STATUS OF WATER QUALITY IN THE

AMAZON BASIN

EXECUTIVE SUMMARY
Note from Venezuela:

especially for management issues, and ANA, for technical issues. This dynamic was carried out directly on all the products delivered through written technical evaluations.

Cooperation Treaty (ACT), the results of this study will be beneficial to all 8 Member Countries, including Suriname despite not being part of the hydrographic basin.

General Note:

This study was conducted considering the hydrological limit of the Amazon Basin, and for this reason, Suriname, was not considered in the analyses of information of the Member Countries are represented, do not constitute a judgment on any other Treaties or International Acts in force between the Parties, nor on any other agreements, treaties, conventions, or protocols in force between them, nor on any international agreements in force between them.

In the case of the Bolivarian Republic of Venezuela, data from the Brazo Casiquiare and Río Negro, which correspond to the Venezuelan Amazon,

The designations and information used in this technical publication of ACTO, and how data, maps, images, and charts containing geographical information are represented, do not constitute a judgment on any other Treaties or International Acts in force between the Parties, nor on any agreements, treaties, conventions, or protocols in force between them, nor on any international agreements in force between them.

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REPORT ON THE STATUS OF WATER QUALITY IN THE AMAZON BASIN

PREFACE

Amazonian Strategic Cooperation Strategic and the Amazon Cooperation Treaty (ACT) are initiatives that aim to promote cooperation among countries in the region. The ACT was established in 1995 as a platform for political dialogue and regional cooperation. With the creation of the Amazon Cooperation Treaty Organization (ACTO) in 2001, the eight countries of the Amazon basin came together to address the challenges of sustainable development in the region. The ACTO has been instrumental in promoting regional cooperation and integration in this globally important region with a view to planning and implementing actions between the Member Countries, including water monitoring and management of transboundary water resources.

The project aims at strengthening cooperation among Amazonian countries and promoting the technical and financial cooperation of the National Water and Basic Sanitation Agency (ANA) of Brazil, of which the National Institute of Amazon Research (INPA) is an agency, in the context of the Amazon Cooperation Treaty Organization (ACTO) with the objective of exchanging technical cooperation on the management of aquatic ecosystems and water resources in the Amazon region. The project seeks to strengthen cooperation among Amazonian countries through the establishment of a network of monitoring stations for water quality indicators, exchange of technical cooperation in the monitoring of water quality, training of institutions and professionals, and the development of strategies for the sustainable management of aquatic ecosystems and water resources in the Amazon region.

The project also aims at strengthening the National Institute of Amazon Research (INPA) as an institution responsible for research on water quality in the Amazon region. The project seeks to strengthen cooperation among Amazonian countries through the establishment of a network of monitoring stations for water quality indicators, exchange of technical cooperation in the monitoring of water quality, training of institutions and professionals, and the development of strategies for the sustainable management of aquatic ecosystems and water resources in the Amazon region.

In conclusion, the project seeks to strengthen cooperation among Amazonian countries through the establishment of a network of monitoring stations for water quality indicators, exchange of technical cooperation in the monitoring of water quality, training of institutions and professionals, and the development of strategies for the sustainable management of aquatic ecosystems and water resources in the Amazon region.
CONCEPTUAL AND METHODOLOGICAL BASIS

After specifying the context, methodology, and premises for the study, sub-chapters were
written and submitted to the Member Countries to define the objectives of the work to be
carried out and criteria which data would be needed for the full development of the
study. The methodology of the study is based on the Pressure-State-Response (PSR) methodology
which identifies the pressure factors that can affect the quality of surface water in the
Amazon Basin. The PSR methodology was applied to diagnose the water quality situation in
water bodies in the Amazon Basin.

The study leads to two final reports. The Final Report consolidates all the primary
information gathered during the study, that is, the “status” in qualitative terms of the
water situation at the national and regional levels of the Amazon Basin, and this Executive
Summary introduces a synthesis of the results achieved.

To calculate these proportions meaning important consonance and alignment with the
different regional realities, written questionnaires and videoconferences to learn about the
different regional realities, interviews were carried out with representatives of Member
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Countries through written questionnaires and videoconferences to learn about the
region. The PSR methodology is based on the idea that human activities exert pressure
on the environment, affecting the status of quality and quantity of natural resources and
infrastructure. This information, together with other relevant data for the study, is available in the
Context of the water quality status in the Amazon Basin countries.

With these results, the best global practices in water management were included to
toys to prepare for the strategic management of the water quality in the Amazon Basin. It includes a set of proposals for various themes and actions to be developed in
the region. The study also incorporates the
multiplicity of visions related to the region’s development and the preferences towards
proposals for specific measures and actions to be developed at
sub-national, national, and intergovernmental cooperation levels of ACTO, based on
institutional management and shared management among neighboring countries, and the
formal subordinated to the focus of this study. It is proposed a
systematized best practices to contribute to a better management, monitoring, and control
of water quality in the ARB.

With the monitoring data and within the scope of the Regional and basin
the quality of action on water quality in the Amazon Basin. The Pressure-State-Response (PSR)
methodology is applied to diagnose the water quality situation in water bodies in the
region. The methodology is based on the Pressure-State-Response framework as a
pressing system of monitoring, evaluation, and decision making, in addition to an effective
strategic management.

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Context of the water quality status in the Amazon Basin countries.

Table 1. Area of Countries in the Amazon Basin

<table>
<thead>
<tr>
<th>Country</th>
<th>Total Area (km²)</th>
<th>Area of ARB (km²)</th>
<th>% of Country Area</th>
<th>Area of ARB (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>8,515,707</td>
<td>3,709,067</td>
<td>62.73%</td>
<td>62.73%</td>
</tr>
<tr>
<td>Colombia</td>
<td>1,133,063</td>
<td>345,462</td>
<td>5.84%</td>
<td>5.84%</td>
</tr>
<tr>
<td>Ecuador</td>
<td>248,619</td>
<td>131,265</td>
<td>2.22%</td>
<td>2.22%</td>
</tr>
<tr>
<td>Guyana</td>
<td>209,902</td>
<td>12,565</td>
<td>0.21%</td>
<td>0.21%</td>
</tr>
<tr>
<td>Bolivia</td>
<td>1,089,314</td>
<td>713,152</td>
<td>12.06%</td>
<td>12.06%</td>
</tr>
<tr>
<td>Peru</td>
<td>1,291,221</td>
<td>961,459</td>
<td>16.26%</td>
<td>16.26%</td>
</tr>
<tr>
<td>Venezuela</td>
<td>912,235</td>
<td>39,626</td>
<td>0.67%</td>
<td>0.67%</td>
</tr>
<tr>
<td>Total</td>
<td>5,912,598.61</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Source: Calculated by intersecting the IBGE/uni00A0administrative base/uni00A0(2016)/uni00A0and/uni00A0the/uni00A0ANA/uni00A0ottocoded base (2017)*
The hydrographic base used in this study was extracted from the ottobasins base (ANA, 2017), only a file that selected only one area of the Amazon Basin, totaling 129,705 ottobasins.

Figure 3. Sub-basins - Division and characteristics

To simplify the required analyses, they were grouped based on the largest tributaries of the main channel of the Amazon River, which resulted in six sub-basins: Lower Amazon, Madre de Dios/Madeira/Mamoré, Marañon/Solimões, Tapajós, Vaupés/Siapa/Negro and Xingu.

These sub-basins and their main characteristics are presented in Figure 3. It is worth highlighting that the Amazonian watershed used in this study has a hydrological character (in blue), which differs from that used by RAISG to delimit the Amazonian Biome (in red), as well as from the limit used by ACTO in the Strategic Action Program (SAP) (in yellow), all represented in Figure 3.
2. USE AND OCCUPATION OF THE AMAZONIAN SOIL

The occupation of the Amazon began around 14,000 years ago, when groups of Asians arrived in the Amazon River valley. More complex indigenous groups emerged and began to use resources from the forest in different and varied ways, leading to different land use and occupation practices. The land use and occupation practices varied according to the different stages of the historical process and the different cultural groups that occupied the Amazon Basin.

2.1. USE AND OCCUPATION OF THE AMAZONIAN SOIL

Based on the drainage area and hydric topology, Pfafstetter (1989) elaborated a methodological proposal for the hierarchical codification of hydrographic basins. The basins are treated as areas of contribution of the stretches of the numerically codified hydrographic network and considered the main input of the areas of the direct contribution of each stretch of this same hydrographic network. The details of the methodology are presented in Product 3.

Source: Adapted from IBGE (2020) and Atlas of Hydroclimatic Vulnerability of the Amazon Basin OTCA (2021).

Currently the Amazon Basin is home to approximately 33 million people, of which 1.1 million refer to the indigenous population, representing 3.6% of the total population. This population, distributed over the seven countries, is concentrated mainly along the large rivers of the basin and the western border, which is the Andes Mountains, and in regional hub cities. Figure 4 shows the distribution of the current population. The population distribution by sub-basins level 3 can be observed. It should be noted that this information refers to the territory that covers, exclusively, the Amazon River Basin.

Figure 5 below shows the current land use and occupation situation in the Amazon Basin.

In the 17th and 18th centuries, characterized by the administrative phase, there was a significant decrease in the number of Amazonian Indigenous Peoples. However, as soon as the inner forest was discovered and inhabited by European settlers, both native and exploitation remained low impact (KIRBY et al., 2005). From then on, the so-called “colonial occupation” was consolidated, encompassing cities such as La Paz, Cusco, Putumayo, and riverine municipalities settled in more interior regions of the forest, such as Manaus, Iquitos, and Trinidad, in a not very condensed form (MOYA, 2018; WORLD BANK, 2021).

As a consequence, and already being in the 19th century, the population configuration of the Amazon region was primarily composed of mixed indigenous populations, which could be traced back to the indigenous peoples at that time and for which the indigenous populations were social entities that were not discriminated against or considered part of the indigenous population. These were formed by the mixing of the forest, with significant changes in the landscape, especially in Brazil, due to the opening of roads that paved the way for pastures and predatory logging, especially in the Brazilian Amazon. In this period, in addition to these pressures, other activities intensified, such as mining, hydroelectric dams, and oil lots, now including the other countries.

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2. GENERAL CHARACTERISATION OF THE BASIN

When Europeans arrived at the Amazon River, they faced a dense forest inhabited by Indigenous Peoples of diverse cultures who benefited from the forest to support a reasonably large population (VERÍSSIMO, 2014). Cunha et al. (2006) indicate that before European colonization the Amazonian Indigenous population was around seven million inhabitants. Despite such significant number, this population managed to extract all their subsistence from the forest, causing low impact on the soil, mainly due to the cultivation method, which used the so-called relay of land, allowing time for natural revegetation, providing an anthropogenic soil of greater fertility, entitled “black Indian land.”

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2.2. NATURAL PROTECTED AREAS AND INDIGENOUS LANDS

The Amazon is an emblematic and internationally known region. Before its exploitation started, it was an isolated area with severely restricted access, which was only by river (Kirby et al., 2005). Since then to the present waterway transport has been the main means of transportation in the region. Subsequently, together with the beginning of the exploitation of natural resources there was greater pressure for preservation, mainly small and large-scale fires that were taking place. Corridors, river ecosystems, watercourses and natural lands, such as the Natural Protected Areas (NPAs) and Indigenous Lands (TIs). (Figure 6)

The Natural Protected Areas account for 1,349,169 km², while the Indigenous Lands occupy 1,804,174 km², representing 22.82% and 30.51% of the total area of the Amazon Basin. The region has about 395 NPAs and about 3,610 Indigenous territories distributed among 305 ethnic groups, which suffer the negative effects from the exploitation of the basin. Both the Natural Protected Areas and the Indigenous Lands play a fundamental role in environmental preservation involving the conservation of water resources, conservation of forests and biodiversity, and reduction in the effects of climate change, among others. The indigenous people have always been characterized by the use and adequate management of natural resources, without compromising the ecosystems, and this practice has proved to be of the utmost importance for the conservation of biodiversity. It is beyond dispute that indigenous people's knowledge brings several insights for sustainability as a whole, such as the rational use of the soil, refraining from hunting more than necessary, and no depletion of water resources, either quantitatively or qualitatively.

2.3. FLOOD AREAS

The Amazon region is naturally characterized by floodable areas (Figure 7). In ecological terms, floodable areas periodically receive lateral contributions of water, whether from rivers, lakes or through the underground contribution or precipitation. In the case of the Amazon region, the floodable areas affected by rivers and lakes are of greatest interest (Soares et al., 1999).

Millions of years ago, nearly 25% of the Amazon region was transformed into an aquatic ecosystem by the dynamics of flood pulses, which is a natural process that enriches the soil with sediments that are dragged from the various Andean basins to the lowlands. The process has been life-defining for indigenous cultures as floods contribute to the abundance and high diversity of aquatic species, especially fish and birds, to the flooded sites that become a rich source of food. Thus, this flood period is a fundamental for the consolidation of the food chain, sustaining the biodiversity that is the basis for life maintenance of Indigenous Peoples (RAISG, 2020).

It is worth stressing that, due to their specificities, floodable areas quickly recycle organic matter and nutrients, thus making the soil fertile to conduct socioeconomic activities, implying higher productivity indicators if compared to dry areas (Soares et al., 1999). On the other hand, these areas, when preserved, are extremely important water quality assurance and for the local biodiversity, for they are habitats for several species of fauna and flora. This dichotomy makes floodable areas the scene for various conflicts in land use, occupation, and the exploitation of water resources.
2.4. HYDROGEOCHEMICAL CLASSIFICATION OF AMAZON RIVERS: CLEAR, WHITE AND BLACK WATERS

The Amazonian rivers have different hydrogeochemical characteristics in terms of pH, conductivity, mineral salts, suspended solids, organic substances, and color, reflecting the relationship between geology, vegetation, and their characteristics. These three categories can be visualized in the images below, which show the subtle differences in their coloration.

**Clear waters** originate from ancient geological formations, and the plains flooded by them are called igapós (SANTOS, 2012; ZEIDEMANN, [s.d.]). Their coloration is clear, transparent, yellowish-green to olive. These are the most transparent waters, with pH ranging from acidic to basic and intermediate electrical conductivity.

**White waters** come from the drainage of sandy soils, called campina, campinarana, or Amazonian caatingas, their floodplains are of low fertility and are covered by flooded forest (SANTOS, 2012; ZEIDEMANN, [s.d.]). The waters are brown, brownish to reddish in hue. These waters have intermediate transparency and high electrical conductivity.

**Black waters** come from the drainage of clay soils, called várzeas, and their floodplains are called igapós, (SANTOS, 2012; ZEIDEMANN, [s.d.]), their coloration is brown, brownish to reddish. These waters have intermediate transparency and high electrical conductivity.

These pressures corroborate the main causes of water contamination in the Amazon Basin laid out in the Transboundary Diagnostic Analysis (ACTO, 2018), citing mining activities, domestic and industrial wastewater, river transport, among others. A study by Rios-Villamizar et al. (2020) suggested the inclusion of waters of intermediate characteristics in addition to the three main categories, especially in the lower order tributaries, as can be seen in the following figure. These stretches represent rivers with many transitional hydrochemical stages and strong influence of rainfall seasonality.
Deforestation in the Amazon Basin is one of the oldest pressures faced by the region, and it is a complex, multi-causal phenomenon that has affected the region in several ways. The expansion of human settlement and the need for land for various purposes, such as agriculture, mining, infrastructure, logging, grazing, and agriculture, have all contributed to deforestation in the region. The Amazon Basin is characterized by the presence of floodable zones, which are areas that are periodically flooded by rivers, and these areas are prone to deforestation. The process of deforestation in the Amazon Basin is driven by a complex interplay of factors, including demand for land, economic incentives, and political decisions. The Amazon Basin is a region of significant biodiversity, and deforestation is seen as a threat to this biodiversity.

Figure 9 illustrates the deforestation regions identified between 2001 and 2018. As shown, the deforestation regions are characterized by the presence of floodable zones, which are areas that are periodically flooded by rivers, and these areas are prone to deforestation. The process of deforestation in the Amazon Basin is driven by a complex interplay of factors, including demand for land, economic incentives, and political decisions. The Amazon Basin is a region of significant biodiversity, and deforestation is seen as a threat to this biodiversity.

Figure 10 shows the total number of fires per sub-basin. As shown, the sub-basins with the greatest number of fires are the Tapajós, Xingu, and Vaupés/Siapa/Negro sub-basins. TheTapajós sub-basin is the one with the greatest number of fires, with 242 fires identified between 24 and 25 October 2021. This is followed by the Xingu sub-basin, with 212 fires, and the Vaupés/Siapa/Negro sub-basin, with 187 fires. The Center for Nuclear Energy in Agriculture (Cena) concluded that the impacts of deforestation in the Amazon Basin are causing in the environment a chain reaction.

3.1. DEFORESTATION

Deforestation in the Amazon Basin is one of the oldest pressures faced by the region, and it is a complex, multi-causal phenomenon that has affected the region in several ways. The expansion of human settlement and the need for land for various purposes, such as agriculture, mining, infrastructure, logging, grazing, and agriculture, have all contributed to deforestation in the region. The Amazon Basin is characterized by the presence of floodable zones, which are areas that are periodically flooded by rivers, and these areas are prone to deforestation. The process of deforestation in the Amazon Basin is driven by a complex interplay of factors, including demand for land, economic incentives, and political decisions. The Amazon Basin is a region of significant biodiversity, and deforestation is seen as a threat to this biodiversity.

Although forest fires are a very old practice that has also been adapted by the indigenous population, the purpose of this practice is also to control the intensity of the burning. The water bodies and land in the Amazon Basin are both affected by this practice, and the process of deforestation in the Amazon Basin is characterized by the presence of floodable zones, which are areas that are periodically flooded by rivers, and these areas are prone to deforestation. The process of deforestation in the Amazon Basin is driven by a complex interplay of factors, including demand for land, economic incentives, and political decisions. The Amazon Basin is a region of significant biodiversity, and deforestation is seen as a threat to this biodiversity.

3.2. FOREST FIRES

The National Institute for Space Research (INPE) of Brazil monitors fires via satellite in near-real time, analyzing the satellite data in order to detect fires. The INPE has detected a significant increase in the number of fires in the Amazon Basin, relating this fact to the decrease in rainfall in the south portion of South America.

The Centre for Nuclear Energy in Agriculture (Cena) concluded that the impacts of deforestation in the Amazon Basin are causing in the environment a chain reaction. The process of deforestation in the Amazon Basin is driven by a complex interplay of factors, including demand for land, economic incentives, and political decisions. The Amazon Basin is a region of significant biodiversity, and deforestation is seen as a threat to this biodiversity.

In parallel, ACTO is also performing real-time monitoring of fires through the Amazon Regional Observatory, along with data provided by INPE, and the Operational and Intelligence Center for the Amazon Forest System (Gipeana), which will serve as a database for the national protection of land in the Amazon.

The figures show the data from the INPE system resulting from the AQUA M-T satellite in near-real time, analyzing the satellite data in order to detect fires. The INPE has detected a significant increase in the number of fires in the Amazon Basin, relating this fact to the decrease in rainfall in the south portion of South America.

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3. MINING

There are several mining operations in the Amazon Basin that are granted (exploration or exploitation) by the governments of the countries in which the basin is located, with a direct impact on public health, water quality, and the local ecosystem, resulting in other direct damage to water quality.

Among the impact of mining activities, it is relevant to mention the concentration of heavy metals in water resources, such as changes in pH and other chemical components, that, in turn, can alter the balance of other physical and chemical-physical processes. The discharge of mining effluents directly impacts the hydrological system of the Amazon Basin and the influence of mining activity on public health, there are direct impacts on water resources, such as changes in pH and other chemical components. In this sense, illegal mining stands out affecting negatively the entire hydrological system of the Amazon Basin and the influence of mining activity on public health.

Although the mining grants in the basin exploit various types of minerals, the most common is gold, which requires the use of mercury for extraction. In the case of illegal mining, mercury contamination has occurred and the mining activities have caused direct damage to the environment.

Heavy metals are of particular concern in relation to public health due to their cumulative toxicity. Consumption of mercury through contaminated fish can cause accumulation in the body, affecting mainly kidneys, liver, digestive system, and nervous system, interfering with the functioning of the body as a whole.

3.3. MINING

The mining sector is a significant pressure on water quality as water bodies are affected by polluting substances such as oils, grease, silt, clay and heavy metals, including mercury. Extractive activities, such as illegal mining, can have serious environmental and public health consequences for local communities and the ecosystem in general.

There are two main mining operations in the Amazon Basin that are granted: exploration mines (those granted for research purposes, without the removal of material, to analyze whether or not there is a deposit that exists, its feasibility for exploitation, ore studies and other similar purposes) and exploitation mines, which means that there is the removal of natural resources. Note that some mines are granted for both cases, both for exploration and exploitation.

3.4. AGRICULTURE AND LIVESTOCK

Agricultural activities are a type of pressure that significantly impact water quality, but differ according to the activity, as agriculture is more associated with diffuse pollution, while livestock farming is both diffuse and point source. Agricultural activities are a type of pressure that significantly impacts water quality, but differ according to the activity, as agriculture is more associated with diffuse pollution, while livestock farming is both diffuse and point source.

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3.5. HYDROELECTRIC PLANTS

In the area covered by the Amazon Basin there are different types of undertakings for electric power generation, among which stand out the hydroelectric power plants which are directly related to the quality of the water.

The construction of these undertakings, usually large ones, significantly affects the biocenosis of the basin, generating extensive effects on the surrounding region and the physical, chemical and biological alterations to the hydric system. Some of these alterations are: (i) acidification of the water when there is no previous deforestation in the basin; (ii) eutrophication produced by the leaching of fertilizers in adjacent arable areas; (iii) interference in migratory and reproductive processes of the ichthyofauna; (iv) hydrological alterations downstream of the reservoir; (v) increase in the sediments and (vi) increase in cases of waterborne diseases; (vii) alteration in water temperature, oxygenation (dissolved oxygen) and nutrient concentration; (viii) retention of phosphorus and export of nitrogen capable of eutrophicating downstream of the reservoir (HYNES, 1979; HENRY, 1989; HARPER, 1992; CMB, 2000; NAIME, 2012).

Figure 16 illustrates the Hydroelectric Power Plants (HPP) and Small Hydroelectric Plants (SHP) identified in the Amazon Basin, and the following chart accounts for these structures, including the planned undertakings, showing the potential growth of this activity in the basin.

3.6. OIL EXPLORATION

According to the study “Amazonia under pressure” (own translation - RAISG, 2020), one of the activities contributing to the water resources of the basin is oil activity, which represents 71% of the resources, concentrated in the Orinoco and Rio Negro basins. Oil exploration occurs in the Amazon basin and the construction of oil wells results in the modification of the water regime and the transportation of crude oil on the large pipelines. Since entering the river system is a source of contamination, these actions may affect all the aquatic and terrestrial environments. In the area covered by the Amazon Basin, the oil activity impacts water resources.

Despite the accidents involving the oil industry, no water quality monitoring points were identified by government agencies in these regions, whether already impacted or not. This data gap poses a risk by not allowing for the monitoring and understanding of how the activities impacting on the water resources of the Amazon Basin is oil activity, which represents 71% of the resources, concentrated in the Orinoco and Rio Negro basins. Oil exploration can be observed, since most of the fields are in the exploration and potential exploitation phases. Despite the extensive area of this activity in the basin, as shown in Figure 17, few areas of exploitation and exploration are known.

Contamination of water bodies by oil, and its derivatives, affects both natural and agricultural ecosystems, with long-term consequences. Despite its effects, the type of activity, the volume of oil inside pipelines, and the type of oil, the extent of the incident and the time of year, contaminants can affect a large area and damage several species of both aquatic and terrestrial biota. The characteristics of the water bodies in which the accident occurs are also relevant. The larger the volume of water, the longer the persistence of the oil, and consequently the extent of damage. In rivers with high flow, the oil is dispersed and transported, which reduces the severity of the incident. In fast-moving water, the oil appears as “mousse”.

Figure 17. Oil fields in the Amazon Basin

Legend

Type

In exploitation

Request

Potential

In exploitation

Under exploitation

In operation

Source: RAISG (2020) data processed by Cobrape.
3.2. DOMESTIC SEWAGE AND SOLID WASTE

Domestic sewage and solid waste, with their inherent characteristics, represent a significant source of pollution in the Amazon region. The discharge of untreated sewage and solid waste into water bodies is a major concern in the region, as it can negatively impact water quality and the health of aquatic ecosystems.

Domestic sewage waste is rich in organic matter, which, when discharged into water bodies in large quantities, can reduce the dissolved oxygen, causing fish mortality and making water bodies unsuitable for human consumption. Domestic sewage also contains pathogenic microorganisms, which can lead to the spread of waterborne diseases.

Solid waste pollution in the Amazon region is exacerbated by the lack of proper waste management systems in many areas. Tons of liquid and solid waste are dumped directly into rivers, affecting water quality and the health of aquatic ecosystems.

Pollution from domestic sewage or solid waste is a problem directly related to rapid urbanization and the lack of adequate infrastructure for the treatment and disposal of these waste products. This situation is particularly evident in the municipalities of the Amazon River Basin (ARB), where there is little official data on sanitation infrastructure and on how these sources of pollution impact water bodies.

3.3. WATERWAYS

The Amazon Basin is one of the main transport routes for goods and people, facilitating the exchange of goods and services between the region and the rest of the world. The main channel of the Amazon Basin is the Amazon River, which flows through nine countries, covering a length of approximately 6,400 kilometers.

The Amazon River is not only a vital transport route but also a source of pollution, with the discharge of untreated sewage and solid waste into water bodies and the transport of toxic products and the disposal of ballast water, which can bring exotic species and increase the risk of pollution.

The use of rivers as transport routes has always been a determining factor in the settlement of the Amazon region. The construction of waterways has allowed for the transport of goods and people, facilitating the exchange of goods and services between the region and the rest of the world.

The Amazon River Basin is a vast region with diverse landscapes and ecosystems, which are threatened by pollution from different sources. The Amazon River is not only a source of pollution but also a vital transport route for goods and people, facilitating the exchange of goods and services between the region and the rest of the world.

The main channel of the Amazon Basin is the Amazon River, which flows through nine countries, covering a length of approximately 6,400 kilometers. The Amazon River is not only a vital transport route but also a source of pollution, with the discharge of untreated sewage and solid waste into water bodies and the transport of toxic products and the disposal of ballast water, which can bring exotic species and increase the risk of pollution.
3.9. CLIMATE CHANGE

The Amazon biome is characterized by high rainfall rates. However, the region has had repeated periods of drought. The Intergovernmental Panel on Climate Change (IPCC), through the AR6 Report released in 2021, has identified that the Amazon rainforest has experienced a decrease in rainfall in the last decades, especially in the dry season.

The increase in temperature intensifies evaporation, raises water temperatures, reduces the humidity in the air, and increases in evaporation rates, which consequently generates less soil moisture. Changes in temperature and precipitation in the Amazon Basin directly affect the so-called “flying rivers”. These rivers are characterized by the large atmospheric mass generated by the Amazon forest, which condenses and becomes water, creating rivers. This is one of the regions with the highest potential of wind energy.

The report is based on five emission simulations, a set called CMIP6 (Coupled Model Intercomparison Project Phase 6). There are two low emission scenarios, one medium emission scenario and two high emission scenarios. The resulting estimates for Amazonia were obtained based on the data from the monitoring carried out by the Member Countries of the ACTO, which excludes Ecuador, Guyana, Suriname, and neighboring biomes.

Although the most recent data from the Global Carbon Project shows a 7% increase between the years 1992-2021, the Intergovernmental Panel on Climate Change (IPCC) has reported that large-scale deforestation can cause significant changes in the climate. The report states that deforestation directly affects the quality of water bodies. The reduction of forest cover results in a decrease in the amount of water that is transpired, which changes the water cycle and balances the hydrological system.

4. SURFACE WATER QUALITY STATUS

In order to characterize the quality of the water as regards organic pollution, a Potential Organic Pollution Indicator (POPI) was calculated, shown below.

The report points out that part of the global vegetation cover had a 7% increase between the years 1992-2021, which is not yet possible to relate it directly to existing monitoring data. Climate change can also be considered a pressure on the quality of the Amazonian waters although it is not yet possible to relate it directly to existing monitoring data. Drought in Amazonia, for instance, reduces water bodies, compromises aquatic life and reduces oxygenation, which aggravates the situation even more. In this scenario, riparian populations are hindered in their economic and daily activities, in addition to becoming more vulnerable and compromising their livelihoods (ANA, 2012).

The pressures presented, more specifically burning, deforestation and livestock are some of the activities responsible for the increase in greenhouse gas emissions, which is directly related to climate change. The increase in temperature intensifies evaporation, raises water temperatures, and reduces the humidity in the air, which consequently generates less soil moisture. The increase in temperature and evaporation in the Amazon Basin directly affect the so-called “flying rivers”. These rivers are characterized by the large atmospheric mass generated by the Amazon forest, which condenses and becomes water, creating rivers. This is one of the regions with the highest potential of wind energy.

Countries and made available for this study, which excludes Ecuador, Guyana, Suriname, and neighboring biomes. Despite the variation in methodologies and parameters monitored by the countries, the use of water quality indices was seen as important to the countries in order to facilitate data interpretation. Water quality indices represent the composition of an indicator from monitoring data of different parameters, with the aim of facilitating data interpretation.

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The methodology adopted to assess the “State” takes into account the legal water quality standards of the ACTO Member Countries. Thus, the legal limits of each country associated with the use of water for public supply and the protection and conservation of aquatic environments were considered. In some cases and for various reasons, they were bonded with the use of water for public supply and the protection and conservation of aquatic environments.

Water quality monitoring data

The water quality assessment for the report was based on monitoring data received from Bolivia, Brazil, Colombia, and Peru. Figure 19 presents a summary of the number of these monitoring data available by year. It is noteworthy that Ecuador did not provide monitoring data, Guyana and Venezuela do not monitor the Amazon Basin in their territory and Suriname has no water bodies in the basin.

The data received totals the monitoring of 161 different parameters distributed into 10 categories as shown in Figure 20, with variation of these parameters by monitoring point (in situ), which represent those determined in the field, among which stand out pH – related to water acidity, biological parameters, and solids.

A similar project is developed through the SO-Hybam (Current Hydro-Geodynamics of the Amazon Basin) project, which consists in obtaining hydrological data collected from satellite sensors, called “virtual stations”. Through these radars, river and reservoir level estimates and information for assessing water quality and meteorological conditions in the Amazon Basin includes information on suspended sediment concentration for 15 stations between 2000 and 2021.

Other monitoring data

A similar project is developed through the SO-Hybam (Current Hydro-Geodynamics of the Amazon Basin) project, which consists in obtaining hydrological data collected from satellite sensors, called “virtual stations”. Through these radars, river and reservoir level estimates and information for assessing water quality and meteorological conditions in the Amazon Basin includes information on suspended sediment concentration for 15 stations between 2000 and 2021.

All data received (Figure 22) came from the 1,938 monitoring points presented in Figure 21, with a breakdown by country.

Subsequently, the data was consolidated to reduce those points with extraneous locations and those that did not present data for the period of analysis, resulting in 705 stations. As shown in Figure 23, they were organized among those that presented data in the years 2019 and those that had at least seven years of data.
Water quality analysis

Ten water quality parameters were analyzed: electrical conductivity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), phosphorus, nitrate, dissolved oxygen (DO), turbidity, total dissolved solids, and pH. All these parameters are known to be related to the water quality status and can provide insight into the water quality condition.

4.1. ELECTRICAL CONDUCTIVITY

The electrical conductivity (EC) in the Amazon Basin, presented in Figure 24, shows that in 2019 most stations presented average values compatible with the hydropower characteristics. Additionally, the estimated POPI defined based on the EC values can be used to evaluate the water quality condition.

The river would need a flow rate up to 2 times greater than the current one in order to dilute the load of BOD concentration up to 5 mg/L. The estimated POPI indicated that in 2019 most stations presented average values compatible with the hydropower characteristics. In general, the averages found are consistent with the expected range of values. The exceptions occurred in two of the Madre de Dios/Madeira/Mamoré sub-basin, located in rivers in this category presented average values compatible with the hydropower characteristics.

The trend test was not identified in most of the stations that presented data. However, in the Xingu sub-basin, the trend test was identified in 3 stations, indicating a trend of reduction in EC. The trend test was also identified in 2 stations of the Madre de Dios/Madeira/Mamoré sub-basin, indicating a trend of increase. In general, the averages found are consistent with the expected range of values. The exceptions occurred in two of the Madre de Dios/Madeira/Mamoré sub-basin, located in rivers in this category presented average values compatible with the hydropower characteristics.

4.2. pH

The pH values in Figure 25 show that in 2019 most stations presented average values below the expected range for this category of water. In general, the averages found are consistent with the expected range of values. The exceptions occurred in two of the Madre de Dios/Madeira/Mamoré sub-basin, located in rivers in this category presented average values compatible with the hydropower characteristics.

Table 3: Categories of the Potential Organic Pollution Indicator (POPI)

<table>
<thead>
<tr>
<th>Category</th>
<th>POPI Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate A</td>
<td>140 - 782</td>
<td>Waters with conductivity between 30 and 180 μS/cm, neutral pH, with some specific points that are more acidic and even more basic than expected. They are in regions of intense deforestation.</td>
</tr>
<tr>
<td>Intermediate B</td>
<td>60 - 140</td>
<td>Waters with conductivity between 140 and 30 μS/cm, neutral pH, with some specific points that are more acidic and even more basic than expected. They are in regions of intense deforestation.</td>
</tr>
<tr>
<td>Intermediate C</td>
<td>&lt; 60</td>
<td>Waters with conductivity &lt; 60 μS/cm, neutral pH, with some specific points that are more acidic and even more basic than expected. They are in regions of intense deforestation.</td>
</tr>
</tbody>
</table>

4.3. DISOLVED OXYGEN (DO)

The dissolved oxygen (DO) values in Figure 26 show that in 2019 most stations presented average values below the expected range for this category of water. In general, the averages found are consistent with the expected range of values. The exceptions occurred in two of the Madre de Dios/Madeira/Mamoré sub-basin, located in rivers in this category presented average values compatible with the hydropower characteristics.

The trend test was not identified in most of the stations that presented data. However, in the Xingu sub-basin, the trend test was identified in 3 stations, indicating a trend of reduction in DO. The trend test was also identified in 2 stations of the Madre de Dios/Madeira/Mamoré sub-basin, indicating a trend of increase. In general, the averages found are consistent with the expected range of values. The exceptions occurred in two of the Madre de Dios/Madeira/Mamoré sub-basin, located in rivers in this category presented average values compatible with the hydropower characteristics.

Legend

- Insufficient historical data
- Reduction
- No Trend
- Increase
- greater than the current one
- less than the current one
- equal to the current one
4.4. POTENTIAL ORGANIC POLLUTION INDICATOR (POPI)

According to Figure 27, most of the ARB presented an expected POPI compatible with the "Very good" category, a few were in a "Good" situation, and a small number presented a category in "Regular" and only one chapter in "Poor". It is noteworthy that these ARB are the most frequent, especially in the Amazon and Madeira-Mamoré sub-basins.

In the Amazonas/Tapajós basin, it was possible to identify a larger number of cities with POPI in the "Regular" category, due to the higher proportion of urban areas and the presence of pollution sources. In the Madeira-Mamoré basin, the urban areas are smaller, and the POPI is mainly in the "Very good" category.

A critical area is observed in the Upper Amazonas sub-basin, near the Caruari river, the largest tributary of the Amazonas River. This area is characterized by high pollution levels, resulting in a "Poor" category, as shown in Figure 27. The pollution sources in this area are mainly urban and industrial, with a high concentration of population and economic activities.

To complement this study, the Mercury Observatory (2021) presented the results of campaigns carried out in the Amazon Basin, highlighting the presence of mercury contamination in various ecosystems, including fish and humans. The levels of mercury found in the fish samples were related to the proximity to pollution sources and the contamination in the water bodies. The results indicate that mercury is bioaccumulated in these organisms, as living organisms do not metabolize these metals, so any concentration can have adverse effects on aquatic organisms, especially fish and other upper food chain organisms, as their prey may have higher concentrations, which is known as biomagnification.

The tool created by the Mercury Observatory brings together scientific literature resulting from a systematic review conducted between 1980 and 2021, compiling records of mercury contamination in humans and fish from different countries in the Amazon Basin. The data show that mercury contamination is widespread in the basin, with high concentrations found in fish and humans, especially in the tributaries of the main rivers.

With regard to mercury, whose impact is most studied in the Basin, all the 2019 averages from the river systems of Gauja and Burdeos (2017) indicated reduced concentrations, five of which are the same ones in which arsenic contamination was expected. In the Malinowski et al. (2017) study, the levels of mercury found in the fish samples were related to the proximity to pollution sources and the contamination in the water bodies.

For most locations, the contamination in fish is found in the rivers Madeira, Tapajós and Negro. For most localities, the contamination in fish, especially in the tributary of the main rivers, concentrations are lower than the most restrictive legal limit (0.0001 mg/L). However, levels above the most restrictive limit were found in specific points, and resulting in the largest urban areas being highlighted.

Illegal mining, combined with burning and deforestation, is a common practice in the Amazon Basin, especially in the Madeira-Mamoré sub-basin, near the city of Santarém, and in the Lower Amazonas sub-basin, near the city of Manaus. The contamination found in the fish samples was related to the proximity to pollution sources and the contamination in the water bodies.

4.5. METALS

Mercury is the most toxic metal present in the Amazon, with an average concentration of 0.01 mg/L in the water. The contamination in humans is due to the exposure of contaminated food and air. In Brazil, this is not the case in all countries. It is smuggled by miners to capture gold and is easily transported to the Amazon Basin, where it is enriched by the gold mining activity.

The tool created by the Mercury Observatory brings together scientific literature resulting from a systematic review conducted between 1980 and 2021, compiling records of mercury contamination in humans and fish from different countries in the Amazon Basin. The data show that mercury contamination is widespread in the basin, with high concentrations found in fish and humans, especially in the tributaries of the main rivers.

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As such, the results of the means monitored for these parameters are only indicative of the harmful effects of mining on water quality, and trend in 2019. It is noteworthy that these metals are among those with low solubility and trend in 2019. It is noteworthy that these metals are among those with low solubility and are not metabolized or excreted, bioaccumulation occurs, and results in very high concentrations in fish. These pollutants in water bodies.

Specific studies on the concentration of metals in living organisms are more representative of the harmful effects of mining on water quality and human health. The results of the means monitored for these parameters are only indicative of the harmful effects of mining on water quality. Bioaccumulation occurs, and results in very high concentrations in fish. These pollutants in water bodies.
The response given by governments and society to the degradations in the quality of surface water in the Amazon basin is the result of actions that have been carried out to protect the genetic base, ecosystem services, and societal assets, mainly through national policies and international agreements. The protection of the natural environment and the sustainable management of its resources are the priority objectives of the governments in the region. For the purpose of this study, one of the most significant responses to the stresses acting on the surface water quality will be analyzed. It is emphasized that “response” is the central of the Pressure-State-Response methodology. In the relation of the reduction of risk factors, pressure has not obtained in a very short, even though they may appear as a response to a problem.

Various actions have been taken to address the situation described above. It is not possible to list here the actions taken, but they were directly affected in the state of water quality, and they include both public and private entities and often several actions are undertaken on an ad-hoc basis.

Some actions are of the high risk type and are described below. This is not an exhaustive list of all the actions, in order to achieve a better quality, but an attempt to synthesize the actions that, more than responses, act to improve the state of water quality in the Amazon basin are also presented.

**Mining**

The new position relative to mining in the Amazon basin in the illegal gold mining that characterizes the same with mining and social conflicts. According to SCRAM (2016), it is necessary to promote studies on the impacts of mercury emissions from illegal gold mining and implement recovery programs for the downstream affected areas.

To comply with the Minamata Convention on Mercury, Colombia has adopted Law No. 1658/2013, which regulates the use and trade of mercury in mining operations within five years. In addition, it adopted several measures to phase out the use of mercury, replacing it with clean technologies in all areas where it is used in mining operations. In Ecuador, the creation of the Mercury Observatory developed by WWF-Brazil, in partnership with the “Ministerio del Ambiente” of Ecuador has helped to identify areas degraded by garimpo activities. The use of mercury in mining activities will constitute an important response for the mitigation of the presence of mercury in Amazonian rivers.

Some of the initiatives implemented to reduce mercury contamination in the Amazon Basin and allow it to be viewed in georeferenced form.

With regard to studies conducted, the Mercury Observatory is an important initiative was established that contains relevant data and information regarding the state and trends of mercury contamination in the Amazon region and allows it to be viewed in georeferenced form.

**Industries**

The industrial sector is one of the main sources of pressure on the environment. The discharge of effluents and the reuse of treated wastewater, authorizing works on natural resources, are services that are in the process of being phased out, as is the case with the use of mercury in mining activities. The use of mercury in mining activities will constitute an important response for the mitigation of the presence of mercury in Amazonian rivers.

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**Tourism**

Tourism is one of the main sources of pressure on the environment. The discharge of effluents and the reuse of treated wastewater, authorizing works on natural resources, are services that are in the process of being phased out, as is the case with the use of mercury in mining activities. The use of mercury in mining activities will constitute an important response for the mitigation of the presence of mercury in Amazonian rivers.

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**Agriculture**

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**Public Policy**

Public policy is one of the main sources of pressure on the environment. The discharge of effluents and the reuse of treated wastewater, authorizing works on natural resources, are services that are in the process of being phased out, as is the case with the use of mercury in mining activities. The use of mercury in mining activities will constitute an important response for the mitigation of the presence of mercury in Amazonian rivers.

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**Population**

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With regard to studies conducted, the Mercury Observatory is an important initiative was established that contains relevant data and information regarding the state and trends of mercury contamination in the Amazon region and allows it to be viewed in georeferenced form. **Conclusion**

The countries of the Amazon have an important role in the challenges related to the protection of water resources in the region. The Amazon countries have legislation on sanitation in order to provide this important public service. However, in general, the levels of sewage and solid waste collection and treatment are low in the Amazon basin. The Amazon region is characterized by a high degree of urbanization and industrialization, which has led to an increase in the demand for waste management services. Therefore, it is crucial that these countries take measures to improve the state of sanitation services in the region, in order to achieve the objectives established within the context of the Pressure-State-Response methodology.

**References**

works in coordination with universities in Ecuador to develop soil treatment technologies since 2014 with the aim of remediating contamination through environmental clean-up. In Ecuador, the company Petroecuador has been developing the Amazonia Viva Project, which is focused on preventing and remediating contamination of the Amazon River. One of the main activities of this project is the development of technologies to remediate contamination caused by oil spills. According to Petroecuador (2018), some accidents were caused by oil spills in the Amazon River in 2014 and 2015. Another source of contamination in the Amazon region is the oil industry. Oil exploration, production, and transportation activities can lead to oil spills, which can affect the environment and human health. In addition, the Amazon region is home to a large number of indigenous communities who rely on the river for their livelihoods. Therefore, it is essential to develop and implement strategies to prevent and remediate oil spills in the Amazon region. This can be achieved through the development of technologies and the implementation of policies and regulations that promote the protection of the Amazon River. In addition, it is necessary to strengthen the monitoring and inspection systems to ensure that these technologies are effectively implemented. The implementation of these strategies will contribute to the protection of the Amazon region and the well-being of its inhabitants. Oil Exploration

The Amazon region is rich in oil resources, and several companies are engaged in oil exploration activities. However, oil exploration activities can lead to environmental degradation and social conflict, especially in the Amazon region. Therefore, it is essential to develop and implement strategies to mitigate the impact of oil exploration activities on the environment and society. This can be achieved through the development of environmental impact assessments, which are designed to evaluate the potential environmental and social impact of oil exploration activities. In addition, it is necessary to strengthen the monitoring and inspection systems to ensure that these assessments are effectively implemented. The implementation of these strategies will contribute to the protection of the Amazon region and the well-being of its inhabitants. Oil Extraction

Oil extraction activities can lead to environmental degradation, social conflict, and human health problems, especially in the Amazon region. Therefore, it is essential to develop and implement strategies to mitigate the impact of oil extraction activities on the environment and society. This can be achieved through the development of environmental impact assessments, which are designed to evaluate the potential environmental and social impact of oil extraction activities. In addition, it is necessary to strengthen the monitoring and inspection systems to ensure that these assessments are effectively implemented. The implementation of these strategies will contribute to the protection of the Amazon region and the well-being of its inhabitants. Deforestation and Fire

Deforestation and fires in the Amazon region are a significant source of environmental degradation and social conflict, especially in the Amazon region. Therefore, it is essential to develop and implement strategies to mitigate the impact of deforestation and fires on the environment and society. This can be achieved through the development of environmental impact assessments, which are designed to evaluate the potential environmental and social impact of deforestation and fires. In addition, it is necessary to strengthen the monitoring and inspection systems to ensure that these assessments are effectively implemented. The implementation of these strategies will contribute to the protection of the Amazon region and the well-being of its inhabitants. Waterways

Waterways in the Amazon region are essential for integration and regional development in the Amazon region. However, waterways in the Amazon region are increasingly affected by pollution, and this can lead to environmental degradation and social conflict. Therefore, it is essential to develop and implement strategies to mitigate the impact of waterways pollution on the environment and society. This can be achieved through the development of environmental impact assessments, which are designed to evaluate the potential environmental and social impact of waterways pollution. In addition, it is necessary to strengthen the monitoring and inspection systems to ensure that these assessments are effectively implemented. The implementation of these strategies will contribute to the protection of the Amazon region and the well-being of its inhabitants. Hydroelectric power plants

Hydroelectric power plants can contribute to the sustainability of the Amazon region, but they can also lead to environmental degradation and social conflict. Therefore, it is essential to develop and implement strategies to mitigate the impact of hydroelectric power plants on the environment and society. This can be achieved through the development of environmental impact assessments, which are designed to evaluate the potential environmental and social impact of hydroelectric power plants. In addition, it is necessary to strengthen the monitoring and inspection systems to ensure that these assessments are effectively implemented. The implementation of these strategies will contribute to the protection of the Amazon region and the well-being of its inhabitants.
Once the network is completed, 111 monitoring points will be installed in three different regions of the basin, in order to gather all the necessary information for the monitoring of water quality in the Amazon. These points will be placed in river mouths, lakes, and coastal areas, and will be equipped with sensors to monitor various parameters such as temperature, pH, dissolved oxygen, turbidity, and nutrient concentrations. The data collected from these monitoring points will be used to create a comprehensive database of water quality in the Amazon Basin, which will serve as a reference for future research and decision-making.

The Regional Network for Monitoring the Quality of Surface Waters for the Amazon Region (RR-MQA) is the result of the initiative of 8 Amazonian countries (Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela) to promote the development of a high-quality water monitoring system in the Amazon Basin. The network was designed to provide real-time information on the status of water quality in the region, allowing for the identification of any changes or trends in water quality that may impact the health and well-being of the Amazonian population.

The RR-MQA network consists of a system of monitoring points located throughout the Amazon Basin, which are equipped with state-of-the-art technology to collect and transmit data on water quality parameters. The data collected from these points is then analyzed and used to create maps and other visualizations that can be used to track changes in water quality over time.

The RR-MQA network is supported by the Amazon Cooperation Treaty Organization (ACTO), which is an intergovernmental organization established to promote regional cooperation in the Amazon Basin. The ACTO provides funding and technical support to the RR-MQA network, and works with governments and other stakeholders to ensure that the network is able to collect and provide accurate data on water quality in the Amazon Basin.

The RR-MQA network is an important tool for the management of water resources in the Amazon Basin, and is an essential component of the efforts to protect and preserve the biodiversity and other natural resources of the region. By providing real-time information on the status of water quality, the RR-MQA network is helping to ensure that the Amazon Basin is able to continue to provide the resources and services that are vital to the health and well-being of the region's people and ecosystems.
6.1. CRITICAL AREAS

Considering the existing data, and its heterogeneity in terms of space, time, and monitored parameters, an initial critical matrix of water quality was identified. Further, based on the application of the PER methodology, especially based on the pressures identified; areas where the POPI of organic pollution is defined, based on press indicators, shown in the following figures:

- Pressures: comprise areas of deforestation, illegal mining, and urbanization and are shown in red (Figure 31).

- Pressures in special areas: comprise the overlap of pressures already mentioned with the areas considered special: protected areas, indigenous territories, and flood zones (Figure 32).

Figure 31. Critical areas in terms of pressures
Source: Cobrape (2022).

Figure 32. Critical areas in terms of pressures in special areas
Source: Cobrape (2022).

Figure 33. Critical areas in terms of pressures in headwaters
Source: Cobrape (2022).

Figure 34. Critical areas in terms of POPI (Potential Organic Pollution Indicator)
Note: ranges defined based on the legislation of Amazonian countries, being specific for this study.

The figures show that the pressures are distributed throughout the sub-basins of the ARB, notably present in headwaters and special areas, especially in indigenous territories. This is a general concern, since in these areas there is usually no monitoring of water quality, and traditional communities usually consume water without prior treatment. Although agriculture and livestock stood out in terms of occupied area, the significant impact of mining was evident - two pressures that can be associated with a third pressure.
deforestation: this is the natural stage of deforestation. This is commonly the natural stage of deforestation, and which results in alterations in water quality, especially when the natural baseline is defined. The advance of mining, which leaves the populations vulnerable to water-borne diseases and generates contamination of water bodies, is especially evident in mining and hydropower projects. The impact of flooding of the Amazon on the Marañón/Solimões sub-basin, in the headwater regions and near Iquitos (Peru). The need for adequate monitoring is also highlighted, so that this relationship can occur and the results of the heavy metal contamination can be validated with Member Countries. The steps identified through the application of the four stages mentioned in Section 2 of the present paper were also seen in the analysis of the mercury concentration for the Marañón/Solimões sub-basin. The elaboration of the Proposal for the integral management of the water quality of the Amazon Basin in the following sections is a joint project of the Member Countries of the Amazon Basin Treaty Organization (ACTO) and the Amazon Cooperation Treaty Organization (ACTO). The elaboration of the Proposal is based on the results of the water quality assessment

6.2. PROPOSAL FOR INTEGRAL MANAGEMENT OF WATER QUALITY IN THE AMAZON BASIN

The elaboration of the Proposal for the integral management of the water quality of the Amazon Basin in its current state is a joint project of the Member Countries of the Amazon Basin Treaty Organization (ACTO) and the Amazon Cooperation Treaty Organization (ACTO). The elaboration of the Proposal for the integral management of the water quality of the Amazon Basin in the following sections is a joint project of the Member Countries of the Amazon Basin Treaty Organization (ACTO) and the Amazon Cooperation Treaty Organization (ACTO). The elaboration of the Proposal is based on the results of the water quality assessment conducted in the Amazon Basin Treaty Organization (ACTO) and the Amazon Cooperation Treaty Organization (ACTO). The elaboration of the Proposal is based on the results of the water quality assessment conducted in the Amazon Basin Treaty Organization (ACTO) and the Amazon Cooperation Treaty Organization (ACTO). The elaboration of the Proposal is based on the results of the water quality assessment conducted in the Amazon Basin Treaty Organization (ACTO) and the Amazon Cooperation Treaty Organization (ACTO). The elaboration of the Proposal is based on the results of the water quality assessment conducted in the Amazon Basin Treaty Organization (ACTO) and the Amazon Cooperation Treaty Organization (ACTO). The elaboration of the Proposal is based on the results of the water quality assessment conducted in the Amazon Basin Treaty Organization (ACTO) and the Amazon Cooperation Treaty Organization (ACTO). The elaboration of the Proposal is based on the results of the water quality assessment conducted in the Amazon Basin Treaty Organization (ACTO) and the Amazon Cooperation Treaty Organization (ACTO).
6.3. CHALLENGERS FOR WATER QUALITY MANAGEMENT IN THE AMAZON BASIN

One of the main results of applying the PSR (Pressure-State-Response) methodology was the identification that adequate information, both spatially and temporally, is needed in the basin. Several bottlenecks were identified, such as the need for continuous and long-term funding for monitoring activities; the need for a more integrated view of the pressures, states, and responses taking into account different data sources; the need for a better understanding of the natural conditions so they can be included in the definition of water quality assessment standards; the need for more detailed analysis of these problems; each country should possess and share this information.

The implementation of the Amazon Regional Observatory has been prioritized by ACTO’s activities, such as the implementation of the Water Quality Monitoring Network in the basin. This process requires building a discussion forum supported by technical analyses and consultations with the basin’s institutions and the need for continuous actions with long-term funding. This process encompasses a better understanding of the natural conditions so they can be included in the definition of water quality assessment standards.

The Mercury Observatory can be considered a good example of the results of applying the PSR methodology. Several studies published on this topic, however, they are usually developed by different entities of the Member Countries or, better yet, from the National Information Systems. The Mercury Observatory compiles, stores and publishes the data coming from different governmental institutions and organizations, as a space for articulation in different areas of information of the Amazonian countries. This observatory is based on the implementation of the PSR methodology for water quality management in spatial and temporal terms; monitoring focused on defining water quality assessment standards, that they can be included in the definition of water quality assessment standards.

The natural characteristics of the different types of Amazonian rivers; monitoring focused on defining water quality assessment standards.

More specifically about water quality monitoring, several bottlenecks were identified, such as the need for continuous and long-term funding for monitoring activities; the need for a more integrated view of the pressures, states, and responses taking into account different data sources; the need for a better understanding of the natural conditions so they can be included in the definition of water quality assessment standards.

One of the major results of applying the PSR (Pressure-State-Response) methodology was the identification that adequate information, both spatially and temporally, is needed in the basin. Several bottlenecks were identified, such as the need for continuous and long-term funding for monitoring activities; the need for a more integrated view of the pressures, states, and responses taking into account different data sources; the need for a better understanding of the natural conditions so they can be included in the definition of water quality assessment standards.