Climate Change Adaptive Strategies for Buildings and Public Health

by

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ABSTRACT

Reducing the impact of climate change on buildings and public health will require ongoing preparation and action. Much effort thus far has emphasized mitigation activities to decrease a building's greenhouse gas emissions into the environment. However, buildings need to also adapt to accommodate the growing effects of heat waves and urban heat islands, and subsequent energy demands, especially cooling. While the public health effort to adapt to climate change will be critical, the building sector will also be instrumental in helping to reduce the impact of climate change on buildings and the built environment, and to ensure that the needs of occupants are met.

KEYWORDS

Built environment, buildings, climate change, public health, adaptation

1.0 INTRODUCTION

The accumulation of greenhouse gases (GHGs) has been a dominant cause of climate change. The Intergovernmental Panel on Climate Change's recent Fourth Assessment Report[1] shows that there is growing evidence that global warming is associated with changes in the climate. These changes include increased frequencies of natural disasters, more extreme weather events, and rising sea levels from the widespread melting of snow and ice.[1] These climactic changes can affect public health in many ways.[2, 3, 4] Accordingly, societies need to prepare for, and effectively respond to, the changing climate. Two strategies are commonly identified to manage the effects of climate change: mitigation, which is associated with reducing climate change, especially GHG emissions, and adaptation, which includes designing, implementing, monitoring, and evaluating strategies to reduce the effects of climate change. Both strategies address technological, institutional, and behavioral options.[1] While mitigation approaches to reduce GHG are often emphasized, a concomitant effort to work on public health adaptation to climate change will also be important to help prepare the public for ongoing changes.[5] Thus, it is critical to consider both mitigation and adaptation activities for reducing long-term, potentially hazardous effects on human health. We attempt to describe the important role that buildings and the built environment, collectively, should also be considered within this public health and climate change framework.

Mitigation strategies are continually being developed to reduce GHG from the built environment, yet there are opportunities to simultaneously integrate adaptation strategies (e.g., material selection, energy use, building design, etc.). These efforts can assure the resilience of the building sector to more effectively respond to increasing climate variability. Furthermore, as the building sector and overall built environment influence human health and welfare both in the indoor and outdoor environment, they are an integral part of the process.[6]

The anticipated health effects to climactic changes can include morbidity and mortality associated with temperature extremes and air pollution-related exposures. Effects of vector-borne and zoonotic diseases, especially on those organisms that are sensitive to and disrupted by climactic factors, may also emerge in areas where they had been limited.[2] The implications and threats of climate change to the overall

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infrastructure, including the building sector, are also becoming better understood. The estimated global anthropogenic GHG emissions (in carbon dioxide [CO_2] equivalents) contributed by residential and commercial buildings was 7.9% in 2004[1] and efforts have primarily focused on reducing GHG from buildings. However, the impact of global warming over time on physical structures and their ability to adapt to changing climactic conditions should also be considered. With the increasing number of heat waves and the effect of the urban heat island, for example, the building sector will need to adapt to rising energy demands for cooling while maintaining indoor comfort and a healthy environment.

2.0 EFFECTS OF CLIMATE CHANGE ON HUMAN HEALTH: HEAT WAVES

There has been considerable research on the health effects associated with extreme heat. These health effects, along with periods of elevated temperatures outside the normal range of climate variability are projected to increase in frequency throughout the world and become more intense in the future.[7] Therefore, heat-related health effects are increasing in public health significance. In fact, many cities have reported excess mortality that has been attributed to extreme heat. Heat wave events are typically marked with sustained high temperatures that are often hotter than those to which the population is accustomed. These exposures can cause mild symptoms, such as heat stress or exhaustion, or exacerbate existing respiratory and cardiovascular conditions, which can lead to more severe health effects or be fatal. In the United States, heat waves kill more people than other natural disasters including hurricanes, tornadoes, floods, and earthquakes combined.

In 2003, Europe reported experiencing abnormally high temperatures in the summer and observed an unprecedented number of deaths—35,000 in the region.[8] In France alone, 14,800 deaths were reported between two weeks in August, and many were among persons >75 years of age.[9] During this time in France, peak temperatures of 104°F (40°C) were recorded and remained elevated for two weeks.[10]
Vulnerable populations, which often include the elderly, young children, those with underlying medical conditions, and those without air conditioning, are disproportionately affected during heat waves as they may be more sensitive to temperature extremes.[11,12, 13] With a growing elderly U.S. population, these trends suggest that temperature-related morbidity and mortality are likely to increase in the future.

Vulnerability can also vary by geographic area, especially among those expected to experience the greatest changes in average temperatures.[13] As in Europe, these changes may be the most significant among residents in more temperate zones who may not be as acclimated to high temperatures and may be at greater risk.[14] In addition, these regions may also have increased concentrations of ozone and other air pollutants that are influenced by rising temperatures.[15] High levels of ozone can exacerbate existing respiratory and cardiovascular diseases.

3.0 EFFECTS OF CLIMATE CHANGE ON URBAN ENVIRONMENTS: URBAN HEAT ISLAND EFFECT

The urban “built” environment adds to the climate change-driven increases in temperature. Cities and climate are evolving together in a manner that will intensify both the effect of heat and the vulnerability of urban populations to heat-related death.

More than 50% of the world now lives in cities, and urban areas are gaining an estimated 67 million people per year. Further estimates suggest that approximately 5 billion people, or 60% of the projected global population, will be living in urban areas by 2030.[16] This rapid urbanization transitions communities to engineered infrastructures that increase thermal-storage capacity, resulting in significant changes in the urban climate compared to neighboring rural regions. This is known as the urban heat island (UHI) effect. There is growing concern that the UHI effect can intensify and prolong the duration of extreme heat events.[16]

UHI has increased air temperatures in cities 2°F–8°F compared to surrounding suburban and rural areas, often due to solar energy absorbed by dark paved surfaces and buildings, fewer vegetation and trees, heat emitted from buildings and vehicles, and reduced air flow around buildings. UHI absorbs heat during the daytime, causing the surface temperatures of urban structures to become 50°F–70°F (10°C–21°C) warmer than ambient air temperatures.[16] In the evening, the energy is radiated out, raising nighttime minimum temperatures in the urban environment and keeping them relatively high.[17] This phenomenon makes it more difficult for the population to recover, which contributes to general discomfort, respiratory difficulties, heat cramps and exhaustion, nonfatal heat stroke, and heat-related mortality. Harlan et al. (2006),[14] found that Phoenix, Arizona residents living in warmer neighborhoods experienced increased health risks from heat stress.

Rising temperatures are likely to increase the demand for air conditioning and other sources of cooling. Research has shown that for every 1°F (0.6°C) increase in air temperatures (starting from 68°F–77°F [20°C–25°C]), cooling increases the demand for electricity by 1.5%–2.0%. This suggests that 5%–10% of community-wide demand for electricity is used to compensate for the UTI effect.[18] Demand may also increase pollutant emissions from regional power plants and other power sources that can contribute to the formation of ozone and other air pollutants,[20] thereby affecting public health.

4.0 ADAPTATION AND MITIGATION: BUILDINGS SECTOR

The Fourth Assessment Report[1] detailed mitigation-related activities to reduce GHG emissions from the building sector. Energy use in buildings is typically high and inefficient, so efforts to reduce carbon emissions have often targeted buildings. Various design strategies have been developed to reduce carbon emissions, such as changing the building stock, using natural ventilation[20], and better insulation and windows to improve thermal performance. Integrating approaches to increase energy efficiency and renewable energy, such as adopting the Leadership in Energy and Environmental Design (LEED) standards into building design, can reduce annual average carbon dioxide emissions by 350 metric tons (385 tons) in the United States.[21]

However, there has been less discussion in the Fourth Assessment Report about adapting residential and commercial buildings to climate change. Future approaches should therefore consider the ability of the building sector to adapt to climate variability and also to protect the health of the occupants and the public. After the heat wave in 2003, French researchers indicated that the quality of the built environment was an important factor in understanding the causes of excess mortality.[10] These adaptations can include modifying the building's energy use, peak demand, equipment life, and building stock.[22]

Thus, when selecting technologies to mitigate the effects of GHG, it is important to consider adapting building regulations, materials, and construction techniques to ongoing events associated with climate change. Smith and Levermore (2008)[23] suggested that approaches such as altering a building's façade (e.g., use of high-reflectivity materials), green roofs, urban greening, and design to allow cooling winds, can help lower the temperature in the urban micro-environment by reducing its heat absorption and emission. Adapting building codes, for example, to address these changes can help to guide better building practices and can also lead to public health benefits. Further, the changing pattern of energy use and rising energy demand will likely continue to influence the design and efficiency of building services, especially those supporting the increasing need for cooling and heating.[23,24]

A growing body of technology helps maintain the thermal comfort of people in urban environments. Other existing technology, such as sensor arrays have often been used to monitor the health of buildings, and may also serve as a useful tool to help assess the ability of the building sector to withstand climate variability over time and the resiliency of the building materials.

5.0 BUILDING SECTOR INFRASTRUCTURE AND PUBLIC HEALTH

Several heat-related events, such as the 1995 heat wave in Chicago[25] and 2003 heat wave in Europe revealed that the existing infrastructure lacked the capacity to deal with the impact of these disasters. The failure to adapt, such as reducing UHIs, meeting electricity and cooling demands, and reducing population vulnerability to heat stress, may leave a community poorly prepared to cope with adverse changes, which can lead to severe consequences.[2,5] Building design, its impact on local climate, and its ability to maintain human comfort—both short- and long-term changes, and on a micro- and macro-scale—will therefore be significant.

A driving force for adapting to climate change is to ensure basic public health protection. Adaptation is a process, so it is important to understand local and regional vulnerability, the adaptive capacity of the population, and future potential climate risks.[5]

6.0 COLLABORATIVE EFFORTS AND NEXT STEPS

Great complexity surrounds climate change. In order to effectively plan for these events, increased efforts to develop, mitigate and adapt strategies at the urban level requires a multi-disciplinary approach through collaborating with engineering, architecture, construction, community/urban planning, and public health professionals.

The health effect of extreme weather events is influenced by the vulnerability of the environment, the population, and its ability to recover from them. These factors rely on the resiliency of the building sector and its ability to protect the health of the population. Therefore, the challenge is to support the design, development and growth of new and existing urban environments in a sustainable manner that promotes public health. Further, policy and planning should be implemented and maintained to reduce the future vulnerability of urban populations to events such as extreme heat.[23]

The building community has an important role in adapting to climate change for there are co-benefits of better designed buildings for sustainability and health. Advancing efforts for adaptation will be challenging, but essential and require ongoing assessment and action. Thus, the building community will need to be engaged in and aware of the design, implementation, and monitoring of building resiliency and indoor comfort. This will be important in not only assuring the sustainability of the buildings and the community over time, but this will also protect public health and overall population vulnerability from events such as extreme heat.

7.0 REFERENCES

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