Amazonian Forest: The Products of Agroecological Systems

Climate Change Division

Considerations about the Natural Forest and Economic Exploitation for its Conservation and How to Develop Sustainable Agroforestry Systems that Induce the Reduction of Deforestation

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Considerations about the natural forest and economic exploitation for its conservation and how to develop sustainable agroforestry systems that induce the reduction of deforestation

The Amazon Third Way Initiative

Carlos Nobre, Júlia Arieira, Nathália Nascimento

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1. Contextualization - The occupation of the Amazon and its socio-environmental consequences

The Legal Amazon comprises the states of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, Mato Grosso, Tocantins and part of the state of Maranhão, occupying an area greater than 5,000 km^2, which is equivalent to 58.9% of the Brazilian territory (IBGE, 2019). Being a diverse region and rich in biodiversity and culture, the Amazon welcomed European culture, during the 17th and 18th centuries with significant developments and considerable negative impacts on its natural elements and the pre-colonial social aspects (Koch et al 2019). Colonization established structures to human settlements based on the occupation vision from European culture and models of nature exploration based on the removal of spices and raw materials that characterized the colonial model (Homma, 1992).

A new model of occupation and exploitation of resources was implemented in the Amazon centuries later. From the 1960s , the Brazilian Government created a series of projects to encourage the occupation of the Amazon region, financing the expansion of the road network, providing fiscal and credit support to facilitate access to land, and encouraging the replacement of the forest by agricultural activities (Becker, 2010; Herath, 2005). Until today, the inheritances of this model of development and occupation in the Amazon are still expressed in the strong investment in infrastructure projects, such as opening roads and building hydroelectric dams, as well as in the predominant agricultural model that still perceives the forest as an obstacle to the regional development.

On the other hand, the Amazon, as the birthplace of remarkable cycles that supported Western development, such as rubber and its functions, has its biodiversity being presented as a solution to many problems that afflict humanity and its civilizing process. Evidence of the use of biodiversity for human well-being can be found in the more than 2000 medicinal species known today (Barata, 2012), used by the local population that maintains a strong culture of traditional medicine based on local knowledge. In addition, there are at least 1,250 species (Barata, 2012) from which essential oils with high economic value can be extracted, in addition to use in food, cosmetic and medicinal traditions. However, it is necessary to understand the need for a break with previous development models to ensure that the insertion of biodiversity products as a key element in the regional economy does not culminate in its unbridled exploitation and capable to integrate traditional knowledge into the that concerns the management of resources and that guarantees the improvement of the quality of life for the inhabitants of the region.

The Legal Amazon has a population of approximately 27 million inhabitants, 76% of whom live in urban areas (PNAD, 2015). In 2017 the region participated with 8% for the Brazilian GDP, a significant advance compared to the 5.8% in 1997 (IBGE, 2017). Nevertheless, the income of people in the region has remained below than the national average. In some aspects, has worsened over the years, representing a comparative loss of income for the region's population in relation to the national's population, even with economic growth. The socials index of Amazon are among the worst in Brazil, for example, the region's average HDI (Human Development Index) and 0.680 (IBGE, 2010) compared to 0.794 in the southeastern region of the country. In addition, the municipalities of the Marajó archipelago in the state of Pará have the worst HDIs in all of Brazil, with the municipality of Melgaço showing the lowest HDI of Brazil with only 0.418 (PNUD, 2010[1]).
Another example is the wage income in the region that was 83.7% of the national average in 2007, while in 2017 the wage income was reduced to the equivalent of 77.9% in relation to the national, even with the industrialization of the region. Although the region's industrialization process has resulted in economic growth, it cannot be said that the benefits of this development have been transferred to the population in a balanced way, which requires specific assessments and studies on how to improve income distribution, avoiding exacerbating inequality (Bunker 1989).

The Amazon has a substantial portion of its area already deforested. The Amazon biome has 4.2 million km^2, where 0.7 million km^2 (20%) has already been deforested (shallow cut), (IBGE, 2018; INPE, 2020), of which a large percentage is abandoned. Areas that are not abandoned are being used for livestock and annual crops such as soybeans and cotton (TerraClass, 2014[2]), that is, activities focused on *commodity* agriculture . On the other hand, the growing percentage of recovered area with the adoption of SAFs Agroforestry Systems (Carneiro and Navegantes-Alves, 2019) is notable.

The continued strategy of implanting large-scale agriculture, following the European model and originating in the South and Southeast regions of Brazil, is particularly attributed to the international demand for grains (such as soybeans, corn, among others) (Gibbs et al, 2015, Rajão et al, 2020). As exhaustively demonstrated by research organizations, the predominance of monocultures significantly impacts microclimate, soil, biodiversity, in addition to destroying natural and native *habitats*,

[1] https://www.br.undp.org/content/brazil/pt/home/idh0/rankings/idhm-municipios-2010.html
[2] http://www.inpe.br/cra/projetos_pesquisas/dados_terraclass.php

since there is no defined policy on landscape connectivity, even for legally occupied areas (SPAROVEK et al, 2019). In addition, the impacts of monocultures on ecosystems include loss of biodiversity (Decaëns et al. 2018), change in landscape structure that affects the provision of ecosystem services such as rain production and carbon sequestration (Leite - Filho et al., 2019), appearance of pests (Aristizábal and Metzger, 2019) , waterproofing of the soil, and contamination of groundwater by pesticides and fertilizers (Weihs 2020). Monocultures can be potentially detrimental to the productivity of other productive systems in their surroundings, they can also compromise, in the medium and long term, the biophysical conditions essential for their own continuity (Huera-Lucero et al., 2020). In addition, the interface with public protected areas is little pacified in terms of management of public protection instruments, particularly the interface between the Forest Code and the National System of Conservation Units (acronym in Portuguese SNUC) (National System of Conservation Units).

Most agribusiness systems implemented do not involve a large contingent of labor, contributing to social imbalance and possible rural exodus. Therefore, everything suggests that the implanted system of monoculture agriculture and non-agroforestry systems, brings advantages only in the economy of scale.

In addition to deforestation, the Amazon is also experiencing an intense process of forest degradation (Bullock et al., 2020), which consists of the partial removal of vegetation at a level that impacts its functioning. Forest degradation is fueled mainly by illegal logging and harmful agricultural practices, especially those that adopt the cutting and burning system.

2. Amazon rainforest: economy and ecosystem services

Economic and production activity in the Amazon forest cannot dispense with considerations on the benefits that result from maintaining the forest on a large scale. In recent years, the term “ecosystem services” provided by the natural forest or its ecological systems has been consolidated (Aznar-Sánchez et al. 2018). Contrary to the perception of many decades ago, it is now recognized that atmospheric circulation in the planetary system has a strong interaction with large-scale forests, especially tropical forests (Mitchard 2018; Spracklen et al., 2018). This fact is extremely important in the Amazon Basin, as this is the largest hydrographic basin on the planet (~ 7 million hectares), consequently generating numerous benefits at the continental and planetary level, but also at the regional and local level. This occurs through the integration of evapotranspiration mechanisms coupled with transcontinental air currents and vertical movements of air masses, resulting in moisture transport throughout the South American continent, even with limitations to the transport of water vapor beyond the Cordillera of the Andes (Fu et al., 2013b; Wright et al., 2017). The hypothesis of removal of a significant area of the Amazonian forest may imply the loss of its systemic function in the interaction with the movement of humidity through the atmosphere, on a large scale (Nobre et al., 2016). In this scenario, there will be adaptive and probably negative effects, impacting regions to which the humidity of the air moves and provides precipitation (rain) that enables agricultural and livestock production at the continental level. Models of biogeochemical studies demonstrate that the humid tropical forest, maintained on an adequate scale, enables not only the economy of the agricultural and livestock sector, its production chains, but also the continuous feedback of its conservation (Nobre et al., 2016, Leite-Filho et al. 2019). This fact is associated with the maintenance of the hydrological balance of influential river basins, as well as with the regulation of the distribution of rainfall and temperatures in a vast region of the Americas, which has even more distant influences (Marengo et al., 2018; Sorribas et al., 2016).

For this reason, the maintenance of humid tropical forests, especially the Amazon, requires priority in the development of forest management systems that allow production with economic value (Nobre & N obre, 2018), coupled with the valorization of the ecosystem services that generate tangible benefits, even if diffuse, that should be considered as of planetary importance of the forest.

By understanding the ecosystem as an integrating concept of the economic activities of modern society, we were able to seek a new and contemporary concept that should be understood as a result of international debates, which have taken a great boost since UNCED (Rio 92) when definitive instruments of commitments between signatory countries to the United Nations agreements are now adopted. In this sense, in recent decades it has been possible to verify numerous initiatives implemented by the most diverse sectors of society, which have taken advantage of converging and conciliatory concepts in the use of the natural forest as a source of food, fiber and energy supply, maintaining its conserved ecological structure, as well as cultural and social values. This document seeks mainly to value this information.

2.1. Economic alternatives in the Amazon

The Amazon offers several opportunities for more sustainable use than replacing the tropical rainforest with other non-forest uses. Although large-scale agriculture and livestock, large-scale monoculture systems that have replaced forests result in advantages of high productivity, it is noted that their impact has been showing significant losses in the security of the ecosystem in general (Lathuilliere et al. 2017). In this sense, in the long term, large-scale monoculture systems must be evaluated to increase the interaction with productive and economically viable forest systems, in an interspersed and orderly manner, so that we can achieve the best economic and environmental balance of these productive practices. The demonstration that native forests can have comparable and even better economic productivity in some circumstances (Nobre and Nobre 2019), can be the key to coexistence between the agricultural sector of production of *commodities* and the maintenance of preserved forests, breaking the mistaken concept that forests are an obstacle to the economic development of the Amazon region. We have never been as close as we are today to a reality where the conservation of biodiversity, as well as respect for the rights of traditional populations in the search for a balance between development and conservation.

In the last decades, the region has been taken by a growing occupation race involving the production of the following commodities: beef (livestock), soy (agribusiness), energy, mineral (aluminum, iron, copper, gold, manganese etc.) and forest products (wood, rubber, andiroba, copaiba, Brazil nuts, açaí, etc.) (Rajão e al., 2020).

Diversely, in the context of the Brazilian cosmetics market, which generated around 20 billion dollars in 2010, the Amazon still has a little participation, providing only raw material with low added value (Barata, 2012). Among many structured markets worldwide, such as cosmetics and essential oils, the use of biodiversity in the Amazon rainforest is a real alternative to large-scale perennial supply (Nobre & Nobre 2018). However, Brazilian activity in this market is predominantly for the exportation of citrus oils, not originated in the Amazon. The example of the orange in 2018, when produced more than 16 million tons, generating more than 9 billion in revenue (IBGE, 2018), in comparison to the oilseed products of the NTFPs that yielded around R $ 115 million and produced a little more than 59 thousand tons in the same period. Among these products, the most outstanding in the Amazon region is copaiba oil and Cumaru almond, with revenues of around R $ 8 million and a production of 335 tons (IBGE, 2018; SFB, 2019[3]).

[3] http://snif.florestal.gov.br/pt-br/ultimas-noticias/553-sfb-lanca-o-boletim-snif-2019

3. Agroforestry Systems (Portuguese acronym SAF) as a smart alternative to the commodity economy

The relationship between forest and agriculture in the Amazon happens from a historical context. In a very succinct summary, agriculture in the Amazon take place after that which initially settled in the Northeast and Southeast regions of Brazil, during the colonial period. After the colonial period, the exploration of the Amazon in the 20th century occurs through extraction (wood, rubber, ore etc.) and subsequent introduction of the occupation model similar to what occurred in the Northeast and Southeast, ie, with the removal of the forest and replacement for non-forest uses, particularly in a region of the state of Pará called “Bragantina”. This model followed the typical European agriculture, which had been introduced in Africa and some countries in Asia, by the Europeans in the colonization processes. In the Amazon, this model has expanded more slowly, given the crown's focus on the success of NE and SE agriculture. In a second phase, especially in the interiorization of the state of Pará and in the expansion of occupation of the Brazilian Midwest, already in the 20th century, extensive livestock farming takes on other modalities strongly linked to the occupation and dominion of the Amazonian territories and, with that, defined the majority activities of the population settled in the region. By the end of the 20th century, a scenario of complete transformation of large extensions of the Amazon had already consolidated systemic changes, creating the presence, after the extensive livestock cycle, of monoculture and large-scale agriculture, especially grains and different agricultural commodities.

In this way, the economic activity of using the forest was limited to the use of wood and its replacement by agriculture, with no significant expression of forest use in sustainable management. In addition, the installed agricultural systems did not see any opportunities for integrating economic activity that included the forest, understanding it as a hindrance. It was only at the end of the 20th century that some concepts of forest management, both of wood, but also of non-timber forest products (NTFPs) integrated the standing forest to the coexistence of the economic use of forest areas. In this context, the agroforestry system has become an important ally and has expanded as a concept for the vision of regenerative agriculture, which apparently contradicts much of the concept that agriculture, however conservationist, always causes impacts on soil loss (soil erosion [4]), however small it may expected. However,

[4] In modern agriculture, agronomic practices seek to minimize the impacts of farming, but it presents "practically impossible" agriculture with "zero erosion". However, the evolution of the concepts proposed in different alternative models for modern agriculture, allow us to glimpse a convergence of methods that allow regenerative agriculture for the tropical environment and others.

the concept of regenerative agriculture[5] presents itself as a novelty of agronomic concepts. At the beginning of the 21st century which, while not antagonizing modern agriculture[6], seeks to incorporate innumerable concepts of ecological management to the practices of modern agriculture. This concepts incorporation allow the recovery of the ecological functions of the soil and of an "agroecosystem" in which, in addition to avoiding the loss of soil-forming elements (clays, sands, organic materials and other components), stimulate the revitalization with the incorporation of materials originating in the agricultural activity and possible imports of materials originating in crop rotation, for example: no-tillage or the installation of fast-growing tree species with cycles of growth medium term, for incorporation into the soil (green manure), or even ancestral practices such as "terra-preta de indio"[7]. All of these practices seek to avoid soil degradation, enrich systems that were originally infertile and / or revitalize the losses resulting from agricultural practices incompatible with the edapho-climatology of the Amazon region or others.

Agroecosystems or Agroforestry Systems (SAF) are presented as one of the alternatives to produce intelligently in the Amazon, both agricultural, forestry and biodiversity products, or also called *products of socio-biodiversity* (involving traditional communities and / or products originating in the Amazonnatural environment, such as countless varieties of cassava, cocoa, among many others). **SAFs are forms of integrated land use and management, in which trees and shrubs are used in association with agricultural crops in the same area, simultaneously, synergistically and also in time sequence** (Atangana et al., 2014).

From a structural point of view, SAFs are important for combining trees and agricultural crops, optimizing crops, methods and knowledge (Atangana et al., 2014). These systems prove to be more sustainable because they seek beneficial effects of interactions between species, because they use natural ecosystems as a model and replicate ecological characteristics to agricultural systems: the highest productivity comes both from the complementary relationships between the components and from the more efficient use of resources (space, water, light, nutrients, etc.). Added to this context, a better social, economic and cultural adaptability in the production process. SAFs are therefore configured as a maximized use of the aggregate environment, different from monoculture agriculture that

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[5] Regenerative agriculture, although not yet classified as an alternative agriculture, is presented as being able to recover the set of fertility and ecosystem factors, which may be similar or close to the original conditions of an area implanted with modern or conventional agriculture

[6] Modern Agriculture, the concept: https://pt.wikipedia.org/wiki/Agricultura_moderna ;

[7] Terra Preta de Indio: https://www.embrapa.br/en/busca-de-noticias/-/noticia/1493237/terra-preta-de-indio-desperta-interesse-da-ciencia-internacional

maximizes the success of only one or a few species. Proper management of agroforestry systems allows regulation of the level of solar incidence in the forest, maximizing the use of carbon and increasing photosynthetic rates (Suárez Salazar et al. 2018), in addition to reducing input costs to increase system productivity, when plants facilitate nutrition (nitrogen fixers) are combined (Kelty 2006), offering opportunities to add food security, economic and social value to rural producers (Arco-Verde 2013), with great potential for evolution in technological terms.

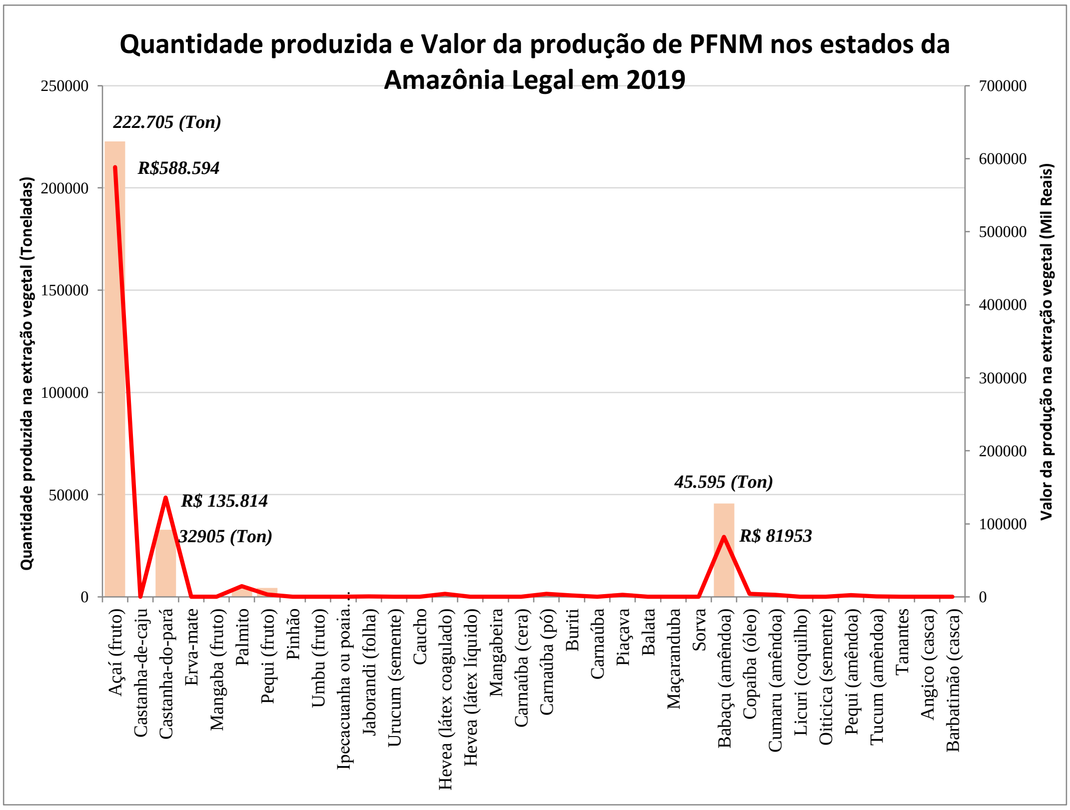
Many local communities in the Amazon, and in other tropical regions, use forest resources as an essential component of community and social livelihoods. Further to the traditional use of forest resources (for example, resins, fruits, seeds, medicines, wood, etc.), a new concept of community-based forest management (CBFM - *Community Based Forest Management*) has been developed in recent decades in Brazil. In this type of management, activities are conducted by external agents, such as the government, international or local non-governmental organizations, or a combination of the three (Sunderlin, 2006). This complexity and diversity of contexts, actors, objectives and strategies proves to be complex a unique definition of what "community forest management" means in the Amazon (Amaral Neto, et al. 2005). However, this concept was fundamental for a Federal Community and Family Forest Management Program (Decree No. 6874, 2009), to be adopted with the following broad definition: "*execution of management plans carried out by family farmers, settled by agrarian reform and by traditional peoples and communities to obtain economic, social and environmental benefits, respecting the mechanisms of sustaining the ecosystem* ". Such public policy is one among many existing initiatives. In this sense, Decree 6874 shows the convergence of concepts that guide this document. There is a very wide range of initiatives, projects, undertakings, etc., which seek to achieve similar objectives and here we seek to aggregate such information, demonstrating the importance of definitive deepening of forest management in SAFs as the main tool for forest conservation, through its potential productive.

4. Non-Timber Forest Products

There is clear evidence that productive systems, more convergent with the structure of the natural forest, are economically viable and can be implemented with due synergy in integrated systems with the production of grains, meat and Non-Timber Forest Products (NTFPs). **NTFPs include products extracted from the forest, with the exception of wood**. They are used in various ways by extractive populations that transform oils, fruits, seeds, leaves, roots, barks and resins obtained from nature into utensils, food, medicine, among others (Fiedler et al, 2008). This is a trend view of countless contemporary researchers and one that should be the target of public policies, but also of actors in the financial sector and investors interested in good economic results.

An excellent example of an integrated system already tested is that of species that produce NTFPs such as açaí, cocoa, and Brazil nut, i.e., important products in the context of traditional communities and that generate subsistence, surplus income generators and other economic activities for forest communities and entrepreneurs. In the states of the Legal Amazon, among the NTFPs with the highest amount produced and production value, açaí, Brazil nut, and babassu (Figure 1) stand out.

Figure 1. Quantity produced and Heat from the production of NTFP in the States of the Legal Amazon in 2019



Source: IBGE, 2019.

Such forest products are also demanded by the large-scale economy and exports and agribusiness. The acai fruit, cocoa, and Brazil-nut coupled to the other as cupuacu, bacuri, rubber, peach palm, rosewood, guarana, are examples of species that have been used in both homogeneous crops, such as biodiverse systems.

Most of the NTFPs produced (Figure 2) is into the category of food products, responsible for 84% of all types of NTFP and where the açaí, the Brazil nut and the Palmito stand out. The second category with the largest amount produced is oilseeds, responsible for 15% of the NTFPs products. Babaçu, copaíba and cumaru stand out in this category. Some common species in the region and of great commercial value (Figure 3) do not yet have a systematic database with data on production and marketing, but they are of great importance in the daily life and source of income of traditional families in the Amazon, such as cupuaçu, bacuri and andiroba, for example. What also demands the systematization of data on common products in communities in order to facilitate their transformation into products and sources of income.

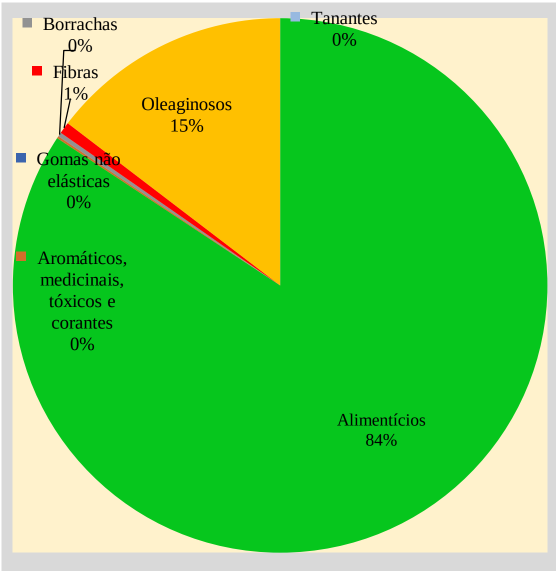


Figure 2. Quantity produced of NTFPs in tons in 2019 in the states of the Legal Amazon. (IBGE, 2019)

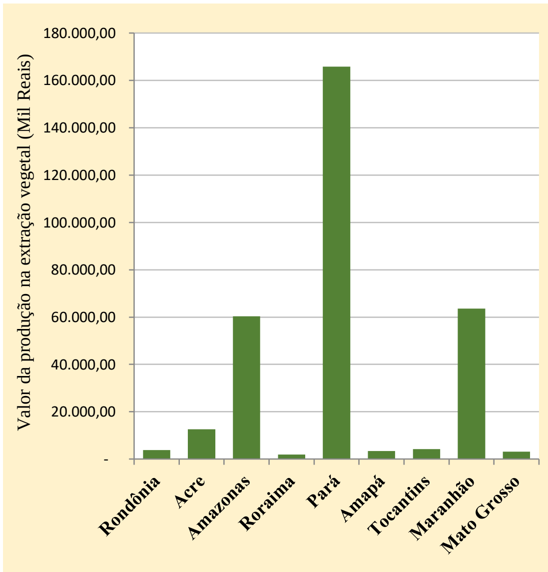


Figure 3 . Value of the production of NTFPs in 2019 in the states of the Legal Amazon. (IBGE, 2019)

Pará is the state with the highest production of NTFPs, it is also the one with the highest yield, especially due to the commercialization of açaí and Brazil nuts. The state is followed by Maranhão and then by Amazonas.

4.1. PFNM traceability: the importance of monitoring and control mechanisms for forest maintenance

Studies show that illegality in logging in the Amazon region reaches 80% of the total produced. This illegal wood becomes legalized along its supply chain, due to failures in the State's control and monitoring systems (Miller, Taylor & White, 2006; Greenpeace, 20 17[8]; Brancalion et al. 2018). Especially in the last two decades, initiatives have been developed to seek the solution of these problems, using technologies that are based on the concepts of traceability and supply chain management. In Brazil, the Forest Origin Document stands out (DOF; IBAMA, 2006[9]), under the responsibility of the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) and the Forest Products Commercialization and Transport System (SISFLORA; SEMA, 2009[10]), created by the Environment Secretariat of the State of Mato Grosso and used by other States, such as Pará and Rondônia. However, such legal instruments are vulnerable and need technological improvement to fulfill their role of quality control and combating illegality.

Recently, SINAFLOR (www.ibama.gov.br/flora-e-madeira/sinaflor) was created , an electronic platform that aims to control the origin process of wood, coal and other non-timber forest products and by-products, in addition to tracking from the exploration authorization to the transport, storage, industrialization and export of products. It was foreseen that all states of the Federation should be using SINAFLOR until January 1st , 2018. However, the deadline was extended from June 30th, 2019 to January 31st, 2021. SINAFLOR quickly provides for the certification of the Plans Sustainable Forest Management and gives more security to the transfer of timber credits to the DOF system (Document of Forest Origin). SINAFLOR information is integrated into the base of the Rural Environmental Registry (CAR) for a real monitoring of the deforestation dynamics in the states (MMA, 2018). This system is still in the initial development phase and has the potential to integrate with other information bases, but the lack of efficient means for data acquisition and standards for the exchange of mutual information between the other systems involved in the production process and monitoring systems have made this system inefficient (Brancalion et al., 2018).

In addition to geoprocessing tools for monitoring production chains, there are traceability mechanisms linked directly to products, based on DNA analysis that combined with the tracking of land use can make up the monitoring of the environmental and social impacts of the production of NTFPs. The advances achieved in the last two decades have allowed a variety of biology and molecular genetic techniques to be applied in studies to discover and characterize biodiversity, helping in its traceability (Dias et al. 2015, Hajibabaei et al. 2006; Kress et al.

[8] https://www.greenpeace.org/brasil/hubfs/Greenpeace_BloodStainedTimber_2017.pdf
[9] https://www.ibama.gov.br/flora-e-madeira/dof/o-que-e-dof#:~:text=31.-
,O%20Documento%20de%20Origem%20Florestal% 20 (DOF)% 2C% 20institu% C3% ADdo% 20by% 20Portaria, including% 20o% 20carv% C3% A3o% 20vegetable% 20native
[10] http://monitoramento.semas.pa.gov.br/sisflora/relatorios.html

2005, Lahaye et al. 2008, Lima et al. 2018, Williams et al. 2001). The methods of identifying ancient DNA (Pääbo et al. 2004) make it possible to obtain DNA sequences from products already processed, such as wooden floors and furniture (Double Helix Tracking Technologies, 2011), since these products undergo processes that degrade DNA, similarly to the DNA of old samples (albeit by different processes). Bearing in mind that DNA represents a unique code for each organism, these applications have gained popularity (CBOL Plant Working Group, 2009) and are already being used for several purposes in the forest sciences, such as molecular tree identification, recognition of wood products legally extracted, as well as the quality control of these products (Degen and Fladung, 2007; Double Helix Tracking Technologies, 2010[11]; German Institute for Forest Genetics, 2008; Lowe et al. 2010 ; Dormontt et al. 2015). Some of the major import centers for timber and non-timber forest products (eg Europe and the United States) have for years indicated the use of DNA-based methods as an efficient way of controlling points of entry into Europe (European Commission DG Environment, 2008[12]). Based on this, researchers from Australia (Lowe et al. 2010) have already proposed a DNA-based procedure for verifying the integrity of the production chain to confirm the legal origin of wood products from *Intsia palembanica* Miq. (Leguminosae) in Indonesia. However, the region with the largest production of wood products in the country and one of the main in the world, the Amazon, is completely devoid of these tools for native species. This is an opportunity of great significance for adding value to the product of the forest (timber or non-timber) and such traceability technology is becoming increasingly necessary to comply with international trade commitments and compliance with nature-based agreements. conservation of biodiversity and the Rio-92 agreements.

Given the above, in view of the strong positive effect to be achieved in the Brazilian forest sector, the expected benefits of traceability actions include:

- Transparency of information and production processes for society;
- Ensuring that the forest ecosystem is being used sustainably;
- Reduction of social injustices and deforestation that are associated with the production of coal, soy, cattle and others;
- Reduction of tax evasion;
- Control of information for licensing purposes, making it faster to issue transport authorizations and to inspect / monitor cargo of products transported in the country and exported;
- Identification of frauds along the production, transformation and commercialization chain of products.

Technologies such as *Hyperspectral* can contribute to improve monitoring in the future, through satellite image, the technology obtains data on the composition of species in certain

[11] https://www.doublehelixtracking.com/
[12] https://ec.europa.eu/environment/forests/pdf/ia_report.pdf

areas, providing information to distinguish açaí monocultures among other types of forest occupation. *Hyperspectral* technology makes it possible to distinguish between the forest and tree or mixed crops with native species. This tool can reduce inspection costs, allowing the tracking of bioproduct cultivation areas, as well as informing whether such occupations are the result of recent deforestation. We should also mention the example of *Lidar*, which is being widely handled and tested as a way to monitor forest areas, through the composition and structure of species. These technologies offer a range of responses that will allow the establishment of new databases focused on the premises of the Amazon 4.0 Program.

To ensure the viability of implementing systems for the "Traceability of Forest Products", the following steps are strongly recommended: (i) Development of a reference model applied to the management of the chain of custody of Brazilian forest products; (ii) Development of a Framework for the traceability of Brazilian products and services; (iii) Development of a prototype to validate the proposed scope.

5. The Forest integrated to the Productive System in the Amazon Territory

We start from the premise that the Amazonian forest continuum will only be permanent if the forest is included in the coexistence with modern society as an economic asset (Becker and Stenner, 2008). For this, its use and exploitation must be sustainable. The forest allows the subsistence of a large human contingent and has enormous potential to add economic value to the products of sustainable extraction, generating surpluses and substantial wealth. On the other hand, if in the occupation of the Amazon territory, the forest does not integrate the productive system as a key element, it will be constantly at risk of being replaced by other types of land use, considered more profitable and with potentially disastrous environmental implications. The impacts of this can encompass a series of externalities that threaten the forest system and establish a future where the Amazonian forest continuum tends to disappear, or fragment and may culminate in a process of forest savanization (Nobre et al, 2016).

There is abundant evidence that any other use and occupation systems in the Amazon region, at medium and large scales, that are not predominantly integrated with the original forest, generate increasing impacts and negative externalities at small, medium and large scales, pointing to a thesis of that the best economic option for land use in the Amazon is that capable of integrating man with the natural and original forest. Experiences show that the more the human being fights against the forest, the worse his defeat will be. The opposite is also true.

The key recommendations for the long-term conservation and preservation of the forest in the Amazon territory can be listed in the following items, adapting economic, technological and cultural aspects:

1. Fixation of traditional populations and rural communities;
2. Healthy access to urban centers and centers and commercialization structures;

3. Viability of the lifestyle of native or traditional peoples;
4. Broad access to adequate technology that adds value to the forest product;
5. Access to financial resources and technical support viability;
6. Harmonization of public policies related to markets, pricing practices, financial support, incentives, flow structure, conservation, connectivity, etc .;
7. Innovation: access, training and support for entrepreneurial management.

The harmonious integration of these items, which should promote the maintenance of large forest areas in the Amazon, makes economic, preservation and conservation activities viable, and must be linked to the economic development of the region.

In this context, SAFs are considered sustainable because their area of implantation can be used permanently and continuously, minimizing the need for cutting and burning the forest. This can contribute positively to increase the chances of fixation of the man in the field. This system does not exclude monocultures, but combines market products with subsistence products, allowing to limit the risks to the producer, whether climatic or market.

The need for labor-dependent work, whether its own, or contracted or exchanged, becomes more homogeneously distributed over time and inserted in the annual cycle, allowing greater diversity of products within the same rural unit, all resulting diversity of planted species. And unlike agribusiness, it also employs a large amount of labor. Another relevant point concerns the scenic beauty provided by forests (facilitates local and regional, community or regular tourism, which can also be understood as an additional source of income) and the environmental concern of traditional communities in relation to climate change (increases environmental resilience) (Wandelli, 2013). They are, therefore, key factors that the populations of these places are increasingly paying attention to recovering degraded areas and maintaining SAF areas. These advantages historically contribute to those involved in agroforestry systems not promoting new deforestation, making it possible to accommodate new generations with diversity, avoiding rural exodus, whose dynamics have regional peculiarities from the Amazon.

In this context, it is possible to envision a wide range of activities in SAF, in a coordinated manner, so that initiatives do not incur deforestation, provided that the operationalization has strong implementation and coordination structures (role of projects and enterprises such as Amazônia 4.0). This is feasible, since there is already a good culture of participation and integration in the Amazon region, with communities and community entrepreneurship. This community entrepreneurship is very important for local acceptance of converging external initiatives that observe local interests. For this situation to be successful, it is essential to have an incentive and attractions aligned with the different interest groups and their regionalities. It is, therefore, essential that an operational research is designed and implemented, so that it is possible to harmonize local interests and integrate stakeholders. There are numerous initiatives in this kind of element has been driven by public organizations and other private third sector in several Amazon regions, with excellent results.

Therefore, it is evident that the exploitation of extractive species (native species) does not contribute to the increase in deforestation. These species are also used for implantation in areas already deforested and / or degraded and also have great potential for coexistence with livestock systems (silvo-pastoral). Native species are generally managed following an economic cycle divided into three phases, as an example of açaí: (i) natural harvest of native açaizais, predominantly on the banks of rivers, maintaining a reasonable diversity, but with low productivity; (ii) native açaí groves that are managed and enriched, with drastic interventions, aiming at increasing the species density and genetic improvement; (iii) homogeneous plantations, usually on dry land, in places that have already suffered deforestation. In areas where native production is already present, there has already been a significant increase in productivity.

On other fronts of extractive activity, with the application of innovative technologies, management and intelligent entrepreneurship, it has been possible to demonstrate a “bioeconomy” based on the sustainable exploitation of products for the pharmaceutical industry, food, cosmetics, energy, fibers and other materials. With sustainable management, economic incentives, effective monitoring and inspection and traceability through high technology (DNA, GIS certifications etc.), it is possible to consolidate a supply chain for "bioindustries", boosting the local and regional economy, respecting social rights, traditional peoples, and protecting the ecosystems of the Amazon.

In order for all of these factors to be integrated, it is essential to raise awareness among the inhabitants (riverside dwellers, family farmers, extractivists, indigenous people, etc.), with inclusive alternatives that facilitate harmonious coexistence between communities, social structures, local cultures, with systems of scale, such as livestock, soy, cotton, palm or even cassava.

6. Public instruments and policies as an incentive to sustainable practices

As a strategy to stimulate responsible expansion of agroforestry systems in the Amazon Region, it would be crucial to create instruments and public policies to encourage and support more sustainable uses by those interested, integrating the interests of traditional populations and rural communities. Thus, developing a public policy and policy of sectors of the economy, to increase exchange with the private sector is relevant to facilitate private investments with security and robust regulation. Following these premises, the different types of SAF initiatives can be inserted in a sustainable development program based on sustainable use of forests, whose participants would receive incentives (technological, socioeconomic, financial subsidies, etc.). This allows for permeability with regional, national and international systems, both for markets, operational relationships and also interaction with ecosystem service mechanisms. In addition, synergies can be established with the different mechanisms of the Climate Conventions (REDD[13]) and Biodiversity (CDB, TEEB[14]).

The promotion of programs for participation and engagement of producer families should provide numerous advantages and security in obtaining direct gains, such as social benefits, support for associations, production activities and sustainable income generation, empowerment and entrepreneurship. Participants could join different initiatives, making producers contribute to the elaboration of agreements and terms of commitments with a minimum agenda resulting from participatory and integrative decisions with basic requirements, as follows:

i. Participation in organizational processes, for example the Community Protocol advocated in agreements of the Biodiversity Convention;
ii. Participation in training on agroforestry systems and environmental services;
iii. Search for dialogues with different stakeholders that lead to a commitment to non-deforestation of primary forests;
iv. Integration with education (eg, entry or stay of children in school), among other measures to involve the family and the entire social fabric at regional and local level.

7. Main models of agroecosystems implemented in the Amazon

Traditional agricultural systems in the Amazon (such as slash and burn, subsistence and extensive livestock farming), that is, those that adopt low technology, have promoted the continuity of an inefficient, unequal, outdated and unsustainable economy in the region (Nobre et al., 2016). In addition, historically the regional economy has made little progress in integrating sustainable production chains, especially those based on non-wood products from the forest, whose primary materials have great potential for adding value, in addition to being strongly demanded by the domestic and foreign markets, with particular emphasis on European and Eastern demand (Nobre & Nobre 2018, Rajão et al., 2020). In addition, different sectors of the economy that consume products that may originate in the Amazon are still little consumed due to the lack of structured supply in their origin, which, like açaí, is largely processed and added economic value in other countries. being only exported in its basic form.

Agroforestry Systems (SAFs) have great potential for the recovery of degraded lands (Sanchez et al., 1994, Ospina 2017) and offer an alternative production system for abandoned lands, using natural products from proven forests. economically viable and that can be produced in integrated systems of grains, meat and non-timber forest products (NTFPs). In addition, agroforestry systems have the important mission of fixing regional agriculture, establishing

[13] REDD: *Reduced Emissions from Deforestation and Degradation* : Reducing Emissions from Deforestation and Degradation.
[14] TEEB: *The Economics of Ecosystems and Biodiversity* : Global *Ecosystems and Biodiversity* Initiative

practices that integrate perennial species with annual harvest species and thereby stop the environmental degradation caused by modern agriculture[15], when implemented in regions and situations of fragile soils or other factors. With this, it also helps to increase the productivity of the rural property and to improve the family income. For this to work, some practices must be recommended and must be aligned with training for farmers to incorporate practices that reduce pests and diseases, as well as improving the plant's management of the property, assisting the producer in managing numerous factors that lead to the success of his activity. In short, a well-applied agroforestry system can generate increased productivity, efficiency in the use of soil nutrients and allow access to public policies for valuing SAF in terms of development, credit, science and technology (Fearnside 1995). The system of conventional agriculture, dependent on imported technologies (genetics, implements, advice, etc.) from non-tropical regions or not available in the set of factors that make its success possible, and often become little adapted to the Amazonian reality. This has led to situations that aggravate the living conditions of small and medium-sized Amazonian landowners, even when in other tropical regions the practices are highly successful. When seeking to transfer a practice to the region but without the correct adaptation or availability of the set of success factors, this has resulted in degradation and low development. The biggest consequences of advancing this model that is not adapted to the region is deforestation, pollution of water and soil sources, burning, desertification, etc.

In this sense, **this document sought to gather experiences that demonstrate economic and environmental success, through models that integrate the Amazonian reality, practices adapted to the use of the forest as part of the land use model and considering cultural aspects and traditional and regional knowledge.** Some examples of agroecosystem models implemented in the Amazon were selected and will be presented below.

7.1. RECA Project

The Consortium and Densified Economic Reforestation (RECA) originates from a group of farmers from various parts of Brazil, based in an INCRA demarcation, in the old Santa Clara rubber plantation (District of Nova California, Porto Velho, RO). They work with 24 species, 12 of which are fruit, 3 medicinal, 6 wood, 1 for seed production, 1 for latex production and 1

[15] Modern Agriculture is a concept and advent of the first industrial period. Its practice occurs in countries and regions that have been successful in the industrialization and manufacture of machinery and mastery of soil management practices with chemical inputs and optimization of logistics and production transportation. As a result, it is an agriculture that focuses on the production of surpluses, a good marketing structure and the generation of economic wealth. In many regions, where the factors do not converge, however, modern agriculture can generate distortions such as the rural exodus and aggravate social inequality, resulting in other socio-economic problems. In the Amazon region, there are indications that another model may be more successful, especially with regard to territorial management, which integrates agricultural activity and components of modern agriculture, safeguarding its distortions and allowing other structures to drive regional economic development.

exotic. Altogether there are about 300 families associated with RECA, in addition to another 400 families of local producers who supply products.

The average income per family practically doubled in 7 years, from R $ 613.00 / month / family to R $ 1,150.00 / month / family, mainly due to the intensification of SAFs and the improvement through the agribusiness (Franke et al. 2004). Everything indicates that this type of system, when implemented systematically, takes a period of readjustment of production and becomes substantially more productive and profitable. Conversely, the activity of cattle ranching tends to deplete production capacity, especially when extensive, due to the high impacts on environmental degradation from pastures, which start to require substantial external inputs (fertilization) and also due to the legal limitation for new deforestation, particularly in rural settlement circumstances.

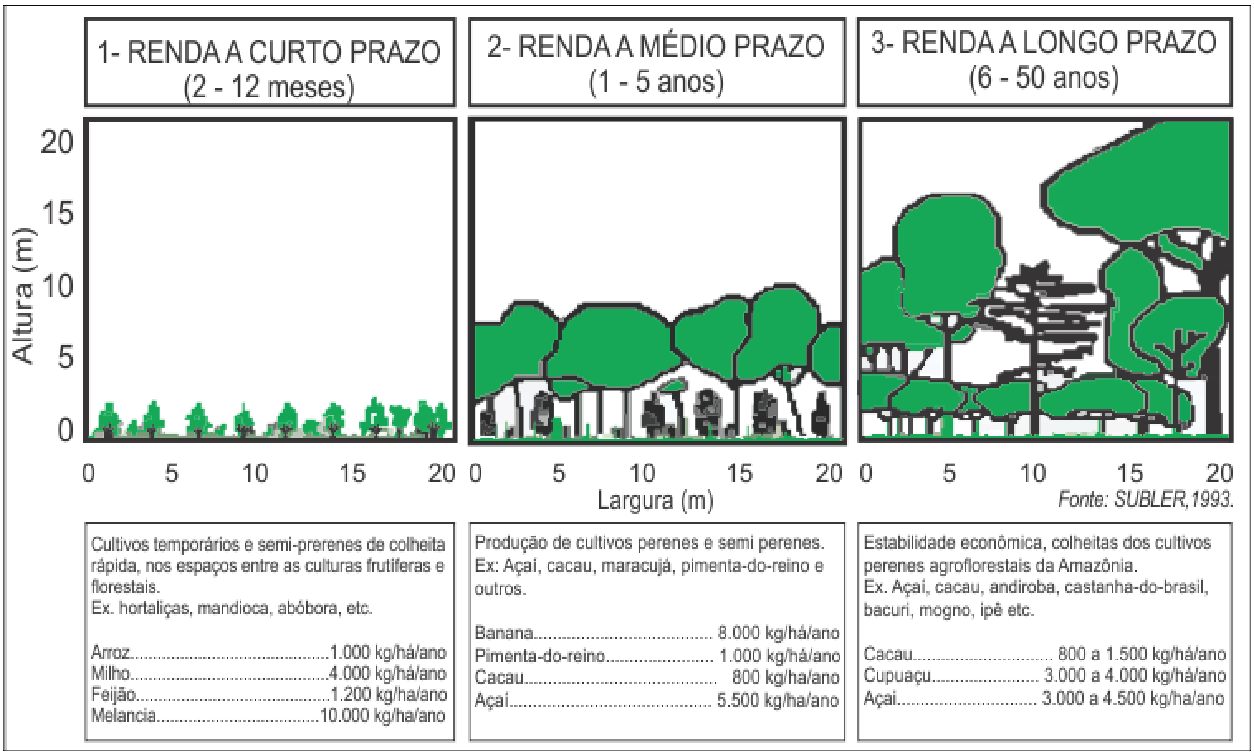
Although there are already numerous experiences of sustainable livestock in the Amazon region, there is evidence that rational and technological extraction offers similar or better yields than high-productivity livestock, in addition to allowing for verticalization and processing of products at the local and / or regional level. Thus, the adoption of more sustainable land use practices is recommended, observing the profitability of productive systems, among them, the intensification of perennial crops in SAFs and other more sustainable uses. The RECA project's socioeconomic organization model, through cooperativism, contributed to the improvement of producers' living conditions and their relationship with the environment. This demonstrates that policies directed to SAFs through cooperatives, more efficient production processes, associated with the processing and commercialization of production through agro-industries, enabled improvements in the production system and an increase in the added value of products. This contributed to relevant social and economic returns, verified by the increase in income and quality of life of the farmers involved (Franke et al. 2004).

7.2. __CAMTA Project__

The Mixed Agricultural Cooperative of Tomé-Açu (CAMTA) is a cooperative created by descendants of Japanese installed in the northeastern region of Pará. They are nationally and internationally recognized for having developed a remarkable agroforestry model, used in 850 properties in the municipality of Tomé-Açu (Homma, 2014; Villela, 2019). Known as SAFTA

(Tomé-Açu Agroforestry System) (Figure 4), this model employs productive and financial efficiency, respecting local traditions and guaranteeing the commercialization of its production (CAMTA, 2015).

Figure 4 - Profile of Tomé-Açu Agroforestry Systems - SAFTA, successive production and income chain (CAMTA, 2015).



The CAMTA is formed by 176 Japanese-Brazilian members, comprising 422 SAFs, grouped into 14 families (Table 1), of which the composition of plants varies from two to the limit of seven plants. In addition, CAMTA absorbs the production of more than 2,800 family farmers in Vale do Acará and Baixo Tocantins, remunerating fairly, without middlemen, providing technical assistance, and providing better living conditions for producers. This entire system directly or indirectly employs 10,000 people in the region and preserves more than 17,000 hectares of forest. Revenue in 2014 was around R $ 74 million, processing more than 12 million tons of fruit per year and selling to both the domestic and foreign markets, with a capacity to store more than 3,000 tons of fruit pulp per year (CAMTA, 2015).

Table 1 - Presence of crops as components of the 422 SAFs identified among Japanese-Brazilian farmers in Tomé-Açu, Pará (Homma, 2014).[16]

Market at present		Secondary Market	Market potential or how shading	No defined market
Culture to guarantee initial income	Culture as permanent income			
Pimenteira-do-reino (194)	Cacaueiro (297)	Pupunheira (11)	Timber species[17]	Camu-camu (3)
Maracujazeiro (24)	Açaizeiro (156)	Mangueira (8)	Castanheira (92)	Noni (3)
Bananeira (9)	Cupuaçuzeiro (140)	Abacateiro (4)	Seringueira (55)	Cumaru (2)
Mamoeiro (2)	Taperebazeiro (35)	Muricizeiro (3)	Puxuri (8)	Neem (17)
Mandioca (1)	Aceroleira (21)	Rambutazeiro (2)	Piquiazeiro (4)	Cardamono (1)
	Coqueiro (16)	Goiabeira (2)	Bacurizeiro (3)	Malang (1)
	Limoeiro (15)	Urucunzeiro (2)	Baunilha (1)	Achachairu (1)

[16] Note: The numbers in parentheses refer to the presence of cultures in the set of 442 identified SAFs.

[17] Mahogany (56), teak (26), paricá (24), freijó (24), yellow ipe (24), andiroba (14), cedar (14), para-para (3), ferrule (2), acapu (1), tatajuba (1).

Timber species = acapu (*Vouacapoua americana* Aubl.); andirobeira (*Carapa guianensis* Aubl.); cedar (*Cedrela odorata* L.); ipe (*Handroanthus serratifolius* (Vahl) S.Grose); mahogany (*Swietenia macrophylla* King.); to-to (*Jacaranda copaia* (Aubl.) D.Don); paricá (*Schizolobium parahyba* var. *amazonicum* (Huber ex Ducke) Barneby); tatajuba (*Bagassa guianensis* Aubl.); teak (*Tectona grandis* LF); virola (*Virola surinamensis* (Rol. ex Rottb.) Warb.).

(²) Straw (10), erythrine (6), gliricidia (2), ingazeiro (1).

Shading species: erythrine (Erytrina sp.); gliricidia (Gliricidia sepium); ingazeiro (Inga edulis Mart); straw (Clitoria racemosa).

Scientific names of fruit trees and others: avocado (*Persea americana* Mill.); apricot tree (*Mammea americana* L.); achachairu (*Garcinia humilis* Vahl); bacurizeiro (*Platonia insignis* Mart.); vanilla (*Vanilla planifolia* Jacks. ex Andrews); coffee tree (*Coffea arabica* L.); cashew (*Anacardium occidentale* L.); camouflage (*Myrciaria* dubia (HBK) Mcvaugh)); sugar cane (*Saccharum officinarum* L.); starfruit (*Averrhoa carambola* L.); cardamom (*Elettaria cardamomum*); coconut tree (*Cocos nucifera* L.); coumaru (*Dipteryx odorata* (Aubl.) Willd.); oil palm (*Elaeis guineensis* L.); guava (*Psidium guayaba* L.); soursop (*Anona muricato* L.); orange tree (*Citrus sinensis*); lemon tree (*Citrus limon*); papaya (*Carica papaya* L.); manioc (*Manihot esculenta*); mangosteen (*Garcinia mangostana*); hose (*Mangifera indica*); marang or malang (*Artocarpus odoratissimus*); murucizeiro (*Byrsonima crassifolia* (L) HBK); neen (*Azadirachta indicates* A. Juss.); noni (*Morinda citrifolia*); piquiazeiro (*Aspidosperma desmanthum*); pulluri (Licaria *puchury-major* (Mart.) Kosterm.); rambutanzeiro (*Nephelium lappaceum* L.); *sapodilla* (*Manikara zapota* L.); sapucaia (*Lecythis pisonis* Camb.); taperebazeiro (*Spondias mombin* L.); uxizeiro (*Endopleura uchi* (Huber) Cuatrec.).

Market at present		Secondary Market	Market potential or how shading	No defined market
Culture to guarantee initial income	**Culture as permanent income**			
	Gravioleira (15)	Laranjeira (2)	Uxizeiro (1)	Sapucaia (1)
	Mangostãozeiro (5)	Sapotizeiro (1)	Species shaders with no market value [2]	Cafeeiro (1)
	Dendezeiro (5)	Abricoteiro (1)		Cana-de-açúcar (1)
		Cajueiro (1)		
		Caramboleira (1)		

The project sells black pepper, cocoa beans, noble vegetable oils and 15 flavors of tropical fruit pulps, in areas ranging from 25 ha to more than 2,000 ha, with a large part of SAF production being found in small and medium-sized properties, while properties over 400 ha have a higher percentage of pasture and monocultures in their areas (Homma, 2014; Villela, 2019).

The average productivity of agroforestry systems varies depending on the arrangement of the species produced: an example of SAFs with three species could obtain, on average, an annual gross income of R $ 65,551.56 in an area of 273 ha, with a profitability of R $ 240,11 per ha; in areas larger than 1,000 ha, with more than five species, the income can reach R $ 316,468.50, yielding R $ 250.56 per ha / year. However, in SAFs in smaller areas (20 to 30 ha) and ranging from three to five species, the profitability per hectare reached values of R $ 1,341.86 to R $ 1,792.01, with annual gross income of R $ 29,521, 00 to R $ 46,592.50, presenting the best values for land efficiency (Pereira, 2016). It is noteworthy that the arrangement of species and the size of areas provides this variation in yield, demonstrating that producers need to monitor and continue to improve their SAF systems to obtain the best productivity and yields. These examples allow a specific analysis in real conditions, allowing conclusions on a medium scale to be able to compare with other agricultural activities that do not include forest management activity. In these examples, there are combinations in which pasture or agriculture activities are used, always integrated with natural forests and enriched with species of economic interest, allowing preservation, conservation and economic activity in order to produce surpluses to what is necessary for the subsistence of the property agricultural or family. The following tables and infographics (Figure 4), illustrate some models and operational structures that guide producers' decisions.

7.3. Jaborandi Project

The Jaborandi Project is coordinated by the Carajás Extractive Cooperative (Coex Carajás, PA). Jaborandi extractivism has been taking place in the Flona de Carajás in the State of Pará for the last 30 years, with 39 members, with each team ranging from 10 to 12 people for their collection. The FLONA (National Forest) structure is provided for in the National System of Conservation Units, managed by a competent public body in the corresponding jurisdiction. In this case, as it is a National Forest, it is managed by ICMBIO, a federal agency linked to the Ministry of the Environment. In other words, it is a public area granted through regulation that allows economic use by registered people and that are organized in a community and associative way to live, manage and produce in this area, without transferring land ownership to the user, therefore it is not passive of indebtedness backed by land ownership, therefore any financial mechanisms adopted by land users can only be contracted through the delivery of produced production, or through non-reimbursable financial resources ("lost fund"). In Flona de Carajás, extraction takes place in an area of 70 thousand ha, of which 9 thousand ha are effectively managed. The cooperative pays its members R $ 1.70 per kg of dry leaf and resells it to Sourcetech Química Ltda. The dried leaves of jaborandi are classified into three types, according to the quality of drying, which is determined by the pilocarpine content: 1st level - AA, 2nd level - A and 3rd level - B.

According to authors, there is evidence of unwanted practices by buyers that hinder purchase by type AA, which defect the drying process (Homma, 2014; Gumier-Costa, 2016). The current value per kg of dry leaf of the jaborandi ranges from R $ 12.00 to R $ 14.00. Another product is jaborandi seeds, which are being sold at R $ 150 per kg. The production of a team can reach 5,000 kg of dry leaf in one month of production. The net salary for the '*folheiro'* is around R $ 2,500.00: as the family usually participates during the harvest period, the family income has the potential to increase (Ferreira, 2019).

Although the income obtained by the *folheiros* is modest and because it is an activity developed during the dry season, this income acquired can quadruple the monthly income of the *folheiros*. However, living exclusively on jaborandi is not viable, mainly due to the difficulty of integrating different communities into the market context to leverage production (Gumier-Costa, 2016). To make this activity viable, *folheiros*, from their Cooperative, look for mechanisms to start the operation of selling pilocarpine[18] for values that can reach up to R $ 80,000.00 per liter of product. In this way, value is added to this product and the income of the

[18] alkaloid found only in jaborandi leaves

folheiros is increased from the processing of the jaborandi leaf in the cooperative (Ferreira, 2019).

7.4. Small Cocoa Producers at Transamazônica

With almost half a century of occupation of Transamazônica, there are still serious problems of infrastructure, education, basic sanitation, crime, dispute over land, among others. With the cocoa market on the rise worldwide and economic activities not satisfactorily responding to the problems arising from poverty and illegal deforestation, agroforestry activity with cocoa production has attracted attention as a potential tool for the rehabilitation of degraded / altered areas, capable of reconciling production with forest conservation (Braga, 2019).

The cocoa industry, particularly in the Amazon, can be an excellent example of an opportunity for small and medium producers, since their national and international market is well structured. A small (in terms of Amazonian areas) rural landowner, operating in rational and modern agroforestry systems (SAFs), can be just as successful as larger-scale cattle producers. A regional case of transamazonian production, with good replicability, cocoa generated an annual revenue of U $ 40,517.36 per year in an average area of 64 ha (US $ 633.08 / ha.year), while in the same region, cattle producers they need an area of 140 ha for an average annual income of U $ 22,315.49, that is, US $ 159.39 / ha.year (Braga, 2019), that is, more than 400% in the additional income per hectare. According to Braga, much more than that, cocoa producers also tend to occupy smaller areas and conserve more forests (47 ha cocoa and 36 ha cattle), in addition to running less risk of diseases, given that cocoa is a plant adapted to the region and Nelore cattle, the primary breed of cattle, have numerous health and safety problems, which smallholders do not always have access to appropriate solutions.

Thus, in the Transamazônica region, the agroforestry system with cocoa and other native species, in favorable soil conditions, can be an alternative to extensive livestock, as shown by the PhD work of Daniel Palma Perez Braga, in 2019. In addition to cocoa, SAFs diversify the family income and, at best, may include the use of native plants (cupuaçu, cashew, palm trees, among others), as well as non-wood forest products, adapted to the region (Braga, 2019).

7.5. Small Producers in Northern Mato Grosso

The Ouro Verde Institute (IOV), from Alta Floresta / MT, founded in 1999, has an innovative management proposal. To consolidate this management, the institute has a technical-administrative structure and groups of farmers organized in the so-called " Base Centers ", responsible for discussing their development strategies with rural communities and implementing transformation actions. One of the priority actions of these centers is to support the planting and management of agroforestry systems (SAF) as a strategy for environmental recovery, generation and diversification of income for farmers' families. To this end, it develops training actions, technical advice and the search for financial support for the installation of agroforestry. Since 2010, about 2,700 ha of FAS have been implemented, including areas with different purposes. 1,500 farming families have already benefited. These agroforestry systems have been implemented in an innovative way with the direct planting of agricultural and forest species in a system commonly known as "*muvuca de semente*" (i.e., seed crowding). The seeds needed to implement the SAF are produced by the farmers themselves. Farmers who have SAF and participated in the commercialization projects had an increase in their monthly income in the order of R $ 1,200, practically double the previous income that was mostly based on livestock for milk production. This initiative has also provided potential for the generation of ecosystem services, such as: forest connectivity, improvement of biodiversity (especially perception of the increase in the population of animals), protection of springs and streams, improvement of soil fertility. In these SAFs, forest species are implanted (jatobá, pine cuiabano, mojoleiro, aroeira, tamarindo, paineira, timburi, pente de macaco, ipe, garapeira, copaiba, champagne, angico, rubber tree, pacova, leucena, pitanga, peroba, pequi, embaúba, cajú do mato), fruit species (açaí, avocado, fig, ingá, guaraná do mato, jackfruit, mango, murici, soursop, pitanga, annatto, cashew) and annual crops in the initial phase (rice, beans, pumpkin, corn etc.) (Alexandre Olival, personal communication, http://www.iov.org.br/Programa/3/).

7.6. Amazonbai Project

The Amazonbai Project is carried out in the Bailique Archipelago, a region formed by 8 islands at the mouth of the Amazon River, Amapá. According to IBGE (2020), a population of 10 thousand people resides in this region, being characterized as a traditional population that lives on the basis of local subsistence, with a predominance of fishermen, farmers and extractivists, with açaí and fish as the main products income generators for families in the region. Through this project, families today are the protagonists of its history, as they have gained direct access to açaí consuming markets, through associative mechanisms of interaction between producers and their communities.

The Amazonbai Project is an example of an initiative designed by community members and implemented as a social enterprise, which emerged after the approval of the Bailique Community Protocol in 2015[19]. The Protocol consisted primarily of building internal agreements for coexistence and relationships between communities and the external actor, in addition to providing for use, management and protection of genetic heritage and associated traditional knowledge agreements. This first step took place in the period between 2013 and mid-2015. In 2016, communities decided to work on developing the productive chains of forests as a source of income and improving the quality of life. Subsequently, the communities decided to create an association to represent the 40 member communities of the Protocol and to assume the management of the project. Initially, four production chains were defined: açaí, fish,

[19] http://www.fundovale.org/iniciativas/projeto-encerrado-producao-de-cadeias-produtivas-sustentaveis-locais-do-protocolo-comunitario-do-bailique-ap/

essential oils and medicinal plants. The açaí chain is the only one implemented so far. All chains have in essence to combine quality education and training in good management and production practices.

In order to add value to açaí as a strategy that would help communities better understand and protect the forest and its routine and the impacts of the exploitation of this chain on life, the project sought a certification system that would be recognized in the world. In 2016, the project underwent the Forest Stewardship Council (FSC) certification process and, in 2018, it was successfully evaluated for having the characteristics of providing Ecosystem Services in its activities, with this the initiative seeks to be aligned with certification concepts for markets of organic food among others.

The communities involved in the project have prioritized quality education in the territory: for this, a percentage of the revenue from the sale of açaí production is reserved for this purpose. There are plans to consolidate the concepts of Escola Família (School-Family), applied in the communities involved. In 2017, a Cooperative was created that currently has 150 individual members, composed of collectors and collection processors. The products from this sustainable territorial planning carry the brand developed as AMAZONBAI, allowing it to be recognized and to access various types of national and international markets. However, it is known that the production capacity of the fruit today reaches more than 300 thousand cans (14 kg) per harvest. The volume sold in the last three years reached just 40 thousand cans (average 186 t / year). The producers, through their association, decided to concentrate their efforts and investments in the agro-industry with the capacity to process pulp and other derived products for an initial production and commercialization of 200 tons of pulp per harvest. Even with reduced sales in the last three years. It is estimated that sales and the value received through the cooperative was much higher than if it had been sold to intermediaries in Macapá. The project currently has 2,996 hectares of certified açaí in Bailique and about 2,000 hectares more in the process of certification in the territory near Macapá, called Beira Amazonas.

7.7. __Health and Joy Project__

The Health and Joy Project (PSA) is a non-profit civil initiative that has been operating since 1987 in the Brazilian Amazon, providing and corroborating participatory procedures for integrated and sustainable community development that collaborate in a demonstrative way to access and make public policies available in the region, improving the quality of life of communities and the exercise of citizenship by the populations served (PSA, 2020).

Currently, the PSA serves about 30 thousand people from rural communities, mostly from traditional populations, some of them in social vulnerability, located in Santarém, Belterra, Aveiro and Juruti, in the western region of Pará. The participatory process, involving leaders and community members, has been indispensable for the results to be relevant and permanent. The project operates in several areas such as: territorial development, community health, education, culture, communication and forest economics.

CEFA (Centro Experimental Floresta Ativa) is the first socio-productive unit built by PSA, inaugurated in 2016 in Comunidade do Carão, in the Tapajós-Arapiuns Extractive Reserve (Resex). This Resex stands out for being the most populated in Brazil, with about 22 thousand people in approximately 70 communities, inhabiting an area of 650 thousand hectares. The development of this project was only possible from the joint work initiated in 2013 between PSA, Chico Mendes Institute for Biodiversity Conservation (ICMBio) and the Organization of Associations and Residents of Resex Tapajós-Aripiuns (Tapajoara), as well as residents and local associations.

CEFA is a modular environment that includes permaculture and agroecology dissemination units, in addition to promoting a constant and diversified agenda of courses and training programs to the community, acting as a training and technology center, where institutional and community events, events are held which seek to achieve, among many objectives, socialization, training and sharing experiences among different regional actors and with other interest groups in the region and other locations. CEFA has a low environmental impact and values traditional knowledge and has systematically implemented demonstration works on bioconstruction (alternative and traditional technologies), with the application of energy efficiency methods, adequate waste treatment, use of natural light and ventilation, rainwater reuse, among other practices. CEFA has a nursery with a productive capacity of 250 thousand seedlings per year of forest and fruit species. A trained technical team monitors and maintains this nursery. The seeds are acquired through collection at Resex and their production occurs through joint efforts. In the period from 2013 to 2016, about 37 thousand seedlings / year were produced and commercialized, among which the main species are: açaí, andiroba, cocoa, cashew, Brazil nuts, cedar, coconut, copaíba, freijó, yellow ipê, itaúba, jacarandá, jatobá, jucá, passion fruit, marupá, mahogany, rosewood, piquiá and pupunha (PSA, 2020). The common practice in the Resex region is the predominant use of “cutting and burning” of the forest, however, with the implementation of the PES, there has been a change in agroecological production practices, avoiding unnecessary cutting and burning, generating recovery of degraded areas and promoting income generation for families on a sustainable basis (ICMBio, 2018).

7.8. Refloramaz Project

The Forest Restoration Project by Family Farmers in the Eastern Amazon (Refloramaz) was developed by Embrapa Amazônia Oriental, Federal University of Pará and CIRAD[20], with the common objective of understanding the forest recovery processes employed by family farmers in the Northeast of Pará, in a wide region, one of the most populous in the Amazon region, comprising from Bragantina, Belém, Marajó and Tomé-Açu. Being in a populous region and with many urban centers, the properties tend to be of a smaller scale and with a high participation of family farming.

The project carried out a survey of 160 recovery experiences in five municipalities in the period from 2017 to 2019, assessing the benefits of various practices in environmental, social and economic terms. Various activities have been developed with the groups of farmers, so that they can share their plans, challenges and motivations to recover their areas. With these procedures, the project aims to promote public incentive policies to recover degraded areas in the Amazon and to value local restoration experiences (Carneiro and Navegantes-Alves, 2019; Ferreira, 2020).

7.9. Summary of socio-economic benefits of analyzed initiatives

Table 2 below summarizes some economic, environmental and social indicators of the SAF initiatives analyzed in this study.

Table 2 Economic, environmental and social indicators of the main SAF experiences in the Amazon.

Types of SAF in the Amazon	Farmers involved	Area with SAF (ha)	Monthly Income / Family (R $ / month)	Monthly Income / Area (R $ / ha)
CAMTA	5.000	8.500	3.000,00	441,18
RECA	10.000	17.000	5.000,00	735,29
Jaborandi	7.500	12.750	4.000,00	588,24

[20] https://agritrop.cirad.fr/594902/1/Mapa%20Refloramaz%20leve.pdf ; https://www.embrapa.br/en/amazonia-oriental/busca-de-noticias/-/noticia/40611830/recuperacao-ambiental-com-agroflorestas-e-tema-de-roda-de-conversa-no- for ; https://ur-forets-societes.cirad.fr/en/main-projects/refloramaz

Types of SAF in the Amazon	Farmers involved	Area with SAF (ha)	Monthly Income / Family (R $ / month)	Monthly Income / Area (R $ / ha)
Small Cocoa Producers at Transamazônica	7.447	122.810	5.600,00	84,89
Small Farmers in Northern Mato Grosso	1500	2.700	1.200,00	166,67
Amazonbai	141	2.996	5.000,00	58,83
PSA (CEFA)	22.000	650.000	1.600,00	13,54
Refloramaz	800	1.930	N/D.	N/D.

N / A. : Not available.

Comparing the data in Table 2 with those obtained in the literature for the cultivation of soybeans and livestock, it can be seen that the activities of SAFs are highly profitable.

Some references allow a quick comparison, based on official data from the Brazilian government, for example from the National Supply Company (CONAB), an autarchy of the Ministry of Agriculture, which publishes data on activities at the national level. For soybean crops, monthly revenue is estimated at R $ 280 per hectare (CONAB, 2019). As for livestock, the literature presents as monthly net profit, at best, R $ 56 per hectare (Câmara and Mobiglia, 2019), with numerous reports of losses in livestock activity today.

SAFs vary in the diversity of managed species. Poorly diversified systems are characterized by a low diversity of species and relatively small areas. The use of external inputs is extremely low, as the system already has an ecological balance and a high level of nutrient cycling: when necessary, only natural products are applied. The handling in these areas is done only by hand and with the help of a brush cutter, pruning equipment and small saws. Due to the high level of complexity, they are easily confused with natural forests, due to the intense presence of fauna and flora. The average size of the plots is 2.16 ha and with 21-22 plants / system. The main species are: açaí, acerola, andiroba, avocado, pineapple, bacuri, banana, bacaba, biriba, bacuri, banana, bacaba, biriba, bacabi, coconut, cupuaçu, cocoa, coffee, cashew, copaíba, guava, ipê, ingá , jambo, jackfruit, jaranã, orange, lemon, papaya, mango, muruci, mahogany, pupunha, paricá, black pepper, sapucaia, taperebá and tangerine (Carneiro e Navegantes-Alves, 2019 ; Ferreira, 2020).

8. Forest restoration arrangements developed by farmers in the region

Although the recovery experiences are in the same region, they present great differences between the municipalities. However, even showing different ways of recovery, all live in the same territory and influence each other, having as main motivations for forest recovery the scenic beauty, environmental concern and economic factors, seeking to make possible a coexistence with the forest, preserving it and developing a healthy forest economy. Based on this diversity, five main forest restoration arrangements were developed by farmers in the region (Carneiro and Navegantes-Alves, 2019; Ferreira, 2020), which are:

A) Natural regeneration

These are areas abandoned by producers that, over the years, have regenerated, with ages varying between 10 and 70 years, with an average of 26 years. This recovery mode is found in 50% of the areas, the largest dimensions of which are 20 ha, housing about 50 species on average. Among the main species that make up this system, are: lacre, sucuúba, verônica, louro amarelo, sucupira, araracanga and cedar. For producers, these areas mean the return of biodiversity, through fauna and flora, the use of wood for domestic uses and the well-being provided by this system (Carneiro and Navegantes-Alves, 2019; Ferreira, 2020).

B) Agroforestry Home Gardens

This recovery method has peculiar characteristics due to the close relationship between families and their home gardens, which are mostly made up of native species, mainly aimed at family consumption and which in recent years has also turned to economic use. Most of these systems have a good level of biodiversity in agricultural practices, even though they are small plots with an average size of 0.63 ha in 68% of the lots, with an average of 13 species, among which are: açaí, banana, coconut, cupuaçu, cashew, guava, ipe, jackfruit, orange, lemon, mango and pupunha. Because it is a traditional method in the Eastern Amazon, systems with up to 50 years of age are found (Carneiro and Navegantes-Alves, 2019; Ferreira, 2020).

C) Agroforestry systems

Little diversified

This system is characterized by a low diversity of species and relatively small areas. In this model , conventional management techniques are generally used, with the use of chemical fertilizers, pesticides, irrigation and agricultural mechanization. The average size of the area dedicated to SAF is 1.49 ha, with an average of 3.6 species, among which the main ones stand out: açaí, cocoa, cupuaçu and black pepper (Carneiro and Navegantes-Alves, 2019 ; Ferreira , 2020)

Diversified

An expressive level of species diversity stands out in this agroforestry, and management is complex in these areas, that is, producers need strong care and specific knowledge to maintain their production. The plants of greatest commercial value follow technical standards and the others are arranged according to the morphological and site conditions. The complexity in these systems favors less use of chemical fertilizers and greater use of organics. Maintenance is carried out manually, with the help of low-impact equipment such as coastal brushcutters, as heavy mechanization is not feasible. The average size of the plots is 2.34 ha and averages 11 to 12 species per system. The following species stand out among many: açaí, banana, cupuaçu, cashew, orange, lemon, mahogany, paricá and pupunha (Carneiro e Navegantes-Alves, 2019; Ferreira, 2020).

Highly diversified

This method of forest recovery is characterized by a high degree of complexity, differentiating itself from the others in that it involves extremely complex practices and requires specific information, such as: light conditions, water, enrichment of capoeira, handling of plants, decomposition of organic matter, among others. The use of external inputs is extremely low, as the system already has an ecological balance and a high level of nutrient cycling: when necessary, only natural products are applied.

The handling in these areas is done only by hand and with the help of a brush cutter, pruning equipment and small saws. Due to the high level of complexity, they are easily confused with natural forests, due to the intense presence of fauna and flora. The average size of the plots is 2.16 ha and with 21-22 plants / system. The main species are: açaí, acerola, andiroba, avocado, pineapple, bacuri, banana, bacaba, biriba, bacuri, banana, bacaba, biriba, bacabi, coconut, cupuaçu, cocoa, coffee, cashew, copaíba, guava, ipê, ingá , jambo, jackfruit, jaranã, orange, lemon, papaya, mango, muruci, mahogany, pupunha, paricá, black pepper, sapucaia, taperebá and tangerine (Carneiro e Navegantes-Alves, 2019; Ferreira, 2020).

9. Economic, environmental and social impacts of stimulating the implementation of SAFs in the Amazon

Research carried out in the Amazon has identified the economic viability of agroforestry systems. There is evidence that the revenue generated by one hectare of SAF is equivalent to the revenue of 4 or 5 hectares with monoculture of annual crop. Another indicative reference estimates that for each real invested in SAF a net return of R$ 5.08 to R$ 14.19, which confirms the economic viability of agroforestry systems in the Amazon (Gonçalves et al. 2017).

The Amazon Biome has 12.8 million hectares of agriculture or non-vegetated areas in transition to forest cover (MAPBIOMAS, 2020). It can be inferred that such areas would be destined for agriculture, but without current market conditions they will probably be classified as "productive" when in fact they are in very low or in an unproductive state. This immense territory corresponds to 21.7% of the total "open" agricultural area of the Amazon Biome and 2.5% of the total area of the biome. If only one tenth of that area were dedicated, through a coordinated and orderly effort to establish Agro-Forestry Systems, associated with the production of Non-Timber Forest Products (NTFPs), that is, with a strong dedication to food production, it would be possible to see an 85% increase in the number of farmers involved (about 100 thousand farmers), with an average monthly income per family of around R $ 3,400.00.

In order to disseminate more complex productive systems, land use decisions by farmers in the Amazon depend on different technical and cultural factors, therefore dependent on technological development, economic financial support and dissemination of types of initiatives that result in high attractiveness for small and medium rural entrepreneurs.

The land tenure structure and market integration issues, such as access to technology, productive knowledge, credit policies, the labor market, etc., determine the efficiency of technological adoption (Kitamura et al. 1994). In addition, the promotion actions must be integrated into policies aimed at the conditions of local populations, determining the necessary measures to support family farming.

It is essential to publicize and consolidate attractive markets for a diverse range of native products, already with regionally or internationally consolidated markets , such as Brazil nuts (*Bertholletia excelsa*), açaí (*Euterpe oleraceae* or *precatoria*), babassu (*Attalea speciosa*), cajá (*Spondias mombin*), cupuaçu (*Theobroma grandiflorum*) , bacaba (*Oenocarpus bacaba*), buriti (*Mauritia flexuosa*), andiroba (*Carapa guianensis*), rosin (*Protium* sp.), Copaiba (*Copaifera* spp.), Pupunha (*Bactris gasipaes*), piaçava (*Leopoldinia piassaba*), rubber tree (*Hevea brasiliensis*), coumaru (*Dipteryx odorata*). In addition to these, there is a range of other lesser-known products that may receive support from the current "best known" and also achieve the same popularity, a fact that occurred with açaí in recent decades, when it was only known in the northern region of Brazil and today, in addition to being known throughout the national territory, it has already assumed a leading role in pro-biotic foods in industrialized countries.

In addition, there are many other natural products considered in extractive ventures, which can be directed to drugs, edibles or cosmetics. Such products arouse growing interest from national and international companies. Therefore, it is urgent to establish new sustainable development strategies for the Amazon.

As a policy to support SAF initiatives, something similar to the Bolsa Floresta Program is recommended, with the involvement of producer families, including, as advantages, the security of direct gains, social benefits, support for associations, production and generation activities sustainable income. To join the initiative, producers would need to meet the following requirements:

- participation in workshops;
- training in agroforestry systems and environmental services;
- no deforestation of primary forests;
- entry or stay of children in school.

The AMAZÔNIA QUADRO PONTO ZERO initiative converges numerous complementary concepts and visions for the development of the Amazon region and will enhance responses to the social and economic demands of family farmers, at in the same time combating negative social impacts, such as slave and child labor. Moreover, it should create a culture of value- adding entrepreneurship , allowing the generation of wealth that promises modern agriculture, but fails to achieve, for countless social groups, in the Amazon region.

Açai Cultivation

There is no evidence of large continuous plantings of açaí on land in the Amazon. The largest enterprises known to have açaí monoculture are located in the Mesoregion of Northeast of state of Pará (119,518 hectares), Marajó (43,628 hectares) and the Metropolitan Region of Belém (23,127 hectares). For the dimensions of these territories, these areas must be considered small. The State of Pará is the largest producer of açaí from terra firme (monoculture), with a total area of 190,586 hectares. However, this is the total sum of area and has no expression in large monocultures, such as the palm. Thus, a universe of 200,000 hectares distributed in countless small and medium occurrences is an area with little significance compared to other traditional cultures.

It is important to point out that in regions with the highest consumption and production of açaí, there is evidence that the monoculture projects of the species are mostly accompanied by institutions such as EMBRAPA (Amapá and Pará), added to research centers at universities. This factor increases the reliability that cultivation practices follow technical and sustainable parameters, in line with the posture and mission of these research and teaching institutions. As an example, numerous studies have already recommended the preferential use of areas previously occupied with annual or semi-perennial crops, avoiding the deforestation of primary vegetation (EMBRAPA, 2002[21]), use of equipment and processes compatible with the environment (SUFRAMA, 2003[22]) and the focus on the recovery of degraded areas and carbon fixation (SEDAP, 2016[23]).

10. Improving the monitoring of production chains in the future

Databases generated by numerous institutions, public or private (eg INPE, INPA, NGOs, States or international organizations) such as the CAR, are fundamental sources for understanding the origin of the areas with the implementation of SAFs. Only by crossing this information and monitoring it, through time series, will it be possible to assess whether the emergence of new areas of SAFs originates from original forests or altered forests, or even if they are installed by the recovery of degraded areas or even transformations of productive pastures in agroforestry or agro-silvo-pastoral systems. That is, a certain type of SAF may have different origins and some of these transformations may not be desired, for example, when they represent a degradation of the original pristine forest that will be transformed into a SAF of few species, or even monocultures such as da Palma, which expanded greatly in the Amazon.

On the other hand, a pasture, degraded or not, that has been recovered for an SAF, even with a reduced number of species, can be a desired transformation, as it can still evolve into a more complex forest system with greater ecological functionality, everything this assuming SAF's economic viability. Thus, the crossing of necessary information in environmental licenses issued by State agencies is essential for rural activities, in addition to marking the beginning of a process that qualifies the regenerative purpose of SAF, in addition to avoiding unwanted degradation.

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21 https://www.agencia.cnptia.embrapa.br/Repositorio/Producaodefrutos+Circ_tec_26_000gbz56rpu02wx5ok01dx9lcobm2bes.pdf

22 http://www.suframa.gov.br/publicacoes/proj_pot_regacionais/acai.pdf

23 http://www.sedap.pa.gov.br/sites/default/files/PROGRAMA_PRO_ACAI.pdf

11. **Incentive policies for Agroforestry in Brazil**

One of the first legal bases of agroforestry systems is the Brazilian Constitution of 1988, which, although it does not mention directly the SAFs, considers the social function of rural property in Brazil in order to guarantee the livelihood of families in line with the conservation of the environment (BRASIL, 1988). In the early 2000s, the implementation of SAFs in the Brazilian Amazon gained a great boost with the creation of the Proambiente Program, which emerged as a demand from groups and associations of rural producers in the Amazon. Despite some administrative gaps, the innovative character of the Program was fundamental for the discussion on a more sustainable agricultural production method, including agroecology practices, the creation of specific lines of credit for the activity and proposals for remuneration for ecosystem services (Mattos, 2011).

The SAFs also received great encouragement in the changes brought by Law 12.625 / 2012 to the Brazilian Forest Code that authorized the implementation of SAFs in areas of Permanent Preservation and Legal Reserve in small properties. In this case, in addition to the implementation of SAFs being considered an important source of income and food for farmers' families, it also constitutes an intelligent strategy for the recovery of degraded areas, contributing to the sequestration and carbon stock (as also highlighted in Law 12,114) and for the recovery of soils, water resources and biodiversity. The recognition of the importance of SAFs for families of rural farmers as well as for the recovery of the ecosystem is evidenced in the National Plan and Policy for the Recovery of Native Vegetation - PLENAVEG / PROVEG (Decree No. 8.972, of January 23, 2017), which consider the SAFs are a key activity in the recovery of forest ecosystems while providing food security and an economic alternative for families and avoiding the deforestation of new areas for agricultural production.

An important element present in the SAFs incentive policies in Brazil is the payment for ecosystem services, which also aims to provide the maintenance and recovery of ecosystems and provide an extra source of income for rural families. The National Policy for Payment for Environmental Services (Law 14,119 of January 13, 2021) recognizes SAFs as an important area that can be the object of Payment for Ecosystem Services initiatives, emphasizing the important role that SAFs play in the functioning of ecosystems, especially degraded ecosystems, targets of recovery actions.

Although there is a relevant base of public policies that recognize the importance of SAFs and that can be understood as a great support for the adoption and maintenance of this practice throughout Brazil, some challenges still need to be overcome, for example, both access to credit regarding the insertion of families in payment programs for ecosystem services requires proof of land tenure regularity, which for many families, especially in the Amazon, are difficult to prove. The great land irregularity in the Amazon also constitutes a great barrier to possible payment contracts for ecosystem services. In addition, for producers who are able to access credit lines and establish contracts, logistical deficiencies in the Amazon may jeopardize the insertion of agroforestry products in the regional market. These factors show the real incentive for SAFs to integrate a set of public policies from different sectors that also seek to solve old regional problems such as the land issue in the Amazon, as well as a new vision of infrastructure, based on the lowest environmental impact.

12. **The need of a new Bio-economy for the Amazon**

The risks of a tipping point of savannization[24] in the Amazon are increasing due to the anthropogenic drivers: 1. of global climate change—that has caused an increase of temperature of about 1.5 C in all of the Amazon basin and cause extreme droughts such as in 2005, 2010 and 2020; 2) regional deforestation that causes increases of temperature and diminishes the recycling of water by the trees, making the air above the forest warmer and driers, conditions that reduce rainfall formation (in comparison, the air over an undisturbed forest is moister and cooler, ideal conditions for condensation, formation of droplets, clouds and rain); 3) Rainforests are wet and very resilient to fires; however with warmer temperatures, extreme droughts and continued forest degradation, the forests and becoming more vulnerable to fires. All these drivers synergistically attached are increasing the risk exceed the tipping point. Therefore, it is urgent reduce deforestation to zero in less than a decade and restore large areas of forests both through natural regeneration of areas abandoned by agriculture and livestock farming, but also by expansion of agroecological systems to provide a large quantity and variety of products of the biodiversity to ignite the new bio-economy. Therefore, this session of the document is the natural follow up of the preceding session that focused on agroecological system and how to ensure that those systems will support forest restoration on very large scale.

12.1. Different bio-economy concepts and how it should be for the Amazon

First, it is important to note that there are different definitions of bio-economic. FAO defines bio-economic in a broad way as production, use and conservation of biological resources, including associated knowledge, science, technology and innovation, to provide information, products, processes and services to all economic sectors aiming at a sustainable economy.

Brazil's Ministry of Science and Technology bases its definition of bio-economy on the European model: a set of economic activities based on the use of sustainable biological resources to replace raw *materials of fossil origin in the production of food, feed, materials, chemicals, fuels and energy, among many others, for the promotion of health, development and sustainable growth and well-being of society.*

It is observed that this definition following the European model explicitly mentions the substitution of fossil raw materials for the production of bio-fuels, plastics, and numerous other products, a goal strongly aimed at combating climate change since more than 80% of European emissions are due to fossil raw materials (coal, oil, natural gas).

Following this same logic, the Brazil's National Confederation of Industry includes biofuels from cane, corn and soybeans monoculture as important elements of its definition of bioeconomy, launched in August 2020 (CNI, 2020). There are no elements in this definition, however, that guarantee significant changes in land use patterns, and may even reinforce or induce new vectors for deforestation in the Amazon.

[24] Synergism between climate- and land-use (deforestation, fire) changes which induce to critical and irreversible change (tipping point) for the Amazon forest system to flip to degraded savannas in most of the central, southern, and eastern Amazon (Lovejoy and Nobre, 2018).

And the situation in our country is something very different from Europe. More than 70% of our emissions are due to agriculture and deforestation itself, that is, associated with changes in land use patterns. In this way, our definition of bio-economy should not only follow the European model, although it is very important to develop and implement a global bio-economy free of fossil raw materials.

In the ecological context of the Amazon, considering its immense biodiversity, FAO's concept of bio-economy should be expanded to consider only the sustainable use of biological resources with the forest standing in order to preserve terrestrial and aquatic ecosystems, including the valorization of traditional knowledge. At the same time, we must together with the implementation of a bioeconomy focused on the unique characteristics of the Amazon also make it circulate from the beginning, that is, an innovative circular bioeconomy based on the rich biodiversity of the Amazon forest, a "*circular bioeconomy of standing forest and healthy and flowing rivers* "(Nobre and Nobre, 2019; Nobre and Nobre, 2020).

Recognizing that biodiversity is the diversity of life, Dasgupta (2021) defines that the biodiversity economy is the economy of the entire biosphere. Going further, it is defined that the concept of circular bioeconomy at the global level is strategic and urgently needed to overcome the climate crisis and biodiversity loss. Palhí et al., 2020 propose a plan of 10 actions to create a "*circular bioeconomy for well-being*":

> *1.Focus on sustainable well-being; 2. Investing in nature and biodiversity; 3. Generate fair distribution of prosperity; 4. Rethink food systems, land uses and health holistically; 5. Transform industrial sectors; 6. Rethinking cities through ecological lenses; 7. Create a possible regulatory framework; 8. Deliver mission-driven innovation to policy and investment agendas; 9. Enable access to finance and highlight the ability to take risks; and 10. Step up and expand research and education.*

In particular, the second objective deals specifically with biodiversity: *"investing in nature and biodiversity through two interdependent strategies... the first strategy should promote more species-rich systems in agriculture, aquaculture and forestry. The second strategy should protect large contiguous biodiversity systems to prevent species extinction and biodiversity erosion."*

Bugge et al. (2016) indicate key elements for the various views on bioeconomy, illustrated in the following figure (Table 3). According to Villa Nova's analysis (2020),*"the three visions seek to integrate approaches adopted by organizations and countries but are correlated and interdependent in creating an agenda of bioeconomy and sustainability."* The challenge for tropical forests is conceptual development—followed by policies and implementation mechanisms—of the bio-ecological view of the table below, but at the same time to add to the immense biotechnological potential of aquatic and terrestrial ecosystems and their biomaterials.

Table 3. Visions of bioeconomy (Bugge et al., 2016).

	The Bio-Technology Vision	The Bio-Resource Vision	The Bio-Ecology Vision
Aims & objectives	Economic growth & job creation	Economic growth & sustainability	Sustainability, biodiversity, conservation of ecosystems, avoiding soil degradation
Value creation	Application of biotechnology, commercialisation of reserach & technology	Conversion and upgrading of bio-resources (process oriented)	Development of integrated production system and high-quality products with territorial identity
Drivers & mediators of innovation	R & D[1], patents, TTOs[2], Research councils and funders (Science push, linear model)	Interdisciplinary, optimisation of land use, include degraded land in the production of biofuel, use and availability of bio-resources, waste management, engineering, science & market (Interactive & networked production mode)	Identification of favourable organic agro-ecological practices, ethics, risk, transdisciplinary sustainability, ecological interactions, re-use & re-cycling of waste, land use, (Circular and self-sustained production mode)
Spatial focus	Global clusters/Central regions	Rural/Peripheral regions	Rural/Peripheral regions

1. Technology Transfer Offices
2. Research & Development

13. Assessment of the Current Situation in the Amazon and impacts on Amazonia 4.0

In addition to the changes at the project level, it is also important to highlight substantial changes in the broader context. It must be recognized that there has been a major change in the perception of the risks the Amazon is facing due to the large uptick in deforestation and fires in 2019 and 2020. That has led to a global outcry against such trend. That may be very useful in creating a global and regional consensus on the urgency of seeking solutions. In particular, the increase in deforestation rates in the first half of 2020 raised global concerns to the point that a large group of investment funds sent a letter to Brazilian Government warning that the country was under great risk of losing investments if it failed to reduce deforestation and fires. Since 2019, the global outcry has led also to the creation of the Amazon Council led by Brazil's Vice-President Gal Hamilton Mourão. This Council took more directly responsibility to reduce environmental crime of deforestation and fires in the Amazon. It also started to discuss the prospects of a new bio-economy for the Amazon.

The concept of a novel bio-economy of standing forests and flowing rivers is becoming increasingly accepted. Our project has drawn much greater interest by various sectors in Brazil and in other Amazonian countries and got tremendous attention by the international and national media, including articles features in North American and European newspapers and scientific magazines. The concept of Amazonia 4.0 is becoming known and broadly discussed in many fora, including Davos. That is a positive sign for the near-future implementation of our project. For instance, the core concepts of the Amazon Third Way/Amazonia 4.0 project had the opportunity to be presented to the Synod of the Amazon, in the Vatican. The foundational ideas of a bio-economy of forests standing and rivers flowing appeared in the Synod's final document[25] and is poised to become a priority for engagement with and empowerment of local communities in the Amazon basin.

It has become clear throughout 2019 that Brazil will maintain its commitments to the Paris Accord, including its NDCs. That calls for nearly zero deforestation in the Amazon by 2030 to meet its NDC's targets of 43% GHG emission reductions compared to 2005 emissions. However, increase of deforestation rates and return of discussion of large infrastructure projects in the Amazon poses a threat to the attainment of such goals of GHG emission reduction. At the end of the BRICS (Brazil, Russia, India, China, South Africa) Meeting on 14 November 2019 all countries reaffirmed their commitments to the Paris Accord.

13.1. Leticia Pact for the Amazon Region

Amazonian countries signed the LETICIA PACT FOR THE AMAZON REGION on 6 September 2019 in the Amazonian city of Leticia, in Colombia, in which they agreed on 14 points leading to sustainable development of the Amazon region, its populations, protecting the forests, its biodiversity and indigenous and traditional populations. The the Leticia Pact contain 16 recommendations. In particular, four items that have a direct relation to the Amazon Third Way Initiative/Amazonia 4.0 are here highlighted:

10. Strengthen the mechanisms that support and promote the sustainable use of forests, sustainable productive systems, responsible consumption and production patterns that promote value chains and other sustainable production approaches, including, those based on biodiversity.

11. Promote joint action aimed to the empowerment of women inhabiting the amazon region to encourage their active participation in the conservation and sustainable development of the Amazon region.

12. Strengthen the capacities and participation of indigenous and tribal peoples, and local communities in the sustainable development of the Amazon region, acknowledging their fundamental role in the conservation of the region.

13. Promote research, technological development, technology transfer, and knowledge management processes with the purpose of guiding the adequate decision-making and promoting the development of sustainable environmental, social and economic entrepreneurship.

All these items have a direct link to the development of a new bio-economy for the Amazon, in particular item 13 is strongly associated to the concepts of Amazon 4.0, that is innovative

[25] http://www.vatican.va/roman_curia/synod/documents/rc_synod_doc_20191026_sinodo-amazzonia_en.html

research and technological development—along with capacity development of Amazonian populations—to promote the emergence of sustainable eco-entrepreneurship, a pillar of development never existent in the Amazon. Following, we summarize the Third Way Initiative-Amazon 4.0 project.

14. The Amazon Third Way Initiative

14.1. Background

For decades the Amazon development debate has been torn between opposing views of land use: on the one hand (that we call The First Way), with a vision of setting aside large tracts of the Amazon forests for biodiversity conservation purposes and, on the other hand, with a resource-intensive development vision, mostly through agriculture/livestock, energy, and mining (The Second Way).

The Amazon Third Way Program proposes to reconcile these opposite views. With its implementation strategy called Amazonia 4.0, it is conceived as a "disruptive" program, designed to open up new research, technology, and learning-based opportunities to value and protect the Amazon ecosystems, and to serve the interests of indigenous and traditional peoples who are their custodians. It aims at development of an equitable and socially inclusive, biodiversity-driven 'green economy' which harnesses nature's value through sustainable products of standing rainforests and flowing rivers.

Time has come to unleash opportunities inherent in Amazonia's unique and diverse ecosystems, among others by rapidly prototyping and scaling innovations that apply a combination of advanced digital, biological, and material technologies of the 4th Industrial Revolution (4IR). These technologies are increasingly and profitably harnessing biological and biomimetic assets across many industries - from pharmaceuticals to energy, food, cosmetics, materials and mobility - not only in the Amazon, but in many places around the world.

Bioeconomy must generate local entrepreneurship, diversified bio-industries, and value-added products across all links of the value chain, and it must effectively utilize modern technologies of the 4IR. The guiding principle in developing a standing-forest-flowing-rivers economy is not to see the region as a mere producer of primary commodities (agricultural, timber, mineral, etc.) as inputs to industries elsewhere, but rather to have deep roots in the Amazon region's unique biodiversity as a foundational element, and to bring benefits to its local people.

Major collateral benefits of ambitious, competitive bioeconomic development are the salvage of biodiversity and climate functions of Amazonia's forest and river systems, on a huge scale that matters to all Amazonian countries and the world.

14.2. The Two Components of Amazonia 4.0:

The *Amazon Creative Labs*

The ambition of the program's knowledge-generation and capacity development component, the *Amazon Creative Labs,* is to enable leapfrogging from extractive and low income, low value-added agriculture models to state-of-the-art solutions that add value to existing, biodiversity-based value chains, and to explore new ones, all the way to high-end genomics and biomimetics.

Amazon Creative Labs come with local capacity building, intellectual property rights assignments, and case-by-case experimentation with unique, economically competitive product ranges, and designs to increase local incomes towards an inclusive, vibrant and powerful bioeconomy.

Amazon Creative Labs (ACLs) have a two-fold goal:

On one hand, they **disrupt business-as-usual** by creatively associating local socio-biodiversity knowledge with production methods, equipment and market trends and latest 4IR technologies made available at local and regional scale. Among many others, such technologies include: smart manufacturing; automation with advanced sensors and dedicated computing; biosensors for quality analysis; IoT (Internet-of-Things) equipment and data cloud; 3D printing; portable genomic sequencer, electron microscope, virtual and augmented reality for training and technical assistance; logistic improvements with cargo drones; broadband internet connectivity; electricity provided by solar Photovoltaic (PV) energy systems, fully product traceability by Quick Response (QR) codes and microchip technologies, direct link between producers and consumers through smartphone apps and social media for marketing access and product customization, etc.

On the other hand, they serve as testbeds for discovery and development of new products, processes and activities emerging from the interactions of experts along the value chain, and of innovative entrepreneurs in two-way interaction with local populations and traditional knowledge. In ACL field workshops—taking place in forest communities, towns and also on regional university campuses--participants will gain new knowledge, and they will have means and incentives to grow their creativity, bringing along their own inputs, biological assets, processing skills and practices and references. They will be enabled to combine their inherent knowledge with new learnings and tools in innovative, participatory product development. ACLs will be developed with proper combination of knowledge from advanced biology laboratories; experts on all aspects of the value chains; high tech innovation hubs and labs from Brazil and other Amazonian countries, and other parts of the world.

Currently, we have designed Amazon Creative Labs for a few value chains (Cocoa-Cupuaçu; Brazil Nuts; Four Special Cooking Oils) and one for Genomics. We are starting construction of the fist Lab (Cocoa-Cupuaçu value chain).

The Rainforest Business School

New business requires new business education. The world's first Rainforest Business School is being designed to structure a new field of business knowledge - for a new generation of experts. Target audiences include MBA students, the industry and business communities, administrators of public programs and policies, and specialized civil society enterprises that relate to sustainable forest and fisheries management.

The ambition of the Rainforest Business School is to develop an interdisciplinary rainforest business curriculum, with due emphasis not only on technical and business fields, but also on understanding and respect for environmental safeguards, intellectual property, and local community rights and cultures. Above all, the Rainforest Business School will serve the local people, business community and public administrations, covering science, product- and value chain development, market mechanisms, socio-cultural, legal, and policy subjects. The Amazon Creative Labs will serve as field campuses, in various locations.

The Rainforest Business School is being developed as a partnership between University of São Paulo's Institute of Advanced Studies (IEA-USP) and State University of Amazonas (UEA).

15. Conclusion: A propositional vision for the Amazon

The economic activity of the Amazon's natural forest has great potential yet to be developed when considering Non-Timber Forest Products (NTFPs) and those coming from agro-ecosystems (SAFs). Preliminary financial analyzes, in systems that are still incipient, point to a great potential for profitability of these alternative systems compared to traditional activities such as soybean and livestock farming, with the advantage of being conducted without degradation and deforestation, allowing the continuation with the support of the Amazonian ecological system. However, it will be necessary to stimulate research directed and based on the abundant existing knowledge about resources and examples of small and medium scale of success. There is limited scientific knowledge on some fronts, such as expandability on a large scale. At the same time, there is little "dialogue" between the models of modern agriculture and the traditional knowledge needed for an integrated natural forest management system: a barrier to be overcome.

Compared to established markets in modern agriculture, forest production resulting from managed forest is still small and disorganized. There is a lack of organized and structured production chains for most species with economic potential. As the majority of these exploited native species are produced in the context of extractive communities, there is a need to prepare such interest groups, taking into account the necessary technical and scientific knowledge and advancing in their gaps. Therefore, the rural extension services of public and private organizations have a great mission, but with evident high potential to be realized. The expansion of technical and scientific knowledge and its transfer to the producer is fundamental.

To leverage this sector, it will be important that focus groups are well prepared and versed in techniques of organization and social entrepreneurship. The implementation of the new development model in the Amazon involves encouraging production in agroforestry systems (SAFs) developed for the recovery of deforested or degraded areas, consolidating an action and / or public policy for forest restoration. A training and capacity building system will be necessary for orderly development to take place, fundamental work to be coordinated with System S bodies (SEBRAE, SENAC, SENAI, SESC etc.), in addition to EMBRAPA regional units, and why not others? Be implemented.

The articulation and integration of AMAZÔNIA QUATRO Ponto ZERO with the different institutions and sectoral organizations is a factor in making the concepts viable, since such institutions operate, to a large extent, in isolation due to their corporate policies or institutional mission. Thus, in addition to the roles defined for the project, it will be essential to establish a proposal and connectivity strategy with the different organizations operating in the region.

AMAZONIA QUATRO PONTO ZERO initiative will be able to "take the paper" off countless public policies that encourage applied research projects and cooperation programs focused on the development of sustainable land use models. Thus, involving forest management for non-wood and agroforestry products, generating conservation and development. This context should also generate regulatory mechanisms for establishing a Minimum Price Guarantee Policy, coordinated with programs such as CONAB, for forest management products and products of Sociobiodiversity origin. In this context, the examples presented above, which involve agribusiness communities and value chains, must be carefully observed.

The future of the Amazon can assumes several paths, from disorderly occupation, with consequent deforestation and few opportunities to improve the quality of life in the region, or we can envision the maintenance of the managed forest and its values, with broad participation from the society that still resides in rural zones, riverside and small communities distributed throughout the region. For this second path of development, it is essential to create large areas of conservation, public or private, created by SNUC or by other mechanisms. Such wide areas must be accessible to the local entrepreneur, small, medium or large, allowing preserving biodiversity integrated with economic activities, prioritizing areas of native forest as assets that generate NTFPs. In this case, the intensive use of areas already deforested may also be converged to the recovery of territories through agro-ecosystems, promoting social and economic development for the region.

Therefore, it is important to definitively include forest and agroforestry management, focusing on NTFPs, in the context of economically viable options for land use, in addition to defining areas for absolute preservation of biodiversity, not allowing deforestation to isolate fragments of exploited forests and promoting connectivity between public and private areas.

There is abundant evidence that any other use and occupation systems in the Amazon region, at medium and large scales, which are not predominantly integrated with the original forest, generate increasing impacts and negative externalities at small, medium and large scales, pointing to a thesis of that the best economic option for land use in the Amazon is the integration of man with the natural and original forest. Experiences show that the more the human being fights against the forest, the worse his defeat will be. The opposite is also true.

16. References

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