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Mitigation of Extreme Heat and Sustainable Cooling

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Abstract

The last 5 years have seen the hottest weather on record with many countries experiencing exceptionally warm spells. Extreme heat impacts on health, productivity and economics and the impact is greatest in cities and it dis-proportionally affects the urban poor. This paper initially gives data on global temperature change, as well as the prevalence and impact of extreme heat in cities.

To help cities mitigate the impacts of extreme heat the Adrienne Arsht-Rockefeller Foundation Resilience Center and the Extreme Heat Resilience Alliance in collaboration with the UN Environment Programme, the Cool Coalition, RMI, the Global Covenant of Mayors for Climate and Energy, Mission Innovation and the World Economic Forum's Global Commission on BiodiverCities by 2030 are developing a toolkit for city officials. This paper describes the toolkit called the Heat Action Platform.

The Heat Action Platform is a living, engagement-oriented tool for city officials, practitioners, and financial institutions to find guidance, both existing resources and tailor-made solutions, on reducing the human and economic impacts of extreme heat at the regional or municipal level. The platform offers opportunities to engage with world-leading experts across a diversity of disciplines to plan, fund, implement, and measure heat resilience actions. The paper describes

the rationale behind the heat action platform, its development and how it is being used to mitigate the impacts of extreme heat. Future opportunities to collaborate are identified.

1.0 Introduction

This paper follows a relatively new collaboration from a number of organisations on extreme heat and potentially how to mitigate. Extreme temperatures have been experienced in most locations over the last decade and prevalence is increasing. The impacts are significant, diverse in nature and often differentially affect poorer countries and communities, since they are often geographically in warmer climates where people have less resources to mitigate.

The collaboration have been actively researching the subject for several years now. The Adrienne Arsht-Rockefeller Foundation Resilience Center (Arsht-Rock) have been addressing through identifying immediate, scalable solutions to address the widespread and intensifying consequences of climate change since 2019. The Cool Coalition, RMI, the Global Covenant of Mayors for Climate and Energy, Mission Innovation have all been active in the subject and developed "Beating the Heat" a sustainable cooling handbook for City Officials launched at COP26. and the World Economic Forum's Global Commission on BiodiverCities by 2030 are developing a toolkit for city officials (UNEP, 2021). Whereas the City of Athens was one of first cities to appoint a Chief Heat Officer to address climate resilience and mitigation initially locally and now globally in 2021.

In 2022, the various teams listed above started to work together to raise the profile of the subject, understand the work that has been published in this area and support Arsht-Rock in the development and implementation of a Heat Action Platform to enable City Officials to mitigate the impact of extreme heat. The focus of this paper is to introduce this topic and continue to build awareness of the subject. The paper describes some of climate data and future temperatures predictions, the impact of extreme heat, the development of the Heat Action Platform and how it is being used to mitigate the impacts of extreme heat. Future opportunities to collaborate are identified.

2.0 Climate data and future projections

Since the 1980s, each decade has been warmer than the previous one. The year 2022 surpassed the average temperature for the 20th century of 13.9°C by 0.86°C, making it the sixth warmest year on record since worldwide records began in 1880 (National Centers for Environmental Information, 2022). The previous nine years since 2014 rank as the nine warmest years on record, with the ten warmest years in the 143-year record all occurring since 2010 (ibid, 2022). Every month's worldwide surface temperature in 2022 was among the 10 warmest for their respective month. (ibid, 2022)

There is no doubt that we are living in an increasingly warming world, setting new heat records nearly every year, and significantly impacting the health and productivity of communities worldwide. Observations indicate that the frequency, length, and size of extreme temperature

events are increasing globally. Heatwaves account for the deadliest weather-related hazard and the dangers posed by extreme heat are growing at an alarming rate due to climate change (IFRC, 2022). Between 2000 and 2016, around 125 million more people were exposed to heat waves (World Health Organization, 2018), with more than 70,000 additional deaths in Europe in 2003; and 55,000 deaths in Russia during the 2010 heatwave (IFRC, 2022).

Future global temperature increases are dependent on how effective strategies are to reduce release of greenhouse gases. Predictions based on the IPCC Sixth Assessment give a number of scenarios with global temperature change prediction of between 1.4°C and 4.4°C by 2100 above preindustrial levels. With second most extreme scenario giving an average global temperature increase of 3.6°C but also reports that 50-year heat waves will occur nearly 40 times more often (IPCC, 2022).

Individual countries have published their own predictions for climate change. In the UK we have assessed the growth in potential demand for cooling using cooling degree days by comparing recent annual cooling degree days compared to long term averages. The results of our analysis are shown in Table 1 below. This shows that cooling degrees in London in 2020 (represented by Gatwick) be similar to Rouen in France between 2000-17. If this rate of increase in temperature continues over the next 20 years the temperature will be similar to Barcelona in 2020.

Location	Ave. annual cooling degree days 2000–17	Ave. annual cooling degree days 2017-20	% increase
Gatwick	29	46	57%
Rouen	52	83	59%

Table 1. Long term change in cooling demand in London

According to the report 'Assessment of Climate Change over the Indian Region' published by the Ministry of Earth Science, Government of India, the average temperature over India will rise by approximately 4.4 degree Centigrade by the end of the 21st century as compared to 1976-2005 average. The report also warns that the frequency of heat waves during the summer season (April - June) will rise by 3-4 times with twice the average duration.Extreme heat is not only limited to the Indian sub-continent but such instances are also a reality in the European region.

In cities and urban areas there are additional climate impacts associated with the urban heat island effect (UHIE). This potentially leads to increase in temperatures due to heat absorption on roads, lack of natural ventilation and vegetation in built up areas and heat rejection from buildings and equipment. It has been reported that the UHIE could lead to rise in urban temperature by 10

degrees Centigrade as a result London has recently (2022) revised the severe weather and natural hazards frameworks to account for extreme heat.

However, human health is not the only variable affected by climate change and the excessive heat we are currently experiencing. Consequences are also being felt in terms of water availability, rising sea levels, animal extinction, food insufficiency, and increased poverty (United Nations, n.d.). All these factors combined, life on earth could be in jeopardy within a few decades if efforts to counter climate change are not strengthened.

3.0 Impact of extreme heat

In a warmer climate, heat waves are becoming more severe, frequent, and longer lasting. Natural cold occurrences are also expected to decline significantly (IPCC, 2007). As a result and under a business-as-usual scenario, the worldwide average number of cooling days will increase by around 25% by 2050. (IPCC, 2007) Currently, extreme conditions exist on less than one percent of the planet, primarily in the Sahara (UNEP, 2021) but that is likely to increase significantly. Even temperate climates like the UK have experienced extreme conditions with a record temperature of 40.3°C being recorded in 2022, nearly 2°C higher than the previous high (Met Office).

Extreme and prolonged heat has cascading effects on ecosystems, agriculture, water, energy as well as on human health, productivity, and wellbeing. During the last decade, extreme heat in India, China, the Pacific NorthWest, Europe, and other parts of the world has negatively impacted hundreds of millions of people (C40, 2021). These extreme heat incidents have directly impacted the health and well-being of people and especially in the case of urban dwellers living in low socio-economic conditions. Particularly vulnerable are also infants and young children (UNICEF, 2022), the elderly, people that are chronically ill, as well as women that are pregnant or breastfeeding (IFRC, 2022). The list of the health effects of heat waves is long and it includes significant mental health problems. Heat also causes lack of sleep and fatigue, which increases workplace accidents (UCLA, 2021) and lowers productivity (ArshtRock, 2021). Urban commercial activity tends to decline as well. There is evidence indicating that heatwaves notably increase violence in communities (Lancet, 2021), and even lower the ability of children to learn (PBS, 2019).

Recent extreme heat events have encourage governments to develop plans. Some national and local authorities but not all have strategic plans, early warning systems, and/or other measures to protect the vulnerable and mitigate the severe effects of extreme heat and its concomitant crises: drought, wildfires, floods and pollution. Extreme heat raises the number of deaths and hospitalizations, inflicts loss of wages, lowers school attendance and creates inhumane conditions for the urban poor. It also reduces crop yields, inhibits pollination, creates water scarcity and increases cattle related diseases and other ecosystemic pathogens. Finally, extreme heat affects modern urban infrastructure not built with such temperature specifications such as asphalt roads, steel railways, bridges and energy systems (WP, 2022).

This, while 1 in 7 people globally (1.2 billion people) do not have adequate access to cooling (SEforALL, 2022): the rising heat, coupled with lack of access to cooling, is a grave threat to

people's ability to survive extreme temperatures, store nutritious food, or receive a safe vaccine, ultimately undermining the ability of humans to thrive and the achievement of the SDGs.

4.0 Categorizing and naming heat waves

Despite the overwhelming evidence, public understanding of the risks of heat is low compared to other natural disasters.

Current heat warning systems do not fully account for heat's risk to human health, and need to be enhanced to address the dangerous gap between the damage caused by heat and our awareness of the threat. Categorizing extreme weather events using health-based metrics promotes better disaster preparedness and response, higher impact public messaging, and, ultimately, saves lives. Meteorological terms such as heat index or wet bulb temperature can be complex and difficult to understand. Categorization using health-based metrics and improved public messaging are key steps towards helping local residents understand the risks they face and deliver the protection they deserve. It also allows for more efficient and targeted allocation of government resources, and specific disaster preparation and messaging that can be scaled to meet the challenge of an upcoming heat wave.

Experience shows that when authorities base their heat warning system on health-based metrics like estimated mortality or morbidity and link effective communication and intervention strategies, they save lives. A 2018 study of heat warning systems in the United States found that the only city with a heat warning system that saves lives is Philadelphia, which uses a health-based metrics warning system.

Hurricanes and other dangerous weather events are already frequently named, and this helps to sound the alarm on an upcoming public health emergency and build a culture of preparedness. The naming of weather hazards improves clarity when communicating with the public, and research has found significant improvement in residents' preparedness when storms are named. Currently, heat waves are named in an ad hoc fashion for reference and archival purposes such as the 2020 "Labor Day Heat Wave" in California and the "Pacific Northwest Heat Dome" event of 2021.

In Europe, the City of Athens, Greece, and the City of Seville in Spain, two European cities increasingly suffering from extreme heat events, piloted during the summer of 2022 a new heat/health categorization system with technical support by Arsht-Rock Resilience Center. The Arsht-Rock methodology is data-driven and unique to each individual city. After analyzing several decades of local meteorological and health data provided by each of the two cities, a special algorithm was created capturing the co-relations. This city specific algorithm was then used to predict the severity of the next heatwave's impact on the local populations. In July 2022 temperatures soared in the City of Seville, reaching and exceeding 42° C/108° degrees for several days. Seville's sophisticated heat wave naming and categorization system identified Heat Wave Zoe – the world's first-ever heat event to officially be named, creating a unique awareness raising event for the dangers of extreme heat.

5.0 The Need for Sustainable Cooling

To cope with extreme heat and its impacts, global demand for cooling to achieve thermal comfort is rising: this will result in a greater demand for fossil fuel-based energy to power air conditioners and other cooling appliances, which will ultimately contribute to rising emissions and global warming. In a detrimental feedback loop, the rising demand for cooling contributes to further climate warming (UNEP and IEA, 2020).

The use of air conditioners and electric fans accounts for almost 20% of the total electricity used in buildings worldwide today and, if not managed properly, energy needs for space cooling will triple by 2050, together with associated emissions (IEA, 2018). Considering current cooling practices and future predictions, the projected rise in global power consumption for space cooling will account for 18% of the overall increase in global carbon dioxide (CO2) emissions from 2016 to 2050 (UNEP, 2021).

It is unrealistic to hope coping with extreme heat, while depending on cooling strategies that exacerbate global warming. In the next four decades, by focusing on improving energy efficiency and phasing out extremely polluting refrigerants, our planet could avoid the equivalent of four to eight years' worth of global yearly greenhouse gas emissions based on 2018 levels (UNEP and IEA, 2020).

To achieve these climate benefits while expanding access to thermal comfort, the Cool Coalition have proposed the following holistic to mitigate the impacts of heat in a sustainable way (Cool Coalition, 2019). This is:-

- REDUCE where possible the need for mechanical cooling through better urban planning and building design, passive solutions, and nature-based solutions.
- SHIFT cooling to renewables, district cooling approaches, solar powered cold chains, and other low-carbon cooling solutions
- IMPROVE conventional cooling by increasing the efficiency of air conditioning and refrigeration equipment and demand response measures
- PROTECT vulnerable people from the effects of extreme heat and consequences of unreliable medical and agricultural cold chains
- LEVERAGE cooperation between different actors active in cooling and affected by extreme heat impacts to achieve a greater collective impact

6.0 Description of the Heat Action Platform (HAP)

The REDUCE, SHIFT, IMPROVE, PROTECT and LEVERAGE approach was used in development of the Beat the Heat Handbook published at COP26. The Heat Action Platform, launched in May 2022 at the World Economic Forum, built upon this and is intended to be an online one-stop shop where users—particularly practitioners, policymakers, and development finance institutions—can learn how to reduce the risks and impacts of heat. More details on the HAP can be found here (Arsht-Rock, 2023).

The goals of the platform are:

1. Connect practitioners and community leaders with global experts to co-develop heat resilience solutions that meet local needs.
2. Support implementation of heat adaptation and mitigation resilience initiatives related to extreme heat and urban cooling.
3. Identify environmental, economic and social benefits of different heat resilience interventions.

The platform offers opportunities to engage with world-leading experts across a diversity of disciplines to plan, fund, implement, and measure heat resilience actions.

It was developed by the Adrienne Arsht-Rockefeller Foundation Resilience Center (Arsht-Rock), the UNEP-led Cool Coalition, the Global Covenant of Mayors for Climate and Energy, Mission Innovation, and RMI, in partnership with the WEF's Global Commission on BiodiverCities by 2030. The platform is available in English and Spanish.

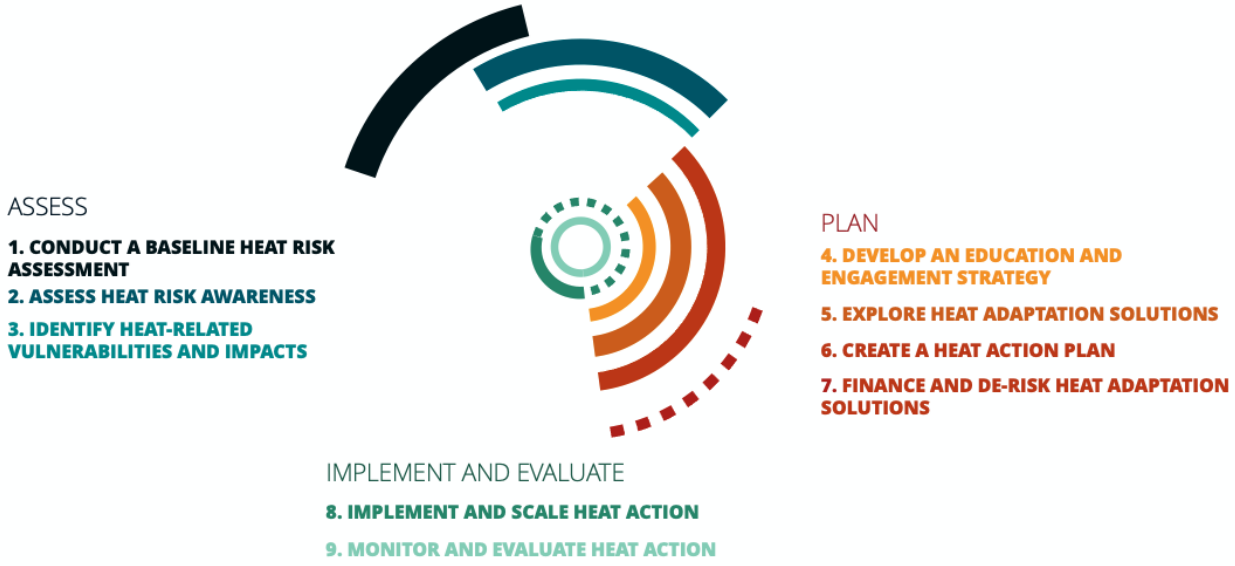

Figure 1: The 9 modules of the Heat Action Platform's educational framework.

Many resources related to heat planning and adaptation already exist, but there is no go-to online repository where best practice resources are all in one place and organized coherently within educational and analytical frameworks, alongside additional decision-support tools. The platform will enable users to develop a robust approach to mitigating the effects of climate change, as well as reduce carbon emissions from mechanical cooling and make a much better environment for residents and community to live and work.

The platform's Heat Policy Tool, a filterable repository of 90 heat resilience solutions with a growing database, is a prioritization tool that provides tailored solutions to users anywhere in the

world. Each "solutions card" contains a combination of a specific policy (e.g., mandate, tax incentive, public commitment) and an intervention (e.g., green infrastructure, cool roofs).

The platform might be used for:

1. A heat action plan or similar planning initiatives: If you are preparing a climate-focused plan such as a heat action plan you can proceed through the steps largely in sequence, recognizing that much of the assessment and planning can and should be done concurrently.
2. An individual project/policy initiative with the goal of safeguarding people from heat: Many of the steps recommended for developing an overall plan are applicable, in a narrower focus, when considering individual projects and policies.
3. A component or lens for another plan to embed heat preparedness strategies: If you are looking to embed elements that protect people from heat in another plan, you will have varying amounts of existing assessments accessible. You can use the platform to assist with identifying solutions and financing options.
4. A reference to evaluate the effectiveness of heat resilience efforts for funders and investors: If you are looking to support investments in heat resilient communities or projects, you may not have direct experience with such efforts, limiting your ability to engage, assess funding opportunities, and invest. You can use the platform to understand global best practices for designing and implementing integrated, multi-solution approaches to heat resilience.

7.0 Plans for testing

Following a user testing process in Fall 2022 that solicited feedback on the platform from over 20 organizations and experts from around the world, in 2023, Arsht-Rock and its partners will workshop and pilot the platform with cities, national and regional governments, and development finance institutions. These pilots are intended to test the platform “on the ground” and support government planning for heat and project preparation.

In parallel, Arsht-Rock will incorporate user feedback into the platform, restructuring it and adding new topics, visual assets, and features (e.g., search capability). This will include the translation of the platform into 2-3 additional languages.

New resources and tools will be continually added to the tool, and platform content will be updated – this platform must be a living resource because heat planning is a dynamic and rapidly changing space. Through this process, Arsht-Rock and its partners aim to make the platform the center of gravity for anyone who is concerned about how heat is impacting them, their communities, or their constituents and partners.

8.0 Conclusions and next steps

The paper describes the challenge associated with extreme heat facing us all. It describes the temperature conditions experienced recently and the potential future trends. The impact of this will be significant on health but also have other socioeconomic impacts which are described. The impact will be felt by the most vulnerable communities.

To prepare for this a method of categorizing and naming heat waves is described, alongside the approach to deliver cooling more sustainably. The Heat Action Plan being developed for use by local authorities and councils is described. Opportunities to be involved in piloting or testing the platform is encouraged.

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