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BATTLING THE BLAZE – CHALLENGES POSED BY HEATWAVES AND EFFECTIVE MITIGATION TECHNIQUES



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Introduction to Heatwaves - A Critical Challenge:

¹In a stark wake-up call to the world, a groundbreaking rapid attribution study has issued a dire warning: the blistering heatwaves scorching the United States, China, and southern Europe throughout July 2023 are no longer isolated anomalies but ominous harbingers of our rapidly changing climate. This urgent revelation demands our immediate attention as we delve into the escalating crisis of heatwaves and their profound impact on our planet. The truth is unsettling as we witness a world where extreme heat is becoming all too commonplace and explore the far-reaching consequences that demand swift action. According to the findings of the study, the scorching heatwaves that gripped the United States, Europe, and China in July 2023 surpassed the temperatures of a world untouched by climate change by a staggering margin: 2 degrees Celsius hotter in the US (United States), 2.5 degrees Celsius hotter in Europe, and 1 degree Celsius hotter in China. These remarkable revelations underscore the grim reality of our planet's shifting climate and the profound impact it is having on our daily lives.

A heatwave is typically announced when the temperature of a particular region rises by about 5 – 6 degrees for a prolonged period. The criteria for heat waves vary from region to region. Heatwaves are a growing concern these days due to the rapid rise in temperatures owing to global warming and climate change. These devastating heatwaves, as evidenced by the alarming data, cast a wide-reaching shadow of adversity upon society, the environment, and the economy. In the United States, an astounding "historic" heatwave enveloped the nation, subjecting nearly one-third of its population to heat warnings. Records were obliterated as temperatures soared above 37.8 degrees Celsius, leaving communities in turmoil. As for southern Europe, the merciless grip of the "Cerberus" heatwave has led to a surge in hospital cases, painting a grim picture of the region's struggle to cope with the relentless scorching conditions. The intertwined repercussions on society, ecosystems, and the economic landscape serve as a stark reminder of the urgent need to address the growing heatwave crisis.

¹ <https://www.carbonbrief.org/record-breaking-2023-heat-events-are-not-rare-anymore-due-to-climate-change/>



Fig:1- Heatwaves in 2023 (Source: ncei.noaa.gov)

Need for Proactive Strategies and Collaborative Efforts:

People are dying from the unbearably scorching heat more than ever. Record highs in temperatures have been noted across the globe. In China, the stark reality of climate change was driven home when the remote Sanbao township in the Turpan depression of Xinjiang witnessed a temperature spike to an unprecedented 52.2 degrees Celsius on July 16, 2023, shattering the previous record of 50.3 degrees Celsius set in 2015.

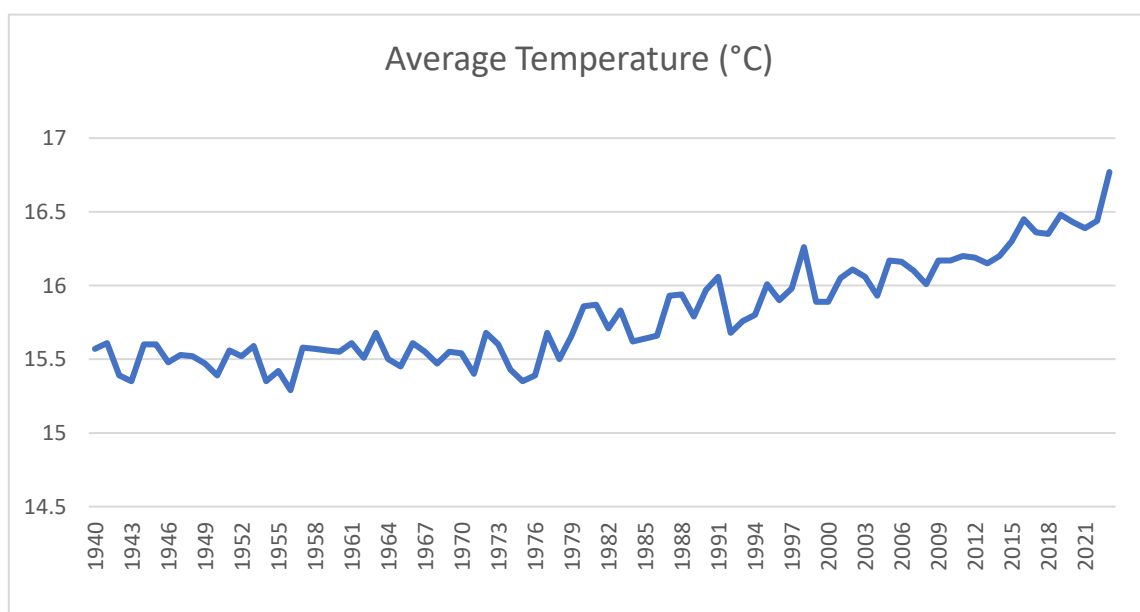


Fig:2- Average temperature (Source: climate.copernicus.eu)

Cacti that thrive in hot and humid environments are also dying and disintegrating due to the rise in temperature beyond endurance.²For instance, Arizona's iconic saguaro cacti are grappling with dire consequences amid the state's unprecedented stretch of extreme heat. The traditional summer monsoon rains, upon which these cacti heavily depend, have withheld their arrival. This climatic anomaly is putting the resilience of these cacti to a strenuous test, both in their natural habitats and within urban landscapes. Tania Hernandez, a research scientist at Desert Botanical Garden, notes that the relentless Phoenix heat, soaring above 43 degrees Celsius for an unrelenting 25-day period, is pushing these remarkable saguaros to their limits.

Therefore, it becomes vital for us to understand the impacts of heatwaves in a comprehensible manner and formulate mitigatory strategies as a community to prevent drastic consequences.

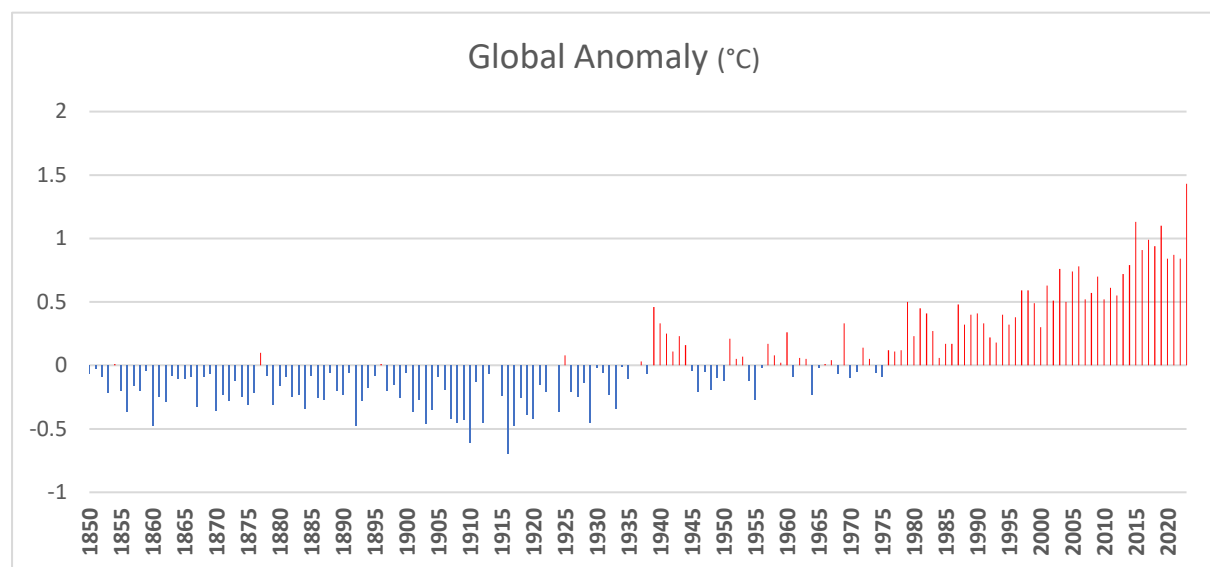


Fig:3- Global Anomaly (Source: climate.copernicus.eu/)

Misconceptions

Identifying common misconceptions about heatwaves

1. Heatwaves are merely another sizzling summer day:

Most people tend to treat heatwaves like any other sweltering summer day without understanding the potentially fatal consequences of a heatwave. A scorching summer day signifies a temporary rise in temperature, exceeding seasonal norms briefly due to several factors. A heatwave denotes an extended period of noticeably elevated temperatures, often surpassing historical averages for days or

² <https://www.reuters.com/business/environment/saguaro-cacti-collapsing-arizona-extreme-heat-scientist-says-2023-07-25/#:~:text=Cacti%20need%20to%20cool%20down,years%20to%20die%2C%20Hernandez%20said.>

weeks.³ For instance, the average long-term statewide annual temperature of Arizona is 15.4 degrees Celsius.⁴ But the longest recorded heatwave lasted for 101 days in Arizona in 1937 when the temperature was 38 degrees Celsius. Heatwaves induce not only discomfort but also increase deaths, strain infrastructure, heighten energy demand, and impact various sectors. Understanding the distinction between a hot day and a heatwave is vital for understanding the broader implications of changing climate patterns and the urgency of implementing mitigatory measures adaptive technologies.

2. Heatwaves only cause high temperatures:

Heatwaves cause a multitude of climatic conditions such as wildfires, accelerated evaporation of water from water bodies, and diminished air quality. For instance, the Panama Canal is currently facing a dire situation as it struggles with a significant decline in rainfall, which has plummeted to a mere 30 to 50 percent of the historical average. This extraordinary precipitation deficit is making the surrounding region endure one of its driest years in 143 years, as per data provided by the Smithsonian Tropical Research Institute (STRI). This severe scarcity of rainfall stands as the primary cause behind the concerning decline in water levels in the Panama Canal. As temperatures rise during heatwaves, vegetation becomes increasingly susceptible to ignition, fuelling the onset and rapid spread of wildfires. In a tragic incident, a firefighting plane crashed in Greece, claiming the lives of two airmen. This tragedy unfolded amidst a scorching Mediterranean summer heatwave, with Algeria also battling a deadly inferno that has taken at least 34 lives. Southern Portugal continued to grapple with massive forest fires, devastating approximately 15,000 hectares of precious woodlands. The worst of these blazes engulfed the southern Odemira region, leading to the evacuation of thousands and even threatening the renowned tourist destination of the Algarve. Experts attribute these recurring and intensifying heatwaves to the undeniable effects of climate change, with the Iberian Peninsula experiencing a disproportionate burden, marked by increased droughts and escalating wildfire occurrences. These fires devastate ecosystems, threaten communities, and affect air quality by releasing particulate matter and harmful gases into the atmosphere. Concurrently, heatwaves accelerate water evaporation, leading to the depletion of water resources that are already dwindling. The water in lakes, rivers, and reservoirs is reduced, posing threats to water supplies for drinking, irrigation, and industrial purposes. Simultaneously, the combination of high temperatures and stagnant atmospheric conditions exacerbates air pollution, causing respiratory issues and burdening healthcare systems.

Embracing the scientific realities of heatwaves is pivotal for effective adaptation and mitigatory strategies, urging us to address not only immediate discomfort but also the profound ecological, societal, and public health ramifications these events entail.

3

<https://azclimate.asu.edu/climate/#:~:text=The%20average%20long%2Dterm%20statewide%20annual%20temperature%20is%2059.7%C2%B0F.>

4

https://en.wikipedia.org/wiki/List_of_heat_waves#:~:text=The%20longest%20continuous%20string%20of,in%20Saskatchewan%20in%20July%201937.

The Environmental, Societal, and Economic Impact of Heatwaves

Relationship between Heat waves and Climate Change

The relationship between climate change and heatwaves is intricately. Due to reckless human activities, the planet is warming, leading to more frequent, intense, and prolonged heatwaves. Additionally, rising temperatures increase the likelihood of extreme heat events, and the warming atmosphere further exacerbates heatwaves. The relationship forms a loop where heatwaves can initiate wildfires, releasing additional carbon dioxide into the atmosphere and further adding to global warming.⁵ Every year, wildfires contribute around 3.5×10^{15} grams of carbon emissions to the atmosphere, which is approximately 40% of the carbon emissions generated from fossil fuel sources. To free the environment from this toxic cycle, the relationship between climate change and heatwaves should be acknowledged and collaborative responses must be formulated to tackle the issue.

Health Impacts: Risks to Vulnerable Populations

⁶Within the context of a warming global climate, a sizeable proportion of children, approximately one in three, are now encountering heightened exposure to extreme heat events. This vulnerability is particularly pronounced among infants and children, who display a limited capacity to effectively regulate their body temperature and a heightened sensitivity to elevated temperatures. Engaging in physical activities and play, they may inadvertently overlook adequate hydration, rendering them susceptible to heat-related ailments. As average air temperatures continue to rise, cases of heat-related illness are on the upswing, with half of those affected being children. This troubling trend, fuelled by the increasing frequency of record heat, presents significant risks to both adults and youngsters.⁷ Among the most vulnerable are infants left in parked vehicles and adolescents who, particularly on scorching days, are exposed to the perils of returning to school and engaging in sports activities. Alarming, over 9,000 high school athletes require treatment for heat-related illnesses annually, underscoring the urgent need for heightened awareness and preventive measures. Furthermore, the susceptibility of developing fetuses within expectant mothers to extreme heat is a growing concern, given the potential for adverse birth outcomes such as preterm delivery, low birth weight, and stillbirth.

Similarly,⁸ the elderly demographic emerges as a particularly vulnerable group in the face of heatwaves, posing critical implications for public health management strategies. Within this group,

⁵ <https://www.science.org/doi/full/10.1126/science.1130370>

⁶ <https://www.youtube.com/watch?v=oK9PdCYTqC8&t=95s>

⁷ <https://www.scientificamerican.com/article/heat-waves-affect-children-more-severely/#:~:text=Cases%20of%20heat%2Drelated%20illness,help%20protect%20them%20from%20overheating.>

⁸ <https://www.cbs8.com/article/news/local/protecting-the-elderly-during-the-heat/509-f28a3678-fc5b-495f-96f3-55b7e6a61f6a>

individuals afflicted by dementia are notably at heightened risk due to challenges in thermoregulation awareness and adaptive behaviour.

Agricultural Consequences: Crop Failures and Food Security

⁹The repercussions of heatwaves on agricultural landscapes have taken a formidable toll on the spring wheat crop during the year 2022. Evidenced by the first-hand account of a farmer in Delhi, the deleterious impact of extreme heat in March is apparent as it contributed to a disheartening 20% reduction in harvest yield. More troublingly, the smaller wheat grains produced under elevated temperatures stand in stark contrast to their regular-temperature counterparts, thereby significantly undermining the selling price of the wheat crop. The resonating consequence of such heat-induced crop depreciation not only reverberates within the agricultural sphere but also extends into the domains of nutrition and economy. This exemplifies an urgent call for multifaceted mitigation strategies that can alleviate the intensifying ramifications of heatwaves on vital sectors of our societal framework.

Ecosystem Disruption: Impact on Biodiversity and Ecosystem Services

¹⁰The harrowing consequences of Arizona's relentless heatwave have cast a grim shadow over honeybee populations, triggering a profound disruption in their delicate ecosystem. At the heart of this ecological issue lies the distressing fate of honeybee hives and their essential food sources, both succumbing to the onslaught of extreme heat. This catastrophic event strikes at the very core of biodiversity as honeybees, the natural pollinators, occupy a pivotal role in sustaining the balance of our ecosystems. The rising heat has left an indelible mark as hives crumble, melt, and disintegrate, often claiming the queen bee in the process. The loss of queen bees within the hives disrupts the process of reproduction as there are no other bees in the hive to take over the queen bee's job of laying eggs. Compounding this disaster, the very sustenance of these bees, the pollen-rich plants, struggles to flourish amidst the sweltering heat. The urgency of this issue cannot be overstated, for the plight of honeybees resonates across human domains, impacting agricultural yields, ecosystems, and subsequently, our own well-being. In this moment of crisis, the plight of these pollinators beckons for swift action - a reminder that placing buckets of water with strategically placed wine corks or small wooden pieces is not just an act of compassion, but a critical measure to safeguard these vital agents of our ecosystem against the relentless threat of heatwaves.

⁹ <https://www.pbs.org/newshour/show/indias-early-heat-wave-has-major-implications-for-agriculture>

¹⁰ <https://www.youtube.com/watch?v=CNvPiILMgQg>

Financial Impacts in Agricultural and Industrial Sectors

¹¹The escalating concern of heatwaves bears an adverse economic aftermath, casting an ominous shadow on investment prospects. Rising temperatures render regions less enticing to potential investors. ¹²According to the Climate Vulnerability Monitor, India experienced a significant income loss equivalent to 5.4% of its GDP (Gross Domestic Product) in 2021 due to an intense heatwave. A 2015 study conducted in India revealed that heat stress had substantial adverse effects, reducing milk yield by 30-35% in crossbred cattle and 20-30% in buffaloes. Beyond the immediate impact on milk production, heat stress also led to alterations in milk composition, affecting both the quality and value of the produced milk.

¹³Findings from a study estimated that the world suffered a staggering \$16 trillion in losses from 1992 to 2013 due to the detrimental effects of high temperatures on human health, productivity, and agricultural output. The surge in heat also amplifies electricity demand, triggering coal depletion and power outages, leading to heat-induced strains on infrastructure.

In India's complex heatwave situation, two things are happening. First, the industrial sector is struggling due to lower labour productivity. Second, agriculture is suffering from reduced output, especially with withering wheat crops causing prices to rise. India now faces a crucial decision point: it must choose between pursuing more development or moving toward sustainable, carbon-neutral practices. This choice will have a significant impact on its future, both economically and environmentally. This calls for a deft balancing act, one where the nation's aspirations must harmonize with the imperatives of ecological resilience or risk the multifaceted repercussions of heatwaves eclipsing the trajectory of economic progress.

Best Practices to help Mitigate the Effects of Heatwave

Addressing Urban Heat Islands

Urban Heat Islands refer to localized areas within cities and metropolitan regions where the temperatures are significantly higher than the surrounding rural areas. This phenomenon occurs due to the concentration of human activities, impervious surfaces, and artificial structures in urban environments, which collectively lead to elevated temperatures. ¹⁴An example of this phenomenon is the glaring 20-degree Fahrenheit difference in temperature between the South Bronx and Central Park in the US. City planners confront an urgent call to action, mandated by the exigencies of this ecological predicament. The imperative to build cities that are not just habitable but amenable to

¹¹ <https://youtu.be/IlzgeFMfg5U>

¹² <https://www.smallcase.com/blog/examining-the-economic-impact-of-indias-heatwave/#:~:text=Unfortunately%2C%20the%20heatwave%20doesn't,to%20the%20heatwave%20in%202021>

¹³ <https://home.dartmouth.edu/news/2022/10/heat-waves-have-cost-world-economy-trillions-dollars>

¹⁴ <https://www.youtube.com/watch?v=0Wevbkcg43g>

thriving existence becomes a paramount challenge. In this pursuit, the integration of green infrastructure emerges as a transformative approach. A vigilant commitment, encompassing welfare checks and social support systems, the linchpin in the endeavour to mitigate the reverberations of heatwaves, a call for collective unity in the face of an evolving climate.

Community Engagement: Public Spaces and Heat-Resilient Neighbourhoods

Amidst the escalating challenges posed by intensifying heat waves in urban areas, the imperative to establish heat-resilient neighbourhood and rejuvenate public spaces has become paramount. The phenomenon of urban heat islands compounds these issues, disproportionately affecting vulnerable communities. Effective community engagement emerges as a linchpin in this endeavour.¹⁵ Amid an unprecedented late winter heat wave in central Brazil, communities are rallying together for relief from heat. A dedicated 53-year-old environmental activist in Brazil is leading the charge by planting green roofs on homes in Rio. These green roofs, which combat the scorching temperatures, are constructed in the tightly packed working-class neighbourhoods where houses often have scrap metal roofs. This community-led initiative harnesses the power of collective action to combat the extreme heat, fostering resilience and reducing the need for energy-intensive cooling and heating systems.

Sustainable Architecture: Building Designs for Heat Resilience

In the pursuit of urban environments capable of withstanding escalating heat challenges, sustainable architecture emerges as a solution, redefining building designs for enhanced heat resilience. Green roofs and living walls, seamlessly melding nature with construction, provide natural insulation and mitigate urban heat island effects. By embracing these sustainable architectural tenets, we are positioned to build an environment that deftly navigates the challenges of an increasingly heat-prone world, exemplifying a harmonious synergy between human habitation and the natural world.

¹⁶Noteworthy examples encompass Mashrabiya, intricately designed Islamic balconies veiled with lattice patterns, serving as thermal buffers; stepwells, integral to Indian temple architecture, offering subterranean respite from soaring temperatures; and windcatchers, a testament to desert communities' wisdom, channelling cooling breezes indoors.

Early Warning Systems: Advances in Prediction and Communication

Early warning systems have undergone remarkable advancements by harnessing cutting-edge technologies for predicting and communicating heatwave events. By integrating sophisticated meteorological data and satellite imagery, these systems can now provide more accurate and timely

¹⁵ <https://www.devdiscourse.com/article/science-environment/2602958-brazil-favela-activist-plants-green-roofs-to-combat-heat-wave>

¹⁶ https://www.instagram.com/p/CvZWOOdt-YP/?img_index=2

forecasts of impending heatwaves.¹⁷For instance, the influence of global warming on heightened extreme precipitation in the US Midwest necessitates a nuanced understanding of its underlying dynamics. Researchers are attempting to reveal the intricate relationships between atmospheric temperature elevation and shifts in circulation patterns to elucidate the factors driving intense rainfall events by developing a machine learning model. Informed by these insights, our approach to long-term community resilience, infrastructure design, and disaster preparedness can effectively address the escalating challenges posed by a changing climate, fostering a future marked by adaptability and robust sustainability.

Smart Cities and IoT: Technology-Driven Heatwave Response

Smart cities are harnessing the power of IoT (Internet of Things) technology to enhance their response to heatwaves. By deploying sensors throughout urban areas, real-time data on temperature, humidity, and other key factors are collected, enabling informed decision-making during heatwave events.¹⁸For example, Palo Alto stands as a beacon of innovation with its implementation of smart city initiatives, notably through the deployment of cost-effective air pollution sensors. This strategic move has resulted in a commendable 36% reduction in greenhouse gas emissions, underscoring the city's commitment to environmental stewardship. Furthermore, Palo Alto has set an ambitious official policy goal of achieving an 80% reduction in carbon emissions by 2030, a testament to its proactive stance in combatting climate change. Through these endeavours, Palo Alto emerges as a model smart city, pioneering sustainable practices that hold the potential to inspire transformative change on both local and global scales.

Personal Preparedness: Staying Safe During Heatwaves

¹⁹Surviving heatwaves requires a combination of strategic measures to ensure well-being. Staying hydrated through ample water consumption, including drinking ice-cold beverages, remains paramount. Additionally, practical techniques such as soaking feet in water buckets or placing damp towels on the head can offer relief. Cold showers and facial sprays provide instant refreshment. To counter dehydration, it is advisable to avoid caffeine and alcohol due to their diuretic effects. Maximizing air circulation by opening doors and windows during the cooler night hours while keeping blinds closed during daytime prevents indoor heat accumulation. Staying on lower levels of buildings, as warm air rises, proves beneficial. Identifying air-conditioned public spaces like libraries and malls offers respite. Decreasing internal heat sources by switching off lights, computers, and ovens helps manage temperature. Implementing fans enhances air movement. By adhering to these guidelines, individuals can effectively navigate heatwaves and safeguard their well-being.

¹⁷ https://youtu.be/_R8r4bB2T4w?si=1U-stCI5bT5dkdLI

¹⁸ <https://youtu.be/nnvRZotnPSU?si=ixUEHMhm4JYumzXg>

¹⁹ <https://youtu.be/ter31IGeXzs?si=HsUwNRKg723jq1SI>

Case studies

1. The Heat Islands of Paris

²⁰Paris has taken proactive measures to combat the sweltering heatwaves that increasingly affect the city during the summer. It has established a network of cool 'islands,' consisting of more than 800 spaces like parks, forests, swimming pools, and museums, where residents and visitors can find relief from the scorching temperatures. These areas, typically 2°C to 4°C cooler than the surrounding streets, owe their cooling effect to features like water and vegetation, enhancing climate resilience and overall liveliness in Paris. To assist people in locating these cool spots, the city has developed the EXTREMA mapping app, which saw 6,000 downloads in its first year. The app also allows residents to provide feedback on these cool islands, enabling the city to make improvements and track the usage of these valuable spaces.

2. Medellín's Green Corridors Project

²¹Federico Gutiérrez, serving as the mayor of Medellín, has spearheaded the transformative Green Corridors initiative, resulting in the successful planting of an impressive 30 million trees. The project's impact is exemplified by the notable reduction of over 2 degrees Celsius in temperatures. Beyond its environmental benefits, the initiative ingeniously revitalized once-abandoned trash sites, historically linked to drug use, into vibrant gardens. Notably, Gutiérrez's visionary approach entailed the employment of dedicated gardeners who received comprehensive training, simultaneously creating employment prospects for the unemployed. This commendable effort has resulted in the establishment of 30 verdant corridors across Medellín, underscoring the mayor's commitment to ecological rejuvenation, temperature moderation, and community empowerment. The success of this project, evidenced by the significant reduction in temperatures and the transformation of urban spaces, highlights the potential of strategic tree planting and environmental rejuvenation in mitigating heatwaves. By adapting similar programs, countries can enhance urban greenery, establish temperature-regulating corridors, and address issues like abandoned spaces creatively.

²⁰ https://www.c40knowledgehub.org/s/article/Cities100-Paris-is-using-blue-and-green-infrastructure-to-tackle-city-heat?language=en_US

²¹ <https://youtu.be/Kv0m2MSlo2s?si=YXcXWHqpNhJ9XOg2>

Conclusion

In conclusion, the escalating frequency and intensity of heatwaves underscore the pressing need for immediate and concerted action. As we witness the tangible impacts of extreme heat on public health, ecosystems, and infrastructure, it becomes evident that complacency is no longer an option. The imperative to implement comprehensive mitigation and adaptation strategies is fuelled by the potential to safeguard lives, bolster community resilience, and preserve the integrity of our environment. By prioritizing proactive measures such as early warning systems, collaborative urban planning innovations, and sustainable resource management, we can navigate the complex challenges posed by heatwaves and forge a path toward a more secure and sustainable future.