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COP 28 Water Agenda: Establishing a Dynamic Blue Economy in Brazil's Amazon Region

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Abstract

In 2024, the preservation of water resources is an important dimension of the global economy striving for a sustainable, equitable and inclusive economic development and growth strategy. The preservation of water resources is an important component in the advancement of the 2030 Agenda for Sustainable Development Goals (SDGs), as established by the SDG 14, and in the development of a sustainable, equitable, and inclusive global Blue Economy. The 2023 UN Climate Change Conference—COP 28 Water Agenda emphasized the vital role played by freshwater resources in the global quest to address sustainable, equitable, and inclusive global economic growth and development. This paper elaborates on the promises and challenges permeating the establishment of a dynamic Blue Economy in Brazil's Amazon region. This paper introduces a Quintuple Helix and a Quadruple Helix framework of analysis to assess the promises and challenges facing the development and establishment of a sustainable Blue Economy in Brazil's Amazon region.

Keywords

COP 28, Sustainable Development, Brazil, Amazon, Blue Economy, Emerging Business Frontier, Quadruple-Quintuple Helix

1. Introduction

In 2024, fresh water resources from around the globe are under severe stress. Close to 2 billion people are currently living in regions of the globe and in countries experiencing water stress. It is estimated that the lack of clean water and poor sanitation are responsible for many diseases afflicting poor countries around

the globe. Unsafe water alone is responsible for close to 1.2 million deaths every year around the globe. It is clear that much still has to be done in order to address the goals and targets of the 2030 Agenda for Sustainable Development (Alexander & Evgeniy, 2012; Pesotsky, Grigorieva, & Chistova, 2021; Ritchie & Roser, 2021; Loganathan & Subrahmanya, 2023; Wang & Ma, 2022; UN, 2023a, 2023b; OECD, 2023b; Gouvea & Gutierrez, 2023; Kuzma, Saccocia, & Chertock, 2023).

It is important to stress that water is vital for life in the globe and there is no currently available substitute for it. Water stress deeply affects countries' economic stability and economic development and growth prospects. For instance, water shortages have a direct impact on productivity growth, in addition to affecting a number of economic sectors such as agriculture, manufacturing, energy and indirect services such as tourism. In addition, economic development prospects could be impacted by effects on overall health of the working population and emergence of epidemics. Moreover, water stress leads to social instability, forced migration, and political instability. In addition, water stress also promotes environmental instability and crisis. Issues such as growing populations, rising disposable income, expanding manufacturing and agriculture, poor infrastructure, and evolving institutional development cause additional water stress. Moreover, the lack of an effective and well developed water resource management governance adds to the country's water stress levels (Alexander & Evgeniy, 2012; Pesotsky, Grigorieva, & Chistova, 2021; Loganathan & Subrahmanya, 2023; Urban & Hametner, 2022; Wang & Ma, 2022; Adam, 2023; Council of the European Union, 2023; UNESCO, 2021, 2022; COP 28, 2023).

Water stress' challenges and opportunities are multidimensional by nature. They are related to the four major dimensions of water resources such as: 1) safety, 2) quality, 3) security, and 4) availability. Any attempt to design, develop, and establish water resource management strategies and governance must pay heed to these interconnected dimensions. More than ever, countries' water resources are increasingly facing the need to address all these dimensions simultaneously (Global Water Partnership, 2000; Gouvea, Kassicieh, & Montoya, 2012; Gouvea, 2015; Akhter, Uddin, Rafa, Hridi, Staddon, & Powell, 2020; IISD, 2023; World Bank, 2023).

Freshwater use by countries is related to their socio-economic factors such as population size and growth, climate characteristics, economic complexity, and the share of agriculture and manufacturing in a country's GDP. In the coming decades, the largest consumption of water is expected to take place in Asia, Africa, and Latin America, and the lowest levels of consumption are expected to take place in North America and in Europe. It is expected that by 2050 close to 6 billion people will suffer water stress as a result of: 1) higher demand for water, 2) reduction in water resources, and 3) the increasing pollution of oceans, rivers, and lakes around the globe (Boretti & Rosa, 2019; ECLAC, 2018; Matoh, Zener, &Genorio, 2022; Chancel, Bothe, & Voituriez, 2023).

The 2023 UN Water Conference and the 2023 COP 28 reaffirmed the need to

address the vital importance of water sustainability strategies, policies, and actions in order to achieve the main goals and objectives outlined by the 2030 Agenda for Sustainable Development Goals (SDGS). The Brazilian Amazon region's water resources played a vital role in Brazil's quest for a sustainable, equitable, and inclusive economic growth and strategy. The next section, discusses the main challenges and opportunities facing the Brazil's Amazon region and prospects for the establishment of a vibrant Blue economy in Brazil's Amazon region.

This paper introduces a Quadruple-Quintuple Helix Model in order to better assess and analyse the main challenges and opportunities permeating the introduction of a vibrant Blue Economy in Brazil's Amazon region. Section II introduces Brazil's Amazon region, paying attention to the region's characteristics. Section III discusses the main challenges and opportunities permeating the establishment of a dynamic Blue Economy in Brazil's Amazon region. Section III outlines the main economic, social, and political stakeholders that must be involved in order to fully establish a water governance structure in Brazil's Amazon region. Section IV introduces the Quadruple-Quintuple Helix Model that provides a framework of analysis to better understand the challenges and opportunities permeating the introduction of a Blue Economy governance in Brazil's Amazon region.

2. Brazil's Amazon Region

The Amazon River Basin is the world's largest, encompassing a number of countries such as Brazil, Bolivia, Colombia, Guyana, French Guyana, Peru, Suriname, and Venezuela. It expands by 7 million square kilometers, and has the world's largest volume of liquid fresh water. The Amazon River is 7 thousand kilometers long and has a discharge of 210 thousand cubic meters of water per second. The region accounts for 20% of the entire world's fresh liquid water. The Amazon River has close to one thousand affluents and tributaries. The Amazon River Basin is also host to the world's largest equatorial and tropical forest, rich in biodiversity. The region plays a key role in Brazil's climate regimes as well as impacts other South American countries' climate as well. The Brazilian Amazon region is also home to the so-called "Flying Rivers Phenomenon" that is responsible for the distribution of rainfall in the other regions of Brazil and South America (IBGE, 2021; Leiros, 2021a; UN, 2023b; UNOSD, 2023).

The Amazon River and tributaries constitute an important source of fish products for the local population, close to 2716 known fish species inhabit the Amazon River Basin. This makes the Amazon River Basin the world's most diversified fresh water river basin. The Amazon basin is also a major transportation hub, where millions of passengers commute every day between municipalities, states, and countries. It is estimated that close to 9.8 million people use Amazon rivers to commute yearly, and close to 3.4 million tons of cargo are also transported in rivers throughout the Amazon region (IBGE, 2021; Oliveira Neto,

2022).

The region is also home to 29.6 million Brazilians, with large metropolitan cities like the city of Manaus, capital of the state of Amazonas, with 2.2 million people. The Amazon region accounts for 5.5% of Brazil's GDP, although it accounts for 60% of Brazil's territory. In 2023, the region is the fastest growing region in Brazil, growing at rates well above the national rate, showcasing the increasing migration to the region and the increasing expansion of economic opportunities such as mining, manufacturing, and agriculture. For instance, the Export Processing Zone (EPZ) located in the city of Manaus houses close to 500 multinational companies, which manufacture a wide array of products from motorcycles to electronic products, generating thousands of jobs (Gouvea, 1998; Gouvea & Kassicieh, 2001; Ministério da Infraestrutura, 2018; Oliveira, 2021; Leiros, 2021b; Nascimento, 2021).

Increasing economic activity throughout the Brazilian Amazon is posing additional stress on the region's water resources, resulting in increasing pollution, among other environmental challenges. The nexus water & energy is also becoming more prevalent in the region as well. For instance, lately, the region is experiencing a dam building boom, which is radically transforming the Brazilian Amazon region. Increasing urbanization, an expanding agriculture, mining operations, urbanization, and expanding manufacturing activities, are increasing the demand for electricity, leading to the construction of more dams in the region. The world's fourth-largest dam, Belo Monte Dam, situated in the Xingu river, is one of the dams already established in Brazil's Amazon region (Gouvea, 2012; Gouvea & Montoya, 2014; Fearnside, 2017; Chiaretti, 2023).

Still, the region suffers from the same contradictions stated by Samuel Taylor Coleridge poem: "Water, water, everywhere, nor any drop to drink." A large segment of the population in the Amazon region, close to 5 million people, still lacks access to safe water. Strong reliance on surface water sources, add to the problem, since in some areas these surface waters are heavily polluted with viruses and microbial content, amongst other contaminants. Moreover, as a result of illegal mining operations in the region, there is the presence of dangerous chemicals, such as mercury. Mercury pollution poses a major threat to fish stocks in the rivers constituting a major health care threat for the local population. In addition, in many communities, the lack of specialized training and capacity building to keep water treatment centers, wells, and other devices working, remains a challenge. In addition, basic sanitary education and information is also lacking in a number of communities in the region, adding more challenges. The main challenge in the Amazon is to translate water availability into water safety. The world's largest reservoir of liquid fresh water does not offer safe conditions for its population. The lack of water treatment plants has resulted in higher levels of infant mortality, close to twice Brazil's average. In the last decade, a number of state governments in Brazil's Amazon region are beginning to pay heed to the nexus unsafe water & waterborne diseases, increasing their in-

vestments in water treatment and on sanitation infrastructure (Coleridge, 1992; Guimaraes, 2020; Silva & Lima, 2020).

The establishment of a "Water Innovation and Technology Center" in the city of Manaus, emphasizing a translational innovation framework and strategy, where local innovations or creative processes could be translated into local development and local manufacturing, offers the potential to address some of the region's pressing water issues. Manaus has the research capacity and manufacturing capability, providing the right innovation and technology environment for the implementation of a translational innovation and technology water center. Moreover, the construction of an "Early Warning System" using smart chemical and biological sensors could also provide policy-makers and members of the civil society more data and information about the health care threats posed by pollutants in the region's rivers (Gouvea & Kassicieh, 2010; Gouvea, Kassicieh, & Montoya, 2012; Gouvea, 2015).

In city of Manaus, like in many municipalities around the Amazon region, there are thousands of wells not registered with the city and state government environmental agencies. Monitoring these wells is extremely important to keep high safety standards in the region. Short-term and long-term groundwater monitoring would include hydrogeological settings, assessment of well performance, and sampling collection and availability of information. Groundwater in the Amazon region should be regularly monitored for biological, mineral, and chemical pollutants and contaminants (Henriques, 2013; Vasconcelos, 2022).

The Brazilian Amazon region is also home to the world's largest underground liquid fresh water aquifer—"Aquífero Alter do Chao." It covers three states in the Amazon region: Amazonas, Pará, and Amapá states. It has a span of 500 thousand square kilometers and covers 3 thousand kilometers, with an estimated capacity of 86 thousand cubic kilometers of water volume. These features make the "Alter do Chao aquifer" the world's largest aquifer. Several municipalities are already drawing water resources from this aquifer. For instance, the city of Manaus relies on this aquifer for 40% of its daily water usage. Thus, the increasing use of this aquifer also poses a number of pollution threats, since abandoned wells and wells built without technical supervision could allow polluted surface water to contaminate the aquifer. It is also important to note that a number of these wells are not registered with the municipalities in the region, making their inspection even more challenging (Azevedo & Campos, 2021; Pimentel & Hamza, 2010; Costa, 2021).

Close to 99% of the all liquid freshwater in the globe are underground water resources. It holds the promise the address a number of the water scarcity issues permeating regions and countries around the globe. Close to 50% of the globe's urban population relied on underground water, and 25% of all global irrigation water comes from underground water resources. These resources promised to address a number of social, economic, and environmental issues related to fresh water scarcity (UN, 2022).

Reconfirming the rank of Brazil's Amazon River Basin as the world's largest,

in 2010, an underground river was discovered below the Amazon river, the "Hamza" river. It flows 4 thousand meters below the Amazon River. It is 6 thousand kilometers long, and has a width that varies between 1 kilometer and 60 kilometers wide. It is formed largely by surfaced water that infiltrates and permeates the Amazon freshwater basin (ANA, 2015; Costa, 2021; Pimentel & Hamza, 2010).

However, as many of the surface water resources it also suffers from a lack of management and governance guidelines and policies. The long-term availability, quality, safety, and security of these underground water resources are closely related to actions and policies that being developed and introduced to govern the usage of these underground resources, and unlocking their ability to have a meaningful social, economic, and environmental on regions and countries around the globe (Illinois Environmental Protection Agency, 2015; UN, 2022).

The Brazilian Amazon region's draught of 2010 and the 2023 draught, raised the importance of addressing the fresh water dimension of Brazil's Amazon region, and its importance in the region's quest for establishing a sustainable, equitable, and inclusive economic growth and development for the region (INPE, 2011; Nascimento, 2023).

The next section will elaborate on the importance of establishing a water network and a Blue Economy governance. This paper introduces a Blue Economy Quintuple Helix and a water Quadruple Helix to better assess and understand the challenges and opportunities facing Brazil's Amazon region.

3. Amazon's Blue Economy

Water sustainability is one of the 21st century major challenges. Thus, designing and establishing governance and integrated water resources management (IWRM) policies and guidelines are a vital component in a region's or a country's quest towards addressing the Agenda 2030 major goals and targets. The effective management of liquid fresh water in the case of Brazil's Amazon region is vital for the region's and Brazil's quest towards the establishment of a sustainable, equitable, and inclusive society and economic development and growth strategy. The Amazon region 2023 draught brings to the forefront of discussion the vital importance of addressing Brazil's Amazon region freswater resources management and governance (Kochhar, Patillo, & Sun, 2015; Safe Water Network, 2015; OECD, 2023b; CEPAL, 2023; ANA, 2023; Fearnside & Silva, 2023).

The creation of water networks and water governance are important steps in securing the sustainability of Brazil's Amazon liquid fresh water reserves and allowing the growth and development of a vibrant Blue Economy in Brazil's Amazon region. A well-designed water governance is the result of a combination of factors such as strong and well-defined water policies, a strong legal and regulatory ecosystem, availability of investment funds, and a top-down and bottom-up societal involvement aimed at developing and managing Brazil's Amazon water resources. It is also important to mention that Brazil's Amazon water governance is also shaped by the local governance characteristics of Brazil's

Amazon region (Trata Brasil, 2023; Araujo & Teixeira, 2022; Karani, Failler, & Gilau, 2023).

The design and establishment of water networks and water governance is one step towards the implementation and achievement of these goals and objectives. Water networks bring together stakeholders such as the private sector, the academic environment, civil society, non-profits, and the government. Water networks lead to open collaboration innovation, and innovation is a key element of water networks and a key element in providing a safer and sustainable water environment (AquaSPE, 2015; Creaco & Pezzinga, 2018; Sirsant, Hamouda, & Shaaban, 2023; Zhou, Gao, & Simpson, 2016).

Participants of the Water Network need to be integrated into a wider water governance structure and framework in order to channel their suggestions to policy-makers and other members more effectively. In addition, participants such as policy-makers also need to rely on research institutions, private sector, NGOS, and on the civil society to have a "full-screen" perspective on the main challenges and opportunities facing all the water network stakeholders. In addition, water networks provide members the ability to develop synergies, connect, and create a dynamic and ongoing learning ecosystem between its members (Castro, Heller, & Morais, 2015; UNCTAD, 2022).

Water networks also need to develop a yardstick to measure its impact on a number of water management and governance dimensions, which includes economic, social, and environmental dimensions. In addition, the water innovation and research network are also expected to result in measurable social, environmental, economic, and also water related innovation and technology impacts and results. Thus, the transformative impacts or water networks also relate to translational innovations, at the social, economic, environmental, and research and innovation dimensions (IDRICA, 2023; Water JPI, 2020; Ahmed, Johnson, Hashaikeh, & Hilal, 2023).

Water networks do not need to be local specific. Open source innovation is a major feature of water innovation networks and as a result, they need to be global innovation oriented. Thus, seeking global solutions and innovations that can be applied locally, acting local and thinking global in terms of finding water solutions. Transboundary water networks are a good example of acting local and thinking global. Universities and research centers constitute a natural conduit as well as the private sector and NGOS facilitation and fostering the global dimension aspect of local water networks. In 2023, the governor of the state of Amazonas and staff members participated in the United Nation's Water Conference in New York, indicating that the state of Amazonas policy-makers are also pursuing a cosmopolitan approach, open to learn from other global policy-makers, further globalizing the state of Amazonas water network (Nyiwul, 2023; Varady, Albretcht, Modak, & Wilder, 2023).

The virtual water network functions as a meeting space for all stakeholders, also allows for online training. The online website also functions as a conduit for stakeholders to express their questions. Thus, the network works as a virtual re-

pository of knowledge, allowing stakeholders to also identify sources of information and capable of also offering self-learning. Thus, water networks need to reflect their unique environment issues, bringing its stakeholders together, emphasizing co-learning and co-discovery of new emerging issues and solutions that need to be addressed and implemented by water network stakeholders (Global Commission on the Economics of Water, 2023; Mukhtarov, Dieperink, & Driessen, 2018).

The internet allows for people to develop personal relationships via a number of social networks. By linking the water network to social media, it is possible to expand the reach of the water network. Besides, in countries like Brazil and Brazil's Amazon region, the penetration of cell phones is higher than computers or tablets. Developing mobile apps or even communicating via text messages may provide invaluable information for stakeholders (Gouvea, Kapelianis, & Kassicieh, 2018; Gouvea, Kapelianis, Li, & Terra, 2022).

In the case of the state of Amazonas, the development of a virtual water network could also play a vital role in promoting the dissemination of knowledge, technologies, and innovations in the region. There is certainly a gap of information between members of the water network that could be eliminated by the establishment of such a network. For instance, local universities such as the Federal University of the state of Amazonas (UFAM) and the State University of state of Amazonas (the UEA) have active and sophisticated water research programs, but not much interaction between the two institutions. Private universities such as Fametro and Nilton Lins, could also benefit from a closer cooperation between local universities and their out-of-state relationships. Other research institutions in the state such as INPA, CBA, and Fapeam, could also further cooperate at the grant research levels, fostering the establishment of a Water Innovation and Technology Center in the city of Manaus.

The state of Amazonas private sector could also rely on the local researchers to implement a Blue Economy—water-centered and water-focused business opportunities. Water-intensive businesses such as fish farming, shrimp farming, and hydroponics could transform the state of Amazonas in a major supplier of fish and shell products, in addition to vegetables. The proximity between the academic dimension of the water network and the local private sector could generate a number of positive synergies further promoting a sustainable economic development strategy, with a positive impact on employment creation. Private companies, such as "Real Bebidas" are exporting bottled spring water from the Amazon, further promoting the creation of a local based Blue Economy. The creation of a "Blue Economy Chamber of Commerce" in the state of Amazonas, in the city of Manaus would help to galvanize and foster the support of the region's private sector, becoming a conduit for the developments of collaborations with other segments of the state of Amazonas society and economy.

Local NGOs such as Centro de Responsabilidade Socio Ambiental da Amazonia (CRSAmazonia), Instituto Amazonia, and Instituto Amazônico de Desenvolvi-

mento Social, Amparo à Pesquisa e a Tecnologia, are some examples of NGOs that can provide important feedback to other stakeholders in the water network.

Since 2019, the government of the State of Amazonas through its environmental related agencies such as Secretaria de Meio-Ambiente—SEMA and local water agencies such as the state's COSAMA has been paying heed to the importance of a top-down & bottom-up governance approach, adopting a "pro-poor" policy to make sure that indigenous populations of the state and river based communities ("Ribeirinhos") are not left out of the Blue Economy Quintuple Helix governance model. Initiatives such as "Agua Boa" and "Salta Z" have benefited close to 130 thousand people in the interior of the State of Amazonas, covering 50 municipalities. The state is also paying heed to a state wide "Water Resources Management" program, and also initiatives to better manage the Taruma-Acu river basin.

At the federal level, we have agencies such as "Superintendência do Desenvolvimento da Zona Franca de Manaus—SUFRAMA" and the "Agência Nacional de Águas (ANA)" as important stakeholders in the design of a water network in the state of Amazonas. It is important to also highlight the fact that the state of Amazonas rivers and lakes basin is interconnected with Brazil's neighboring countries, such as Colombia, Venezuela, Peru, Bolivia, and Ecuador. As a result, the deployment of "water customs", using chemical and biological sensors that can detect pollutants coming from these countries into the state of Amazonas, is also of paramount importance in order to protect the sustainability of the state of Amazonas' Blue Economy. These pollutants can generate a number of negative environmental externalities for the state of Amazonas.

Civil society's participation in the water network is also vital for the success of the Amazon region's water network. Native Brazilians participation and the river-based communities' requests and concerns must be heard and taken into consideration. They are at the bottom of the "water pyramid" in terms of having access to safe drinking water and sanitation services. It is clear that no water sustainability strategies, plans and programs can succeed without their participation (Gouvea, 2014; Gouvea, Lehnemann, & Terra, 2022).

The Dublin Conference in 1992 set the groundwork for the design and establishment of water governance. Water governance can be defined as the set of political, social, economic, and managerial systems that are implemented to develop and manage water resources and the delivery of water services to members of society. Thus, the water sector calls for the establishment of a multi-level participation of the different segments of a region's and country's society, in order to fully reflect how water connects across different economic sectors, people, and regions (Global Water Partnership, 2002; Global Commission on the Economics of Water, 2023).

Water's distributed governance involves a number of stakeholders such as: 1) government, 2) universities and research institutions, 3) the private sector, 4)

civil society, and 5) NGOs. This Quintuple Helix approach allows for the development of an effective water governance strategy. This Quintuple Blue Economy Helix & Quadruple Water Helix approach allows for an effective dialogue amongst participants, a more effective sharing of information, and a better pathway to address conflicts and resolutions. For instance, in the case of Brazil's Amazon region, the inclusion of native communities and poor river-based communities of "Ribeirinhos" in the water governance process, allows for equity and inclusivity in the water governance process. This "pro-poor" approach is fundamental for the success and performance of an equitable, inclusive, and sustainable water Quintuple Helix approach (Batchelor, 2007; Solanes & Jouravlev, 2006; OECD, 2015; Wyoming Department of Environmental Quality, 2015).

4. Blue Economy: A Quadruple-Quintuple Perspective

Thus, government policy-makers may decide on the agenda, main priorities, and on the overall design, however, governance schemes and systems will provide the credibility, and overall society's participation, that will ensure trust in the government's vision for the region and country. Thus, distributed governance may be the most effective way of designing an inclusive and equitable participation by members of the local society in the Blue Economy and water governance systems and programs (Rogers & Hall, 2015; Plummer & Slaymaker, 2007; OECD, 2023a, 2023b).

Moreover, good or effective governance also depends and relies on state capability, accountability and responsiveness. The state must be very aware of designing and implementing policies and guidelines to address gender equity and also establish a pro-poor policy. In the case of the Brazilian Amazon, region making sure that native Brazilian communities and river side communities are being served and heard in their main concerns and demands (OECD, 2015; Frigione and Pezzagno, 2023; UN, 2023a, 2023b).

Moreover, water governance also must include inclusiveness, accountability, shared participation, transparent rules and guidelines, shared information amongst participants, and equitable treatment of all participants inputs (Rogers & Hall, 2015; OECD, 2015; OECD, 2023b).

Figure 1 describes the main dimensions and key stakeholders in Brazil's Amazon region Quintuple Blue Economy Helix, and in the Quadruple Water Helix. The Blue Economy Quintuple Helix calls for an integrated and shared participation of Brazil's government agencies, private sector, Universities and Research Centers, Civil Society, and NGOs. The Water Quaduple Helix pays heed to the four dimensions of fresh water resources: 1) safety, quality, security, and availability (**Figure 1**).

Thus, the Quadruple-Quintuple Helix approach to the Blue Economy governance has also to be framed along the lines of being open and transparent, inclusive, integrative, equitable, accountable, efficient, and aware of the dynamics

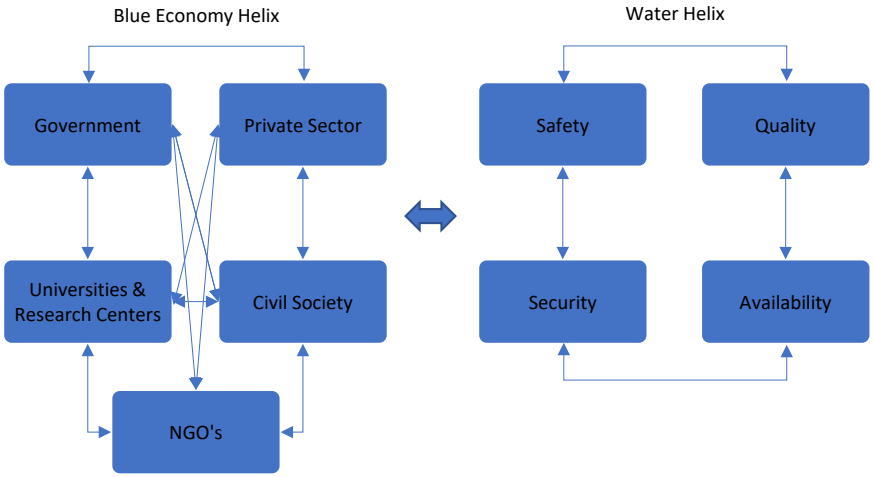

Figure 1. The Quintuple Blue Economy Helix and the Quadruple Water Helix. Source: Elaborated by the authors.

involved in climate change (**Figure 1**). The Quadruple-Quintuple water governance helix has to also be adaptable to local political and economic changes, which are ever changing in Brazil's Amazon region. This dynamic and adaptable multi-stakeholder water governance Quintuple Helix is capable to advancing the water agenda forward in Brazil's Amazon region (Gouvea, Kassicieh, & Montoya, 2012; Carayannis & Campbell, 2021). When comes to the Blue Economy governance, is also important to build checks and balances that will allow for the periodical audit of the governance structure. For instance, issues such as stakeholder's engagement and participation, transparency, allocation of responsibilities, among other dimensions, must be observed and audited constantly in order to keep the governance efficient, effective, and trustworthy (OECD, 2015).

Blue Economy technologies and innovations will play a very important role in promoting effective and efficient Blue Economy governance in the Brazilian Amazon region. As mentioned earlier, from the deployment of biological and chemical water sensors to water purifiers, the region is in need of water innovations and water technologies to promote and establish a sustainable Blue Economy. For instance, the implementation of water "Early Warning Systems" would allow policy-makers the possibility of implementing pro-active measures and policies to address water related crisis. More than 50% of all diseases in the Amazon region are waterborne related diseases, that can be addressed more effectively once more innovations and technologies are appropriately deployed in the region (Gouvea, 2015; Suroso, Hamzah, & Sasongko, 2021; Yale Center for Environmental Law & Policy, 2021).

5. Conclusion

This paper has discussed the pivotal role played by Brazil's Amazon region in Brazil's quest for a sustainable, inclusive, and equitable sustainable economic development and growth. Water resources play and will keep on playing a vital

role in assuring the basic conditions for Brazil's continuous sustainable growth and development. Given the increasing importance of Brazil's liquid fresh water resources, the design of water networks and the erection of a Blue Economy governance and IRWM strategies are of paramount importance for Brazil's economy.

The use of a Blue Economy Quintuple Helix and a Water Quadruple Helix helped to identify the key stakeholders in Brazil's Amazon water ecosystem and in identifying the major promises and challenges facing Brazil's Amazon region water resources. These arrangements have the potential to create and foster a number of innovations and technologies that will address the increasing needs of Brazil's Amazon region. The "Blue Economy Quintuple Helix" by bringing together different segments of the Amazon society provides the conditions for the implementation of an inclusive and equitable approach, by following top-down and bottom-up designs and architecture.

The establishment of a water network in the state of Amazonas will also provide a better understanding of the size of the Blue Economy in the state of Amazonas and its participants. For instance, the creation of a "State of Amazonas Blue Economy Chamber of Commerce" will provide a new impetus and coordination of efforts amongst the state of Amazonas's private sector that is directly involved in the state's Blue Economy and will give them a "voice" in the state's "Blue Economy Quintuple Helix."

Moreover, Brazil's Amazon region Blue Economy will also demand managers and professionals to address the establishment of a vibrant Blue Economy in the region. Universities and technical schools and institutes, should start implementing degrees and programs to fully prepare Brazil's professionals to help unleash the Blue Economy revolution in Brazil's Amazon region.

It is clear that the state of Amazonas and Brazil must do more to in order to achieve Sustainable Development Goal 14 on water and sanitation for all members of Amazon population. A business-as-usual approach to the Amazon region water problems and issues must be challenged and changed. It is urgent that local policy-makers and members of the Amazon Blue Economy Quintuple Helix work in harmony, efficiently, and effectively in order to fully address the region's major water governance issues.

This paper discussed a very important dimension of Brazil's Amazon region: its fresh water resources and how to better manage the region's fresh water resources. Most of the research done on Brazil's Amazon region, has been related to its flora and fauna, but not as much attention and research has been done highlighting the vital importance of managing and governing Brazil's Amazon region fresh water resources. The 2023 drought deeply affecting Brazil's Amazon region, further stresses the increasing importance of the issues and topics covered by this paper.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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