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Review article

Effects of urbanization on bioclimatic comfort conditions

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Abstract: Urbanisation can have a significant impact on bioclimatic comfort conditions, which refer to the combination of temperature, humidity, wind, and solar radiation that affects the human body's ability to cool or warm itself. "Bioclimatic Comfort Conditions" have received great attention worldwide due to urbanisation, which affects human health, meteorology, energy consumption, comfort, and similar factors. This study reviews some recent and relevant works as well as the current challenges for future research using different methods in "Effects of Urbanisation on Bioclimatic Comfort Conditions". The results of the study indicate that urbanisation has a significant impact on temperature, humidity, wind speed, and solar radiation. The urban heat island effect was found to be the main reason for the increase in temperature in urban areas compared to rural areas. The study also found that urban areas had a higher humidity level and a lower wind speed compared to rural areas. The solar radiation levels were also found to be higher in urban areas due to the reflection and absorption by buildings and paved surfaces. Cities may create a better and more livable environment for themselves by putting a priority on biodiversity, lowering noise levels, and managing and improving air and water quality.

Keywords: Bioclimatic architecture, Heat island effect, Green infrastructure, Sustainability.

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Introduction

Urbanisation has led to significant changes in land use and land cover, resulting in a complex and diverse built environment (Dewan & Yamaguchi, 2009). As a result, urban areas are characterised by higher population density, intense land use and land cover changes, and a reduction in natural vegetation cover (Bajocco et al., 2012). These changes have a significant impact on bioclimatic comfort conditions, which refer to the combination of temperature, humidity, wind, and solar radiation that affects the human body's ability to cool or warm itself (Thorsson et al., 2004).

Urbanisation can lead to the creation of an "urban heat island" (UHI) effect, where surfaces in urban areas absorb and retain heat, leading to higher temperatures than in surrounding rural areas (Chapman et al., 2017). This is caused by the increased anthropogenic heat sources and the reduction in vegetation cover and water bodies (Doan et al., 2019). Urban areas also tend to have reduced air movement and ventilation, which can affect the dispersion of pollutants and the cooling of the environment (Georgakis & Santamouris, 2006). Furthermore, urban areas often have increased solar radiation due to reflection and absorption by buildings and paved surfaces and reduced vegetation cover, leading to less

evapotranspiration and increased humidity (Shahmohamadi et al., 2011).

The development of heat islands, which are locations with higher temperatures than rural areas, is one of the most notable effects of urbanisation (Kaiser et al., 2016). This is primarily due to the urban heat island effect, where building materials and human activities cause heat absorption and retention (Shahmohamadi et al., 2011). The bioclimatic comfort conditions in urban areas are further influenced by the specific characteristics of the urban environment, such as the proportion of green spaces, the types of buildings, and the urban layout (Ichim & Sfîcă, 2020). Therefore, understanding the effects of urbanisation on bioclimatic comfort conditions is crucial for the development of sustainable urban environments that are comfortable for their inhabitants (Duy Luan, 2014). This study aims to investigate the effects of urbanisation on bioclimatic comfort conditions in the city of X and provide recommendations for improving bioclimatic comfort in urban areas (Dunichkin et al., 2019).

What is bioclimatic architecture?

Bioclimatic architecture is a design approach that aims to create buildings and spaces that are comfortable for occupants and energy-efficient by utilising the natural resources of the environment, such as sunlight, wind, and temperature (Akande et al., 2015). The goal of bioclimatic architecture is to create a balance between human needs and the natural environment by using passive solar design, natural ventilation, and other sustainable design strategies (John et al., 2005). Fortunately, there are strategies for reducing these adverse consequences through the use of green infrastructure, like parks and green roofs (Akande et al., 2015). Green infrastructure can act as a sink for pollutants, lowering temperatures, increasing evapotranspiration, and enhancing air quality (Hewitt et al., 2020). The detrimental effects of urbanisation on bioclimatic comfort conditions can be lessened with the use of sustainable urban design initiatives (Emmanuel, 2005).

Utilising local bioclimatic conditions for the benefit of the built and natural environments is the first principle of bioclimatic architecture (Figure 1) (*Passive Design | Green Home Technology Center*, n.d.). That strategy should always be founded on a thorough multidisciplinary investigation of each case, from environmental details to cultural considerations to economic analyses (Birkeland, 2012). In the end, safe and comfortable structures that are built do not hurt the environment but rather improve its health and biodiversity (Gallo, 1994).

Effects of urbanization on human health

Human health can be impacted by urbanization in both good and bad ways (Chen et al., 2014). On the plus side, urban regions frequently offer easier access to jobs, healthcare, and educational possibilities (Sørensen, 2018). Additionally, they frequently have populations and cultures that are more varied, which might result in a richer social life (Townley et al., 2011). On the downside, due to things like air pollution, a lack of green space, and sedentary lifestyles, metropolitan environments can be linked to an increased risk of chronic diseases like obesity and heart disease (Figure 2a) (Suresh & Palaniraj, 2018). In addition to increased crime and social isolation rates in urban locations (Henning-Smith et al., 2019). Overall, depending on the unique qualities of the urban environment and the population residing there, the consequences of urbanization on health can differ (Figure 2b) (Nansai et al., 2021). Additionally, poor air quality brought on by urbanization—due to pollution from several causes like transportation and industrial activities—has led to respiratory illnesses and other health concerns (Qiu et al., 2019). Furthermore, changes in the hydrological cycle, such as decreased evapotranspiration and increased runoff, have resulted in reduced humidity levels in urban areas, further exacerbating the effects of heat islands (Gunawardena et al., 2017). When evaluating indoor environments, the most significant factors have traditionally been considered to be human health and comfort (Ongoma et al., 2016).

Urbanization alters the thermal balance in cities and has a negative impact on the environment, aesthetics, energy efficiency, human health, and quality of life for locals (Paulo Rodrigues da Silva et al., 2018). Urban dwellers worldwide are directly affected by issues associated with urban heat island intensity (UHI), which is predicted to rise sharply in the near future (Mohajerani et al., 2017). Heat stress: Due to the "heat island" effect, temperatures in urban areas may be greater than in nearby rural areas. Heat stress and a higher risk of heat-related disorders can result from this (A et al., 2017). Urban locations typically have greater air pollution levels, which can cause a variety of respiratory and cardiovascular health issues (De Marchis et al., 2018). Noise pollution can cause hearing loss, sleep disruptions, and stress-

related health issues since metropolitan areas can be noisier than rural ones (Nnebue & Adinma, 2016).

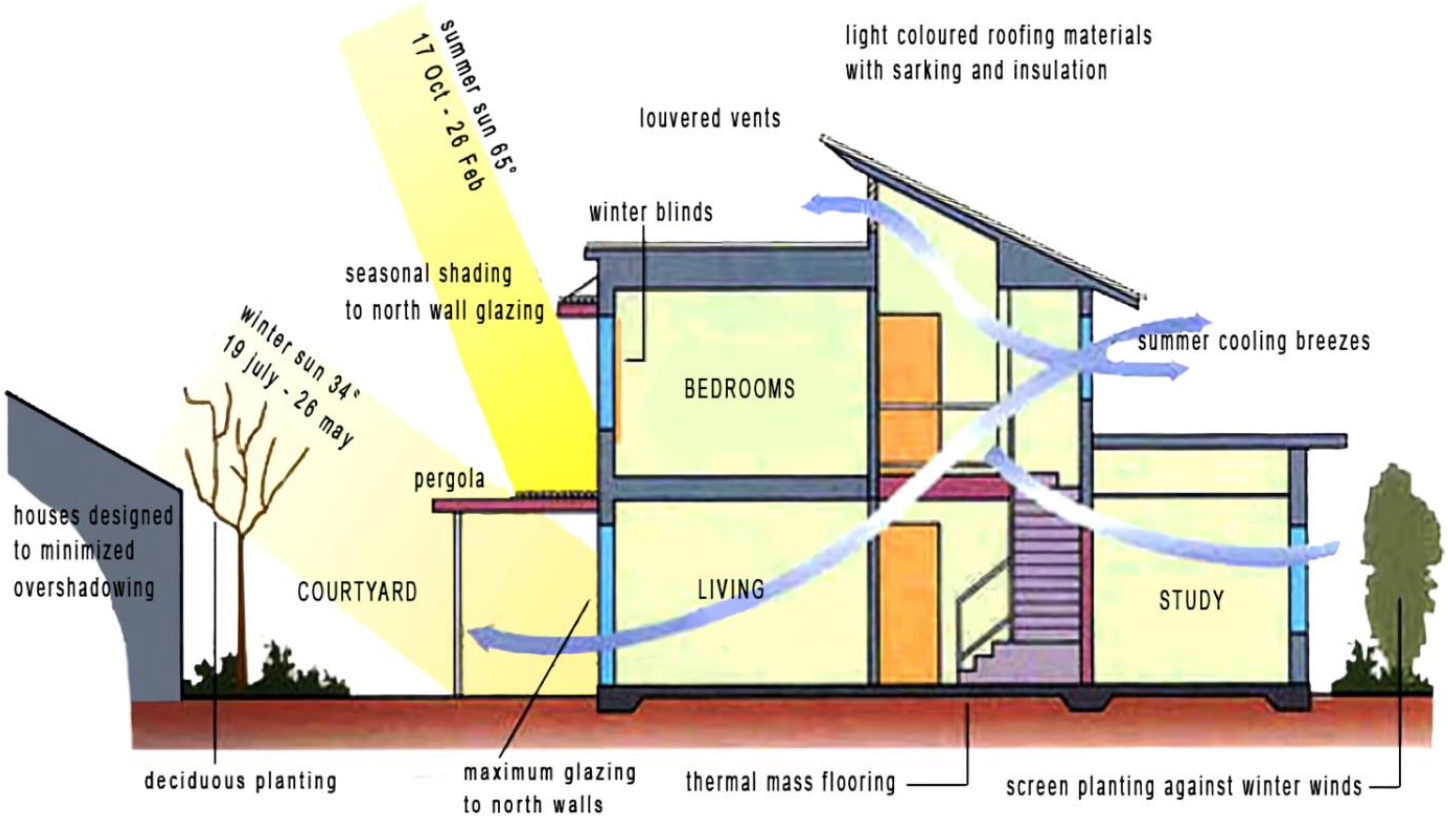

Figure 1. Bioclimatic architecture (Passive Design | Green Home Technology Center, 2023).

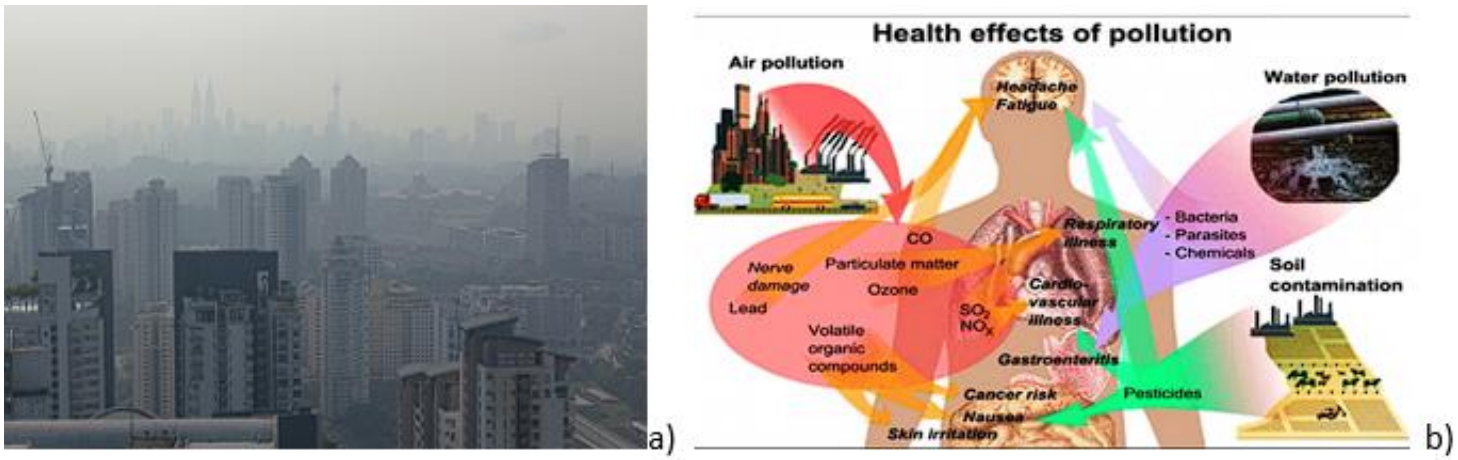

Figure 2. a) Air pollution in a city (Suresh & Palaniraj, 2018); b) the effect of urbanization on human health (Nansai et al., 2021).

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Limited access to green spaces: Compared to rural areas, urban areas often have less green spaces per inhabitant (Haaland & van den Bosch, 2015). This may reduce possibilities for exercise and exposure to the outdoors, which may worsen existing mental and physical health issues (Cox et al., 2018). Urbanization can result in social isolation and a loss of relationships with the community, which can have a negative impact on mental health (Cox et al., 2018). Inadequate housing options brought on by urbanization can result in overcrowding, shoddy living conditions, and poor sanitation, all of which have a detrimental effect on health (Cox et al., 2018). In general, depending on the unique context and how urban development is planned for and managed, urbanization can have both favorable and unfavorable consequences on human health (Duhl et al., 1999). Urban planners and public health specialists should collaborate to develop cities that encourage healthy lifestyles (Crawford et al., 2010).

Urbanization and Meteorology

For addressing the dangers connected with urban growth and for creating practical plans for sustainable urban development, it is crucial to comprehend the effects of urbanization on meteorology (Li et al., 2019). Meteorology can be significantly impacted by urbanization since the built environment can change regional weather patterns (Li et al., 2019). Due to the "heat island" effect, urban areas frequently experience warmer temperatures than the nearby rural areas (Figure 3) (Jha et al., 2011). By altering the heat island effect, which is brought on by the concentration of heat-absorbing materials like asphalt and concrete in metropolitan areas, urbanization can change the local climate. As a result, cities may experience warmer temperatures than nearby rural areas (Mohajerani et al., 2017). This is a result of the lack of vegetation, which usually helps to cool the air through transpiration, as well as the absorption and retention of heat by buildings, roads, and other infrastructure (Mohajerani et al., 2017). Urbanization can also affect precipitation patterns, as the buildings and pavement in cities can cause rainwater to runoff instead of being absorbed into the ground (Saraswat et al., 2016). Modification of precipitation patterns: Due to the transformation of the land surface and the impact of urban structures on the atmosphere, urbanization can result in changes in the distribution of precipitation and the intensity of storms in and near cities (Saraswat et al., 2016). Additionally, air pollution is more prevalent in urban areas, which can have an impact on cloud formation, cloud movement, and precipitation (Li et al., 2019). Urban regions' distinct topography and built environment can also have an impact on wind patterns, creating "urban canyons" or "wind tunnels" where wind speeds can be significantly greater or lower than in the surrounding areas. Urbanization can alter the water cycle and result in more runoff (Juan et al., 2021).

Human comfort and how well interior and outdoor situations are perceived are significantly influenced by meteorological factors, including sun radiation, air temperature, relative humidity, and wind speed (Dec et al., 2018). In particular, the temperature of the surrounding area affects how quickly air moves and how hot or cold it feels (Dec et al., 2018). Additionally, as cities expand, land uses may change, such as when natural areas are

turned into developed ones, which may have an effect on the regional water cycle and weather patterns (Shubinski & Nelson, 1975) (Figure 3). Local climate and meteorology are significantly affected by urbanization (Li et al., 2019). Urban planners and meteorologists must increasingly collaborate to improve the sustainability and livability of urban environments (Wong et al., 2011).

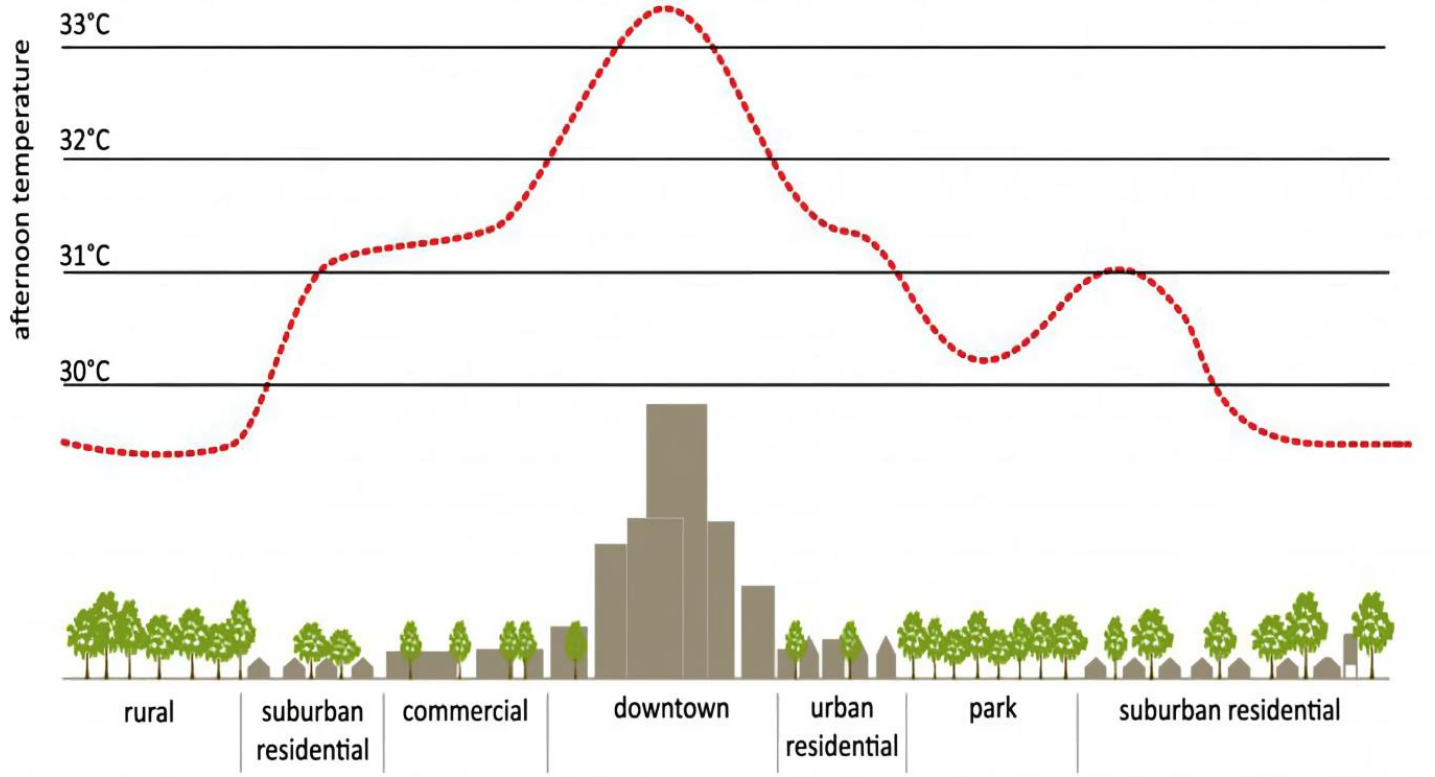

Figure 3. The effect of urbanization on air temperature (Jha et al., 2011).

Comfort and permissible comfort zones in urbanization

Comfort zones in urbanization are geographical, social, and cultural contexts in which people feel comfortable, safe, and secure (Johansson & Emmanuel, 2006). In metropolitan areas, a number of factors can lead to the development of comfort zones (Johansson & Emmanuel, 2006). Comfort zones in metropolitan environments are frequently influenced by elements including the presence of green spaces, accessibility to public transit, the caliber of public services, and levels of crime and safety (Lin, 2014). Urban planners and architects aim to create comfortable environments by incorporating these elements into the construction and growth of cities (Mersal, 2016). The picture depicts the optimal conditions for the human body in the comfort zone, designated (Figure 4). According to statistics, 70% of the population finds this area to be comfortable (Nnaemeka-Okeke et al., 2019). Denotes the area where the human body is less mobile and lightly dressed; it doesn't need to exert much energy to stay comfortable (Nnaemeka Okeke et al., 2019). No strategy should be used in this zone, which only has temperatures between 21 and 26 °C and relative humidity levels between 20 and 70 % (Nnaemeka Okeke et al., 2019). The greater the comfort zone, the more spending is allowed; at this point, there is no longer zero spending, only an acceptable minimum (Baker et al., 2002). Convenient for this location temperature and humidity conditions for 80% of the population, depending on the sex, internal metabolism, size, and activity performance, it might also be appropriate for some human bodies (Manzano-Agugliaro et al., 2015).

Urbanization and energy consumption

The housing sector consumes a significant amount of energy worldwide (Wang, 2014). In order to reduce energy consumption, it is crucial to investigate, evaluate, and integrate bioclimatic architectural systems, taking into account potential passive and active building options (Manzano-Agugliaro et al., 2015). The requirement for energy is rising along with urbanization. This is because urbanization has led to the development of infrastructure for road transport, health systems, and the education

system, all of which need energy (Avtar et al., 2019). With urbanization, energy-consuming devices are increasing, which leads to increased more energy needs (Madlener & Sunak, 2011). Urbanization also causes industrialization and needs energy, so there is a positive relationship between urbanization and energy consumption (Figure 5) (Avtar et al., 2019).

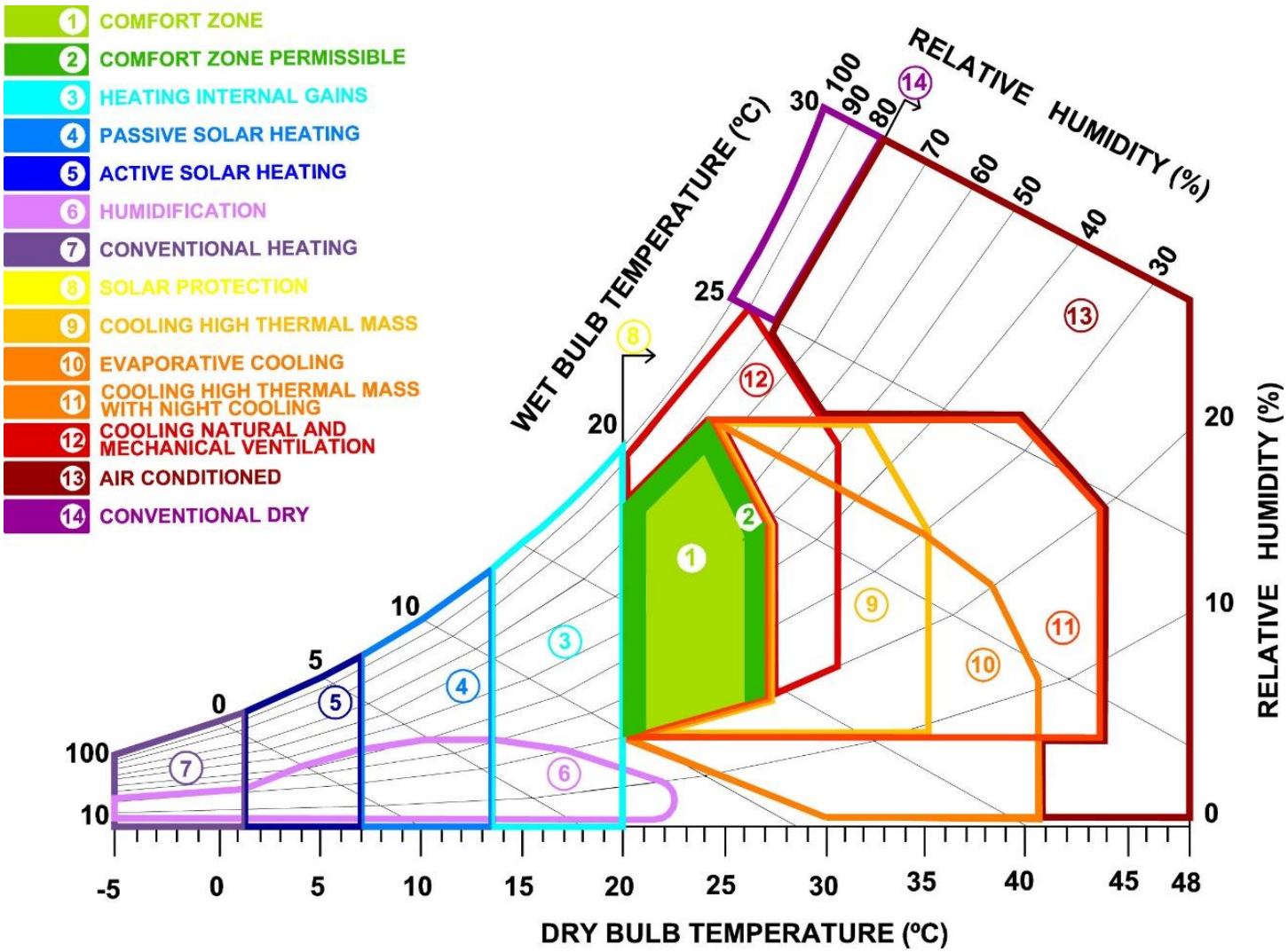

Figure 4. Comfort and permissible comfort zones (Nnaemeka-Okeke et al., 2019).

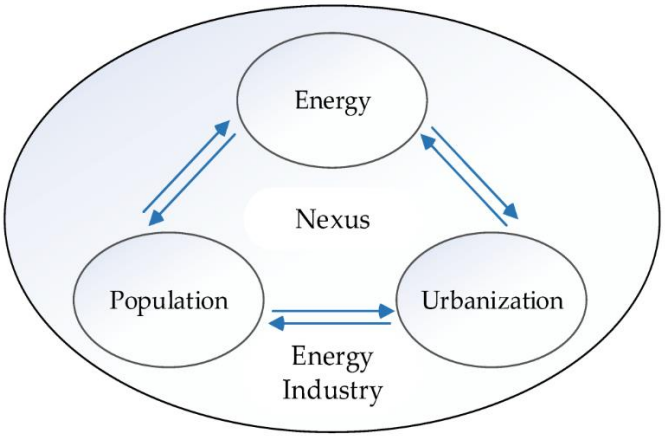

Figure 5. The link between urbanization, energy and population (Avtar et al., 2019).

Urbanization causes a rise in energy use because cities require more energy to support their expanding infrastructure and population (Avtar et al., 2019). This includes the energy needed to move, heat and cool buildings, and light and operate a variety of household and commercial appliances (Schipper et al., 1989). In addition, urbanization often leads to more intensive land use, causing green spaces to be converted into buildings and pavements, resulting in the urban heat island effect and increased energy consumption for cooling (Shahmohamadi et al., 2011). As the world's population continues to move into cities, it is crucial to take into account the connection between urbanization and energy consumption and to work towards the effective and

sustainable use of energy in urban areas (Shen et al., 2011). Cities may create a better and more livable environment for its citizens by putting a priority on biodiversity, lowering noise levels, managing stormwater, and improving air and water quality (Panlasigui et al., 2021).

Conclusion

The bioclimatic comfort levels in cities have been significantly impacted by urbanization. The development of heat islands, which are locations with greater temperatures than rural areas, is one of the most notable effects of urbanization. This is primarily due to the urban heat island effect, where building materials and human activities cause heat absorption and retention. Metropolitan environments can be linked to an increased risk of chronic diseases like obesity and heart disease due to pollution from several causes like transportation and industrial activities, a lack of green space, and sedentary lifestyles. Fortunately, there are strategies for reducing these adverse consequences through the use of green infrastructure which can act as a sink for pollutants, lowering temperatures, increasing evapotranspiration, and enhancing air quality. The detrimental effects of urbanization on bioclimatic comfort conditions can be lessened with the use of sustainable urban design initiatives. Utilizing local bioclimatic conditions for the benefit of the built and natural environments is the first principle of bioclimatic architecture. Overall, the effects of urbanization on bioclimatic comfort conditions are complex and multifaceted. However, urban planning and design can play a critical role in mitigating these effects through the use of sustainable practices and green infrastructure. Cities may create a better and more livable environment for its citizens by putting a priority on biodiversity, lowering noise levels, managing stormwater, and improving air and water quality.

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Conflicts of interest

The authors declare that they have no conflict of interest.

Ethical Approval

No need to ethical approval for this study.

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