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Working Paper

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Suggested Citation: Duran-Fernandez, Roberto; de Carvalho Coutinho, Taciana (2024) : The Amazon: A Puzzle Between Development and Sustainability?, ZBW – Leibniz Information Centre for Economics, Kiel, Hamburg

This Version is available at:

<https://hdl.handle.net/10419/281668>

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The Amazon: A Puzzle Between Development and Sustainability?

Roberto Duran-Fernandez¹ and Taciana de Carvalho Coutinho²

January 2024

Abstract

This paper provides a comprehensive overview of the Amazon, a vital ecological treasure in Latin America. It covers the region's environmental significance as the planet's largest rainforest and a major carbon sink, housing immense biodiversity. The study also traces the Amazon's geological history and its crucial role in the global water cycle. It explores the rich cultural heritage of the Amazon, debunking the myth of an untouched wilderness by revealing evidence of significant ancient civilizations and agricultural origins. The economic analysis highlights the contrast between the region's natural richness and the poverty of its inhabitants, focusing on the challenges posed by extractive industries, geographical isolation, and environmental threats like deforestation. The paper proposes a sustainable bioeconomy model, emphasizing indigenous knowledge and the need for strategic investments and institutional strengthening. It concludes by stressing the importance of a balanced approach to conserving the Amazon while ensuring economic viability for its inhabitants, underlining the region's global significance for environmental health and climate change mitigation.

Keywords: Amazon Rainforest; Environmental Conservation; Sustainable Development; Bioeconomy; Amazonia

JEL Codes: Q01; Q56; Q57; R11; N56

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1. A natural treasure for Latin America

The Amazon is often described as the 'lung of the planet,' located in the heart of Latin America. This vast territory stretches across eight sovereign nations (Brazil, Bolivia, Colombia, Ecuador, Peru, Guyana, Suriname, and Venezuela) and the overseas region of French Guiana, covering an area of about 8.4 million square kilometers (Garzón, 2013). Estimating the population of this region is challenging due to the lack of detailed information; however, it is projected that by 2025, the Amazon will be home to approximately 56 million people (Schiavina, et al., 2023; Freire, et al., 2016). If it were a country, the region would be the sixth largest in the world, slightly bigger than Australia and the third most populous in the hemisphere, only after the United States, Brazil, and Mexico.

This immense ecosystem houses the planet's largest tropical rainforest, nearly four times larger than Central Africa's Congo jungle, the next biggest. The Solimões/Amazon River³ is the world's second-longest, only 250 kilometers shorter than the Nile River. Yet, with an impressive flow of 216,000 cubic meters per second, the Solimões/Amazon carries more water than the Nile, Yangtze, and Mississippi Rivers combined, accounting for 17% of the total freshwater discharged by the planet's rivers (García, 2023; Gloor, 2017). The Amazon biome is one of the world's most crucial, acting as a major carbon dioxide sink and absorbing up to a quarter of all the gas captured on land. Beyond its environmental roles, the Amazon is a haven for a vast array of plants and animals. It is estimated to host approximately 10% of the planet's biodiversity, including unique species like the jaguar, anaconda, and the pink river dolphin (Haywood, 2023; WWF, 2023a).

The Amazon rainforest formed 55 million years ago. The Solimões/Amazon River is relatively young at 11.3 million years, though its current form dates back only 2 million years. Research suggests that an ancestral river, the proto-Amazon, originated in the highlands of a supercontinent when South America and Africa were connected, flowing in the opposite direction of today towards the Pacific Ocean (Mapes, 2009). With the continental drift, South America's collision with the Pacific plate formed the Andes Mountains, blocking its path to the ocean and creating an inland sea in what is now the Amazon basin. Eventually, erosion paved the way to the Atlantic through the Guiana Shield, draining this inland sea. These geological changes gave birth to the Amazon ecosystem and its rich biodiversity (Sena Costa, et al., 2001).

The climate regulation of this ecosystem is part of a delicate balance affecting the entire South American continent. Atlantic winds bring clouds inland, bring on rain in the forest. The trees act like geysers, drawing water through their roots, up their trunks, and out their leaves, releasing moisture back into the atmosphere. Every day, nearly 20 billion tons of water are evaporated by the forest, more than the daily contribution to the Amazon River. The Amazon canopy slows winds from the ocean and helps retain moisture. More water evaporates in the forest than in the ocean, drawing sea winds inland, aiding in bringing more rainfall to the region. This forms the basis of the 'biotic moisture pump' theory. The green

³ In Brazil, it is considered that the Amazon River originates at the confluence of the Negro River, in the city of Manaus. Between its source and this point in Brazil, it is known as the Solimões River.

ocean draws moisture from the blue ocean, and a continuous flow of water through so-called 'flying rivers' is directed towards lands east of the Andes, seasonally irrigated by this water. The 'biotic pump' extracts moisture from the ocean, transporting it inland and regulating the climate across South America. This cycle is the source of surface water in the Solimões/Amazon system, as well as an underground river known as the Hamza River. The hydrographic cycle regulates the climate from the northern continent in Venezuela and Brazil to the Rio de la Plata basin in Argentina (Nobre, 2023; Marengo, 2006; Pimentel & Hazma, 2011; Ferrante, et al., 2023).

2. A Region with a rich history and culture

Latin America was the birthplace of great civilizations in Mesoamerica and the Andes. In the Latin American imagination, the Amazon is often thought of as an untouched wilderness, free from human influence, dotted with small, isolated communities. However, the reality is quite different. South America was the last continental landmass to be inhabited by *Homo sapiens*, around 15,500 years ago, according to the latest research (Prates, et al., 2020). Yet, there is evidence that the Amazon was home to civilizations capable of sustaining large populations. As recently as 2022, a pre-Hispanic settlement was discovered in Llano de Mojos in the Bolivian Amazon. This site consists of a civic-religious architectural complex spanning between 147 and 315 hectares, with pyramid-like structures up to 22 meters high (Prümers, et al., 2022). For context, the Maya complex of Chichen Itza in Yucatan, Mexico, covers an area of 83 hectares.

The architectural center is in the heart of the Casabere culture's territory. It is estimated that this settlement dates from between 600 and 1400 AD and controlled a territory of up to 4,500 square kilometers. The lack of records prevents an accurate approximation of the population of this center; however, population density extrapolations suggest that the area could have supported up to one million inhabitants (De Souza, et al., 2018). By comparison, this number is akin to the population of the Valley of Mexico upon the arrival of the Spaniards in 1519 (Smith, 1997). It is estimated that around this time, the entire rain forest was home to between 6.8 and 8 million people (Palace, 2017).

How was the Amazon able to sustain these vast human populations? Recent studies suggest that the Amazon was one of the centers where agriculture independently originated (Messer, 2020). This immense ecosystem is not only the origin of crops such as cassava, sweet potato, yam, squash, pineapple, papaya, peanut, cashew, guava, and açai, but there is also evidence suggesting that cocoa, traditionally associated with Mesoamerica, originated in this region (Iriarte, et al., 2020).

The influence of agriculture in the Amazon has been so significant that it has shaped the very structure of the forest itself. For example, the likelihood of finding trees and palms that produce edible fruits and nuts is five times greater than that of encountering other species (Ross, 2017). These discoveries suggest that what was once considered virgin forest has, in reality, been shaped by human hands since ancient times, characterizing a family and sustainable agriculture, adapted to the hydrological cycle and to the

means of alluvial plain and upland. The intervention has been so subtle and prolonged that, today, it appears to be part of a natural process.

3. The challenge of economic development

The natural and cultural richness of the Amazon starkly contrasts with the poverty and marginalization of its inhabitants. The Inter-American Development Bank (IDB) estimates that approximately 40% of the Amazon's inhabitants live below the poverty line. The Amazonian economy is based on low-productivity extractive models, characterized by informality and the adoption of business models and technologies ill-suited to the region's reality. Furthermore, violence and illegal activities limit the productive potential of the region (Schor, 2023).

Some authors suggest that the Amazon's natural isolation could serve as a shield for certain industries in some localities. The high costs due to its isolated location disincentivize imports, allowing entrepreneurs the opportunity to meet regional demand by increasing their supply of products and services. For example, a study focused on the Department of Loreto in the Peruvian Amazon identifies a diversity of economic activities sustaining a surprisingly complex economic ecosystem beyond natural resource extraction. The presence of these activities suggests the existence of productive capacities that could be harnessed for higher-value initiatives. These include the food and chemical industries, tourism and creative industries, as well as manufacturing and construction (Hausmann, et al., 2020).

However, it is important to consider that the Department of Loreto in Peru is home to Iquitos, one of the region's most important urban centers. Outside the larger cities, economic alternatives are more limited. In general, the Amazonian economy is dominated by agriculture, livestock activities, fishing, forestry, and mining (Nobre, et al., 2023).

The expansion of agricultural frontiers for agribusiness is the greatest threat to the ecosystem's sustainability. Under a business-as-usual scenario, it is estimated that in the coming years, up to 49,000 square kilometers of tropical forest will be lost to agribusiness (WWF, 2023b). This area is equivalent to the size of the Dominican Republic. Even activities that do not directly impact deforestation, such as fishing, affect the biodiversity and environmental balance of this fragile ecosystem.

Mining is at the extreme, increasing deforestation and contaminating the environment with disproportionate impacts on indigenous communities. Currently, it is estimated that there are over 4,000 illegal mining operations fostering violence and crime (WWF, 2023c). Research conducted by the Center for Socio-Environmental Studies of the Amazon (NESAM) on the dynamics of crime, conflict typification, and violence in cross-border contexts in the State of Amazonas, Brazil, describes the configuration of violence in the territories of traditional peoples and communities as a result of illegal exploitation of natural resources in protected areas (Rapozo, Silva & Coutinho, 2023).

The Amazonian space presents significant gaps in its institutional capacities, presence of the state, human capital, and especially in its infrastructure. Geography defines these gaps. The tropical forest is a natural barrier that limits road construction, making river transport via the Solimões/Amazon River the most important mode of cargo and passenger transport. In practice, Amazonian cities, from Manaus with its two million inhabitants to smaller towns, function like insular economies connected by water, with challenges more akin to those of a Caribbean island than to the realities typically encountered in continental Latin America. The isolation imposed by this geography has significant implications. For example, leveraging economies of scale is extremely difficult, as each population center must invest in its own infrastructure.

Some researchers point to the existence of a 'connectivity trap,' where the lack of connections with external markets hinders the economic potential of the region. Ultimately, this further reduces incentives to improve connectivity. This trap supports the idea that limiting the Amazon's connectivity with the outside world will reduce incentives for deforestation. However, the reality is that deforestation has accelerated recently despite the lack of connectivity. This phenomenon suggests that the problem of deforestation requires an institutional solution and the strengthening of the regulatory framework (Goldstein, et al., 2023).

Furthermore, the geography exerts such a force that it is difficult to imagine for those who have never been in the region. For example, the sediment carried by the river can dramatically change the landscape from one year to the next. Any investment in physical infrastructure near to the river, whether a river port, airport, road, or fiber optic, is exposed to its influence with the possibility of being damaged or rendered useless. Just a few years after construction, a river port can find itself several meters inland, due to the formation of a new island created by sediment accumulation. This alters investment cycles and increases the risk profile of any project.

4. A puzzle between conservation and development

Is it possible to transform the Amazon's environmental wealth into economic well-being for its inhabitants without destroying the delicate balance of this ecosystem? This is a pertinent question for any geography, and could even be extrapolated to a planetary scale. However, the fragility of the Amazon and its regional or global significance compels us to consider whether this question is an unsolvable dilemma or if there is an economic model capable of addressing it.

A first approach to this question is to understand the real value of the ecosystem. The GDP of the Amazon region can be estimated at USD 700 billion, which is approximately 40% of the Brazilian economy's value. However, this figure should be questioned to the extent that it stems from activities that generate deforestation, impact biodiversity, and devastate environmental balance. This is an

inherent problem in measuring GDP, which assigns a monetary value to all activities, even those that destroy natural capital (WHO, 2022).

A more appropriate measurement of the ecosystem should consider the environmental services it provides, including water conservation, soil preservation, and carbon sequestration. The World Bank estimates the value of the Brazilian Amazon at USD 317 billion when considering these variables. This value is seven times greater than the value of all current forest exploitation (Hanusch, 2023). Just considering this estimate for the Brazilian Amazon Forest, plus its estimated monetary value, the Amazonian GDP would be USD 1 trillion, ranking among the world's 20 largest economies, similar to the economy of Saudi Arabia.

Part of this value can be captured through sustainable business models that better exploit the region's productive vocation. The exploitation of Amazonian crops, through sustainable agriculture practices that do not require the devastation of the tropical forest nor demand excessive use of water and fertilizers, is possible. Examples include Amazonian crops like açai, cashew, and camu camu, which are highly valued in international markets, as well as cassava, which is highly nutritious and has the potential to meet the food needs of South American countries. Being endemic to the region, these crops thrive in an ideal environment. Sustainable fishing, respecting closed seasons and allowing for habitat recovery, is another alternative. Finally, tourism should be considered a viable development option.

If pre-Hispanic Amazonia could maintain populations equivalent to a fifth of the current population, a modern economy, integrated into international markets and technologically advanced, should be able to provide a livelihood for the inhabitants of the 21st century Amazon. In other words, it is possible to improve the tools necessary for local populations to lead new production processes, combining local knowledge with innovation through simple and creative technologies.

This effort would require strategic investments in infrastructure, such as roads, electricity, and telecommunications. These investments would help connect the region to the rest of the world and create economic opportunities. Additionally, governments must support the development of sustainable companies operating in the Amazon. These companies can help generate income for local communities and protect the environment. Finally, the effort should be accompanied by institutional strengthening and increased state presence. The governments of the Amazonian countries need to strengthen their institutions to enforce environmental laws and protect the rights of local communities.

However, it is also true that much of the Amazon's value cannot be monetized through market mechanisms. Part of this value corresponds to externalities and public goods, concepts associated with market failures. A market failure is something that can be corrected with targeted public intervention. However, the scope of the environmental services offered by an ecosystem, like the Amazon, turns this system into a global public good (Mazzucato, 2023).

In principle, the management of a public good can be carried out by a government, but in the case of a global public good, there are no institutions capable of managing its protection, conservation, or the

distribution of economic benefits. In this context, the externalities and public goods associated with the Amazon are structural failures that are impossible to correct with targeted interventions. For example, it could be argued that the creation of a carbon emissions market, along with the correct allocation of property rights of the tropical forest, would be sufficient to ensure optimal use of carbon sequestration services. However, as a global public good, the reality is that this effort exceeds the institutional capacities of national governments, requiring supranational institutions to manage these markets and property rights. This necessitates a profound restructuring of economic institutions (Mazzucato & Penna, 2016).

The New Economy of the Amazon (NEA), an initiative of the World Resources Institute (WRI) in partnership with Brazilian research institutions, recognizes that sustainable economic and social development in the region requires profound changes in the economy. The NEA implies restricting emissions in line with the goals of the Paris Agreement, as well as achieving a zero-deforestation target, combining land use optimization and changes in the energy matrix to support the decarbonization of the economy. A central element of the NEA is the concept of bioeconomy, defined by the OECD as an economic system that relies on the sustainable use of biological resources, as well as technological advances that allow for greater efficiency and profitability, while ensuring the protection and preservation of natural ecosystems (OECD, 2018).

The size of the Amazonian bioeconomy must be adjusted to its biocapacity, developing from activities that respect the ecological balances essential for the health of the forest and rivers, on which the population depends. This bioeconomy already exists but remains partially hidden in national accounts due to its high informality and the inadequacy of official methods to capture its value. The total investment required to finance the transition towards the NEA is estimated at USD 525 billion until 2050. This would represent annual investments equivalent to approximately 4.5% of Brazil's GDP. The implementation of the NEA requires collaboration between the public sector, exercising its allocation and distribution functions to guide the economy, and the private sector, contributing its capacity for innovation and playing a key role in driving this new economy (Nobre, 2023).

Finally, the NEA calls for prioritizing a bioeconomy in indigenous territories that is led by native peoples, implementing actions that foresee knowledge exchange, technical-financial support, valuing traditional knowledge, and involving their political representation. Indigenous peoples should lead the planning and operationalization of the productive chains, from production to marketing, based on the needs of their communities.

5. A sustainable future for all

The Amazon is the outcome of both natural history and the people who inhabit it. However, geography is not destiny, and just as the region was once a sea, it now risks becoming a desert. Deforestation and biodiversity loss are the greatest threats facing South American countries, with impacts that extend far

beyond the borders of the Amazonian nations. The majestic tropical forest is the driver of a delicate natural cycle that transports moisture from the Atlantic deep into South America, nourishing an entire continent. The plains of Venezuela, the fertile valleys of Colombia, the Brazilian savanna, and the Argentine pampas owe their existence to the Amazon. Globally, solving the climate crisis demands a healthy Amazon.

Yet, conservation cannot be considered without considering the well-being of the people living in the region. If the Amazon was able to sustain civilizations centuries ago while maintaining its delicate balances, there is no reason to think that this is beyond our reach, with our technology and knowledge. Imagining the Amazon as an uninhabited space, detached from human action, is a mistake. The conservation of the Amazon ecosystem demands a sustainable bioeconomy capable of providing a viable livelihood for its inhabitants.

Just as the Solimões/Amazon River changed its course millions of years ago, today it is within our power to change the course in the development of its people. It is imperative to rethink the Amazon for its true value, for its contribution to maintaining global environmental balance, as a fundamental component for the prosperity of South America, and as a sustainable means of livelihood for its inhabitants, particularly indigenous peoples.

A prosperous and sustainable Amazon is not just a dream or an idealistic goal; it is an imperative necessity and a real possibility. The puzzle between development and sustainability in the Amazon is shared by all regions of Latin America, from the deserts and jungles of Mexico to the glaciers of Patagonia. Every action we take, big or small, every policy implemented, every innovation, and every alliance formed, can be a step towards a future where the Amazon continues to be the 'lung of the world'. The Amazon is a shared heritage of Latin America and the world. Its conservation is essential for the well-being of present and future generations. It is time to act to ensure a sustainable future for this natural treasure.

Disclaimer: This manuscript was originally written in Spanish. It has been translated and proofread using ChatGPT-4. The final manuscript was also reviewed by the authors.

6. References

- [1] Chen, J., Gao, M., Cheng, S., Hou, W., Song, M., Liu, X., & Liu, Y. (2022). Global 1 km× 1 km gridded revised real gross domestic product and electricity consumption during 1992–2019 based on calibrated nighttime light data. *Scientific Data*, 9(1), 202.
- [2] Costa, J.B. Sena, Bemerguy, Ruth Léa, Hasui, Yociteru, & Borges, Maurício da Silva. (2001). Tectonics and paleogeography along the Amazon River. *Journal of South American Earth Sciences*, 14(4), 335–347.
- [3] De Souza, J. G., Schaan, D. P., Robinson, M., Barbosa, A. D., Aragão, L. E., Marimon Jr, B. H., ... & Iriarte, J. (2018). Pre-Columbian earth-builders settled along the entire southern rim of the Amazon. *Nature communications*, 9(1), 1125.
- [4] Ferrante, L., Getirana, A., Baccaro, F. B., Schöngart, J., Leonel, A. C. M., Gaiga, R., ... & Fearnside, P. M. (2023). Effects of Amazonian flying rivers on frog biodiversity and populations in the Atlantic Rainforest. *Conservation Biology*, e14033.
- [5] Freire, S., MacManus, K., Pesaresi, M., Doxsey-Whitfield, E., & Mills, J. (2016). Development of new open and free multi-temporal global population grids at 250 m resolution. In *Geospatial Data in a Changing World; Association of Geographic Information Laboratories in Europe (AGILE), AGILE 2016*.
- [6] Garcia, A. (2023). ¿Cuál es el río más caudaloso del mundo? iAgua. Retrieved from <https://www.iagua.es/respuestas/cual-es-rio-mas-caudaloso-mundo>
- [7] Garzon, W. (2013). Amazonia Bajo Presion. RAIS. Retrieved from <https://atlas2020.amazoniasocioambiental.org/posts/amazonia>
- [8] Gloor, E. (2017). The Amazon hydrological cycle: Past, present and future. University of Leeds. Retrieved from <https://environment.leeds.ac.uk/geography-research-ecology-global-change/dir-record/research-projects/1238/the-amazon-hydrological-cycle-past-present-and-future>
- [9] Goldstein, P., Freeman, T., Rueda Sanz, A., Gadgin Matha, S., Bui, N. T. N., Rao, N., ... & Bustos, S. (2023). The Connectivity Trap: Stuck between the Forest and Shared Prosperity in the Colombian Amazon. CID Research Fellows and Graduate Student Working Paper Series. Retrieved from <https://growthlab.hks.harvard.edu/publications/connectivity-trap-stuck-between-forest-and-shared-prosperity-colombian-amazon>
- [10] Hanusch, M. (Ed.). (2023). A Balancing Act for Brazil's Amazonian States: An Economic Memorandum. World Bank Publications. Retrieved from <https://www.worldbank.org/en/country/brazil/publication/brazil-a-balancing-act-for-amazonian-states-report>
- [11] Hausmann, R., Santos, M. Á., Tudela Pye, J., Li, Y., & Grisanti, A. (2020). La riqueza escondida de Loreto: Análisis de complejidad económica y oportunidades de diversificación productiva. CID Working Paper Series. Retrieved from <https://www.hks.harvard.edu/sites/default/files/centers/cid/files/publications/faculty-working-papers/2020-10-cid-wp-386-economic-complexity-loreto-es.pdf>
- [12] Haywood, A. (2023). Amazon deforestation and climate change. National Geographic. Retrieved from <https://education.nationalgeographic.org/resource/amazon-deforestation-and-climate-change/>

- [13] Iriarte, J., Elliott, S., Maezumi, S. Y., Alves, D., Gonda, R., Robinson, M., ... & Handley, J. (2020). The origins of Amazonian landscapes: Plant cultivation, domestication and the spread of food production in tropical South America. *Quaternary Science Reviews*, 248, 106582.
- [14] Mapes, R. W. (2009). Past and present provenance of the Amazon River (Doctoral dissertation). The University of North Carolina at Chapel Hill.
- [15] Marengo, J. A. (2006). On the hydrological cycle of the Amazon Basin: A historical review and current state-of-the-art. *Revista brasileira de meteorologia*, 21(3), 1-19.
- [16] Mazzucato, M. (2023). Governing the economics of the common good: From correcting market failures to shaping collective goals. *Journal of Economic Policy Reform*, 1-24.
- [17] Mazzucato, M., & Penna, C. (2016). Beyond market failures: the market creating and shaping roles of national development banks. *Journal of Economic Policy Reform*, 19(4), 305-326.
- [18] Messer, A. E. (2020). Amazonian crops domesticated 10,000 years ago. Penn State. Retrieved from <https://www.psu.edu/news/research/story/amazonian-crops-domesticated-10000-years-ago/>
- [19] Nobre, C.A. (2023). O Futuro Climático da Amazônia: Relatório de Avaliação Científica. Articulação Regional Amazônica. Retrieved from <http://www.pbmc.coppe.ufrj.br/documentos/futuro-climatico-da-amazonia.pdf>
- [20] Nobre, C.A., et al. (2023). Nova Economia da Amazônia. São Paulo: WRI Brasil. Retrieved from <https://www.wribrasil.org.br/nova-economia-da-amazonia>
- [21] OECD. (2018). The Bioeconomy to 2030: Designing a Policy Agenda. Retrieved from <https://www.oecd.org/sti/futures/long-termtechnologicalsocietalchallenges/thebioeconomyto2030designingapolicyagenda.htm>
- [22] Palace, M. W., McMichael, C. N., Braswell, B. H., Hagen, S. C., Bush, M. B., Neves, E., ... & Frohking, S. (2017). Ancient Amazonian populations left lasting impacts on forest structure. *Ecosphere*, 8.
- [23] Pimentel, E. T., & Hamza, V. M. (2011). Indications of an underground river beneath the Amazon River: inferences from results of geothermal studies. In 12th International Congress of the Brazilian Geophysical Society (pp. cp-264). European Association of Geoscientists & Engineers.
- [24] Prates, L., Politis, G.G., & Perez, S.I. (2020). Rapid radiation of humans in South America after the last glacial maximum: A radiocarbon-based study. *PloS one*, 15(7), e0236023.
- [25] Prümers, H., Betancourt, C. J., Iriarte, J., Robinson, M., & Schaich, M. (2022). Lidar reveals pre-Hispanic low-density urbanism in the Bolivian Amazon. *Nature*, 606(7913), 325-328.
- [26] Rapozo, P., da Silva, R. C., & Coutinho, T. de C. (2023). Dinâmicas dos Mercados Ilegais, Criminalidade e Representações Sobre a Violência: a cartografia dos conflitos na faixa de fronteira Brasil, Colômbia e Peru no estado do Amazonas. *Boletim de Análise Político-Institucional*, (36).
- [27] Rapozo, P., Silva, R. C., Coutinho, T. C. (2023). Dinâmicas dos Mercados Ilegais, Criminalidade e Representações Sobre a Violência: a cartografia dos conflitos na faixa de fronteira Brasil, Colômbia e Peru no estado do Amazonas. *Boletim de Análise Político-Institucional*, n. 36, dezembro.

- [28] Ross, E. (2017). Amazon rainforest was shaped by an ancient hunger for fruits and nuts. *Nature*. Retrieved from <https://www.nature.com/articles/nature.2017.21576.pdf>
- [29] Schiavina, M., Freire, S., Carioli, A., & MacManus, K. (2023). GHS-POP R2023A - GHS population grid multitemporal (1975-2030). European Commission, Joint Research Centre (JRC). Retrieved from: <http://data.europa.eu/89h/2ff68a52-5b5b-4a22-8f40-c41da8332cfe>
- [30] Schor, T. (2023). Biodiversidad, Desarrollo e Inclusión en la Amazonía. Banco Interamericano de Desarrollo. Retrieved from <https://blogs.iadb.org/sostenibilidad/es/biodiversidad-desarrollo-e-inclusion-en-la-amazonia/>
- [31] Smith, M. E. (1997). Life in the Provinces of the Aztec Empire. *Scientific American*, 277(3), 76-83.
- [32] WHO. (2022). Valuing Health for All: Rethinking and building a whole-of-society approach - The WHO Council on the Economics of Health for all - Council Brief No. 3. WHO Economic Council Health for All. Retrieved from <https://www.who.int/publications/m/item/valuing-health-for-all-rethinking-and-building-a-whole-of-society-approach---the-who-council-on-the-economics-of-health-for-all---council-brief-no.-3>
- [33] WWF. (2023a). Inside the Amazon. Retrieved August 22, 2023, from https://wwf.panda.org/discover/knowledge_hub/where_we_work/amazon/about_the_amazon/
- [34] WWF. (2023b). Mechanized Agriculture: Replacing the forest with plantations. Retrieved from https://wwf.panda.org/discover/knowledge_hub/where_we_work/amazon/amazon_threats/mechanized_agriculture/
- [35] WWF. (2023c). Amazon has more than 4,000 illegal mining sites, shows ACTO study with WWF-Brazil. Retrieved from https://www.wwf.org.br/nossosconteudos/notas_e_releases/english/?86681/Amazon-has-more-than-4000-illegal-mining-sites-shows-ACTO-study-with-WWF-Brazil#:~:text=A%20survey%20produced%20by%20WWF,dumped%20in%20the%20Brazilian%20Amazon