Why Nature-based Cooling?

Background:
Accelerating urbanization and unprecedented global warming have created critical environmental challenges. Every summer has been the “hottest summer on record,” increasing health risks and endangering human life. The rising frequency and intensity of heatwaves, which disproportionately affect vulnerable communities, require urgent and innovative interventions to mitigate rising temperatures. Staying home during heat waves will exacerbate racial/ethnic and socioeconomic disparities in heat-related morbidity and mortality (Gronlund 2014; Benmarhnia et al. 2015). This emphasizes the need for energy-efficient, long-term building adaptation strategies to prevent heat-related deaths. The exact number of heat-related deaths is unknown, but the number is excessive. Another study of 297 U.S. locations from 1997 to 2006 estimated 5,608 heat-related deaths (Weinberger et al. 2020). In developed countries, most heat-related deaths occur indoors, which may be partly due to higher heat exposure inside the home (Gronlund 2014; Fouillet et al. 2006). Expanding access to mechanical air conditioning is the fastest way to reduce home overheating and disparities (CDC 1994). However, tremendous disparities in access to mechanical air conditioning have been documented, explaining racial disparities in heat-related mortality (O'Neill 2005).

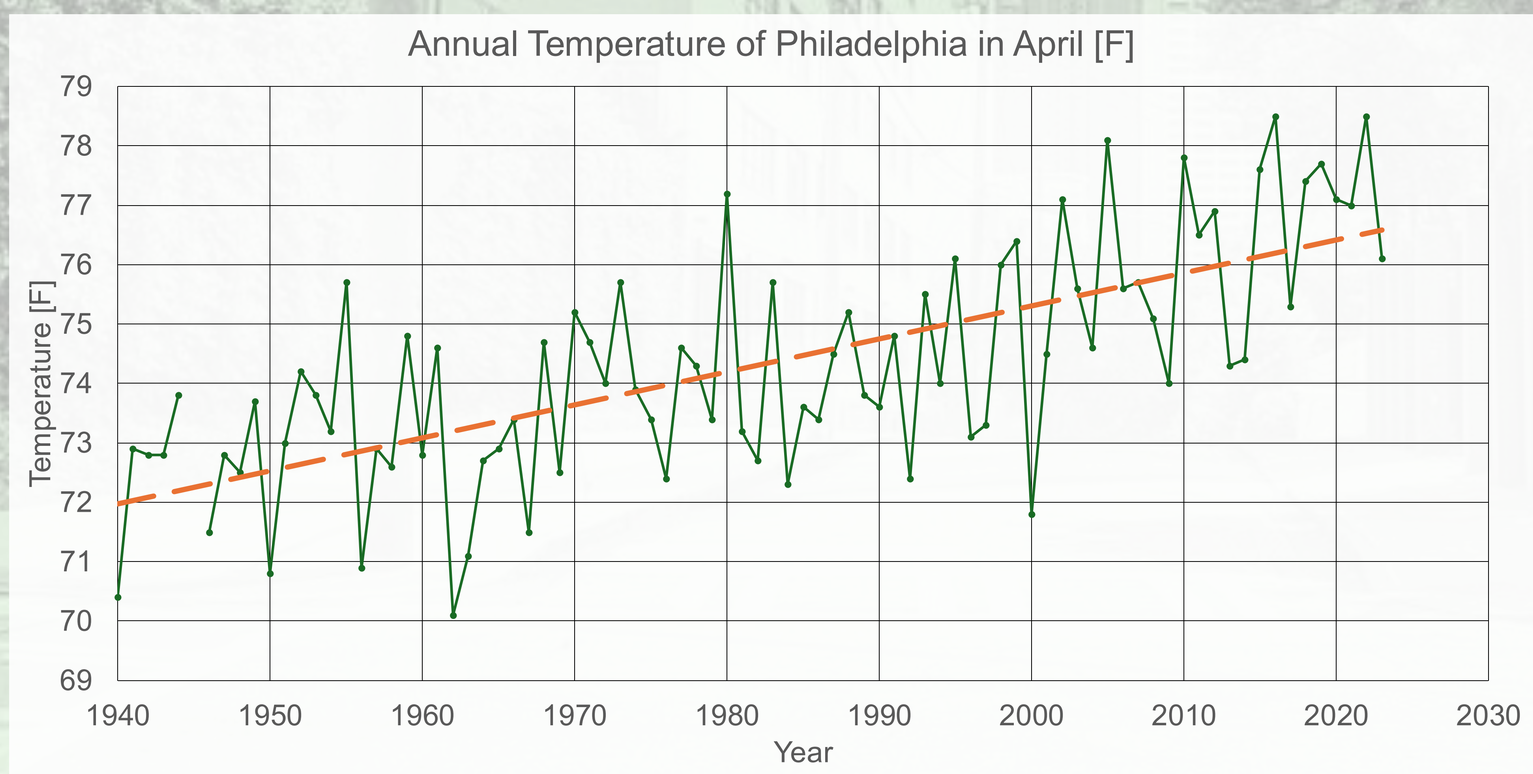


Figure 1. Annual average summer (July – September) temperature since 1940
Source: https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/city/time-series/USW00013739/tavg/12/4/1940-2025 produced 05/12/25

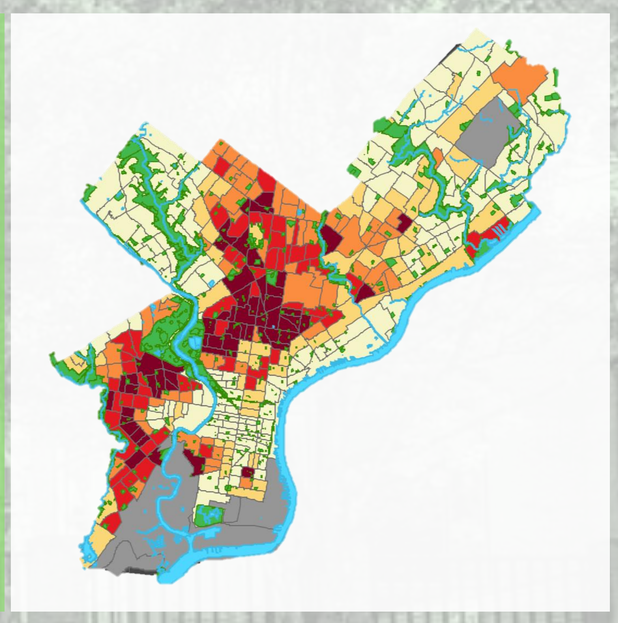


Figure 2. Philadelphia Heat Vulnerability Index interactive map showing neighborhood-level exposure and sensitivity factors related to extreme heat in Philadelphia.
Source: Philadelphia Department of Public Health (n.d.), retrieved from http://environment.upenn.edu/research/communities/adapting-extreme-heat-philadelphia-increase-human-vitality

More than three-quarters of U.S. households with incomes over $100,000 have central air conditioning, while less than 40% of poverty-level households have mechanical cooling systems (U.S. Energy Information Administration 2011). Mechanical air conditioning will increase disparities, energy use, and greenhouse gas emissions in the long run. Air conditioners and electric fans use 10% of global energy (IEA 2018). Based on the most recent Residential Energy Consumption Survey by the U.S. Energy Information Administration, 31% of households in the U.S. reported that they had trouble paying energy bills or adequately heating or cooling their homes (U.S. Energy Information Administration 2017). In qualitative interviews of residents of several major U.S. cities, participants reported utility costs as a barrier to air conditioning use (Sampson et al. 2013). Even if made affordable, peak energy demand during hot days overloads the electrical grid; this problem will intensify with increased global warming (Auffhammer et al. 2017) This, in turn, will contribute to power outages and potentially more dangerous conditions for vulnerable populations (Farbotko and Waitt 2011). There is ample evidence of the negative consequences of relying on mechanical cooling (Isaac and Van Vuuren 2009; Buranyi 2019). Areas across the world have experienced power outages due to excessive energy demands from air conditioner use during heat wave events (Klinger et al. 2014).

Problem
- Every new “hottest summer” magnifies indoor heat risk.
- 42 % of global heat deaths and most US events happen inside homes.
- AC is a stop-gap: fuels 10 % of all electricity use and widens energy poverty.
- Vulnerable groups suffer first.

Objective :
demonstrate opportunities and best practices for equitable integration of nature-based approaches into residential overheating protection strategies in Philadelphia, PA.

Passive Cooling
- Reflective pitched roof designs
- Thermal mass, light-colored interior
- Climate-adapted vernacular design

Landscape Architecture
- Tree canopy and urban greening
- Cool pavements and high-albedo surfaces
- Blue and green microclimate control

Building Envelope
- Low-emissivity and shaded windows
- Thermo-reflective insulated roofing
- Ground floor insulation strategies

Adaptive Behavior
- Occupant education and engagement
- Strategic use of shading and ventilation
- Community-based retrofit support and incentives

NATURE BASED SOLUTIONS

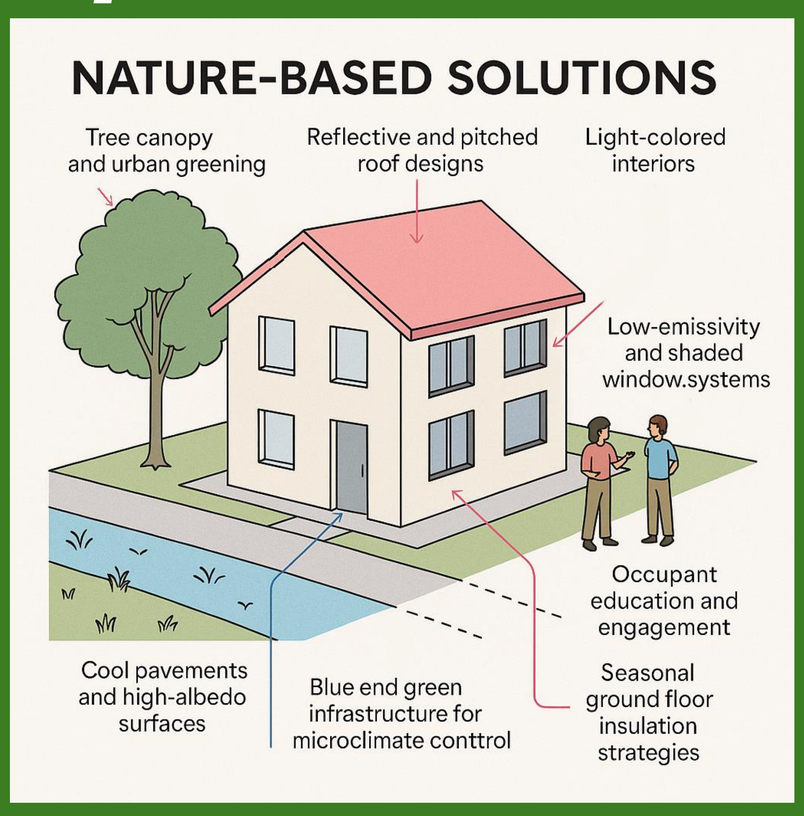
Simi Hoque, Leah Schinasi, Molly Henson and Ramyar Tajik

The majority of individuals spend more than 90% of their time inside buildings, underscoring the critical importance of healthy indoor environments. Excessive heat can have a significant impact on human well-being, affecting both physical and mental health, and prolonged exposure to high temperatures can lead to heat-related illnesses, ranging from heat exhaustion to heatstroke. Vulnerable populations, such as the elderly, young children, and individuals with pre-existing health conditions, are particularly susceptible to the adverse effects of excessive heat. These individuals often spend a significant amount of time indoors, making their homes the primary location where heat-related health issues can arise. Indeed, most heat-related fatalities tend to occur in residential settings, particularly within people's homes. Although mechanical air conditioning is a common choice for regulating indoor climate, it represents an unsustainable approach that will exacerbate health disparities, increase energy consumption, and add to greenhouse gas emissions. Instead, nature-based solutions, including energy-efficient building designs and landcover adaptation methods, can offer more cost-effective and climate-resilient solutions to protect public health from the effects of extreme heat.

In this chapter, we present nature-based solutions that can mitigate the mortality and morbidity associated with heat stress from indoor overheating. We review the literature from passive design, building science, landscape architecture, green infrastructure, and public health to identify behavioral and built environment strategies to address indoor overheating. Behavioral adaptations for cooling include actions and practices that a building occupant can implement to remain cool, such as reducing metabolic load, strategic ventilation, and night flush cooling. Building innovations include the use of reflective roofing and thermal mass to optimize cooling, as well as careful consideration of building orientation and material selection. And on a broader scale, community or regional interventions aimed at reducing urban heat islands involve cultivating green spaces and tree planting and enhancing the reflectivity (albedo) of pavements and rooftops.

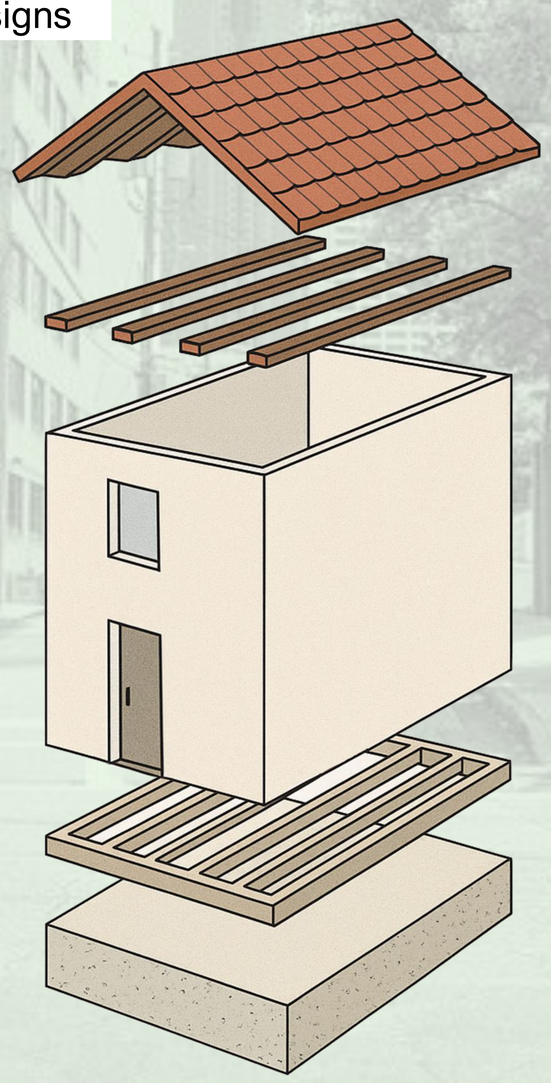
Ultimately by embracing behavioral, building and site design strategies tailored to specific regions and climates, future heat stress-related challenges can be avoided. Moreover, by applying these strategies to reduce reliance on energy-intensive mechanical cooling, we can not only drive down greenhouse gas emissions and forestall the ongoing climate crisis, but also derive multiple co-benefits such as reduced stress, improved wellbeing, increased community engagement, and social equity.

Nature-based solutions to overheating for equitable heat health protection



Design Playbook: From Roof to Region

Reflective pitched roof designs



The Cosmogenesis of Building: Ancient (eco)Logical Construction Practices

Eugenia Victoria Ellis, PhD, AIA

*From the trunk of a gum tree Numbakula fashioned the sacred pole (*kauwa-auwa*) and, after anointing it with blood, climbed it and disappeared into the sky. This pole represents a cosmic axis (*axis mundi*), for it is around the sacred pole that territory becomes habitable, hence is transformed into a world.*

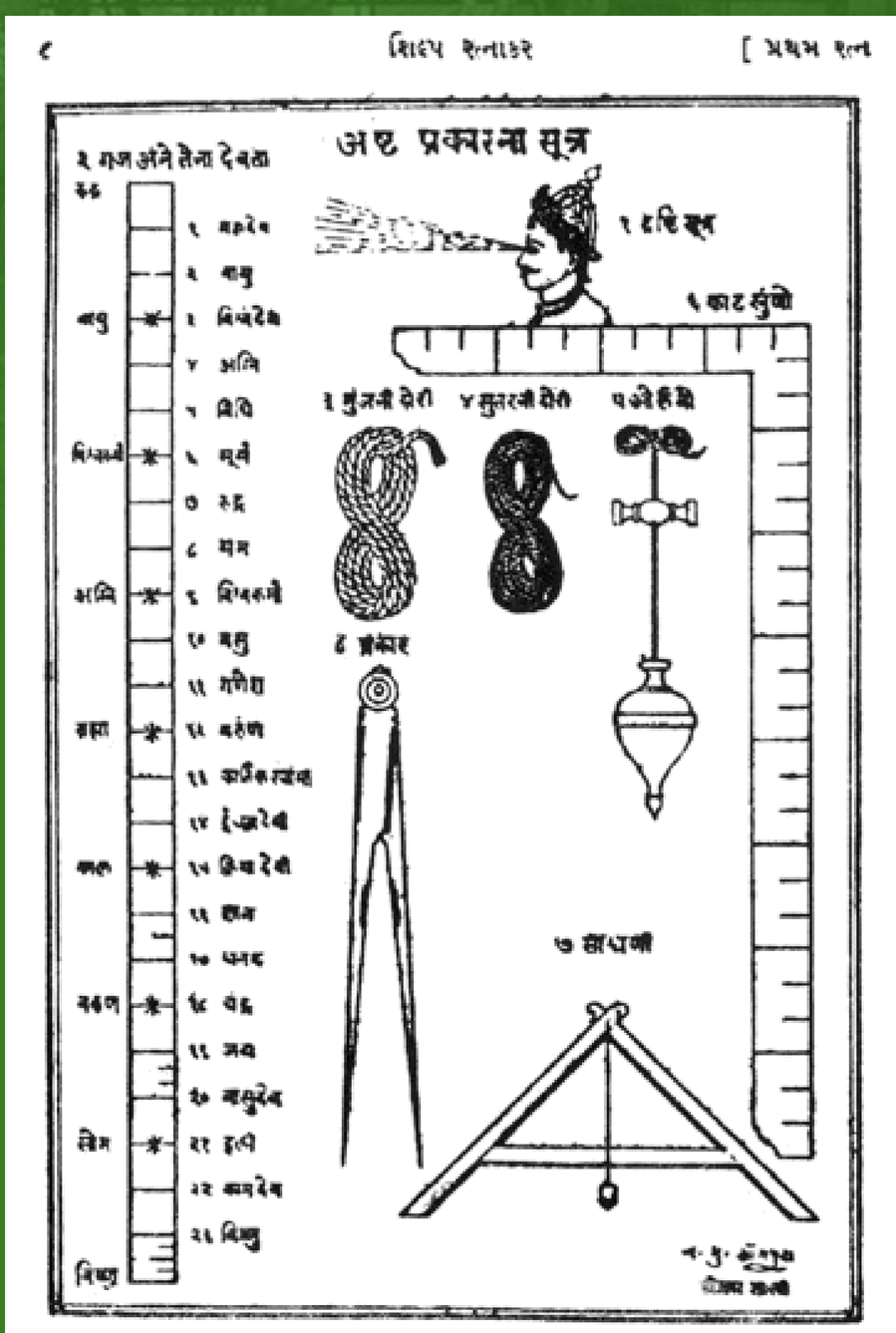
Mircea Eliade, *The Sacred and the Profane*

By looking up in order to contemplate heavenly bodies, and by looking down to examine into the natural influences of the earth, man may acquire knowledge of the cause of darkness and light.

Yih King, Chapter XIII, 1-12

ABSTRACT

The impending threat of climate change on the health of our planet has awakened a new environmental awareness in our culture so that today we are reconsidering the constructed world with respect to nature and the position of the sun to create low-energy sustainable environments. This “new” approach to the design of the constructed world reconsiders nature-positive ancient traditions that have been forgotten due to the new technologies of the past century that have allowed us to defy nature. These ancient traditions were (eco)logical — the forces of nature were used to shape the constructed world to create comfortable dwellings that responded to prevailing environmental conditions. The ancient built world was auspicious because it was oriented with respect to the natural world: the positions of the sun, the stars and the planets. The cosmological origins of building will be demonstrated by considering the ancient practices of *Vāstu Śāstra* and *Feng Shui* as a way of reconsidering present-day nature-positive (eco)logical approaches to design.



Sutrashtaka, the geomancer’s eight tools of measurement
(Chakrabarti, V. 1999: 40)