SCIENCE PANEL FOR THE AMAZON

POLICY BRIEF

THE AMAZON WE WANT
Science Panel for the Amazon

# A NETWORK OF SCIENCE, TECHNOLOGY, AND INNOVATION HUBS TO CATALYZE REGENERATIVE SOCIO-BIOECONOMIES FOR THE AMAZON REGION

*J. Marion Adeney*, Lauro E.S. Barata*, Francisco de Assis Costa, Brigitte Baptiste, Diego Oliveira Brandão, Benito Juárez Vélez, Maritta Koch-Weser, Guilherme Oliveira, Hervé Rogez, Daniella Fartes dos Santos e Silva, Mariana Varese, Julia Arieira*

**Lead Authors*

## KEY MESSAGES

**(i) Developing new, regenerative socio-bioeconomies that bring the biological and cultural diversity of the Amazon to the world, protect and conserve biodiversity, advance climate goals, and bring equitable benefits and opportunities to Amazonian people, can position South American countries as leaders in the global search for solutions to linked biodiversity, climate, and sustainability crises.** The vast reservoirs of biological and cultural diversity in the Amazon region hold enormous, largely unrealized potential to be the basis of such regenerative socio-bioeconomies.

**(ii)** The Amazon's potential can be realized through the combination of **Indigenous and local knowledge, cutting-edge science and technology, and a dramatic acceleration of applied research, innovation, entrepreneurship, and sustainable enabling finance and infrastructure.** A firm, enforceable administrative and juridical framework that guarantees and operationalizes intercultural equity and benefit-sharing is needed to support this social and economic transformation.

**(iii)** A network of science, technology and innovation hubs for the Amazon can play a key role in the transition towards these new regenerative socio-bioeconomies. **Its ultimate goal is to strategically catalyze and accelerate the innovation, investment, and capacities needed to achieve breakthroughs towards such a transition**.

**(iv) Deep collaboration and integrating lessons learned from international, interregional, and interdisciplinary expertise are** key to the success of such a network. By collaborating to mobilize resources, spark knowledge exchange, and build capacity, such a network can achieve cutting-edge global innovation, science, and technology frontiers in the region.

**(v)** There is an urgent need for society to recognize and prepare for "unknown unknowns" that will become highly relevant in the future due to rapid technological change and imminent climate and ecological tipping points. Innovation **hubs must set their sights beyond current possibilities to establish the next generation of nature-inspired/ nature-based solutions, products, and services** (including those based on artificial intelligence, synthetic biology, and micro and nano technologies) that support society's potential to leapfrog or replace harmful value chains.

**(vi) The benefits of this transition, from both environmental and socio-economic perspectives, cannot be overstated**. A collaborative, transboundary network of innovation hubs can play a critical role by engaging and respecting local knowledge and achievements while adopting the best of global innovation. Because of the rapidly changing climate and increasing influence of formal and informal destructive value chains, **time is of the essence**.

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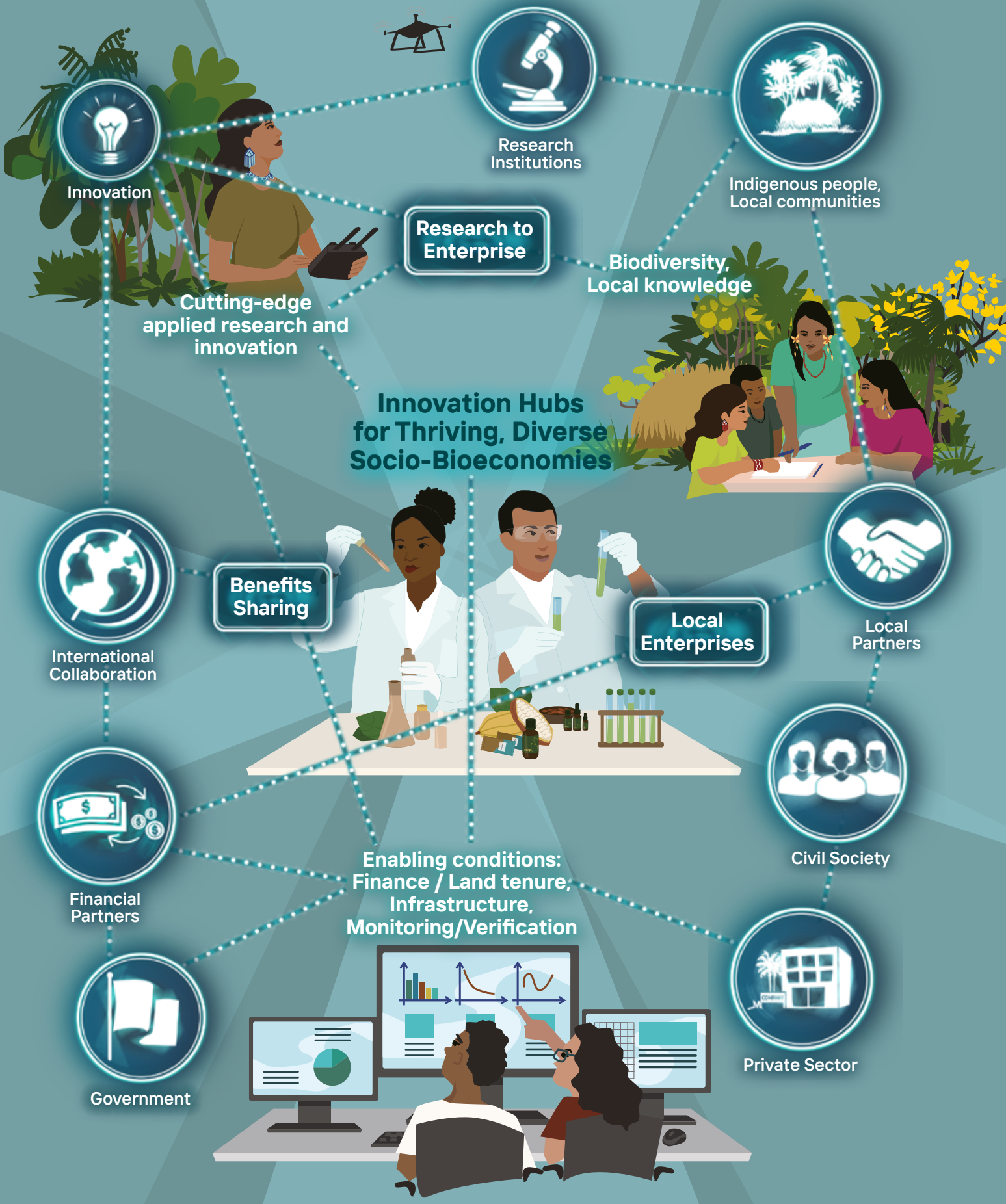
## GRAPHICAL ABSTRACT



## RECOMMENDATIONS

**A network of innovation hubs is critical to chart the path towards a new development approach based on regenerative economies of socio-biodiversity at the speed and scale needed to avoid ecological and social tipping points. The network should:**

**(i) Promote development that strategically avoids the worst pitfalls of the market economy while adopting its positive aspects and adhering to principles consistent with Amazon socio-bioeconomies.**

- These principles promote the sustainable use and restoration of standing forests and flowing rivers; respect, collaboration, and equitable benefit-sharing with local communities; and adding value to healthy ecosystems to conserve biodiversity for a rapidly changing future.

**(ii) Build on current Amazonian research and innovation capacities while leveraging national and international talent and resources.**

- Integrate lessons learned from successful innovation in the global North and South while building on the Amazon's past and current achievements and adapting to meet its specific and local conditions, opportunities, and needs.
- Anchor hubs in diverse Amazonian geographies and ecosystems, including smaller interior cities, to democratize opportunities and capacity development among local populations. Collaborate with existing local, national, and international institutions and create new, innovative entities to apply research results.

**(iii) Incentivize, prioritize, and modernize applied research and development targeted to new sustainable products and value chains that can outcompete and replace destructive production systems.**

- Research goals should include understanding and cataloging, in equitable collaboration with local knowledge holders, properties and opportunities associated with the vast Amazonian biodiversity and ecosystem services. Research should incentivize the use and development of cutting-edge tools and methodologies including biotechnology, synthetic biology, genomics, and artificial intelligence.
- Prioritize focal areas or topics across the network designed to achieve strategically identified positive local and systemic breakthroughs.

**(iv) Develop entrepreneurial cultures within Amazonian institutions.**

- Apply research to develop and nurture sustainable enterprises that expand the pipeline of investable ventures. Specific activities may include strengthening university incubators, establishing robust policies that incentivize innovation and risk-taking, and democratizing opportunities by strategically using open and directed innovation mechanisms such as prizes, challenges, innovation marketplaces, venture startup studios, and accelerators, among others.

**(v) Create focused and strategic opportunities for broad engagement.**

- Engage with students and youth, budding and existing entrepreneurs, educational institutions (including primary and secondary schools), and Indigenous Peoples and local communities. These opportunities should be designed to attract, build, and retain talent (including through stable and competitive pay structures), build bridges between rural and urban communities, and leverage cutting-edge national and international institutions to build capacity through exchange opportunities and deep collaborations and mentorships.

**(vi) Create new financial mechanisms to support sustainable ventures and the hubs network.**

- Attract and de-risk investment, integrate new public-private partnerships and blended-finance, and create innovative benefits-sharing and compensation mechanisms for ecosystem services and local intellectual property applicable at various scales. Secure magnified, creative, and tiered sources of finance, including both non-repayable and repayable capital, as well as securitization instruments, to support enterprises reliably at different stages of growth.

## A. OBJECTIVES OF A NETWORK OF INNOVATION HUBS FOR THE AMAZON

Around the world, researchers, entrepreneurs, governments, and communities are grappling with how to reinvent economies to incentivize sustaining our planet instead of depleting it. In the Amazon region, destructive, economic activities — such as industrial livestock and feed production, land speculation, illegal logging and mining — have led to massive deforestation and degradation, which have brought the region dangerously close to ecological tipping points[1,2]. In response, there are growing calls for strategically developing and expanding socio-bioeconomies of standing forests and flowing rivers that draw on and support healthy ecosystems and local and international knowledge systems, and that provide equitable economic opportunities for rural, urban, Indigenous, and local communities in the Amazon [3–6].

Amazonian countries have much to gain from such a transition to a new, regenerative, and equitable economic trajectory[1,5]. Here, we posit that a network of science, technology, and innovation hubs for the Amazon is critical to achieving this transition. Innovation hubs are commonly defined as clusters of innovation-related institutions, including interconnected research and development centers, entrepreneurial companies, as well as venture capital firms, incubators, start-ups, and fabrication laboratories. They bring together diverse actors to collaboratively develop innovations in the form of solutions, technologies, products, or services[7,8]. By mobilizing and directing local, national, and international resources, capabilities, and opportunities, a network of innovation hubs can play a key role in establishing this new development approach.

To date, the various efforts of governments, the private sector, and civil society organizations to advance Amazonian socio-bioeconomies represent modest beginnings. They remain far too small, slow, and underfunded to achieve the transformation needed, especially given the magnitude of funding currently flowing to formal and informal destructive activities in the Amazon. Further, these efforts have not been supported by necessary enabling conditions of sustainable infrastructure, human capacity, sufficient or innovative finance, and above all, functioning benefit-sharing mechanisms.

A network of innovation hubs focusing on the Amazonian context can identify and stimulate progress towards "super-leverage points" in critical sectors that can induce positive socio-ecological tipping cascades (for examples, see critical sectors for global climate goals identified in Sharpe, 2023[9]). Such strategic focal areas, combined with positive leapfrog technologies, can be game-changers for a transition to regenerative socio-bioeconomies. In our rapidly changing world, innovation hubs will need to consider current and future possibilities to develop the next generations of nature-inspired products, services, and solutions. The ultimate goal of an Amazon network of innovation hubs is to catalyze the innovation, investment, and capacity needed to build science and technology-based, regenerative socio-bioeconomies for the Amazon of "tomorrow."

## B. CURRENT STATE OF INNOVATION-FOCUSED INSTITUTIONS IN THE AMAZON

There is a long history of innovation in the Amazon. Existing innovation-driven institutions and initiatives in the region operate within diverse collaborative networks that range from local and regional to national and international scales. They engage key stakeholders, including governments, the private sector, Indigenous Peoples and local communities, universities, civil society, and financial partners. These initiatives are increasingly supported by diverse funding

sources including governmental, philanthropic, and private sector grants, as well as public-private partnerships and collaborations with development banks and cooperation agencies. Nevertheless, funding scarcity, as well as lack of applied research and entrepreneurial culture, still hampers development of innovative technologies and value chains that could replace harmful commodities and enhance the value of natural resources[10]. Detailed information about the number and types of innovation institutions across the Amazon is limited[10] (but see Fundação Certi). In **Figure 1** we present preliminary maps of innovation-related institutions and their geographic distributions in the Amazonian countries.

Despite the gaps, there is growing interest in investments to support both conservation and biodiversity-related supply chains. In a recent extensive survey, stakeholders across the Amazon identified science, technology, knowledge, and innovation as vital for advancing socio-bioeconomies, while noting that uneven collaboration among academia, government, and other sectors poses a significant bottleneck[10]. A few examples of institutions that develop and apply science to stimulate innovation for Amazonian socio-bioeconomies and biodiversity conservation include the Amazon Biotechnology Center (CBA) and the Porto Futuro Bioeconomy Innovation Center in Brazil, SINCHI in Colombia, and the Center for Amazonian Scientific Innovation (CINCIA) in Peru. These institutions work with innovation across various fields of knowledge including agroforestry, genetics, ecotourism, renewable energy, biotechnology, artificial intelligence, planetary health, monitoring and land-use planning, social innovation, biodiversity credits, environmental remediation, and food innovation. The Food Innovation Laboratory in the Ecuadorian Amazon, for example, prototypes new food products and resolves processing challenges to create market-aligned, industry-changing products.

The Amazonian Creative Labs capacitates communities to establish small industries that add value to local products by integrating cutting-edge techniques with local knowledge to greatly enhance communities' income.

While Amazonian institutions have supported research resulting in discoveries or processes with great potential, most are not at the cutting edge of global innovation, science, and technology frontiers[3], and their results have often not been applied to create sustainable economic opportunities[11]. This gap is reflected in global assessments of innovation ecosystems (e.g., StartupBlink and Startup Genome), in which Amazonian countries (and Amazonian regions in particular) generally score low (although there are distinctive national differences). For example, in assessing innovation centers via numbers of start-ups, incubators, Research and Development (R&D) centers, and investment, StartupBlink lists only four Amazonian countries among the top 100: Brazil (27), Colombia (38), Peru (69), and Ecuador (94). Further, over 90% of the evaluated parameters are concentrated in large cities outside of the Amazon region[12]. In another example, the Latin American Network of Fab Labs developed a study of the Industrial Maturity Index (IMI) levels of six Latin American countries (Ecuador, Colombia, Chile, Mexico, Panama, and Peru). The IMI in Latin America was 2.6 out of 5, indicating a ±60 year gap from the early stages of industrialization to the current state of Industry 4.0. Companies located in the Amazon region showed an even lower IMI of 1.8, which translates to an industrial development gap of between 80 and 90 years[13]. Further, these institutions are not necessarily focused on coordinated and strategic efforts to advance a rapid and scaled transition to regenerative socio-bioeconomies. A network of innovation hubs would need to address these gaps while incorporating and building on the current capacity that these and other institutions provide.

## INNOVATION-RELATED INSTITUCIONS IN THE AMAZON

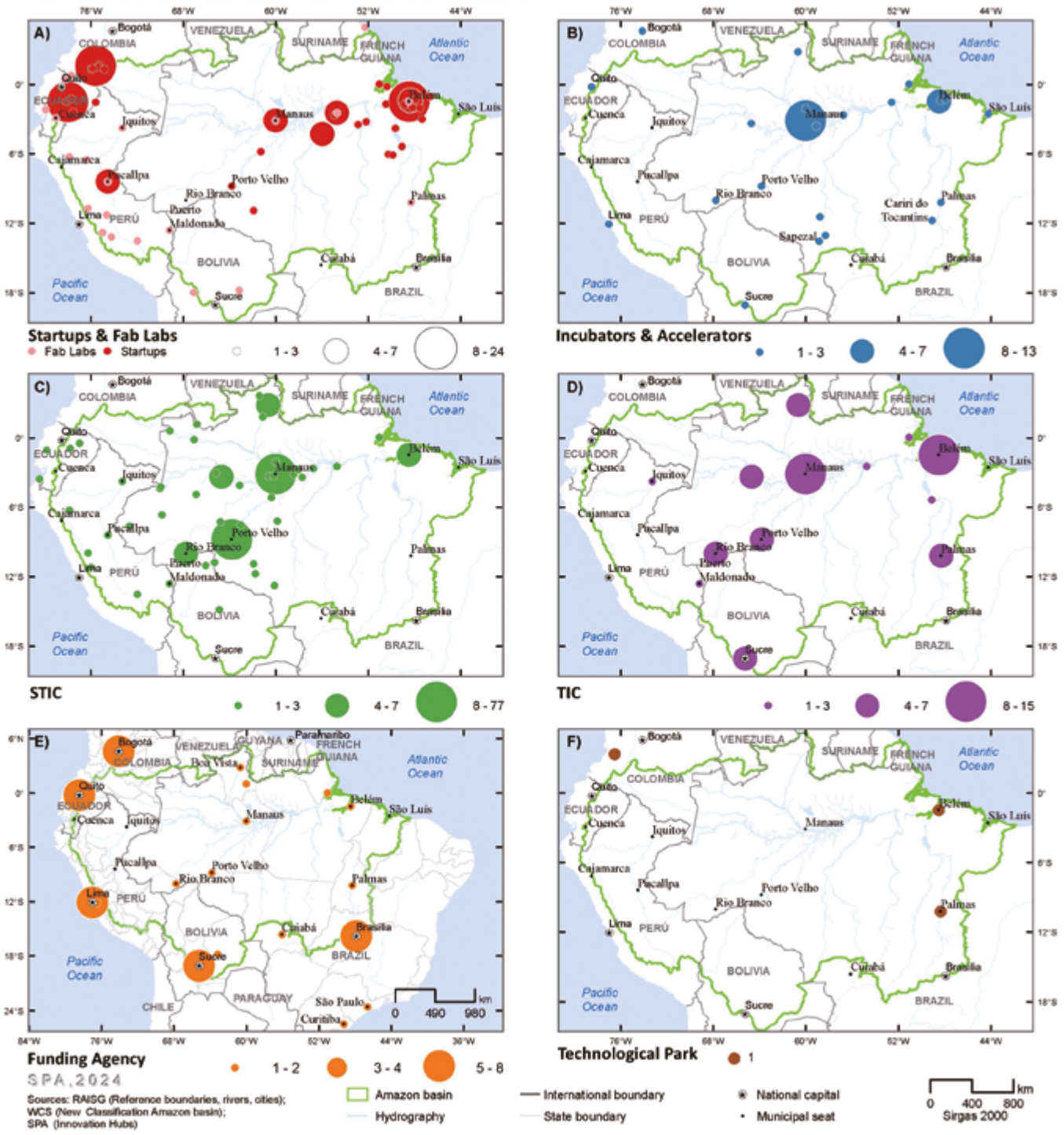



FIGURE 1. **Preliminary mapping of innovation institutions in the Amazon**. Maps highlight various innovation-focused institutions including: a) startups and digital fabrication laboratories; b) incubators and accelerators; c) Scientific, Technological and Innovation Institutions—STICs; d) Technological Innovation Centers—TICs; e) support agencies; and f) Technological Parks. Created with input from regional Science, Technology, and Innovation (STI) organizations, it reveals trends such as the underrepresentation of institutions in rural areas and deforestation frontiers (although spatial gaps don't necessarily indicate the complete absence of STI initiatives).

## BOX: SOCIO-ECONOMIC POTENTIAL OF AMAZON BIODIVERSITY

Growing demand for biodiversity-based resources in sectors as diverse as food, cosmetics, pharmaceuticals, and ecotourism, coupled with advancements in consumer markets, technologies, and business models, is creating new business opportunities to foster resilient and regenerative socio-bioeconomies in the Amazon[14,15]. Beyond being home to 55,000 species of vascular plants, including at least 1,450 known medicinal[16,17] and aromatic plants[18], the Amazon also holds thousands of undescribed species of insects, microorganisms, viruses, and fungi, among others[19]. Currently, 844 medicinal plant species are traded in urban markets[20]. Of 2,253 known useful tree species in the Brazilian Amazon, 1,037 (46%) are utilized for food[21].

The true potential of Amazonian natural ecosystems can be unlocked through science, innovation, and technology (STI). For example, Peru was the first country to commercialize cat's claw (*Uncaria guianensis and U. tomentosa*), an Amazonian vine used in traditional agroforestry systems to treat conditions like arthritis, gastritis, and osteoarthritis. The exported dried material sells for USD 4.30 per kilo, while supplemental capsules in the Netherlands retail for USD 859 per kilo[22]. Fatty oils from Amazonian plants, such as andiroba (*Carapa guianensis*), the palm tucumã (*Astrocaryum* spp.), and uricuri (*Attalea phalerata*) offer opportunities for both cosmetic and biofuel production[23,24]. The average price of copaiba resin oil paid to Amazonian communities is about USD 12 per kilogram, but when distilled into an essential oil, its value rises to USD 75 per kilogram[25]. The açaí (*Euterpe oleracea*) industry in the state of Pará, Brazil alone is projected to grow from USD 0.68 billion in 2019 to 20.01 billion by 2040, driven by rural and urban processing industries[26]. In 2019, the Brazil nut (*Bertholletia excelsa*) industry in Bolivia captured around 74% of the Brazil nut market by quickly adapting to the European Union's strict sanitary import standards through enhanced technology, technical competencies, and financial strategies employed by local companies[27]. Increased R&D funding for added-value products could boost Brazil's GDP by 1.12%, with the Brazilian Amazon's socio-bioeconomies projected to reach USD 7 billion by 2050, nearly three times the 2020 baseline[28].

Agroforestry systems with native trees and other key crops can be used to scale restoration for biodiversity and climate benefits (including carbon sequestration and water cycle stabilization), while providing raw materials for sustainable value chains, generating jobs, and creating added-value potential for new economic ventures and opportunities[29]. These may include existing and new products, such as alternative proteins, nutritional substances, food additives, cosmetics, pharmaceuticals, textiles, bioplastics, and others. Research projects, such as the Amazonian Biodiversity and Bioactive Compounds Project, successfully extracted bioactive compounds from native plants[30]. This represents only the beginning of the long production chain for medicines and still constitutes a small portion of socio-bioeconomy initiatives[10]. Restoration efforts (such as Brazil's target to restore 4.8 million hectares in the Amazon by 2030) can generate up two million direct jobs, and the resulting forest and agroforestry systems may offer economic returns up to 30 times the invested amount[31]. Programs like Fundación Pachamama's Jaguar Credits, with projected sales of 75,300 credits for 2024, highlight the potential of innovative market-based conservation initiatives that can be complemented by products produced through agroforestry or sustainably managed forest-based products. Regardless of the particular products, bio-industrialization and regional scale efforts are needed for a true economic transition[22]. Bioindustries must be created that can supplement or replace current destructive industries, while giving local residents and landowners attractive economic alternatives that are compatible with biodiversity conservation and climate goals[32].

Fostering regional bio-industrialization and entrepreneurship based on Amazonian biodiversity entails numerous challenges including regulatory hurdles, high risk, and insufficient infrastructure and financial investment. Incentives and credit lines for socio-biodiversity-based value chains must be established and guided by clear intellectual property rights and enforcement of relevant legislation[33]. Scaling and adding value to socio-biodiversity-based value chains will require increasing productivity and product reliability, maintaining sustainability, and enhancing human capital for production and processing[21,34]. Strengthening education, R&D, and STI investments in Amazonian countries is crucial[11,28].

Ongoing international commitments, including the Global Biodiversity Framework Fund, present new opportunities. Building strong connections between government, industry, academia, civil society, local communities, and financial partners is crucial for bridging the gap between local knowledge, science, and cutting-edge technology[35]. An Amazonian network of innovation hubs, conceived as a meta-repository of knowledge systems driven by innovation, science, local knowledge, technology, and sustainable financing, can catalyze the innovation ecosystem needed to foster the transition towards new opportunities for socio-bioeconomies in the region.

## C. KEY CHARACTERISTICS OF SUCCESSFUL INNOVATION HUBS AND NETWORKS

Innovation hubs enable people to work together across diverse disciplines to develop novel ideas in a risk-tolerant environment[36]. Networks of innovation hubs seed innovation ecosystems by clustering institutions and resources to coordinate and amplify efforts, sometimes around a particular goal, theme, or technology type[7]. Strategies for developing an Amazonian innovation hub network should draw from innovation history and lessons learned, while accounting for the specific goals, challenges, and needs of such a network in the Amazon.

One of history's most transformative innovation hubs is the United States Defense Advanced Research Projects Agency (DARPA, created in 1957). Breakthrough technologies developed by DARPA have transformative and lasting effects on the global economy and society, including the precursor to the internet and geospatial information systems. Key factors for its success are an institutional structure and culture carefully designed to maximize key characteristics including mission- and results-driven research, agility and tolerance for high-risk/high-reward efforts, world-class, interdisciplinary research and collaboration, and availability of resources to bring products to fruition[37].

The rise of successful African innovation hubs and ecosystems, notably Nairobi, Kenya's "Silicon Savannah" and iHub[38], exemplifies how African innovators have adapted the innovation ecosystem concept to address their specific needs, while incorporating local social and cultural values. Many African innovation hubs have been successful because they have specifically fostered community-led initiatives to provide pathways to entrepreneurship, focused on local solutions to local problems, and benefited from national and international collaboration and investment. For example, M-Pesa, Nairobi's flagship mobile money innovation was a direct response to widespread lack of access to banks and secure funds transfer technology for much of Kenya's population. This innovation forever changed the global approach to financial transactions

and became a model for fintech across the world. (However, it has also been criticized for market domination, vulnerability to hackers, and exploitation of low-income customers, illustrating pitfalls that can arise from technological innovations as they scale.)

To meet the goal of catalyzing the innovation, investment, and capacity needed to build science and technology-based, regenerative socio-bioeconomies for the Amazon, a network of innovation hubs should incorporate characteristics learned from these and other experiences. Further, hubs should be organized around actions or sectors most likely to move Amazonian economies and ecosystems away from negative tipping points or toward creating positive breakthroughs to tip them to sustainable ones[9]. A robust theory of change and focused goal setting with Specific, Measurable, Achievable, Relevant, and Time bound (SMART) objectives[39], and short, medium, and long-term metrics, are essential. Monitoring, adaptability, and learning, as well as ambition and risk tolerance, are also key. The "Principles for a Network of Innovation Hubs in the Amazon" (**see section E** and **Recommendations**) encapsulate these and other key characteristics for success. These should be refined as part of the participatory development process and should address both impacts of individual hubs and impacts of the network as a whole.

## D. TENSIONS, CHALLENGES, AND BOTTLENECKS

There are significant challenges and bottlenecks for achieving the transition to new Amazonian socio-bioeconomies[5] that meet the needs of the Amazon's diverse human and non-human stake- and rights-holders. The innovation hubs proposed here should convene a diversity of actors to develop the vision, tools, and opportunities needed to step outside existing tensions and dichotomies to actualize a new approach to development (**Figure 2**). Below we discuss four of these tensions[28].

### Buen Vivir ↔ Market Capitalism

Socio-bioeconomies incorporate the Indigenous Andean concept of "*Buen Vivir*" ("living well"), which emphasizes harmony between people and nature resulting in sustainable and balanced development[40]. In contrast, free-market capitalism operates with economic growth and concentration of wealth as its primary goals. Since colonial times, this conventional development model has been used to justify the rampant resource exploitation of the Amazon in boom-and-bust cycles of commodity extraction that only benefit a few and that marginalize and devalue collective property arrangements and community resource management schemes[41]. The result is that currently 15–60% of Amazonians have incomes below the poverty line, living hand-to-mouth[42,43].

To be successful, the benefits of regenerative socio-bioeconomies must be within the reach of ordinary Amazonian people[5,44]. New foundations in basic and secondary education, and in scientific, business, and vocational human resource development, are critical. Innovation hubs must develop tools, methodologies, and capacities to enhance value chains that are compatible with local and scientific knowledge and contribute to broader economic and development goals. Broadly accessible programs must nurture entrepreneurial culture and opportunity through technical training, collaboration, and financial support that allow diverse Amazonians to participate in sustainable economic development at various scales and in both rural areas and urban centers.

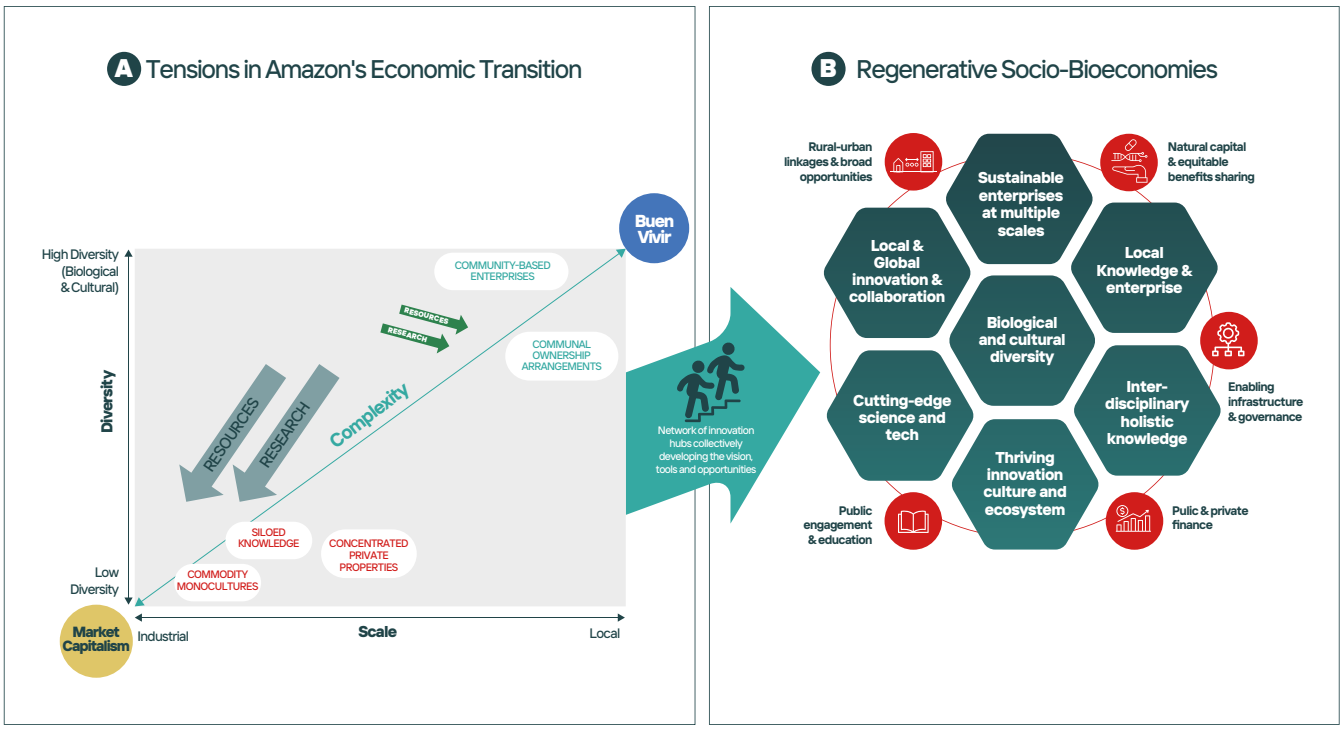



FIGURE 2. Tensions and challenges of the Amazonian context: A) A linear approach to economic worldviews reflecting tensions between the industrial, linear economy currently embodied in market capitalism and the Indigenous concept of *Buen Vivir*. Market capitalism tends to emphasize and channel resources to industrial scale monocultures and concentration of wealth and property. Economies of socio-biodiversity as embodied in the concept of Buen Vivir are diverse, complex, and small scale. B) Regenerative socio-bioeconomies based on cutting-edge science and technology, global and local innovation, and biological and cultural diversity must be integrated into a new circular development model that allows us to collectively step outside of the dichotomies depicted in A). Though not acting alone, a network of innovation hubs can be a key catalyst for this transition by contributing to the vision, policy, technical capacity, democratized opportunity, and innovation ecosystem needed to create this transition.

### Local knowledge and diversity ↔ Research, deep tech, and industrial standardization

A legacy of the colonial approach to development is the lack of sufficient recognition, respect, and incorporation of Indigenous and local knowledge by academia and private sector entities, including those that draw on this knowledge. Further, in the face of rapid and drastic cultural, economic, and ecological changes, much of this knowledge has been, and continues to be, lost[45].

This tension is apparent, for example, in the contrast between industrial agriculture and locally-based diverse and complex agroforestry systems. Developed over millennia, agroforestry systems include both management of diverse native ecosystems and restoration of cleared areas with complex cropping sequences that mimic natural succession patterns[46,47]. By contrast, industrial agriculture focuses on simple systems and large-area monocultures for introduced crops (e.g., soy). It has influenced economic development such that most research, resources, and infrastructure focus on standardized, high-scale production, at the expense of ecosystem and local community well-being[41]. A key role of an Amazonian innovation hub network would be to increase applied research and related policy and technical recommendations focused on how living, diverse biological and local knowledge systems can serve as the foundation of social, ecological, and economic prosperity at local, regional, and national scales.

**Local/community scale ↔ Industrial scale**

Small, socio-biodiversity and community–based enterprises often cannot produce the quality, predictability, and volume of products needed by regional or global industries in search of sustainable, regenerative supply chains. Further, many of the vast array of biodiversity-based products for sale in rural and urban Amazonian markets are part of the informal economy[48] and do not contribute to formal measures of economic activity. Natural capital is also not incorporated, and together these factors increase the misconception that healthy ecosystems (including protected areas and Indigenous lands) do not contribute to economic development. Yet, without an appropriate development model, high demand for products originating in socio-biodiversity may result in businesses based on industrial models, with negative impacts on local cultures and ecosystems. For example, monocultures of açaí planted to meet high global demand[49] do not conform to the principles of a new socio-bioeconomy that support local prosperity and conserve biodiversity.

Instead, diversified industries must adapt to the appropriate scale(s) for the resources and capacities of each Amazonian region to sustainably produce biodiversity-compatible products that together can drive sustainable Amazonian economies. Such enterprises can attract and support companies driving "forest-to-market" and other sustainable supply chains that can supplement or replace harmful ones and enhance the competitiveness of healthy ecosystems. A network of innovation hubs should advance applied research to develop sustainable, value-added, socio-biodiversity-based products and ingredients that meet regional and international demand without increasing nature-related risks. To avoid depleting natural stocks or replicating land-extensive and/or monoculture production, innovation hubs should help develop new sustainable and regenerative production processes. These may include sustainable management and genetically-based monitoring programs for harvesting of wild products (e.g., Biobank)[50] and new regenerative industries based in agroforestry systems and on degraded lands.

Innovation hubs can also play a critical role in developing products and processes for "the middle" of supply chains to provide a variety of economic opportunities at varying scales to local and regional populations. This includes developing innovations in logistics and distribution models, in collaboration with Indigenous peoples and rural and urban communities, to aggregate production from small-scale enterprises to feed larger industries.

**Collective and equitable benefit-sharing ↔ Private wealth accumulation**

It is unrealistic to expect a transformation to sustainable, regenerative socio-bioeconomies without providing alternatives to destructive activities via resources, investments, and abundant and attractive economic opportunities. Resource flows to the Amazon for legal and formal destructive value chains (e.g., cattle, industrial agriculture, industrial mining, and mega-infrastructure) dwarf resource flows for sustainable and regenerative economic activities. The profits from these activities are also inequitably distributed and frequently enrich a few actors or companies, often outside of the Amazon region. Resource flows to illegal and informal destructive activities, such as artisanal small-scale (or " wildcat") gold mining (ASGM), and trafficking of drugs, arms, wildlife, and people, also dwarf sustainable investments[48].

In some cases, resource flows are enabled by policy decisions that create structural barriers to developing thriving, regenerative socio-bioeconomies. For example, the vast majority of government-sponsored loans for small-scale agriculture in the Amazon flow to cattle ranchers, and perverse subsidies encourage the continued development of petroleum-based economies to the detriment of efforts to scale renewable energy[41]. Meanwhile, millions of ordinary Amazonians continue to live without access to electricity, transport, education, health care, or incomes, all of which are needed to support local enterprises in a diversified and equitable economy.

The Amazon provides critical ecosystem services (e.g., water circulation, climate regulation, biodiversity, etc.) that support economies within and beyond the region  Mechanisms to compensate Indigenous and local communities that conserve these ecosystems, and for their knowledge that may support existing or emerging industries, are still nascent and inadequate (e.g., payments for ecosystem services, biodiversity and carbon credits, mechanisms for compensation and benefit-sharing for intellectual property)[51]. This places an unfair burden on these communities to protect ecosystems without adequate compensation, while minimizing and undervaluing the benefits that these ecosystems provide far beyond the Amazon's borders.

A network of innovation hubs has a key role to play in resolving tensions, challenges, and bottlenecks by stimulating and supporting the development of new solutions that address these scientific, educational, social, and policy issues. Such a network will also help develop a new vision for regenerative socio-bioeconomies in the region, by both articulating known opportunities, and by creating the space, mechanisms, exchange and support systems by which yet to be known opportunities can emerge.

## E. MOVING FORWARD: CREATING ENABLING CONDITIONS, DEFINING PRINCIPLES, AND MEASURING SUCCESS

*To move forward with the implementation of a network of science, technology, and innovation hubs for the Amazon, it is important to build on and expand existing capacity, to create synergies among diverse and international actors and institutions, and to have access to continuous economic resources. These topics are developed below in more detail. Here, we provide a roadmap for establishing a network of innovation hubs (**Figure 3**) as well as the set of principles to which innovation hubs should adhere to promote regenerative socio-bioeconomies in the Amazon.*

### Build on current capacity and design for strategic local and systemic breakthroughs

A network of Amazonian innovation hubs must assess and build on the current research and innovation capacity in the Amazon region and incorporate key elements from the global history of successful innovation. First actions should include compiling a comprehensive inventory of Amazonian capacities (e.g., existing institutions, relevant patents filed, etc.) and a synthesis of key regions and existing gaps. Then, select, and build the network around, a set of anchoring institutions in diverse geographies, with an emphasis on including smaller interior cities. Hub institutions should collectively organize around a set of focal areas or topics designed holistically to maximize local opportunities and resources, build synergies, fill needs across the region, and achieve breakthroughs towards strategic positive social and environmental tipping points identified during the hub network development

process. Different regions can develop highly specialized innovation hubs depending on their suitability for different economic sectors. If such institutions do not exist in key places, they will need to be created. Placing network hubs in less developed regions will democratize opportunity and create capacity and support in local populations.

The network should establish strong, complementary, and connected infrastructure. Social sciences, law, and economics must be engaged to collaborate with government and private sector actors to develop innovative safeguards and benefits sharing mechanisms for research and value chains that draw on Amazonian genetic and Indigenous intellectual property. Innovation hubs can also innovate for territorial development policies that incentivize sustainable, enabling conditions such as land tenure, water security, health, education, internet access, logistics, and transportation. Hub governance structures should include local leadership and international collaborators, should emphasize risk tolerance and focus on outcomes, and should build in adaptive management procedures for maximum flexibility and efficiency.

### Incentivize, prioritize, and modernize applied research

Public and private sector research institutions (and their funders) should redirect effort and resources to create the knowledge base for innovations that support and add economic value to Amazonian biodiversity and healthy ecosystems. Currently, much research on economic development is focused on improving harmful industries (such as increasing efficiency and transparency of beef and soy production). Institutions should channel research towards reinventing entire industries to relieve pressure on ecosystems while creating economic growth for the region. Efforts should prioritize understanding and documenting Amazonian biodiversity, in collaboration with local knowledge holders, while also focusing on finding new products and replacements (including for food, fiber, materials, pharmaceuticals, cosmetics, etc.) and on defining sustainable management practices.

Research should incentivize use and development of cutting-edge tools and methodologies including biotechnology, synthetic biology, genomics, and artificial intelligence, among others. Knowledge production for the future will depend heavily on genomics and molecular analytical capacity, computational biology, data integration, and extensive use of artificial intelligence technologies with increasing penetration of generative approaches, high throughput screening capacities, and synthetic biology, among others. And, innovation hubs will also need to engage traditional knowledge as a basis for development. Indigenous and traditional populations should be part of producing scientific knowledge and the entire innovation process, including innovations in finance and safeguards to ensure equitable benefits sharing. Research agendas should include elements strategically designed to boost training and capacity building in cutting-edge tools for the next generation of scientists and entrepreneurs.

### Catalyze enterprise development and develop entrepreneurial culture

Moving research to application in investable enterprises involves not only developing solutions but also creating a culture in which innovation and entrepreneurship can thrive.

Traditional mechanisms such as grants can be modeled on DARPA's time limited, high-risk/ high reward project model. Open innovation approaches use less traditional methods to democratize opportunity (including for underserved groups such as women, youth, and traditional communities), attract additional resources, and encourage out of the box thinking, optimism and ambitious goals (see Conservation X Labs for examples). Programs in market potential, user assessment, business plan development, theories of change, commercialization, and ethics can be built into prize/challenge mechanisms or "open foundry" venture start-up studios to ensure market success and social and environmental safeguards. As many researchers lack entrepreneurial skills and connections, innovation hubs should engage diverse institutions and develop structured opportunities for researchers and entrepreneurs to collaborate with, and mentor, each other.

**Dramatically expand effort, capacity, and opportunity**

Dramatically expanding effort, capacity, and opportunity will be critical for this new economy. Needs extend well beyond training scientists, innovators and entrepreneurs. All kinds of expertise are required including in economics, law, accounting, anthropology, ecology, creative investing, business, administrative, and human resources, design, marketing, and communications, distribution, logistics, transportation, enabling infrastructure, and others. Innovation hubs must strategically develop training and engagement opportunities designed to cultivate the next generation of talent to fill these roles. Students (at all levels), youth, budding and existing entrepreneurs, career professionals, decision makers, and Indigenous and (urban and rural) local communities are among the key actors who should be engaged. The goal is to attract, build, and retain talent through diverse, high-value opportunities that offer stable and competitive compensation.

Equally important is to create exchange, collaboration, and partnerships between rural and urban and local, national, and international communities and institutions. Creating and publicizing high-tech, high-value, and high-status opportunities in new socio-bioeconomies will help to build momentum and public support for a sustainable economic transition. Opportunities to apply research and innovation to the creative economy and the arts are also key. Beyond economic development, such broad engagement should aim to increase passion and pride in the innovations of the Amazon and its contributions to local, national, and international society, culture, and economies.

**Attract and create new financial mechanisms and enabling conditions**

To be effective, this network will need significant, stable, and long-term sources of funding that are crafted for each stage of establishment and scale. A first step should be to collaborate with public and private funding institutions and development banks to design innovative, blended finance mechanisms to support the network in the short, medium, and long-term. Options could include a mixture of public and private capital, grants, tiered and/or derisked investments, bonds, endowments, and/or sinking funds (Project Finance for Permanence schemes

could be a reference point). Funding mechanisms should be designed to be transparent, effective, and flexible (including for international and multi-country efforts), with built-in safeguards, but without the excessive bureaucracy that has hampered effectiveness of some previous efforts.

For planning purposes, core institutions should lay out short, medium, and long-term investment, engagement, and governance strategies during the design and implementation phase (step 3 in the Roadmap, **Figure 3**). For example:

- *Short-Term (1-3 years):* Establish the foundation for launching pilot hubs in key locations through the participatory design process and with core leadership from technical and financial institutions. These efforts will require moderate investments and minimal systemic changes. Initial hubs should target regions with existing infrastructure and focus on strengthening current institutions, establishing strategic international partnerships, and designing for critical breakthroughs.

- *Medium-Term (3-7 years):* Deepening collaboration between governments, international organizations, and the private sector will be critical for scaling the network across Amazonian countries, including less developed areas and transboundary regions. The network and the socio-bioeconomy itself will require moderate to high investments and moderate systemic changes in the form of regulatory support and enabling infrastructure. The hubs should engage economists, investors, and others to create and scale innovative and international financial mechanisms, such as grants, bonds, blended finance, incentives, credits, and benefits-sharing mechanisms to support and scale the hubs themselves and associated socio-bioeconomy ventures. For example, innovations could include a structured Amazon Rainforest Commodity and Product Exchange and mechanisms to provide Indigenous and local communities with legal resources to protect intellectual property and design compensation mechanisms. Also critical is technical support to enable Amazonian enterprises to absorb the large amounts of capital usually allocated by banks and investors.

- *Long-Term (7+ years):* Achieving the full vision of the proposal in the long-term will likely require very large investments and major systemic changes. Establishing fully functioning socio-bioeconomies in the Amazon—where destructive industries are matched or replaced by sustainable value chains—is an ambitious yet attainable goal, assuming that the necessary governance structures and financial models are effectively implemented.

In the short and medium-term, moderate investments and targeted partnerships in the network of innovation hubs can lay the groundwork for the transition to transformative socio-bioeconomies. The long-term success of both the hubs' network and a sustainable economic transition will depend on the scalability of early efforts, effective governance, and sustained financial support. These efforts are increasingly urgent given the magnitude of funding currently flowing to formal and informal destructive activities in the Amazon.

**Activating a Network of Science, Technology, and Innovation Hubs for the Amazon**

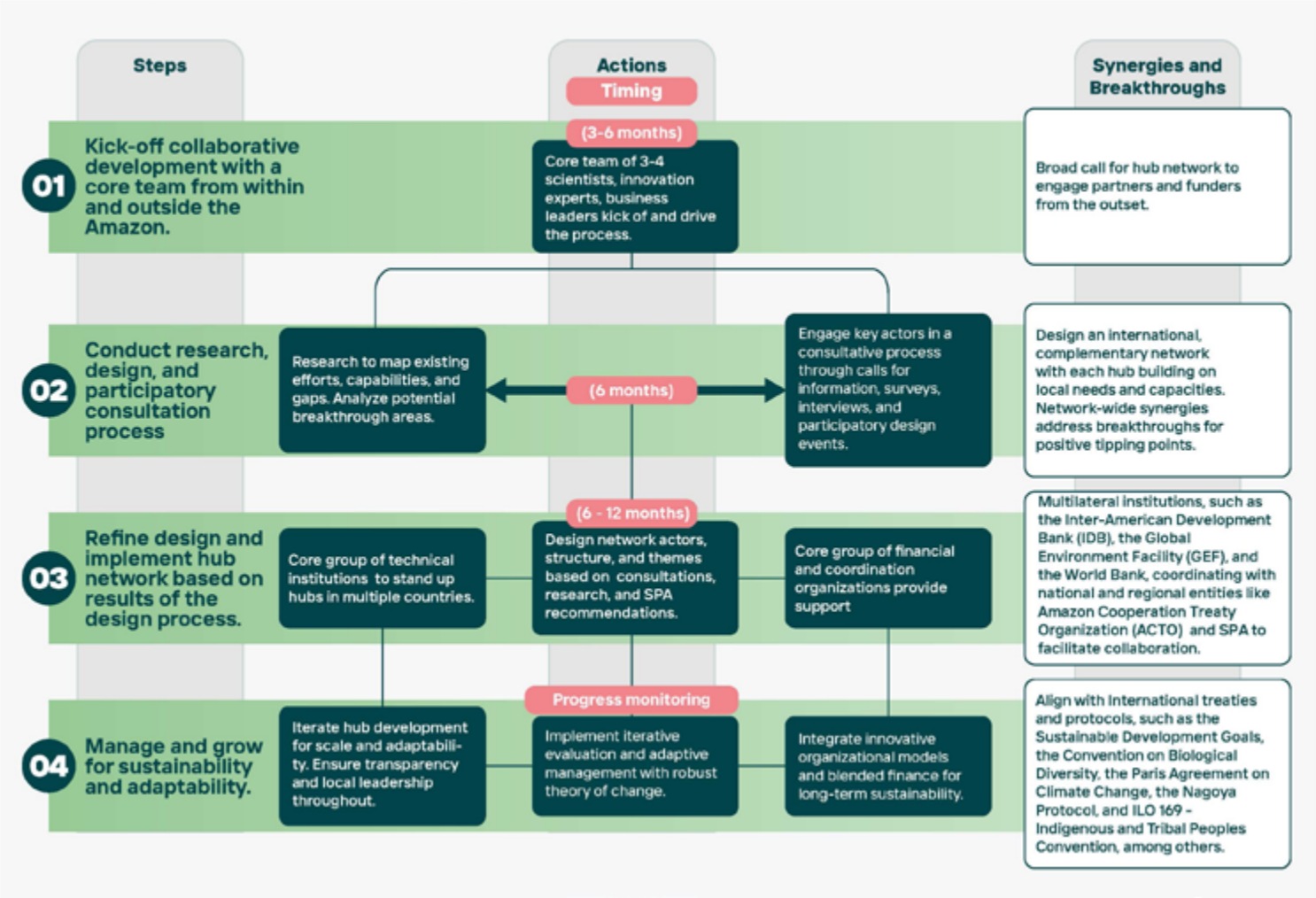



FIGURE 3. **Roadmap for activating a network of innovation hubs in the Amazon:** This plan unfolds in four steps: 1) Building a core team for the network's kick-off, 2) Leveraging existing capacity and designing for systemic breakthroughs, 3) Defining organizational models and key stakeholders, with academic institutions and multilateral entities like IDB and GEF facilitating collaboration, and 4) Accelerate growth of innovation hubs through iterative adaptive management, public private partnerships, and sustainable finance mechanisms. To develop new socio-bioeconomies in the Amazon, the STI hub network must follow key principles, set ambitious goals, measure impact, and adapt as needed.

## Adhere to Key Principles and Measure Success

To make meaningful progress on developing new socio-bioeconomies for the Amazon, the STI hub network must adhere to key principles, set ambitious goals, measure impact, and manage adaptively. Based on the characteristics of success discussed above, and the specific needs, challenges, and context of the Amazon region, we propose the following Principles for the Network of Science, Technology, and Innovation Hubs for the Amazon. We then list potential individual and systemic hub impacts and metrics. Principles and metrics should be refined during the hubs development process.

Key Principles:

1. *Ecological Integrity & Cultural Inclusion:* Support healthy and resilient Amazonian ecosystems and respect and include

Indigenous peoples and local communities as solution co-creators.

2. *Transparency, Participation, & Opportunity:* Transparency is key to building trust. Engage existing capacities, local participation, and leadership. Create broad access to opportunity for Amazonian people.
3. *Systems Thinking Across Diverse Knowledge Spheres:* Embody interdisciplinary, international, and cross-sectoral collaborations. Integrate systems and resilience thinking, recognizing the interconnectedness of environmental, social, and economic systems.
4. *Benefit-Sharing & Respect for Intellectual Property:* Draw from, support, and innovate mechanisms to equitably compensate Amazonian communities for protecting biodiversity and ecosystem services and contributing local knowledge. Incentivize data sharing and respect for local intellectual property (Nagoya Protocol; FAIR/CARE principles).
5. *Technical & Financial Capacity Through Deep Collaboration:* Engage various public and private institutions to build capacity and opportunity, including innovative financial partnerships and mechanisms that ensure sustainability and a just economic transition.
6. *Audacious Ambition, Innovation, & Risk:* Articulate ambitious goals for the transition to regenerative socio-bioeconomies. Encourage out-of-the-box thinking and risk tolerance to build a sustainable innovation ecosystem in the Amazon.
7. *Flexibility, Adaptability, & Learning:* Innovate governance structures and procedures that allow for flexibility and avoid excessive bureaucracy. Continually, monitor, evaluate, learn, and adapt.
8. *Safeguards & "Unknown Unknowns":* Implement safeguards and scenarios planning for unintended consequences. Stay focused on planning for the future, including positive and negative "unknown unknowns" in a rapidly changing world.

Individual Hub Impacts:

- *Research to Enterprise:* Facilitate applied research for developing sustainable, investable, and locally appropriate enterprises and bio-industries. Potential metrics could include solutions developed, enterprises launched, patents filed.
- *Innovation Ecosystem:* Create a culture of innovation and entrepreneurship, including through deep collaboration with local and international partners and by developing ample capacity building and development opportunities. Metrics could include measures of participation, training, and/or engagement of students, local communities, and business people.
- *Economic:* Market penetration or economic benefits of businesses supported by the innovation hubs. Metrics could include access to local, regional, and international markets and job creation numbers, among others.
- *Finance:* Develop partnerships and attract capital, including from public and private sources, to grow the innovation ecosystem. Metrics could include the number of partnerships or innovative finance mechanisms developed and funds raised.
- *Environmental:* Impact of hub-supported innovations (including policy or regulatory recommendations adopted) for environment and biodiversity conservation. Metrics could include biophysical measures such as deforestation reduction or carbon sequestration rates.

- *Benefit-Sharing:* Develop mechanisms to share benefits of ecosystem services or intellectual property with Indigenous peoples and local communities. Metrics could include functioning mechanisms, technical support developed, or resources shared.

Systemic, Network-Wide Impacts:

- *Network Connections:* Connect the Amazon regionally and globally through new partnerships and sustainable value chains.
- *Enabling Conditions:* Recommend and support the development of enabling conditions (policy, financial incentives, territorial planning, land tenure resolution, enabling infrastructure, primary and secondary education, marketing connectivity, etc.) at local, national, and regional levels.
- *Economic Growth:* Track absolute, and/or growth of, contributions of new sustainable enterprises and value chains to standard measures of socio-economic opportunity and growth (e.g., GDP, Human Development Index - HDI, employment, etc.).
- *Public Opinion:* Cultivate pride in Amazonian resources and people locally, nationally, and internationally.
- *International Agreements:* Measure and track progress toward international climate and biodiversity goals, including through recognition of progress in specific sectors identified as potential leverage points for positive tipping cascades.
- *Socio-Economic Measures:* Improve social conditions and opportunities for Amazonian people; demonstrate the potential of socio-bioeconomies to address global climate, biodiversity, and socio-economic crises.
- *Biodiversity and Conservation:* Biophysical measures of conservation including transnational efforts.

## CONCLUSIONS

Amazonian people are inherently innovative and entrepreneurial. For millennia, Indigenous peoples in the Amazon have created large, sustainable population centers and have developed many incredible innovations that we still value today. In modern times, they have adapted to and survived centuries of colonialism, displacement, and repression. Other local communities (such as *caboclos, ribeirinhos*, and afro-descendants) have also integrated their own knowledge systems with their environments to create unique cultural adaptations. Some newer immigrants, attracted to the Amazon through settlement plans or economic opportunities, have also creatively adapted to harsh environments and built diverse communities across the region. Further, the Amazonian population is young and connected to international information and opportunities in unprecedented ways. While the arrival of Starlink Internet, Chat GPT, and AI have the potential to exacerbate inequality and create challenges, they may also empower a generation of youth, with both rural and urban ties, to reinvent their own reality based on the greatest repository of natural and biological resources the world has to offer.

Amazonian countries have the human and biological resources to lead the world in reimagining and creating a new model for sustainable development based on regenerative socio-bioeconomies. A network of science, technology, and innovation hubs has the opportunity and responsibility to mobilize the

resources, knowledge, and capacity of local communities across the Amazon, combined with the energy, ideas, and resources brought by an international community of innovators, to actualize this opportunity for the next generations of Amazonians. This urgent social and economic transition could transform the Amazon into a jewel of new, equitable, sustainable economic development, while conserving its treasure-trove of biological and cultural diversity and bringing pride in the Amazon to the world.

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## GLOSSARY

**Accelerators and incubators:** Organizations or structures that aim to provide logistical, managerial, and technological support to innovative and knowledge-intensive entrepreneurship focused on innovation.

**Benefit-sharing:** The fair and equitable distribution of benefits derived from the economic use of a product, or material originating from genetic resources or associated traditional knowledge, or aimed at the conservation and sustainable use of biodiversity.

**Bio-industries:** Enterprises with infrastructures and technologies capable of transforming primary products into industrialized goods with added value.

**Blended-finance:** Structures that use non-repayable funds and philanthropy to engage third-party capital in initiatives with socio-environmental impact. These hybrid structures can combine various instruments to support projects, such as debt, equity, guarantees, insurance, guarantee programs or funds, grants, payment for results, and technical assistance.

**Compensation mechanisms:** Financial or non-financial tools designed to offset or mitigate negative environmental impacts while promoting sustainable practices. These mechanisms provide incentives for individuals, companies, or governments to engage in environmentally beneficial actions, typically to counterbalance damage caused to ecosystems or biodiversity.

**Entrepreneurial culture:** Entrepreneurial culture refers to the set of values, beliefs, and practices that foster an environment conducive to innovation, creativity, and risk-taking. It creates a setting where individuals are motivated to explore new ideas, develop innovative solutions, and pursue entrepreneurial ventures, driving both personal and organizational growth.

**Innovation in socio-bioeconomies:** Innovation should be guided by a set of economic, ecological, and social criteria, ensuring that new products, processes, and applications offer concrete solutions to societal challenges. It should move beyond sustainability to design products and systems that restore and regenerate ecosystems and communities. This approach involves creating innovations that have a net-positive impact on the environment, contributing to biodiversity restoration and healthy communities.

**Innovation marketplaces:** Platforms that implement new features and services to improve the user experience and increase engagement.

**Leapfrogging:** Leapfrogging is a phenomenon where societies or businesses skip certain stages of development or product generations to adopt more advanced technologies or innovations directly. This can occur by bypassing intermediate technological advancements or deliberately omitting specific product versions in favor of improved, more advanced options. It enables rapid progression by avoiding outdated or less efficient stages in development[52].

**Socio-bioeconomies:** Economies based on the sustainable use and restoration of healthy standing forests and flowing rivers to support the well-being, knowledge, rights, and territories of Indigenous peoples and local communities, as well as all Amazonian residents and the global community (see Garrett, Ferreira et al. 2023).[5]

**Venture studios for start-ups:** A business model focused on building start-ups from the ground up using its own ideas and resources. These studios provide hands-on support across all stages of a start-up's lifecycle, from concept development to scaling, often taking on the role of both founder and investor. This model reduces risks and increases the chances of success by leveraging the studio's expertise, infrastructure, and funding.

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CONTACT

**SPA Technical Secretariat New York**
475 Riverside Drive | Suite 530
New York NY 10115 USA
+1 (212) 870-3920 | spa@unsdsn.org

**SPA Scientific-Technical Secretariat in São Paulo**
Av. Dr. Ademar de Barros, 195 - Jardim São Dimas
São José dos Campos SP -12245-010 - Brazil
+55 (12) 3921-8884 | spasouthamerica@unsdsn.org

**AUTHOR AFFILIATIONS**

**J. Marion Adeney:** Conservation X Labs, 1066 31ST ST NW, Washington, DC, 20007, United States.

**Lauro E.S. Barata** - In Amazon - Empresa de P & D de Bioprodutos da Amazônia; Universidade Federal do Oeste do Pará, Trav Vera Paz ISCO BMT1, sala 316, Santarém, Pará, Brazil

**Francisco de Assis Costa:** Centro de Estudos Avançados da Amazônia e Programa de Pós-Graduação em Economia. Universidade Federal do Pará, Av. Perimetral da Ciência km 01, 66.095-780, Belém, Pará, Brazil

**Brigitte Baptiste:** Rectora Universidad Ean, Cra. 11 # 78-45 piso 10, Bogotá DC, Colombia

**Diego Oliveira Brandão:** Programa de Pós-Graduação em Ciência do Sistema Terrestre. Coordenação de Ensino, Pesquisa e Extensão - COEPE. Instituto Nacional de Pesquisas Espaciais - INPE. São José dos Campos, CEP 12227-010, Brazil; Science Panel for the Amazon (SPA), escritório América do Sul, Av. Dr. Ademar de Barros, 195 - Jardim São Dimas, São José dos Campos - SP, Brazil

**Benito Juárez Vélez:** FabLab Peru Association | The Latin American Fab Lab Network - Fab Lat, Ca. Manuel Prado 313, Satipo, Junín. Peru

**Maritta Koch-Weser:** Programa "Amazonia em Transformação", IEA/USP, São Paulo, Brazil; Earth3000 gGmbH, Am Rittergut 8, D-09629 Bieberstein, Germany.

**Guilherme Oliveira:** Instituto Tecnológico Vale Belém, Rua Boaventura da Silva 954, Belém, PA, 99055-090, Brazil

**Hervé Rogez:** Centro de Valorização de Compostos Bioativos da Amazônia (CVACBA), Universidade Federal do Pará, Av. Perimetral da Ciência km 01, 66.095-780, Belém, Pará, Brazil

**Daniella Fartes dos Santos e Silva:** Centro de Gestão e Estudos Estratégicos – CGEE, SCS Quadra 9, Torre C, 4º andar - Ed. Parque Cidade Corporate, 70.308-200, Asa Sul, Brasília, DF, Brazil

**Mariana Varese:** Wildlife Conservation Society, Avenida roosevelt 6360, Miraflores, Lima, Peru and Citizen Science for the Amazon Network, Av. Roosevelt 6360, Miraflores, Lima, Peru

**Julia Arieira:** Computational Bioacoustics Research Unit (CO.BRA), Instituto Nacional de Ciência e Tecnologia em Áreas Úmidas (INAU), Cuiabá, MT, Brazil; Science Panel for the Amazon (SPA), escritório América do Sul, Av. Dr. Ademar de Barros, 195 - Jardim São Dimas, São José dos Campos - SP, Brazil.

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