Revista ARACÊ
ISSN: 2358-2472

THE CLIMATE CRISIS AND ITS SOCIOECONOMIC AND ENVIRONMENTAL IMPACTS IN THE AMAZON

https://doi.org/10.56238/arev7n4-148

Submitted on: 14/03/2025 **Publication date:** 14/04/2025

Afonso Fonseca Fernandes
Postdoctoral Fellow in Environmental Economics
PhD in Business Administration
PhD in Economics
State University of Amazonas (UEA)
Manaus, Amazonas - Brazil
E-mail: afonsofernandes65@hotmail.com
ORCID: https://orcid.org/0000-0001-7350-2333

Américo Matsuo Minori
PhD in Business Administration
Professional Master's Degree in Production Engineering.
Santa Teresa College (FST)
Manaus, Amazonas - Brazil
E-mail: aminori0235@gmail.com ORCID:
https://orcid.org/0000-0003-2521-4964

João Guilherme de Moraes Silva
Master in Electrical Engineering in Telecommunication
Federal Institute of Education, Science and Technology of Amazonas (IFAM)
Manaus, Amazonas – Brazil.
E-mail: guilherme@ifam.edu.br
ORCID: https://orcid.org/0009-0003-2023-5579

ABSTRACT

The current climate crisis has had an impact on different parts of the planet, especially in the largest tropical forest in the world, the Amazon. This article aims to relate the severe drought that occurred in the years 2023 and 2024, and its main socioeconomic and environmental consequences in the Amazon. The climatic phenomena El Niño, La Niña, the rise in the temperature of the waters of the North Atlantic, deforestation and fires, have caused anomalies of precipitation and temperature in the Amazon region with severe consequences for local communities, the economy and biodiversity in the region. In order to mitigate the effects of the drought, there were emergency actions by government actors, national and international entities, in addition to the suggestion of monitoring climate change, preventive actions by actors and agents of society, and public and social policies for the preservation of the Amazon forest.

Keywords: Amazon. Drought. Biodiversity. Economy. Environment.

Revista ARACÊ
ISSN: 2358-2472

INTRODUCTION

According to Baker *et al.* (2013) the Amazon river basin is fundamental to maintaining the global climate. One of the striking aspects of the Amazon region is the phenomenon of droughts that are seasonal and occur with a certain frequency, alternating with periods of drought and rain. Although drought records for the region are scarce or even non-existent, studies of plants such as the growth rings of the sweet cedar (*Cedrela adorata*) help in the identification of drought extremes and the rise of waters in the past throughout the twentieth century.

According to Barbosa Filho (2023), the El Niño phenomenon aggravated the context of drought in the Amazon in 2023 and 2024, generating a below-normal level of rainfall for the region, repeating the phenomena of 2009 and 2010, considered historic droughts in the Amazon basin.

Also Loureiro *et al*. (2024) reinforced, in the same understanding, the effects of the phenomenon of severe drought in the Amazon in 2023 through climatic factors, among which El Niño stands out, which is the anomalous warming of the waters of the Pacific Ocean and the warming of the waters of the North Tropical Atlantic. These conditions prevent the formation of clouds, reducing the volume of rainfall in the region, and this event began in May 2023 and "extended" to 2024, causing the longest drought in the history of the State of Amazonas. The impacts were drastic, registering the lowest water level in the rivers in the historical series of 52 years; scarcity of food and lack of drinking water for riverside dwellers, leading the 60 municipalities to declare an emergency situation.

The drought negatively impacted the economy of the Amazon region according to Vasconcelos (2023), Athayde (2024) and AMAZONAS (2024b) especially the States of Pará and Amazonas, as the main source of tax collection in the State of Amazonas was affected by a reduction in the revenue of the industries of the Manaus Industrial Pole (PIM), in addition, according to Oliveira (2023) and Zanatta (2024), there was a "drought fee" that ranged from R$ 3 thousand to R$ 10 thousand reais per container transported, raising the costs of supplying inputs and the flow of products from the Manaus Free Trade Zone - ZFM.

In order to mitigate the main and most significant social, economic, and environmental impacts of the 2023 and 2024 drought, there were several actions, both governmental and private sector, and national and international institutions. The actions of the government of the State of Amazonas included the sending of drinking water, basic

Revista ARACÊ
ISSN: 2358-2472

food baskets, medicines, water tanks, implementation of the "class at home" project and dredging of river beds in order to maintain navigability and by the private sector, according to AMAZONAS (2024b) there was the installation of temporary ports near the Municipality of Itacoatiara in order to alleviate the difficulty of logistics of inputs and export of PIM products.

The relevance of the investigation lies in the fact that the effects of the climate crisis are global and severe, and that despite its complexity, it can be described in the social, environmental, and economic tripod.

In view of the above, this article aims to relate the severe drought that occurred in the years 2023 and 2024 in the Amazon and its main socioeconomic and environmental consequences in the Amazon.

THEORETICAL FOUNDATION

According to Barbosa Filho (2023), the prevailing drought situation in the Amazon was aggravated by fires that, if added to the fires, in September 2023 alone, 6,782 hot spots were recorded, according to the National Institute for Space Research (INPE). In addition, based on information from the Regulatory Agency for Delegated and Contracted Public Services of the State of Amazonas (ASERPAM), the logistics of people and products were extremely difficult due to the dependence on waterway transport, in which 90% of the 136 boats operating on the 116 lines in Amazonas worked with half of the transport of people and cargo in 2023.

Complementing the statement of drought or lack of rain and the ebb period of the rivers of the Amazon, Louzada (2023) pointed out that the Amazon suffered the consequences of environmental phenomena such as very severe drought, intense fires, clouds of smoke, and high temperatures. It was in this unfortunate scenario that there were losses of biodiversity with the death of thousands of fish and dolphins due to the lack of oxygen and the high temperature of the river water, in addition to the risks to human health with the clouds of smoke.

In this same line of understanding, Lima (2024) commented on the alert that the Geological Service of Brazil/Superintendence of Manaus (CPRM) issued in relation to the ebb of the rivers of the Amazon in the year 2024, in Manaus there was a 16% chance of the Negro River exceeding the minimum of 12.70, in 2023. He also warned about the effects of the drought, such as the lack of drinking water for riverside, indigenous and

Revista ARACÊ
ISSN: 2358-2472

quilombola communities, which were aggravated by being in distant and almost isolated areas, forcing these communities to improvise the filtration of water from lakes and streams.

The National Institute of Meteorology – INMETRO (2023) confirmed that in 2023 the volume of rain in the entire Amazon region was below average, with the greatest period of scarcity occurring in the months of June, July and August 2023. In September 2023, in Belém (PA) 32.7 mm of total rain was recorded in September and in Manaus (AM) 44.1 mm, these were lower levels in the period, contributing to a very severe drought (INMETRO, 2023). This information is summarized in Table 1.

Table 1 - Comparative rainfall in the Municipalities of Belém and Manaus.

Weather Stations	September/2023	Average (September)	Lowest total in September (1961-2023)
Belém (PA)	32.7 mm	120.1 mm	28.1 mm (1991)
Manaus (AM)	44.1 mm	79.0 mm	0.6 mm (2014)

Source: INMETRO, 2023.

Regarding the economic impacts, Oliveira (2023) and Zanatta (2024) cited the increase in prices of shipping companies during the drought in the State of Amazonas, as they started to charge the "drought fee" that was between R$ 3 thousand and R$ 10 thousand per container, so the flow of goods produced in the Manaus Free Trade Zone (ZFM) was impaired. Normally, the demand for products manufactured in the ZFM is high at the end of the year, which includes *Black Friday* and Christmas; however, the production of these products should form a stock months before, such as July, August and September, precisely the period when the drought occurred in the region.

In the same vein, Athayde (2024) contemplated the ZFM, citing the number of 500 multinational industries that are responsible for about 70% of the GDP of the State of Amazonas and that faced a challenge of paralysis of river navigation in 2024, as the lack of rain prevented the navigation of cargo ships and the supply of essential raw material was interrupted and, in this way, negatively impacted the operations of the industries. In addition to the delay in production, companies were penalized by the increase in logistics costs and the reduction of competitiveness in the market.

Mota (2024) commented on the implementation of temporary ports in Amazonas that boosted the state's economy in 2024, precisely in the dry season. According to

Revista ARACÊ
ISSN: 2358-2472

AMAZONAS (2024b), by October 2024, Amazonas imported US$ 13.5 billion, surpassing US$ 12.6 billion in 2023. In 2023, with port restrictions due to drought, the state recorded only US$ 604 million in imports. Evidence that the temporary ports, located in the Municipality of Itacoatiara, were an assertive option in the drought in the economic view is the effective results of these by handling more than 25 thousand containers in 2024.

AMAZONAS (2024b) also highlighted the measures to support industry and commerce of the Government of the State of Amazonas to mitigate the drought in the State, such as: payment of state tax in two equal installments and environmental licenses for the installation of two temporary ports in Itacoatiara and the Madeira River. The objective of the measures was to provide the competitiveness of these industrial, trade and services due to the logistical difficulties in the transport of products and the collection of the Tax on the Circulation of Goods and Services (ICMS).

Loureiro *et al.* (2024) confirmed in their research on the 2023 drought as a historic and severe hydrological event in the Amazon basin. The causes were the climatic factors El Niño, which caused warming of the waters of the Pacific Ocean, and the warming of the waters of the North Atlantic, which contributed to the reduction of rainfall in the region. The consequences were a significant precipitation deficit throughout 2023, extending into 2024, difficulties in river transport, scarcity of food and drinking water in riverside communities.

Portal Marcos Santos (2024) cited that the State Government of Amazonas issued a decree on July 5, 2024 declaring that the 62 municipalities were in a state of emergency due to the consequences of the drought and fires. In the period from June to November 2024, 22.1 thousand fire outbreaks were fought by the Amazonas Military Fire Department (CBMAM), the Amazonas Environmental Protection Institute (IPAM) carried out 449 fire embargoes and imposed a fine in the amount of R$ 208.5 million, in addition to 51 seizure terms and 194 arrests. The state government sent 202.1 tons of medicines and supplies to the municipalities of the Madeira, Juruá, Purus and Alto Solimões rivers, as well as 708 oxygen cylinders, in addition to the installation of an oxygen plant in the municipality of Envira.

Vasconcelos (2023) reported that the industrial production of the PIM decreased by 2.6% in October when compared to September 2023; and when compared to October 2022, there was a decrease of 5.7%, according to the Brazilian Institute of Geography and Statistics (IBGE). In addition, the drought generated a movement of collective vacations in order not to generate additional costs in the production chain. In the State of Pará, the

Revista ARACÊ
ISSN: 2358-2472

drought had a smaller impact, so the industrial sector managed to grow 0.1% in October when compared to September 2023, and 8% when compared to October 2022. Thus, it was found that the drought had a significant impact on industrial productivity in the North of the country.

METHODOLOGY

The sources adopted in the research were guided by a bibliographic research of articles, publications existing on websites as cnnbrasil.com entities; portal.inmet.gov.br, just to mention as examples, in view of the lack of publications in other sources, especially in journals. One of the reasons for this lack is the fact that the climate crisis has a random characteristic, difficult to predict its occurrence and intensity, speed of growth and decrease of this intensity, in addition to the duration of the crisis. These characteristics tend to be classified as the Black Swan theory (Taleb, 2007; Aven, 2013) or as a typical case of "ripple effect" according to Dolgui and Ivanov (2021).

In other words, the climate crisis can have unprecedented and dynamic behaviors with variable impacts, which can be days and even hours when it comes to the variation of river levels, in the period of drought or drought, as in the case of the climate crisis dealt with in the work.

In this way, the research is based on a case study that occurs in various forms of research in the area of social sciences. The research will be qualitative, descriptive, exploratory. According to Martine et al. (2016 p. 59) "qualitative evaluation is characterized by the description, understanding and interpretation of facts and phenomena, in contrast to quantitative evaluation, called quantitative research, where measurements predominate".

Martine et al. (2026) also adds that case studies are included in qualitative evaluation, as their objective is to focus on a social unit that the researcher must analyze in depth within a real event that has no control over the events or variables, but creatively describes, understands and interprets the case of the research.

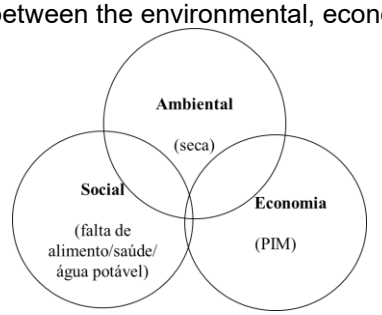
Yin (2015), on the other hand, considers a case study as an empirical investigation of a real and contemporary context, in a detailed way, especially when the boundaries between the reality of the research elements are not clearly evident or predictable.

Figure 1 shows the interaction of the three factors caused by the climate crisis caused by the lack of rain. In the environmental aspect, highlighting as a serious reflection the drought that, as a result, hit the river and even leaving the bed with a trickle of water or

Revista ARACÊ
ISSN: 2358-2472

cracked earth. In the social aspect, the severity is focused on the lack of food, difficulty in precarious health care, people's locomotion, seriously affecting people with disabilities (PCD), the difficulty of obtaining drinking water for a minimum service. On the economic side, the bias caused by the companies of the Manaus Industrial Pole (PIM) was notable both in the supply of inputs and in the demand for products and services.

Figure 1 - Interaction between the environmental, economic and social factors



Source: authors, 2024.

RESULTS AND DISCUSSION

EVOLUTION OF THE DROUGHT

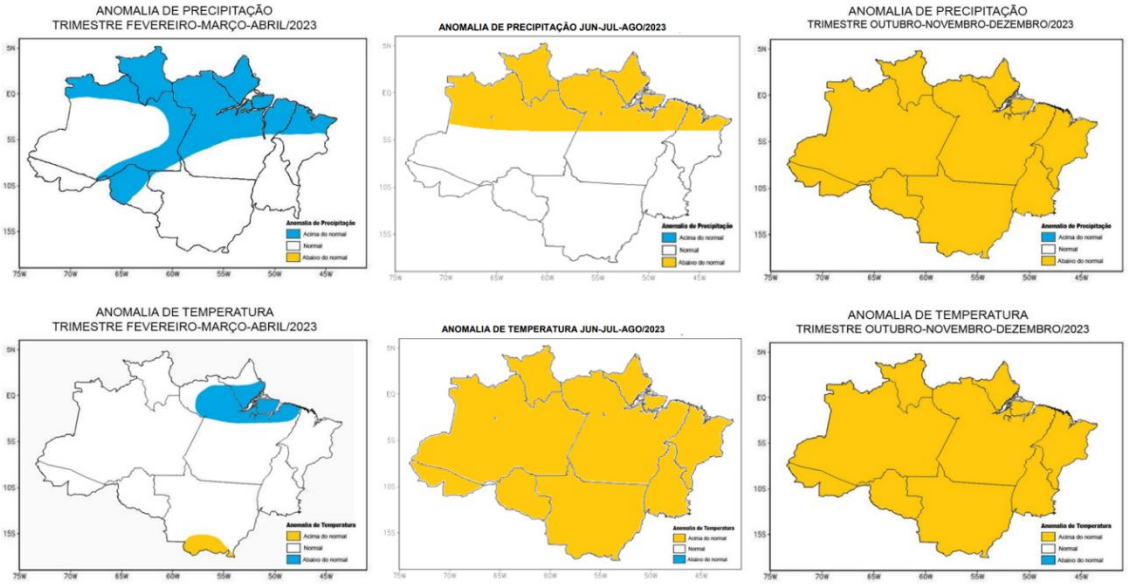
According to the Management and Operational Center of the Amazon Protection System - CENSIPAM, in its Amazon Climate Bulletins (CENSIPAM, 2023), it appears that in the first quarters of February, March and April/2023 rainfall over the Amazon region was above normal, however, the temperature remained within acceptable standards for most of the region.

Nevertheless, in the quarter of June, July and August 2023, there were already signs of severe weather situations in the region. Thus, the drought evolved from the beginning of this quarter with below-normal rainfall, but with high temperatures, both represented by the yellow colors in Figure 2.

Also based on the Climate Bulletins, the peak of the drought was verified in the quarter of September, October and November/2023, in which the entire region suffered the impact of the lack of rain and high temperatures, as can be seen in Figure 2.

Revista ARACÊ
ISSN: 2358-2472

Figure 2 - Precipitation anomaly and quarterly temperature anomaly – 2023



Source: adapted by the authors, Amazon climate bulletin - CENSIPAM, 2023.

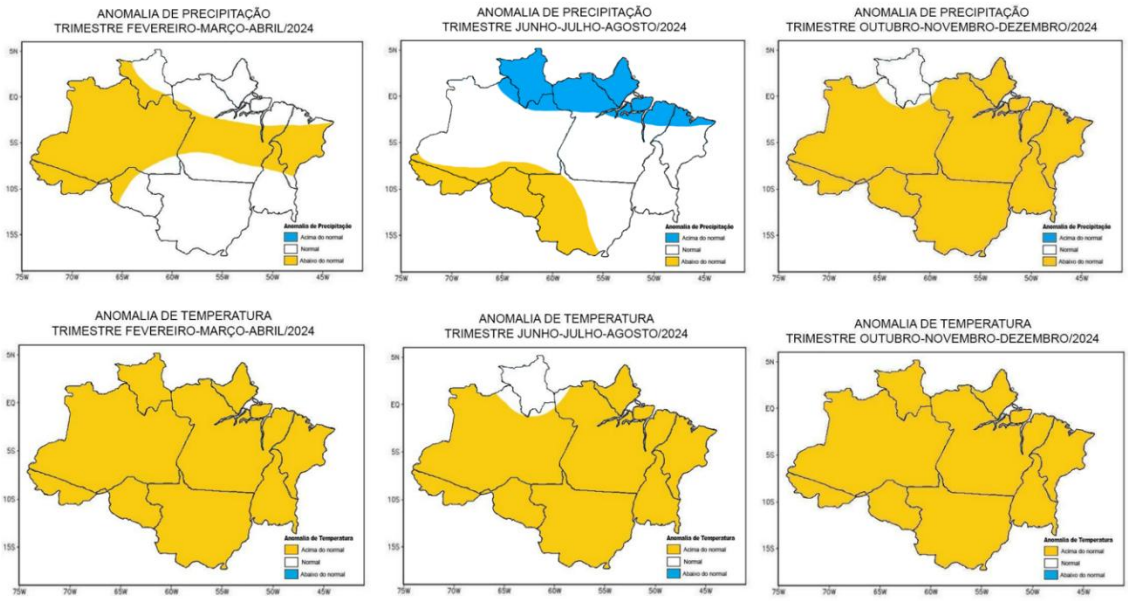
Following the same line of monitoring climate events, CENSIPAM (2024), in its Amazon Climate Bulletins, in Figure 3, it can be seen that in the quarter of February, March and April/2024 there was already evidence of low precipitation, but high temperatures in the region.

In the quarter of June, July and August 2024, there was a precipitation anomaly at the bottom of the map and high temperature, taking over most of the Amazon region.

Nevertheless, in the quarter of October, November and December 2024, according to Figure 3, the region had a low level of precipitation and high temperature, representing the maximum point of the drought.

Revista ARACÊ
ISSN: 2358-2472

Figure 3 - Precipitation anomaly and quarterly temperature anomaly – 2024



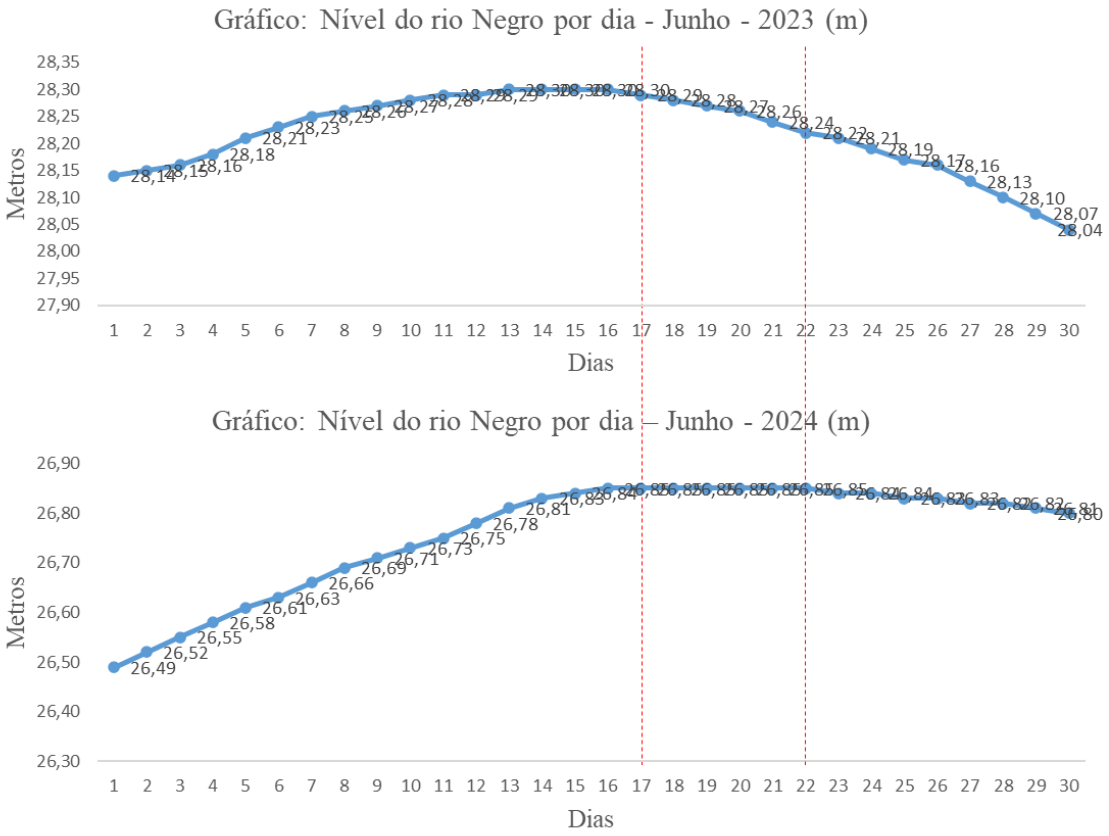
Source: adapted by the authors, Amazon climate bulletin - CENSIPAM, 2024.

Thus, when comparing the evolution of the drought in Graphs 1 and 2, it can be seen that the drought in 2023 occurred faster than 2024, meaning that social and government actors did not have much time to make preventive decisions to mitigate its effects. This observation corroborates the ebb of one of the main rivers in the region, the Rio Negro, which is measured daily, as shown in Graphs 1 and 2.

In the aforementioned Graphs 1 and 2, it can be seen that the daily measurements of the Negro River in June 2023 and 2024, respectively, carried out on the banks of the city of Manaus-AM, by the Port of Manaus, showed that from June 17 (2022) and June 22 (2024) there was the beginning of the ebb of the rivers of the Amazon. Thus, it can be inferred that the action of El Niño and La Niña, which caused the warming of the waters of the Pacific Ocean and the waters of the North Atlantic, contributed significantly to the severe atypical drought in the two consecutive years; being in 2023 more accentuated and in 2024 softer in terms of falling speed.

Revista ARACÊ
ISSN: 2358-2472

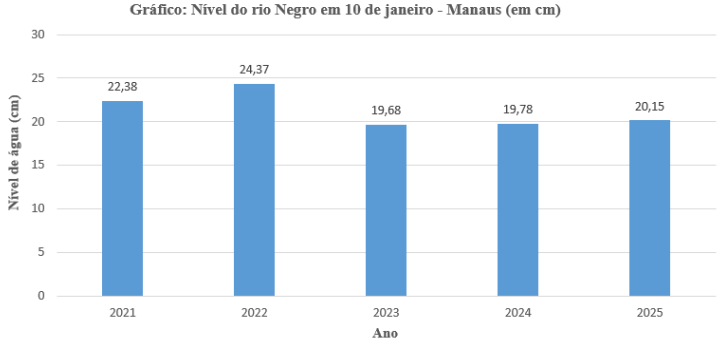
Graphs 1 and 2 - Water levels of the Rio Negro by day – June – 2023 and 2024 (m)



Source: Adapted by the authors - Port of Manaus, 2024.

The SNPH (2025) - State Superintendence of Navigation, Ports and Waterways of the State of Amazonas measured the level of the Negro River on 10/1/2025, in the period from 2021 to 2025, see graph 3, finding that water levels in 2023 were 4.69 cm and 2.70 cm below normal levels for the region in the years 2022 and 2021, respectively, showing the first signs of the severe drought of 2023; The measurement of 19.78 cm in 2024 also showed the repetition of the 2023 drought.

Graph 3 - Water levels of the Negro River on January 10 - Manaus (cm)



Source: Adapted by the authors – SNPH, 2025.

Revista ARACÊ
ISSN: 2358-2472

MAIN ENVIRONMENTAL IMPACTS

Without taking into account phytoplankton and zooplankton among other organisms that make up the Amazon biome, the environmental impacts were immense when it comes to the biodiversity of the Amazon. Thus, with the drought, the most evident and immediate impacts were the death of fish and porpoises (freshwater dolphins) in the region. According to Monteiro (2023), in 2023 209 dead animals were found, and of these, 178 were red dolphins and tucuxis.

According to Soldera (2023) the drought was more severe in the Western Amazon, which comprises: Acre, Rondônia, Roraima and Amazonas, where the ebb of the rivers was extreme, with the water level of the rivers decreasing by 30 cm per day and the water temperature reaching 39°C, higher than the normal 30° C, presenting a lack of oxygen, which led to the death of fish and porpoises. With the increase in fires, temperature and the reduction of moisture in the Amazonian soil, the areas for agriculture and livestock were impacted.

According to BRASIL (2023), in order to control and mitigate the mortality of dolphins in the Tefé lake, the operation of the Botos Tefé Emergency Incident was put into practice, which was divided into: live operation sectors, dead operation and environmental monitoring. In Lake Tefé the water temperature exceeded 39°C, on September 28, 2023, 153 dead porpoises (freshwater dolphins) were found, 130 of which were red porpoises and 23 tucuxis. Of the total, 104 animals were necropsied and tissue samples were sent for histological analysis for cause of death, however, the result was negative for infectious agents such as viruses and bacteria associated with the cause of mass death.

According to SBTNEWS (2024) in the Municipalities of Tefé and Coari, during the 2023 drought, the death of 330 dolphins was recorded. The deaths were caused by the rise in water temperature, which reached 39.1°C. In 2024, 23 dead dolphins were recorded. Of the total of 330 dolphins, 19 were red dolphins or pink dolphins (*Inia geoffrensis*) and 4 were tucuxis (*Sotalia fluviatilis*).

Nunes (2023) and Louzada (2023) reported the death of several fish (see video), dolphins and a manatee during the extreme drought of 2023 in Amazonas, specifically in the Tefé lake, more than 20 dolphins were killed, many of which were found stranded on sandbanks, in addition, fish were found dead due to the reduction in the amount of water, increase in temperature and decrease in water oxygen.

Revista ARACÊ
ISSN: 2358-2472

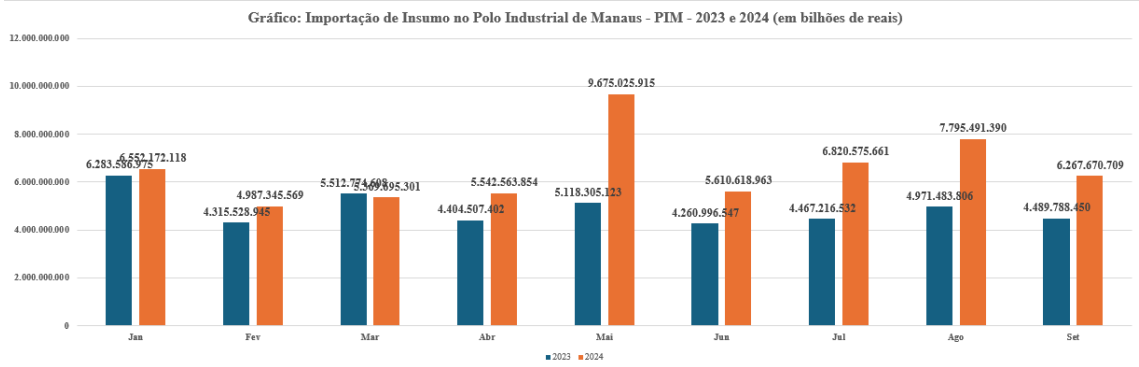
According to Monteiro (2023), the Mamirauá Development Institute detected the death of fish and dolphins on September 23, 2023, and carried out environmental monitoring focusing on water quality such as temperature, oxygen saturation, water level and current flow of Lake Tefé, although it is known that the rise in temperature is harmful to fish, The diagnosis of heat stress is not easy to obtain, since the symptoms are common to several causes of death.

MAJOR ECONOMIC IMPACTS

The economic impacts of this study were concentrated in the Manaus Industrial Pole, as it is the most important sector for the State of Amazonas in tax collection, and according to AMAZONAS (2022), this represented 33.77% of the GDP of the State of Amazonas in 2022.

Although the month of June represents the natural phenomenon of the ebb of the rivers of the Amazon, specifically in 2023 and 2024, this strongly impacted the local economy, especially the Manaus Industrial Pole (PIM). According to Graph 4 of imports of inputs for the PIM, it was found that when comparing the month of May 2023 with a total import of R$ 5,118,305,123 billion with May 2024 with R$ 9,675,025,915 billion, there was an increase of R$ 4,556,720,792, this occurred because the local industry, based on information from agencies such as CPRM and INMET that monitored the climate, were attentive to the repetition of the drought in 2023 and took preventive and strategic actions to avoid the lack of inputs that would harm industrial production at the end of the year 2024.

Graph 4 - Input Imports in the Manaus Industrial Pole – 2023 and 2024



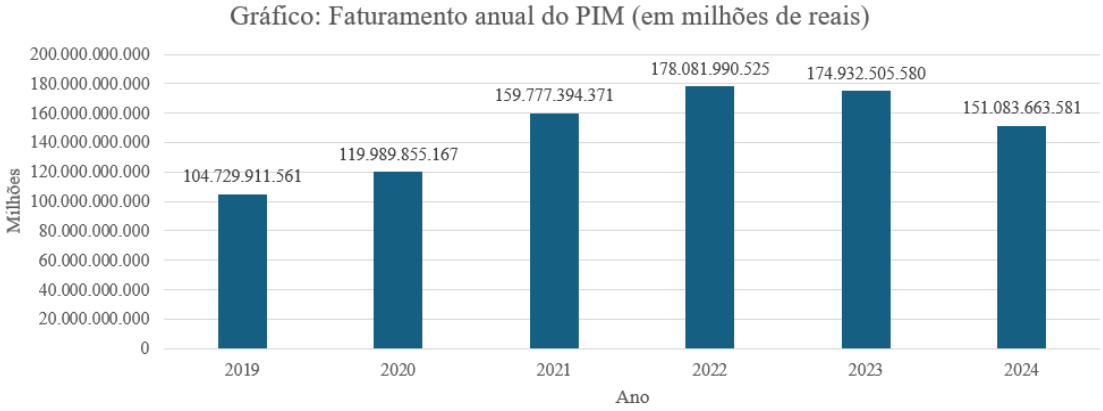
Source: Adapted by the authors - SUFRAMA, 2024.

Revista ARACÊ
ISSN: 2358-2472

Another reflection of the severe drought in the local economy, see Graph 5, was the decrease in the annual revenue of the Manaus Industrial Pole (PIM) in 2023, when compared to 2022. The decrease was R$3,149,484,945 billion, considered quite significant when compared to the growth evolution that had been occurring since 2019.

This negative impact was due to the lack of input supply in production affected by the low water level of the rivers due to the severe drought mentioned above.

Graph 5 - Annual revenue of the PIM



Source: Adapted by the authors - SUFRAMA, 2024.

In view of the atypical drought of 2023 and the possibility of its repetition in 2024, according to Banzeironews (2024), private companies in the port sector: Chibatão and Super Terminais ports, decided to implement temporary ports to ensure the imports of inputs and the flow of PIM products, and in this way, mitigate the losses of the region's industries.

According to the Amazonas Agency (2023), the ports are located on the Amazon River, close to the Municipality of Itacoatiara, and since their installation in September 2024, more than 25 thousand containers have been transported. For a better visualization of the location of the temporary ports mentioned, see Figure 6.

Figure 6 - Location of the temporary ports Chibatão and Super Terminal - Itacoatiara

Revista ARACÊ
ISSN: 2358-2472

Source: Adapted by the authors – Google Earth, 2024.

MAIN SOCIAL IMPACTS

The social impacts were diverse, however, the main ones were the difficulty in river transport of people, access to drinking water, access to food, access to the health system, and access to education.

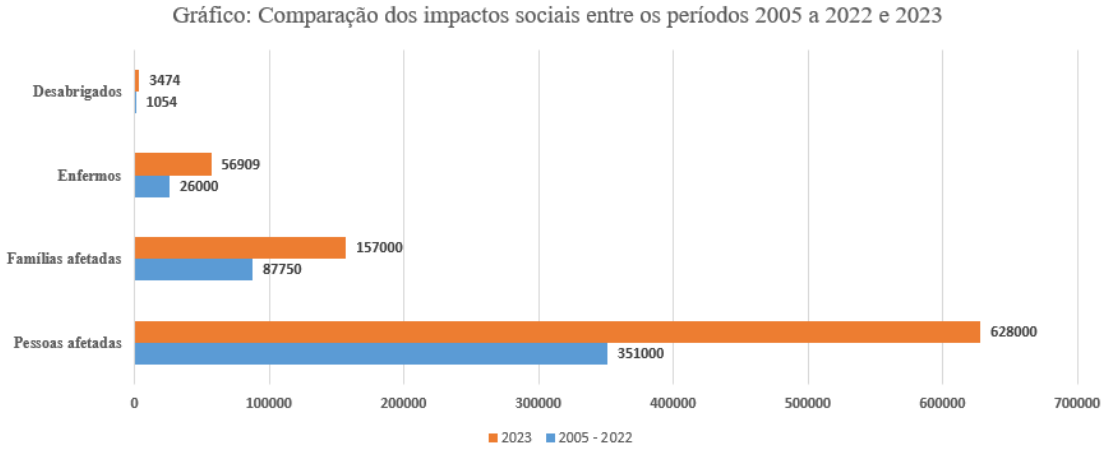
According to the Civil Defense of Amazonas, through the Drought Operation Report (2023), the extreme drought reached more than 90% of the municipalities, making them in an emergency situation decreed by the Government of the State of Amazonas. The lack of rain and the rise in temperature drastically reduced the levels of the rivers, resulting in difficulties in navigating vessels, impairing the transport of people, the lack of supply in the municipalities, the practice of fishing and the increase in respiratory diseases, malaria, schistosomiasis, hepatitis, parasitic infections and dehydration.

According to Graph 6, considering the ebb and flow as a natural phenomenon and comparing 17 years of drought in the period from 2005 to 2022 with the severe drought of 2023, it can be seen that affected people had an increase of 277,000. As for the families affected, there was an increase of approximately 80%, representing an increase of 69,250 in number. Among the sick, there was a growth close to 48% and among the homeless, an increase of 229.6%, that is, a growth more than three times accumulated in the period from 2005 to 2022. This shows that the 2023 drought caused an unprecedented and temporal social impact. The data in Graph 6 show that, in addition to greatly affecting the most

Revista ARACÊ
ISSN: 2358-2472

isolated and vulnerable communities in the region, the climate crisis has caused a social impact of incalculable severity.

Graph 6 - Comparative graph of social impacts between the periods 2005-2022 and the year 2023



Source: Adapted by the authors – Drought Report 2023 - Civil Defense of Amazonas, 2023.

Continuing in the same line of social impact, more specifically for the context of social assistance, sewage, fuel, drinking water, telecommunications, and education, according to Graph 7, were the public services with the highest financial demands because they were most affected by the 2023 drought. The social consequences were serious, given the difficulties faced by the communities along the rivers, such as: the lack of drinking water, transportation of people, people with disabilities (PCD) and access to education, in addition to health care in general.

During the 2023 drought, according to the National Council of Education Secretaries - CONSED, more than 7.3 thousand students were impacted, so face-to-face classes were suspended through Resolution No. 121/2024 of the Department of Education and Culture of Amazonas - SEDUC and Decree No. 50.129/2024 of the Governor of the State of Amazonas, and classes were adopted in accordance with the "home class" project and the offer of a "lunch kit" (CONSED, 2023). In addition, according to SEDUC in the State of Amazonas, there was a reduction in enrollment of 10,125 in High School and 4,274 in Elementary School between 2023 and 2022, respectively, reflecting the consequences of the drought in the Municipalities.

Graph 7 - Comparative graph between the period 2005-2002 and the year 2023

Revista ARACÊ
ISSN: 2358-2472

Source: Adapted by the authors – Drought Report 2023 - Civil Defense of Amazonas, 2023.

DROUGHT MITIGATION

The impacts of the drought on society were considered significant, as families living in riverside communities suffered from food restrictions, access to drinking water, river locomotion and access to education.

In view of the severe drought that devastated the 62 Municipalities of the State of Amazonas in the years 2023 and 2024, the State Government determined the climate emergency through decrees No. 48,167/2023 for the year 2023 and No. 49,763 for the year 2024. According to Decree No. 49.763/2024 the emergency situation in the State of Amazonas comprised the Municipalities located in the Juruá, Purus and Alto Solimões Channels.

One of the biggest problems to the health of the families affected by the drought was the lack of drinking water to meet basic needs, because in addition to the waters of the rivers in the region being extremely reduced, they were unusable to be ingested or even used for cleaning and personal hygiene. In Chart 2, you can see the list of some products such as glasses and water distributed; Regarding the basic food basket, it can be seen in Chart 3 that they are listed by responsible secretariat, with the quantities of baskets sent in the first and second shipments and the total number of baskets received.

Chart 2 – Example of distribution of cups and water - drought 2023

Revista ARACÊ
ISSN: 2358-2472

Source: Adapted by the authors – Drought Report 2023 - Civil Defense of Amazonas, 2023.

According to the Civil Defense of Amazonas (2023), through the 2023 Drought Operation Report, the supply of basic food baskets by the Government of Amazonas to the affected family members was delivered to 9 government secretariats, see Table 3, which were in charge of distributing them to riverside dwellers and communities with logistical support from the Brazilian Army, Brazilian Air Force, and Brazilian Navy.

Chart 2 – Example of distribution of cups and water - drought 2023

ORD	SECRETARIA RESPONSAVEL	1° REMESSA CESTA ENVIADAS	2°REMESSA CESTA ENVIADAS	TOTAL DE CESTAS RECEBIDAS
1	ADS	3000	500	3500
2	COSAMA	12000	4000	16000
3	FVS	1500	0	1500
4	IDAM	28800	2500	31300
5	SEAS	16500	1000	17500
6	SEDUC	5000	500	5500
7	SEJUSC	3000	1000	4000
8	SES	8000	1000	9000
9	DC-AM	4500	500	5000
TOTAL		**82300**	**11000**	**93300**

Source: Adapted by the authors – Drought Report 2023 - Civil Defense of Amazonas, 2023.

The Marcos Santos Portal (2024) also corroborates the understanding of the severity of the 2024 drought by publishing that, in order to mitigate its effects, the Government of the State of Amazonas declared an emergency situation for the 62 municipalities, directing efforts to minimize the social impacts of the affected population. Also, according to the Portal, as part of this fight, the government sent 202.6 tons. of medicines and supplies for the regions of the Madeiras, Juruá, Purus and Alto Solimões rivers, in addition to installing 41 water purifiers, 8 of them in the Alto Solimões channel, in addition to the donation of 4,532 water tanks for the population to have access to drinking water.

Revista ARACÊ
ISSN: 2358-2472

In the same vein of mitigating the drought of social impacts, Marques (2024) points out that the Amazonas Sustainable Foundation (FAS) distributed about 30 water purifying "camel backpacks" in the Rural Zone of Manaus that were delivered to the Bela Vista do Jaraqui Community, 40 km from Manaus, which was suffering from the severe drought in the region. The "camel backpack" is a piece of equipment that captures, treats and stores up to 15 liters of water, consisting of a backpack, a portable filter and a wall support, ensuring access to drinking water.

In the same mitigation understanding, D24AM (2024), AMAZONAS (2024a), D24AM (2024) and BanzeiroNews (2024) highlighted the implementation of temporary ports in Amazonas that boosted the state's economy in 2024, precisely in the period when the drought was severe. The temporary ports, until October 2024, contributed to Amazonas importing US$ 13.5 billion in inputs, exceeding the US$ 12.6 billion in 2023. In 2023, with port restrictions, the state recorded only US$ 604 million in imports.

In order to highlight the relevance of the installation of temporary ports as an assertive option in the drought, the two temporary ports in Itacoatiara handled more than 25 thousand containers associated with the unloading of 21 ships (AMAZONAS, 2024a). In addition to these measures, with the aim of mitigating the crisis, the state government authorized the payment of state tax in two equal installments, in addition to environmental licenses for the installation of two temporary ports in Itacoatiara and near the Madeira River.

Such actions provided and maintained industrial, trade and services competitiveness due to logistical difficulties in the transportation of products, and maintenance of the collection of the Tax on the Circulation of Goods and Services (ICMS).

In addition, according to Brazil (2024), the dredging work of the beds of the Negro and Solimões rivers was adopted in order to ensure the maintenance of navigability. According to the National Department of Infrastructure - Dnit, the intervention had an investment of R$ 400 million and the duration was estimated at five years, currently the stretch that is being worked on is 200km between Manaus-Itacoatiara, but the works of other routes are included, such as: Tabatinga-Benjamin Constant, Benjamin Constant-São Paulo de Olivença, and Coaria-Codajás.

Reinforcing the global concern about the social consequences of the drought, the United Nations Children's Fund – UNICEF (2024) took actions to reduce the impacts of the drought in Amazonas through the field offices in Manaus and Belém, with the support of the

Revista ARACÊ
ISSN: 2358-2472

national Emergency Technical Team and its partners, in donation and installation of materials and equipment for collective water supply solutions in indigenous and riverine communities. The first challenge was to provide jerry cans of mineral water and filters to the most distant communities, as people were consuming muddy and contaminated water.

FINAL CONSIDERATIONS

The article aimed to relate the severe drought that occurred in the years 2023 and 2024, and its socioeconomic and environmental consequences in the Amazon.

The beginning of the ebb of the rivers in the Amazon takes place in June of each year, considered normal and expected for the region. However, the atypical ebb that occurred in the years 2023 and 2024 due to the action of the El Niño and La Niña climate phenomenon, added to the warming of the waters of the Pacific Ocean and the waters of the North Atlantic, severely impacted the Amazon region.

This atypical and severe ebb made life difficult for the riverside dwellers, such as river locomotion, access to food, drinking water. These impacts were not restricted only to local communities, but went further, affecting the Manaus Industrial Pole (PIM), where approximately 500 industries of national and international composition are installed and which make up the region's economy; Nevertheless, the greatest and irreparable loss was of biodiversity with the death of dolphins and fish in the rivers.

In view of the impacts resulting from the severe drought in the region, alert and monitoring systems, and climate prediction models, there were actions to mitigate the droughts of 2023 and 2024 by the state government and national and international institutions, such as UNICEF (2024), which acted by sending medicines, water tanks, mineral water, "camel backpack", in addition to dredging the riverbeds with the support of the Federal Government.

The economic consequences observed in the PIM were found from the decrease in input imports that harmed the level of productivity and competitiveness, in addition to the decrease in revenue between the periods of 2022 and 2023.

Through the "lessons learned" from the 2023 drought and predicting the repetition of the same drought intensity the following year, industries took preventive and strategic actions by importing inputs on a large scale in May 2024 and avoiding further losses.

Thus, in view of the drought in the Amazon in the years 2023 and 2024, preventive actions by actors and agents of society are suggested to mitigate the impacts on the

Revista ARACÊ
ISSN: 2358-2472

Amazon biome, awareness of the seriousness of the drought problem and the engagement of all agents of society to build a sustainable future for the region.

Suggestions for future work on drought in the Amazon include the study of the mechanisms that govern the interactions of the biosphere and atmosphere in the Amazon region; strengthening of public policies to combat deforestation and fires, especially with a focus on inspection, fines and implementation of sustainable practices; and the implementation of environmental education programs to raise awareness among the population about the importance of the Amazon for the regional and global climate.

Revista ARACÊ
ISSN: 2358-2472

REFERENCES

1. Amazon. (2023). Decree No. 48,167, of September 29, 2023, emergency situation in the State of Amazonas in the Municipalities affected by the drought classified as COBRADE 1.4.1.1.0. Official Gazette of the State of Amazonas, Executive Branch – Section I .

2. Amazon. (2024). Decree No. 49,763, of July 05, 2024, declares an emergency situation in the State of Amazonas, in the Municipalities located in the Juruá, Purus and Alto Solimões Channels, affected by the disaster classified as drought COBRADE 1.4.1.1.0. Official Gazette of the State of Amazonas, Executive Branch – Section I .

3. Amazon. (2024a). Temporary ports drive record imports in Amazonas. State Secretariat for Economic Development, Science, Technology and Innovation. Available at: https://www.AMAZONAS.am.gov.br/portos-temporarios-impulsionam-recorde-de-importacoes-no-amazonas-em-2024/. Accessed on: 19 jan. 2025.

4. Amazon. (2024b). Governor Wilson Lima announces measures to support industry and commerce during the drought. Available at: https://www.amazonas.am.gov.br/governador-wilson-lima-anuncia-medidas-de-suporte-a-industria-e-comercio-durante-a-estiagem/. Accessed on: 19 jan. 2025.

5. Amazon. (2025). See the level of the Rio Negro. Ports of Manaus. Available at: https://portodemanaus.com.br/nivel-do-rio-negro/. Accessed on: 10 jan. 2025.

6. Athayde, D. (2024). Impact of drought on the economy of Amazonas. Available at: https://www.riosdenoticias.com.br/colunas/impacto-da-seca-na-economia-do-amazonas/. Accessed on: 22 jan. 2025.

7. Aven, T. (2013). On the meaning of a black swan in a risk context. Safety Science, 57 , 44–51. DOI: 10.1016/J.SSCI.2013.01.016.

8. Baker, P. A., Jenkins, H. S., & Negrón-Juárez, R. I. (2013). Extreme drought events in the Amazon revealed by tree-ring records. In Borma, L. de S., & Nobre, C. A. (Eds.), Droughts in the Amazon – causes and consequences. São Paulo: Oficina de Textos.

9. Banzeironews. (2024). Temporary ports boost imports in AM in 2024. Available at: https://banzeironews.com/portos-temporarios-impulsionam-importacoes-no-am-em-2024/#google_vignette. Accessed on: 16 Dec. 2024.

Revista ARACÊ
ISSN: 2358-2472

10. Barbosa Filho, J. (2023). Severe drought makes Amazonas declare a state of emergency in 55 municipalities. Available at: https://www.brasildefato.com.br/2023/09/29/seca-severa-faz-amazonas-decretar-estado-de-emergencia-em-55-municipios#:~:text=A%20dura%20seca%20que%20atinge,aliviar%20os%20efeitos%20da%20estiagem. Accessed on: 15 Dec. 2024.

11. Brazil. (2024). Dredging works on the Amazon and Solimões rivers are advancing to ensure safe passage. Ports and Airports. Available at: https://www.gov.br/portos-e-aeroportos/pt-br/assuntos/noticias/2024/12/obras-de-dragagem-nos-rios-amazonas-e-solimoes-avancam-para-garantir-passagem-segura. Accessed on: 13 jan. 2025.

12. Brazil. (2023). Technical Bulletin: more than 150 dolphins die in the interior of Amazonas due to extreme drought. Chico Mendes Institute for Biodiversity Conservation. Available at: https://www.gov.br/icmbio/pt-br/assuntos/noticias/ultimas-noticias/mais-de-150-botos-morrem-no-interior-do-amazonas-devido-a-seca-extrema. Accessed on: 05 Feb. 2025.

13. Censipam. (2023). Amazon Climate Bulletin, prognosis February, March and April/2023, vol. 19, n. 1. ISSN 2966-4470.

14. Consed – National Council of Secretaries of Education. (2024). Students in the state network are beginning to be affected by the drought in Amazonas. Available at: https://www.consed.org.br/noticia/alunos-da-rede-estadual-comecam-a-ser-afetados-pela-estiagem-no-amazonas. Accessed on: 19 jan. 2025.

15. Civil Defense of Amazonas. (2023). Technical report on the drought operation 2023. Manaus, AM.

16. Civil Defense of Amazonas. (2024). Technical report on the drought operation 2024. Manaus, AM.

17. D24AM. (2025). After 70 days of drought, the first large ship docks in Manaus. Available at: https://d24am.com/economia/apos-70-dias-de-seca-primeiro-navio-de-grande-porte-atraca-em-manaus/. Accessed on: 05 Feb. 2025.

Revista ARACÊ
ISSN: 2358-2472

18. Dolgui, A., & Ivanov, D. (2021). Ripple effect and supply chain disruption management: new trends and research directions. International Journal of Production Research, 59(1), 102-109. DOI: 10.1080/00207543.2021.1840148.

19. Girardi, G. (2023). Abnormal warming of the Atlantic aggravates drought in the Amazon and poses risks. Available at: https://apublica.org/2023/10/aquecimento-anormal-do-atlantico-agrava-seca-na-amazonia-e-traz-riscos-imprevisiveis/. Accessed on: 19 jan. 2025.

20. Inmetro - National Institute of Meteorology. (2024). The Amazon is facing a period of drought. Available at: https://portal.inmet.gov.br/noticias/seca-atinge-centro-norte-da-amaz%C3%B4nia. Accessed on: 25 Dec. 2024.
21. File. (2024). The isolated drought in the Amazon: the drama of those who do not have water to drink. Available at: https://www.brasildefato.com.br/2024/08/27/os-isolados-da-seca-na-amazonia-o-drama-de-quem-nao-tem-agua-para-beber. Accessed on: 28 Dec. 2024.

22. Louzada, V. (2023). Day by day news: photographer shows impacts of the ebb and fires in the Amazon. Available at: https://diaadianoticia.com.br/fotografo-mostra-impactos-da-vazante-e-queimadas-no-amazonas/#google_vignette. Accessed on: 04 Feb. 2025.

23. Loureiro, L. da S., Maciel, J. S. C., & Real dos Santos, A. L. M. (2024). Influences and impacts of the 2023 drought in the Amazon basin. IV END – National Meeting of Disasters, ISSN: 2764-9040. Brazilian Association of Water Resources.

24. Marques, P. (2024). Community isolated by drought receives water purifying backpacks in the Rural Zone of Manaus. Available at: https://g1.globo.com/am/amazonas/noticia/2024/11/13/comunidade-isolada-pela-seca-recebe-mochilas-purificadoras-de-agua-na-zona-rural-de-manaus.ghtml. Accessed on: 04 Feb. 2025.

25. Martins, G., & Theóphilo, C. R. (2016). Methodology of scientific research for applied social sciences (3rd ed.). Rio de Janeiro: Atlas.

26. Monteiro, M. (2025). Amazon Boiling: The Emergence of Red Dolphins and Tucuxis in Amazonas. Available at: https://mamiraua.org.br/noticias/emergencia-de-botos. Accessed on: 05 jan. 2025.

Revista ARACÊ
ISSN: 2358-2472

27. Mota, R. (2024). Amazonas' GDP grows 3.27% in 2022, above the national average. SEDECTI. Available at: https://www.amazonas.am.gov.br/pib-do-amazonas-cresce-327-em-2022-acima-da-media-nacional/#:~:text=J%C3%A1%20o%20setor%20industrial%20somou,38%2C19%20bilh%C3%B5es%20em%202022. Accessed on: 17 Dec. 2024.

28. Nunes, M. (2025). Fish and dolphins die due to extreme drought in Amazonas and residents are left without access to drinking water and food. Available at: https://conexaoplaneta.com.br/blog/peixes-e-botos-morrem-devido-a-seca-extrema-no-amazonas-e-moradores-ficam-sem-acesso-a-agua-potavel-e-alimentos. Accessed on: 03 Jan. 2025.

29. Oliveira, D. (2024). Drought in Amazonas may impact Black Friday and Christmas. Available at: https://www.cnnbrasil.com.br/economia/macroeconomia/seca-no-amazonas-pode-impactar-black-friday-e-natal. Accessed on: 28 Dec. 2024.

30. Portal Marcos Santos. (2024). Drought in AM: number of medicines and supplies sent to the interior totals more than 19.2 thousand volumes. Available at: https://www.portalmarcossantos.com.br/2024/11/06/estiagem-no-am-numero-de-medicamentos-e-insumos-enviados-para-o-interior-totaliza-mais-de-192-mil-volumes. Accessed on: 03 Jan. 2025.

31. SEDECTI - Secretariat of Economic Development, Science, Technology and Innovation. (2025). Regional gross domestic product, 2022. Available at: https://www.sedecti.am.gov.br/wp-content/uploads/2022/11/PIB_REGIONAL_2020.pdf. Accessed on: 03 Feb. 2025.

32. Soldera, B. (2025). Drought in the Amazon: a threat to all of Brazil? Available at: https://www.aguasustentavel.org.br/conteudo/blog/229-a-seca-na-amazonia-uma-ameaca-para-todo-o-brasil. Accessed on: 21 jan. 2025.

33. SBT News. (2025). Dead dolphins in the Amazon: is there a risk of extinction? Available at: https://sbtnews.sbt.com.br/noticia/brasil/botos-mortos-na-amazonia-ha-risco-de-extincao. Accessed on: 22 jan. 2025.

Revista ARACÊ
ISSN: 2358-2472

34. State Superintendence of Navigation, Ports and Waterways of the State of Amazonas (SNPH). (2025). Port of Manaus – level of the Rio Negro. Available at: https://portodemanaus.com.br/nivel-do-rio-negro/. Accessed on: 09 Dec. 2024.

35. Suframa. (2024). Performance indicators of the Manaus Industrial Pole 2010–2018 to 2023–2021. Ministry of Economy.

36. Taleb, N. N. (2007). The Black Swan: The Impact of the Highly Improbable. Penguin.

37. UNICEF. (2024). UNICEF and partners current to reduce the impact of drought in Amazonas. Available at: https://www.unicef.org/brazil/comunicados-de-imprensa/unicef-e-parceiros-atuam-para-reduzir-impacto-da-seca-no-amazonas. Accessed on: 03 Feb. 2025.

38. Vasconcelos, G. (2024). Drought in Amazonas causes the state's industrial production to fall 2.6% in October. Available at: https://www.cnnbrasil.com.br/economia/macroeconomia/seca-no-amazonas-faz-producao-industrial-do-estado-cair-26-em-outubro. Accessed on: 19 jan. 2025.

39. Yin, R. K. (2015). Case study: planning and methods (5th ed.). Porto Alegre: Bookman.

40. Zanatta, P. (2025). Manaus Free Trade Zone foresees additional cost of R$ 500 million with transportation in the midst of drought. Available at: https://www.cnnbrasil.com.br/economia/macroeconomia/zona-franca-de-manaus-preve-custo-adicional-de-r-500-mi-com-transporte-em-meio-a-seca. Accessed on: 20 jan. 2025.