Challenges of Using Air Conditioning in Hot Climate

Laxmi Goswami

SOEIT, Sanskriti University, Mathura, Uttar Pradesh, India

Email Id- laxmigoswami.ee@sanskriti.edu.in

ABSTRACT: ***Air conditioning (AC) is now the most effective method of cooling interior spaces. However, for a variety of reasons, its growing global use is worrisome. This article examines the issues associated with rising air conditioning consumption and proposes more environmentally friendly solutions. A transdisciplinary method was used to perform a literature review. It was also backed up by instances cities with hot climates. An analytical framework was established to analyse the data, which takes into account four sociological factors. Individual, community, municipal, and national levels are all important. The following are the key problems discovered by the literature review: Environmental, organisational, socioeconomic, biophysical, and behavioural factors all come into play. Several measures are also identified in the study might be taken to slow the rapid rise of air conditioning consumption. However, due to the problem's complexity, there is no one solution to offer long-term cooling. Three main groups of alternative solutions were identified: urban planning that is climate-conscious. Climate-sensitive attitudes and behaviour, as well as building design, alternative cooling technology, and climate-sensitive attitudes and behaviour. The major results involve the issues that arise when individuals are alone responsible for finding cooling solutions, as well as how different social levels may collaborate to develop more sustainable cooling choices. It is determined that a more holistic approach is required, both in terms of integrating diverse solutions and incorporating various levels of society.***

KEYWORDS: ***Air conditioning, Climate change, Sustainability, Transdisciplinary, Urban areas.***

1. INTRODUCTION

One of the most definite effects of climate change is increased heat exposure levels and there is considerable evidence of detrimental health effects of ambient heat. Although there is a considerable risk of heat stroke in tropical and subtropical regions, there is also a significant risk of heat stroke in temperate settings. In more temperate areas, the risk of death from heat waves is higher[1].

Heat exposure is very dangerous owing to what is known as the urban heat island in major cities. Moreover, there are places with climates that are currently hot and become hotter are the regions with high rates of urbanisation and population increase. This puts an increasing number of individuals at danger[2].

Air conditioning (AC) is marketed as an effective way to minimise heat-related health problems by reducing heat stress and protecting against heat exposure by providing interior thermal comfort. Although there are numerous compelling arguments for greater air conditioning use, it is critical to consider the material, discursive, and social elements of the technology. More than a decade ago, an author identified issues connected to AC's broad acceptance, and argues against the non-critical attitude prevalent in several public health and epidemiological research disciplines that advocate AC as the most effective answer[3].

This review article is based on the idea that there are more options than simply choosing a technology solution like air conditioning. This revised and enlarged overview is especially important in light of our growing awareness of climate change and the present increase in air conditioning consumption. If present trends in the usage of air conditioning continue, a researcher predicts a tenfold rise in energy consumption for cooling by 2050. The fastest-growing and densest cities in tropical and subtropical climates are likely to have the most growth[4].

The goal of this review article is to look at the issues that come with greater air conditioning use as well as more sustainable cooling solutions in order to better guide future ways to dealing with urban heat.

Researchers recognised that society is impacted by a collection of global processes of change, such as climate change, population increase, urbanisation, growing inequality, globalisation, and increasing complexity, after being inspired by studies on climate vulnerability. Authors also realised that society reacts to the resultant difficulties either proactively or reactively. It was thought that issues and solutions may be created or handled at multiple levels in society, based on multi-level governance approach. As a result, the author included a

spatial element. The issues were given a dimension, and the debate was organised according to the level of social organisation that the solution addressed. Identification was given special consideration. One problem is reinforced by another in a cyclical connection as a result of another's feedback[5].

Environment and sustainability science, architecture and urban planning, social sciences, health, risk management, and thermal environment research all contributed to the development of search terms for the literature search, which was done in a transdisciplinary setting to ensure a broad identification of challenges and alternative solutions. A three-step procedure was followed:

The first step consisted of: identifying search keywords and alternatives to increasing AC usage, database searches, identifying problems, and categorising challenges in the framework. Step two was using the search keywords and categorisations to see what the current research had to say on the five highlighted problems of greater air conditioning use to deal with metropolitan heat: environmental, organisational, socioeconomic, biophysical, and behavioural. Alternative solutions were found in step three by a second literature search, this time of peer-reviewed articles. It was thought that issues and solutions may be created or handled at multiple levels in society, based on multi-level governance approach. As a result, the author included a spatial element. The issues were given a dimension, and the debate was organised according to the level of social organisation that the solution addressed. Identification was given special consideration. One problem is reinforced by another in a cyclical connection as a result of another's feedback[6].

1.1 Challenges with air conditioning:

This section of the literature study is organised around the five types of difficulties. The first three categories are systemic: environmental, organisational, and economical. The final two—biophysical and behavioural—are personal, yet they are inextricably linked to the cultural environment and socioeconomic circumstances of people.

1.1.1 Environmental challenges:

The usage of electricity or energy grows when AC is adopted. According to current estimates, the globe consumes around one trillion kilowatt hours (kWh) of power for air conditioning each year, which is more than double Africa's entire energy consumption for all purposes. According to Isaac and van Vuuren (2009)'s modelling, global energy consumption for air conditioning will rise quickly in the twenty-first century. The median scenario for AC-induced growth in electricity usage goes from around 300 TWh in 2000 to over 4000 TWh in 2050 and over 10,000 TWh in 2100. The widespread use of air conditioning puts a strain on the energy distribution infrastructure and raises the likelihood of power outages. The choice of cooling technology will become increasingly essential for the evolution of energy usage, according to the IIASA's Global Energy Assessment study (2012). Increased power usage is already generating issues in many regions of the world as a result of these choices.

Because the usage of air conditioning is resource and energy demanding, it may have a detrimental influence on climate change and the environment in general. The sort of energy source utilised to provide the cooling has an influence on climate change. The usage of power is considerably increased while using an air conditioner. AC also adds to the UHI effect and, through heat ejection, has a direct impact on outdoor thermal comfort on city streets. Elevated urban temperatures, especially UHIs, can amplify and prolong heat waves, as well as increase the amount of power used by air conditioners at night. Climate change will increase outdoor heat exposure levels (IPCC 2014), and if current trends continue, both in terms of projected temperature rises and the rate of AC adoption, there will be more AC usage in metropolitan areas, particularly in the tropics and subtropics. This will create a negative feedback loop related to energy use and to the UHI effect.

1.1.2 Organisational challenges:

The organisational difficulties concern how we choose and organise supported services, as well as how we plan and design the growth of our cities. People who become increasingly reliant on air conditioning to cool their houses not only contribute to rising urban temperatures by releasing hot air, but they also increase their susceptibility. Building houses and communities that rely on air conditioning to cope with heat puts them at risk of power outages, which may grow more regular as the usage of air conditioning puts additional strain on the electric distribution system. Increasing interdependencies between societal systems, such as those for electricity production and distribution and those for thermal comfort, are well-known contributors to increased risk and vulnerability, as the increasing complexity increases the likelihood of two or more failures

interacting in unpredictable ways. As a result of these interdependencies, it becomes increasingly difficult to keep track of and manage the many levels of risk, as well as the associated risks real occurrences and judgments made in response to them, as a result of the fact that impacts can propagate across these chains of relationships throughout the board.

People who rely on electricity for cooling are, in other words, reliant not only on the operation of the energy distribution system, but also on the operation of all other linked systems. Because fossil fuels and hydropower stations are the major energy sources in many nations, a growing demand for electricity generates a reliance on global oil and coal prices, as well as political choices surrounding water resource management. Furthermore, such a civilization becomes more vulnerable to cyclones and other natural disasters that can inflict widespread devastation and long-term power outages.

1.1.3 Socioeconomic challenges:

Individuals and businesses are mostly investing in air conditioning at the moment. The original investment, maintenance, and ongoing power bills are all included in the price. In the home, air conditioning is often a local solution that addresses the heat problem in one room at a time, which means that a house or apartment without a central cooling system will require multiple air conditioning systems to cool the whole living space. Central cooling systems are available and are mostly utilised in business buildings or high-end individual residences. Because the cost of installing a cooling system is borne by the individual household, heat inequity exists between the wealthy and poorer parts of society.

Electrical household gadgets are becoming increasingly popular as living standards rise, and household energy usage rises. The issue in Hanoi is exemplified by the fact that the quantity and frequency of air conditioners used are connected to household monthly income and have a higher impact on yearly energy consumption than any other household equipment. Households using air conditioning consumed 4 GJ more power than those without.

1.1.4 Biophysical challenges:

The physiological foundation for heat's impact on people is widely known. Humans are born with a set of thermoregulatory sweat glands as well as a delicate regulation system. This system, however, can be influenced by factors like as pre-existing illness, clothes, age, gender, heat acclimatisation capacity, amount of physical activity, and body size. There are well-documented physiological consequences on the human body when the ambient temperature approaches or surpasses the human core temperature of 37 °C, posing dangers to various organ systems. As the body's core temperature rises, cutaneous blood flow increases and sweating occurs. Heat exhaustion is more likely at core temperatures over 38–39 °C, and above these values, heat stroke can develop, resulting in a breakdown of the thermoregulatory system. Dehydration, accidents, and heat exhaustion are just a few of the health implications, which also include an increased risk of respiratory and cardiovascular illnesses, renal failure, immune system weakness, and mortality.

Using one of the heat stress indices is one technique to measure heat. The relevance of these indices stems from the fact that heat stress is linked to a variety of environmental variables. The Wet Bulb Globe Temperature (WBGT), which is commonly employed in assessments of occupational heat stress, is one of these indicators. Temperature, humidity, and sun radiation are all factors in the ISO standard for WBGT. Depending on the intensity of the task and the clothes worn, a WBGT of 27 °C is considered a threshold for the requirement for worker protection. Assuming that interior temperatures are equivalent to outside temperatures without air conditioning, solar radiation's contribution to WBGT must be negligible.

1.1.5 Behavioural challenges:

In terms of culture, air conditioning has resulted in what may be described as an encapsulation of the house in warm climates, as well as major changes in the social geography of the home and neighbourhood. The expansion of contemporary construction techniques and confidence in current technical solutions to attain indoor thermal comfort has accelerated the use of air conditioning (AC). Local expertise on how to create a suitable temperature, both indoors and out, is lost in the process, and cooling solutions are increasingly delegated to technical experts.

Some experts suggest that as individuals become more acclimated to air conditioning, they become physically and emotionally dependent on it, making them more vulnerable to rising metropolitan heat. As a

result, traditional vernacular building designs that previous generations considered comfortable no longer match modern thermal comfort criteria.

1.2 Alternative or supplementary solutions to air conditioning;

This section focuses on alternatives or complements to the usage of air conditioning. Climate-sensitive urban planning and building design, alternative cooling technologies, and climate-sensitive attitudes and behaviours are all covered in this area.

1.2.1 Climate-sensitive urban planning and building design:

To combat the consequences of climate change, urban planning is critical. Climate-sensitive urban and building design, which refers to methods that adapt the urban landscape to the site, the area, and the environment, can avoid or reduce an unfavourable outdoor and indoor climate. The urban microclimate may be enhanced and the UHI impact decreased significantly with proper urban planning. The height-to-width ratio of urban street canyons, in particular, has a considerable impact on air temperature, solar radiation, and wind speed. Furthermore, how streets and buildings are oriented in respect to the prevailing wind directions has a significant influence on both outdoor and indoor ventilation. When opposed to a scattered urban design, a compact urban design results in significantly less radiation at street level and, as a result, lower daytime temperatures, reducing thermal stress.

1.2.2 Alternative cooling technologies:

Currently, research and development of novel cooling technologies and techniques that might potentially reduce energy usage is underway. Alternatives to traditional air conditioning include district cooling systems and renewable energy air conditioning. District cooling is used in several places throughout the world, such as Singapore, although it is not widely used. Solar cooling and absorption chillers are emerging technologies that have a significant potential to replace traditional cooling technology based on electricity. Solar cooling has the benefit of being both renewable and local, which is beneficial to both the regional energy supply and the energy consumer. Local energy generation increases a region's self-sufficiency and resilience to power outages.

Personal cooling solutions, such as cooling vests made of phase change materials, are also novel cooling technology. Such devices have the ability to chill the microenvironment of a person. However, they are frequently costly, making them inaccessible to the poor or not viewed as a priority. On a personal level, many people who cannot afford air conditioning make their own cooling systems out of basic and inexpensive items like fans, ice, and foam boxes. Some of these ideas have been commercialised in Hanoi to address the needs of low-income families. Although such systems are available to the least fortunate in society, they have their own environmental effect because ice production requires electricity and water.

1.2.3 Climate-sensitive attitudes and behaviour:

When it comes to lowering energy usage, studies show that behavioural adjustments may be more effective than physical ones. As a result, a more sustainable urban development with reduced AC usage and energy consumption necessitates not just technological solutions or professional knowledge, but also civil society participation. It will need efforts from city residents to contribute with adapted built environment and adaptive lifestyle choices, such as keeping in the shade, taking a nap during the warmest part of the day, or wearing climate smart clothes.

Mechanical cooling, which provides thermal comfort by generating a consistent, monotonous atmosphere, has been shown to be ineffective in a number of situations. Instead, because it is suited to both the outside heat and the person, an adaptive environment with aspects of human control has the potential to create a superior thermal environment. A cold stimulus delivered to a single body part (e.g., hand, head) has been proven to lower whole-body thermal stress, according to research[7].

2. LITERATURE REVIEW

Shahi Satyam at al. discussed Design and Development of Portable Air Conditioner in which they discussed how Air conditioning is described as the simultaneous regulation of temperature, humidity, cleanliness, and air motion, depending on the demand. Summer and winter air conditioning are the two types of air conditioning available. The air conditioner cleans, transports, and introduces the air to the conditioned room. It is used to heat and chill the air. The user's need for a portable air conditioner system should be met at the

lowest possible cost. The choosing of a system is influenced by a number of variables. It might be as simple as a temperature reduction or comprehensive environmental management. It might be the cheapest initial investment or the cheapest ongoing costs. The level of cleanliness, acoustics, and load concentration inside the area may all influence the choice. The air water system is used to power the portable air conditioner; with this system, the room unit is supplied with both processed air and chilled water[8].

Anshu Raj et al. discussed Design of Air Conditioning System for Commercial and Domestic Applications in which they explained how In public buildings, room air conditioners are often utilised in a single room. Both heating and cooling are accomplished with RACs. RACs come in a variety of sizes, including 1 tonne and 2 tonne. They determine and find out the precise or near-perfect temperature necessary for the specified room in which AC is installed in this article. This is significant for a number of reasons. A/C unit that is undersized will not chill the room during the summer or hot weather season[9].

Garud Akhilesh Ravindra et al. performed Study of Portable Air Conditioner in which they discussed how Heat has proven to be problematic in Malaysia and other countries. Working on a hot summer day may be exhausting, and you're more likely to make foolish and unintentional blunders. Having a decent air conditioner would be beneficial during these times. When performing work or attending an event, the technician or engineer may find the environment stifling and unpleasant. Air conditioners, on the other hand, are generally advertised as fixed and difficult to move places. Portable air conditioners, on the other hand, are a dollar a dozen yet somehow quite expensive to own. The creators of this project want to create a portable air conditioner that is inexpensive and can consistently chill tiny spaces for a short period of time and space[10].

3. DISCUSSION

This paper focused on several aspects of Air conditioning systems (ACs) which have been used very frequently nowadays by humans. Every system have some cons and pros. Air conditioning (AC) is marketed as an effective way to minimise heat-related health problems by reducing heat stress and protecting against heat exposure by providing interior thermal comfort. Although there are numerous compelling arguments for greater air conditioning use. Use of air conditioning system also bring several disadvantages and challenges with it. These several challenges including environmental, organisational, biophysical, behavioural and economical challenges have been discussed in this paper. This paper also discusses several alternatives which can be used in place of ACs. It provide overview of several existing prior arts of ACs.

4. CONCLUSION

Based on a literature analysis, the objective of the research presented in this paper was to investigate the problems associated with growing AC use and to suggest possible alternative or supplemental solutions that may be more sustainable. The findings demonstrate that there are a number of issues to consider while using air conditioning. The difficulties stem not just from rising energy use and its negative environmental consequences, but also from people and communities growing increasingly reliant on air conditioning. This is because continuous usage of air conditioning might cause individuals to lose their physical and mental capacity to manage heat, making them more sensitive to rising urban heat.

Furthermore, as different socioeconomic groups of society have varying capacity for reacting to rising difficulties, increased heat impacts individuals unequally. The implementation of more climate-sensitive building and urban design, the development of more energy-efficient cooling devices that rely on renewable energy and are also affordable for poor people, the promotion of a change toward more climate-sensitive life styles, and the support of cooperative efforts are all suggested in this paper as ways to slow the rapid growth of AC use. Finally, a more holistic approach is required, both in terms of integrating diverse solutions and incorporating various levels of society.

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