,200	20	3,715	No	0.0%
BC8	C	100%	32,000	20	548	Yes	2.5%
BC4	C	100%	32,000	20	2,400	Yes	2.5%
BC9	C	100%	7,000	37	1,726	Yes	2.5%
BC2	C	100%	7,000	35	400	Yes	2.5%
BC6	C	0%	66	20	4,380	No	0.0%
BC11	C	100%	20,000	20	1,500	Yes	1.0%
BC12	C	100%	20,000	20	857	Yes	1.0%
Eucalypt 1	B1	0%	550	7	375	No	0.0%
Eucalypt 2	B2	0%	550	7	150	No	0.0%
Eucalypt 3	B3	0%	550	7	375	No	0.0%
Banana	B4	100%	19,333	5	1,095	Yes	1.0%
Cocoa	B5	100%	7,000	30	960	Yes	2.5%
Coffee	B6	100%	20,000	18	548	Yes	1.0%
Lime	B7	100%	20,000	12	2,571	Yes	1.0%
Pupunha	B8	100%	20,000	15	548	Yes	1.0%
Manioc	B9	100%	20,000	2	2,190	Yes	1.0%
Average	C		13,189	25	1,636		
Deviation 95%	C		5,959	5	709		
Average	B		11,998	11	979		
Deviation 95%	B		5,876	5	525		

Note: SG&A – Selling, General and Administrative Expense, BC - Business Case.

ENDNOTES

1. The National Rural Environmental Registry System (SICAR, from its initials in Portuguese) is a nationwide electronic system for the integration and management of environmental information on rural properties to subsidize policies, programs, and projects and for controlling, monitoring, planning, and combating illegal deforestation. For more information, see https://www.car.gov.br/#/

2. For more information on forestry concessions, see https://amblegis.com.br/meio-ambiente/o-que-sao-concessoes-florestais/

3. The ComexStat is a system for querying and extracting data from Brazilian foreign trade. Detailed data on Brazilian exports and imports are extracted monthly from SISCOMEX and based on the declaration of exporters and importers. http://comexstat.mdic.gov.br/pt/geral

4. The exchange rates are ensured by the Central Bank of Brazil, guaranteeing the stability of the purchasing power of the currency and the soundness and efficiency of the National Financial System. https://www.bcb.gov.br/#!/n/TXCAMBIO

5. International Financial Reporting Standards 13 (IFRS 13) were issued in May 2011 and defines fair value as the price that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants at the measurement date (an exit price). When measuring fair value, an entity uses the assumptions that market participants would use when pricing the asset or the liability under current market conditions, including assumptions about risk. As a result, an entity's intention to hold an asset or to settle or otherwise fulfill a liability is not relevant when measuring fair value. https://www.ifrs.org/issued-standards/list-of-standards/ifrs-13-fair-value-measurement

6. The International Accounting Standard 41 (IAS 41) – Agriculture. The objective of this standard is to prescribe the accounting treatment and disclosures related to agricultural activity. This standard is applied to agricultural produce, which is the harvested product of the entity's biological assets, only at the point of harvest. https://www.iasplus.com/en/standards/ias/ias41

7. S&P Global Timber & Forestry Index is formed by 25 of the largest publicly traded companies dedicated to owning or managing the upper levels of the supply chain of forests and timber regions. https://us.spindices.com/indices/equity/sp-global-timber-and-forestry-index#

8. Three sessions of the workshop "Silviculture of Native Species: Challenges and Opportunities for a New Forest Economy" were held in:
   - Paragominas, Pará State, from February 22 to 25, 2016, including a field visit to Amata, organized by Amata, WRI Brasil, and IUCN – International Union for Conservation of Nature
   - Southern Bahia State, from March 29 to 30, 2016, including a field visit to Symbiosis
   - Itirapina, São Paulo State, from May 5 to 6, 2016, including a field visit to Fazenda Da Toca, organized by Fazenda da Toca, WRI Brasil and IUCN.

9. Koppen's climate classification is the most widely used system in geographical and climatological studies done across the world, with well recognized simple rules and climate symbol letters. The Koppen climate types are symbolized by two or three characters, where the first indicates the climate zone and is defined by temperature and rainfall, the second considers the rainfall distribution, and the third is the seasonal temperature variation. The case studies described in this Report utilize the following climate types: Af = tropical without dry season, Am = tropical with monsoon; Aw = tropical with dry winter; Cfa = humid subtropical, oceanic climate, without dry season; and Cwa = humid subtropical, with dry winter and hot summer.

10. Iba Report [Relatório Ibá] 2020. https://iba.org/datafiles/publicacoes/relatorios/relatorio-iba-2020.pdf.

11. IBGE (2019). Municipal Agricultural Production - Table 5457: Area planted or destined for harvest, area harvested, quantity produced, average yield and value of the production of temporary and permanent crops. https://sidra.ibge.gov.br/tabela/5457.

12. CEPEA (2018), at the Center for Advanced Studies in Applied Economics- Forest Economy. https://www.cepea.esalq.usp.br/br

13. U.S. Bureau of Labor Statistics. Databases, Tables & Calculators by Subject – Inflation and Prices. https://www.bls.gov/data/#prices

14. The S&P 500 Index or the Standard & Poor's 500 Index is a market-capitalization-weighted index of 500 of the largest publicly-traded companies in the U.S. It is one of the most utilized equity indices. https://www.investopedia.com/terms/s/sp500.asp

15. Amata Annual Report 2017 (unpublished). https://www.amatabrasil.com.br/

16. Climate Smart Agriculture Alimi Impact Ventures 2019. http://www.alimi.com.br/lp/

17. Secex MDIC indices (2018). https://www.gov.br/produtividade-e-comercio-exterior/pt-br

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GLOSSARY

Afforestation. Conversion to forest of a land that historically has not contained forests (IPCC 2019a).

Agroforestry system (AFS). An ecological management system based on natural resources that, through the integration of trees in farm and pastures, diversifies and sustains smallholder production using a large diversity of plants and animals to provide vital community needs (food, health, clothing, and building materials), with social, economic, and environmental benefit (Castro et al., 2009; Leakey 2017).

Benchmark. A market reference for evaluating the performance of an investment.

Business-as-usual (BAU). Refers to the standard day-to-day business operations in an organization. A scenario that represents the most plausible projection of the future.

Brazilian Coalition on Climate, Forests and Agriculture. A multi-sector movement that aims to promote a new economic development model based on a low-carbon economy, created to articulate responses to the challenges of climate change.

Capital Expenditures (CAPEX). Capital expenditures are funds used by a company to acquire, upgrade, and maintain physical assets such as property, plants, buildings, technology, or equipment. CAPEX is often used to undertake new projects or investments by a company.

Capital Asset Pricing Model (CAPM). The relationship between systematic risk and expected return for assets, particularly stocks. CAPM is widely used throughout finance for pricing risky securities and generating expected returns for assets given the risk of those assets and cost of capital (https://www.investopedia.com/terms/c/capm.asp).

Carbon sequestration. Carbon dioxide (CO_2) removal process mediated by organisms, living mainly in oceans, soils, and forests, that capture carbon and release oxygen into the atmosphere, preventing CO_2 from remaining in the earth's atmosphere.

Compound Annual Growth Rate (CAGR). The rate of return that would be required for an investment to grow from its beginning balance to its ending balance, assuming the profits were reinvested at the end of each year of the investment's lifespan.

Cost of capital. The rate of return that a project or company must obtain on its investments to keep its market value unchanged. The riskier the investment's cash flows, the greater is the cost of capital. Keeping the risk constant, projects with returns above the cost of capital should increase the value of the company and vice versa.

Cost of debt. The monetary price of servicing the interest and principal payments of obligations used to raise capital for a company or an individual.

Degraded land. Land in a persistent decline or loss of biodiversity and ecosystem functions and services that cannot fully recover unaided.

Environmental Reserve Quotas (CRA, from its initials in Portuguese). Bonds that represent a natural vegetation coverage area on one property that can be used to compensate for the lack of Legal Reserve on another. Each quota corresponds to 1 hectare and they can be created by rural owners who have an excess of legal reserve to negotiate with producers that have less reserve area than the minimum required. https://www.oeco.org.br/dicionario-ambiental/28921-o-que-sao-cotas-de-reserva-ambiental-cras/.

Extended National Consumer Price Index (IPCA, from its initials in Portuguese). Index indicating the inflation of a set of products and services sold at retail, related to the personal consumption of families. Currently, the target population of the IPCA covers families with incomes equivalent to 1 to 40 times the minimum wage, whatever the source, residing in the metropolitan areas of Belem, Fortaleza, Recife, Salvador, Belo Horizonte, Vitória, Rio de Janeiro, São Paulo, Curitiba, Porto Alegre, Federal District, and the municipalities of Goiania, Campo Grande, Rio Branco, São Luís, and Aracaju. https://www.ibge.gov.br/en/ statistics/ economic/prices-and-costs/17129-extended-national-consumer-price-index.html? =&t=o-que-e

Free on Board (FOB). A term in international commercial law specifying at what point respective obligations, costs, and risk involved in the delivery of goods shift from the seller to the buyer under the Incoterms standard published by the International Chamber of Commerce.

Forest and landscape restoration (FLR). The ongoing process of regaining ecological functionality and enhancing human well-being across deforested or degraded forest landscapes. While FLR sometimes involves the opportunity to restore large contiguous tracts of degraded or fragmented forest land, most restoration opportunities are found on or adjacent to agricultural or pastoral land. In these situations, restoration must complement and not displace existing land uses; this results in a patchwork or mosaic of different land uses including agriculture, agroforestry systems and improved fallow systems, ecological corridors, areas of forests and woodlands, and river or lakeside plantings to protect waterways. https://www.bonnchallenge.org/content/forest-landscape-restoration.

Forest management. The process of planning and implementing practices for the stewardship and use of forests and other wooded land targeted at specific environmental, economic, social, and cultural objectives (FAO 2017).

Greenhouse gases. Gases that absorb and emit radiant energy within the thermal infrared range. The primary greenhouse gases in Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone. The six greenhouse gases limited by the Kyoto Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), and two gas families, hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Integrated systems. Agricultural systems involving integration agricultural activities in the same area. Are they crop-forest integration (CFI), crop-livestock integration (CLI), livestock-forest integration (LFI), and crop-livestock-forest integration (CLFI).

Internal Rate of Return (IRR). A means of comparing investment propositions by calculating the effective annualized rate of return. IRR is a discount rate at which NPV equals zero.

IRR is a discount rate at which the present value of cash inflows equals the present value of cash outflows. If the IRR is higher than the required return, the investment is attractive.

Ipê. The popular name in Brazil for a wide variety of species mainly from the genera *Handroanthus and Tabebuia* (Bignoniaceae). It is considered a noble wood and can be used in the construction of bridges, beams, frames, floors, stairs, furniture, and parts in the manufacture of musical instruments, doors, and windows, among many other purposes.

Lacey Act. The Lacey Act is a 1900 U.S. law that bans trafficking in illegal wildlife. In 2008, the Act was amended to include plants and plant products such as timber and paper. This landmark legislation is the world's first ban on trade in illegally sourced wood products. https://forestlegality.org/policy/us-lacey-act.

Legal Reserve. A term used in Brazil for an area located within a property or rural possession, ensuring the sustainable use of the property's natural resources, assistance in the conservation and rehabilitation of ecological processes, and promotion of the conservation of biodiversity, offering shelter and protection for wildlife and native flora.

Liquidity. The ease with which an asset can be sold at a price close to its intrinsic value.

Natural capital. Natural capital is the world's stock of natural resources, which includes minerals, soils, air, water, and all living organisms. Some natural capital assets provide people with free goods and services, often called ecosystem services. Two of these (clean water and fertile soil) underpin our economy and society, and thus make human life possible. https://en.wikipedia.org/wiki/Natural_capital.

Natural climate solutions (NCS). Conservation, restoration, and improved land management actions that increase carbon storage and/or avoid greenhouse gas emissions across global forests, wetlands, grasslands, and agricultural lands (Griscom et al. 2017).

Net Present Value (NPV). The fundamental measure of profitability of investment projects. NPV equals the sum of present values of all cash flows (inflows and outflows) in a project. If the NPV is greater than zero, the project is profitable. If the NPV is less than zero, you should not invest in the project.

Pre-competitive research program. Cooperative research conducted jointly by normally competing institutions for the purpose of developing new commercially applicable technologies (Longo and Oliveira 2000).

Procurement. Deals with the sourcing activities, negotiation, and strategic selection of goods and services that are usually of importance to an organization.

Reducing Emissions from Deforestation and Forest Degradation (REDD+). An international framework whose name stands for reducing emissions from deforestation and forest degradation, conservation of existing forest carbon stocks, sustainable forest management, and enhancement of forest carbon stocks. This framework was developed by the Parties to the United Nations Framework Convention on Climate Change (UNFCCC).

Reforestation. The term describes generically the planting of forest species, whether native or exotic, with a single or several species, with or without an economic purpose.

Risk-adjusted return. The amount of risk involved in an investment; the higher the risk, the higher return an investor should expect.

Roundwood. Any timber product supplied in log form. It is mainly used for structural applications, as poles, piles, girders, posts, sawn wood, panel products, or pulp.

Sensitivity analysis. A "what-if" analysis referring to a change in a single input variable at a time when compared to a given scenario.

Silviculture. The art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society such as wildlife habitat, timber, water resources, restoration, and recreation on a sustainable basis (U.S. Forest Service 2020).

Sustainable forest management. The process of managing a forest to achieve a continuous flow of forest products and services without undue reduction of the forest's inherent value and future productivity and without undue undesirable effects on the physical and social environment.

Track record. Performance history, widely used in the fund industry to evaluate the performance of the investment portfolio or portfolio manager. Concept used to assess the quality of a portfolio and its manager based on historical data.

Volatility. Term for a statistical measure of the dispersion of returns for a given security or market index. In most cases, the higher the volatility, the riskier the security. Standard deviation is widely relied on to assess risk by measuring the volatility and dispersion of returns.

Weighted Average Cost of Capital (WACC). The capital structure of a project in which cost of equity and debt capital are proportionately weighted.

ABOUT WRI BRASIL

WRI Brasil is a research institute that transforms big ideas into actions to protect the environment and foster Brazil's prosperity in an inclusive and sustainable fashion. It is focused on research and applications of sustainable solutions oriented towards climate, forests, and cities. WRI Brasil combines technical excellence with political articulation and works in close collaboration with governments, private companies, universities and civil society.

WRI Brasil is part of World Resources Institute (WRI), a global research organization whose work extends to over 50 countries. WRI encompasses the work of almost 1000 professionals in offices in Brazil, China, the United States, Mexico, India, Indonesia, Europe, Turkey and Africa.

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