

Considerations for science and technology policies in the context of Amazon sustainability

Considerações para as políticas de Ciência e Tecnologia no contexto da sustentabilidade da Amazônia

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ABSTRACT

This paper presents a brief overview of Science and Technology in the Amazon from a regional perspective. We discuss the role of universities, scientific and technological institutions, and centres of knowledge, and we elaborate on the challenges of mobilising these institutions for sustainable territorial development, considering some territorial attributes and regional actors. For this purpose, we used national data and indicators of postgraduate studies, investments, and geographical distribution of Public Teaching and Research Institutions in the Amazon. Finally, we present paths for developing a regional Science and Technology strategy. We conclude that, despite considerable advances in recent decades, we still face a reality of insignificant investments in the region. It is imperative to have a

project that incorporates Science, Technology, and Innovation into productive dynamics capable of shaping a new development model in the Brazilian Amazon.

Keywords: Amazon. Regional development. Science and Technology in the Amazon. Territorial Development.

RESUMO

O artigo apresenta um breve panorama da Ciência e Tecnologia na Amazônia em uma perspectiva regional, discute o papel das universidades, instituições científicas e tecnológicas e centros de saberes, e discorre sobre os desafios para a mobilização dessas instituições para o desenvolvimento territorial sustentável, considerando alguns atributos territoriais e atores regionais. Para tanto, foram utilizados dados e indicadores nacionais da pós-graduação, investimentos e distribuição geográfica das instituições públicas de ensino e pesquisa na Amazônia e, ao final, são apresentados caminhos para o desenvolvimento de uma estratégia regional de Ciência e Tecnologia. Conclui-se que, apesar do considerável avanço nas últimas décadas, ainda se tem uma realidade de investimentos inexpressivos na região e que é imperativo um projeto que incorpore Ciência, Tecnologia e Inovação às dinâmicas produtivas, capazes de conformar um novo modelo de desenvolvimento na Amazônia brasileira.

Palavras-chave: Amazônia. Desenvolvimento regional. Ciência e Tecnologia na Amazônia. Desenvolvimento territorial.

1 INTRODUCTION

The expansion of the agricultural and economic frontier into the Amazon, presented as a project of national integration associated with the ideology of progress and development during the Military Dictatorship in the 1960s, was the response of both national and international capital, coordinated with the Brazilian state, to the new dynamics of the world system (Castro, 2010). The development model, devoid of adherence to territorialities and the traditional peoples and communities of the Region but integrated into the space of globalisation through an enclave economy, from mining to agribusiness – including soybeans, livestock, black pepper, eucalyptus, and oil palm, among others – persists. The construction of transportation, energy, and communication infrastructure, carrying human, ecological, economic, and cultural impacts, adapted the Amazon to capitalist objectives throughout the second half of the 20th century (Silva, 1999).

The expansion of extractive activities such as large-scale mining and agricultural projects, and in the western part of the Amazon, the promotion of subsidised industrialisation in the Manaus Free Trade Zone, promoted new urbanisation dynamics in the Region (Sathler *et al.*, 2009). It intensified an unprecedented trajectory of conflicts between these capital interests and local populations, including indigenous peoples, quilombolas, squatters, and traditional populations.

From a critical perspective of this model, this article reflects on strategies for promoting Science and Technology, starting from the realisation that these capital-carrying dynamics to the central regions of capitalism in Brazil and the world have not yet internalised, on a scale, the fruits of knowledge enough to generate sustainable socioeconomic dynamics and the provision of quality public services in the Region. On the contrary, the integration of the Amazon into national and global capital dynamics has sharpened social inequalities. This work focuses its analysis on the inequality of investments in Science and Technology, considering that the economic enclaves of the development model implemented in the Amazon have shown little capacity to produce and disseminate knowledge for the protection and sustainable use of natural resources (Becker; Stenner, 2008).

Quality education and research are fundamental to enable universal access to housing, clean energy, mobility, sanitation, security, internet, productive development, and job and income generation in an

innovative and lasting manner. As such, they are structural elements to generate innovative, productive dynamics, territorialised, that optimise the use of natural resources (Becker, 2010) from the perspective of the six axes of the ongoing Federal Government's ecological transformation plan: (i) sustainable finance; (ii) technological deepening; (iii) bioeconomy; (iv) energy transition; (v) circular economy; and (vi) infrastructure and climate adaptation (Brazil, 2023).

The institutional framework of Science, Technology, and Innovation (ST&I) plays a crucial role in consolidating the capacity of Amazonian territories to offer products, processes, and services. This dimension is essential for promoting sustainable development with endogenous and lasting bases, significantly contributing to regional development strategies (Monteiro, 2010). Due to the cultural diversity, size, peculiarities, and increasing fragility of the ecosystems in the world's largest tropical forest, Higher Education Institutions (HEIs) and Scientific and Technological Institutions (STIs) in the region should be the guiding element for planning and implementing public policies in the Amazon (Candotti *et al.*, 2023).

The Ministries of Science and Technology (in Portuguese, MCTI) and Education (in Portuguese, MEC) in Brazil have been responsible for the policy and management of Science, Technology, and Innovation (ST&I). They have focused on horizontally promoting research and personnel training through agencies such as the National Council for Scientific and Technological Development (CNPq), the Financing Agency for Studies and Projects (Finep), and the Coordination for the Improvement of Higher Education Personnel (Capes). The policy developed by these entities, particularly between 2005 and 2014, aimed to strengthen existing Higher Education Institutions (HEIs) and Scientific and Technological Institutions (STIs). It also aimed to establish new teaching and research units in the Legal Amazon region and expand campuses in rural areas. This initiative resulted in the creation of an unprecedented educational, scientific, and technological infrastructure in the region, supported by substantial investments (Candotti, 2023b).

However, this virtuous cycle, which also brought about the inclusion of indigenous peoples, quilombolas, and students from the poorest segments of the population through the Affirmative Action Law (Law 12.711/2012), was abruptly interrupted in 2016 with the Constitutional Amendment n 95 establishing a spending cap. Between 2005 and 2015, new universities and federal institutes were built, campuses expanded to medium-sized municipalities in the Amazon, teaching and research laboratories constructed in rural areas, and undergraduate and graduate courses diversified. However, the investments made to train qualified human capital have not yet been able to develop local productive forces on a sustainable basis. One reason for this gap is that qualified professionals have not been integrated into retention policies in their municipalities and regions, and the knowledge produced by HEIs and STIs is not integrated into the social demands of municipal governments, social organisations, and local productive processes managed by associations and cooperatives (Candotti *et al.*, 2023).

This scenario raises the issue that educational and research institutions and centres of regional knowledge and expertise have not yet been able to fully contribute to regional development or integrate into national government policies, with a leading role in formulating and implementing those policies. This process of alienation, inherited from colonial times, wherein external economic and political agents think, plan, and execute qualified services (Gonçalves, 2015) in the region, reproduces the abysmal gap of inequalities reflected in all spheres of economic and social life in the Amazon, making it vulnerable to attacks from backward sectors of the agrarian and mineral economy integrated into national and global chains.

2 METHODOLOGY

The initial references for this article were gathered from the coordination of the Amazon Working Group of the Council for Sustainable Economic and Social Development (CDESS/Secretariat of Institutional

Relations), led by Professor Ennio Candotti. Candotti's contributions and his thesis on strengthening Amazonian institutions of S&T, ICTs, and HEIs, and the necessary direct involvement of the large contingent of graduates and postgraduates from the region in the effort to promote economies and social well-being, with conservation and value addition of material and immaterial aspects of the Amazon, are fully reproduced in this article. Ennio's academic contribution and leadership within the Brazilian scientific community and the Amazon have witnessed that knowledge integrated with territorial demands provides consistent advancements in collective practices and visions for paradigm shifts in development.

In order to reflect on the considerations presented to the CDESS by Candotti, a survey of national postgraduate indicators was conducted, allowing us to assess the inequalities in investment in Science and Technology when comparing the Amazon with other regions. For example, the concentration areas of postgraduate courses, the number of graduated students, and the production of scientific articles were analysed. The geographic distribution of ICTs in the Region and investments in public HEIs in the Amazon were also examined, aiming to outline a brief overview of the challenges for mobilising HEIs and ICTs in a strategy aimed at reducing inequalities as a regional development policy on territorial bases, addressing their specificities and multiple scales.

A selected bibliography on regional development and disparities in scientific and technological infrastructure among regions was consulted. Institutional portals of the federal government containing public information were digitally collected, especially from the Coordination for the Improvement of Higher Education Personnel (Capes), to organise quantitative data illustrating this work, which were organised into tables and graphs and served as inputs for outlining this brief overview of ST&I in the Amazon.

Finally, recommendations are presented for the integration of the Amazon into the national plan for ecological transformation, which aims to change the foundations of Brazilian industrial production towards a sustainable matrix, with Bioeconomy among its main lines. Additionally, proposals are put forward that relate reducing social inequalities to strengthening and activating higher education and technological formation systems and scientific development, integrated into sustainable territorial development in a broad sense.

3 INEQUALITIES IN SCIENCE AND TECHNOLOGY

The Military Dictatorship organised the occupation of the Amazon for the benefit of large national and international capital through growth poles implemented with tax benefits and financing provided by a framework of policies and institutionalities implemented by Sudam (Superintendence for the Development of the Amazon) and the Bank of the Amazon (Basa). Activities considered potential for economic growth in the region were "livestock, agriculture, plant, mineral, and animal extraction, and industry" (Sudam, 2019).

The implementation of the policies of the military governments was influenced, among other factors, by the theory of poles by François Perroux, a French economist, which proposed inducing growth through the allocation of resources to activities with recognised regional comparative advantages capable of radiating development and altering rural and urban dynamics:

Thus, they were anchored in a vision of regional development based on the need for spatial concentration of capital, capable of producing imbalances, and, as a result of these indirect development processes through the emergence of a chain of forward and backward linkages of productive activities considered "key" (Monteiro, 2005).

Nearly sixty years later, the development of the Amazon is still dependent on the dynamics derived from these poles, whether from the industrial one of the Manaus Free Trade Zone, created in 1967, or

from the Agribusiness, Agrominerals, and Forest poles, as described by the Polamazônia program of 1974, which advanced over the forests, soils, and subsoils of the Amazon in this period. The mineral economy, with highlights such as Carajás, Trombetas, and Amapá, has seen a dizzying advancement since the publication of the Brazilian Mineral Yearbook I in 1972.

This model promoted the growth of agricultural activities in the Amazon and regional specialisation in the export of raw materials, led by enterprises that operate as enclaves, more or less intensive in technologies and innovations but incapable of transferring knowledge and well-being to local populations. On the contrary, it led to the territorial expropriation of small family producers, indigenous peoples, quilombolas, and other traditional peoples, normalised by new state legislative and administrative instruments, such as, for example, in 1971, which established the Union's domain over unoccupied lands within 100 km along federal highways. The new public policies shaped state intervention according to the different territorial arrangements required during the international division of labour and the needs of large capitals, especially agribusiness and mining monopolies.

Science in the Amazon was originally linked to the interests of global geopolitics and the national state in the exploitation of the region's natural resources, from research to improve extractive and agricultural production to providing adequate sanitary conditions for the economic extraction of resources and the construction of infrastructures that would enable enterprises to compete in the international market (Nonato; Pereira, 2013). The region's new role as a frontier for exporting natural products conferred upon it the "character of a 'scientific frontier,' that is, a socioterritorial unit capable of being incorporated within a State project that takes it as a challenge for knowledge" (Faulhaber, 2005, p.241). The author refers to Arthur César Ferreira Reis's Report of 1956, which draws the Brazilian state's attention to the fact that the Amazon is "a world to be discovered and identified."

The first public scientific institutions established in the Amazon were the Emílio Goeldi Paraense Museum, still in the 19th century, followed in the 20th century by the School of Pharmacy of Pará; the Faculty of Dentistry, Medicine, and Surgery of Pará; the School of Engineering of Pará, the Evandro Chagas Institute; the Agronomic Institute of the North, and the School of Agronomy of the Amazon. In the 1950s, influenced by the post-war technological race, the National Institute of Amazonian Research and the Federal University of Pará were created (Nonato; Pereira, 2013).

In the 1960s and 70s, the Federal Universities of Amazonas, Maranhão, and Acre were inaugurated. The Free University School of Manaus (1909) and the University of Manaus (1913) are considered the first universities in Brazil in the History of Ufam. Between the years of foundation or reestablishment, from the 1950s to the 1990s, the growth of these institutions was inertial.

During the 2000s, there was a significant effort to decentralise universities that, in the previous period, were restricted to the main capitals of the Region, Belém and Manaus. Today, the nine states of Legal Amazonia gather in 160 of its municipalities, 300 campuses of Federal Universities, Federal Institutes of Higher Education, and public Institutes of Science and Technology (Almeida, 2023).

There have been many significant advances in teaching, research, and development in the last twenty years and technologies kept within institutions or published in specialised media. However, the knowledge produced in the Amazon has not yet been able to change the regional development model broadly and systemically. There are several products, processes, and biodiversity value chains benefiting from innovations originating in local scientific institutions; however, these initiatives have not shown the strength to influence a shift away from the primacy of the primary-exporter model as a drain on natural resources and the flows of public and private investments directed to the Region. Similarly, knowledge and technologies for management, production, and processing of products generated by public research have not yet been the subject of diffusion and extension capable of promoting innovations and economic and social dynamics with an impact on reducing inequalities among local populations.

Not only in the Amazon but throughout Brazil, the profile of Brazilian science has undergone a major transformation in recent decades. On one hand, there has been a considerable increase in national scientific production linked to the vertiginous growth of postgraduate education in the last 20 years (Schwartzman, 2022). However, this growth is still marked by significant inequality among the five regions.

The availability of higher education courses in the North region¹ is proportionally much lower when compared to the Southeast region, for example. In 2022, there were 387 courses offered in the North region, representing only 12% of the 3,181 courses offered in the Southeast region (Brazil, 2024). Additionally, there is a pronounced shortage of Exact and Earth Sciences and Engineering postgraduate programs, representing only 13% of the courses offered in the North region (Figure 1) (Brazil, 2024). This situation limits the possibility for young people to choose careers in these areas. For instance, there are only two Botany programs and two Geology programs, and out of the more than sixty units of Embrapa, only nine are located in the Amazon. The budget for these units, along with 26 stations and nuclei of the Company, in 2022 was R\$480 million, 15.4% of Embrapa’s global budget, which was R\$3.1 billion in the same year (Candotti, 2023a).

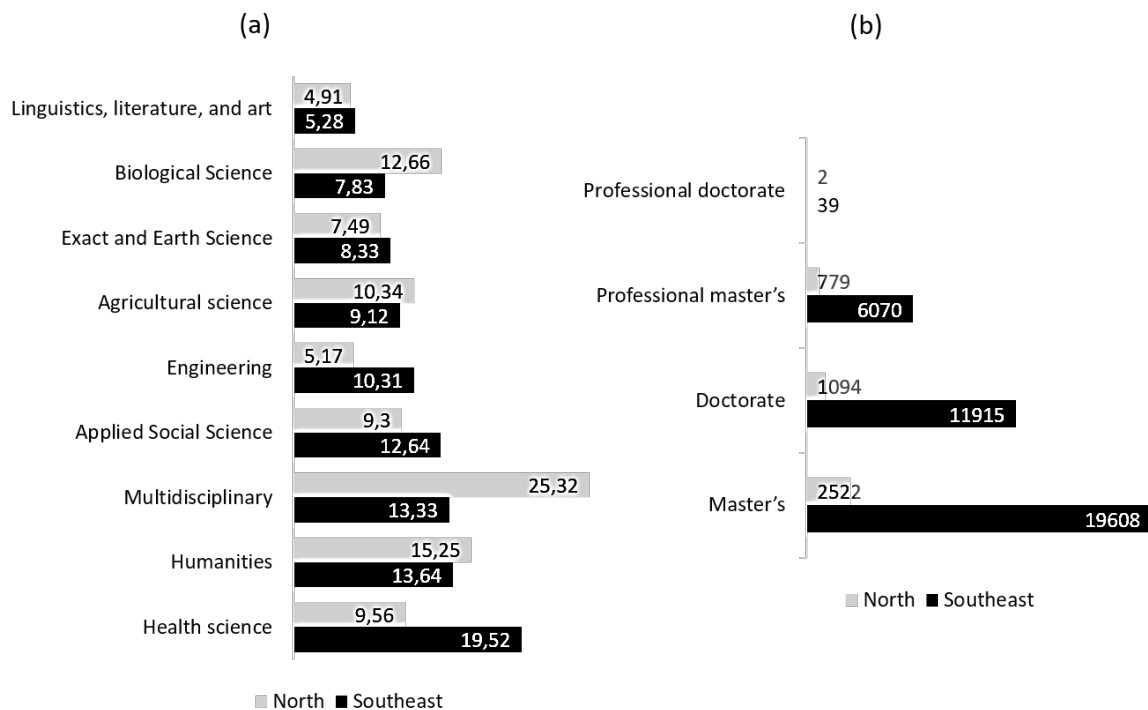


Figure 1 – (a) Percentage of postgraduate courses by major areas - North and Southeast regions; (b) Graduates by academic degree in the North and Southeast regions

Source: Brazil (2024). Authors’ elaboration.

In the same year, in the North region, 4,397 students were awarded degrees, including masters and doctors, about 19 masters and 4.5 doctors per 100,000 inhabitants, just over 10% of those awarded in the Southeast region, which totalled 37,632 postgraduates, 30 masters, and 14 doctors per 100,000 inhabitants (Figure 1b).

The qualifications of researchers, the availability of courses, and the scientific and technological infrastructure reflect regional scientific production’s performance. While in the Southeast, there were 16 publications of articles in journals or magazines per 100,000 inhabitants, in the North region, this indicator reached only 5 publications (Brazil, 2024).

Considering the criteria of the main Research and Development (R&D) calls, these distortions penalise the allocation of resources for the Amazon and reduce the capacity of regional ICTs to compete with those of the Southeast-South, and consequently isolate the knowledge about the region in institutions outside its territory, with low involvement of Amazonian society. This is a problem that historically repeats itself with the place of the Amazon in Brazil's development, that is, a logic of the region being seen in a reductionist way as a stock of raw materials, with a predominance of commodity exports (Monteiro, 2021). An expectation is projected for the Amazon to resolve the enormous problems caused by the imbalances of sixty years of a model that destabilised its socio-environmental conditions with its own means in conditions where the inequality of all economic, social, and infrastructure factors are not considered.

Indeed, in recent years, few policies have advanced in the effort to consider the territorialities and specificities of the region, among them health, special selection processes for indigenous and quilombola peoples, tropical research and health programs from Fiocruz, network doctorates like Bionorte, among other successful efforts.

At the heart of the issue is how to treat unequal things as unequal. This is the guideline that guided Celso Furtado's formulations about the Northeast and elevated regional development planning policies in Brazil to a higher level. To the historical construction of regional asymmetries inherited from the colonial period and the way we constituted ourselves as Empire and Republic, Furtado (2013a) associated the Brazilian industrialisation policy, driven by strong political centralism, since Getúlio Vargas, which shaped the division of labour in the country, between an industrialised Center-South and the other regions producing raw materials, subordinate to it.

This diagnosis marked a disruptive change of course led by Celso Furtado, taking Sudene from Rio de Janeiro to the Northeast and, from there, redesigning regional policies based on territorialised studies and human capital (Theodoro, 2020). The clash of interests faced by Celso Furtado in the course of building policies that would withdraw control of federal resources from the northeastern oligarchies and give these resources a social and economic purpose of reducing structural inequalities was a new approach in the conception of macro public policies, guided by the need for regionalisation radicalisation.

Already in the 2000s, reflecting on what the author called the "Metamorphoses of Capitalism," he denounced the increasingly greater income disparities between peripheral and central countries and the emergence of "a time of great enrichment of humanity and, at the same time, of aggravation of the misery of a broad majority" (Furtado, 2013b, p. 452). To face these trends increasingly associated with the capitalist accumulation process, Furtado indicated strategic thinking about the future and its possibilities:

More than ever, the new challenges will be of a social nature, and not mainly economic, as occurred in previous phases of capitalist development. Political imagination will thus have to take precedence. It is wrong to pretend that there is no longer room for utopia. This is the greatest challenge facing the new generation; I invite them to take it on without fear. (Furtado, 2013, p. 457)

Over these sixty years, the Amazon has not benefited from policies commensurate with its social, environmental, and economic challenges. Income transfer programs like Bolsa Família, housing programs like Minha Casa Minha Vida, have had emancipatory impacts on the most vulnerable families. However, the program with the most structural impact was the University Restructuring Program (Reuni), with the creation of two Federal Universities in the interior of the state of Pará² and the expansion of campuses to municipalities with more than 50,000 inhabitants. In the wake of these investments, there was also a multiplication of interiorised Technological Institutes and State Universities campuses.

It is important to note that, over the past sixty years, regional development policies for the Amazon have not had a structural character of reducing inequalities with a social component, as in the Northeast, with specificities aimed at the region benefiting from industrial deconcentration that occurred from

the 1980s onwards. Along with industrialisation, universities in the Northeast followed this dynamism, expanding their formative spectrums and thus integrating themselves into the country's knowledge system at higher levels (Bacelar, 2014).

A recent study by Elsevier reported in the press (Yamamoto, 2023) identified that Brazilian universities and research centres were the main contributors to publications on the Amazon, made between 2012 and 2021 and that the University of São Paulo (USP) is the institution that publishes the most about the region, with over four thousand articles in the period. In second, third, and fourth places are the Federal University of Pará (UFPA), the National Institute of Amazon Research (Inpa), and the Federal University of Amazonas (Ufam), based in Pará and Amazonas.

However, academic rankings must consider the sizes of the institutions. In this case, when considering the publication/researcher indicator in relation to the number of publications, the results would be very different: "the productivity of Amazonian institutions is much higher (about three articles published per person in the period from 2012 to 2022) compared to any Brazilian University (less than one article per person in the same period)" (Pedro Pequeno, personal communication). Having profiles and focus on regional issues in their various themes and contexts, even with very limited resources, researchers from Amazonian institutions continue to maintain their productivity. With more doctors, masters, and research resources, Amazonian institutions would significantly increase scientific production and, more than that, grow in the impact of knowledge on human, economic, and environmental development in the region.

A recent study on the distribution of funding and scholarships from CNPq and Capes in Brazil for biodiversity studies (Stegmann *et al.*, 2024) highlights that, although per capita allocation is equitable between regions, aspects such as the geographical dimension and ecological relevance of the Brazilian Amazon must be considered. In the North region, 1.5 times more researchers are working on biodiversity programs than in the Southeast region, a scenario that reverses when it comes to resource distribution. While the Southeast region received about US\$ 2 per km² to finance biodiversity research through CNPq's Universal call, the North region received US\$ 0.13. This deficit in research investment is incompatible with the hyper-diversity of the forest valorisation strategy through technological enhancement.

The numbers mentioned here demonstrate high productivity per researcher, even in adverse situations of infrastructure, continental geographic distances, and discontinuity in research funding. This means that the insertion of these researchers into the ST&I environment, even with adversities, makes research cheaper than for external researchers and their insertion into the territorial realities in which they study.

4 THE ROLE OF UNIVERSITIES, SCIENTIFIC AND TECHNOLOGICAL INSTITUTIONS, AND CENTERS OF KNOWLEDGE

Despite the unfavourable investment scenario compared to other regions of the country, since 2005, Amazonian Higher Education Institutions have graduated an unprecedented number of professionals, more than doubling the number of master's degrees and quadrupling the number of doctoral degrees (Almeida, 2023). The educational, scientific, and technological infrastructure responsible for these results is present in 166 municipalities, where there are 330 campuses linked to 34 research institutes and public federal and state universities, as well as other scientific institutions (Almeida, 2023).

The expansion of Higher Education and Science, Technology, and Environment Institutes to the interior of the Amazon and beyond was a political guideline of the Lula and Dilma governments³. These institutions now employ hundreds of professionals, graduates, masters, and doctors who are educating thousands of young people from urban and rural peripheries and forest peoples.

Moreover, these institutions play a fundamental economic role for the municipalities where they are located by directing a significant flow of public resources to these cities, such as the R\$ 7.6 billion budgeted for 2024 in the North region. These resources are extremely significant, as can be observed when comparing these values with municipal budgets. With the exception of Belém and Manaus, which are atypical cases because the resources received by the federal universities of Pará and Amazonas are redistributed to several campuses within these states, the dimension of the financial contribution of HEIs can be assessed by their budgets. In this regard, in at least five capitals of the Region: Macapá, Rio Branco, Boa Vista, Porto Velho, and Palmas, the budgets of Higher Education Institutions correspond, on average, to 26% of municipal budgets, as detailed in Table 1.

Table 1 – Higher Education Institutions (HEIs) - Financial contribution to the municipality seats in absolute values and relative to the public budgets of each municipality seat (Current values in R\$ millions of 2024)

Municipality seat	Universities and Federal Institutions	Budget of HEIs		Budget of the municipality seat (B)	(A/B) %
		By institution	By municipality seat (A)		
Belém	Universidade Federal do Pará	1.802,30		5.300,00	51,7
	Instituto Federal do Pará	626,94	2.740,03		
	Universidade Federal Rural da Amazônia	310,8			
Santarém	Universidade Federal do Oeste do Pará	243,92	243,92	1.804,55	13,52
Marabá	Universidade Federal do Sul e Sudeste do Pará	174,05	174,05	1.996,17	8,72
Manaus	Fundação Universidade do Amazonas	974,66	1.438,96	9.088,00	15,83
	Instituto Federal do Amazonas	464,3			
Macapá	Universidade Federal do Amapá	288,96	418,09	1.620,91	25,79
	Instituto Federal do Amapá	129,13			
Rio Branco	Universidade Federal do Acre	441,46	605,73	2.231,59	27,14
	Instituto Federal do Acre	164,27			
Boa Vista	Fundação Universidade Federal de Roraima	301,83	472,01	2.452,36	19,25
	Instituto Federal de Roraima	170,18			
Porto Velho	Universidade Federal de Rondônia	368,99	718,13	2.640,86	27,19
	Instituto Federal de Rondônia	349,13			
Palmas	Fundação Universidade Federal do Tocantins - Palmas	381,46	694,47	2.291,00	30,31
	Instituto Federal de Tocantins	313,01			
Araguaína	Universidade Federal do Norte de Tocantins	116,53	116,53	1.120,99	10,39
	TOTAL	7.621,92	7.621,92	30.546,43	24,57

Source: <https://portaldatransparencia.gov.br/>. Annual Budget Law (LOA, 2024) of the host municipalities. Accessed on 12/02/2024. Authors' elaboration.

According to Table 1, the institutions mentioned are located in capital and medium-sized cities. The potential of these institutions for promoting endogenous development is vast and multidimensional, especially if policies regarding Teaching, Research, and Extension are coordinated around common goals in each of the municipalities where they are located. For a more precise assessment of this potential, the scientific and technological infrastructure of other institutions should be included, such as Embrapa, which is present in all states of the Amazon and has 26 experimental campuses and various laboratories, including those for soil and plant physiology, agribusiness, fishery technology,

entomology, biological control, and animal and plant health, among many others, being an example of the possibilities open to interinstitutional territorial arrangements in the Amazon.

These numbers demonstrate that overcoming the relative lag of the Amazon in the country's scientific and technological race requires a bold and continuous plan to increase the capacity for training professionals at the undergraduate and graduate levels, associated with an increase in scholarships and other incentives for research development on a large scale, as well as mechanisms to encourage the retention of PhDs in the region (Monteiro; Albuquerque; Albuquerque, 2024).

Currently, however, it is observed that HEIs and ICTs could expand articulation and cooperation among themselves, coordinating their Institutional Development Plans (IDPs) with joint goals and strengthening strategies that encourage complementarity between these institutions, with more network projects, especially in graduate education and research. What prevails is a race that does not connect the knowledge generated in universities and ICTs with the relevant social processes for local and regional development, with the central axis being the ecosystem needs and territorial specificities (Monteiro, 2021).

Therefore, it becomes fundamental for the Brazilian government to continue the program of internalising education and research institutions in the Amazon, which is still heavily concentrated in the region's largest cities, with great potential to become increasingly widespread. In addition to the coordinated expansion, the profound challenges of Amazonian realities and diversities require continuous stimulus for internal cooperation among institutions. Their trained professionals can amplify the impact of knowledge production and Extension on productive processes, innovative social initiatives, and efficiency in implementing public policies emanating from state and national governments.

The network of protected areas in the Amazon, including Indigenous Lands and Conservation Units (UCs) for sustainable use and integral protection at the three levels of government, covers 198 million hectares, equivalent to 47% of the biome's territory (MMA, 2023). About 28% are UCs, and 72%, or 115 million hectares, correspond to the extension of Indigenous Lands. On the other hand, the populations living in urban areas of the Amazon amount to 28 million inhabitants (IBGE, 2021), in a network of cities that grows without infrastructure and with low physical and telecommunications connectivity with other regions of the country.

The forms of occupation and land use in the Amazon are decisive for the development of the territorial strategy. A strategy for inducing good productive practices and protecting peoples and ecosystems can be successful if it starts with socioeconomic segments linked to the territories of agrarian reform settlements, extractive reserves, quilombola territories, Indigenous Lands, and riverine peoples of the Amazon. Increasing the productive and social efficiency of these territories is essential to protect areas that still hold forests (about 50% of the Amazon) and to stimulate other segments to choose sustainable production systems, as well as to add value to natural resources wasted or exported as commodities, which prevails in the current economic matrix of the Amazon.

To have an idea of the magnitude of the challenge, the number of Extractive Reserves (Resex) existing in Brazil from 1990 to 2019 reached 95 units, corresponding to an area of 15.5 million hectares, with 29 states (30.53%) and 66 federal (69.47%) reserves, with a population of over 60 thousand people (Brazil, 2020). Of these, 72 are continental Resex, and 23 are marine Resex, corresponding, respectively, to 1.38% of the national territory and 0.17% of the coastal area. In the Amazon biome, 80% of the Resex are located, representing 95% of the total area of these UCs (Euler; Silva; Almeida, 2021).

Figure 2 highlights the advancement of the agricultural frontier over the Amazon and the location of HEIs and ICTs that could be mobilised for research development with a strong identity with the needs of the territories, considering the impacts already consolidated, those in progress, and those projected in the medium and long term.

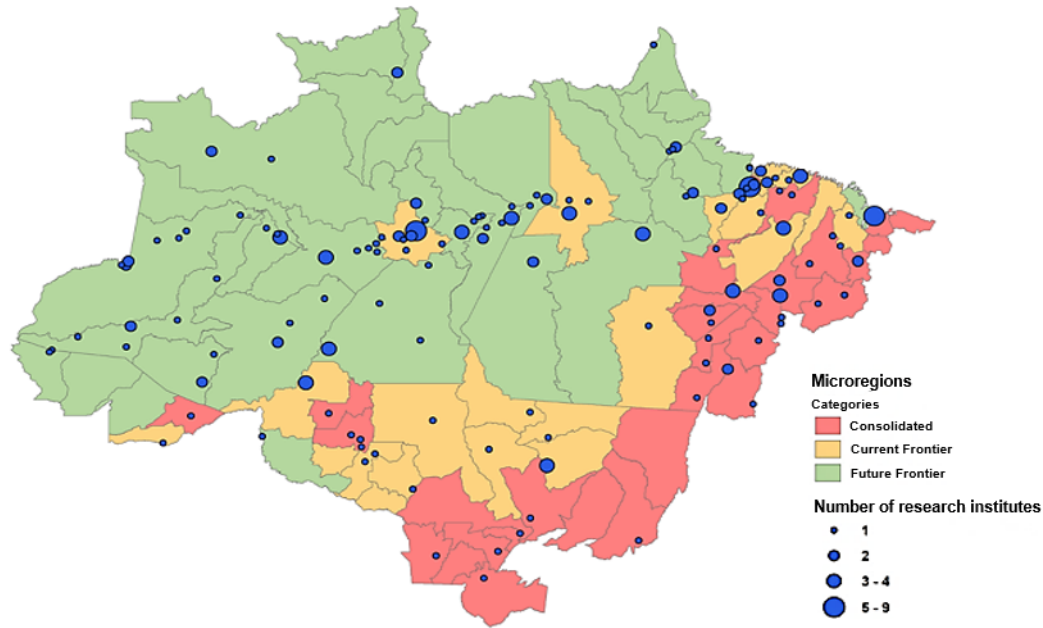


Figure 2 – Number of education and research institutions in microregions – agricultural frontier advancement

Prepared by: José Maria Cardoso da Silva and Ima Vieira (Unpublished data).

The Amazon biome comprises 85 microregions in different stages of economic frontier advancement, considering the percentage of native vegetation as follows: below 50% - consolidated; between 50-80% - current frontier; and above 80% - future frontier. These regions adhere to an occupation model based on the exploitation of natural resources and forest conversion, which implies biodiversity loss on a large scale (Vieira *et al.*, 2005; Vieira; Silva, 2024). An approach of bioeconomy as a solution to ensure “standing forests” requires strong governance, coordination, and integration with various sectors and social participation. This includes valuing regional human and social capital and the knowledge rooted in local communities (Vieira, 2023).

5 CHALLENGES FOR MOBILISING SCIENTIFIC INSTITUTIONS FOR REGIONAL DEVELOPMENT

The current contingent of qualified teachers and researchers in various fields of knowledge, such as Engineering, Botany, Sociology, Health, Law, Economics, Biotechnology, among dozens of other disciplines, “awaits to be summoned to participate as citizens, politicians, and professionals in the battle for respect for rights, environments, and diversity currently being waged in the Amazon”. (Candotti, 2023b, p.1).

Higher education institutions and research institutes in the Amazon mobilise intelligence and knowledge that occupy territories close to the fields where the battle for development, knowledge, and conservation is being fought. The qualified human resources of these institutions can and are interested in contributing to the definition of the modes of implementation of social, economic, scientific, and environmental policies determined by the government. This mobilisation of forces can be accompanied by another, which offers a training program for forest peoples in community centres and campuses of universities and Federal Institutes installed in the interior, enabling them to participate and earn income in efforts to effectively utilise natural products, reforestation, collection of forest products, and management of conservation units. In short, participating in programs that recognise the value of the botanical and social diversity of the forest.

Professor Ennio Candotti proposed as a guideline “strengthening community centres and campuses of public universities in the interior of the Amazon” to mobilise citizens and young people from the interior

and expand regional capacity in Sciences and in the execution of policies for the region and beyond, and facing the challenge of keeping qualified young people in the interior of the Amazon, allowing public policies to be guided by citizens who live in the region, in the countryside, in urban areas, in floodplains, and along the rivers for cultural, scientific, and sustainable economic development.

It is noted that from the seeds planted in 2005, we are harvesting important fruits for the development of the Amazon interior that can now help address the challenges posed by the devastations of recent years: in the last twenty years, the campuses of Federal and State Universities, Embrapa, and other Institutes, installed in the municipalities of the interior of the Amazon, have multiplied (Candotti, 2023b, p.1).

Ennio Candotti formulated a proposal, forwarded to the Council for Sustainable Economic and Social Development – CDESS, where he was a representative for the Amazon, for a scholarship program that guarantees a continuous training process in postgraduate studies, with the counterpart of providing services to federal, state, and municipal public bodies committed to local development consultations for sustainable territorial development.

In this sense, a Science, Technology, and Innovation System in the Amazon should be created, advised by a regional conference, to, among other things, outline a research agenda oriented towards local needs, as well as define strategic fields of knowledge with innovative potential for inclusive and sustainable regional development.

The proposed strategy for mobilising the capacities of ST&I installed in the interior of the Amazon and their articulation with the territorialisation of priority segments for the development proposed here: family farmers, indigenous peoples, populations of urban social and economic peripheries, quilombolas, extractivists, and fishermen, among other traditional peoples of the Region, can be made viable by a mix of research, extension, and continuing education scholarships and by government actions and programs and projects aimed at boosting sustainable solutions for the Amazon.

The idea is to territorialise the ST&I infrastructure, with the main agents of action being the graduates of educational and research institutions trained in the first wave of investments in higher education in the interior of the Amazon during the Lula and Dilma governments. From the perspective of innovation, the sense of systemic integration with social, cultural, and continuous productive modernisation processes is mentioned here (Cassiolato; Lastres, 2005). The authors converge on the understanding of this article concerning stimulating local and multi-scalar creativity.

...the relevance of incremental and radical innovations and the complementarity between them, as well as between organisational and technical innovations and their distinct internal and external sources (...). This, in turn, is seen as an organisation inserted in socio-economic and political environments that reflect specific trajectories. Thus, each case must be understood according to its peculiarities, its position, and its role in national and international contexts, in order to evaluate which strategy should be most appropriate for its development (Cassiolato; Lastres, 2005, p. 37).

The statement below, uttered by Professor Ennio Candotti in his efforts to be heard in the profusion of solutions for the Amazon, presented in the current context by multiple agents of the national and international scene, is mentioned here as a general recommendation:

The Amazon rainforest, its ecosystems, and diverse peoples attract worldwide ecological, cultural, and climatic attention. Its documented and consolidated knowledge cannot be neglected. The communities and associations living in the interior must actively participate in this mission of monitoring and research (Candotti *et al.*, 2023, p.3).

Next, we reproduce in full the proposals sent by Ennio Candotti, as notes for discussion at the Amazon Summit.

August Letter (suggestions from Ennio Candotti of the Museum of the Amazon)

When addressing Regional Integration, among the recurring themes is the challenge of how to promote an educational program committed to training and retaining young people - including young people from forest peoples - in the region, enabling them to master the art of knowing and sustainably exploring, with science, technology, experience, and traditional knowledge, the forest, the biodiversity and geodiversity of the lakes, surface waters, and groundwater of the Amazon.

To the goals of intensifying youth training, we must add the education and vocational training of farmers and fishermen, who live in the interior of the Amazon, allowing them to master agroforestry techniques, seed collection, pasture restoration, reforestation, and environmental monitoring as well as the management and use of fishery resources.

In Brazil, we propose to train young people and farmers not only in large urban centres but mainly in the interior of the Amazon, in the municipalities and territories immersed in natural laboratories, in the numerous campuses of public institutes and universities located there, and offer them quality of life, economic, and cultural conditions to remain there, close to the battlefields of forest and water defence, human rights, indigenous, and community rights (...).

The great challenge we face in institutionalising centres, stations, or institutes in the interior is to equip them with investments, skills, and infrastructure so that they can contribute to the development of local production systems, particularly in agricultural, fishing, extractive, handling, or bioeconomy industries (...). We ask under what conditions development poles can prosper (exploiting natural ecosystems and the bioeconomy)?

In response, we mention items that require attention from Public Policies to address deficiencies in: quality of basic education, health care and prevention, energy stability and internet access, access to clean water and sanitation, speed in production transportation, and also the absence of basic instruments of the Judiciary System such as the Public Defender's Office (there are only two Public Defenders in the region occupied by São Gabriel da Cachoeira, Santa Isabel, and Barcelos in Amazonas, an area of approximately 50,000 km² - equivalent to a Paraíba).

The design of public policies capable of promoting higher education, vocational training, and the desired development should initially observe which investments are being made by the Union and States, in each municipality headquarters of campuses of public education institutions and dimension the costs of the recommended interventions to promote the retention of trained young people, doctors, engineers, anthropologists, etc. (...) However, resources for operational and capital costs are insufficient to operate and utilise the installed human resources infrastructure, even if precariously.

How then to finance the equipment of the campuses and improve the urban infrastructure of these municipalities? We suggest integrating the institutes and their campuses (and the investments made in salaries, etc.) into a Development Project that contemplates strengthening not only higher education in the interior but also health, environment, and education institutes, energy sources, the telecommunications network, and seek new resources to finance them in their own funds or in C&T funds such as the FNDCT4, environmental funds like the Amazon Fund, or incentives for R&D in Suframa of MDIC, FUST, telecommunications, BNDES, SUDAM, and State FAPES of the Amazon (...). The creation of an Institute of the Mouth of the Amazon (with campuses in different states such as Amapá and Pará) dedicated to research and monitoring of coastal and marine environments, the transition of life between freshwater (Amazon River) and saltwater (Oceanic) environments is being proposed by the institutes of Pará and Amapá (Candotti, 2023).

To the above-mentioned vocalised proposals, the need to link national strategies to the goals of the Belém Charter, the Amazon Summit, and intergovernmental efforts to reduce carbon dioxide (CO₂)

emissions through the sustainable use of natural resources and the insertion of the Amazon in Brazil's new industrialisation efforts is added. Amazonian translations for productive promotion policies and production and territorial engagement of scientific knowledge and local knowledge are necessary.

According to Bourg (2002 *apud* Freitas, 2023, p.213), he states: "the political-institutional principles that legitimise the implementation of education, science, technology, and art programs to development models are social and political requirements." In the case of the Amazon, the author adds that the principles that should guide the implementation of educational, scientific, and technological policies and programs should be guided by the assumption of the "political commitment to instrumentalise it to combat poverty and social inequality (...), building sustainable bases for the cycle of lasting development for Brazil" (Freitas, 2023, p.213).

Regional development planning, based on territorial and ecosystemic bases, presents itself as imperative since it is in the territories where the problems occur and the chances of the most effective solutions involving local intelligence happen. The interaction of human action in Amazonian landscapes interconnects productive processes, cultures, contextualised environmental dynamics (Vieira, 2023), and these are important aspects for an interdisciplinary scientific agenda for the region.

The idea of ecosystemic integration that occurs in the frameworks of environmental and human degradation, when applied to solutions for development in sustainable territorial bases, enhances the incorporation of local factors, notably the knowledge and efforts of its qualified professionals.

6 CONCLUSIONS

The promotion of sustainability policies in the Amazon depends on territorially referenced knowledge, with broad engagement of HEIs and ICTs, acting in cooperative strategies and oriented towards short, medium, and long-term results. Overcoming inequalities in investments in Science, Technology, and Innovation, as well as in research incentives, contextualised in local problems to be addressed so that the region enters a cycle of green economy, broadly, multiscale, and inclusive.

The ideas and proposals presented here suggest that it is necessary and urgent to formulate a strategy that enables the integration of graduates from Amazonian educational and research institutions directly into the advisory of productive processes and through a continuous training process, with the counterpart of providing services to federal, state, and municipal public agencies, in programs aimed at sustainable territorial development.

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NOTES

1 | The data from Capes is for the North region and not for Legal Amazonia.

2 | Federal University of Western Pará (Ufopa) and Federal University of Southern and Southeastern Pará (Unifesspa). Accessible at <https://reuni.mec.gov.br/>, accessed on 02.02.2024.

3 | Available at <https://reuni.mec.gov.br/>, accessed on 02.02.2024.

4 | FNDCT – National Fund for Scientific and Technological Development; MDIC - Ministry of Industry and Commerce; Fust - Telecommunications Service Universalization Fund.

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