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Navigating the Nexus: Insights from the COVID-19 Pandemic for Climate Change Mitigation

Umamah M., Mufti A.[1], Kashif Ali[2], Sheeba Jilani[3], Farooqi I.[4], M.A. Khan[5], Pervaiz R. Khan[6] and R. Dhupper*

Amity Institute of Environmental Science, Amity University, Noida – 201313, India
[1]Department of Physiology, All India Institute of Medical Sciences, New Delhi – 110029, India
[2]Department of Physiology, Jamia Millia Islamia, New Delhi – 110025, India
[3]Department of Chemical Engineering, Aligarh Muslim University, Aligarh – 202002, India
[4]Department of Environmental Engineering, Aligarh Muslim University, Aligarh – 202002, India
[5]Department of Statistics and O.R., Aligarh Muslim University, Aligarh – 202002, India
[6]Biology Department, College of Natural & Computational Sciences, Adigrat University, Adigrat – 7040, Ethiopia
✉ dhupperrenu@gmail.com

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Abstract: This study explores the intricate interplay between global warming, climate change, the COVID-19 pandemic, air pollution, and climate change mitigation. Drawing on lessons learned from the pandemic, we delve into the complex web of environmental challenges and policy responses. The COVID-19 crisis has highlighted the importance of early and determined action, broad public support, equitable policies, global cooperation, and transparent decision-making. While short-term emissions reductions have been observed, addressing climate change requires sustained, transformative change on a global scale. Our analysis underscores the urgency of applying the pandemic's insights to combat climate change, recognising the interconnectedness of environmental, economic, and public health challenges.

Key words: Climate change, COVID-19 pandemic, global warming, air pollution, climate change mitigation.

Introduction

"Global Warming" and "Climate Change" are often used interchangeably but refer to distinct yet interconnected phenomena. Climate change encompasses a broader range of alterations in Earth's environmental conditions, including temperature, humidity, air pressure, wind patterns, cloud cover, and precipitation over an extended period. On the other hand, global warming relates explicitly to the impact of greenhouse gases on the planet's average surface temperature. The term "global warming" was initially coined by geochemist Wallace Broecker in his 1975 article titled "Climatic Change: Are We on the Brink of a Pronounced Global Warming?" published in Science magazine (Gale Cengage, 2018).

Figure 1 provides an overview of climate change and global warming immediately preceding and during the onset of the COVID-19 pandemic. The significance of even a slight increase, such as one degree Celsius, in global temperatures cannot be underestimated. It results in a cascade of adverse effects, including more frequent and severe heatwaves, wildfires, storms, droughts, rising sea levels, and disrupted ecosystems. These changes have far-reaching implications for various industries and economies worldwide. It is crucial to emphasise that

*Corresponding Author

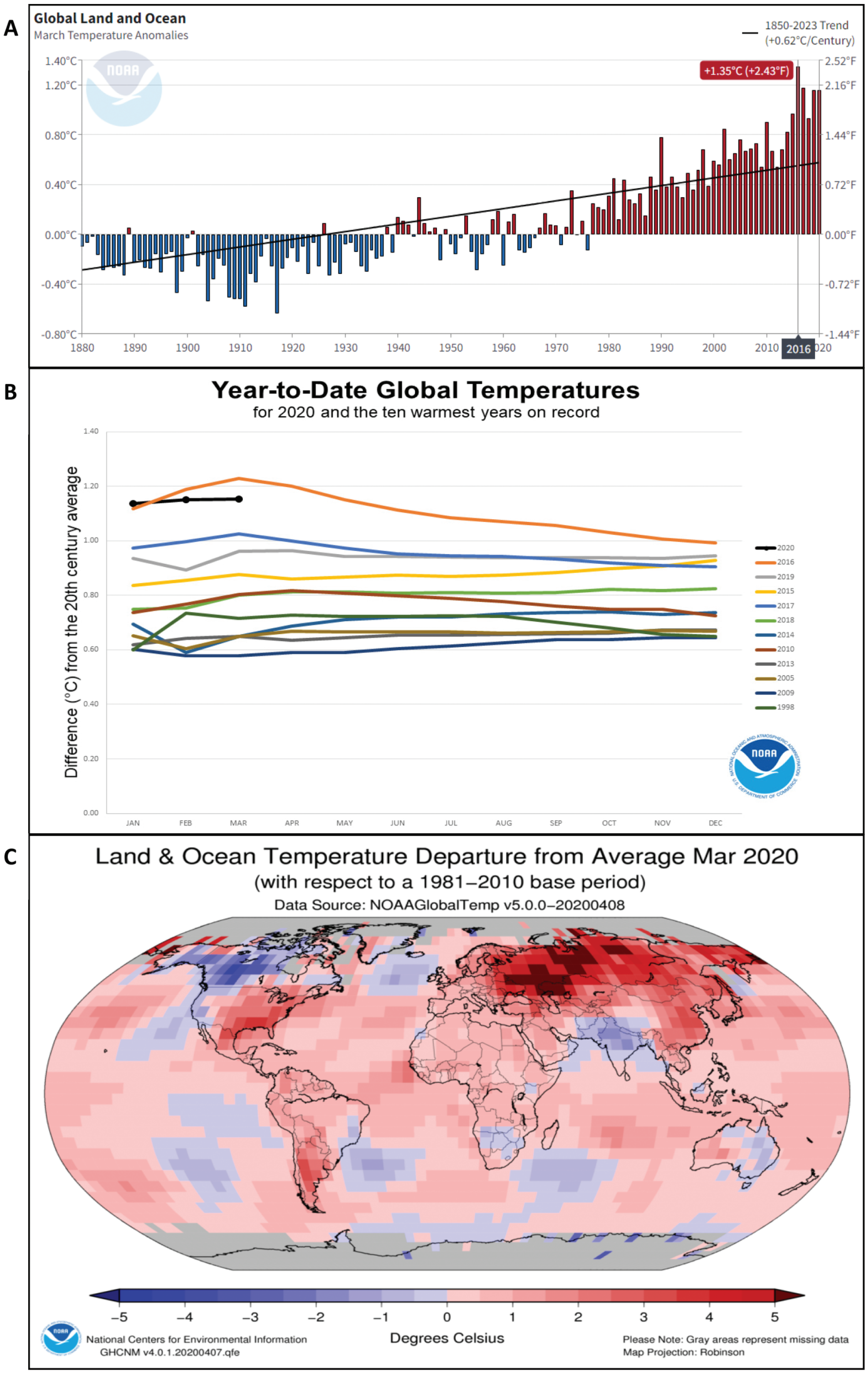

Figure 1: A – 2020, the hottest year: Increase in global temperature in 2020 (+0.97°C) vs 20th century average. From https://www.ncdc.noaa.gov/sotc/global/202003; B – Global 2020 Year-to-Date Temperature Anomalies-Global Climate Report for March 2020, published online April 2020, retrieved on August 2, 2020, from https://www.ncdc.noaa.gov/sotc/global/202003/supplemental/page-1; C – Earth's margin for error narrows after another year of record heat (2020 matched 2016 as the world's hottest year on record from Bloomberg.com).

every fraction of a degree matters, as demonstrated by the Paris Agreement of 2015, which set an ambitious global target to limit warming to 1.5°C, a reduction from the previous 2°C goal. Achieving this target could spare millions of people from extreme heatwaves and offer more time to adapt to shifting environmental conditions.

To monitor and analyse global temperature records, several reputable organisations play a pivotal role, including the National Oceanic and Atmospheric Administration (NOAA), NASA Goddard Institute of Space Studies, the U.K. Climate Research Unit, the Japanese Meteorological Agency, and Berkeley Earth (source: https://www.ncdc.noaa.gov/sotc/global/202003, Figure-1A). Figure 1A compares year-to-date temperature anomalies for 2020 with the ten warmest years. Notably, January to March 2020 recorded an average global land and ocean surface temperature of 1.15°C (2.07°F) above the 20th-century average, marking the second-highest temperature in recorded history (Global Climate Report, 2020; Figure 1B).

This study also identifies a significant shift in growth-climate responses over the past four to five decades, indicating the impact of ongoing climate change on juniper growth (Aref et al., 2014, 2016). The anticipated rise in temperature and declining rainfall in the coming decades is expected to elevate further the risk of altitudinal range shifts for *J. procera*. The Intergovernmental Panel for Climate Change (IPCC, 2014) forecasts a temperature increase between 1.4°C and 5.8°C by the end of the century, with a more pronounced impact on the Asian continent, including a change of +0.13°C per decade (National Centers for Environmental Information, 2017). Global data suggest a potential 2 to 3°C increase in average annual temperatures for mountain environments by 2055 (Nogues-Baravo et al., 2007). This study aims to examine the complex interrelationships between global warming, climate change, the COVID-19 pandemic, air pollution, and climate change mitigation. Drawing lessons from the pandemic, the study aims to elucidate the critical policy insights and challenges of addressing these global environmental and public health issues. Ultimately, the research seeks to guide future climate change mitigation efforts by leveraging the experiences and responses observed during the COVID-19 crisis.

COVID-19, Air Pollution, and Climate Change

Recent research has unveiled a complex interplay between air pollutants, infectious respiratory diseases, and COVID-19 (Cai et al., 2007; Domingo et al., 2020; Horne et al., 2018). Air pollution has been identified as a contributing factor that can increase susceptibility to COVID-19, possibly due to enhanced expression of enzyme ACE-2 in respiratory cells exposed to pollutants (Brook et al., 2020; Paital & Agrawal, 2020; Pope et al., 2004, 2020). The rapid global spread of COVID-19, which emerged in China, has been categorized into two modes: direct transmission through aerosols and droplets in the air and indirect transmission via contaminated surfaces in the immediate environment of infected individuals (Eslami & Jalili, 2020; Karia et al., 2020).

Notably, the COVID-19 lockdowns implemented in 2020 had both positive and negative impacts on the environment and energy consumption. However, the root causes of climate change are closely linked to factors such as temperature, wind speed, and humidity, which can also influence the prevalence of pandemics (Islam et al., 2020; Mousazadeh et al., 2021; Tan et al., 2005; Xie & Zhu, 2020). Recent studies have explored the multifaceted relationship between COVID-19, air pollution, and climate change, focussing on mental health and the influence of air quality on COVID-19 mortality (Ali & Islam, 2020; Marazziti et al., 2021). Amnuaylojaroen and Parasin (2021) have highlighted the positive and negative aspects of the complex relationship between COVID-19, air pollution, and climate change.

Relationship Between COVID-19 and Climate Change

The connection between COVID-19 and climate change is intricate, with the COVID-19 pandemic being relatively recent (emerging in 2019) while climate change is a long-term phenomenon. This inherent disparity in timelines has limited our ability to establish transparent cause-and-effect relationships between the two due to data scarcity and the short duration of the pandemic (Amnuaylojaroen, 2021). However, research by Rodo et al. (2021) suggests that absolute humidity (AH) and temperature are linked to influenza outbreaks, influencing epidemic progression. In tropical regions, SARS-CoV-2 exhibits higher airborne survival and transmission rates than influenza viruses. Temperature variations exceeding 30°C have been identified as a primary factor inhibiting aerosol transmission in the case of influenza, with limited direct effects on global temperatures by 2030 resulting from pandemic-induced reductions in human mobility (Forster et al., 2020). This concept aligns with the "anthropause," highlighting reduced human impact on wildlife during the pandemic (Rutz et al., 2020).

Meteorological factors, including temperature, relative humidity (RH), absolute humidity (AH), and wind speed (WS), have been scrutinized for potential correlations with COVID-19 transmission. Several studies have identified positive associations between temperature and daily COVID-19 cases in Thailand, Singapore, India, and China (Kumar & Kumar, 2020; Pani et al., 2020; Sangkham et al., 2021). Conversely, rising temperatures have inverse relationships with daily new COVID-19 cases in Brazil and Canada (To et al., 2021; Wu et al., 2020). Variables like relative humidity (%), absolute humidity (gm^{-3}), and wind speed (m/s) have shown mixed positive and negative correlations with COVID-19 cases in different countries, including Thailand and Turkey (Paital & Agrawal, 2020; Sahin, 2020; Wu et al., 2020). Lower relative humidity has been experimentally linked to increased transmission of influenza viruses (Gardner et al., 2019), and the stability of the SARS coronavirus at low moisture may contribute to its spread in subtropical climates (Chan et al., 2011).

In the case of air pollution, the relationship with COVID-19 is multifaceted, displaying positive and negative correlations (Amnuaylojaroen and Parasin, 2021, Figure 2). Several studies have reported an increased COVID-19 mortality rate associated with higher levels of air pollutants. However, COVID-19 lockdown measures have led to a reduction in air pollution levels. The relationship between specific contaminants, such as ozone (O_3) and nitrogen oxides (NOx), with COVID-19 is complex, with both positive and negative correlations reported in various regions (Lolli & Vivone, 2020; Sangkham et al., 2021; Zoran et al., 2020). The concentration of carbon monoxide (CO) and sulphur dioxide (SO_2) has shown both negative and positive correlations with COVID-19 cases, making it challenging to draw definitive conclusions (Zhu et al., 2020).

Long-term exposure to fine particulate matter (PM2.5) has been associated with increased cardiovascular mortality and hospital admissions (Cole et al., 2020; Wu et al., 2020). Several studies have revealed positive correlations between daily new COVID-19 cases and surface PM2.5 and PM10 concentrations (Zoran et al., 2020). COVID-19 lockdown measures have contributed to reductions in nitrogen dioxide (NO_2) and CO concentrations in various regions (Kumari and Toshniwal, 2020; Mostafa et al., 2021), further underscoring the complex interplay between air pollution and the pandemic.

COVID-19 and Climate Change Mitigation

The COVID-19 pandemic and climate change represent systemic risks to human prosperity, with significant externalities and challenges. Examining the successes

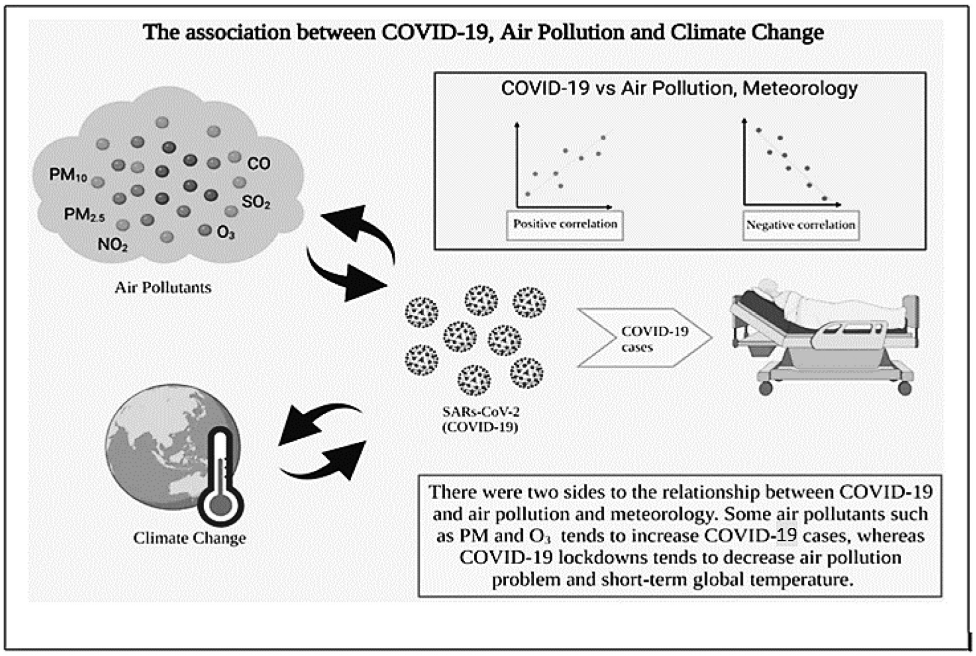

Figure 2: The association between COVID-19 and Air Pollution and Climate Change-created with BioRender.com (After Amnuaylojaroen and Parasin, Frontiers in Public Health, 2021, 9: 662499. Doi:10.3389/foubh.2021.662499).

and shortcomings of COVID-19 policy responses offers valuable insights for climate policy and progress. The COVID-19 pandemic has drawn attention to short-term reductions in greenhouse gas (GHG) emissions, public health responses, and the importance of clean recovery stimulus packages. To inform climate change mitigation policies, five key comparisons have been framed based on the early stages of the COVID-19 pandemic, along with five associated lessons:

- Delay is costly, but early and determined action is politically tricky.
- Broad public support is critical for early action, and underestimating damage impacts public support.
- Policies must adequately address existing inequalities to prevent the worst outcomes.
- Global problems require multiple forms of international cooperation and solidarity.
- Transparency of normative positions is needed to navigate value judgments at the science-policy interface (Klenert et al., 2020).

While effective in mitigating the spread of COVID-19 (Flaxman et al., 2020; Hsiang et al., 2020), Lockdowns may not directly translate to climate change mitigation policy success. Although the pandemic reduced GHG emissions, it does not necessarily provide a straightforward model for climate change action. The reduction in global CO_2 emissions by approximately 17% in mid-April 2020 compared with 2019 levels underscores the economic consequences of the pandemic (Le Quere et al., 2020).

The nexus between the COVID-19 pandemic and climate change underscores the complexity of addressing global challenges. While short-term emissions reductions and public health responses are evident in both cases, climate change mitigation requires profound and lasting transformations of the global economy. The economic costs of limiting climate change to below two degrees are projected to be significantly lower than those incurred by COVID-19 containment measures, challenging previous arguments against climate policy (Klenert et al., 2020) (Figure 3).

Conclusion

The intricate interconnections between global warming, climate change, COVID-19, air pollution, and climate change mitigation reveal a complex tapestry of environmental challenges. The lessons gleaned from the COVID-19 pandemic offer valuable insights into policy responses and the potential for short-term reductions in greenhouse gas emissions. However, it is crucial to underscore that addressing climate change requires a sustained and profound transformation of the global economy and society.

The COVID-19 pandemic has demonstrated that delays in taking decisive action can be immensely costly regarding public health and economic impact. Early and

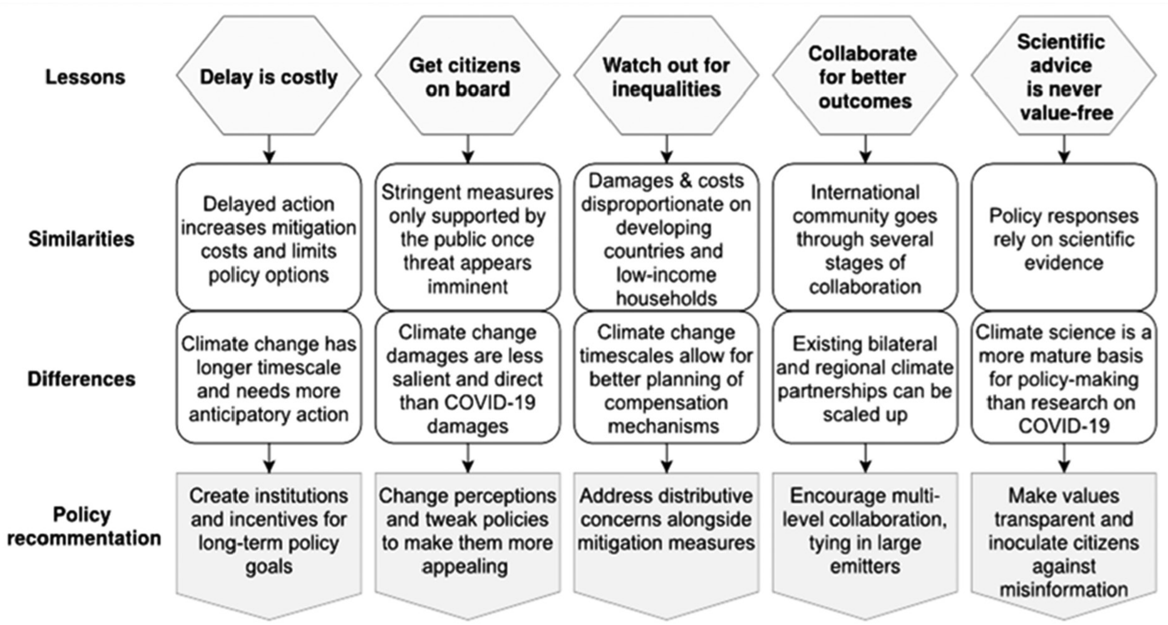

Figure 3: Summary of similarities and differences between COVID-19 and climate change and policy frames for climate change (after Klenert et al., 2020).

determined effort is essential to mitigate the immediate effects of a crisis and navigate the complexities of long-term challenges such as climate change.

Furthermore, the pandemic has emphasised the critical role of broad public support in facilitating early action. Underestimating the consequences of a crisis can erode public confidence and hinder effective responses. Climate policymakers can draw lessons from the pandemic's experiences to foster public engagement and support for ambitious climate action.

It is also evident that policies must address the immediate crisis and tackle underlying inequalities to prevent the worst outcomes. The pandemic has exposed and exacerbated disparities in healthcare access and socioeconomic vulnerability. Similarly, climate change disproportionately affects vulnerable communities. Therefore, climate policies must be designed with equity and social justice.

Global challenges like COVID-19 and climate change require multifaceted international cooperation and solidarity. The pandemic has highlighted the need for a coordinated global response to address crises that transcend borders. With its far-reaching consequences, climate change necessitates even stronger international collaboration to reduce emissions, adapt to changes, and support vulnerable nations.

Transparency in decision-making and normative positions is vital in navigating the complex interface between science and policy. Just as precise and reliable information has been crucial in responding to the pandemic, transparency is essential in addressing climate change. Open and honest communication is necessary to build trust, foster collaboration, and make informed policy decisions.

In summary, while the COVID-19 pandemic has provided a glimpse into the potential for short-term reductions in greenhouse gas emissions and the importance of public health responses, it is essential to recognise the fundamental differences between addressing a global pandemic and mitigating climate change. Climate action demands long-term commitment, transformative change, and a deep understanding of the interconnectedness of environmental, economic, and public health challenges. As we reflect on the lessons learned from the pandemic, we must channel that knowledge and determination towards the urgent and ongoing fight against climate change. The time for resolute action is now, and the pandemic's lessons provide a valuable compass for charting a more sustainable and resilient future for our planet.

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