

**FUTUROS DA ÁGUA**  
RESILIÊNCIA,  
GOVERNAÇÃO  
E ADAPTAÇÃO 

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**Sustentabilidade ambiental e o papel do ensino superior: um estudo de caso do rio Tapajós, na Amazônia**

*Environmental Sustainability and the role of Higher Education: a case study of the Tapajós River in Amazon*

**Luís Alípio Gomes**

**Tânia Suely Azevedo Brasileiro**

**Helana Miranda da C. Gomes**

**Resumo**

Este estudo analisa a degradação ambiental do rio Tapajós, na Amazônia brasileira, com foco na contaminação por mercúrio associada ao desmatamento e à mineração artesanal. Examina a literatura científica sobre esses impactos e discute o papel das universidades na promoção da sustentabilidade socioambiental. As instituições de ensino superior têm papel essencial na formação de conhecimentos, valores e práticas voltadas à consciência ambiental, ao desenvolvimento sustentável e ao envolvimento comunitário na região amazônica.

Palavras-chave: Amazônia; Rio Tapajós; Contaminação por mercúrio; Ensino superior; Sustentabilidade ambiental.

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**Abstract**

This study examines the environmental degradation of the Tapajós River in the Brazilian Amazon, focusing on mercury contamination linked to deforestation and artisanal mining. It analyzes the scientific literature on these impacts and discusses how universities can promote socio-environmental sustainability. Higher education institutions play a key role in shaping knowledge, values, and practices that contribute to environmental awareness, sustainable development, and community engagement in the Amazon region.

Keywords: Amazon; Tapajós River; Mercury contamination; Higher education; Environmental sustainability.

## Introduction

Environmental issues, such as water pollution and contamination, degradation, crises of natural resources, energy, and food, highlight what is recognized as a civilizational crisis (Leff 2002). The Amazon is one of the ecosystems most affected by this crisis, with noticeable impacts on agriculture, biodiversity, human health, and water quality (Buckeridge 2008). It is no coincidence that Goal 6 of the United Nations (UN) Sustainable Development Goals (SDGs) addresses “Clean Water and Sanitation.” Specifically, Target 6.6 states that, by 2020, ecosystems related to water including mountains, forests, wetlands, rivers, aquifers, and lakes should be protected and restored.

In 2022, an aerial image of the Tapajós River, located in the Northern Region, State of Pará, Brazil, gained significant regional and international attention. The waters of the Tapajós River have long been recognized for their blue-green hue, a characteristic even celebrated in the anthem of the municipality of Santarém. The anthem poetically compares the river’s waters to the blue color of the sky, a homage to the beauty of the Tapajós River. But why did this aerial image draw so much attention? The image clearly revealed a striking change in the color of the Tapajós River, particularly near an internationally renowned tourist attraction, the beach of Alter do Chão (Figure 1). The waters were no longer blue or emerald green. Instead, the Tapajós River’s water resembled the muddy color of the Amazon River.

The mosaic of information and news associated various potential causes for this phenomenon, ranging from the presence of algae to deforestation and illegal gold mining activities.

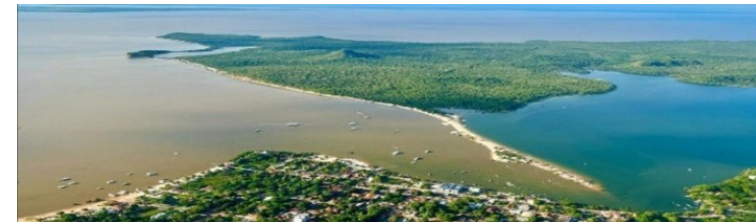


Figure 1. Difference in the coloration of the Tapajós River  
Available at: <https://o-boto.com/blog/cor-alterada-no-rio-tapajoes-reflexoes-sobre-o-aumento-da-turbidez-e-suas-possiveis-causas>. Access: 1/5/2025.

Faced with the various explanations regarding the causes and consequences of this phenomenon, one point was consensual: the waters of the Tapajós River were different; their coloration was no longer the same. In summary, beyond seeking an explanation, urgent measures needed to be taken. Thus, it is important to ask: considering the risk to the water resources of the Tapajós River, what does the scientific literature say about its current condition? Could the change in water coloration be associated with anthropogenic activity? If so, what type(s) of activities have been the primary drivers of this phenomenon? Furthermore, what role do higher education institutions located in the Amazon play in relation to the water resources of this region, and how can they contribute to the training of professionals (bachelor’s and licentiates) aligned with environmental sustainability?

These questions guide the organization, systematization, and presentation of this study, which seeks to discuss the relationship between universities and environmental sustainability.

## Methodology

A qualitative research approach was adopted, utilizing bibliographic research that included scientific articles. The studies, research and participation in an international research group called Climate U made it possible to carry out the

approach about Environmental Sustainability and the role of Higher Education. To research about a case study of the Tapajós River in the Amazon the following databases were selected: Web of Science, ScienceDirect and SCOPUS. The search string were: “water” AND “mercury” AND “Rio Tapajós”. There was no limit of time for publication. The question to motivate the research were: what does the scientific literature say about pollution of Tapajós River? Could the change in water coloration be associated with anthropogenic activity?

### Results And Discussion

It was identified 4 articles in SCOPUS, 1 article in Web of Science, 15 articles of 23 of ScienceDirect. The titles, abstracts related to the theme of this research were considered.

### Tapajós River: the announced contamination

One of the main pollutants impacting the Tapajós River Basin (Figure 2) is mercury (Hg), a metal that naturally exists in Amazonian soils (Patry *et al.* 2013).

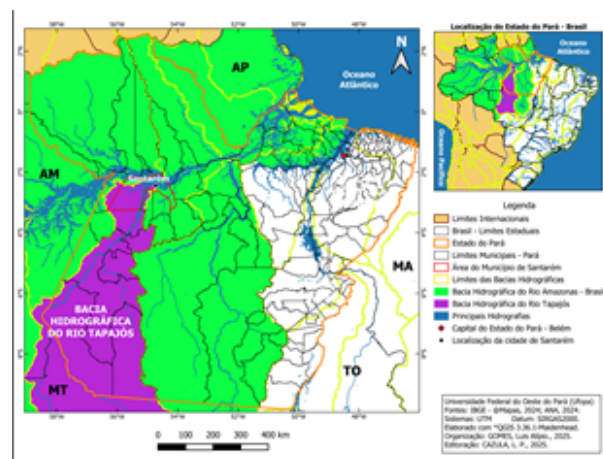


Figure 2. Tapajós River Basin. Publishing: CAZULA. L.P., 2025

The deforestation that drives erosive processes leads to an increase in the transfer of mercury from the soil to aquatic ecosystems (Farella *et al.* 2001). The severe soil erosion along the banks of the Tapajós River causes multiple imbalances in the aquatic ecosystem, such as increased water turbidity and organic matter deposition, among others (Farella *et al.*, 2001; Berzas Nevado *et al.* 2010)). Once water is contaminated, fish consumption becomes a vector for mercury proliferation among humans (Maurice-Bourgoin *et al.* 2000). The population of small communities along the Tapajós River relies on fish as their primary source of animal protein. Since 1992, studies have confirmed that mercury contamination in fish consumed in the region (Carvalho Da Silva *et al.* 2022; Pinheiro *et al.* 2000).

In addition to the impacts of deforestation, another factor contributing to the contamination of the Tapajós River Basin is the intensification of artisanal mining activities. Artisanal and small-scale mining has been widely practiced in the Amazon and provides income for approximately 35,000 workers in the Tapajós region of Pará, Brazil. These workers are commonly referred to as “garimpeiros” (Junior e Carvalho 2023). Studies indicate that the uncontrolled use of mercury (Hg) in artisanal gold extraction has released thousands of tons of mercury-contaminated waste into the Amazon biome (Meneses *et al.* 2022). The disposal of this material has not only degraded water quality but also affected the quality of life of people living in the riverside communities of the Tapajós basin, as well as urban populations (Meneses *et al.*, 2022). For decades, populations in Amazonian communities have been consuming mercury-contaminated fish, as confirmed by several studies.

The consumption of contaminated fish has also been identified as a potential risk for the onset of symptoms of Minamata disease (Pinheiro *et al.*, 2000). Even populations living far from gold mining sites are impacted, whether through fish consumption, atmospheric emissions, deforestation, or the disturbance of

river sediments, which contribute to mercury release into the environment (Roulet *et al.* 1998). These factors provide some explanations for the observed changes in the coloration of Tapajós River waters. Other sources suggest that, in addition to mining activities, increased turbidity may result from a higher presence of algae, sediment runoff due to soil erosion in the basin's tributaries – driven by deforestation for logging, agriculture, and livestock – soil disturbance, chemical substance disposal, and potential tailings dam overflows during the flood season.

Given this chaotic scenario, what can be done to mitigate these environmental impacts and address the risks of water contamination in the Amazon? The answer is neither simple nor straightforward. Research suggests that mitigating mercury contamination affecting local populations requires the implementation of a health surveillance program (Meneses *et al.*, 2022) or maintaining an epidemiological surveillance program (Pinheiro *et al.*, 2000). A medium- and long-term solution lies in investing in the initial and continuing education of professionals who acquire socio-environmental knowledge, values, and attitudes through their training, promoting best practices. The university, as a strategic locus for this training, will be addressed next.

### The university and its commitment to environmental sustainability

A theoretical framework supports the importance of higher education in addressing sustainable development. The rationale for this is deeply rooted in the identity of higher education itself, which has been emphasized over the last millennium. According to Mello (2011) higher education became a priority concern for funding agencies and governments at the beginning of the millennium. The 1998 UNESCO World Conference in Paris, involving approximately 5,000 participants from 182 countries, affirmed higher education as both public good and

a public service. Considering that capitalism has undergone a long process of restructuring, this transformation has profoundly impacted universities through:

“a vast, dense, and even unpredictable agenda of fundamental changes in higher education systems... involving, among other initiatives: diversification in the provision of education; degree titles; curriculum reform; changes in legal frameworks; innovations in teaching technologies; reform of governance structures; adjustments in statutes and faculty careers; methodologies and teaching modes; changes in funding and academic planning systems; creation of accreditation systems compatible with international quality requirements; establishment of new institutional evaluation parameters, and other measures – all to adapt higher education institutions (HEIs) to the new demands of flexibility, universality, efficiency, and competitiveness in the dynamic and interactive landscape of the global economy” (Mello, 2011, p. 33-34).

In the context of 21st-century higher education, it is essential to critically analyze what this reality means for the role of universities. Cunha and Leite (1996) question whether the university's purpose is limited to maintaining isolated professional careers, preparing individuals for a predetermined societal model, or merely reproducing social relations. They argue for revitalizing teaching and learning within universities as a continuous concern, coupled with the pursuit of scientific knowledge aimed at fostering more just societies.

University education should not simply cater to labor market demands. If it did, the university's role could be reduced to training rather than educating (Coelho & Furtado 2016). Academic life gains meaning when it expands and deepens the cultural and human horizons of faculty and students by distinguishing “the necessary from the contingent, the permanent from the mutable, the essence from the appearance, the essential from the accessory, the individual and specific from the general and universal” (Coelho & Furtado, 2016, p. 101). While the university is not the sole vector for this expansion, its contribution

is significant.

In the context of sustainability, a course, curriculum, or professional training is not merely a collection of subjects and syllabi. Instead, it represents a structured effort in reading, systematic study, teaching, understanding, questioning the sense and origin of the world, human actions, society, knowledge, integral education, and the university itself. As a formative institution, the university must prioritize the pursuit of knowledge and the recognition of ancestral wisdom through a dialogical process, challenging the physical and social world, inspired by Plato and Aristotle’s admiration, René Descartes’ methodical doubt, and Husserl’s rigor in thinking and learning. This approach necessitates “forming and self-forming, cultivating the vibrant and provocative knowledge of sensitivity, imagination, intelligence, thought, and action among students and professors” (Coelho & Furtado, 2016, p. 103). In summary, it is the responsibility of this millennial institution the university:

“[...] to work so that undergraduates and postgraduates, at different levels, dedicate themselves to study and education, enabling them to participate in the creation of new forms of collective and personal life, and professional practices aligned with autonomy, freedom, equality, fraternity, and democracy, which, however, only exist in a relationship – often uneasy – with others” (Coelho & Furtado, 2016, p. 102-103).

It is understood that individuals with university education are more receptive to engaging in actions directed towards environmental sustainability. This is primarily due to the projective function of higher education institutions, which aim to disseminate a set of values in students’ lives (McCowan 2022). However, this function is not restricted to the classroom. The academic community comprising professors, students, and staff – conducts activities in their areas of operation that impact nature and the environment, whether through the production of solid waste or carbon emissions.

This indicates that the dissemination of values must reach the

various sectors that comprise the institution as a whole, both internally and externally. Externally, universities provide services to organizations through consulting work, project execution, and direct interaction with the community. These are typically identified as extension activities, research initiatives, or scientific collaborations. These external stakeholders are also influenced by universities and act as “impact drivers for society as a whole” (McCowan, 2020a, p. 10).

In the academic context, several authors have conducted research and published works on this subject (Brasileiro et al. 2023; Caeiro et al. 2013; Gomes & Brasileiro 2018; ROLLESTON et al. 2023). Rolleston et al. (2023) argue that universities influence students’ practices, attitudes, and knowledge, primarily through their teaching.

Figure 3 highlights how the university environment – committed to environmental sustainability – through teaching, research, extension, and governance, exerts influence on society as a whole. Education for sustainability helps maintain a level of environmental awareness, preventing deforestation and preserving the forest. This process generates impacts on the biosphere, particularly in terms of conservation and preservation. Conversely, there is also a reverse process – from society to the university.

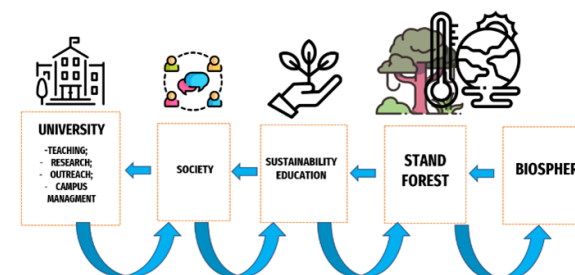


Figure 3. Levels of impact. Elaborated by the authors (2025).

Thus, universities need to strengthen their curriculum and pedagogy to more effectively achieve the desired outcomes. In

a survey conducted with students from universities in Fiji, Kenya, and Brazil, the results showed that students feel encouraged when their universities demonstrate a commitment to the environment. Researchers suggest that student learning in universities can form a virtuous cycle, creating opportunities for deeper learning, particularly on topics related to sustainability, while fostering student engagement in projects and campaigns on environmental issues (Rolleston *et al.*, 2023).

McCowan (2022) argues that teaching about sustainability in universities, such as addressing climate change, has become not only crucial but also inevitable. There is an understanding that education for sustainability fosters discussions about a new green agenda for teaching, based on the following approaches: skills for “green jobs”; skills or capacities to develop a “green” lifestyle focused on quality of life; and skills for a “green” transformation, which involve identifying oppressive structures in society (Kwauk, C. & Casey, O. 2021).

Regarding higher education and the Amazon, Gomes *et al.* (2022) emphasize that the implementation of this approach in universities can be achieved if the values of nature and land connectivity are prioritized by higher education institutions located in the Amazon. This is an indispensable condition for institutions in this region: to highlight and integrate into their teaching dimension research, extension, management, and discussions on sustainability. This is particularly important because the predatory culture of the “Western man,” characterized by technical-scientific dominance, must be reconsidered. Sustainable education emerges as a viable strategy for re-educating humanity to value the Earth (Gadotti 2004).

## Conclusion

Humanity has transformed planet Earth to such an extent that economic activities have caused significant social, economic, and environmental impacts. It is essential not to lose sight of the need for change, particularly in a society marked by consumerism within a capitalist system. As Senegalese ecologist Babia Dioum states, “In the end, we will conserve only what we love. We will love only what we understand. We will understand only what we are taught” (Frisk e Larson 2011:2).

The rivers of the Amazon, such as the Tapajós River, have been the subject of numerous reports due to changes in the color of their waters. A recurring question arises: what should be done in this situation? Sanitary and epidemiological measures are necessary; however, “no institution in modern society is better positioned, and none is more obligated to facilitate the transition to a sustainable future than colleges and universities” (Orr 2002:96).

In this context, it is crucial to develop a socio-environmental sustainability policy with integrated actions in teaching, research, outreach, and management at higher education institutions located in the Amazon region. It is equally important to intensify and/or create initiatives that promote sustainability in university curricula across undergraduate and graduate programs, which are responsible for training human resources who will act in this region or anywhere on the planet whether as professionals in various fields or as policymakers.

Finally, universities located in the Amazon, regardless of their programs or fields of knowledge, must adopt interdisciplinary approaches and innovative teaching methods to train professionals with a focus on socio-environmental sustainability.

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