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Unprecedented Challenges in Urban Areas Due to Climate Change

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Abstract: Climate change, arising from both natural processes and anthropogenic emissions, poses a formidable threat to life on Earth. Greenhouse gases (GHGs), notably carbon dioxide (CO2) and methane (CH4), primarily from fossil fuel combustion, play a pivotal role in driving large-scale climatic impacts (IPCC, 2013; Xu and Lamarque, 2018). This paper explores the intricate relationship between air pollution and climate change, emphasizing the shared emission sources, climatic characteristics, and chemistry, as well as integrated mitigation measures. The major GHGs—water vapor, ozone (O3), nitrous oxide (N2O), CO2, and CH4—contribute to global warming, with CO2 and CH4 dominating at 90% (Kumar and Imam, 2013; EPA, 2020). The interconnection between air pollution and climate change extends to emission sources, climate dynamics, and potential mitigation actions. Both phenomena carry profound implications for human health, exemplified by particulate matter (PM) adversely affecting health and influencing climate forcing and meteorological phenomena by acting as cloud nuclei. Simultaneously, the consequences of global warming, ranging from rising temperatures to extreme weather events, ocean acidification, and sea-level rise, underscore the urgent need for comprehensive solutions. While these challenges are often treated as separate issues in research and policy, their inherent interconnectedness demands a holistic approach to effective mitigation strategies.

IndexTerms **- Climate adaptation, nature-based solutions, environmental pollution, human health, urbanization.**

INTRODUCTION

The paramount threat to life on Earth emanates from climate change, a complex phenomenon fueled by both natural processes and anthropogenic activities. Greenhouse gases (GHGs), particularly carbon dioxide (CO2) and methane (CH4) stemming predominantly from fossil fuel combustion, exert a substantial influence on the climate (IPCC, 2013; Von Schneid Messer et al., 2015; Xu and Lamarque, 2018). This paper delves into the intricate interplay between air pollution and climate change, highlighting the shared emission sources, climatic characteristics, and chemistry that bind these phenomena. Emphasizing the critical role of GHGs such as water vapor, ozone (O3), nitrous oxide (N2O), CO2, and CH4, which collectively contribute to global warming, the discussion underscores the urgency of adopting holistic approaches to mitigate the far-reaching consequences of this interlinked environmental crisis.

CLIMATE CHANGE, AIR POLLUTION AND CITIES

Climate change poses a significant threat to life on Earth, arising from both natural and human-induced emissions of air pollutants, especially greenhouse gases (GHGs). These pollutants, such as water vapor, ozone (O3), nitrous oxide (N2O), carbon dioxide (CO2), and methane (CH4), contribute to global warming, with the latter two accounting for 90% of GHGs and primarily stemming from fossil fuel combustion.

Air pollution and climate change are intricately linked in terms of emission sources, climate characteristics, and mitigation measures. They have profound consequences for human health, as exemplified by particulate matter (PM), which not only impacts health negatively but also influences climate forcing and meteorological phenomena. Global warming manifests in various ways, including rising temperatures, drought, declining water resources, melting ice sheets, coastal flooding, ocean acidification, rising sea levels, and more frequent extreme weather events.

Despite being viewed as distinct problems, these issues are interconnected, necessitating a holistic approach to solutions. The warming effect of global warming is intensified by urbanization, leading to urban heat islands and aerosol radiative forcing. The interplay among climate change, the urban heat island effect, and air pollution is expected to heighten the risk of poor human health in cities globally.

The impact of climate change on health risks is more substantial in areas of lower air quality, as evidenced by studies linking climate variables and health outcomes. Air pollution affects atmospheric evaporation and may lead to insufficient moisture for crop production. Additionally, hotter metropolitan climates exacerbate the mortality effects of air pollution, particularly in relation to pneumonia.

Climate change influences the lifespan and health impacts of pollutants, such as PM2.5, highlighting the interconnectedness of climate change and air pollution mitigation. Mitigation measures for specific air pollutants can contribute to temperature reduction and simultaneously improve food security and human health.

Addressing the overconsumption of energy is crucial in combating GHG emissions and mitigating global warming. Developing sustainable energy programs, managing natural resources effectively, reducing fossil fuel energy demand, enhancing product efficiency, and transitioning to cleaner fuels in transportation are essential steps in addressing this complex issue.

HEALTH AND ENVIRONMENTAL RISKS TO CITIES UNDER A CHANGING CLIMATE

Global warming will profoundly affect human well-being, particularly through increased risks of water- and vector-borne infectious diseases. The intricate pathways connecting climate change to health are influenced by social, natural, biological, and economic factors, with the spread and persistence of pathogens playing a crucial role in disease transmission. The hazards posed by global warming include the escalation of extreme weather events (e.g., droughts, heatwaves, floods) and air pollution, impacting human health and exacerbating existing vulnerabilities, especially in urban populations of low- and average-income nations (IPCC, 2014).

Additionally, climate change amplifies concentrations of secondary pollutants like O3, affecting human health and deteriorating building materials. Recent evidence suggests that climate change is associated with adverse health outcomes, and by 2050, cities worldwide may experience more frequent and intense heatwaves, linked to O3 exceedance. Although the direct impacts of extreme climate events on well-being are not conclusively proven, studies indicate that human activities over the past 50 years have contributed to environmental changes.

The health implications of climate change encompass various issues, including thermal discomfort, reduced work capacity, respiratory problems exacerbated by air pollutants and aeroallergens (e.g., COVID-19, asthma), infectious diseases (vector-borne and water-borne), food insecurity and malnutrition due to diminished crop yields, and mental health crises such as post-traumatic stress disorders related to natural hazards. The reduction of fossil fuel exploitation holds the potential for significant health and economic co-benefits (Patz et al., 2014), underscoring the importance of long-term climate change mitigation and adaptation measures. As heatwave occurrences and other climate-related changes are expected to increase, the impact on human well-being is anticipated to be substantial.

NATURAL HAZARDS AFFECTING CITIES

Projections on global warming indicate a surge in the frequency and magnitude of natural disasters, impacting both the global community and the environment (IPCC, 2018). Natural hazards can lead to extensive losses, causing significant disruptions to societies, economies, and biodiversity due to their interaction with coping capacity, vulnerability, and exposure (UNISDR, 2020). The intensity of hazards is influenced by the impact on communities, with the scale of effects contingent on decisions made regarding life and surroundings.

Rapid urbanization, particularly in areas vulnerable to climate change, exposes cities globally to substantial risks, especially those situated along waterways or near coastlines. Gu (2019) examined the exposure and vulnerability of 1,860 cities to various natural disasters, emphasizing the need for enhanced resilience and adaptation strategies to achieve Sustainable Development Goals (SDGs). Nearly 58% of the studied metropolitan areas were highly exposed to at least one of six natural hazards, while around 14% and 2% were profoundly exposed to more than two and three hazards, respectively. The world's most risk-prone cities, primarily in East Asia (China, Taiwan, the Philippines, and Japan), face threats from floods, storms, earthquakes, and other disasters, given their coastal locations (Gu, 2019). Illustrates the ten most severely impacted cities globally by natural hazards. Floods, earthquakes, and wind storms affected 43.9%, 32.8%, and 18.2% of inhabitants, respectively, with an additional 5.2% potentially impacted by storm surges and tsunamis. The catastrophic effects of natural hazards in densely populated cities underscore the urgency of disaster risk planning and management, especially in the world's largest metropolitan areas (Debele et al., 2019)

GLOBAL HEALTH AND ECONOMIC BURDEN DUE TO NATURAL HAZARDS

Climate change-induced challenges, including droughts, heatwaves, and floods, pose exacerbated threats in low- to middle-income countries due to factors such as poverty, insufficient development, and a heavy reliance on natural resources (Rogelj et al., 2016). As illustrated 3, 83%, 32%, and 7% of cities were identified as high-risk areas for natural hazard-related mortality from at least one, two, and three out of the six types of natural hazards. Furthermore, 76% of the analyzed 1,860 metropolitan areas were located in regions profoundly susceptible to flood-related mortality.

These natural hazards not only significantly impact human lives and health, as depicted, but also exert substantial disruptions on the local economies of metropolitan areas and, in some instances, entire countries. They indicates that 89% of cities were situated in regions highly vulnerable to economic damage from at least one natural hazard. In the case of flooding, about 72% of the 1,860 metropolitan areas analyzed were positioned in areas of high exposure and vulnerability to associated economic damage. The same data provides corresponding data for other hazards, revealing the levels of exposure, vulnerability, mortality, and economic damage. In essence, these findings suggest that the majority of metropolitan areas faced high exposure to both flood-related mortality and economic damage.

GRAND CHALLENGES TO FILL EXISTING GAPS FOR HEALTHY CITIES UNDER CLIMATE CHANGE

Addressing air contamination and climate change is a global imperative, with profound implications for human well-being and economic prosperity. Although long-term solutions exist, the immediate priorities for tackling these issues vary among nations. Implementing advanced methods to mitigate both global warming and air pollutants can not only enhance human health and the environment but also contribute to economic growth. Despite being traditionally viewed as separate concerns, atmospheric aerosols (particulate matter) and global warming share commonalities in properties, sources, and mitigation measures. Policy trade-offs may have contributed to this separation, but strategies that reduce greenhouse gases (GHGs) can simultaneously reduce ambient aerosols from the same sources (Kumar and Saroj, 2014).

Climate change and air pollution are interconnected issues with shared causes and mitigation measures, such as green infrastructures. While numerous opportunities exist to address both challenges, blind prioritization of one aspect can inadvertently worsen the other. Ideal strategies necessitate careful regulation, legislation, and presentation, requiring compromise and cooperation on both fronts. Coordinated global action considering the linkages between air pollution and climate change is urgently required.

The intricate relationship between climate change and air pollution underscores the need for better coordination in future policies. Evaluating the impact on human well-being of alternative policy approaches to address both climate change and pollution will be a crucial focus of future research. City planning initiatives that integrate the shared interests of climate and health are gaining attention, emphasizing the necessity for holistic, interdisciplinary approaches and nature-inspired solutions. The active involvement of multiple stakeholders is essential for the sustainability and effectiveness of identified strategies, presenting another critical area for expanded research in the coming years. As the founding Chief Specialty Editor, I look forward to prospective publications on these vital topics in the "Climate Change and Cities" section of the journal.

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