Chapter 10

The Amazonia Third Way Initiative: The Role of Technology to Unveil the Potential of a Novel Tropical Biodiversity-Based Economy

Ismael Nobre and Carlos A. Nobre

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.80413

Abstract

Abstract For the last two decades, the Amazon development debate has been torn between attempts to reconcile two rather opposing views of land use: on one hand, a vision of setting aside large tracts of the Amazon forests for conservation purposes (referred hereafter to as The First Way) and, on the other hand, seeking a 'sustainable' resource-intensive development, mostly through agriculture/livestock, energy and mining (referred hereafter to as The Second Way). The decrease of Brazilian Amazon deforestation from 2005 to 2014 (about 75% decline) opens a window of opportunity to conceive a novel sustainable development paradigm: The Amazonia Third Way initiative (A3W). It can represent a new opportunity emerging to protect the Amazon ecosystems and the indigenous and traditional peoples who are their custodians and at the same time develop a vibrant, socially inclusive biodiversity-driven 'green economy' in the Amazon by harnessing Nature's value through the physical, digital and biological technologies of the 4th Industrial Revolution (4IR). 4IR technologies are increasingly harnessing these assets across many industries from pharmaceutical to energy, food, cosmetics, materials and mobility, and making profits. A3W addresses ways to channel to the Amazon the benefits of the 4IR for the creation of bio-industries and local development as it protects the forests.

Keywords: Amazon, Fourth Industrial Revolution, Amazonia Third Way, Amazonia 4.0, Amazon sustainable development, land use

1. Introduction

It is more urgent than ever to find alternative ways to develop the Amazon. This realization comes with the science-based analysis that the Amazon may have come much closer to a tipping point than previously thought. Recent analysis [1] lends support to the idea that the whole Amazon system might flip to second stable climate-vegetation equilibrium, with degraded savannas covering most of the central, southern and eastern portions of the basin.

The drivers of such change are deforestation, climate change and increased forest fires. Given the simultaneous and synergistic impact of these drivers of change, total deforestation must not exceed 20–25% to avoid transgressing a potentially irreversible tipping point.

Global climate considerations also matter: CO_2 emissions from forest burning may well be the biggest unresolved global climate challenge. Without reductions in rainforest burning, including in the Amazon, international goals called for in ratified international Conventions for climate, biodiversity and water protection cannot be reached.

The heightened critical risk to the Amazon forests calls for intensifying the search for disruptive socioeconomic alternatives and transformations. For many decades, contradicting strategies to develop the Amazon have been at work: conservation (we call it the *'First Way'*) versus resource-intensive development (which we call the *'Second Way'*). Considerable efforts were made by successive governments and by NGOs to reconcile those two ways through agricultural 'sustainable intensification',—albeit with meager results. The question therefore remains how to unveil the potential of a forest-biodiversity economy in the Amazon.

We argue that a radically different *'Third Way'* for sustainable development of the Amazon is within reach. We propose to utilize modern technologies of the 4th Industrial Revolution to harness the biological and biomimetic assets of the Amazon's biodiversity. And we postulate that this *Third Way* can support a standing forest-flowing river bio-economy while being socially inclusive [2].

2. Methodological framework

The methodological approach of this study starts with a perfunctory examination of land use patterns in the Amazon. We examine two distinct models of land use pathways that in general terms may direct and define the maintenance or not of the Amazon forest. The first model is characterized by expansion of protected areas in the Amazon. It has been labeled 'The First Way'. In the other model, it is prevalent intensive natural resources exploitation. It has been labeled 'The Second Way'. In Section 3 of this chapter we briefly assess the overall results of these models in land use (for a comprehensive review, see [2]). We present updated literature data in support for current trends in land use changes, such as planned infrastructure, policies and evidence of ongoing land use processes and change.

We pose two research questions to guide the next phase of the study: Overall, current and planned patterns of land use are environmentally sustainable in the long run? If not, what would be an alternative way? The answers are developed from the basic concepts proposed by [2] for the so-called Amazonia Third Way (A3W), which is based upon a novel economic model. This rests on an innovative, knowledge-based standing forest-flowing rivers bio-economy, valuing the Amazon's renewable natural resources, biological and biomimetic assets,

http://dx.doi.org/10.5772/intechopen.80413

environmental services and biodiverse molecules and materials. A conceptual model of the A3W is proposed with the main drivers for its planning and implementation. Two of these drivers, namely Technological Drivers and Capacity Development, were considered key to the construction of A3W and are further developed in this work. The technologies of the 4th Industrial Revolution were coupled with core A3W guidelines, leading to the conceptual definition of the Amazonia 4.0. **Figure 1** shows a diagram of the methodological approach used in this work.

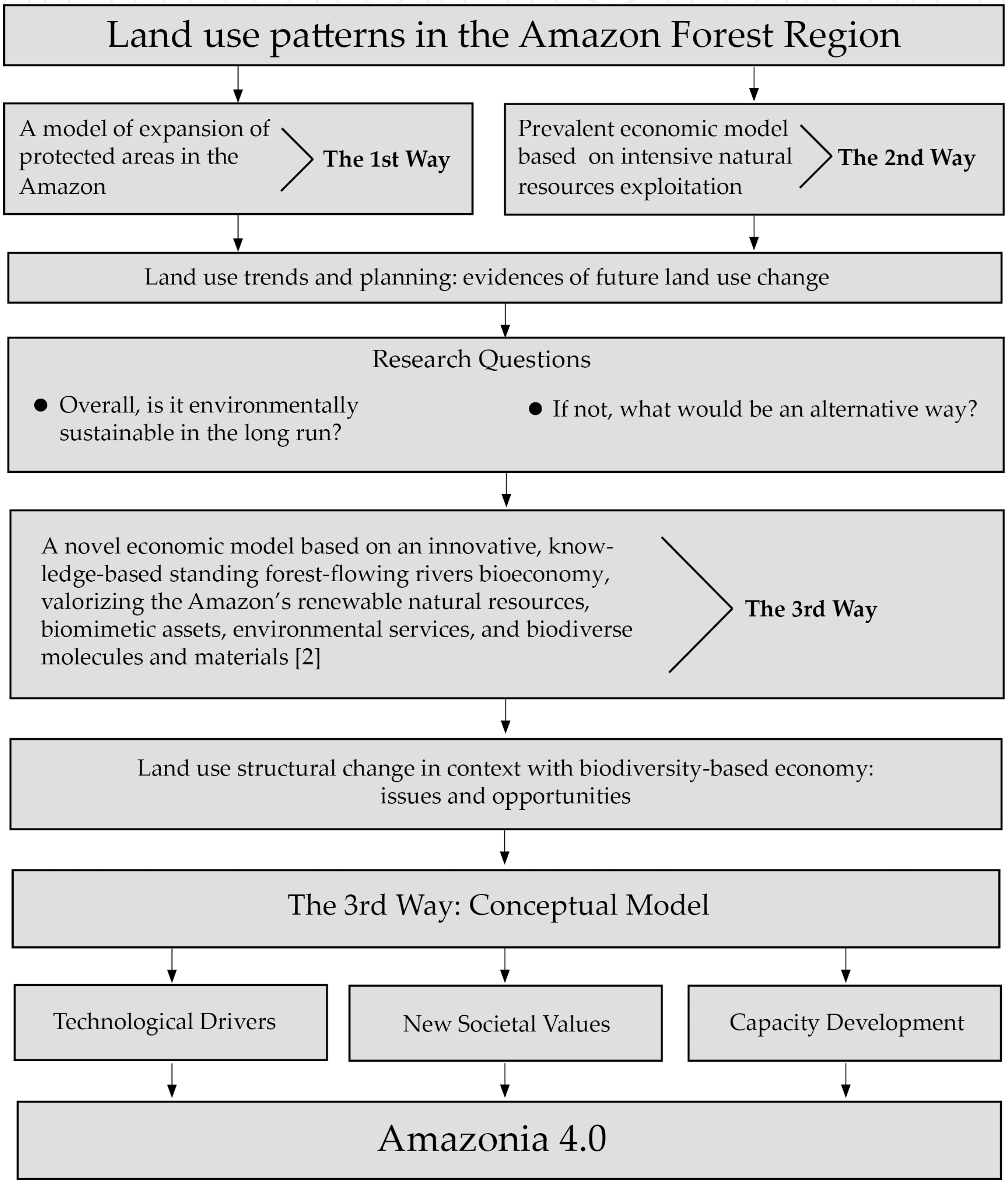

Figure 1. Methodological diagram for the conceptual development of the Amazonia Third Way.

3. Land use trends and planning: evidences of future land use change pathways

The Amazon forest biome has a total of 45.4% of its territory formed by protected areas and indigenous territories [3] as depicted in **Figure 2**. This large area where the forest is predominantly protected or managed in a sustainable way [4, 5] is the ballast that makes the First Way a possible model of land use for the Amazon. An effective example of the implementation of conservation policies by Amazonian governments is given by Brazil. In the 1990–2013 period, protected areas of the Amazon have grown from 11 to 125 million hectares and indigenous land have grown from 33 to 125 million hectares [6]. Indigenous territories and protected areas occupy 47.85% of the Brazilian Amazon [7].

On the other hand, the model of resource-intensive development (Second Way) rests mostly on economic activities that lead to the elimination of the forest and had cycles of intense growth for many decades. RAISG's 'Deforestation in the Amazon (1970–2013)' (see **Figure 3**) study indicates that up to 9.7% of the region have been deforested until the year 2000, and that between that year and 2013 that rose to 13.3%, which represents 37% increase in 13 years [9]. Given that, by and large, Amazon deforestation rates increased in the last 5 years, it is likely that total deforestation is close to reaching 16% of the whole basin by 2018.

Other studies show that protected areas and indigenous territories are not necessarily blocking deforestation completely. Although deforestation in indigenous territories in the Amazon remains relatively small, rates have grown 32% between 2016 and 2017 [7]. That points out that

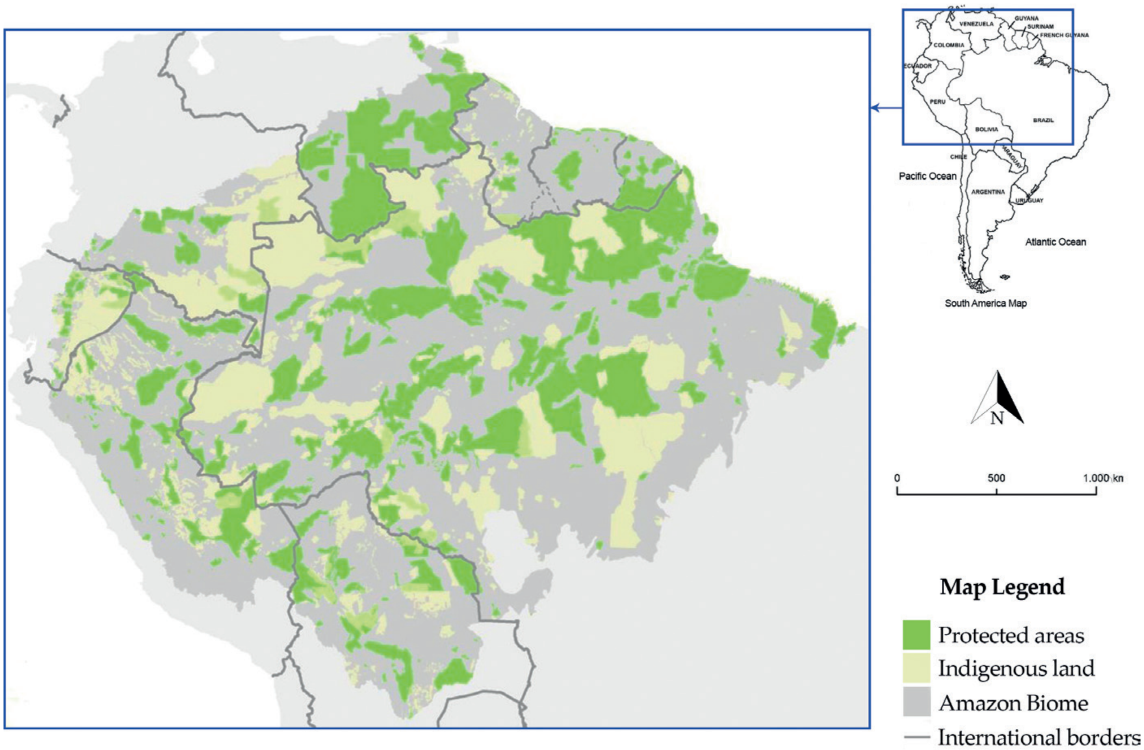

Figure 2. Protect areas in the Amazon basin. Source: Conservation International [8].

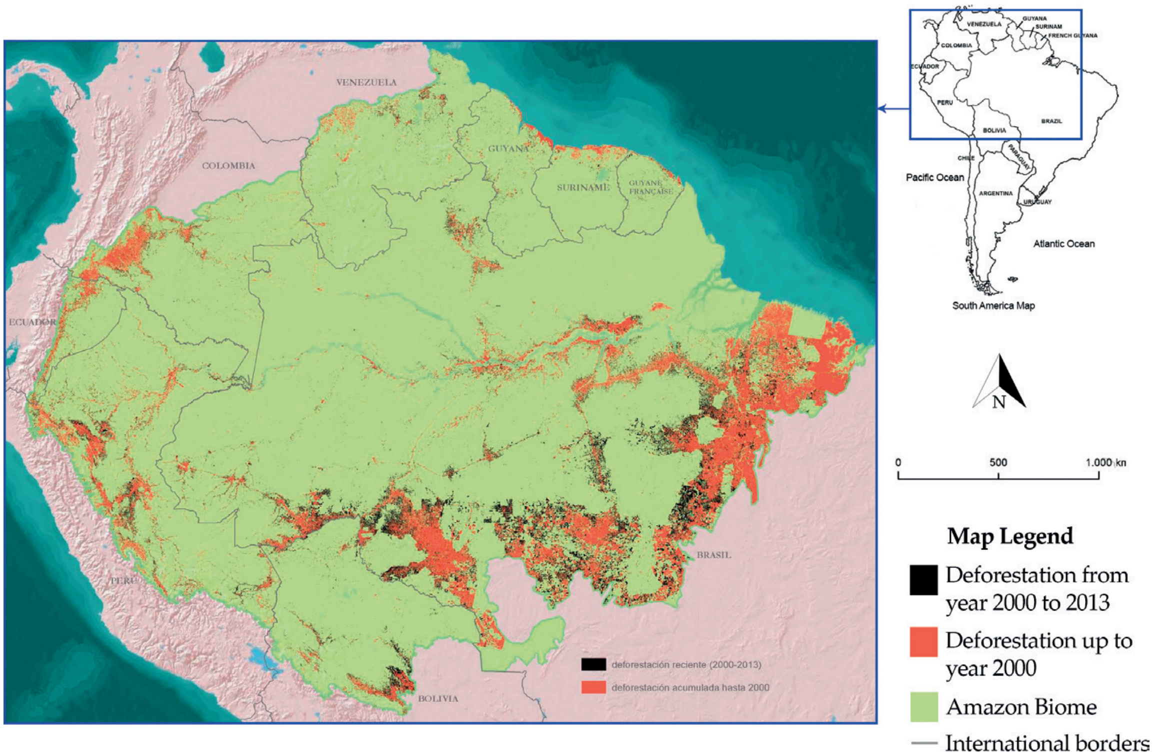

Figure 3. Mapping of deforestation of the Amazon forest biome for two distinct periods: the total accumulated up to 2000 (red color) and the increment from 2000 to 2013 (black color). Source: RAISG [9].

the barrier formed by indigenous land and other protected areas may vanish under the pressure of environmental crime and expansion of the commodities frontier, if adequate protection policies are not enforced. The increase of deforestation in some indigenous territories occurs at a time when the total rate of destruction of the Amazon rainforest fell by 16%, from 7892 km^2 in August 2015–July 2016 to 6624 km^2 in August 2016–July 2017. Notwithstanding the observed decrease, the level is still extremely high in absolute terms [7]. For the same period, the *Sistema de Alerta de Desmatamento* (SAD) from Instituto do Homem e Meio Ambiente da Amazônia (Imazon) detected an increase of 22% in the rate of deforestation in protected areas [10].

Besides the current evidences indicating that protected areas may not be a good proxy for permanent forest conservation because the prevalent model of intensive use of natural resources is a permanent dynamic force toward disrupting it, there are evidences that the future can be even more challenging for the First Way to ensure forest conservation. Official Amazonian countries' planned infrastructure developments indicate a huge increase in the construction of dams, roads, railroads and ports [11] throughout the Amazon basin. These types of infrastructure pose severe threats to the forestland through their construction and will almost certainly induce new developments of high deforestation profile.

Land use change in the Amazon: sustainability or deforestation?

In the Brazilian Amazon, which comprises 65% of the whole biome, deforestation figures from 2005 to 2017 show that a period of consistent decrease from 2004 to 2012 may be now reversed (**Figure 4**).

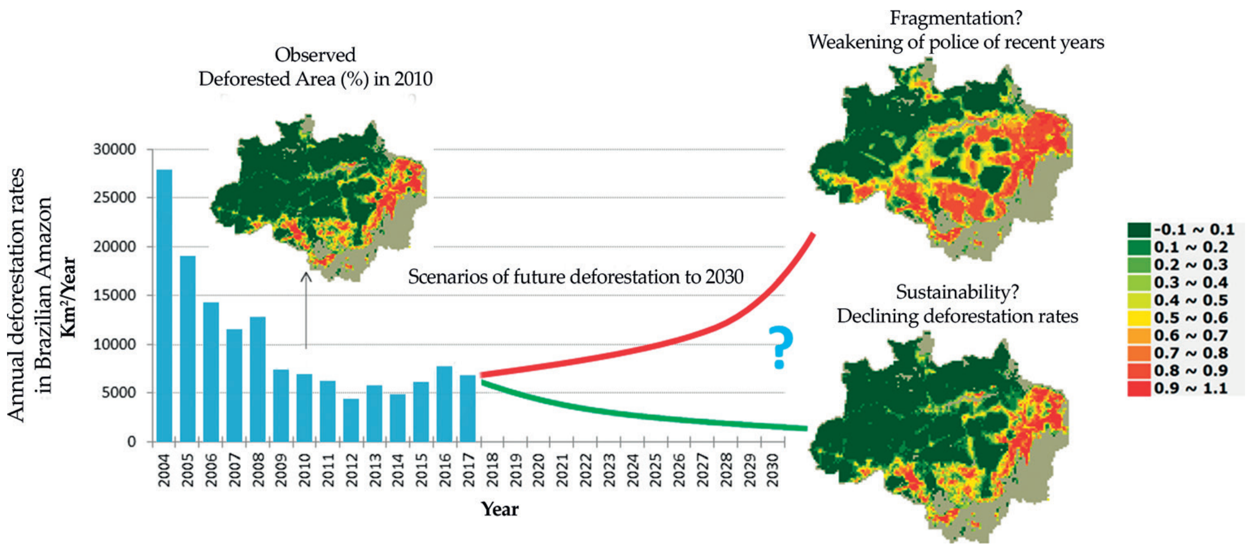

Figure 4. Annual deforestation rates in Brazilian Amazon (km^2) from 2004 to 2017 and map of fraction of land cover change for 2010 (left panel) based on PRODES data [14] and projections of two possible scenarios for the Amazon in the future up to 2030 [13]: one of large deforestation (called 'Fragmentation') and one of declining deforestation (called 'Sustainability').

Future land use change in the Amazon has been modeled [12, 13] for two rather opposed scenarios which lead to very different land cover changes (**Figure 4**). In one of them (the so-called 'Fragmentation' scenario), there is a continuous weakening of strict deforestation control policies successfully implemented from 2005 to 2012 in Brazilian Amazon and expansion of resource-intensive activities leading to agricultural and livestock expansion, resulting in over 50% of the Brazilian Amazon deforested by 2050. That is a scenario quite consistent with a progression in time of the Second Way. The other scenario in **Figure 4** (the so-called 'Sustainability' scenario) calls for continuation and strengthening of the environmental policies to bring deforestation rates close to zero in the near future. It is the land cover change scenario compatible with the Third Way.

The economic rationale to protect the tropical forests (The First Way or the 'Sustainability' scenario of **Figure 4**) rests to some degree upon the assumed low costs of maintaining intact forests as carbon storage and carbon sinks as a non-costly way to mitigate climate change in comparison to more expensive alternatives such as switching energy systems to renewable energy. Calculations for Brazil [15] estimate savings up to USD 100 billion/year to 2030 for Brazil to fulfill its NDC commitments to the Paris Accord if deforestation of the Amazon and Cerrado biomes can become smaller than 4000 km^2/year and the bulk of its commitment to reduce national emissions 43% relative to 2005 emissions by 2030 come from land use policy and not from rapidly switching the energy matrix to renewable energy. However, it is clearly short-sighted to view only the carbon pathways as justification to preserve tropical forests. In fact, the Third Way Initiative raises various limitations of such approach (see [2]) and proposes that, in addition to ecosystems services, the economic potential of tropical forests rests on their biological and biomimetic assets to a larger extent.

4. Identification of issues and opportunities for sustainable socioeconomic development

In this chapter, we analyze the issues and circumstances that have impeded to date socioeconomic development based on Amazon biodiversity assets to occur in large scale. We point out the major failures in dimensions such as concepts (imagination challenges), knowledge (research and information challenges) and implementation (governance and policy challenges & entrepreneurial capacity failures), and the lack of imagination of the potential of an innovative green economy based on nature that goes beyond the Amazon regional institutions. In the opportunity side, we present a summary of a major review in the scientific and technical literature, which identified more than 200 species of Amazonian plants with known potential to provide raw for an initial low-end bio-economy in the Amazon. Many biodiversity products of the Amazonian flora follow have established value chains. We did qualitative analysis on a sample of it to identify its main characteristics, problems, virtues and bottlenecks. This analysis included selected cases of innovative entrepreneurship leveraging relatively low-end technologies and evaluation of 25 enterprises that markets non-timber products of Amazonian biodiversity. The sample encompasses a range of segments, types, sizes and bio-assets processed.

4.1. Conceptual failures for sustainable tropical development

The challenges to achieving sustainable development in the Amazon can be broadly categorized in three categories, similarly to a conceptual framework laid out for planetary health [16]:

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

The lack of imagination of the potential of an innovative green economy based on nature is not restricted to the Amazon regional institutions. Economic viability studies for the Amazon of serious institutions such as the World Bank almost completely ignore such potential. For example, recent studies [17] continue to see the value of forest products in an exclusively extractive way and assume very low returns. For example, less than $10 per year per hectare for non-timber products and just over $20 for sustainable selective logging. They ignore the concrete case of market success of agroforestry systems such as çaí, with proven annual returns of between $200 and $1000 per hectare [18], adding more than $1 billion annually to the regional economy [19].

The intense resource-based agribusiness, mining and hydropower in the Amazon generate wealth and little of that is reinvested to propel health and education improvements within the Amazon beyond what is called for in the licensing process. That is in part due to the regressive taxation system and in part due to historical inefficiencies in investments in public services. For instance, the highest average per capita income region in Pará—annual per capita income of close to R$50,000—is the iron ore-rich Carajás area, with overall income higher than national average. However, social indicators such as health and education services are no different than other regions of the State of Pará and much lower than national averages. In summary, very little of the wealth remains in the region and improves the wellbeing of the population.

The discourse on sustainability has been allowed to proceed as a sign of the times and to be aligned with global trends starting with the 1992 Earth Summit in Rio and to transmit an international aura of adherence, but in fact the concrete development policies for the Amazon never in fact deviated from the one devised by the military government out of geopolitical concerns: livestock and agricultural occupation to ensure sovereignty and exploitation of minerals, hydropower and fossil fuels as drivers for economic development.

The intense and swift expansion of the Brazilian agriculture frontier in the Amazon resulted not only in the growth of the country's GDP since the 1960s, but also in the rates of tree felling and greenhouse gas emissions—a consequence of conversion of forest landscapes into pasture for cattle raising and agricultural fields for grain production. Some numbers illustrate this human-orchestrated metamorphosis. Since 1997, more than 20 billion trees have been cut in the world's largest rainforest. In 2016, more than half of the 8000 km^2 of Amazon deforestation was transformed into new pastures. Currently, beef and dairy farming and production account for 45% of gross Brazilian GHG emissions.

The main public policies responsible for the sharp reduction in deforestation from 2005 to 2014 seem to have already reached their limit, so much so that deforestation has been growing in 2015 and 2016, even in a period of historic economic recession, demonstrating once again the decoupling of deforestation with economic growth, neither when GDP grows nor when GDP shrinks. The underlying reasons for continued land cover change are more complex than simply responding to global markets.

Unfortunately, we may not have a long window of time to change course with respect sustainable pathways for the Amazon. Tipping points not to be transgressed for forest-climate stability are in the horizon. The synergistic effects of land cover and climate changes, and with increased forest fires due to a combination of forest degradation, use of fire in agriculture and droughts, make the risks even greater. Earth system modeling [2] shows that the synergistic combinations of those drivers could lead to a relatively rapid transition to new forest-climate equilibrium with loss 50–60% of the forest over eastern, southern and central Amazon, replaced by degraded savannas and dry forests. The sense of urgency to avert a systemic risk to the Amazon forests must be kept in mind in the search for solutions.

4.2. Potential of a biodiversity-based bio-economy

The knowledge of nature, accumulated over 3.5 billion years of evolutionary processes, that finds in the Amazonian biodiversity one of its greatest showrooms, is a potentially very large bio-economic asset. The number of molecular substances with specific and usable functions is practically incalculable, since each existing species is itself a biochemical design laboratory. And most species are yet unknown and every 3 days, on average, one new species is discovered [20].

Even though a single substance with a desired function discovered by the study of living things in the Amazon could be biologically synthesized and produced industrially by laboratories to reduce costs or to provide quantities demanded for world consumption, the intrinsic knowledge that generated its form and function was stored in the forest and ready to be copied.

A review carried out in the scientific and technical literature as part of this work identified more than 200 species of Amazonian plants with known potential to provide raw for an initial low-end bio-economy in the Amazon. A reduced listing of the 20 very promising species that have been widely used, integrate local productive chains or show strong potential use in food, cosmetics, perfumery, medicinal, advanced materials and biotechnology have their distribution modeled. The listing includes rosewood (*Aniba rosaeodora*), Brazil nut (*Bertholletia excelsa*), cumaru/tonka (*Dipteryx odorata*), açaí (*Euterpe oleracea*) and rubber tree (*Hevea brasiliensis*) among other. A sample distribution for rosewood in the territory is shown in **Figure 5**.

Few of the biological assets of Amazonian biodiversity are known, others are being researched for their nutritional, structural, biochemical and market properties, to become products of future use.

A good example of this transition in the area of food is the açaí fruit of the *Euterpe oleracea* palm, widely and historically consumed only by local populations until the 1990s. From then on, it gained the world for its nutritional and functional qualities and its flavor, even with the operational difficulties of being a fresh, minimally processed fruit transported frozen from the vicinity of the forest to consumer markets elsewhere in Brazil and abroad (e.g., to the US and Japan) [18]. Its botanical genus (*Euterpe*) bears the name of one of the nine muses of Greek mythology, daughter of Zeus, who represents pleasure and happiness, as many consumers of açaí pulp may well attest.

Like açaí, many of the Amazonian biodiversity foods are traditionally consumed by the local population, with marked flavors and excellent nutritional properties, as well as functional foods and nutraceuticals in many cases. Camu-camu (*Myrciaria dubia* (HBK) McVaugh), for example, has 4 times more vitamin C than acerola [22]; murici (*Byrsonima crassifolia* (L.) Rich.), has excellent antioxidant properties [23], as well as açaí, that reached global markets. In addition to antioxidant activity and being a source of five types of carotenes, taperebá (*Spondias mombin* L.) is a rich source of vitamin A, at the rate of 100 g of fruit corresponding to more

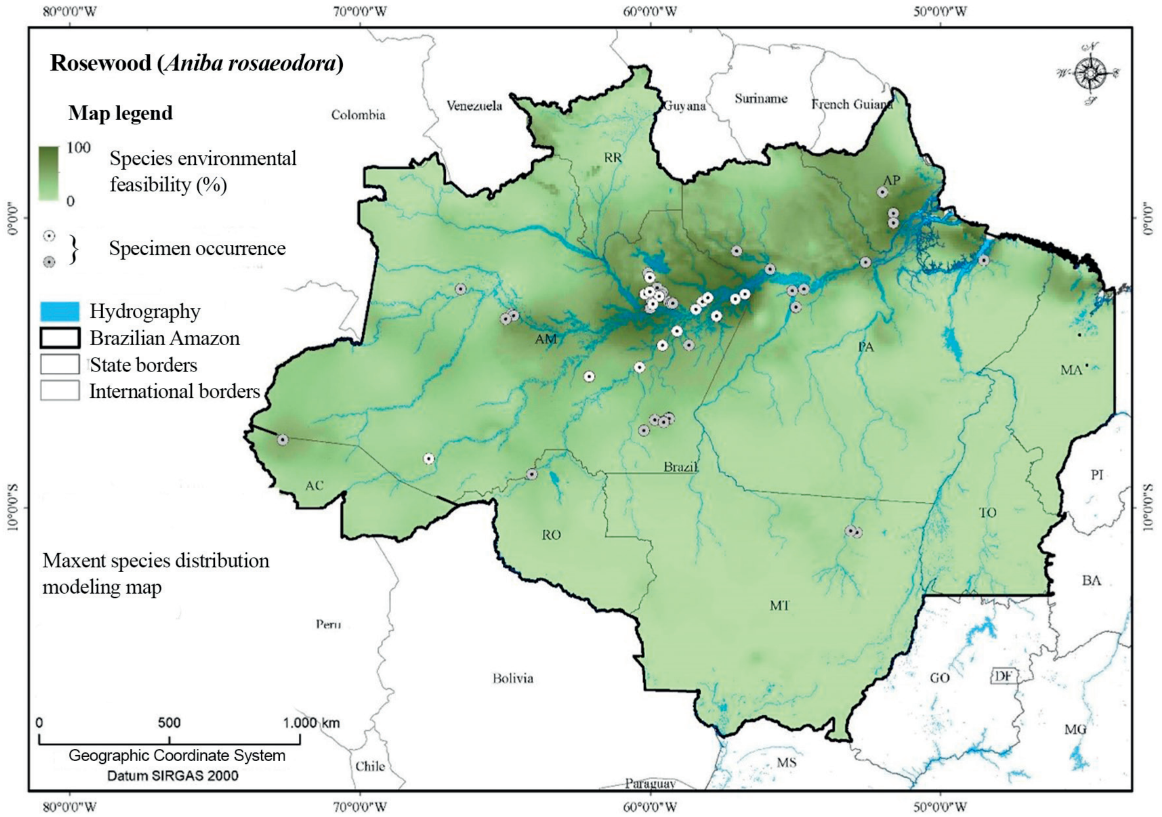

Figure 5. Geographic distribution for rosewood (*Aniba rosaeodora*) in the Brazilian Amazon [21].

than 37% of the daily needs of the vitamin [24]. Besides the well-known Brazil nut (*Bertholletia excelsa*), which is already a nut consumed worldwide for a long time, there are many other fruits and seeds of the Amazon with potential to gain new markets, such as cumaru-ferro (*Dipteryx odorata*); cupuaçu (*Theobroma grandiflorum*); uxi (*Endopleura uchi* (Huber) Cuatrecasas); graviola (*Annona muricata* L.); patauá (*Oenocarpus bataua* Mart.); guaraná (*Paullinia cupana*); priprioca (*Cyperus articulatus* L.); and bacuri (*Platonia insignis*), among many others.

The raw materials of Amazonian biodiversity are used in the industry of essences and oils to make cosmetic and perfumery products. As an example, the cumaru-ferro (*Dipteryx odorata)* fermented seeds produce an essential and industrial oil, while coumarin (*coumarinic anhydride*), which is an aromatic essence used as a narcotic and stimulant [25]. This oil is also used as a fixative in the perfumery industry [26]. Another example is andiroba (*Carapa guianensis*) available in the market in the form of essential oil, with anti-inflammatory, moisturizing, healing properties [27], being also sold for especially sensitive skin care cosmetics [28].

Açaí has also been studied and is used far beyond food: in the cosmetics sector its oil has properties for skin nutrition, revitalization and hydration, it contains omega 6, it is an antioxidant agent rich in polyphenols indicated for the formulation of anti-aging products [29, 30]. The anthocyanin present in large quantities in the açaí pulp was used in an application as a natural marker for teeth bacterial plaque [31] with large potential markets. In another development, nanoparticles of açaí oil are used to treat cancerous lesions [32]. Proving that applications of biodiversity raw materials tend to be innumerable, especially when combined with modern technological tools and cutting-edge research, a natural plastic was developed from açaí, with polyurethane produced from the seeds [33]. Discarding the abundant açaí berry seeds is a potential environmental problem in the pulp for food production cycle. The development of a plastic from the seeds also shows the possibilities of using by-products of a production chain in other associated chains for an even more efficient bio-economy with minimized externalities.

Other examples of uses of bio-composites are ucuuba (*Virola surinamensis*) from which a patented [34] butter is produced, which is capable of providing a matte effect in the skin. From the leaves and branches of the pau-rosa (*Aniba rosaeodora* Duckei), the linalool compound is extracted [35] which is one of the traditional components of the classic Channel No. 5 perfume. Currently, the following products of the Amazonian biodiversity for diversified products are on the market for cosmetics applications: Babaçu (*Orbignya oleifera*) oil, Buriti (*Mauritia flexuosa*) oil, Brazil nut (*Bertholletia excelsa*) oil, Copaíba (*Copaífera officinalis*) oil, Passionflower (*Passiflora edulis*) oil, Urucum (*Bixa orellana*) oil, Patauá (*Oenocarpus bataua*) oil, Pequi (*Caryocar brasiliense*) oil, Bacuri (*Platonia insignis*) oil, Cupuaçu (*Theobroma grandiflorum*) oil, Murumuru (*Astrocaryum murumuru*) oil and Ucuúba (*Virola surinamensis*) butter.

Research in the medical field confirms the value of many indigenous traditional medicines and goes beyond, with its own and advanced research methods [36]. As an example, we can mention the chichuá (*Maytenus guiane*nsis Klotzsch ex Reissek) that presents anti-leishmaniosis [37] and anti-microbial [38] compounds; guaraná (*Paullinia cupana*) with its properties for the treatment of Alzheimer's disease [39], priprioca (*Cyperus articulatus* L.) with anticonvulsant properties [40], babaçu (*Orbignya phalerata*) with a cicatrizing compound [41], sacaca (*Croton cajucara* Benth.) with hypoglycemic properties [42] and as ulcer healing [43], pracaxi (*Pentaclethra macroloba* Willd.) with anti-hemorrhagic activity [44] and natural larvicide [45], in addition to estoraque (*Ocimum micranthum* Willd.) with its antifungal [46] and antioxidant [47] properties.

Quercetin is a flavonoid that has the ability to suppress free radicals and thereby help preserve the brain and heart, keep the immune system active, protect the body against cancer, and act to prevent diseases, especially neurodegenerative diseases such as Alzheimer's disease [48]. Quercetin, present in many foods but in low concentrations, is obtained from the natural purification process of the fava d'anta (*Dimorphandra mollis* Benth) [49]. And the uncera (cat's claw) (*Uncaria tomentosa* and *Uncaria guianensis*) and is largely used in the pharmaceutical industry [50]. Pilocarpine, an alkaloid with extensive use in ophthalmology [51], is extracted from jaborandi (*Pilocarpus microphyllus* Stapf ex Holm). These are many other examples of species already studied that integrate or can integrate local production chains in the production of drugs and phytotherapeutics.

But the biological assets also have application in industry, with emphasis on endophytic fungi (*Coniochaeta lignaria*, for example) with the capacity to degrade lignin in the cell walls of plant cells, with great potential for the bioenergy industry [52].

Another study with phytosterols isolated from endophytic fungus (*Colletotrichum gloeosporioides*), an Amazon fungus, offers potential sources of novel natural products for exploitation in medicine, agriculture and the pharmaceutical industry [53]. Microorganisms are an attractive source of new therapeutic compounds, they serve the ultimate readily renewable, and inexhaustible source of novel structures bearing pharmaceutical potential [54].

State-of-the-art research can unveil new and surprising uses even for forest assets that have been exploited for a long time. For instance, that is the case for natural rubber (*Hevea brasiliensis*). When combined with nanoclay composites using biomechanical technology, it results in an advanced material to be utilized as artificial skin (Biocure)—a patented active material that induces the formation of new blood vessels (angiogenesis) and new tissues (neoformation) on the surface on which it is applied [55]. Latex and clay compounds have also been developed to manufacture high-tech tire (run cooler, thus increasing tire durability and fuel economy), anti-rust coatings, tennis balls, gloves and masks [55].

4.3. Summary of Amazon value chains

The biodiversity products of the Amazonian flora follow well-defined paths between the origins of the raw material, to its processed form for final consumption or to be reprocessed into components for very high specialty products. The value-added paths of biodiversity products involve multiple steps and social and business actors, varying according to the nature of the raw material, the products to be processed and the location of the harvesting and processing regions. As a general rule, the production of the raw material, which may be fruit, seed, sap, or other part or component of the plants occurs in the rural environment. They may come from primitive areas of natural forest or managed agroforestry systems (SAF), such as natural forests with extensive extractive species and intercropped planted forests.

The rural area is home to communities where the first basic stages of preparation of the material collected or harvested for subsequent supply occur, such as cleaning, threshing, drying and other low-tech processes. Logistic processes such as the transport of the material from the collection and production sites to the pre-processing sites, storage and shipment to the processing centers also occur in the rural domain. In every aspect of this beginning of the value chain, there are opportunities for individual, family, cooperative or business based on local entrepreneurship.

After pre-processing, the materials are taken by boat or truck to companies or cooperative facilities in the Amazon or in another region in Brazil or in other Amazonian countries (e.g., Bolivia) where most or the entire product's actual processing takes place, in facilities with varying degrees of automation. From there it is ready for consumption, locally or in markets elsewhere in Brazil or abroad. Based on a comprehensive study we conducted with value chains of five plant species, we developed a conceptual diagram that represents the main places, environments and activities carried out throughout the whole transformation cycles, from inputs origin to final consumption, as shown in **Figure 6**.

Not all paths shown in **Figure 6** have fair remuneration in the value adding they represent. A 2005 study for cumaru (*Dipteryx odorata*) value chain in the State of Pará, Brazil, illustrates the problem [56]. The markup was 75.0% for the intermediary, 166.7% for wholesale companies in towns nearer production areas, and 233.3% for the wholesale companies from Belém, the State capital. The total markup from the beginning to the end of the market chain was approximately 500%. The price of the nut ranged from R$3.00 per kg for the collectors to R$18.00 per kg for the wholesale companies. It was observed that the exporting companies, which generated unequal gains within the chain, imposed the major additions to the product price. There were approximately 2700 families involved in cumaru nuts collection, exported mainly to Japan, France, Germany and China.

Another evidence of such imbalance in the value sharing was revealed by our study of five value chains. While Brazil nut (*Bertholletia excelsa*) seeds, mostly from manual forest extraction, come from dozens of places along the Amazon basin, the value aggregation of such yields takes place only on just a few locations furnished with processing plants, as shown in **Figure 7**.

Recent corporate social responsibility efforts focused on purchasing biodiversity products from communities or cooperatives have generated more balanced and fair-trade relations, as

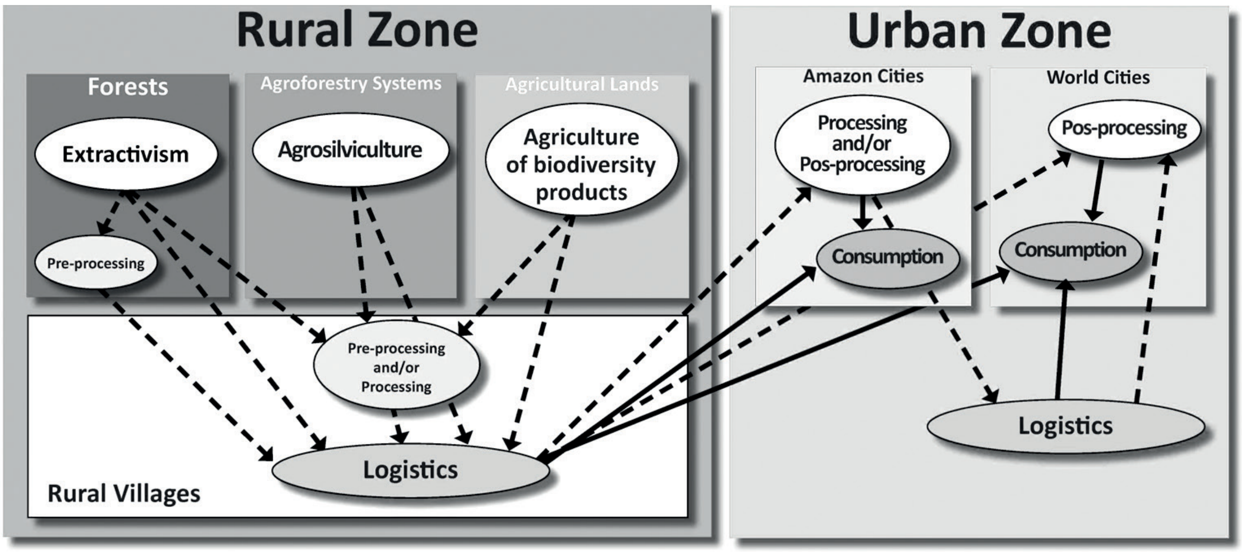

Figure 6. Conceptual diagram of the location of the basic stages of value chains of Amazonian biodiversity products. Solid lines mean the last stage of a product in the value chain [21].

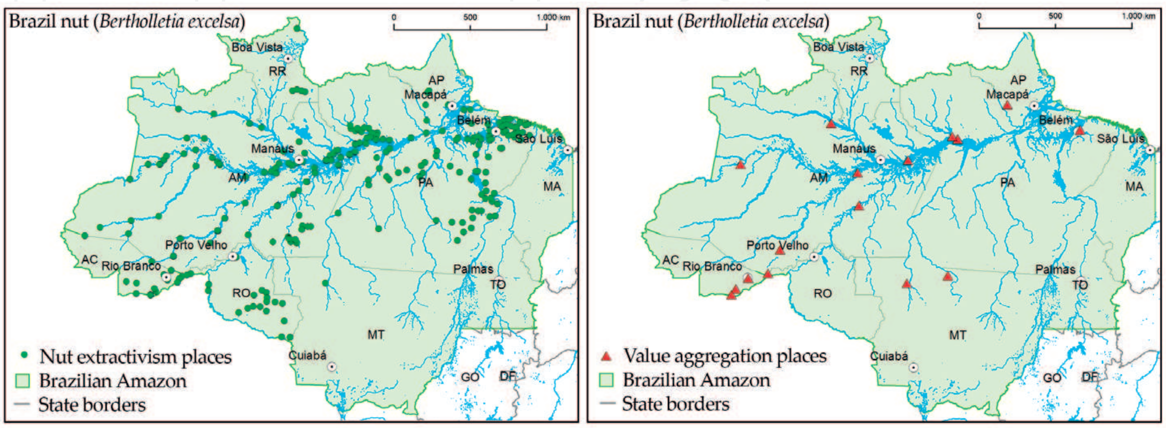

Figure 7. Differences between the many places where Brazil nut (*Bertholletia excelsa*) is collect in the forest (left map) and the few places where there is value aggregation of it (right map), in the Brazilian Amazon, found in a sample survey [21].

with the operations of a range of forest products purchased by the Natura company and açaí purchased by the Sambazon company. However, the typical market distortions in the values paid to the extractivist-producer by intermediaries still has to be resolved.

Agroforestry systems (SAF—Sistema Agroflorestal) are agricultural crops intercropped with tree species, used to restore forests and recover degraded areas. The SAF technology overcomes terrain limitations, minimizes degradation risks inherent in agricultural activity and optimizes the achieved productivity. There is a reduction both in soil fertility losses and pest attacks. The use of trees is fundamental for the recovery of ecological functions, since it allows the reestablishment of much of the relationships between plants and animals. The tree components are inserted as a strategy to combat erosion and the contribution of organic matter, restoring soil fertility. Two successful tropical agroforestry projects illustrative of this system in the Amazon are the CAMTA cooperative [57] in Tomé Açu, in the state of Pará and the RECA cooperative [58] in Abunã, in the state of Rondônia.

4.4. Innovative entrepreneurship leveraging relatively low-end technologies

With the advancement of consumer markets, technologies and business models, new business development opportunities have emerged from the products of Amazon biodiversity. Four examples of this innovative entrepreneurship model were selected to demonstrate the combination of technology and corporate social responsibility for the generation and fair distribution of benefits to all links and actors of value chains. Two of the examples illustrate production companies and the other two examples show companies that developed digital platforms to increase efficiency in transactions and traceability of biodiversity products.

The first example is the Tahuamanu company, a Bolivian producer of Brazil nut products, which illustrates the case of an Amazonian company that innovated by applying relatively low-end technologies, to all links of the Brazil nut productive chain, reflected in tremendous increases in productivity and benefits also to collectors at the base of the value chain. The 2016 severe El Niño-related drought in many parts of the Amazon may have wreaked havoc to the Brazil nut production that supplies the company. It is reported a 70% drop in harvest in 2017, responsible for laying off over 300 employees from his Cobija processing plants [59]. This unprecedented fall in production raise the question of the potential impact of climate change on the new development paradigm for the Amazon.

The second example is the NATURA cosmetics company and its bio-industrial operations. It is probably the most successful case of exploration Amazon biodiversity assets within the most desirable parameters of socio-environmental excellence. Natura has developed a network of suppliers of raw materials from Amazon biodiversity that organizes production of almost 3000 families across the region. It supports training programs and community empowerment toward sustainability. The example of the ucuuba butter shows how the combination of innovative R&D and training communities in sustainable exploitation can deliver good results. Ucuuba trees were used as timber for broom sticks and that was accelerating risks of tree extinction. Butter was developed out of the ucuuba seeds and that new product found its way in cosmetics of high added-value. Floodplain communities of the Marajó Island were trained to collect and pre-process the seeds for sale to Natura and to other companies which also process ucuuba butter. The net profit of those operations for those families is three times larger per year as compared to the only once income for felling the tree. Natura is also promoting the bio-industrialization in the Amazon itself. It opened the Ecopark, an industrial complex in Benevides, near Belém, state of Pará.

The third example is the FLORAUP digital platform that shows how information technology can be used to foster direct connection between local producers, from their remote locations in the forest, with potential buyers of their Amazon biodiversity products. After 1 year on air, the platform has only 57 registries, perhaps due to the relatively low digital connectivity of remote communities across the Amazon.

Finally, the fourth example is ORIGENS BRASIL, a production chain tracking digital platform. The platform allows anybody to know instantly the origin of the product that contains assets of Amazonian biodiversity since its raw material harvesting, its history and actors involved in the production. This is done simply by pointing a smartphone to the product packaging, which is equipped with a QR Code that accesses a remote live database. If one assumes that responsible consumers are an accelerating trend, such traceability platforms are in dire need for the Amazon.

4.5. Traditional bio-industries

Natural products developed on a sustainable basis have a long history in the Amazon since the rubber boom years. An increasing demand for these products for traditional and innovative uses in the food, cosmetics, perfumery and pharmaceutical industries has promoted new business opportunities in the Brazilian Amazon. As part of this trend, advances in biotechnology research have demonstrated a key role in expanding this potential, thus boosting the value chains that have as one of the main attributes the bio-industries focused on the processing of forest raw materials into biodiversity products.

This research evaluated 25 enterprises that markets non-timber products of Amazonian biodiversity. The sample encompasses a range of segments, types, sizes and bio-assets processed. From international corporations with more than 100 years in the market of extracting the finest Amazonian essences, to innovative indigenous entrepreneurship of collecting and selling forest's native species seeds in large amounts to support much needed reforestation efforts elsewhere.

These industries deliver a vast array of products: It ranges from an exfoliating agent of açaí seed (Beraca company) to a powder form of the same fruit for energy drinks (Yerbalatina Phytoactives and 100% Amazônia companies). The Amazon-based bio-industry is also well-defined and consolidated in the supplying chains of oils and essences. As early as 1921, the essential oil extracted from the pau-rosa (*Aniba rosaeodora*) wood, a native tree from the Amazon, which is rich in the aromatic compound linalool, was the main ingredient of the famous French perfume Chanel n° 5 [35]. From them on, the supplying of the finest and unique ingredients from the Amazon biodiversity thrived, adopting, mostly, adequate standards for social and environmental sustainability, which was not always the case with Pau-Rosa. Today, extracts of cumaru are present in the most famous and popular fragrances (Givaudan company) and the ingredients market for the cosmetics industry is supplied with essential oils of priprioca (Laszlo Aromaterapia & Aromatologia companies), pracaxi (Amazon Forest Trading company); copaiba (IFF—International Flavors & Fragrances company) and andiroba (Amazonoil company), among many other.

Another sector that has shown significant growth is the food, functional food and nutraceutical industries (e.g., Sambazon, Tahuamanu companies). Companies in this sector tap in the healthy food market and, by applying relatively low-end technologies, have put Amazon bioactives available worldwide at anyone's table. As a rule of thumb, most sectors have benefited from the adoption of newer and accessible technologies in their processing facilities. From Brazil nuts micro-factories for peeling seeds (COOPERACRE cooperative) to agrosilviculture producer's cooperatives focused on traditional bio-industries (CAMTA, RECA cooperatives).

In our study, we analyzed many products offered by the Amazon traditional bio-industries based on two defining axis: the amount of technology involved in the making of their products and the degree to which they are closer or further to their original state as furnished by Nature. It was a qualitative analysis and it shows status classes for these products. The diagram in **Figure 8** shows the result of this qualitative analysis.

As it might be expected, values such as environmental sustainability, social development and fair-trade are a matter of concern for virtually all operations, to a greater or lesser extent, from small chestnut cooperatives to the giants of the essences and cosmetics sector. Nevertheless, there are reports of large traditional bio-industry operations that required botanical resources at large scales that have driven transformation in the supplying of natural asset, once coming from extractivism or agroforestry systems, into an asset generated from monocultures in the agroindustry's usual patterns. It also disrupted traditional handmade extractive processes [60]. Accommodating increasing demands for bio-products with limitations inherent to Nature's carrying capacity and traditional and local people culture, needs and potentials

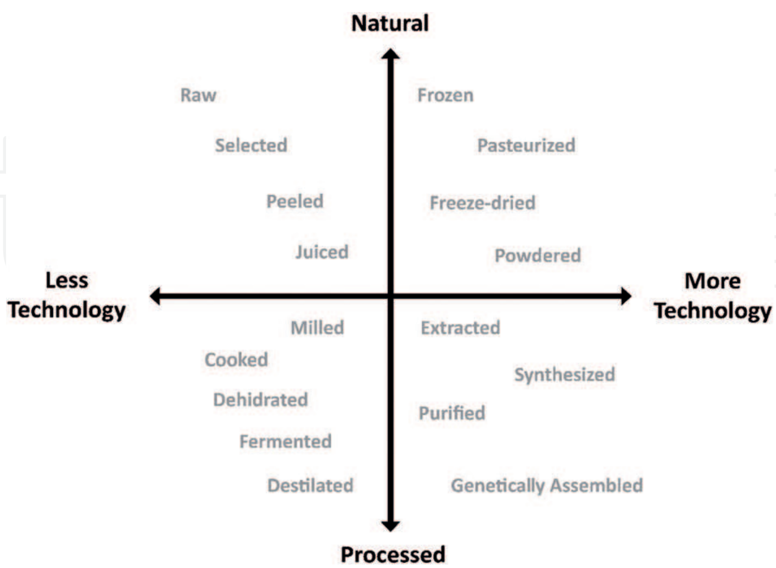

Figure 8. Diagram depicting status classes for Amazon bio-industry products based on the amount of technology involved in their making and the degree to which they are closer or further to their original raw material state as furnished by nature [21].

http://dx.doi.org/10.5772/intechopen.80413

for insertion into new economic development paradigm is an imperative challenge for a real sustainable Amazon development strategy.

The industrial sector transforming biodiversity assets into available consumables act in the interface between biodiversity, biotechnology and bio-industry, which involves a complex system of partnerships between companies, universities, research institutes, official financial agencies, organized communities and cooperatives inside and outside the Amazon region.

5. Amazonia Third Way as a disruptive alternative

The *Amazonia Third Way* initiative is conceived as a disruptive social and technological transformation toward a sustainable Amazonian development path. It calls for '*an Amazon-specific Fourth Industrial Revolution innovation (4IR) "ecosystem". This system must be able to rapidly prototype and scale innovations that apply a combination of advanced digital, biological, and material technologies to the Amazon's renewable natural resources, biomimetic assets, environmental services, and biodiverse molecules and materials*' [2].

In support of socioeconomic development, systemic innovations will also apply to enhancing biodiversity-based value chains. Ideally, these would shape a unique 'Amazon-brand' able to conquer global markets [61–63].

The Amazonia Third Way Initiative promotes in-depth research on alternative pathways for sustainably developing the Amazon territory, in harmony with the twenty-first century's Zeitgeist. Forests in the Amazon are the result of evolution over millions of years. Nature has developed a wide variety of biological assets, which include metabolic pathways, and genes of life on land, in aquatic ecosystems, and in their natural products—both, chemical and material—in conjunction with biomimetic assets, that is, the functions and processes used by nature.

4IR technologies increasingly harness these assets across many industries from pharmaceutics to energy, food, cosmetics, materials and mobility. Indeed, they are making profits, but to date these profits have not been channeled back to conserve the Amazon and to support the custodians of nature—indigenous and traditional communities—and also urban population in the region.

Within a proper legal and ethical framework, the Amazonia Third Way Initiative offers unprecedented opportunities to local populations to develop a vibrant, socially inclusive 'standing-forest, flowing-river' green economy. By harnessing nature's value through physical, digital and biological technologies of the 4th Industrial Revolution, we can simultaneously protect the Amazon ecosystems and their traditional custodians.

The region is still largely disconnected from the main centers of technological innovation dealing with 4IR technologies and the advanced bio-economy. The Amazonia Third Way Initiative is conceived as a multi-level path toward a new inclusive bio-economy, combining a highly innovative, entrepreneurial and technological economy with the re-valuation of non-timber forest products and industries with low-end technologies.

5.1. Determinants of sustainable development pathways for the Amazon

The conceptual framework for the *Third Way* follows the overall structure of **Figure 9** for the determinants of sustainable pathways for the Amazon.

At the broader level, **first** we need to understand the nature of the socioeconomic and political drivers accounting for the rapid transformation of the Amazon in the last 50 years and the consequences of the resource-intensive development policies in action in contrast with the view of forest preservation and setting aside large tracts for conservation.

As mentioned before, the Third Way Initiative is not one more attempt to reconcile resource-intensive development with conservation. Instead, it will seek to implement the twenty-first century paradigm of knowledge societies to Amazon realities through research and development, entrepreneurship, twenty-first century skills and education, and fit for purpose sustainable development policies toward a standing forests-flowing rivers inclusive bio-economy.

Second, we deal with solution spaces, recognizing that an important effort has been done to identify and diagnose the risks to the Amazon of the current development actions and policies, including their fragilities. We are in urgent need to find feasible solutions of a different nature: driven by communities and by an entrepreneurial revolution powered by the Fourth Industrial Revolution and not only by powerful legacies, assisted by altogether more sustainable policies based on knowledge, be it scientific/technological or traditional.

Third, we discuss in more detail the role of some key enablers and catalysts to jumpstart sustainable pathways for the Amazon in two categories, those to enable a biodiversity-based

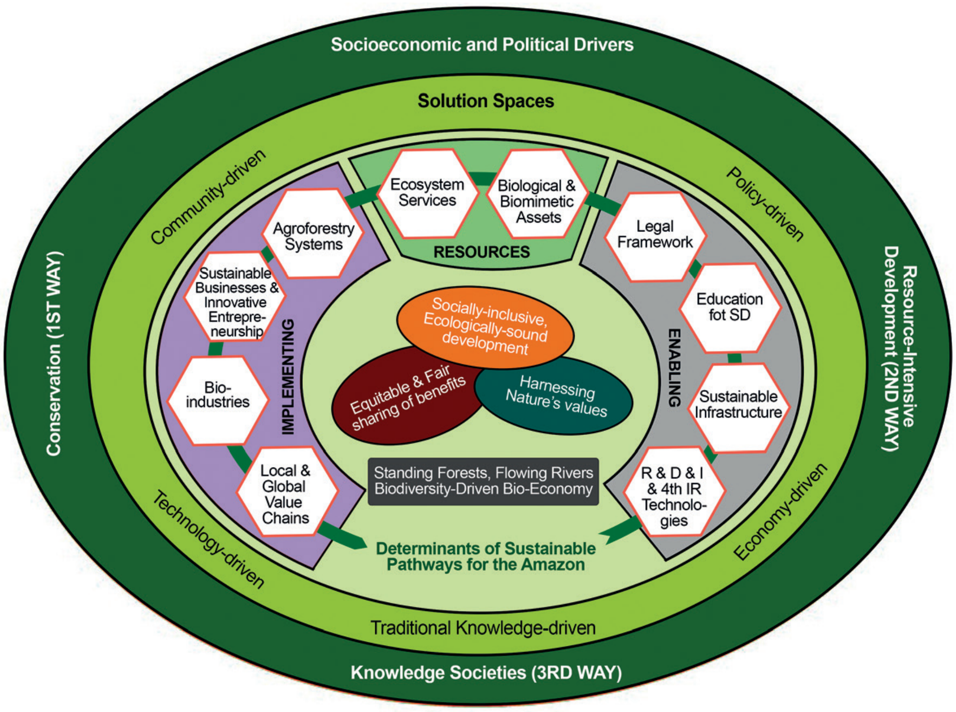

Figure 9. Determinants of sustainable pathways for the Amazon. The Amazonia third way initiative seeks '*to add value to the heart of the forest' by promoting a* novel sustainable development paradigm based upon harnessing biological and biomimetic assets of Amazon biodiversity.

http://dx.doi.org/10.5772/intechopen.80413

development, namely research, development and innovation; harnessing the Fourth Industrial Revolution technologies to unlock the economic value of nature; and conducive regulatory framework; and those necessary to implement such novel paradigm, agroforestry systems; innovative entrepreneurship; bio-industries; product-based and knowledge-based value chains.

5.2. Fourth Industrial Revolution and innovation ecosystems in the Amazon

Within the Amazonia Third Way initiative, an approach has been developed to operationalize the principles and practices that will allow a proposed paradigm shift for Amazon sustainable development. It defines seven interconnected realms: (1) the existing natural knowledge; (2) the ability for learning from nature; (3) the capacity to applying biodiversity-based knowledge to human needs; (4) the capacity to producing biodiversity-based goods and solutions; (5) the insertion of biodiversity-originated products on a local-to-global bio-economy; (6) the fair sharing of socioeconomic benefits and life quality improvement for all; and (7) the rising of an Amazon Biome intrinsic valuing. With the advancements of 4th Industrial Revolution (4IR) technologies and its wide accessibility, we identified ways it can interact and make feasible a game-changing realization of such realms. We call '**Amazonia 4.0**' the prospects of realization of these seven elements by means of technological accessibility and resources, and market transformation made available by the 4IR.

The existing Natural knowledge is an initial condition of the system; it does not depend on any human technology. It is a source of information we inherited from evolutionary processes, occurring associated with 3.7 billion years old life on Earth. The A3W initiative targets to keep it going its course, valorizing it in many ways.

Learning from Nature is inherent to humans ever since we became a species (*Homo sapiens*) as a part of the Natural system. Ancient and traditional knowledge come greatly from observing and interacting with the natural elements. As we evolve, we became more apt to understand Nature's intrinsic knowledge with the building of science and its instruments. With 4IR technologies, which include biotechnology, advanced computing, genomics, nanosciences, materials science and advanced sensor platforms, we can learn from Nature in a depth and such fast pace never imagined before.

Applying knowledge from Nature to human needs is the next natural consequence. This is the realm of invention and innovation. 4IR technologies can boost invention and prototyping of new products and solutions. More than just facilitating invention, it creates demand for new solutions, advanced materials and innovative products.

Once a new biodiversity-based product or solution is developed, producing it in varying scales is the next outcome. It may utilize biodiversity inputs directly on its making or can only be sourced from biodiversity knowledge. To carryout industrial operation in the Amazon has been always a challenging, if not impossible, operation. With the changes brought by 4IR technologies and market demands, industrial equipment became smarter, lighter and customizable. It became possible to have plenty of electrical solar-powered energy in the forest, with equipment connected with satellite internet and local crews trained with virtual and augmented reality, for example. With 4IR technologies, including advanced sensors and AI, it is possible to control more precisely the use of natural resources to prevent possible negative impacts.

Insertion of biodiversity-originated products on a local-to-global bio-economy is a key for driving wide interest in conserving the bio-assets. Different than the traditional model of supplying commodities for further processing and generating value away from its origins, 4IR technologies and new manufacturing paradigm eases and redefines the possibilities to produce in close association with the local people on local environments, yet reaching global markets. Complicated logistic typical of a vast forest territory can be easily offset using self-flying cargo drones, for example.

Fair sharing of socioeconomic benefits and life quality improvement for all involved, including forest stakeholders and final consumers can be levered by 4IR technologies and social changes brought by the technological revolution. With distributed ledger technologies like blockchain and holochain, we propose the creation of the Amazon BioBank. It is a framework for attributing value to many instances of Amazon socio-biodiversity. Biological assets, biomimetic insights and discoveries, traditional knowledge, local people forest skills and other sources of resources will be registered in the Amazon BioBank digital platform through holochain distributed ledger technology [64]. The Amazon BioBank share common principles with the Earth Bank of Codes [65].

Aside from any specific technology, the ultimate, long-term result of these chain of events and realizations would be the rising of a socially shared Amazon Biome intrinsic value. The social valuing of Nature and its knowledge as an end in itself is an ideal state of relationship between humans and other elements of the natural system. By becoming acquainted and perceiving many times actual benefit from products and solution based on the Amazon biodiversity, made available by the chain of events depicted above, one can realize the value of the tropical forest. As a utilitarian value first, that over time may crystalize as core life, intrinsic value, forming the personal and social foundations to hold attitudes and behaviors that imply, support and demand conserving the Amazon Biome.

The 'innovation ecosystems' proposed in the Amazonia Third Way initiative are creative-productive arrangements based on the Amazon 4.0 principles that synergistically align several '*ignition powers*' for a novel Amazon bio-economy. Major research laboratories and universities are knowledge centers on biodiversity. Processes, molecules and genetic information with potential for diverse uses are discovered on daily basis. Start-ups are companies that specialize in rapidly transforming knowledge into business that tends to transform traditional consumer and service markets. Prospects for the industries with Internet of Things, or 4.0, announce new products to be created with computational tools, to be 'uploaded' and produced at any scale. Inventors and new businesses can idealize customized or niche-specific products, which are done automatically, even overnight. A dynamically well-developed and structured environment for locally rooted associations of (1) knowledge, (2) business and (3) production form the 'innovation ecosystems'. They are a way for transforming the biological wealth of the Amazon into economic wealth, locally anchored, with social benefits for communities and sustainable mechanisms for conservation of the forest.

5.3. Capacity development as a necessary condition for the Amazonia Third Way initiative

To begin to walk down the *Third Way* we need, above all, capacity development.

http://dx.doi.org/10.5772/intechopen.80413

As results of the long-standing Program to Protect the Rainforests of Brazil (PPG-7) show, the lack of entrepreneurial skills has stood in the way of developing a non-timber bio-economy in the Amazon. Only with field-based knowledge and supporting academic curricula can tap into the Amazon's biological and biomimetic assets, and the mainstreaming of a standing forest-flowing river, biodiversity-based bio-economy be achieved. To do that, we propose the development of a capacity program 'Amazon Creative Labs' (ACL). The program is designed to promote technical, technological and entrepreneurial capacity development focused on non-timber products of the Amazon biodiversity, with training events carried out directly at local communities and towns throughout Amazon region.

We propose the launching of Amazon Creative Labs (ACLs)—laboratories for innovative experimentation set up throughout Amazonia. They will provide intensive training linked to local potentials to generate a virtuous insertion on bio-economy-related new opportunities. Typically, Creative Labs will be located in smaller communities, villages and towns, assembled on tents or on floating platforms packed with state-of-the-art equipment and technology for both, wide audience learning processes and core value chain local development.

Amazon Creative Labs will enable development of small-scale innovation ecosystems for co-design, co-development and co-creation of solutions and applications, serving as an effective interface with the knowledge and practices of the Amazon people.

The Amazon Creative Labs will operationalize sustainable 'Solution Spaces' (see **Figure 1**). It is of critical importance that the Labs be community oriented, joining technology and traditional knowledge, and designed to contribute toward a strong local and regional economy.

The Labs will promote capacity development activities focused on a number of products of Amazon biodiversity illustrative of an array of bio-economic and even bio-artistic applications, such as food, nutraceuticals, cosmetics, fragrances, pharmaceuticals, industrial oils, art crafts, bio-art, biomimicry, etc. Training activities can enable local communities to gather more information on the natural resources available to them, including the use of high-end technologies such as, genome sequencing.

The exposure to 4IR technologies will allow innovative concepts to emerge. With the assistance of technology experts on the one hand, and entrepreneurship specialists on the other, groups of participants from Amazonian communities, villages and towns will be invited to develop new applications and to prototype (at least digitally) such innovations. The Labs' creative environment will bring 4IR concepts like mass customization, democratized invention and smart & autonomous factories, powered by Industrial IoT, to a meaningful level with practical outcomes accessible at planned local and regional clusters of custom-sized processing and manufacturing plants.

Alongside communities—forest people, riverine communities and agroforestry farmers—young undergraduate or just graduated students interested in creating sustainable biodiversity-based businesses in the Amazon will be engaged. The expectation is that such 'on the ground' collaboration will give rise to new partnerships.

The Amazon Creative Labs design includes solar photovoltaic panels, convertors and batteries, for steady power supplying, and connection to broadband satellite internet. These features will allow digital, internet-connected equipment to work for prototyping potential applications of new products and processes. These infrastructures, operating in remote regions of the Amazon, are also proof of concept of how the newest available and accessible technologies can reach and benefit the whole spectrum of the social pyramid, from their everyday life to new work opportunities.

ACLs also include a focus on the realm of biomimetic, that is, the functions, processes and mechanisms of living organisms that, once learned, can provide insights and solutions for engineering new technologies and innovative products. They also leverage applications, including the high-end of genetic resources and genomics; prototype innovative processing of materials through the diverse links of value chains—raw materials, intermediate products, all the way to finished products.

To illustrate the potential of ACLs, we designed the three following conceptual examples of applications, based on currently available technologies and equipment. A final design should incorporate new technological solutions specifically tailored for solving implementation and scaling challenges and include consultation with local communities for accessing their specific needs, priorities and potentials.

A line of Amazon Creative Labs will deal with value chains feed by inputs from local biodiversity and an example of that is themed after nutraceutical Cupulate, a chocolate made from the seeds of Amazon fruit Cupuaçu, instead of cacao. From forest picking to creating a final product that combines basic Cupulate with other products of very high nutritional value, the lab also includes utilizing a 3D food printer for unique chocolate designs and precise dosage of the added natural micronutrients. A by-product of Cupulate-making is cupuaçu pulp, which is then freeze-dried in a value chain of its own. Heavy-lift electric-powered drones can help overcome logistics challenges the region poses, by easily and quickly taking loads of nutraceutical cupulate sculptures and bars to a nearby gateway.

Another example of ACLs focus is the Brazil Nuts value chain, known for the discrepancies between its higher cost for consumers and the low remuneration local people who harvest it from the forest receive. To change this, in one end, the ACLs will target extractivism issues, like processes precariousness that halts productivity and seeds' price, with accessible technological resources including GIS mapping, micro-controlled sensors arrays (for health safety on seed's harvesting and storing) and comprehensive traceability systems (origin and processes). At the same time, ACLs will carry out further locally based nut processing, using equipment that extracts oil and flour, by-products with greater trading value. With top technical education and processes precisely controlled with the aid of computers, sensors and biotechnological checks for sanitary standards, it becomes possible to output export-grade quality products strait from the forest vicinities. Those inputs also allow bringing to small villages the manufacture of even more processed products targeted to the natural cosmetics and nutraceuticals markets.

Another line of ACLs will tackle the potential of making Amazon local inhabitants aware of the genetic value of biodiversity and to take part in genome sequencing projects. The lab will take participants into a knowledge journey departing from the biodiversity that can be seen all the way to the microscopic and nanoscopic structures of it, and to the grasping of the

http://dx.doi.org/10.5772/intechopen.80413

molecular coding of life. To achieve this, the Lab will make use of optical and portable electron scanning microscopes and virtual and augmented reality gear, furnished with contents to experience and understand organic chemistry complex structures. At the end, participants will carry out actual DNA sequencing through ultra-portable genome sequencers, allowing for registering genomes of species and benefiting from the provisions of benefit sharing of the Nagoya Protocol of Access and Benefit Sharing (ABS).

6. Discussion and conclusions: envisioning the future for the Amazon

Systemic risks to the maintenance of the Amazon forest due to the synergistic combination of the main human drivers of change—namely regional climate change due to both deforestation and global warming, and augmented forest vulnerability due to fires—poses an urgent challenge to avoid an irreversible threshold being transgressed that would threaten to turn over 50% of the forest in degraded savannas in the second half of this century [2].

The natural resource-intensive mode of development (the Second Way) is the dominant mode of development and receives generous government subsidies for its continued advancement. Investments in conservation, forest restoration and a sustainable economy in the global tropics of about $20 billion annually receive less than 3% of total investments. The bulk of investments (around $770 billion annually) goes to the expansion of commodities frontier of cattle, grains, oil palm [66] and also to road, energy and mining infrastructure, which are also key drivers of deforestation [67]. One more detrimental effect of such path is the increasing rural violence in the Amazon. Brazil has the highest number of assassinated rural and environmental leaders since 2015, with more than 140 killings, mostly in the Amazon [68].

It is becoming crystal clear that trying to reconcile resource-intensive development with conservation is not leading to lasting and permanent solutions. Deforestation rates are still very high and do not show a tendency to go down near zero and rural violence is on the rise. Social inequalities in the Amazon remain high and are not improving at a fast pace at least to bring social indicators to the national averages of the Amazonian countries. Imposing strict conservation to protect large swathes of the forest has had clear successes over the last decades in the Amazon—about 50% of the Amazon forest is under some kind of protection. However, that in itself does not guarantee protection forever for tropical forests and eventually may affect the livelihoods of local population as is the case documented for Madagascar [69] who may bear a high cost for forest conservation.

The Amazon Third Way Initiative seeks to demonstrate the urgent need for a conceptual, educational and entrepreneurial revolution—a revolution based on knowledge, traditional and scientific. The current economy of meat, grain and timber in the Brazilian Amazon is less than $10 billion a year. The economy associated to biological assets of Amazon biodiversity in a few industries (food, cosmetics, oils, etc.) is already worth 30% of that and distributes income in fairer ways and benefits more of the local population. However, that is a tiny portion of the potential of a sustainable economy hidden in the biological and biomimetic assets of Amazon biodiversity that the Amazon Third Way initiative attempts to address and give visibility to. We will be estimating the real hidden economic value of these assets in a next phase of the initiative.

The Amazon forest is not a void of human presence. Diverse communities live all over the region. Even some communities of new settlers of the 1970s and 1980s have looked to find ways of generating income in agroforestry systems. There is rich traditional knowledge in many of indigenous and caboclo communities. Supporting the diversity of communities and economic pathways for a standing forest-flowing rivers economy is mandatory.

From a more general standpoint, sustainable development pathways based on natural resources exploitation should in principle put the local populations as priority. That is not the case for the Amazon currently (low HDI and other social indicators). Therefore, the Third Way Initiative also proposes that new sustainable paradigms have the development policy as a central tenet. The sustainable economy should first and utmost be means of wellbeing to the Amazonian people. That is not the case of the Second Way, where the Amazon is seen important for intensive resource exploitation for the Amazonian countries as a whole and taxation of the resource wealth should redistribute benefits as public services for all in the Amazon. However, a regressing taxation system does not realize that.

The Amazon has a number of good examples of biology laboratories and a number of entrepreneurship initiatives that beyond economic development target social responsibility and deployment of sustainable biodiversity value chains. They are true pioneers into the new era of sustainability. However, they are as yet a small minority. They may even accrue national and international visibility and are role models, but in critically insufficient numbers to create momentum economically and socially to give clout to the rupture needed to put Amazon on a different track.

The new model must rely on these existing good examples, on the diversities of forest communities across the Amazon, on state-of-the art knowledge generations laboratories and innovative entrepreneurship and build up from there.

In due course, one has to build up momentum for enhancing the policies that are necessary to uplift the Third Way; investment in zero-deforestation value chains; reducing the enormous subsidies for commodities that drive deforestation; but as importantly invest in knowledge generation through a network of advanced biology laboratories in the Amazon, in Amazonian Countries and internationally in association with private R&D labs and science-based start-ups and creation of innovation ecosystems throughout the regions. That is a pre-requisite to the development of local next generation bio-industries in towns and cities of the future.

By attracting venture capital and productive investments both for R&D and for industries, the political interest in the Third Way will rise in the eyes of governments to a tipping point in which government investments and subsidies will start to flow to this other type of economy, even on the absence of visionary governments that would see the potential of a new Amazon bio-economy and would design the pathways to reach it.

The implications of harnessing the Fourth Industrial Revolution to unlock the economic value of the Amazon's biological and biomimetic assets for governments, start-ups, corporations and R&D centers are profound. Partnerships among public and private R&D innovation labs to create a number of hubs of innovation throughout the region is necessary. This would accelerate new research and development leading to new products and innovations relevant for many industries locally and worldwide. Amazonian countries with immensely valuable natural assets would have an additional source of income to help protect these resources and support indigenous and traditional communities. These funds would create a new incentive on the part of communities and governments to protect rather than destroy natural habitats. The interest in understanding and sustainably using our biological and biomimetic assets could propel a new era of scientific exploration of life on the planet. Large new markets for sustainably sourced innovation could be created. Technology companies and start-ups seeking to demonstrate compliance with the Nagoya Protocol could be certified, through the transparency that distributed ledger technology offers.

In sum, development policy in the Amazon has historically taken two pathways. The first embraces nature conservation and protects large swathes of territory from any human activity. The second approach has focused on conversion or degradation of forests for the production of agricultural commodities like meat and soya or tropical timber at the forest frontier, and also mineral commodities and the build-out of massive hydropower generation capacity. These uses together have been historically responsible for the massive deforestation of the Amazon.

There is, however, a Third Way within reach in which we aggressively embrace high-tech innovation and look at the Amazon as a tremendous source of biological and biomimetic assets that can provide new, innovative products and services for current and new markets. System-level change in the Amazon as proposed cannot be executed single-handedly. On the contrary, we are proposing collaboration with leading public, private, academic and philanthropic actors for the journey ahead, engaging Indigenous and traditional communities across Amazonian countries, uniting the best capabilities of regulators, R&D centers, universities, technology start-ups and visionary companies all over the world.

The Amazonia Third Way can be the most effective Land Use Change Planning policy for the Amazon because it is fully based on a standing forest-flowing river bio-economy. If successful, this new development model can be applied to all tropical regions helping to preserve the Earth's great biological diversity. We have an important choice to make. The future of the Amazon and its impact on the planet lie so clearly in the balance. Time is not on our side, but we can still choose the Third Way.

Acknowledgements

This work has been supported by the National Institute of Science and Technology for Climate Change via CNPq Grant Number 573797/2008-0 and FAPESP Grant Number 2008/57719-9 and additional financial support by the Climate and Land Use Alliance (CLUA) and Moore Foundation. We express our thanks to Juan Carlos Castilla-Rubio and Luciana Castilla for their contributions to the development of the Amazon Third Way Initiative.

Author details

Ismael Nobre[1]* and Carlos A. Nobre[2,3]

*Address all correspondence to: nobreismael@gmail.com

1 Independent Consultant, São Paulo, Brazil

2 Institute of Advanced Studies/University of São Paulo, São Paulo, Brazil

3 WRI Brazil, São Paulo, Brazil

References

[1] Lovejoy TE, Nobre CA. Amazon tipping point (Editorial). Science Advances. 2018;**4**. http://advances.sciencemag.org/content/4/2/eaat2340/tab-pdf

[2] Nobre CA, Sampaio G, Borma L, Castilla-Rubio JC, Silva JS, Cardoso M. Fate of the Amazon forests and the Third Way. In: Proceedings of the National Academy of Sciences. Sep 2016;**113**(39):10759-10768. DOI: 10.1073/pnas.1605516113

[3] RAISG. Amazônia 2017—Áreas protegidas e territórios indígenas. Available from: www.raisg.socioambiental.org

[4] Adeney JM, Christensen NL, Pimm SL. Reserves protect against deforestation fires in the Amazon. PLoS One. 2009;**4**(4):e5014

[5] Crisostomo AC et al. Terras Indígenas na Amazônia Brasileira: Reservas de Carbono e Barreiras ao Desmatamento. Brasilia, Brazil: Inst Pesquisa Ambiental Amazônia; 2015

[6] ISA—Instituto Socioambiental. Terras Indígenas no Brasil. 2015. Available from: https://pib.socioambiental.org/pt/c/terras-indigenas/demarcacoes/localizacao-e-extensao-das-tis

[7] ISA—Instituto Socioambiental. Desmatamento cresce 32% nas Terras Indígenas da Amazônia brasileira, aponta ISA. 2017. Available from: https://www.socioambiental.org/pt-br/noticias-socioambientais/desmatamento-cresce-32-nas-terras-indigenas-da-amazonia-brasileira-aponta-isa

[8] Conservation International. Indigenous Land Protected Area. 2013. Peru. Available from: http://www.conservation.org/publications/Documents/CI_WCC2016_Amazonia-Mapping-Natural-Capital.pdf

[9] RAISG. Deforestación en la Amazonía (1970-2013). 2015. 48 p. Available from: www.raisg.socioambiental.org

[10] Fonseca A, Salomão R, Ribeiro J, Souza Jr C. Ameaça e pressão de desmatamento em Áreas Protegidas: SAD de agosto a outubro de 2017. p. 1. Imazon. Belém. 2017

[11] IIRSA. Informe de la Cartera de Proyectos del COSIPLAN 2017. Available from: http://www.iirsa.org/admin_iirsa_web/Uploads/Documents/CARTERA_DIGITAL_INGLES.pdf

[12] Aguiar APD, Vieira ICG, Assis TO, Dalla-Nora EL, Toledo PM, Santos-Junior RAO, et al. Land use change emission scenarios: Anticipating a forest transition process in the Brazilian Amazon. Global Change Biology. 2016;**22**:1821-1840. DOI: 10.1111/gcb.13134

[13] Aguiar APD, Ometto JP, Nobre CA, Lapola DM, Almeida C, Vieira IC, et al. Modeling the spatial and temporal heterogeneity of deforestation-driven carbon emissions: The INPE-EM framework applied to the Brazilian Amazon. Global Change Biology. 2012;**18**:3346-3366

[14] PRODES. Taxas anuais de desmatamento na Amazônia Legal Brasileira. 2017. Available from: http://www.obt.inpe.br/prodes/dashboard/prodes-rates.html

[15] Rochedo PRR. The threat of political bargaining to climate mitigation in Brazil. Nature Climate Change. 2018;**8**:695-698. Available from: https://www.nature.com/articles/s41558-018-0213-y

[16] Whitmere S et al. Safeguarding human health in the Anthropocene epoch: Report of the Rockefeller Foundation-Lancet Commission on planetary health. Lancet. 2015;**386**:1975-2018. DOI: 10.1016/S0140-6736(15)60901-1

[17] Soares-Filho BS et al. Economic Valuation of Changes in the Amazon Forest Area: Value Maps for Non-timber Forest Products (NTFPs). 1st ed. Belo Horizonte: Ed. IGC/UFMG; 2017. 82 p

[18] Brodizio EW. The Amazonian Caboclo and the Açaí Palm. Forest Farmers in the Global Market. Vol. 16. Advances in Economic Botany. New York, NY: The New York Botanical Garden Press; 2008. 403 p

[19] Costa FA. O açaí do Grão-Pará: arranjos produtivos e economia local, constituição e dinâmica (1995-2011). Núcleo de Altos Estudos Amazônicos. Originally presented as thesis requirement for promotion to titular professor, Universidade Federal do Pará. Belém, PA, Brazil. 2016

[20] Valsecchi J, Marmontel M, Franco CLB, Cavalcante DP, Cobra IVD, Lima IJ, et al. Atualização e composição da lista—Novas Espécies de Vertebrados e Plantas na Amazônia 2014-2015. Edição: Iniciativa Amazônia Viva da Rede WWF (Denise Oliveira e Sandra Charity), WWF-Brasil (Jorge Eduardo Dantas e Mariana Gutiérrez). Brasília, DF e Tefé. AM: WWF e Instituto de Desenvolvimento Sustentável Mamirauá. 2017

[21] Homma AKO. Extrativismo vegetal na Amazônia: História, ecologia, economia e domesticação. Embrapa. Brasília, DF. 2014. 468 p. Avalilable from: http://www.alice.cnptia.embrapa.br/alice/bitstream/doc/1016352/1/LivroExtrativismoHOMMAONLINE.pdf

[22] Yuyama K et al. Camu-camu: um fruto fantástico como fonte de vitamina C. Acta Amazonica. 2002;**32**(1):169-174

[23] Sousa MSB. Mecanismos de ação antioxidante de extratos de murici (*Byrsonima crassifolia* (L.) Kunth). Dissertação de Mestrado, Faculdade de Saúde Pública, Universidade de São Paulo, São Paulo. 2013. DOI: 10.11606/D.6.2013.tde-24052013-153230. Recuperado em 2017-06-16, de www.teses.usp.br

[24] Tiburski JH et al. Nutritional properties of yellow mombin (*Spondias mombin* L.) pulp. Food Research International. 2011;**44**(7):2326-2331

[25] Carvalho PER. Cumaru-Ferro. Comunicado Técnico 225. EMBRAPA. 2009. ISSN: 1517-5030

[26] Funasaki M et al. Amazon rainforest cosmetics: Chemical approach for quality control. Química Nova (São Paulo). 2016;**39**(2):194-209. DOI: 10.5935/0100-4042.20160008. Available from: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0100-40422016000200194&lng=en&nrm=iso> [Accessed: Oct 29, 2017]

[27] Kimura VT et al. The effect of andiroba oil and chitosan concentration on the physical properties of chitosan emulsion film. Polímeros, São Carlos. 2016;**26**(2):168-175. DOI: 10.1590/0104-1428.2013. Available from: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0104-14282016000200168&lng=en&nrm=iso> [Accessed: Oct 29, 2017, Epub June 14, 2016]

[28] Beraca. Product Catalogue [Website]. 2017. Available from: http://beraca.com/rainforest-oleo-de-andiroba.php

[29] Portinho JA, Zimmermann LM. Beneficial effects of açaí. International Journal of Nutrology. 2012;**5**(1):15-20

[30] Pérez V, Bokov A, Van Remmen H, Mele J, Ran Q, Ikeno Y, et al. Is the oxidative stress theory of aging dead? Biochimica et Biophysica Acta. 2009;**1790**(10):1005-1014

[31] Domingues AFN et al. Pigmentos antociânicos do açaí (Euterpe oleracea Mart.) como evidenciadores de biofilme dental. In: Pessoa JDC, Teixeira GH de A, editors. Tecnologias para inovação nas cadeias euterpe. Brasília: Embrapa; 2012

[32] Montes-Fuentes V. Terapia fotodinâmica mediada por nanoemulsão à base de óleo de açaí (*Euterpe oleracea* martius) para o tratamento de melanoma in vitro e in vivo. 2014;**xvii**:163 f. il. Tese (Doutorado em Biologia Animal)—Universidade de Brasília, Brasília, 2014

[33] Biofabris—Instituto de Biofabricação—Proj. no 2008/57860-3. Plástico de açaí. Revista Pesquisa FAPESP Edição n. 260. Outubro 2017

[34] Oliveira Dias AF et al. Cosmetic Composition Providing a Matte Effect, Process for Preparing Ucuhuba Butter and Use Thereof (US 20110256075 A1). 2011

[35] May PH, Barata LES. Rosewood exploitation in the Brazilian Amazon: Options for sustainable production. Economic Botany. 2004;**58**(2):257-265

[36] Viegas C Jr, Bolzani V da S, Barreiro EJ. Os Produtos Naturais e a Química Medicinal Moderna. Quimica Nova. 2006;**29**(2):326-337

[37] Meneguetti DU de O et al. Screening of the in vitro antileishmanial activities of compounds and secondary metabolites isolated from Maytenus guianensis Klotzsch ex Reissek (Celastraceae) chichuá Amazon. Revista da Sociedade Brasileira de Medicina Tropical. 2016;**49**(5):579-585

[38] Lima RA et al. Microbiological evaluation of isolated compounds from the bark of maytenus guianensis klotzsch ex reissek (celastraceae). Electronic Journal of Management, Education and Environmental Technology (REGET). 2016;**20**(1):592-603

[39] Trevisan MTS et al. Screening for acetylcholinesterase inhibitors from plants to treat Alzheimer's disease. Química Nova [online]. 2003;**26**(3):301-304. ISSN: 0100-4042. DOI: 10.1590/S0100-40422003000300002

[40] Bum EN et al. Anticonvulsant properties of the methanolic extract of *Cyperus articulatus* (Cyperaceae). Journal of Ethnopharmacology. 2001;**76**(2):145-150

[41] Amorim E et al. Efeito do uso tópico do extrato aquoso de Orbignya phalerata (babaçu) na cicatrização de feridas cutâneas: estudo controlado em ratos/Topic use of aqueous extract of Orbignya phalerata (babassu) in rats: Analysis of it's healing effect. Acta Cirúrgica Brasileira. 2006;**21**:67-76. (Suppl. 2). DOI: 10.1590/S0102-86502006000800011

[42] Farias RAF et al. Hypoglycemic effect of trans-dehydrocrotonin, a nor-clerodane diterpene from *Croton cajucara*. Planta Medica. 1997;**63**(6):558-560. DOI: 10.1055/s-2006-957766

[43] Hiruma-Lima CA et al. Effect of essential oil obtained from *Croton cajucara* Benth. on gastric ulcer healing and protective factors of the gastric mucosa. Phytomedicine. 2002;**9**(6): 523-529

[44] Silva JO et al. Antihemorrhagic, antinucleolytic and other antiophidian properties of the aqueous extract from *Pentaclethra macroloba*. Journal of Ethnopharmacology. 2005;**100**: 145-152

[45] Santiago GMP et al. Avaliação da atividade larvicida de saponinas triterpênicas isoladas de Pentaclethra macroloba (Willd.) Kuntze (Fabaceae) e Cordia piauhiensis Fresen (Boraginaceae) sobre *Aedes aegypti*. Brazilian Journal of Pharmacognosy. 2005;**15**(3):187-190

[46] Vieira PRN et al. Industrial Crops and Products. Chemical composition and antifungal activity of essential oils from Ocimum species. 2014;**55**:267-271

[47] Sacchetti G et al. Journal of Agricultural and Food Chemistry. Composition and Functional Properties of the Essential Oil of Amazonian Basil, Ocimum micranthum Willd., Labiatae in Comparison with Commercial Essential Oils. 2004;**52**(11):3486-3491. DOI: 10.1021/jf035145e

[48] Ansari MA, Abdul HM, Joshi G, Opii WO, Butterfield DA. Protective effect of quercetin in primary neurons against Abeta(1-42): Relevance to Alzheimer's disease. The Journal of Nutritional Biochemistry. 2009;**20**(4):269-275. DOI: 10.1016/j.jnutbio.2008.03.002 [Epub 2008 Jul 7, 2008]

[49] Roseghini R, Rocha DS, Clarêncio J, Costa SL, Costa MFD, Tardy M, et al. Flavonoid rutin alters the viability and function of mitogen-stimulated splenocytes and thymocytes

compared with non stimulated cells. Immunopharmacology and Immunotoxicology. 2007;**29**(2):271-285

[50] Heitzman ME, Catherine CN, Winiarz E, Vaisberg AJ, Hammond GB. Ethnobotany, phytochemistry and pharmacology of Uncaria (Rubiaceae). Phytochemistry. 2005;**66**(1):5-29

[51] Durrani AM, Davies NM, Thomas M, Kellaway IW. Pilocarpine bioavailability from a mucoadhesive liposomal ophthalmic drug delivery system. In International Journal of Pharmaceutics. 1992;**88**(1-3):409-415. ISSN: 0378-5173. DOI: 10.1016/0378-5173(92)90340-8

[52] Hargreaves PI. Bioprospecção de novas celulases de fungos provenientes da floresta amazônica e otimização de sua produção sobre celulignina de bagaço de cana/ Paulo Iiboshi Hargreaves. Dissertação (Mestrado em tecnologia de Processos Químicos e Bioquímicos)—Universidade Federal do Rio de Janeiro-UFRJ, Escola de Química, Programa de Pós-Graduação em Tecnologia de Processos Químicos e Bioquímicos. Rio de Janeiro. 2008

[53] Carvalho JM et al. Phytosterols isolated from endophytic fungus *Colletotrichum gloeosporioides* (Melanconiaceae). Acta Amazonica, Manaus. 2016;**46**(1):69-72. Available from: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0044-59672016000100069&lng=en&nrm=iso> [Accessed: Oct 27, 2017]. DOI: 10.1590/1809-4392201500072

[54] Chandra S. Endophytic fungi: Novel sources of anticancer lead molecules. Applied Microbiology and Biotechnology. 2012;**95**:47-59. DOI: 10.1007/s00253-012-4128-7

[55] Rippel MM. Borracha natural e nanocompósitos com argila. Quimica Nova. 2009;**32**(3):818-826

[56] Silva TM da et al. O mercado de amêndoas de Dipteryx odorada (cumaru) no Estado do Pará. Floresta [S.l.]. 2010. ISSN: 1982-4688

[57] CAMTA. Sistema Agroflorestal de Tomé-Açu—SAFTA [Website]. 2017. Available from: http://camta.lwsite.com.br/voce-conhece-o-safta

[58] RECA—Associação dos Pequenos Agrossilvicultores do Projeto Reca [Website]. 2017. Available from: http://www.projetoreca.com.br/site/

[59] ERBOL—Periódico Digital. Firma castañera paralizará operaciones y más de 300 se quedarán sin empleo. Available from: http://www.erbol.com.bo/noticia/economia/06042017/firma_castanera_paralizara_operaciones_y_mas_de_300_se_quedaran_sin_empleo

[60] Pinheiro CUB. Extrativismo, cultivo e privatização do jaborandi (Pilocarpus microphyllus Stapf ex Holm.; Rutaceae) no Maranhão, BrasilExtrativismo, cultivo e privatização do jaborandi (Pilocarpus microphyllus Stapf ex Holm.; Rutaceae) no Maranhão, Brasil. Acta Botanica Brasilica. 2002;**16**(2):141-150. DOI: 10.1590/S0102-33062002000200002

[61] Nobre CA. Brazil: Boost pro-forest economics. Nature. 2014;**510**:210

[62] Homma AKO. Em favor de uma revolução tecnológica na Amazônia. Tropical Plant Pathology. 2012;**37**:1-17

[63] Messias FB, Nascimento EP. Economia criativa para o desenvolvimento sustentável da Amazônia. In: Anais do SICASA e ANPPAS Amazônia. Anais Manaus (AM): UFAM/ANPPAS; 2016

[64] MetaCurrency. The CEPTR Project. 2018. Available from: http://ceptr.org/ [Acessed: May 18, 2018]

[65] World Economic Forum. Harnessing the Fourth Industrial Revolution for Life on Land. Towards an Inclusive Bio-Economy. Fourth Industrial Revolution for the Earth Series. 2018. Available from: www3.weforum.org/docs/WEF_Harnessing_4IR_Life_on_Land.pdf [Accessed: May 18, 2018]

[66] Haupt F et al. Progress on the New York Declaration on Forests. Finance for Forests. Goals 8 and 9 Assessment Report. Available from: forestdeclaration.org. New York. 2017

[67] Sonter L et al. Mining drives extensive deforestation in the Brazilian Amazon. Nature Communications. 2017;**8**:1013-1018. DOI: 10.1038/s41467-017-00557-w

[68] Global Witness. Defender of the Earth: Global Killings of Land and Environmental Defenders in 2016. Global Witness Org. 2017. Available from: www.globalwitness.org

[69] Poudyal M, Jones JPG, Sarobidy Rakotinarivo O, Hockley N, Gibbons JM, Mandimbiniana R, et al. Who bears the cost of forest conservation? Peer Journal—Life and Environment. 2018;**6**:e5106. DOI: 10.7717/peerj.5106