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Review Article

Perspective on the Era of Global Boiling: A Future beyond Global Warming

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As the unpredictable nature of the Earth's climate persists, the scholarly attention dedicated to climate research has undergone a notable transition, shifting its emphasis from the conventional notion of global warming to a greater disconcerting occurrence commonly referred to as "global boiling." The present article endeavors to elucidate the scientific evidence that posits a discernible alteration in climate patterns, specifically towards an exacerbation of extreme heat events. Furthermore, this study aims to delve into the various factors that are believed to be instrumental in precipitating this noteworthy phenomenon. Furthermore, we engage in a comprehensive examination of the potential ramifications on ecological systems, human communities, and the imperative necessity for proactive measures aimed at both mitigating and adapting to these challenges. This paper endeavors to elucidate the potential issues presented by the period of global boiling through a thorough examination of existing research and data. Furthermore, it seeks to underscore the significance of concerted efforts to effectively tackle this pressing matter.

1. Introduction

The phenomenon of global warming, which is primarily caused by the emission of carbon dioxide (CO_2), methane (CH_4), and various other greenhouse gases in the Earth's atmosphere has resulted in a multitude of extensively documented consequences [1]. These consequences encompass elevated sea levels, heightened occurrence of heatwaves, and alterations in the distribution of precipitation [2, 3]. The topic of global warming has garnered significant attention within the realm of climate science for a considerable period of time, with a substantial body of research elucidating the progressive escalation of the Earth's mean surface temperature as a direct consequence of anthropogenic actions, predominantly the release of greenhouse gases [4].

The complex relationship between the Earth's climate and human activity has been a subject of great interest for scientists, policymakers, and society. Throughout the course of several decades, the dialogue pertaining to climate change has been mostly centered around the foreboding concept of global warming, an undeniable outcome resulting from human activities that release greenhouse gases into the atmosphere [4]. Nevertheless, as humanity navigates through the unexplored realms of the 21st century, a novel and ominous occurrence has emerged, exerting its influence on our shared awareness—the epoch of global warming. The phenomenon serves as evidence of the more rapid rate at which climate patterns are changing, beyond the traditional understanding of gradual warming. The issue of global warming continues to be a prominent worry, and it is now accompanied by an imminent and urgent threat—a future marked by unprecedented and intense heat events [5].

The shift from global warming to global boiling represents a period in which the Earth experiences not only an increase in average temperatures but also a heightened occurrence and severity of heatwaves that pose significant challenges to our ecosystems, society, and economy. In the contemporary period, there is a recurring pattern of temperature records being consistently broken, rendering heatwaves no longer exceptional occurrences. Consequently, the persistent presence of intense heat significantly influences our lives in profound manners. As the scientific community strives to understand the complex mechanisms driving this transition, it is crucial to grasp the diverse variables contributing to the phenomenon known as global warming. The inexorable increase in greenhouse gas emissions and the various feedback processes operating inside the Earth's climate system both play significant roles in shaping the complicated fabric of this imminent phenomenon. Examining these variables, their interconnections, and the resulting consequences constitutes a significant intellectual pursuit, which leads us to a comprehensive comprehension of the epoch characterized by global warming.

Recent climate data elucidate a disconcerting pattern—a progressive intensification in instances of extreme heat phenomena that surpass the hitherto-perceived norm within the purview of the overarching phenomenon of global warming [6]. The frequency, intensity, and geographic extent of heatwaves have exhibited an observable increase, as documented by Mora et al. [7]. The phenomenon commonly referred to as "global boiling" has surfaced as a conceptual framework to elucidate the escalating intensification of thermal conditions, thereby signifying the propensity for temperature extremes to attain magnitudes that exert substantial perturbations upon both ecological systems and human societies. In the month of July in the year 2023, an unprecedented level of heat was observed, surpassing all the previously recorded climatic data [8]. This occurrence is highly probable to have exceeded temperature records spanning a significant timeframe of approximately 120,000 years [8]. These extreme weather phenomena have not merely surpassed previous records but have done so by a substantial margin, exceeding them by several degrees [8]. In the elevated regions of the Andes, the transition from the winter season to an intensely scorching summer is observed. Based on the ERA5 data procured from the European Union-funded Copernicus Climate Change Service (C3S), it has been observed that the initial three weeks of July have exhibited the highest temperatures ever recorded within a three-week timeframe. Furthermore, the ongoing month is currently poised to surpass all previous records, both for the warmest July and the warmest month overall. The temperatures have been correlated with the occurrence of heatwaves in substantial regions of North America, Asia, and Europe. These heatwaves, in conjunction with the outbreak of wildfires in nations such as Canada and Greece, have exerted significant ramifications on the well-being of individuals, the natural surroundings, and economic systems [8]. The global mean temperature experienced a temporary surpassing of the 1.5°C threshold above the preindustrial level, occurring specifically during the initial and subsequent week of the month, albeit within the confines of the observational error [8]. Since the month of May, there has been a notable elevation in the global mean sea surface temperature, surpassing historical records for this period [8]. This anomalous increase has played an important role in the occurrence of an exceptionally warm July [8].

The transition from global warming to global boiling signifies a novel domain within the realm of climate science, necessitating a comprehensive comprehension of the intricate mechanisms that propel this metamorphosis. While the phenomenon of global warming primarily centers around the gradual rise in temperatures, the concept of global boiling elicits apprehension due to its potential for sudden and catastrophic temperature surges, which may have far-reaching consequences on various aspects such as agriculture, biodiversity, water resources, and human well-being. The notion of global warming has emerged as a pivotal subject within the realm of climate discourse over the course of several decades [9]. Nevertheless, current empirical data and future projections indicate an impending phase of heightened intensity characterized by the occurrence of extreme heat events. This article presents the concept of the epoch of global boiling and explains its significance in the context of climate change. The evidence of change towards extreme heat was presented as part of results from global climate model simulations based on the Max Planck Institute for Meteorology Earth System Model, specifically version 1.2 (MPI-ESM1.2), including surface temperature and the heat index, while the main factors driving global boiling, such as CO_2 emissions, urban expansion, and deforestation, were presented in the following section. In the final session, worldwide collaboration was considered to deal with the global boiling. We did a literature search using two databases, Web of Science and SCOPUS, to explicate the viewpoint on global boiling and extreme heat issues. For each search phrase, the title, abstract, and keyword of a particular string were thoroughly examined. The search terms used were "extreme heat," "global warming," and "temperature increase." The selection of the pertinent literature from the past decades was based on the sufficiency of data quantity and access to full text.

2. Evidence of Change: the Shift towards Extreme Heat

The discernible shift from global warming to global boiling is becoming increasingly apparent within the realm of scientific discourse as an expanding corpus of research literature underscores the projection of extreme heat occurrences. In previous studies, a plethora of scholarly investigations have extensively documented the projection of global temperatures throughout the preceding century, thereby elucidating the prevailing phenomenon of global warming [10]. Gupta [11]'s study findings highlighted the rapid increase in the occurrence of extraordinarily high temperatures, providing the first signals of the shift to a heightened heat regime. Heatwaves, which can be characterized as extended durations of abnormally elevated temperatures, have emerged as a central area of investigation in the evaluation of evolving climate dynamics [11]. Mukherjee et al. [12] accomplished a study that presented persuasive data demonstrating a noticeable increase in the frequency of heatwaves across various geographical regions. The escalation was attributed to the influence of human activities on the climate system. The study conducted by Perkins et al. [13] provided additional clarification regarding the connection between increasing levels of greenhouse gases and the augmentation of heatwave severity. Heatwaves, which can be characterized as protracted durations of abnormally risen temperatures, have exhibited an escalating frequency and heightened intensity within the past few years. The research undertaken by Arnell et al. [14] yielded empirical findings that lend credence to the proposition positing a significant escalation in the occurrence of extreme temperature anomalies. Conspicuously, an observable increase has been reported in the probability of European summers encountering exceptionally elevated temperatures, a phenomenon that has demonstrated a twofold escalation since the latter portion of the 20th century [14]. The amplification of heatwaves provides an opportunity to emphasize the evolving climate trends that are progressively prone to increased occurrences of extreme temperature circumstances [14]. The spatial and temporal patterns of extreme heat events provide additional evidence for the ongoing transition towards a state of global boiling.

Previous studies provided the basis for comprehending the current climate changes, particularly the transition from global warming to a heightened situation. Building upon the current state of knowledge, the recent findings derived from the Intergovernmental Panel on Climate Change's Sixth Assessment Report (AR6) serve as crucial updates and projections, as depicted in Figures 1 and 2. These findings further emphasize the urgent need to address the ongoing climate crisis. The result of the global climate model simulation was obtained from the Copernicus Climate Data Store (https://cds.climate.copernicus.eu/), as shown in Figure 1. It depicts the temporal trends of annual global surface temperature over the period of 1990–2100, as simulated by the Max Planck Institute for Meteorology Earth System Model, specifically version 1.2 (MPI-ESM1.2). These simulations were conducted as part of the shared socioeconomic pathway (SSP) scenarios, which are a set of plausible future socioeconomic conditions. The MPI-ESM1.2 model is one of the models participating in the Coupled Model Intercomparison Project Phase 6 (CMIP6), which is a collaborative effort to compare and evaluate climate models. The references for this information are Mauritsen et al. [15] and O'Neill et al. [16] for the MPI-ESM1.2 model and Eyring et al. [17] for the CMIP6 project. Within the framework of CMIP6, an assemblage of scenarios referred to as the shared socioeconomic pathways (SSPs) has been formulated with the objective of encompassing a wide spectrum of plausible socioeconomic trajectories [18]. The employed models have consistently implemented a spectral truncation technique, resulting in an approximate horizontal resolution equivalent to a grid spacing of 200 kilometers. In accordance with the CMIP6 experiment, a comparative analysis of the surface temperature reveals similar patterns when juxtaposed with the historical period spanning from 1990 to 2014. This observation holds true across multiple scenarios, namely, SSP1–2.6, SSP2–4.5, SSP3–7.0, and SSP5–8.5. The elucidation of each individual scenario was formally stipulated within the confines of Table 1. Following the historical period, it is observed that the trend of surface temperature exhibits a general inclination towards an upward trend across most continents, encompassing various climate scenarios. In the Asian region, it is projected that the surface temperature will experience an increment of 0.63°C, 1.03°C, 1.36°C, and 1.63°C corresponding to the scenarios SSP1–2.6, SSP2–4.5, SSP3–7.0, and SSP5–8.5, respectively. In the European region, it is projected that the surface temperature will experience increments of 0.41°C, 0.75°C, 1.29°C, and 1.61°C corresponding to the scenarios SSP1–2.6, SSP2–4.5, SSP3–7.0, and SSP5–8.5, respectively. In the African region, it is projected that the surface temperature will experience an increase of 0.97°C, 1.33°C, 1.61°C, and 1.81°C under the scenarios of SSP1–2.6, SSP2–4.5, SSP3–7.0, and SSP5–8.5, respectively. In the North American region, it is projected that the surface temperature will experience an increment of 0.76°C, 1.25°C, 1.67°C, and 1.98°C under the scenarios of SSP1–2.6, SSP2–4.5, SSP3–7.0, and SSP5–8.5, correspondingly. In the South American region, it is projected that the surface temperature will experience an increase of 0.50°C, 0.83°C, 1.15°C, and 1.31°C under the scenarios of SSP1–2.6, SSP2–4.5, SSP3–7.0, and SSP5–8.5, respectively. In a comprehensive perspective, the surface temperature demonstrates analogous patterns across the diverse scenarios until the midpoint of the century (specifically, the years 2040 to 2050), after which divergences become apparent until the conclusion of the century. Significantly, it is worth mentioning that the SSP5–8.5 and SSP3–7.0 scenarios exhibit the most pronounced impact, leading to an increase in surface temperature, with the most substantial alteration observed in North America, amounting to 1.67°C and 1.98°C for the SSP3–7.0 and SSP5–8.5 scenarios, respectively. These findings are consistent with the results of a previous study. For example, Ruosteenoja and Jylhä [19] conducted an analysis of data from many models to ascertain the likelihood of intense heatwaves in Europe across four different warming levels. Their work provides reliable probability for the occurrence of such heatwaves. According to their suggestion, it is estimated that the yearly count of heatwave days will grow significantly in northern Europe, by three to four times, and in southern Europe, by more than six times, when comparing the 2.0°C global warming level to the 0.5°C level. The annual heatwave extreme index, a metric used to quantify the intensity of heatwaves, experiences an approximate fourfold increase in the northern region and a tenfold increase in the southern region.

The exacerbation of extreme heat events has the potential to initiate feedback mechanisms that subsequently enhance the escalation of temperatures. The research conducted by Li et al. [20] brought attention to the inherent capacity of soil moisture-temperature interactions to engender localized areas of heightened temperature and protracted durations of heatwaves. The mechanisms possess the capacity to engender self-perpetuating cycles, thereby intensifying the predicaments presented by global warming. The escalation of extreme heat occurrences carries significant ramifications for human well-being, particularly among susceptible demographics who encounter amplified vulnerabilities. The research conducted by Green et al. [21] has provided evidence of an upward trend in the occurrence of heat-related

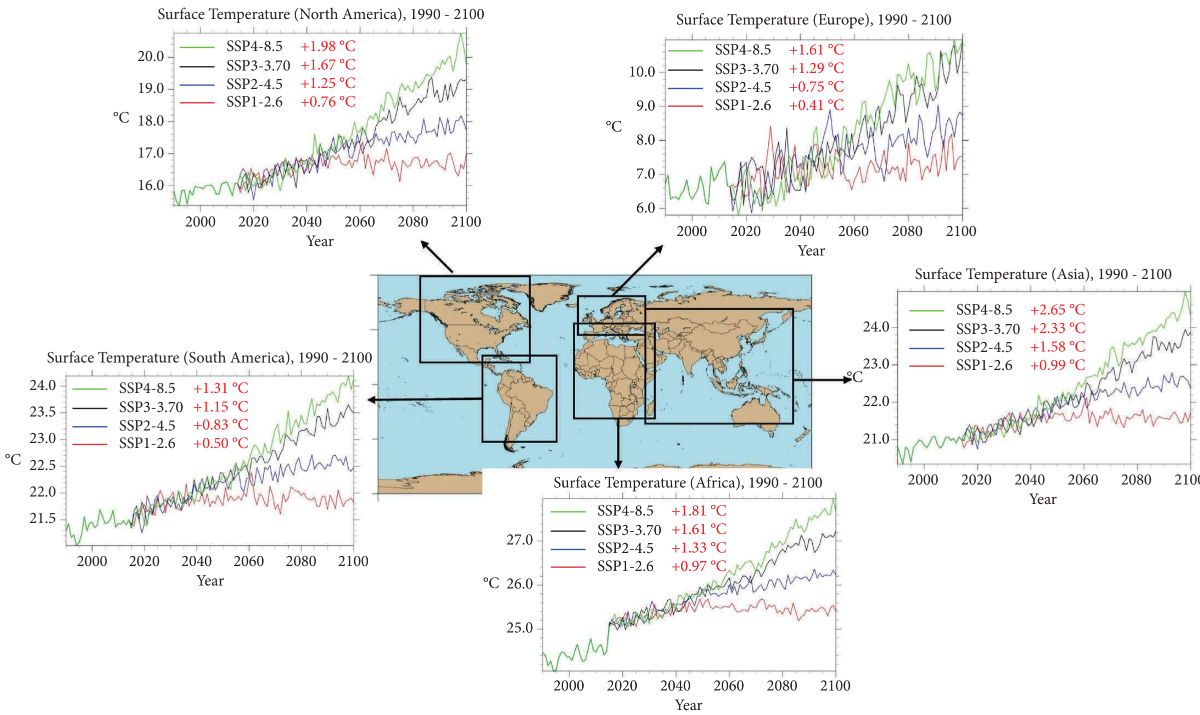

Figure 1: Annual total projections of global surface temperature in five continents including Asia, Europe, Africa, North America, and South America for the four CMIP6 SSP pathways over the period 1990–2100 from MPI-ESM-1.2-LR.

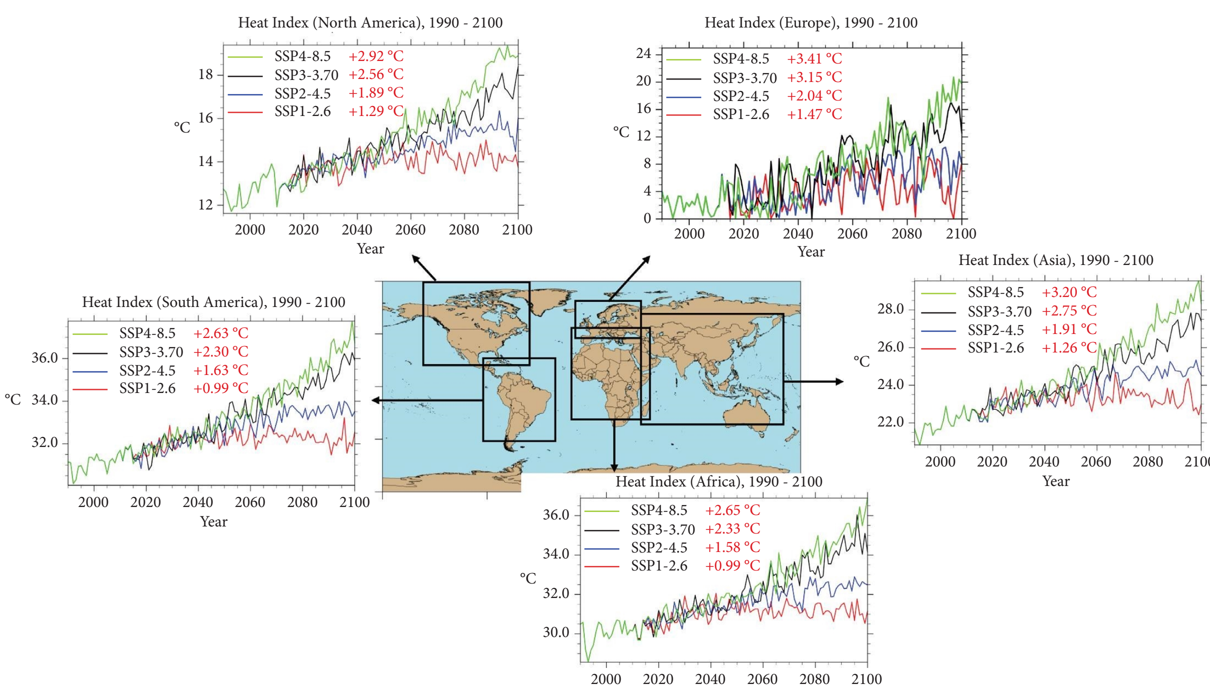

Figure 2: Annual total projections of the global heat index in five continents including Asia, Europe, Africa, North America, and South America for the four CMIP6 SSP pathways over the period 1990–2100 from MPI-ESM-1.2-LR.

mortality and morbidity. This phenomenon is particularly pronounced in urban regions, where the urban heat island effect serves to amplify the issue at hand. Furthermore, the scholarly work conducted by Davis and Gertler [22] shed light on the possibility of encountering unparalleled levels of heat stress, which could have significant implications on both labor productivity and economic performance. The ecological systems are experiencing the repercussions of the global warming phenomenon. Recent scholarly investigations have elucidated alterations in plant phenology,

Table 1: Definition of shared socioeconomic pathways (SSPs).

SSPs	Definition
SSP1–2.6	Global CO_2 emissions are being drastically decreased but at a slower rate. After the year 2050, the goal of zero emissions is reached. According to this scenario, the temperature rise will stabilize at roughly 1.8°C by the end of the century
SSP2–4.5	CO_2 emissions will remain at current levels until midcentury, when they will begin to fall. Socioeconomic elements continue to follow their historical patterns with no noticeable change. Slow progress towards sustainability is being made, with disparities in development and income growth. Temperatures will climb by 2.7°C by the end of the century under this scenario
SSP3–7.0	Greenhouse gas emissions and temperatures continue to rise, with CO_2 emissions nearly tripling from current levels by the year 2100. Countries grow more competitive with one another, stressing national and food security issues. Temperatures had risen by 3.6°C at the end of the century
SSP5–8.5	This is the "worst-case scenario". CO_2 emissions are expected to nearly treble by the year 2050. The global economy is expanding rapidly, but this expansion is being powered by the extraction of fossil fuels and the adoption of energy-intensive lifestyles. By the year 2100, the average global temperature will have risen by a disastrous 4.4°C

species distribution, and ecosystem structure consequent to episodes of heightened thermal intensity [23]. The findings serve to underscore the inherent susceptibility of ecosystems to swift fluctuations in temperature, which may ultimately result in perturbations within the realm of biodiversity and the provision of ecosystem services. A recent study conducted by Amnuaylojaroen et al. [24] in mainland Southeast Asia reveals that climate change is anticipated to result in a rise in heat stress ranging from 0.1°C to 4°C under the worst-case climate scenario RCP8.5. In addition, it is projected to cause a decline in job performance ranging from 4% to over 10% across mainland Southeast Asia in the near future. According to a study conducted by Vargas Zeppetello et al. [25], it was shown that the likelihood of experiencing elevated heat index values is projected to rise by 50–100% in a significant portion of tropical regions and by a factor of 3–10 in numerous midlatitude areas. Figure 2 illustrates the heat index results across several climate scenarios as presented in the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 6 (AR6). It displays the heat index (HI) projections derived from multiple climate scenarios, which were generated using the MPI-ESM1.2 simulation. Table 2 presents the health impact-based classifications of HI values.

According to projections, the heat index in the Asian region is expected to increase by 1.26°C, 1.91°C, 2.75°C, and 3.20°C under the scenarios SSP1–2.6, SSP2–4.5, SSP3–7.0, and SSP5–8.5, respectively. Within the European region, it is anticipated that the surface temperature will undergo increases of 1.47°C, 2.04°C, 3.15°C, and 3.41°C, aligning with the scenarios SSP1–2.6, SSP2–4.5, SSP3–7.0, and SSP5–8.5, respectively. According to projections, the African region is expected to undergo surface temperature increases of 0.99°C, 1.58°C, 2.33°C, and 2.65°C under the scenarios of SSP1–2.6, SSP2–4.5, SSP3–7.0, and SSP5–8.5, respectively. In the North American region, it is anticipated that the surface temperature will increase by 1.29°C, 1.89°C, 2.56°C, and 2.92°C under the scenarios of SSP1–2.6, SSP2–4.5, SSP3–7.0, and SSP5–8.5, respectively. According to projections, the surface temperature in the South American region is expected to rise by 0.99°C, 1.63°C, 2.30°C, and 2.63°C under the scenarios of SSP1–2.6, SSP2–4.5, SSP3–7.0, and SSP5–8.5, respectively. The future heat index exhibits a comparable pattern to surface temperature, displaying analogous trends across many scenarios until the middle of the century (particularly, between the year 2040 and 2050). However, divergences become evident thereafter until the end of the century.

The evidence supplied demonstrates a significant correlation between surface temperature and the heat index (HI) across different scenarios and geographical areas. The anticipated rise in surface temperatures resulting from climate change across various shared socioeconomic pathways (SSPs) is expected to have a consequential impact on the heat index, a measure that combines temperature and relative humidity. In general, there is a notable and constant upward trend observed in both surface temperature and the heat index until about the middle of the century (between the years 2040 and 2050) across various scenarios. This suggests that with the increase in global temperatures, the combined influence of temperature and humidity will result in elevated heat index levels. Nevertheless, subsequent to this inflection point, disparities become discernible, suggesting that the rate of fluctuation in the heat index can differ among various shared socioeconomic pathway (SSP) scenarios and geographical areas. According to the projection, the SSP5–8.5 and SSP3–7.0 scenarios are anticipated to result in the most significant rises in surface temperature and the heat index. The correlation between the critical upward trend in surface temperature and the concurrent elevation of the heat index carries substantial consequences for the dangers associated with heat, such as heat-related illnesses and their effects on human health and overall welfare.

3. Factors Driving Global Boiling

The data pertaining to the factors influencing global warming, such as carbon dioxide (CO_2) emissions, forest area, and population, were acquired through a data of Our

Table 2: The present study examines the impacts of the heat index, as derived from the heat index data provided by the Pueblo, CO, the United States National Weather Service website.

Temperature ranges	Notes
27–32°C	Caution: fatigue is possible with prolonged exposure and activity. Continuing activity could result in heat cramps
32–41°C	Extreme caution: heat cramps and heat exhaustion are possible. Continuing activity could result in heat stroke
41–54°C	Danger: heat cramps and heat exhaustion are likely; heat stroke is probable with continued activity
>54°C	Extreme danger: heat stroke is imminent

World in Data (https://ourworldindata.org/). The raw data of forest area, population, and CO_2 emission were based on Food and Agriculture Organization of the United Nations (UN) and UN Urbanization Prospects.

The transition from the phenomenon of global warming to global boiling is not a fortuitous event but rather a result of a multifaceted interplay between natural and anthropogenic factors. The rise in atmospheric greenhouse gas concentrations can be attributed primarily to anthropogenic activities, with the burning of fossil fuels being a prominent contributor [26]. The phenomena of global warming are commonly attributed to the elevated concentration of atmospheric CO_2, as extensively discussed by Yoro and Daramola [27]. The Intergovernmental Panel on Climate Change (IPCC) has said that the rise in average global temperatures since the mid-20th century is highly probable to be a result of the escalation in human-caused greenhouse gas emissions. This increase in emissions has led to the warming of the Earth's surface and lower atmosphere [28]. In addition, the study undertaken by Matthews and Wynes [29] provided a clear understanding of the indisputable correlation between cumulative carbon dioxide (CO_2) emissions and the anticipated rise in world temperatures. Figure 3 illustrates the temporal shift in global emissions, beginning in the middle of the 18th century and extending up to the year 2021. It is evident that emissions during the period preceding the Industrial Revolution were characterized by a significant degree of minimalism. The rate of emissions growth remained very modest until the middle of the 20th century. In the year 1950, the global emissions of carbon dioxide (CO_2) amounted to a total of 6 billion metric tonnes. By the year 1990, the aforementioned quantity had experienced an almost fourfold increase, surpassing a total of 22 billion tonnes. The rate of emissions has shown significant growth, with the current annual emission level exceeding 34 billion tonnes. The rate of emissions rise has exhibited a deceleration in recent years; nonetheless, it has not yet attained its maximum level. It is evident that over a significant portion of the 20th century, Europe and the United States held a prominent position in terms of global emissions. By the year 1900, the majority of emissions, over 90%, were generated inside the geographical boundaries of Europe or the United States. This trend persisted until the year 1950, wherein these regions continued to contribute more than 85% of the total emissions on an annual basis. However, over the past few decades, there has been a substantial shift in this regard. During the latter half of the 20th century, there was a notable increase in emissions observed in various regions worldwide, with a special emphasis on Asia and, more prominently, China. Currently, the United States and Europe collectively contribute to little less than 33% of global emissions. The results presented in this study is consistent with previous studies conducted by Ponce de Leon Barido and Marchall [31], who employed statistical modeling techniques to investigate panel data on annual CO_2 emissions from 80 nations spanning the years 1983–2005. According to their findings, several regions exhibit a statistically significant and positive elasticity in both fixed-effects and random-effects models. These regions include lower-income Europe, India and the subcontinent, Latin America, and Africa. The data further support previous research, indicating that urbanization plays a significant role in determining greenhouse gas (GHG) emissions in both developed and developing countries [26, 32]. The increase in CO_2 emissions is expected to contribute to the acceleration of global warming, perhaps leading to serious levels of heat in the future.

In the context of environmental dynamics, it is important to acknowledge the significant influence exerted by land use changes, specifically deforestation and urban expansion, on the modification of regional and local climate patterns. Lawrence and Vandecar [33] have demonstrated a correlation between deforestation and climate change. According to their findings, the complete deforestation of tropical regions results in a rise in global average temperatures, while global average precipitation remains unaffected. The range of projected global warming spans from 0.1°C to 0.7°C, as reported by Jiang et al. [34]. Hence, the deforestation of tropical regions would potentially result in a twofold increase in the observed warming. According to the United Nations, deforestation rates have exhibited a decline since the 1990s within the context of deforestation. Nonetheless, the period spanning from the 1990s to the 2000s exhibited minimal advancements, with a projected decline of approximately 26% in rates throughout the 2010s. In the year 2022, the Food and Agriculture Organization (FAO) released an independent evaluation utilizing remote sensing techniques. This evaluation did not include data pertaining to the 1990s, but it did provide an estimation of a 29% decline in deforestation rates between the early 2000s and 2010s. This is a notable advancement, but there is a pressing need for a much-accelerated pace of progress. Significant quantities of primary forests continue to be lost annually on a global scale. To provide a contextual

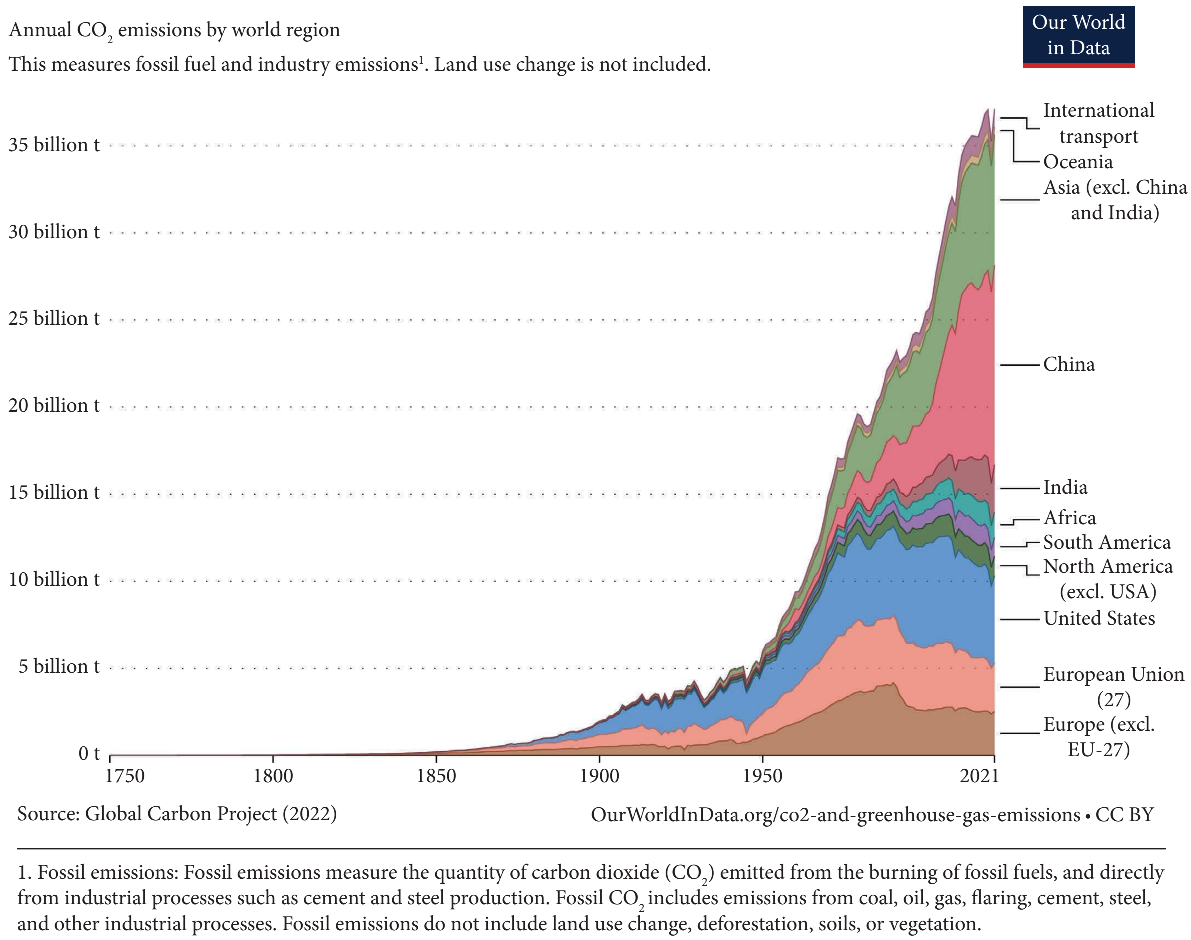

Figure 3: Annual CO_2 emission from different regions during 1750–2021 [30].

framework for these numerical figures, it is noteworthy to highlight that over the course of the 1990s and the initial decade of the 2000s, a landmass comparable in magnitude to that of India underwent deforestation. According to the data of the Food and Agriculture Organization (FAO) in the year 2020 via Our World in Data in Figure 4, there has been an annual net loss of 4.7 million hectares of forests worldwide during the span of a decade starting from 2010. Nevertheless, the rates of deforestation exhibited a considerably greater magnitude. According to the United Nations Food and Agriculture Organization (FAO), an estimated annual deforestation rate of 10 million hectares of forest has been reported.

Urban areas, renowned for their manifestation of the urban heat island phenomenon, undergo elevated temperatures because of diminished vegetation coverage and amplified heat absorption [36]. The research conducted by Chakraborty et al. [37] shed light on the considerable extent of temperature disparities between urban and rural areas, as well as the consequential ramifications for heat-related consequences. The phenomenon of urban development has been found to elicit a localized warming effect, in conjunction with the broader issue of climate change, as demonstrated by Krayenhoff et al. [38]. The process of transforming underdeveloped land into urban expansion has been observed to induce localized warming phenomena through the modification of biophysical characteristics of the land surface [39]. This localized warming effect is an additional contributor to the broader nonlocal warming caused by greenhouse gas emissions, as noted by Krayenhoff et al. [38]. The phenomenon of urban warming and adaptation cooling is subject to significant meteorological influences, such as wind patterns, cloud cover, and precipitation [40]. Consequently, these effects exhibit notable regional, seasonal, and annual variations [41]. According to estimates of urban and rural populations based on 2018 data, the global population is estimated to be 7.6 billion people, with 4.2 billion living in urban areas and 3.4 billion living in rural areas in the year 2050 [42, 43]. As of the year 2018, the global population is estimated to be approximately 7.6 billion individuals, with 4.2 billion residing in urban regions and 3.4 billion residing in rural areas [43]. According to projections, the global population is expected to reach approximately 9.8 billion by the year 2050 [43]. Meanwhile, the global urban population is projected to exceed the rural population by more than twofold, with around 6.7 billion individuals residing in urban areas compared to 3.1 billion individuals in rural areas [43]. It is estimated that by the year 2050, most countries will see a demographic shift where more than 50% of their populations will reside in urban areas [43].

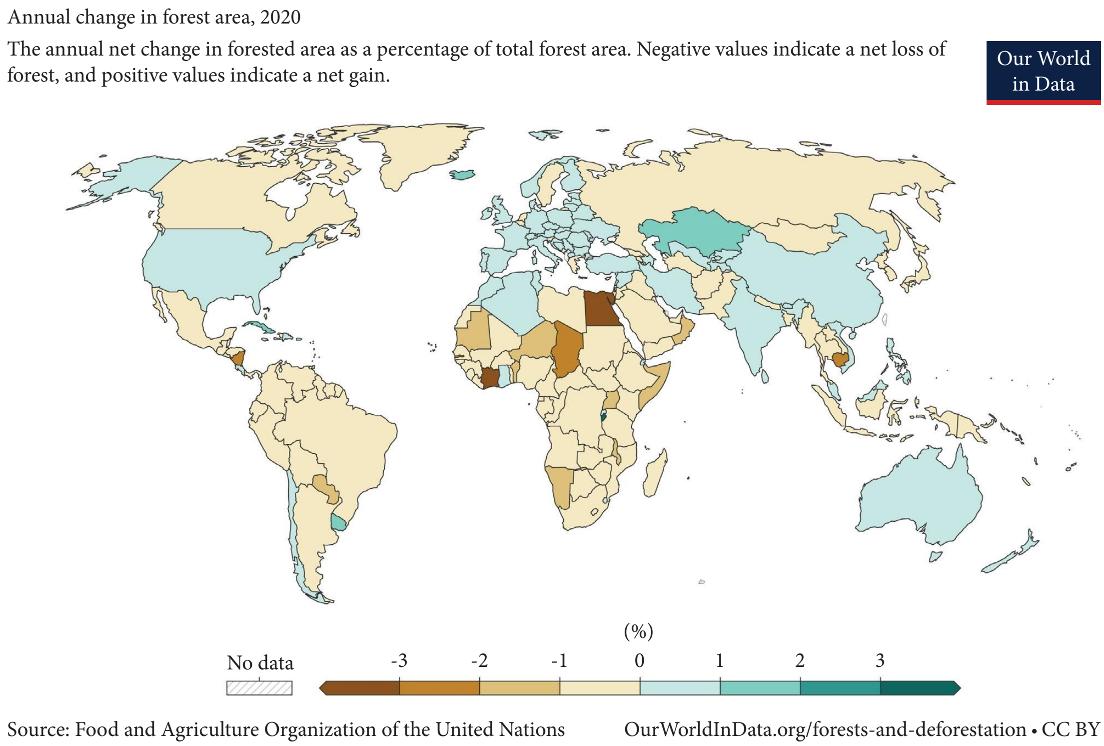

Figure 4: Annual global change in forest in 2020 compared to 2010 [35].

In theory, the intricate interplay between the Earth's oceans and the atmospheric system serves as a significant factor in the modulation of climatic patterns [44]. Dewitte et al. carried out a study that illustrates the impact of changes in sea surface temperatures and ocean currents on the complicated dynamics of atmospheric circulation. These alterations have the ability to produce long-lasting high-pressure systems, which in turn play an important role in the emergence of heatwaves [45]. Positive feedback mechanisms, exemplified by the diminution of surface albedo as a consequence of ice melting, have the potential to intensify temperature amplifications [46]. Furthermore, it is important to note that aerosols, encompassing both natural and anthropogenic sources, exert a significant impact on the Earth's radiative equilibrium through their ability to scatter and absorb solar radiation [47]. The potential of aerosols to induce a cooling effect through the process of sunlight reflection is contingent upon their specific composition and spatial dispersion, as outlined by the Intergovernmental Panel on Climate Change in 2013. The research conducted by Wang et al. [48] brought attention to the possibility of regional aerosol impacts exacerbating heatwaves in specific geographical locations. Furthermore, alterations in soil moisture levels and the occurrence of drought conditions have the potential to enhance the intensity of extreme heat events [49]. The diminishment of evapotranspiration caused by drought conditions results in a decline in the cooling capacity of vegetation, thereby engendering elevated surface temperatures [50]. The study conducted by Chiang et al. [51] revealed a robust association between heatwaves and the intensity of drought across diverse geographical areas.

The shift from global warming to global boiling is a result of various factors, including the rapid and exponential rise in greenhouse gas emissions, particularly carbon dioxide (CO_2), primarily caused by human activity, particularly fossil fuel combustion [52]. This has led to the warming of the Earth's surface and lower atmosphere, making global warming a significant worldwide issue [52]. The analysis of historical data reveals a notable surge in carbon dioxide (CO_2) emissions, specifically observed during the mid-20th century, resulting in an accumulation of more than 22 billion tonnes by the year 1990 [53]. Currently, the annual emissions have exceeded 34 billion tonnes, but there has been a decline in the rate of growth [53]. The spatial distribution of emissions sources has also changed, with Europe and the United States being primary producers of global emissions [54]. However, in recent decades, there has been a significant increase in emissions from Asia, particularly China [54]. Currently, the combined emissions from the United States and Europe account for less than 33% of world emissions, indicating a notable relocation of the primary sources of emissions [54]. Urbanization, a prominent characteristic of human progress, serves as an additional catalyst for exacerbating global warming [55]. Urban regions exhibit the urban heat island effect, where temperatures are enhanced due to diminished vegetation and heightened heat absorption [55]. Deforestation, arising from land utilization changes, has significant implications for climate trends, potentially doubling global mean temperatures [56]. Although some reductions in deforestation rates have been made, the ongoing loss of primary forests underscores the need for intensified conservation efforts [56]. The estimated trajectory of urban population growth indicates a significant spike, leading to urban populations surpassing rural populations by a substantial margin by the year 2050 [57]. This process exacerbates localized warming patterns, contributing to the escalation of difficulties linked to increasing temperatures.

4. The Role of International Cooperation and Call to Action

The advent of the epoch characterized by worldwide thermal elevation highlights the imperative for a unified global endeavor aimed at mitigating the mounting complexities presented by episodes of heightened temperatures [58]. International cooperation assumes a paramount significance in the formulation and execution of efficacious strategies aimed at alleviating the repercussions of global boiling [59].

The resolution of global challenges necessitates the implementation of comprehensive global solutions [60]. The necessity to strengthen global collaboration is of utmost importance in order to promote the widespread sharing of information, transfer of technology, and provision of financial aid [61]. Nations must participate in collaborative research initiatives actively, facilitate the exchange of best practices, and collectively strive to solve the fundamental issues that contribute to the phenomena of global boiling [62]. The constant advocacy for stronger international climate agreements and obligations is of utmost importance for the global community [63]. The imperative to empower individuals via the acquisition of knowledge and to improve public awareness are essential components of the imperative to engage in proactive measures [63]. It is of the utmost importance that governments, educational institutions, and media outlets prioritize climate education and communication [63]. This is essential to foster a comprehensive understanding among citizens regarding the gravity of the global boiling phenomenon as well as to equip them with the necessary knowledge and tools to actively participate in mitigating its effects. The adoption of sustainable consumption patterns and lifestyle changes by individuals has the potential to yield substantial impacts [64]. The collective endeavor of reducing energy consumption, minimizing waste, and making environmentally conscious choices can effectively contribute to the mitigation of carbon emissions [65, 66]. Promoting conscientious consumption and production practices is imperative in the battle against global warming [66].

Investments in scientific inquiry, technological advancement, and innovative endeavors play a pivotal role in propelling our comprehension of the phenomenon of global boiling and formulating efficacious remedies [67]. It is crucial for government agencies, private sector entities, and philanthropic organizations to commit significant resources towards the facilitation of research efforts that effectively address the unique problems presented by extreme heat events [68]. The impact of global warming is primarily experienced by local populations [69]. Granting local leaders and communities the power to develop and implement specific adaptation and resilience strategies that cater to their specific needs is of utmost importance for governments [70]. In order to protect the contextual relevance and effectiveness of offered solutions, it is crucial to prioritize the promotion of community engagement and the facilitation of participatory decision-making processes [71].

International agreements and frameworks have played a pivotal role in effectively tackling the pressing global environmental issues, notably climate change [72]. The Paris Agreement, which was adopted in the year 2015, signifies a significant endeavor to foster global cooperation among nations in addressing the issue of climate change through the establishment of specific objectives pertaining to the reduction of greenhouse gas emissions [73]. The scholarly investigation conducted by Victor et al. [74] placed significant emphasis on the prospective efficacy of global climate accords in mitigating the escalation of temperatures and cultivating collaborative efforts. Effective international collaboration comprises not just policy agreements but also the transmission of exemplary practices, cutting-edge technologies, and vital knowledge [75]. Horstmann and Hein [76] argued that the acquisition of information and understanding obtained from the experiences of a specific location has considerable potential to provide valuable insights to other places facing similar issues. The establishment of the Climate Technology Centre and Network (CTCN) under the United Nations Framework Convention on Climate Change (UNFCCC) has successfully facilitated the transfer of technologies related to climate change and the improvement of capacity-building initiatives among nations [76].

Scientific inquiry and empirical evidence serve as the bedrock for comprehending and mitigating the ramifications of planetary boiling [77]. International collaborations facilitate the consolidation of resources and specialized knowledge, thereby fostering the production of comprehensive and precise evaluations [78]. The World Climate Research Programme (WCRP) endeavors to facilitate interdisciplinary investigations pertaining to the dynamics and ramifications of climate, thereby cultivating an extensive international consortium of scholars [79].

The allocation of financial aid from developed countries to developing ones assumes a crucial role in expediting the execution of climate change adaptation and mitigation initiatives [80]. The Green Climate Fund (GCF) has been established within the framework of the United Nations Framework Convention on Climate Change (UNFCCC) with the primary objective of offering financial aid to developing nations as they tackle the multifaceted and interrelated challenges stemming from climate change [81]. The study performed by Ciplet et al. [82] shed light on the importance of financial transfers in promoting reliability and enabling cooperation. The Conference of the Parties (COPs), a recurring event, serves as a forum for nations to convene and exchange information regarding advancements, reflect on encountered obstacles, and seek assistance for endeavors related to the issue of climate change [83].

5. Conclusion

The present stage of global warming is an indisputable and urgent actuality that necessitates prompt and enduring involvement from people, societies, governance, and international organizations. The escalating frequency and heightened intensity of extreme heat events necessitate a pressing imperative to mitigate their repercussions and adjust to evolving climatic patterns. The primary imperative necessitates significant decreases in greenhouse gas emissions. The imperative lies in the hands of the global community to assume the onus of ensuring that nations are held answerable for their commitments as stipulated in climate accords, all the while cultivating a milieu that is conducive to the formulation of ambitious objectives for the reduction of emissions. The deployment of adaptation techniques is critical in protecting vulnerable communities from the negative consequences of rising temperatures. In terms of urban planning, it is critical to prioritize the development and implementation of heat-resistant infrastructure, the establishment and preservation of green spaces, and the widespread use of cool roofs. Early warning systems, healthcare infrastructure, and public health actions have the ability to successfully mitigate the health risks associated with rising temperatures.

The transition from global warming to global boiling is a complex research area with numerous critical aspects that require further investigation. Researchers should focus on the attribution of high heat events, understanding the underlying causes and driving factors, and understanding climate-feedback mechanisms. They should also examine urban heat islands and their effects on climate patterns, explore effective approaches to alleviate urban heat, and examine ecosystem reactions to increased thermal intensity and shifting climate conditions. Understanding the health implications of extreme heat events and increasing temperatures is crucial, with a focus on communities susceptible to these effects. Continuous monitoring of global greenhouse gas emissions is also essential for evaluating progress in carbon footprint reduction and developing effective climate policy and mitigation strategies.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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