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Amazon cities and climate change

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Abstract

Manaus, due to the growth process it has undergone in recent decades, is among the cities with a high level of environmental vulnerability. According to the IPCC 6th Climate Change Report, the impacts of climate change will hit hardest the poor populations with limited adaptive capacity. This article shows the IPCC's warnings about the risks of global warming, the great inequalities in the distribution of Amazonian populations, and the seriousness of the increase in deforestation and greenhouse gas emissions that compromise the lives not only of the region's inhabitants, but of the planet as a whole. Moreover, it emphasizes the need for urgent solutions in order to contain the degradation process of the Amazon rainforest, actions that include defending the Amazonian biome and the objective and efficient confrontation of the problems of pollutant emissions, through energy efficiency practices.

Keywords: nature, Amazon rainforest, climate change and socio-environmental vulnerabilities.

1. Introduction

Despite its proximity to the largest rainforest on the planet, the city of Manaus, capital of the state of Amazonas, is one of the most deforested cities in Brazil. This fact denounces the development process that was based on occupation policies of the region focused on capitalistic interests. Consequently, between cycles and cycles, the city has disqualified itself as an Amazonian environment, because the speed with which the vegetation has been destroyed is a measure of the level of concern with the use of natural resources that create insurmountable contradictions between the city and nature.

The Amazonians, on the other hand, assimilated the idea of development allied to large investments, and started to "repress" and "control" nature by creating impermeable environments and infrastructures lacking basic services such as sanitation, health, and housing. This insanity is reinforced by socioeconomic and regional inequalities that contribute to the feeling of not belonging to the environment.

In this context, the problems resulting from this dynamic do not seem to have any connection with it. It seems difficult to relate the loss of biodiversity with the feeding of the populations; the use of transportation with atmospheric pollution, the advance of urbanization and industrialization with the exhaustion of the soil and the contamination of water resources, or even deforestation with the increase in global temperature. For this reason, the reintegration of nature into the urban landscape is an almost impossible "mission", but it is very

important for the planet's climate balance. "The Amazon needs a new economy, based on the standing forest and flowing rivers, and one that promotes the prosperity and well-being of the Amazonian population, whether in cities, rural communities, indigenous, quilombola or riverine communities." (WRI Brazil, 2022)

This article discusses the threats generated by the development model, in connection with the latest report of the Intergovernmental Panel on Climate Change (IPCC), where it became clear that the effects of climate change in urban centers are increasingly visible and frequent. For Evers et. al. (2021), new evidence points to the worsening hydric and energy crisis that Brazil is facing and that places the country facing a triple challenge: "recover the economy after the pandemic, face the threats generated by climate change and advance in its long-term development goals."

2. The Amazonian Cities: a brief history

Amazonas, over time, has suffered the negative effects of public policies that emerge from the central power and from mistaken and distorted understandings of the Amazonian reality. In the past and in the present, the economic rationality of capital has disregarded the geographic and cultural diversities of the region and of the forest's peoples, subordinating them to the dynamics of capital and to an occupation process based on the old practice of occupying in order to develop. To understand how this occupation process took place and its relation to the environmental problems that resulted from it, it is worth taking a short historical stroll through the past.

The development of the region, since the time of the "Drogas do Sertão", has always been linked to river navigation, subsidized by the Federal Government and stimulated by the extraction of natural resources. In fact, the Amazon is still living on subsidies nowadays. These subsidies help soften production costs, but also mask a situation of prosperity, stimulating inertia in the search for permanent alternatives. (Valois & Cartaxo, 2007)

Since the state is hydrically dominated by rivers, streams, lakes, and igapós, communities and villages were created in the course of these paths. They were the so-called "wood ports" that served as supply points for fuel, charcoal and wood. Note that since the 18th century, the interest in the "drogas do sertão" (drugs of the backlands) favored the establishment of some farms on the banks of the rivers, but this was not a significant extractive activity. The extractivism really expanded after the rubber trade, at the end of the 19th century (1880-1920) and with it came steam navigation and the occupation process of the Amazon. (Alkmin, 2000)

Coinciding with the period that followed the Proclamation of the Republic (1889), Manaus experienced great transformations, as rubber was increasingly in demand as a raw material for global industries. The city grew in infrastructure, gained public transportation, electric streetcars, telephony and electricity, but also in population, inflated by the contribution of migrants from the northeast who, for lack of access to opportunities in the region of origin, migrated with hope of better days.

With the increase in rubber production, meeting the world demand, high European investments transformed the city, giving it the status of a metropolis. In this period Amazonas experienced its economic and cultural apogee, but the "Rubber Boom" lasted only as long as its extraction contributed to the enrichment of a few, to the increase of profits and state revenues. Socially, despite having generated a lot of wealth and prosperity, the

benefits were not universalized and exclusion was potentiated by the exploitation of the poorest segments of society. Besides this, the profits were not invested in a lasting economic development for the region, that is, no industrial policy was implemented in Amazonas and no measures were taken to preserve so much wealth. When the Asian rubber expanded provoking a drop in the prices of Hevea brasiliensis, came economic stagnation leaving a trail of abandonment so well portrayed in the words of Melby (apud Hall, 1991, p.23): "Buildings were abandoned, refined mansions became empty, parks and boulevards lost their frequencies, and scrub grew back on many streets.

Several "questionable" attempts to implement regional development policies materialized after the rubber failure, among them the creation of the Superintendence of the Plan of Economic Valorization of the Amazon-SPVEA (1953-64), whose goals were to be met through five-year plans with priority given to agriculture, river transport improvements, communication, energy and health. Its greatest achievement, the construction of the Belém-Brasília highway, did not correspond to the proposed objectives. On the contrary, inspired by the interests of the nascent automobile industry, it was the main responsible for the acceleration of the occupation process that occurred from then on. It is estimated that "the road attracted 174,000 migrants in the 1960-70 period, in a very disorganized and unplanned way". (Martine apud Hall, 1991, p.25)

In substitution of the already discredited SPVEA, the Superintendency of Amazon Development (SUDAM) was born, whose economic strategy was to copy the development model applied in the Northeast, with some success at the time, fomenting industrialization by means of tax incentives with financing from domestic and foreign private capital. Law number 5,174 "[...] granted 50% exemption from income tax due until 1982 to those who invested in agriculture, cattle-raising, industry and basic services such as education, transport, colonization, tourism and public health" and these incentives were raised to 100% for projects in the Amazon. (Hall, 1991, p.26)

“Operation Amazon" was also created with geopolitical objectives that aimed at occupation through inter-regional immigration. The occupation occurred mainly in the eastern part of the region, which can be explained by the ease of access to major markets through Belém-Brasília. The western part of the Amazon would have to deserve more than the mechanisms historically used to attract investments considering the major obstacles represented by the continental distances. (Garcia, 2004)

The Decree-Law 288 of February 28, 1967, which expanded and regulated the legislation of the Manaus Free Trade Zone, emerged as a specific policy for Amazonas, but consisted of an alternative for regional development with great impact on the city's growth. There was an increase in income and employment, population growth, and on the other hand it also represented the beginning of a huge urban and wealth concentration.

Even considering that migration is an old phenomenon, because since the first human groupings the mobility of people and groups of people has been a constant fact, the contribution of the Manaus Free Trade Zone was specific to the intense process of rural-urban migration, changing the regional settlement pattern and accelerating the pace of urbanization. About this intense urbanization, it is questionable what actually grew, if the city or if poverty, because the pressure that the city suffered on public services subverted the urban space promoting disorderly occupations, slum housing without sanitation or basic infrastructure, in addition to the

centripetal effect on the rural population generating an unprecedented emptying in the Amazonian space.
Investment in cattle ranching was also a strategy for the occupation of the Amazon strongly influenced by private interests. However, the initial optimism due to the abundance of cheap land, labor with minimal knowledge requirements, and rapid return on capital was replaced in the late 1970s by frustration resulting from the impacts of environmental degradation. Moreover, many ranchers "[...] were using the scheme as a front to obtain cheap money that was diverted to other activities, a not uncommon aspect of agricultural credit in Brazil in general". (Hall, 1991, p. 44)
One realizes, in reality, that population growth would not be the main factor of environmental imbalance, since, as Procópio states (2000, p.230), "[...] *la dégradation de l'environnement amazonien n'est pas une exception*". What intensifies this imbalance is, according to the author, "[...] *le pouvoir de destruction de la modernité capitaliste*". Still incisively, he reinforces: "*Les pratiques nocives pour l'environnement ne peuvent être dissociées de l'impunité dont jouissent les classes dirigeantes, de la corruption et des privilèges que accompagnent les actions des sociétés que font un usage abusif des ressources naturelles*".
Completing this brief historical journey, it can be seen that the absence of policies aimed at the fixation of the man in the countryside generated the rural exodus, the overpopulation of urban centers and the consequent negative effects on the environment and on the quality of life of the populations. As far as the city of Manaus is concerned, its predominance over the other municipalities means the concentration of more than half of the population of Amazonas today estimated at 4,269,995 inhabitants (IBGE estimate, 2021). Manaus is the privileged center of the most expressive economic activities in Amazonas and this reality transforms the city into a fetish for those who struggle for survival in the poor and distant rural areas. The attractions of the city, the air of metropolis, the dynamics of life in the capital are factors that feed the expectations of a better future. However, they push under the carpet the reality of misery and poverty that awaits the great majority of these immigrants. Hence the great rural exodus verified and its connection with economic, social, and environmental poverty, because many of those who migrate from the countryside to the urban area find unfavorable living conditions, adding to the contingents of slum dwellers and homeless people who, living in subhuman situations, have no alternatives but to deplete nature's resources.
At each demographic census, the population indexes are multiplied, increased by the migratory flows that inflate the city of Manaus, demonstrating that the state of Amazonas, as well as all other regions of the world, has become increasingly urban. As shown in Figure 1, this accelerated and constant growth of the Manaus city population, is evident from the 1970s to the present day.

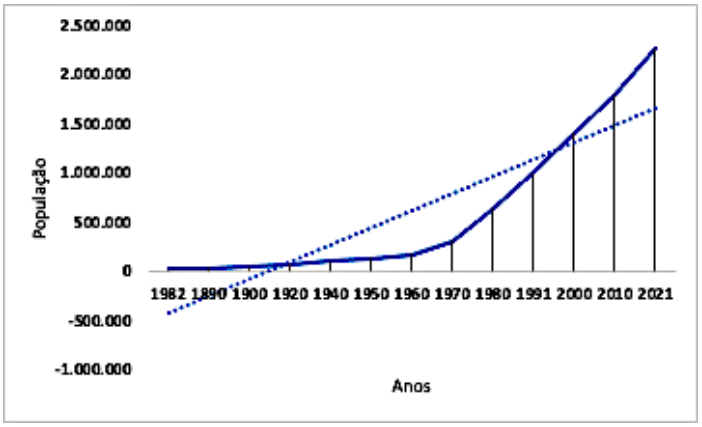


Figure 1: Population growth of Manaus city.
Source: Prepared by the authors (IBGE data)

The imbalance in population distribution in the state can also be proven by the high demographic density of the capital city. Comparing the population of Manaus with the other Amazonian municipalities (Table 1), it can be seen that the Manaus demographic density, in 2021, was 1.43 hab/km2 while that of Parintins, the second most populous city, was almost 20 times lower, that is, 0.074 hab/km2.[1]

Table 1. Estimate of the resident population in the Municipalities of Amazonas with reference date on July 1st 2021

	Population
Manaus	2.255.93
Parintins	116.439
Itacoatiara	104.046

Source: Prepared by the authors (IBGE data)

Despite a depopulated rural area and a forest that absolutely dominates the region, deforestation continues to occur on an increasing scale. Therefore, it was not the needs of development itself that caused the destruction of the Amazonian ecosystems, nor are the legitimate demands of the Amazonians for better living conditions that still today put pressure for the destruction of the remaining resources of nature. What in fact determines environmental vulnerability are the public policies articulated with less ethical objectives aimed at benefiting certain sectors of the economy, such as contractors, mining, industrial fishing, etc. These activities are deliberately and orchestrically dismantling the entire legal framework of environmental management that, if before it was never valued as it should, today is being dismantled with the specific purpose of creating obstacles to conservation, evaluation, monitoring and enforcement of the use of nature that still resists. (Palazzo JR., 2012)

Within this context in which the cities of Amazonas, and especially the city of Manaus were formed, it is

[1] The calculations were made by the authors based on IBGE data, considering the Amazonas state area of 1,571,000km2

impossible to ignore the fragility of these cities in the face of the impacts of the climate crisis. The impermeability of urban environments that seeks to control natural and climatic movements such as rainfall, solar radiation, periodic flooding of rivers and streams, has created an urbanization and construction model that has led cities to today's reality and that holds them responsible for "70% of greenhouse gas emissions." (Evers et. al., 2022) In this sense, it can be seen that cities have been configured as the main centers of CO_2 emissions in the world. (Assumpção et. al., 2019)

Within the scope of issues that affect the lives of the population, scientific studies on vulnerability and adaptation to climate change have been expanding in recent decades due to the large occurrence of extreme events that directly impact human society, considering vulnerability as the probability of occurrence of an adverse effect to social welfare, according to Wisner (2009 apud Santos et. al., 2017). There is no denying the close relationship between urban risks and the issue of land use and occupation: the issues determining the environmental conditions of the city delineate the environmental problems of greater difficulty of confrontation. (Jacobi & Sulaiman, 2016)

In this perspective, climate change gains great visibility, as it brings profound social, economic, political and environmental implications, directly interfering in the degree and/or perception of socio-environmental vulnerability. (Santos et. al., 2017)

There is a strong correlation between climate, ecosystems, and human society, and these interactions are the basis of the risks resulting from climate change, ecosystem degradation, and loss of biodiversity. This degradation process had its bases in human societies that were transformed, driven by an economy that was unable to recognize the depletion of natural resources and, as a consequence, cities grew increasingly congested, concentrating large populations, precarious infrastructures, and accentuated urban poverty. This scenario of most urban areas worldwide is no different in the state of Amazonas, especially in the city of Manaus.

Manaus, apparently dissociated from the nature that surrounds it, seems to forget that society and its economy have, in the ecosystems, the life support that provides stability with regard to climate, food, drinking water, among other goods and ecosystem services that nature provides. These issues become crucial in the face of increasing events of deforestation, predatory hunting and fishing, mining, etc., events that have escalated in recent times, causing the loss of biodiversity and the extinction of some Amazonian species.

In addition to removing forest cover, deforestation causes important changes in rainfall patterns. Likewise, the loss of biodiversity resonates in climate change, because the behavior of ecosystems and species is impacted by the increase in temperature and changes in rainfall patterns since they determine the mobility of living beings in the region.

These interrelations were observed by Working Group II of the IPCC 6th Assessment Report and contributed by providing data on the impacts of climate change and on ecosystems, biodiversity, and human communities globally and regionally, as well as the vulnerabilities and limits of nature and human societies to adapt to these changes. Therefore, the Report shows no only the dangers, it also points out the possibilities for adaptation.. It brings together the knowledge accumulated by scientists about the threats that must be faced and what can be done to minimize their effects, that is, to limit the even greater increases in temperature that will endanger

all of humanity. (IPCC, 2022)

3. Contributions from the Intergovernmental Panel on Climate Change (IPCC)

The scenario on climate change is worrying, because according to the IPCC's Sixth Report (AR6), finalized on February 27, 2022, climate change already impacts all regions of the world severely. If greenhouse gas emissions are not reduced by half within this decade and we do not begin to scale up adaptation measures immediately, serious disruptions could be on the way.

According to AR6, each of the last four decades has been successively warmer than any preceding decade since 1850 and the influence of human activities on the accelerated warming process is unquestionable as can be confirmed by looking at Figure 2 which compares the two scenarios (with anthropogenic interference and only as a result of natural events).

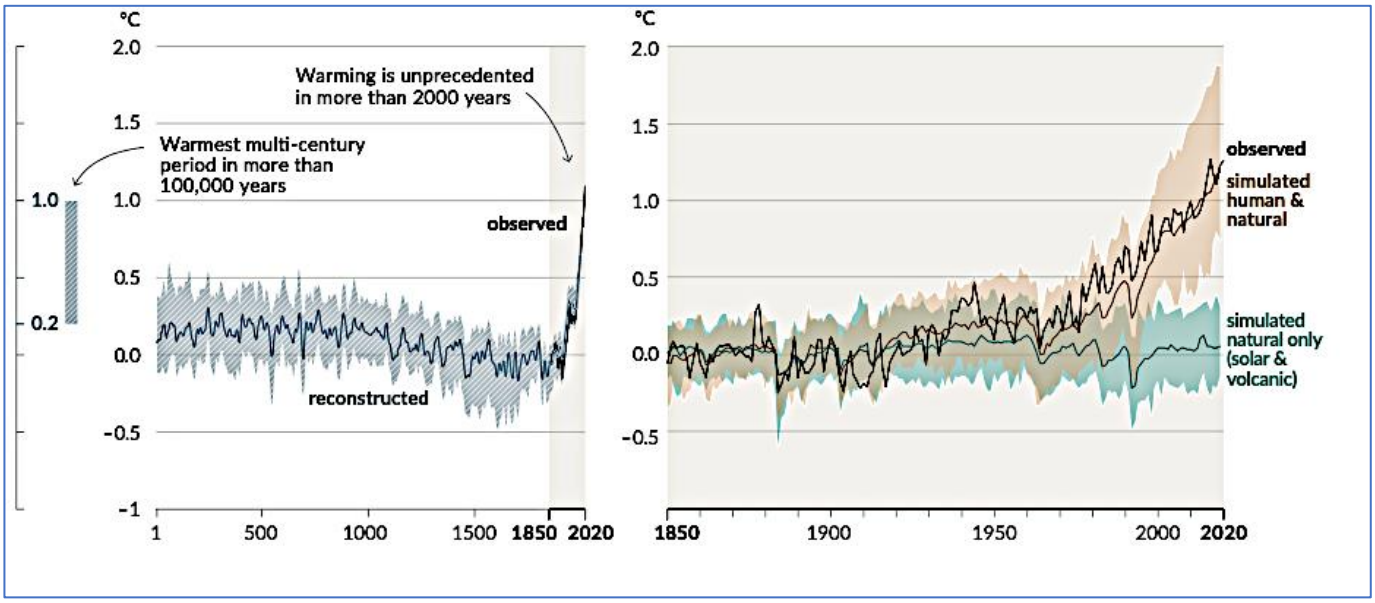


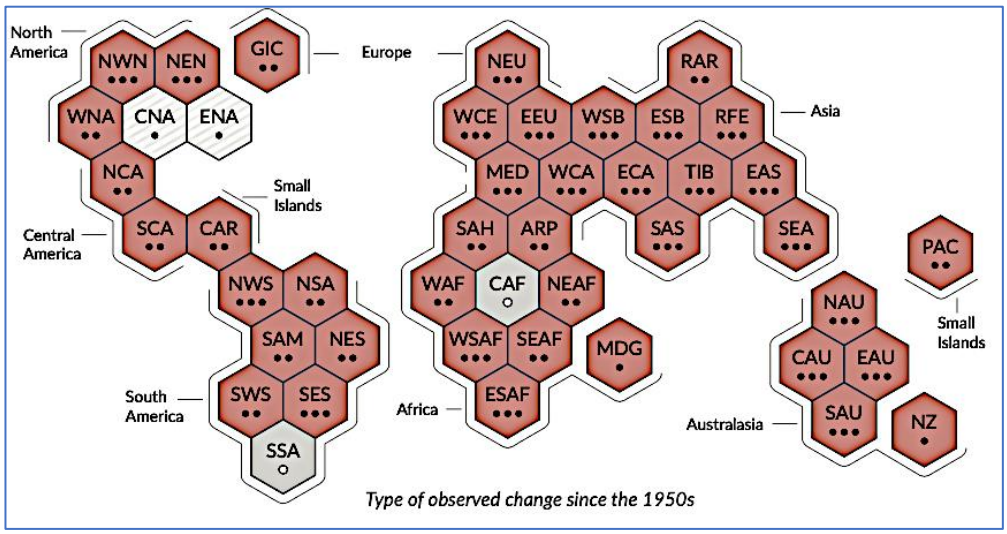
Figure 2: Changes in global surface temperature relative to 1850-2020.
Source: IPCC, 2022

Figure 2 illustrates the time series of the planet's average temperature over the last 2,000 years. This is a very rapid and unprecedented change that is only similar known during the last interglacial era that occurred 100,000 years ago (Artaxo, 2022). On the right of the figure we can see the changes in global temperature since the industrial revolution, the black line shows the increase in temperature throughout this period of time, the green shadow shows the change in temperature due solely to natural forcing and the pink shadow shows the increase in temperature due to all natural forcing plus anthropogenic forcing. (IPCC, 2022)

The new report also reveals another important issue, which are extreme weather events. Figure 3 shows the extremes related to temperature (a) and the extremes associated with heavy rainfall events (b) in various regions of the world. Figure (3a) shows that most of the surface of the planet already experiences hot extremes, North America, Europe, Australia, western and eastern Africa, Asia, Central America, and much of South America; Figure (3b) shows that southeastern South America is also experiencing an increase in extreme heavy

rainfall events in this region.

(3a) Warm Extremes



(3b) Rainfall Extremes

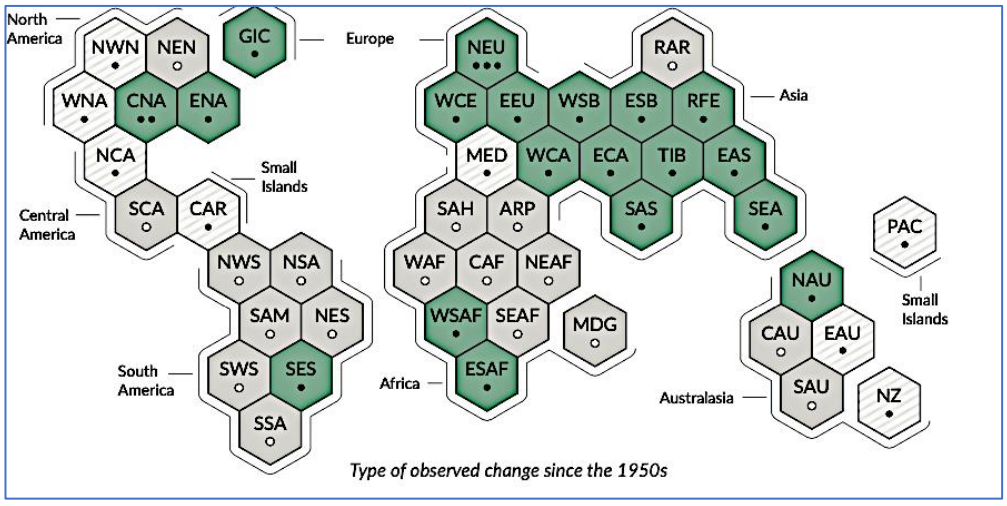


Figure 3 (a,b): Anthropogenic influences contributing to observed changes in temperature extremes and climate extremes.
Source: IPCC, 2022

The IPCC Report considers 5 scenarios that project temperature changes: two very optimistic but desirable scenarios that will be referred to here as "optimistic 1" and "optimistic 2", two more realistic scenarios regarding the achievement of the Paris agreement goals, "achievable 1 and achievable 2" and a "pessimistic" scenario, not desirable if greenhouse gas emissions continue at their current rate. The 5 scenarios consider global warming as the sum of past and future emissions, thus, considering the most optimistic scenario, and the long-term forecasts (2081-2100), the global average temperature should stay above 1°C to 1.8°C and, in the most pessimistic forecast of the publication, the best estimate for the average temperature increase on the planet, considering the long term, will be 4.4°C, and it is very likely that this warming will be in a range of

3.3°C to 5.7°C. (Table 2)

Table 2. Changes in global temperature of the planet, evaluated for 20-year periods in the five illustrative emission scenarios considered by the IPCC

	Short-term 2021-2040		Mid-Term 1041-2060		Long-term 2081-2100	
Scenario	**Best Estimate (ºC)**	**Very likely range (ºC)**	**Best Estimate (ºC)**	**Very likely range (ºC)**	**Best Estimate (ºC)**	**Very likely range (ºC)**
Optimistic 1	1.5	1.2 to 1.7	1.6	1.2 to 2.0	1.4	1.0 to 1.8
Optimistic 2	1.5	1.2 to 1.8	1.7	1.3 to 2.2	1.8	1.3 to 2.4
Realistic 1	1.5	1.2 to 1.8	2.0	1.6 to 2.5	2.7	2.1 to 3.5
Realistic 2	1.5	1.2 to 1.8	2.1	1.7 to 2.6	3.6	3.8 to 4.6
Pessimist	1.6	1.3 to 1.9	2.4	1.9 to 3	4.4	3.3 to 5.7

Source: IPCC, 2022 (adapted by the authors)

The geographical distribution of these temperature increases is also an important piece of information in the IPCC Report. Since the increase in temperature is not homogeneous throughout the planet, in the most pessimistic scenario, the Amazonian region would have its thermometers raised by an average of 5.5ºC to 6ºC, causing changes in the order of 20% in the rainfall regime. Even in an optimistic scenario of 2ºC warming, as shown in Figure 4, Brazil, the Amazon and the Center-West region of Brazil will have an increase in temperature of about 3.5ºC. (Artaxo, 2022)

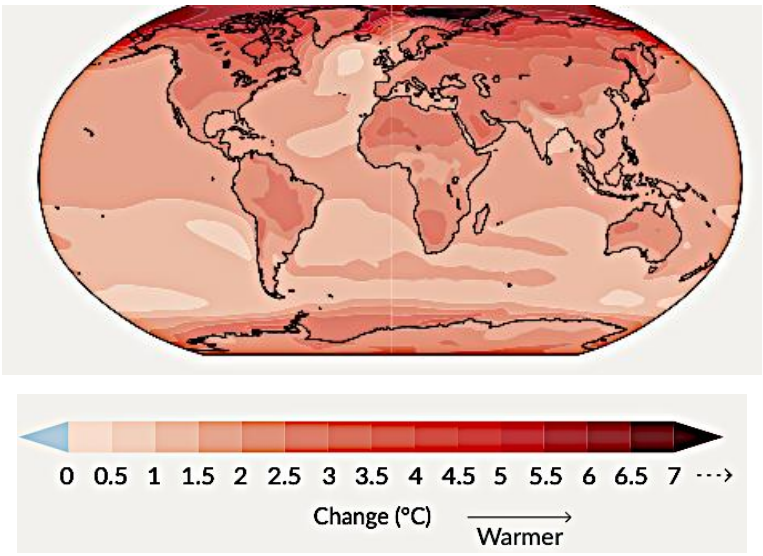


Figure 4 - Simulated change at 2°C global warming.

Source: IPCC, 2022

That climate change is causing drastic and frequent effects, such as storms, flooding, drought, forest fires, and other extreme phenomena, is established and plausible. However, with each report, new information is added and new, more detailed "predictions" of future trends become available. The new International Panel on Climate Change Report (AR6) shows worsening climate damage, with more severe impacts than expected. Moreover, it draws special attention to the fact that this reality, which affects the whole world, is more painful for the most vulnerable, as it raises to high levels the frequency and intensity of extreme weather phenomena responsible for material losses and the displacement of populations.

Recent headlines related to extreme weather seem to be straight out of a science fiction book: even the world's richest countries cannot control widespread fires - which are burning as far as the Arctic. Deadly floods in Germany and Belgium in July 2021 completely destroyed buildings and cars, and more than 1,000 people are still missing. Hundreds have died in floods in China. The northwestern United States, known for its cold weather, reached over 38°C for several days. And the Arctic lost an area of sea ice equivalent to the size of Florida between June and mid-July 2021. (Waskow & Gerholkt, 2021)

All these changes are just a sample of what could still happen, as they are the result of average warming of only 1.1°C above pre-industrial levels. In previous assessments the IPCC had warned of the risks of warming above 1.5°C and the new report predicts that in the next two decades the world will probably reach or exceed this limit.

The situation, considering the new Report, tends to compromise the planet even more, since more than four billion people (4.22 billion) live in urban areas, and this represents about 54% of the world population. The interrelations between the growth of urbanization and climate change generate impacts that can be classified into two types: those arising in urban areas and having negative effects on climate change; and, climate change having negative effects on urban areas. (Xiaoying et. al., 2006)

The scenario is aggravated because the exposure of human populations to these risks, on a global level, has grown faster in cities and towns where adaptive capacity is limited, thus affecting, on a larger scale, the poor populations of the planet, unplanned neighborhoods, and informal dwellings. And even if we succeed in reducing carbon emissions, the greenhouse gases already in the atmosphere will cause significant climate impacts by 2040, making the Paris agreement's global target of 1.5°C insecure.

As a result of this population increase experienced in all urban areas worldwide, the danger faced by people and property due to climate change increases proportionally. These are interconnected and often irreversible impacts of climate change on ecosystems, biodiversity and the human being system. In the context of climate change, harm can arise from the dynamic interactions between climate-related hazards, exposure, and the vulnerability of affected human and ecological systems.

According to AR6, between 2015 and 2020, the world's urban populations grew by more than 397 million people, and more than 90% of this growth was in the least developed countries. Therefore, according to the Report's data, the number of people expected to live in urban areas highly exposed to the impacts of climate change has increased substantially in these 5 years and more than 2.5 billion people are believed to live in

urban areas by 2050, with about 90% of this increase concentrated in the Asian and African regions. Furthermore, climate impacts are felt disproportionately in urban communities, such that the most economically and socially marginalized are most affected by these impacts. In naturally warmer regions, population growth coupled with global warming will increase heat exposure for more people, the most economically and socially weakened. "The IPCC predicts that by 2030, extreme droughts in the Amazonian region will boost migration to cities, where indigenous peoples and traditional communities are likely to be forced to live in the peripheries". It is a new risk that must be considered which consists of humans responses to climate change. (Levin, et. al., 2022)

The IPCC projections for these climate events reveal that an event that occurred every 50 years before human influence on climate, will be 39 times more frequent if we allow 4°C warming, and a drought that occurred every 10 years, will occur 4 times every 10 years. This will greatly affect agriculture and obviously the health of the Amazon rainforest, since the forest depends on water for its productivity. However, if warming is limited to 2ºC, these events will be 13.9 times more frequent. (Artaxo, 2022)

Based on this scenario, it is estimated that at 1.5°C warming, more than 350 million people living in urban areas will be exposed to water scarcity due to severe droughts; and at 2°C warming there will be 410.7 million people. And although exposure to adaptation limits is unevenly distributed, urban adaptation difficulties exist in all regions of the world and for all types of risks. Governance capacity, financial support, and the legacy of past investment in urban infrastructure limit how well cities and agglomerations are able to adapt. (IPCC, 2022)

This is a complex and heterogeneous reality which cities experience simultaneously: problems that characterize a reality of poverty/irregular occupations of environmentally fragile areas that multiply throughout the cities, such as slopes and floodable areas; environmental sanitation problems arising from the low rate of sewage collection and treatment; and problems related to high consumption patterns - air pollution and increased volume of solid waste. (Jacobi & Sulaiman, 2016)

Some developed countries have made significant progress in controlling air pollutants. These advances have been globally important; however, air quality continues to affect many people in developing countries. This situation is caused by rapid population growth combined with increasing energy demand, weak pollution control standards, dirty fuels, and inefficient technologies. Some governments have begun to address this problem, but very stringent measures are needed to reduce the serious impacts of air pollution on global public health. (Cartaxo et al, 2018)

COVID-19 problems were also considered by AR6, as the pandemic had a substantial impact on urban communities and climate adaptation, revealing systemic underinvestment that resulted in multiple and persistent health-related vulnerabilities. According to the IPCC, the pandemic is estimated to have pushed between 119 and 124 million people into poverty, with South Asia and sub-Saharan Africa each contributing about two-fifths of this total. (IPCC, 2022)

Although the mechanisms that may lead to the relationship between air pollution and Covid-19 transmission are not yet known, some publications show evidence of the association of the virus with fine particles, which, when inhaled, would facilitate the entry of viral agents into the body. On the other hand, the Covid-19

pandemic has also induced changes in household priorities, aggravating some problems that are unfortunately very common in Brazil, such as solid waste disposal (MSW), which can take on huge proportions when considering the significant number of people confined in small spaces in urban peripheries.

In Brazil, a study published by Getúlio Vargas Foundation (FGV), reveals that 62.9 million Brazilians live with a per capita household income of up to 497 Reais per month in 2021. This is 9.6 million more than in 2019, "almost a Portugal of new poor people emerged during the pandemic". This study also presents the ranking of the 27 Federation Units year by year, and highlights Amazonas as the second state with the highest poverty rate as shown in Figure 5. (Neri, 2022)

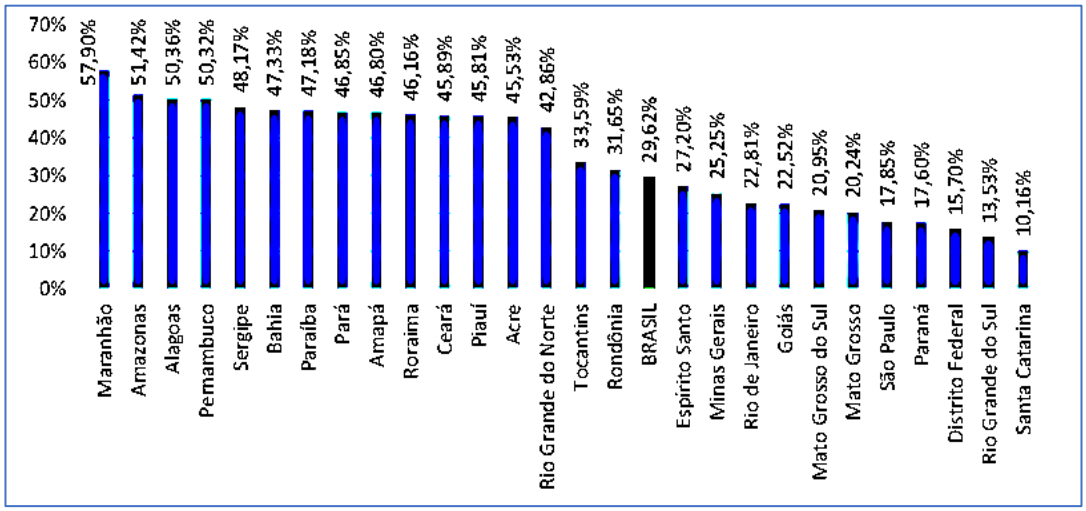


Figure 5. Amazonas' position in the Brazilian poverty ranking (2021).
Source: Neri, 2022 - FGV Social

The AR6 report also makes a projection of CO2 emissions absorbed by terrestrial and oceanic carbon sinks as per Figure 6. Today, total CO2 emissions are 40 billion tons of CO2 per year, 70% is reabsorbed by terrestrial ecosystems and oceans, but in the future this absorption may drop to 38%, which will accelerate global warming. (Artaxo, 2022)

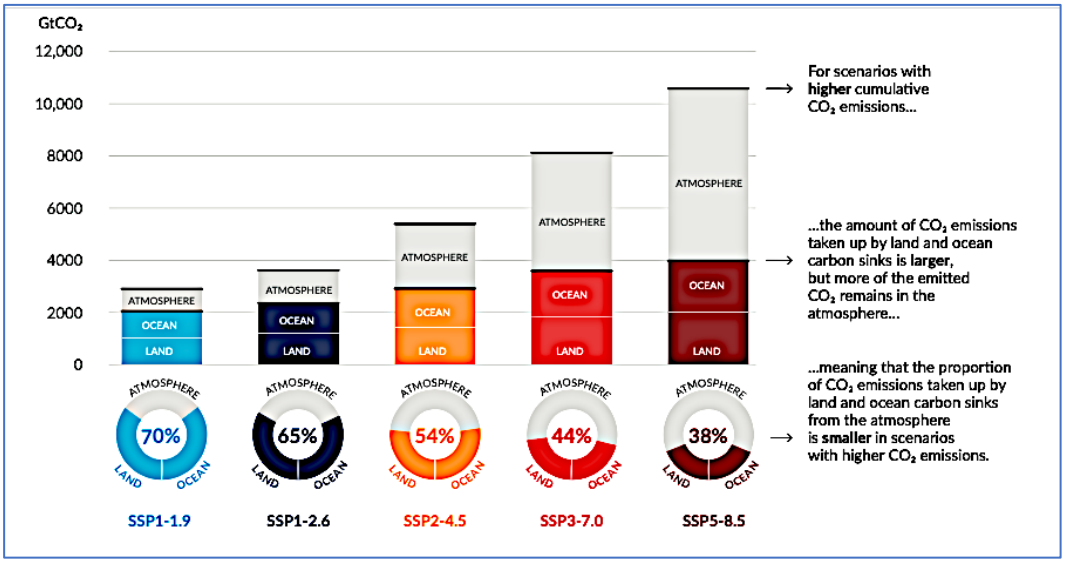


Figure 6. Proportion of CO2 emissions absorbed by land and ocean carbon sinks under the 5 IPCC scenarios.
Source: IPCC, 2022

The IPCC evaluated, for the first time, the role of heat islands[2], a phenomenon whereby cities retain energy and become warmer due to the lack of elements that cool the environment such as vegetation and bodies of water. This phenomenon is characteristic of the city of Manaus, where densely built areas combined with little vegetation cover, contribute to the change in the energy balance characterizing the so-called "heat islands". Probably, according to AR6, this event will intensify and a warming of 1.3 º C should be expected due to the increase of the heat island and another 1º C due to the increase of heat sources in urban areas, such as the increased use of air conditioners. (IPCC, 2022)
However, if adaptation measures such as vegetated areas are implemented in more developed urban centers, these can be cooled, indicating that increasing green areas is one of the ways to make cities more resilient to climate change.

4. The Amazonian Vulnerabilities

In order to understand the transformation process that has occurred in Amazonian societies, it is important to point out some climatic peculiarities that give the region a unique feature, specific to equatorial regions. The climate of the Amazon is defined by the interaction of several ocean-atmosphere phenomena, and by atmospheric systems that act at different space-time scales. (Santos et. al., 2017)
Equatorial regions are regions of low pressure because of solar heating resulting in high temperatures and the ascent of air masses that decrease in density due to heating. Warm air masses head towards the temperate regions by the upper parts of the atmosphere, while cold air masses take opposite path, converging towards the equator by the lower parts of the atmosphere. The Earth's rotational motion causes these masses to deviate to the right or left of their trajectory in the northern or southern hemisphere, respectively. However, as they travel through the lower layers, they suffer friction with the surface and, for this reason their speed is lower, even more so in urban areas, because the tall buildings increase the coefficient of friction between the wind and earth. (Torres & Machado, 2011)
These are some characteristics of the humid equatorial climate, according to the classification of climates proposed by Strahler in 1969 (apud Torres & Machado, 2011). It occurs in areas of dense and varied vegetation cover, it is hot with average annual temperatures that range between 25 °C and 27 °C. Rainfall is abundant during several months of the year with annual values exceeding 2,000 mm, and may exceed 3,000 mm annually in the western part of the Amazon.
A factor that is also important in determining the air temperature is the topography. With the exception of the extreme north of Amazonas and the extreme south of Rondônia whose relief presents high areas and moderate

[2] Manifestation of the increase in temperatures caused by physical characteristics (high density of buildings, concentration of building materials with high energy potential of emissivity and reflectance) and urban activities (COSTA et. al., 2009).

temperatures, the Western Brazilian Amazon has a plain relief and high temperatures (Liberato & Brito, 2010). These conditions, geographical position, plain relief, little movement of air masses, radiated heat and air temperature, interact to determine a greater capacity to retain water vapor. In the Amazonian region, with greater amount of solar energy received, the atmosphere has a high concentration of water vapor and, therefore, produces greater cloudiness, favoring heat gain. The large amount of water vapor is also responsible for the high temperatures. (Torres & Machado, 2011)

Even if emission levels are maintained, air quality varies according to the greater or lesser dilution of pollutants, which is determined by meteorological, topographical, and urban conditions. When these conditions are unfavorable to pollutant dispersion (calmness and low humidity, for example), air quality worsens in relation to the parameters, carbon monoxide (CO), particulate matter (PM), and sulfur dioxide (SO2). The same occurs with respect to ozone and its precursors in places where the intensity of sunlight is higher. (Goldemberg & Lucon, 2008)

By evaluating these conditions, one can understand why the accelerated urbanization process of the capital of Amazonas probably consisted in one of the most harmful transformations operated in the city, causing potentially disastrous results in the energy balance, in the climate, in the socio-spatial distribution and in the economy of the region. It can be seen that, as in so many other cities around the world, the growth process of the Amazonian cities and especially Manaus, was inspired in a remote past, because with the emergence of the industrial society, the economic system invested trusting in a "hypothetical" inexhaustibility of nature. By treating nature as an inexhaustible source of resources, independent of human relationships, it led societies to an uncontrolled exploitation of its riches and an unbridled consumerism that, in the end, clashed with the limitation of the resources themselves.

An instigating issue that threatens the lives of the region's populations is the contrast between the low socioeconomic indicators and the exuberance of the largest equatorial forest on the planet. However greater this wealth may be, it cannot justify the waste and the omission regarding the risks resulting from the impacts inflicted on the environment, because the strategic "merchandise" in the war against climate change are the vast stocks of commercial wood and carbon that abound in this biome and that are being decimated by fires and other illegal activities. (Da Cruz, 2022)

Scientific evidence indicates that the Amazon may be very close to a tipping point with deforestation rates accelerating a process of rainforest "savannization" that may become irreversible if these rates exceed 20% to 25% of the entire forested area of the Amazon Basin. Currently we have already lost 18%. A possible "savannization" of the Amazon is likely to cause new CO2 emissions into the atmosphere and significantly alter rainfall patterns, affecting South America's food production and the country's hydric and energy security. (WRI Brazil, 2022)

In the case of the Amazon, whose forest is essential for carbon storage, the combined effect of global warming and local deforestation interferes with the natural climate variability, alternating between rainy and dry seasons. (Gonzalez & De Oliveira, 2021)

These reflections do not arise by chance. INPE (National Institute for Space Research) uses four monitoring systems for the Amazon: the Brazilian Amazon rainforest Monitoring by Satellite (PRODES) which uses the images sent by the American Landsat satellite and which since 1988 has produced annual estimates of deforestation rates for the Legal Amazon (Acre, Amapá, Amazonas, Goiás, Mato Grosso, Pará, Rondônia, Roraima and Tocantins); the DETER (Deforestation Detection in Real Time) which consists of a fast monthly survey used since 2004 with data from the American satellites Terra and Aqua and the Sino-Brazilian satellite CBERS. The function of these two satellites is to send out alerts of deforestation outbreaks, to provide support to the inspection and control agencies; the DEGRAD (Mapping of Forest Degradation in the Brazilian Amazon) which maps areas in the process of deforestation where the forest cover has not yet been totally removed; and the DETEX (Detection of Selective Logging) which monitors forest management areas, showing whether the selective logging is in accordance with what has been authorized by the environmental agencies.

Definitely, it is not possible to ignore the data from satellite images, which are increasingly accurate and available to experts and non-experts in general. According to information extracted from the INPE monitoring systems, 729,781.76 km2 were deforested by 2020 in the Amazon Biome, meaning approximately 17% of the referred biome, and of these, almost half of the deforestation occurred in the last 20 years.

Only between August 1st, 2020 and July 31st, 2021, 13,235 km2 were deforested, the largest deforestation since 2006. This rate represents, according to the Project for Monitoring Deforestation in the Legal Amazon by Satellite (PRODES), an increase of 21.97% in relation to the deforestation rate in the previous period. (Table 2)

Table 2. Deforestation in Legal Amazon

State	PRODES 2020 Km2	PRODES 2021 Km2	Variation %
Acre	706	871	23,37
Amazonas	1.512	2.347	55,22
Amapá	24	39	62,5
Maranhão	336	363	8,04
Mato Grosso	1.779	2.263	27,21
Pará	4.899	5.257	7,31
Rondônia	1.273	1.681	32,05
Roraima	297	336	29,97
Tocantins	25	28	12

Source: INPE, 2022 (adapted by the authors)

According to an analysis by Agência Brasil based on data from INPE (Table 2), the states of Pará, Amazonas, Mato Grosso, and Rondônia alone contribute 87.25% of deforestation, with Pará being the state with the highest absolute deforestation contribution (5,257 km2) and also the state with the lowest percentage variation

in deforestation. This means that between 2020 and 2021, Pará had a 7.31% increase in deforestation while Amazonas reached 55.22% as seen in Figure 7.

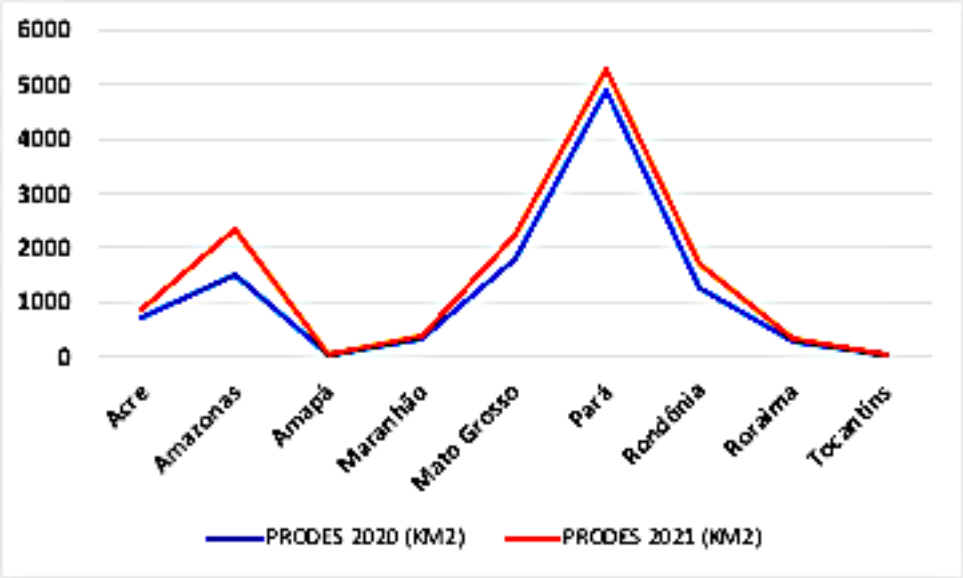


Figure 7. Proportion of CO2 emissions absorbed by land and ocean carbon sinks under the 5 IPCC scenarios.

Source. INPE, 2022 (adapted by the authors)

Highlighting the state of Amazonas, one can see in Figure 8 the historical evolution of deforestation rates during the last 34 years, with highlight to the year 2021, whose values exceeded the highest peak occurred in 1995.

Figure 8. Historical evolution of deforestation rates in Amazonas since 1987.

Source: INPE - PRODES, deforestation (2022)

These are alarming numbers that add, to the crises of socioeconomic inequality, the risk of the forest becoming an ecosystem close to savannas, in addition to the constant threats to its inestimable biodiversity.

Despite the worrisome picture that is emerging, there are measures that can be taken, among them the global

transition to clean energy and the radical reduction of emissions (net zero). However, cutting emissions is not enough, part of the Carbon that is already in the atmosphere needs to be removed, and it is in this sense that Amazonas and the Amazon populations have a decisive role. Nature itself provides the necessary technology capable of promoting carbon removal, photosynthesis. As any child knows, through photosynthesis plants absorb carbon from the air (CO2) and store it in their roots in the soil. "[...] the work of our green allies could be equivalent to something close to a third of the emissions reduction needed to stay below the 1.5°C range. What we need to do to collaborate with nature is to protect "natural habitats around the world that store billions of tons of carbon." (TNC, 2022)

Finally, an economic system based on the incessant increase of production and consumption cannot be considered sustainable. The contradictions are crystal clear: the development of cities has had the important reinforcement of technology which, among other contributions, has improved energy efficiency but, on the other hand, has increased energy production and consumption, implying the intensive use of resources and the inducement of new impacts on nature.

This impasse seems insurmountable, but in fact, it has not been faced with objectivity, because it is not a question of creating opposition to efficiency, because, in order to achieve productive growth with low pollutant gas emissions, one must implement the best energy efficiency practices, but it is imperative not to allow efficiency measures to cause the rebound effect by encouraging increased consumption.

5. Conclusion

The abundant data presented here demonstrate the unquestionable need to implement radical changes in the concepts and public policies directed towards making cities environmentally and socially sustainable, as a way to confront the growing deterioration of living conditions and the multiplication of environmental risks, aiming at the development of the Amazon region.

The importance of the forest and all its biodiversity is unquestionable, and the risks of extinction of these resources also threaten the extinction of life. Measures to reduce poverty are also urgent, both as a demand of humanity and because, if poverty levels are not vigorously reduced, environmental collapse will have serious consequences for the survival of all species on the planet and for the planet itself. This fact becomes clear as one perceives poverty as the deprivation of basic human capabilities, leading to unsustainable use of natural resources, as the only way to resist one's own extermination.

The Intergovernmental Panel on Climate Change makes new warnings, reducing the time for the ability to balance the current needs with those that will be essential to maintain future populations, that is, to reduce greenhouse gas emissions by half even in this decade, protect the natural habitat of species, intensify the use of clean energy, implement energy efficiency practices, and act severely to reduce poverty levels, and also develop the adaptive capacity in the face of natural disasters, are some of the necessary measures.

With regard to poverty, we have seen how much the vulnerability indexes have increased after the health crisis that hit the planet, showing, especially in the poorest corners of the world, the inability to meet the basic needs for survival. Without attending to the destitute population, Brazil has uncovered millions of individuals living in poverty, meaning individuals without dignified conditions of existence, without income, without health,

without hospitals, without oxygen, and with the increase of hunger and misery. Given this picture, the eradication of poverty in all its forms and dimensions is the greatest challenge of this generation, since there will be no development without addressing issues that involve social protection systems and reducing vulnerability to environmental and economic risks.

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