SCIENCE PANEL FOR THE AMAZON

POLICY BRIEF

THE AMAZON WE WANT
Science Panel for the Amazon

A NEW INFRASTRUCTURE FOR THE AMAZON

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KEY MESSAGES

(i) Infrastructure in the Amazon has prioritized national development and other interests, which were generally tilted towards extractive activities (mining, energy, agriculture/cattle) and domestic industrial policies (e.g., Manaus Free Zone) rather than needs of local populations or environmental concerns, such as maintaining and protecting the high diversity of terrestrial and aquatic ecosystems, resulting in an unsustainable, low-quality development process.

(ii) A new paradigm is necessary for adapting existing infrastructure, and for planning and building future infrastructure, at both national and subnational levels. This new paradigm should be based on the concept of a spatial configuration and include the consideration of nature-based solutions and Indigenous and local knowledge (ILK). Existing transportation infrastructure has led to deforestation in the region. It is crucial that any investment in transport is accompanied by strong regulation and enforcement to avoid further forest loss. Connectivity improves when the full range of transport options (water, air, rail, road) are considered in a network manner. In the case of the Amazon, water transport and aviation are options that could provide connectivity with a lower environmental impact, taking into consideration adaptation to extreme climate events (e.g., droughts, floods, heatwaves, wildfires).

(iii) The Amazon exports power generated by large hydroelectric installations, while itself facing significant energy supply deficits, especially for isolated populations. A new sustainable development model calls for healthy flowing rivers and demands that no new large hydropower dams be installed. Small-scale hydrokinetic turbines may offer energy provision in remote areas. Likewise, ensuring access to affordable, reliable, and small-scale renewable energy for all in the region is a must.

(iv) Water is abundant in the Amazon, but access to clean drinking water and sanitation is limited. New methods and technologies to promote safe drinking water and sanitation are key and require an integrated approach, which should also include the deployment of solid waste management solutions that consider the circular economy concept.

(v) Digital connectivity is a strategic aspect for social and economic development and integration, and for social inclusion. Development of the communications sector can contribute to the well-being of all, reducing barriers in access to education and health services, and facilitating the development of new innovative processes, products, and markets in the region.

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RECOMMENDATIONS

(i) New sustainable infrastructure for the Amazon should be planned by and for Amazonians, assuring that local perspectives and realities are heard and taken into consideration, addressing the needs of a new socio-bioeconomy of healthy standing forests and flowing rivers, and maintaining healthy ecosystems in the region.

(ii) Infrastructure should be part of a plan to create wealth and jobs while protecting the environment. Solutions for each community should be developed with local people, identify positive examples and best practices, and establish knowledge exchanges that involve relevant stakeholders and decision makers. The specific characteristics and needs of each community should be considered, and local people should be empowered to participate in the development of new projects.

(iii) Low-carbon multimodal transportation options should be prioritized, such as river transport and small-scale electrical aviation, which can significantly mitigate deforestation, forest degradation, and other associated impacts resulting from road construction and use.

(iv) Energy solutions for the Amazon should prioritize the use of local available resources, avoiding options that drive social-environmental conflicts (such as dams). Investment should be made in decentralized power generation to allow energy provision for isolated communities without the need for extensive expansion of power lines. For this purpose, microgrids based on renewable energy sources are a good option. In addition, energy solutions should promote substitution of fossil fuels in local transport.

(v) It is crucial to improve, construct, and maintain sanitation facilities across the Amazon region. Adequate controls on urban sewage, plastic pollution, mercury and other heavy metals, and agrochemicals are needed. Regional governments and municipalities must prioritize sewage treatment to preserve the health of aquatic biota and human populations. Medium and large cities should consider refurbishing existing water and sewage treatment plants and recovering critical plants, while small cities and rural areas can use artificial wetlands. Isolated households, rural areas, and small cities can also use phytoremediation, a low cost, effective, sustainable sanitation option. Further studies are needed regarding the possibility of implementing these solutions in big Amazonian cities.

(vi) It is critical to develop connectivity projects based on new business models, such as community networks, involving local people directly. The use of satellite links and fifth- and sixth-generation mobile telephony technologies (5G/6G) to deploy access networks are the best options for the region.

(vii) It is necessary to create enabling conditions for the new infrastructure paradigm, which involves setting the stage for its successful implementation by addressing legal, financial, technological, and human factors. Prerequisites to implement the new infrastructure paradigm effectively include: a robust and supportive policy framework, adequate funding, research and development, capacity building, stakeholder engagement, and strengthening local institutions and governance systems.

A. INTRODUCTION

The Amazon is home to a diversity of residents, including an estimated 410 Indigenous groups and a multitude of riverine communities whose livelihoods are intertwined with the region's biodiversity[1,2]. The Amazon is also home to an estimated 6 million smallholder farmers and approximately 28 million urban residents that today account for at least 70% of the region's population[3]. Meeting the infrastructure needs

of the region's diverse residents is a challenge, especially so given the substantial gaps in the provision of basic services to Amazonian people (e.g., clean water and sanitation, transportation, communication/digitization services[4]), and the multiple and often opposing worldviews about the region's development among Amazonians[5].

In an effort to maximize access to mineral wealth and other commodities, expand national and international markets, and reduce the transportation cost of commodities, Amazonian nations and territory have pursued coordinated infrastructure plans to construct multimodal transportation corridors that connect the Atlantic and Pacific Oceans, as well as the Amazonian region, with the rest of South America and the world[6,7] (Figure 1). These plans have included the construction of 147 hydropower projects (in addition to 160 already under construction or in operation) to expand electricity output in support of

GRAPHICAL ABSTRACT: A new paradigm is necessary for adapting the infrastructure of the Amazon.

industrial development and the construction of reservoirs to enhance navigability of the Amazon River and its tributaries (Figure 1). The socio-environmental costs of such infrastructure are very high[8]. For example, roads lead to deforestation; over 90% of deforestation occurs within 5.5 km of existing roads[1,9]; and, in many cases, dam construction has resulted in high levels of illegality and inequality in nearby cities due to migrant workers, in addition to violations of Indigenous peoples and local communities' (IPLC) rights[1,10,11]. Some aspects are not sufficiently taken into account as potentially impacted by infrastructure, such as non-monetary benefits provided by Indigenous and local knowledge (ILK) and innovation, biodiversity, and other aspects brought by standing and connected forests and rivers[12].

For the Amazon, a region of continental dimension, planning mostly transpires in top-down fashion, and power imbalances favor economic and political actors who exert pressure to build the infrastructure they desire,

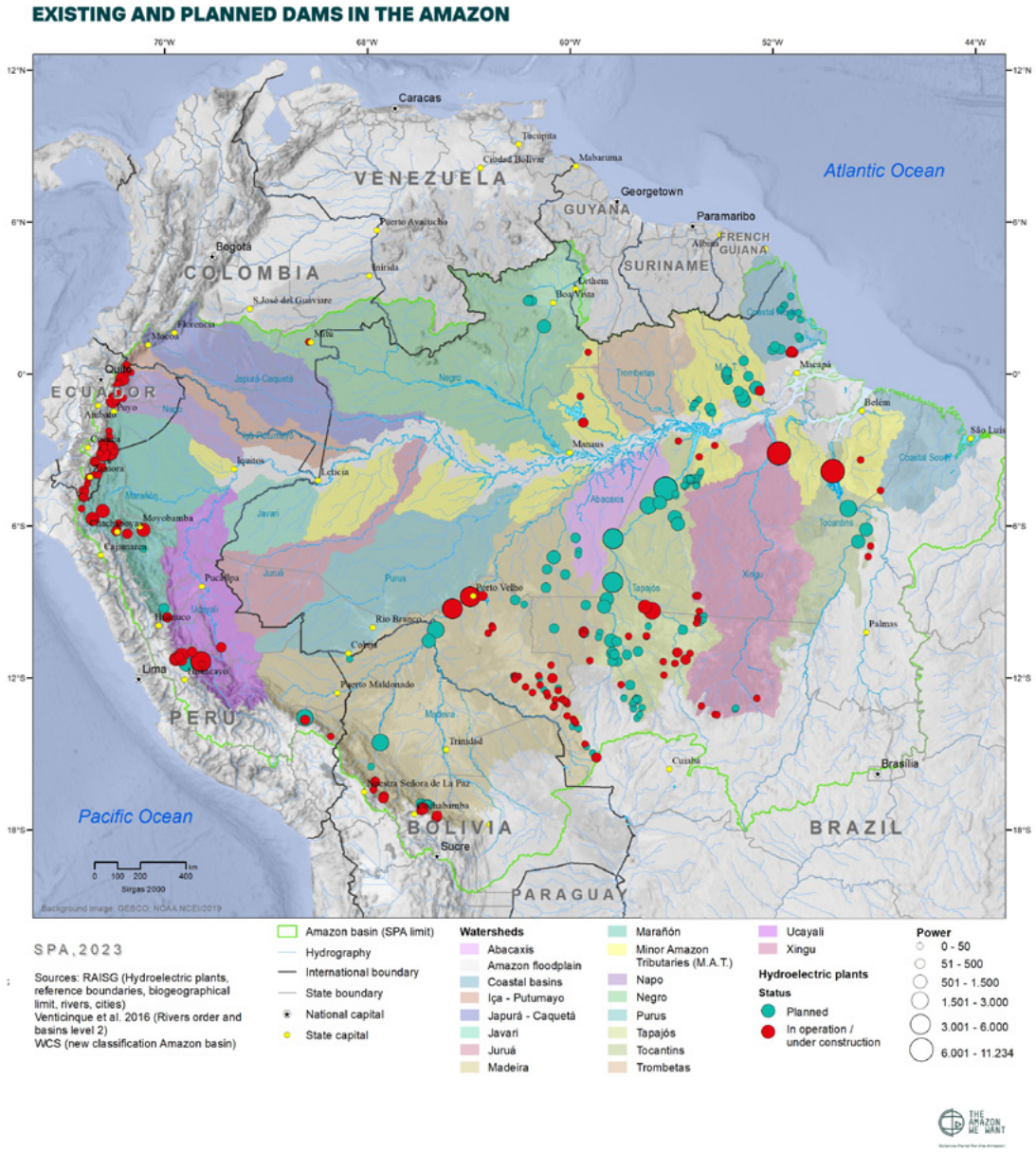

FIGURE 1. Existing and planned infrastructure in the Amazon for (a) transport, and (b) energy production through the establishment of hydroelectric plants.

despite social groups advocating for strict social and environmental regulations and prior consultation during these projects[13-20]. Nevertheless, infrastructure influences the attainment of all the Sustainable Development Goals (SDGs)[21]. Therefore, a new paradigm is needed to define sustainable and resilient infrastructure for the region.

The new infrastructure paradigm should consider the six principles[i] proposed by G20 countries to guide quality infrastructure investments to advance green, resilient, and inclusive development[22], as well as the

[i] Principles: "Maximizing the positive impact of infrastructure to achieve sustainable growth and development; Raising economic efficiency in view of life-cycle cost; Integrating environmental considerations in infrastructure; Building resilience against natural disasters; Integrating social considerations in infrastructure investment; Strengthening infrastructure governance".

7 principles[ii] from the SPA's "Living Amazon Vision"[5]. The primary concern should be to identify connectivity and accessibility improvements that promote zero deforestation, facilitate socio-bioeconomic growth[23], increase access to opportunities and job prospects, and enhance living standards. Local knowledge and science should be used to consider regional seasonal climate variation, and to project potential Amazonian futures as a function of global climate change[24] and variable portfolios of green infrastructure investments[25,26]. Natural hazards can disrupt infrastructure, negatively impacting the region's competitiveness, highlighting the importance of building resilience against these effects. In addition, the infrastructure planning and implementation process in the Amazon should follow a more inclusive, horizontal, democratic model. This revised approach aims to actively involve all stakeholders, embracing the diversity of realities in the region, with a special emphasis on engaging IPLCs. Furthermore, an environmentally- and socially-sound infrastructure could become a catalyst for the well-being of Amazonian populations and the protection of the region's resources[27].

This policy brief focuses on transportation, energy, water and sanitation, and digital infrastructure. While recognizing the inseparable nature of infrastructure with governance and financing, the two latter topics are not fully covered in this document.

[ii] Principles: "1. The Amazon is a geodiverse and biodiverse system that must be valued, respected, and protected. 2. Amazonian ecosystems' functions provide benefits at multiple scales. 3. Use of the Amazon's natural resources and its ecosystems must support ecological processes, functions, and livelihoods in the face of a climate crisis and potential tipping points. 4. Urban and rural areas of the Amazon must function as integrated productive systems that promote and support a wide range of socio-economic and ecological benefits. 5. Amazonian governance must include participatory processes of engagement between diverse stakeholders and across scales for the well-being of the whole. 6. The Amazon houses diverse experiential knowledge systems and cultures resulting from the connection between people and nature, or biocultural diversity, which must be valued, recognized, and protected. 7. Recognition of the rights of Indigenous peoples, Afro-descendant, and other local communities and ensuring their access to justice is paramount to promoting well-being for all."

B. INCLUSIVE INFRASTRUCTURE SOLUTIONS

1. Transportation

An efficient transportation network is paramount for the economic development in all nations. An integrated system of roads, railways, waterways, ports, and airports is the artery that enables the smooth flow of people, goods, and services, reducing transportation costs and expanding market reach. Moreover, it facilitates access to employment opportunities, education, and health, and it fosters cooperation and exchange of ideas, helping to disseminate solutions within and across communities. Inadequate logistic systems hinder smooth operations, leading to an escalation of transaction costs which can diminish the region's competitive edge. The challenge of efficiently transporting people and products is widely recognized as a significant impediment to the development of the Amazon's regional economy[28-30].

Roads in the Amazon are deeply connected with deforestation[8,9] therefore, giving priority to alternative transport modes could help achieve the aspired connectivity with lower environmental impacts. Roads, both legal and illegal, facilitate access to land speculators and machinery for mining and (illegal) logging, resulting in encroachment on protected areas and IPLCs' territories, often leading to land disputes and social conflicts[8,31] A better-informed decision-making process, considering places where economic returns are positive and negative impacts are comparatively low, would result in the construction of far fewer roads, in carefully-chosen locations that could avoid socially and environmentally sensitive areas[28]. Even in these cases road construction should be accompanied by an increase in law enforcement and participation

of local stakeholders. Reducing reliance on road networks in the Amazon is of paramount importance to safeguard biodiversity and protect IPLCs' territories, respecting their ways of life and cultural heritages[9,32,33].

In the case of railroads, while they may be a less environmentally damaging option than roads, they also generate deforestation and socio-environmental impacts, both directly and indirectly[8,34,35]. Railways are advantageous for transporting large volumes of goods over long distances[36]. As a result, railways in the region are mostly planned for freight export[37-39], as it is not justifiable to transport passengers in a low-density population area. Therefore, it is important to understand who benefits from railways' construction in the Amazon. The lower freight costs of planned railways are expected to contribute to the conversion of pasture to soybeans, possibly leading to displaced deforestation[8,40,41]. As with roads, rail expansion is not normally justified if socio-environmental impacts are considered. However, maintenance of existing railroads is encouraged to avoid road expansion with similar routes, as happened in Amapá, Brazil[42].

The Amazon region has a complex and extensive river network. Amazonian populations have flourished along rivers for a long time, using rivers as a means of transportation[43,44]. This network is intensively used today and plans to use rivers as the main transportation option have been touted as a development strategy for decades[45,46]. While river transport may have severe impacts on aquatic ecosystems[47], it has the greatest efficiency per tonne transported[48]. Nevertheless, improvements in navigation infrastructure are needed to enhance the efficiency and safety of river transport[49,50]. In addition, investments are necessary to ensure year-round navigation and improve efficiency, as the dry-season can threaten navigability, especially in strong El Niño years, and restrict the flow of people, goods and services[24,51]. During the years 1998, 2005, 2010, 2015/2016 and 2023/2024, the Amazon was severely impacted by unprecedented droughts and rising temperatures, exacerbating vulnerabilities caused by anthropogenic land-use changes and climate change combined effects[52]. Advance forecasting of water levels can enhance waterway transportation efficiency, by guiding vessel size selection and maintaining navigable conditions[53]. However, further research is needed to develop clean, multiscale vehicles adaptable to varying hydrological channel sizes, particularly in light of the potential for more frequent and severe dry seasons under climate change scenarios.

Small-scale aviation could complement river transportation in the Amazon region. Air transportation can play a fundamental role given the region's long distances, low population densities, and diverse weather conditions. Air travel connects the Amazon region to each other and the world, transporting people and high-value cargo. Small aircraft, such as bush planes, serve remote communities with essential goods and supplies[54]. Although the operational costs may be high, their relevance is centered on the fact that they offer the possibility of having access to any remote location within the Amazon[55]. Seaplanes use existing river transport infrastructure bringing financial gains without the need for massive investment in airport infrastructure. Seaplanes are already used in the region and could also create new economic opportunities and improve access to essential services for people living in remote areas[56].

2. Energy for All

There is a paradox in the Amazon because, while it produces power generated by large hydroelectric installations (Figure 1), in general this power is exported to other regions and the Amazon faces significant energy supply deficits, relying on the use of fossil fuels to produce the electricity consumed in large parts of the region[57,58]. Further, isolated populations, including many IPLCs, lack access to electricity. Inadequate access to reliable electricity harms human well-being and local production. The viability of activities like fishing, açai processing, cassava flour production, and other forest product value chains hinges on consistent access to reliable electricity for processing, storage, transportation, and maintaining competitiveness[27,30].

The primary energy challenge in the Amazon region has been ensuring universal access. Even when there is energy provision it often falls short of satisfying local demand. Consequently, energy provision should be based on multi-objective criteria that consider factors such as energy affordability and availability, environmental impacts, and potential production linkages and their contribution to reducing poverty[59-61]. In the Amazon, electricity supply can be split into three types, each with its own challenges: (1) national interconnected systems, (2) non-interconnected systems fed by electricity provided mainly through generators running on diesel or gasoline, and (3) those in remote regions without any formal access to electricity but where sometimes energy is supplied independently, for example by the collective initiative of the inhabitants in the acquisition of diesel or gasoline generators, or by the installation of solar panels by non-governmental organizations[61].

The expansion of national interconnected systems could be done, for example with floating solar photovoltaic (PV) systems placed on reservoirs, or with the use of agrivoltaics on degraded pasture land[30]. Additional large-scale dams should not be built in the Amazon[47]. National grids do not cover the entire Amazon and, consequently, decentralized power generation is preferable in most situations. For isolated communities, both in non-interconnected systems and those in remote regions without any formal access to electricity, the focus should be on building small-scale, decentralized power generation infrastructure based on local renewable sources[62].

The region has large potential for PV generation, small-scale hydropower plants with hydrokinetic turbines, and modern utilization of biomass. In some places wind could also be used; according to the Global Wind Atlas (2023)[63], wind potential is mostly concentrated in Brazil and along the Guyana border, and in coastal zones. Also, on the Atlantic coast both tide and ocean thermal energy conversion (OTEC) could be good options. Additionally, thermal or electric valorization of residues and use of biogas from water and organic waste treatment facilities might contribute to providing clean water and energy for the region while providing waste and wastewater management solutions. All these alternatives could help in the transition to a low carbon economy, and improve the region's well-being. Needless to say, regional difference potentials and seasonal availabilities of each source mandate that a combination of sources be used to guarantee power availability and reliability3[0,57,64-68]. In addition, the electrification of isolated and remote rural communities should be preceded by effective planning with local stakeholders, including the establishment of management mechanisms guaranteeing the

sustainability of electrification projects. Tailor-made electrification solutions should align with local characteristics and potential[69].

Finally, the Amazon region should move away from fossil fuels whenever possible, even in the transportation sector, which can be greatly electrified (e.g., electric boats and planes)[30,70,71]. Besides electrification, biofuels may be needed in the transition to a low carbon economy. Raw materials for biofuels range from oilseeds to general lignocellulosic biomass, and to agricultural and forestry residues, all of which can be used to transform biomass into fuel[30,72-75]. Bio-sustainable aviation fuel production may play an important role in the decarbonization of the aviation sector if coupled with successful strategies to control deforestation[76]. What is key is that developing a biobased energy system needs strong controls to avoid incentivizing deforestation.

3. Water and Residue Management

Although the Amazon is usually seen as a place of water abundance, access to clean drinking water can be challenging due to the region's size and remoteness, as well as the potential for contamination from various sources, with 7 out of 10 Amazonians lacking access to safe drinking water and sanitation[77]. It is necessary to research new methods and technologies to promote safe drinking water for people, but also for domestic use, food production, and other purposes[78]. Solutions to improve potable water access could include rainwater harvesting and storage[79]; riverbank filtration[80]; protection of wells and springs[81]; water filtration systems with biosand filters, ceramic filters, or membrane filters to remove contaminants and pathogens from the water[82]; boiling and/or chlorinating water before drinking it to kill harmful microorganisms[83]; and UV water purifiers[84].

An interesting option for the Amazon, where there is abundant rainfall, is domestic rainwater harvesting (DRWH). These systems collect water with a much lower level of contamination than many rivers, which can have high levels of heavy metals and pollution[85]. In addition, it is low cost and easily installed and maintained[86].

Access to sanitation is limited in the Amazon, with most municipalities collecting less than 20% of wastewater[78,87], and worse statistics in rural and remote areas. Concentrated heavy rains, which are on the rise, cause extensive flooding and overwhelm what infrastructure does exist[88]. A critical problem is that Amazonians living downriver from urban centers face contamination from raw, untreated sewage. Additionally, water contamination from mercury used in illegal mining is increasing, impacting human health and biodiversity[47,89,90]. It is necessary to reduce or eliminate pollution entering rivers and remediate damage to those ecosystems.

Improving sanitation in the Amazon region requires a multi-faceted and comprehensive approach. The construction and maintenance of sanitation facilities in both rural and urban areas is necessary. For rural and remote areas, some examples could be composting toilets or biogas digesters (which can both manage waste and generate energy), artificial wetlands, and/or the use of plants for sewage treatment (phytoremediation)[91]. Large cities can also incorporate these nature-based solutions[92,93]. Native wetland plants, such as water hyacinths and cattails, can absorb and break down pollutants in wastewater, purifying the water. Constructed wetlands or floating treatment systems can be used, where wastewater is directed to plants to absorb nutrients and contaminants. While this approach is considered

simple to operate and maintain, cost-effective, and aligned with ecological conservation principles[91], further studies are needed regarding the specific conditions and contexts under which it can be implemented in large Amazonian cities. Moreover, cities with more than 100,000 inhabitants should consider refurbishing existing water and sewage treatment plants and recovering critical plants. It is worth mentioning that natural vegetation cover also improves water quality and reduces treatment costs[94-96.]

Solid waste management solutions are needed, ideally using the concept of the circular economy. A key element involves the reduction of waste and pollution[97]. When reducing production is not possible, recycling can be achieved through the establishment of dedicated recycling centers, incentivizing the buy-back of recyclable materials, and promoting their reuse in local industries. Furthermore, fostering local handmade craftsmanship that utilizes recyclable materials can contribute to waste reduction and creative resource utilization, as is the case of the Kichwa women, who have created a collective of Indigenous women working to transform organic materials and inorganic waste into handmade goods to gain financial independence[98]. Incorporating new research and innovative technologies represents another promising avenue in the waste sector followed by the facilitation of the circulation of products and materials.

4. Digital Infrastructure to Bridge the Digital Divide

Connectivity is a strategic aspect for regional development and integration, and for digital inclusion. Internet access can promote innovation in the provision of services, in addition to reducing the costs of commercial transactions[99]. The World Bank[100] recognizes access to information and communication technologies (ICT) as a tool for education, health, economic development, and social welfare. The development of the ICT sector contributes to innovation, making it possible to produce products with high added value, and is important for national and international integration. ICT also plays a crucial role in bridging the gap in healthcare access for geographically dispersed populations. Digitalization and telemedicine in particular help to improve the efficiency of the entire healthcare process, being useful both for prevention and for accessing specialized medical consultations and monitoring the treatments followed by patients[101]. This was evidenced during the COVID-19 pandemic, when this type of service was widely adopted[102]. At the same time, digitalization may reduce demand for transport and associated fuel consumption, although it is important to mention that there is still a materials footprint to digitalization.

There is a historic lack of digital connection and connectivity in the Amazon. The current telecommunications model incentivizes connectivity only in high-income areas, high-density regions, or new construction areas where the private sector has a viable business case to ensure a return on investment. Recent internet expansion through low Earth orbit (LEO) satellites has a high cost[103]. A good initiative using this technology is the "Conexão Povos da Floresta" project in the Brazilian Amazon, which has installed satellite internet and solar energy kits in ten Yanomami communities. The goal is to reach at least 500 dispersed communities this year, allowing them quality digital connectivity[104].

Alternative models are critical to attract the necessary capital and integrate the region into the digital world. Connectivity solutions via fiber optics or radio already reach the headquarters of municipalities. However, access and intermediary networks ("backhaul") lack innovative solutions to serve forest peoples and isolated rural communities. Boosting socio-bioeconomy initiatives[23] will be facilitated through adopting community network models that can connect and are based on cost sharing for network acquisition, assembly, operation, and maintenance. In the technological context, the use of satellite links and fifth- and sixth-generation mobile telephony technologies (5G/6G) to deploy access networks are the best options. The combination of LEO satellite links and internet of things (IoT) devices leveraging 6G mobile telephony enables a techno-economic innovation ecosystem in the Amazon focused on maintaining healthy standing forest and flowing rivers, promoting the socio-bioeconomy, and improving the daily lives of Amazonians[105].

C. CONCLUSIONS

This policy brief has focused on transportation, energy, water and sanitation, and digital infrastructure, providing a glimpse of potential solutions. The importance of a completely new infrastructure for the Amazon region cannot be downplayed, as it is key for the well-being of all Amazonians. This new infrastructure needs to be designed considering the unique characteristics of the Amazon region, both in terms of its human populations and its extraordinary biodiversity. To implement the new infrastructure paradigm effectively it is imperative to establish and foster the proper enabling conditions for a region that is so particular.

One of the key enabling conditions is the development of a robust and supportive policy framework. This entails creating regulations and guidelines that align with the objectives of the new infrastructure paradigm. These regulations should go beyond country borders and use cooperation among countries. In many Amazonian countries law exists in relation to environment protection and implementation of new infrastructure. Nevertheless, the environmental policies are not always properly enforced or implemented[106-108]. For example, environmental impact assessments (EIA) should be used to gauge social and environmental harms, recognizing that their efficiency is limited since they narrowly focus on one or a few proximate infrastructure projects and consider short time horizons[109-111]. Infrastructure planning and subsequent EIAs should consider basin-wide, integrated infrastructure projects, potentially capturing cumulative and synergistic impacts from the entire infrastructure system[24]. In addition, the new infrastructure paradigm requires a long-term perspective and should include mechanisms that promote sustained commitment and continuity in implementing this paradigm, even in the face of political change or economic fluctuation. And because all infrastructure may facilitate illegal activities (as it does legal ones), parallel law enforcement is also paramount, together with the creation of mechanisms to avoid corruption that would change the planning and implementation of projects[112].

Adequate funding is essential to kickstart and sustain infrastructure projects within the new paradigm. This can involve public and private investments, grants, localized short-term subsidies, innovative business models that include local populations, payment for environmental services, or other financial mechanisms to ensure that projects are financially viable and can move forward

sustainably with a basin-wide focus. The challenges posed by financial needs should be analyzed, because it is a very complex issue and should be aligned with the new paradigm.

Research is critical since it can help to inform existing and potential socio-environmental impacts of existing and planned infrastructure. It can help to create innovative solutions based on the local context, and plan for resilience against natural disasters, climate change, and other unforeseen circumstances. Cutting-edge technologies and mechanisms can be designed to encourage the adoption of advanced, sustainable, and efficient infrastructure solutions. In addition, the establishment of efficient data and information systems is vital for monitoring and managing infrastructure projects. This enables real-time decision-making and the ability to adapt to changing circumstances. Furthermore, in areas where there is no clear solution yet, investment in research and innovation is necessary to find alternatives that fit the many local contexts in the Amazon region, bringing to light how to use available resources in a sustainable way.

Capacity building and stakeholder engagement are of supreme importance to bolstering local governance systems. This involves developing the skills and knowledge base of professionals and the local labor force to strengthen local participation, as well as investing in education, training, and technical assistance to empower local communities to manage their resources, participate in decision-making processes, and implement sustainable practices. Fostering knowledge exchange among local communities, researchers, and policymakers can facilitate the development of context-specific solutions, being especially important to open discussions on the incorporation of sustainability standards in territorial planning and execution of infrastructure projects in the Amazon region[113]. The promotion of inclusive and transparent governance mechanisms can amplify local voices and address their needs, besides facilitating accountability[5]. In that sense, it is imperative to empower Amazonian voices and ensure their active participation in the design of the region's infrastructure, preserving their cultural heritage and cultivating a thriving socio-bioeconomy that can raise their standard of living[23,114]. It is essential that the aspirations, needs, and knowledge of the Amazon's inhabitants are woven into the fabric of planning and infrastructure development, fostering a truly inclusive approach. Through this concerted effort, a synergy between the Amazonian population and the broader development initiatives can be achieved.

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