



# **Mitigation Measures for Climate Change: An Environmental and Public Health Emergency**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## **ABSTRACT**

The Intergovernmental Panel on Climate Change (IPCC), established in 1988, is an international organization responsible for assessing climate change, its progression, and associated impacts. To date, six Assessment Reports (AR1 to AR6) have been published, presenting the scientific foundations, observed and projected effects, as well as mitigation and adaptation strategies. The

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objective of this study was to evaluate the main environmental and human health impacts described in the IPCC reports, as well as to identify the mitigation measures recommended. The methodology employed consisted of a systematic documentary review of the six IPCC Assessment Reports: AR1 (1990), AR2 (1997), TAR (2001), AR4 (2007), AR5 (2014), and AR6 (2021). The reviewed documents highlight a range of environmental impacts, including the rise in average global temperatures, sea level rise, and the increasing frequency and intensity of extreme weather events. In the field of health, notable concerns include the rise in heat-related illnesses, respiratory diseases, vector-borne outbreaks, and threats to food and water security. Among the identified mitigation strategies are the transition to renewable energy sources, the adoption of sustainable agricultural practices, and the development of integrated policies with differentiated responsibilities. The implications of this study emphasize the urgency of implementing strong public policies and coordinated actions among governments, businesses, and communities, with the goal of building a sustainable and resilient development model. Adopting these measures is essential for protecting the environment and public health for current and future generations.

**Keywords:** *Vulnerability; human health; environment; sustainability; public health.*

## LIST OF ABBREVIATIONS

AR1	: Assessment Report 1;
AR2	: Assessment Report 2;
AR4	: Assessment Report 4;
AR5	: Assessment Report 5;
AR6	: Assessment Report 6;
CC	: Climate Change;
CH <sub>4</sub>	: Methane;
CO <sub>2</sub>	: Carbon Dioxide;
GHG	: Greenhouse Gas;
GtCO <sub>2</sub>	: Gigatonnes of Carbon Dioxide;
GtCO <sub>2</sub> e	: Gigatonnes of Carbon Dioxide Equivalent;
GW	: Global Warming;
HFCs	: Hydrofluorocarbons;
IPCC	: Intergovernmental Panel on Climate Change;
N <sub>2</sub> O	: Nitrous Oxide;
O <sub>3</sub>	: Ozone;
PFCs	: Perfluorocarbons ;
RCPs	: Representative Concentration Pathways;
SF <sub>6</sub>	: Sulphur Hexafluoride;
TAR	: Third Assessment Report;
UN Environment	: United Nations Environment Programme;
UV-B	: Ultraviolet B Ray;
WHO	: World Health Organization;

## 1. INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) is an international organization established in 1988 by the United Nations Environment Programme (UN Environment) and the World Meteorological Organization (WMO). It studies climate change (CC), its evolution, and its impacts across multiple contexts. The IPCC's assessments and reports are conducted by three Working Groups and include a Synthesis Report, along with Special Reports developed during each assessment cycle (Houghton, 1986). The

Working Groups are: Working Group I (Physical Science Basis), Working Group II (Impacts, Adaptation, and Vulnerability), and Working Group III (Mitigation of Climate Change) (IPCC, 1996,2001,2007,2013). Additionally, the IPCC has a Task Force on National Greenhouse Gas Inventories, dedicated to developing and refining methodologies for calculating and reporting national greenhouse gas (GHG) emissions and removals (Brazil, 2022).

Up to the publication of its latest report in 2021, the IPCC had released six assessment reports.

The first report (AR1), released in 1990, provided a pioneering analysis of the scientific basis of climate change, highlighting rising GHG concentrations and warning of the potential risks of global warming (GW) (Garner et al., 2018). The second report (AR2), published in 1997, built upon AR1's projections and presented the first evidence of human influence on CC. It also contributed to the formulation of the Kyoto Protocol in 1997, which set legally binding emission reduction targets primarily for developed countries, based on the principle of common but differentiated responsibilities (Scovazzi & Lima, 2021; Mundo, 2016).

In 2001, the third report (TAR) introduced advanced projections using Global Atmosphere-Ocean Climate Models and underscored the urgent need for mitigation measures, with greater emphasis on socio-economic factors and population vulnerabilities (Alexander, 2016). The fourth report (AR4), published in 2007, confirmed human influence on CC, presented detailed GHG emission scenarios and their impacts, and played a key role in strengthening international negotiations, culminating in the Copenhagen Accord at the 15th UN Climate Conference in 2009 (Lampis et al., 2020).

The fifth assessment report (AR5), published in 2014, introduced Representative Concentration Pathways (RCPs), which outline key scenarios for studying climate change impacts. It emphasized the urgency of limiting global temperature rise to 2°C and played a crucial role in shaping the Paris Agreement in 2015, which set a goal to reduce GHG emissions by 37% by 2025 (Bezerra et al., 2019). The sixth report (AR6), published in 2021, highlights the urgent need to reduce GHG emissions to limit global warming to 1.5°C. It examines climate change impacts on ecosystems, biodiversity, food security, water resources, and human health. The report also proposes mitigation and adaptation strategies, including transitioning to renewable energy, adopting sustainable agricultural practices, and implementing integrated policies with differentiated responsibilities. Furthermore, it addresses climate justice issues, emphasizing the disproportionate impacts on vulnerable communities (Brazil, 2022).

The analysis of climate change over the years, as presented in the IPCC reports, reflects the complexity and uncertainty surrounding the issue. Climate change remains one of the most

pressing challenges for scientific research, forecasting, and policy development, particularly regarding its interactions with the economy (Xepapadeas, 2023).

Mitigating climate change is one of the most urgent social objectives of this and the coming decades. The absence of effective mitigation actions could result in significant environmental and human health impacts (Emmerling et al., 2024). Therefore, this article aims to summarize and review the primary environmental and human health impacts identified in the IPCC reports over the years, as well as to highlight the mitigation measures suggested to reduce the damage caused by advancing climate change.

## 2. METHODOLOGY

This research was characterized as a documentary study (Sá-Silva et al., 2009). For this purpose, the methodological criteria of an integrative literature review were adapted, following the model proposed by Cooper, (1984). This method enables the synthesis of existing scientific knowledge on a given topic, allowing for the identification of research gaps and the strengthening of evidence to support health practices and public policies. The process was divided into six sequential stages, as described below:

### 2.1 Identification of the Topic and Formulation of the Research Question

The central theme focused on climate change mitigation measures and their impact on environmental and human health. The guiding question was: *"What are the main impacts of climate change on human and environmental health, and what are the primary mitigation measures proposed in the IPCC reports to address these impacts?"*

### 2.2 Establishment of Inclusion and Exclusion Criteria and Definition of Data Sources

The six official IPCC reports—AR1 (1990), AR2 (1997), TAR (2001), AR4 (2007), AR5 (2014), and AR6 (2021)—published between 1990 and 2021, were used as primary sources. These reports were selected because they represent the IPCC's official data on climate change monitoring and assessment, compiled from extensive reviews of scientific literature available at the time of each publication. The inclusion criteria were: (1) official documents produced by

the IPCC; (2) inclusion of data on environmental and health impacts; and (3) presentation of mitigation measures. These topics were specifically extracted from the aforementioned reports. Therefore, other types of documents (e.g., journal articles, term papers, dissertations, theses, and others) were excluded from data extraction.

### 2.3 Categorization of the Studies

After selection, the reports were organized in an analysis spreadsheet containing the following categories: year of publication, main environmental impacts, main health impacts, proposed mitigation measures, and other relevant observations. All selected data were reviewed by three of the authors to identify which issues appeared repeatedly across the reports for further analysis and discussion.

### 2.4 Evaluation of the Included Studies

Based on the IPCC's own criteria, data from the reports were selected primarily based on the persistence and recurrence of specific themes over time, which were then analyzed.

### 2.5 Interpretation of the Results

Interpretation was conducted following both a temporal and thematic approach. The main shifts in the understanding of climate impacts and the strategies recommended to address them were identified, with an emphasis on those measures that showed the greatest evidence of effectiveness and feasibility from both an environmental and public health perspective.

### 2.6 Presentation of the Review and Synthesis of Knowledge

The findings were presented in the form of a descriptive synthesis, illustrating the evolution of impacts and recommended responses throughout the IPCC reports. The analysis also highlighted relevant gaps for future research, particularly regarding the integration of climate mitigation strategies and global health policy.

The data was extracted from the IPCC reports available on the Ministry of Science, Technology, and Innovation website and the Intergovernmental Panel on Climate Change (IPCC) portal through a data review process. The data was collected separately for each year of publication and then compiled into tables to identify persistent issues over the years and the emergence of new topics to be considered by

decision-makers. Data collection was conducted between May and June 2024. The data was collected from published documents, which are therefore public in nature. Therefore, the study was not submitted to an ethics committee.

## 3. RESULTS AND DISCUSSION

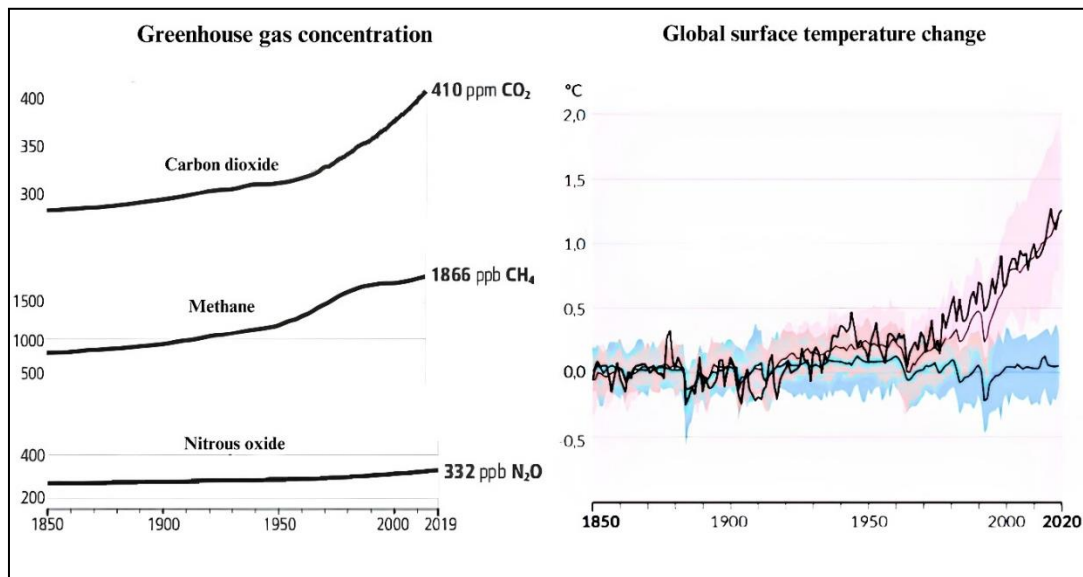
The IPCC has conducted detailed assessments and provided comprehensive scientific, technical, and socio-economic information on climate change. Its analyses have highlighted environmental and climate indicators, predicted environmental impacts, examined effects on human health, and recommended mitigation measures (Emmerling et al., 2024).

Concentrations of GHGs such as CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O have increased significantly since the late 19th century (Fig. 1), mainly due to human activities such as burning fossil fuels and deforestation (Brazil, 2022). In this context, the rising GHG emissions and their harmful impact on ecosystems have become a growing global concern, particularly regarding mitigation efforts. One of the primary contributors is the transportation sector, primarily due to fossil fuel consumption (Emmerling et al., 2024).

The average global temperature has followed the same trend as increasing GHG emissions, reaching levels unprecedented in more than 2,000 years. The most significant warming has occurred in recent decades, with human influence being the main driver of this increase (Brito, 2022).

### 3.1 Analyzed Indicators

The indicators employed by the IPCC to assess the impacts of climate change are fundamental for researchers, policymakers, and society at large to comprehend both current trends and future projections of climate-related events. These indicators are periodically updated in the IPCC's assessment reports and encompass a broad set of metrics, including greenhouse gas emissions (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, O<sub>3</sub>, HFCs, PFCs, and SF<sub>6</sub>), atmospheric concentrations of these gases, regional climate projections, temperature and precipitation patterns, and the frequency and intensity of extreme weather events. Additionally, the reports consider radiative forcing from greenhouse gases and aerosols, issues related to agriculture and forestry, vulnerability to sea-level rise, and the broader impacts of climate change on natural and human systems, such as ecosystems, water resources, and public health.



**Fig. 1. GHG emission scenario from 1850 to 2019 and a comparison between human influence and natural causes on the rise in average global temperature from 1850 to 2020**

*\*In pink, the simulation of both human and natural causes; in blue, the simulation of natural causes only (solar and volcanic).*

*Source: Adapted from the Intergovernmental Panel on Climate Change - IPCC (2022).*

Additionally, other specific patterns are assessed, such as global average surface temperature; diurnal temperature range; frequency of hot days/heat index; cold days/frost events; continental precipitation; heavy precipitation events; drought frequency and severity; global mean sea level; duration of river and lake ice cover; extent and thickness of Arctic sea ice; non-polar glaciers; snow cover; El Niño events in permafrost; plant and animal distribution changes; reproduction, flowering, and migration patterns; and coral reef bleaching.

Based on these indicators, projections are made regarding climate change's impacts on various societal sectors, including human health, environmental problems, and economic losses resulting from disasters. Despite the efforts of working groups, indicators must be continuously updated and refined to effectively monitor rapid climate change and ensure that the global community has the necessary information to respond effectively (Forster et al., 2023).

### 3.2 Environmental Impacts

The results presented in Table 1 highlight various environmental impacts caused by climate change, depicting a concerning scenario for both the short and long term. These impacts range from changes in atmospheric composition marked by significant increases in

greenhouse gas emissions to direct and indirect effects on terrestrial and marine ecosystems, as well as profound socio-economic consequences.

The IPCC Special Report on Global Warming of 1.5 °C suggests that achieving the 1.5 °C target, as stipulated in the Paris Agreement, would significantly reduce projected risks and further exacerbation of observed climate change impacts compared to the current warming level of 1.1 °C above pre-industrial temperatures (Mechler et al., 2020).

However, human behavior has exhibited contradictions. For example, global greenhouse gas (GHG) emissions rebounded sharply in 2021 after a single-year decline during the COVID-19 pandemic lockdowns in 2020. Total global GHG emissions reached  $55 \pm 5.2$  GtCO<sub>2</sub>e in 2021. The primary contributing sources were CO<sub>2</sub> from fossil fuels and industry ( $37 \pm 3$  GtCO<sub>2</sub>), CO<sub>2</sub> from land use and forestry ( $3.9 \pm 2.8$  GtCO<sub>2</sub>), methane (CH<sub>4</sub>) ( $8.9 \pm 2.7$  GtCO<sub>2</sub>e), nitrous oxide (N<sub>2</sub>O) ( $2.9 \pm 1.8$  GtCO<sub>2</sub>e), and fluorinated gas emissions ( $2 \pm 0.59$  GtCO<sub>2</sub>e). Before this event, in 2019, emissions were  $55 \pm 5.4$  GtCO<sub>2</sub>e, nearly the same level as in 2021. Initial projections indicate that CO<sub>2</sub> emissions from fossil fuels, industry, and land use changes will remain similar in 2022, at  $37 \pm 3$  GtCO<sub>2</sub> and  $3.9 \pm 2.8$  GtCO<sub>2</sub>, respectively (Jain, 2022).

**Table 1. Environmental impacts projected by the IPCC reports (AR1 1990, AR2 1997, TAR 2001, AR4 2007, AR5 2014, and AR6 2021) as a result of climate change**

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- Emissions of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, and other greenhouse gases are projected to rise significantly by 2025.
  - Global warming of up to 0.3°C per decade, with sea level rising between 0.3 and 1 meter by 2100.
  - Uneven distribution of temperature increases.
  - Surface ocean temperature projected to rise between 0.2°C and 2.5°C.
  - Increased pollen and spore levels, along with worsening air pollution impacts.
  - Changes in ocean salinity and circulation, affecting marine ecosystems, increasing the risk of coral bleaching, and spreading marine diseases.
  - More frequent heat waves, storms, and floods, influencing the spread of infectious diseases.
  - Disruptions to terrestrial and aquatic ecosystems, leading to habitat loss and threats to vulnerable species.
  - Higher demand for electrical cooling, with potential risks of power supply failures.
  - Reduced availability of freshwater resources.
  - Increase in maximum temperatures, fewer cold and frosty days, and more extreme heat events.
  - More frequent heavy rainfall events and increased summer droughts.
  - Greater peak wind speeds and intensified rainfall from tropical cyclones.
  - Impacts on agriculture, forestry, fisheries, energy, and tourism due to natural disasters such as floods, droughts, and landslides.
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Source: Authors, 2025

Environmental impacts reflect ecological imbalances caused by human exploitation of natural resources. The increase in GHG emissions over recent years has contributed to climate instability, including rising temperatures and adverse effects of air pollution, leading to social, economic, and demographic consequences (Antoni & Fofonka, 2018).

In this context, rising temperatures have led to glacier and polar ice cap melting, contributing to a 0.3-meter rise in sea levels over the last century (Brazil, 2022). Changes in precipitation patterns have resulted in more frequent and intense extreme weather events, such as floods, droughts, heatwaves, and storms (Araújo & Oliveira, 2022). Additionally, ocean acidification due to CO<sub>2</sub> absorption is threatening marine life, particularly corals and mollusks (Brazil, 2022).

### 3.3 Impacts on Human Health

Climate change has increased the incidence of heat-related illnesses and exacerbated health problems such as infectious, respiratory and allergic diseases (Fernandes et al., 2021). Changes in climate patterns have affected the distribution of disease vectors such as mosquitoes, increasing the risk of epidemics and vector-borne diseases such as malaria and dengue fever (Carvalho et al., 2020).

From 2000 to 2019, the World Health Organization (WHO) documented a tenfold increase in reported cases worldwide, rising from 500,000 to 5.2 million. The year 2019 marked an unprecedented peak, with reported cases spreading to 129 countries. In 2023, the Americas region reported 4.1 million suspected dengue cases, including 6,710 severe cases and 2,049 deaths, with Brazil reporting the highest number of suspected cases, followed by Peru and Mexico. Since the beginning of 2023, more than 5 million dengue cases and 5,000 deaths have been recorded globally in 80 countries (WHO, 2023). This increase is associated with the greater distribution of the *Aedes aegypti* and *Aedes albopictus* vectors, influences from climate change and fragile health systems in regions with complex humanitarian crises. Favorable weather conditions, such as heavy rainfall and high temperatures, also contribute to mosquito breeding and virus transmission, exacerbating dengue outbreaks (WHO, 2023).

Vulnerable communities, especially in developing countries, face threatened food and water security, with negative impacts on nutrition and access to drinking water in various regions of the world, contributing to social instability, forced migration and insecurity due to climate impacts (Table 2) (Brazil, 2022).

**Table 2. Impacts on human health projected in the IPCC reports (AR1 1990, AR2 1997, TAR 2001, AR4 2007, AR5 2014, and AR6 2021) as a consequence of climate change**

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- Increase in epidemics and vector-borne diseases, including malaria, lymphatic filariasis, schistosomiasis, leishmaniasis, river blindness, dengue fever, and encephalitis.
  - Rise in heat-related deaths and illnesses.
  - Higher risks of drowning, respiratory diseases, leptospirosis, and diarrhea.
  - Impacts on food security, with reduced crop yields, especially in tropical regions.
  - Increased malnutrition with severe consequences for child growth and development.
  - Socioeconomic and demographic impacts due to the destruction of homes and infrastructure.
  - Greater incidence of deaths, illnesses, and injuries caused by storms, wildfires, and droughts.
  - Effects on the human immune system and vision due to UV-B radiation exposure.
  - Water and food shortages, along with a rise in infections in highly urbanized areas.
  - Shifts in the patterns of vector-borne and viral diseases due to changes in rainfall and temperature.
  - Large-scale human migrations, leading to altered settlement patterns and social instability.
  - Increase in respiratory and allergic diseases.
  - Negative impacts on mental health due to declining quality of life.
  - Changes in the geographical distribution of disease vectors, placing large populations at risk.
- 

*Source: Authors, 2025.*

Changes in ecosystems, as a reflection of the impacts of climate change, also have an impact on the health and well-being of the global population, either directly or indirectly. As research has shown and as pointed out in the IPCC reports. Impacts on human health occur due to extreme weather conditions, which can vary depending on the region and social, environmental and economic conditions (Pereira et al., 2020).

Among the impacts are an increase in epidemics caused by vectors, respiratory diseases, diseases related to the significant increase in temperature, malnutrition as a result of changes in agricultural food production, large migrations of people due to climate and socio-economic changes, leading to disruptions in settlement patterns and social instability, as well as impacts on the mental health of populations affected by extreme weather conditions that force them to change their way of life, forced migrations, and the very process of readapting to new environments, social and environmental conditions (Uchoa et al. , 2019). In this sense, there is the impact on health services and the capacity of the Unified Health System to care for direct and indirect victims, and the system has guidelines for this public (Silva et al., 2023).

The most recent IPCC study shows that every (half) degree of warming increases the magnitude of the risks of anthropogenic climate change in all sectors and regions, and that disadvantaged and vulnerable populations are at disproportionately greater risk due to present and future warming. In principle, the IPCC considers

it possible to achieve the 1.5 °C target, even with current mitigation technologies; however, massive expansion and rapid operationalization are required (Mechler et al., 2020), as well as cross-sectoral support to mitigate and address the short- and long-term consequences.

### 3.4 Mitigation Measures

It is evident that conventional mitigation efforts alone are insufficient to meet targets for maintaining environmental and public health. Therefore, adopting alternative approaches appears inevitable. Although many existing technologies contribute to impact mitigation, greater investments in highly efficient processes and logistics remain necessary (Fawzy et al., 2020). These aspects can be further explored through unbiased scientific studies and analyses.

In this regard, biofuels stand out as a crucial research focus, emphasizing technological advancements and the need for policymakers to devise strategies through public policies in these sectors (Brito, 2022). Some measures aimed at reducing environmental impacts on ecosystems and human health are presented in Table 3.

In the mitigation context, the priority is to reduce GHG emissions by transitioning to renewable energy sources such as solar and wind power and adopting carbon capture and storage technologies. The energy transition and the promotion of sustainability in agriculture and forestry are essential components for significantly reducing sectoral emissions (Mesquita & Bursztyn, 2018).

**Table 3. Mitigation measures to be implemented to address the impacts projected in the IPCC reports (AR1 1990, AR2 1997, TAR 2001, AR4 2007, AR5 2014, and AR6 2021)**

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<ul style="list-style-type: none"> <li>• Achieve net-zero CO<sub>2</sub> emissions and substantial, rapid reductions in CH<sub>4</sub> and other greenhouse gases (GHGs).</li> <li>• Improve air quality by reducing aerosol pollution.</li> <li>• Transition from fossil fuels to renewable energy sources.</li> <li>• Promote sustainability in agriculture and forestry, including reforestation.</li> <li>• Reduce food waste and increase the use of biomaterials.</li> <li>• Advance research on adapting agricultural practices to climate change.</li> <li>• Implement differentiated responsibilities for industrialized and developing countries.</li> <li>• Prioritize environmental protection as a foundation for sustainable economic growth.</li> <li>• Accelerate research programs to reduce scientific uncertainties.</li> <li>• Develop new technologies in energy, industry, and agriculture.</li> <li>• Improve coastal zone management and sustainable resource use.</li> <li>• Capture methane (CH<sub>4</sub>) from landfills and reduce refrigerant leakage from mobile and stationary sources.</li> <li>• Enhance land management and agricultural practices, including agroforestry and sustainable soil management.</li> <li>• Promote water conservation through rainwater harvesting, reuse, desalination, and efficient irrigation.</li> <li>• Support agricultural adaptation by adjusting planting schedules, relocating crops, and improving land management.</li> <li>• Strengthen urban and infrastructure resilience planning.</li> <li>• Develop integrated policy strategies.</li> </ul>
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Source: Authors, 2025

In addition, implementing strategies such as reducing food waste and utilizing biomaterials plays a crucial role in lowering the global carbon footprint. Assigning differentiated responsibilities enables countries with varying capacities and levels of development to contribute equitably to achieving these goals (Mesquita & Bursztyn, 2018).

To address the unavoidable impacts of climate change, adaptation measures are essential. These include constructing resilient infrastructure, managing natural resources sustainably, and implementing urban and rural planning policies that account for emerging climate risks. Effective coastal zone management and the sustainable use of resources are critical to protecting vulnerable communities from rising sea levels and extreme weather events (Brazil, 2022).

Furthermore, techniques such as water conservation, urban resilience planning, and sustainable infrastructure development are vital for strengthening the adaptive capacity of cities and rural regions. The coordinated integration of these strategic approaches is essential for addressing climate change challenges effectively and sustainably, ensuring a resilient future for global populations (Artaxo, 2022).

### 3.5 Future Prospects

According to the projections of the IPCC reports and other contemporary studies, the future impacts of climate change on human health and the environment are likely to intensify in the coming decades. It is estimated that the progressive rise in average global temperature will result in more frequent extreme weather events, such as heat waves, prolonged droughts, and severe storms, directly affecting food security due to a drop in agricultural productivity and a shortage of drinking water (IPCC, 2021).

An increase in the incidence of vector-borne infectious diseases is also projected, with geographical expansion into regions previously free of these diseases (Liao et al., 2024). In addition, the increase in respiratory diseases associated with temperature variability, relative humidity, and worsening air pollution could trigger new epidemic outbreaks, raising morbidity and mortality rates and negatively impacting the economy (Tran et al., 2023).

Rising sea levels are expected to cause mass population displacement, especially in coastal areas, contributing to the emergence of climate refugees and worsening social conflicts and



socio-environmental inequalities (Cardozo et al., 2023). The destruction of ecosystems and the expected loss of biodiversity also threaten environmental services that are essential for human survival, such as pollination, soil regeneration, and water purification. In addition, the psychosocial and psychiatric impacts of prolonged exposure to natural disasters, material losses, and insecurity about the future such as anxiety, depression, and post-traumatic stress are likely to intensify (IPCC, 2021).

As the impacts advance, the need for effective climate change mitigation strategies becomes increasingly evident. Policies need to be revised and effective actions implemented in a way that not only reduces negative impacts but also fosters sustainable and resilient development (Pirani et al., 2024).

To date, various public policies and national and international agreements have been developed to mitigate the impacts of climate change on human health and the environment. In Brazil, we highlight the National Climate Change Policy (PNMC), which guides the reduction of GHG emissions (Brasil, 2009), and the National Plan for Adaptation to Climate Change (PNA), which focuses on vulnerable sectors such as health, agriculture, and water resources (Brasil, 2016). Also in the national context, programs such as the ABC+ Program (Adaptation Plan and Low Carbon Emission in Agriculture) encourage sustainable agricultural practices with lower carbon emissions (Brazil, 2021).

At the international level, we highlight the Paris Agreement (2015), signed in the context of the United Nations Framework Convention on Climate Change (UNFCCC), in which the signatory countries undertake to limit the increase in the global average temperature to well below 2°C, with efforts to limit this increase to 1.5°C. Another relevant instrument is the 2030 Agenda for Sustainable Development, which includes specific targets for climate action (SDG 13), clean and affordable energy (SDG 7), and sustainable cities and communities (SDG 11) (World, 2016).

Despite the progress made, complementary policies are still needed to strengthen the response to climate challenges. The transition to renewable energy sources must be accelerated, combining investments in research so that new production methods can be developed that are technically efficient, environmentally appropriate,

and financially profitable. Otherwise, it is unfeasible to replace the matrices if this only serves to move the market with a new product that will generate more environmental liabilities (Maier et al., 2021).

Climate impacts are an ongoing challenge and have already become embedded in daily life. Therefore, measures to enhance climate resilience in both urban and rural communities will be essential. This includes urban planning that integrates green spaces and climate-adaptive infrastructure, as well as strengthening sustainable agricultural practices capable of withstanding extreme weather conditions (Pirani et al., 2024).

Regarding mitigation and adaptation policies, it is crucial to consider disparities between different regions and communities, particularly those most vulnerable to climate change. Implementing differentiated responsibilities, based on each country's resources and capacities, is essential to ensuring equitable and just progress (Pollitt et al., 2024).

The interconnected nature of climate challenges with other global issues such as food security, public health, and migration demands a holistic approach that integrates multiple sectoral policies. This requires more effective coordination among government sectors and stronger collaboration between public and private entities (Pirani et al., 2024).

#### 4. CONCLUSION

In view of the growing urgency to mitigate the impacts of climate change, it is essential to analyze and implement effective mitigation measures. The IPCC reports provide a comprehensive analysis of the environmental and human health impacts of global warming and changing weather patterns. From extreme weather events to the spread of disease and the scarcity of natural resources, the effects of climate change are intensifying, negatively affecting communities around the world.

To reduce this damage, the IPCC highlights the importance of robust mitigation policies. This includes transitioning to clean and renewable energy sources, improving energy efficiency and reducing GHG emissions. In addition, adopting adaptation measures to strengthen infrastructure and help vulnerable communities cope with the

climate impacts, both environmental and on health and well-being, that are already underway. The various and ongoing strategies are fundamental to reducing the risk of disasters and mitigating the impacts of those that do occur, they are investments and practices for sustainable development.

The implementation of effective measures will not only safeguard the environment and biodiversity, but also play a crucial role in promoting public health and preventing disease. Key actions such as reducing air pollution, ensuring food security, and mitigating the risks of natural disasters are fundamental to building a sustainable and resilient future. Therefore, it is imperative that governments, businesses, and communities join forces and act collectively to address this global challenge, ensuring a safe, healthy, and equitable environment for present and future generations.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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