Understanding extreme heat and entry points for action

Australian Red Cross · ISET International · Monash University · IFRC · Zurich

Acknowledgements

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Cover Image: Silhouette of residents exercising in a park with the City of Sydney in the Background. Source: iStock

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What is PERC?

The Post-Event Review Capability (PERC) is a systematic framework for the analysis of a disaster event. It focuses on how a specific hazard event became a disaster and what worked and what didn't work in terms of disaster risk reduction, preparedness, response, and recovery with the goal of developing considerations for building resilience to future hazard events[1]. PERCs have been carried out across the globe after floods, bushfires, and tropical cyclones, and have been applied in both urban and rural settings. This study is the first PERC on extreme heat.

Extreme heat is the deadliest climate hazard in Australia - it kills more people than all other natural hazards combined[2]. This PERC, collaboratively delivered by Australian Red Cross, ISET-International, Monash University, the International Federation of Red Cross and Red Crescent Societies, and Zurich Australia explores the effects of ongoing extreme heat events in Adelaide, and in Australia more generally.

The objective of this research is to gain a deeper understanding of how communities adapt to extreme heat, the strain placed on local resources by repeated extreme heat events, and the long-term health and social impacts of these events.

This brief is one of three from the PERC Adelaide study. See also, "Understanding extreme heat and entry points for action" and "Strengthening resilience to extreme heat: an Adelaide case study".

Methodology used in this study

This study is based on in-person and online interviews conducted primarily in June and July 2025, complemented by desk research. A wide range of actors - including representatives from local and state governments, researchers, engineers, meteorologists, city planners, educators, emergency responders, health professionals, union representatives, and community organisations - contributed to the study through key informant interviews, offering a rich mix of experience, expertise, and insights.

Over the summer of 2024-2025, Adelaide experienced many hot days and an extended hot season. Overall, 2024 was the second hottest year on record (after 2019), and minimum temperatures were the hottest on record. However, interviewee insights reflected how intangible and fleeting the experience of extreme heat can be. Rather than focusing just on heat experienced in the 2024-2025 summer, what emerged from this PERC was a broader picture, informed by interviewee experiences of hot summers over the past decade, and of what heat impacts can and might look like as temperatures continue to rise.

Urban Climate Resilience Program

The PERC Adelaide study is aligned with and complementary to the Urban Climate Resilience Program UCRP brings together global actors - including the International Federation of Red Cross and Red Crescent Societies (IFRC), ICLEI, C40 Cities, R-Cities and Plan International—to advance climate resilience initiatives in urban contexts across nine countries. Funded by the Z Zurich Foundation, Australian Red Cross, in partnership with Zurich Australia, is leading UCRP implementation in Australia with a focus on Western Sydney. The PERC Adelaide study highlights shared experiences of extreme heat and common challenges faced by urban communities, which are applicable to both Adelaide and Sydney and demonstrate the broader relevance of the findings for cities across Australia and beyond. In this context, UCRP Australia represents an integrated approach to urban climate resilience, combining community-led, ground-up action with engagement of local governments and city-level actors to drive sustained policy change. Together, PERC and UCRP enable Australian Red Cross to deepen understanding of heat risk through diverse expert and stakeholder perspectives, while building locally led solutions that translate evidence into tangible improvements in people's lives.

1. The problem of heat

Heat is rapidly becoming one of the biggest global challenges; temperatures are rising worldwide, and Australia is no exception. As shown below, measured temperatures have significantly increased over the past 50 years, and the past 15 years have been among the hottest since 1876. According to the Australian Climate Risk Assessment[3], extreme heat days are projected to continue to increase, with impacts to health and economic output: deaths due to extreme heat could quintuple and economic output could be reduced by AUD135-423 billion by 2063[4].

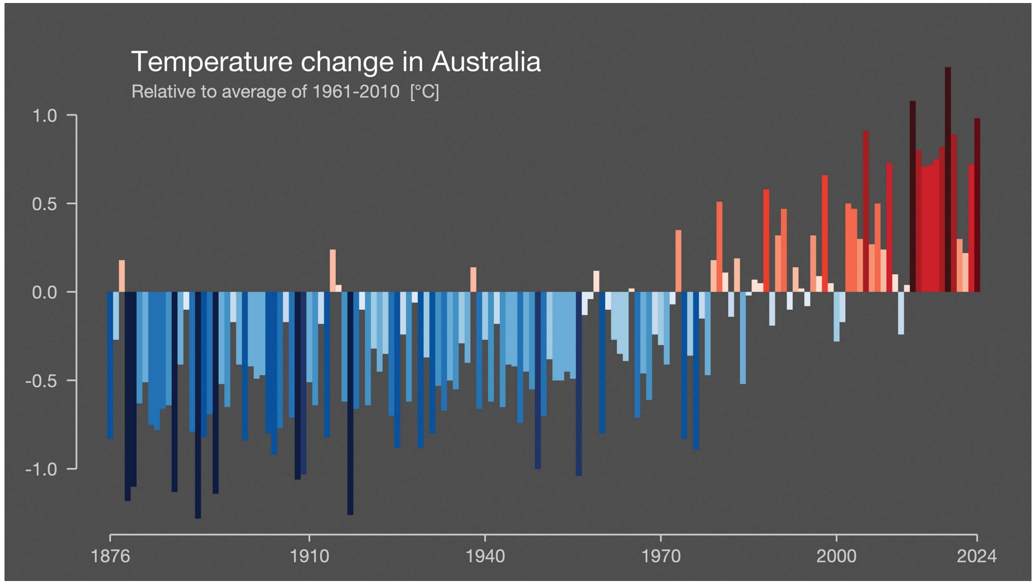


Figure 1: Temperature change in Australia for the period 1876 to 2024, relative to the average temperature from 1961-2010 (i.e. the average temperature from 1961-2010 is set at zero and years that were colder than that average are shown in blue and years hotter than that average shown in red). This illustrates how much cooler measured temperatures used to be, and how much hotter they have become, particularly since 2000. From https://showyourstripes.info/c/australasia/australia/all

In spite of the data and projections, long-term adaptation to the impacts of increasing temperatures has not received the attention it warrants. Heat impacts virtually all systems - including power, water, shelter, transportation, health, livelihoods, and education. We need to understand the impacts that heat has and could have on these systems so that we can adapt and ensure the services these systems provide, services which underpin the very functioning of society, can continue uninterrupted.

This brief provides insight into the challenges posed by and opportunities to address heat, drawing on learning generated in a 2025 Post-Event Review Capability (PERC) study in the city of Adelaide, South Australia. As the first heat PERC, the study sought to understand both key questions and answers about heat impacts and resilience in an urban setting, illustrated with examples and case studies from Adelaide.

This report also brings together current thinking about heat as a hazard that is broadly applicable to any context. However, this study is fundamentally focused in an urban setting; rural settings will have a unique set of challenges specific to that context.

The challenge of learning about what heat means to different people living in different contexts as temperatures rise and what to do about it cannot be overstated. Heat is different to other hazards in many ways, including how people experience it. While many people have not experienced the direct impacts of floods or bushfires, the potential for these hazards to become disasters is well understood. Heat, on the other hand, is more insidious. Though everyone experiences it, heat impacts vary widely, and heat is perceived more as an individual or isolated challenge than a growing societal problem. Understanding the different ways people talk about heat, when heat is a problem, why heat isn't talked about, and how to adapt to heat is critical to begin to tackle the mounting threat of heat.

Urban environments and heat

While temperatures are rising around the world in both rural and urban settings, cities are heating up faster than the global average[5]. By 2050, the urban population exposed to high temperatures will increase by 800 percent; an estimated 1.6 billion people[6] living in cities will face frequent disruptions to health, education, livelihoods, and systems due to extreme heat. For Australia, where over 86 percent of residents live in urban environments as of 2024[7], the challenges of urban heat are particularly relevant.

Urban areas often experience significantly higher temperatures than their rural surroundings due to the urban heat island (UHI) effect, where heat-absorbing surfaces such as asphalt and buildings, limited vegetation, reduced airflow, and heat emissions from machines like cars and air conditioners increase heat[8 9]. UHI effects can be city-wide, but can also create pockets of extremely high heat in small, localized areas (these are sometimes referred to as intra-urban heat islands[10]), increasing both daytime and nighttime temperatures and significantly increasing heat risk.

Localized urban heat is typically not taken into consideration in weather forecasts and heat warnings; as a result, areas that experience such heat can be at significantly greater risk than the forecast suggests.

Urban heat disproportionately impacts lower income areas due to higher density of buildings and infrastructure and less green space[11]. The impacts of urban heat are further exacerbated in many of these areas by poor-quality construction and by the inability of residents to afford active cooling like fans, air conditioning, and refrigerated air. Adelaide faces similar UHI challenges to other cities around the world. Both new developments to accommodate the needs of a growing urban population and infill are contributing to the UHI. PERC interviewees noted that dense construction, limited tree cover, artificial turf[12], and poorly insulated structures increase the heat exposure of Adelaide residents; this is corroborated by the Urban Heat and Tree Mapping Project conducted by Green Adelaide.

The particular nature of many urban environments around the world - dense, less green space, more heat absorbing surfaces - increases the heat exposure for urban residents. However, it also provides entry points for adapting to heat through, for example, planning and development, converting paved lots to green space, planting trees, using energy efficient building materials and design, and building up rather than out.

Leveraging these entry points will help to ensure that cities and communities reduce their risk and build heat resilience for both today and the future.

2. The many faces of heat: from heatwaves to chronic heat

Heat is rising rapidly across the globe, posing an increased threat to human health, livelihoods, and essential systems. As this threat is changing rapidly and presents in different ways around the world, there are many ways of describing the challenge. Below are definitions for various common heat terms, adapted from the Red Cross Climate Centre[13].

Extreme heat: Unusually high daytime and/or nighttime temperatures, sometimes combined with other factors like humidity, wind, or solar radiation, that create above-normal heat stress compared to local climate conditions. What is considered “extreme” varies by region and season, depending on typical temperature ranges and/or local thresholds for heat-related impacts. Extreme heat may last for a single day, several days (heatwave), or even longer periods (chronic heat).

Heatwave: Heatwaves are defined by the World Meteorological Organization (WMO) as “a period where local excess heat accumulates over a sequence of unusually hot days and nights”[14]. In practice, heat is generally not characterized as a heatwave unless it is a minimum of three consecutive days and nights of unusually hot weather during which local excess heat accumulates. However, there are no universal numeric limits to characterise heatwaves; most heatwave criteria are based on heat impacts that are defined locally and can vary significantly at (sub-) national scales, due to factors such as geography and topography, built environment, acclimatisation of the local population, and atmospheric and other conditions[15].

Chronic or seasonal heat: Persistent or recurrent periods of unusual or extreme heat over weeks or months. While these conditions may not meet standard heatwave definitions, they can still result in heat stress and cumulative health risks, productivity losses, and infrastructural strain. Chronic heat can also be an extended heatwave or a series of heatwaves in rapid succession. Addressing chronic heat requires responses beyond emergency management, focusing instead on sustained solutions that target structural and social determinants of risk[16].

Heat stress: A condition that occurs when total heat input exceeds the capacity of the human body or a system to dissipate or tolerate that heat. Heat input can come from environmental sources (air temperature, humidity, solar radiation), internal metabolic activity (e.g., physical exertion), or other heat sources (e.g., machinery, indoor environments). In humans and animals, heat stress can occur even under non-extreme weather, when internal or environmental heat accumulates faster than it can be released (e.g., by sweating) leading to rising core temperature and risks of heat-related illness and death. In plants, heat stress typically results from sustained or extreme environmental heat, often combined with water stress, and can cause wilting, reduced yields, dieback, or death. For infrastructure, excessive heat (from the atmosphere, direct solar load, or waste heat) can soften or melt materials, impair efficiency, and increase the likelihood of failure.

Resilience: Resilience can mean different things and is used in many ways. Here, we define resilience as “the ability of a system, community, or society to pursue its social, ecological, and economic development and growth objectives, while managing its disaster risk over time in a mutually reinforcing way”[17]. This definition emphasises that the goal of disaster resilience is long-term well-being. However, as risk changes, maintaining that well-being may require the ability to take adaptive action and to make fundamental changes to systems to adapt to changed risk.

Urban Heat Island (UHI): Urban areas often experience significantly higher temperatures than their rural surroundings due to heat-absorbing surfaces like asphalt and buildings, limited vegetation, and heat emissions from machines like cars and air conditioners. UHI effects can be city-wide, but can also create pockets of extremely high heat in small, localised areas. UHI effects increase both daytime and nighttime temperatures and can significantly increase heat risk. Localized urban heat is typically not taken into consideration in weather forecasts and heat warnings; as a result, areas with high urban heat can be at significantly greater risk than the forecast suggests.

For many communities, traditional and local knowledge has long described heat patterns – from seasonal cycles and local cooling practices to indicators of when heat becomes dangerous for people, plants, and animals. However, different countries, and even jurisdictions within countries, use different terminologies to describe the same or similar aspects of heat.

Though these heat terms are in broad use, the practical distinctions between terms and experiences can blur. One day of extreme heat can leave people with heat stroke. Heatwaves with high nighttime temperatures rather than extreme daytime temperatures can lead to poor sleep and the erosion of people’s mental and physical health. Relentless hot weather can result in weeks of chronic heat.

Across sectors, the same blurring of definitions is evident: health services face surges in heat-related illness; energy and water systems strain under prolonged demand; and labour, housing, and urban planning sectors confront cumulative stresses that no longer fit within the boundaries of a “heatwave”.

Realistically, these terms describe overlapping experiences of a growing hazard. People, institutions, and sectors alike should use and adapt the language that best reflects their local realities, while working toward a shared understanding of heat risk.

Case study: How heat warnings are calculated in Australia

The goal of heat warnings is to provide advance information about when potentially impactful heat will occur. Over the last two decades it has become increasingly evident that “potentially impactful” includes more than just peak daytime temperatures. In 2006, a heatwave in Adelaide resulted in repeated, severe failure of the electrical infrastructure at night, causing widespread blackouts. This led to investigations by the energy regulator into why energy generators were unable to maintain power[18].

At the time, nighttime temperatures were not part of the forecasts; the Bureau of Meteorology (BoM) heatwave warnings were issued when the forecast was for a maximum temperature of 40°C or more for three days or 35°C or more for five days. Consequently, a heatwave warning alone did not provide energy generators the information they needed to meet demand and maintain operations. This led the BoM to work more closely with stakeholders and redevelop the system for calculating and issuing heat warnings.

The BoM now calculates an ‘excess heat factor’ (EHF) index[19 20], which is location-specific, for use in forecasting and warning for heatwaves. Conceptually, what the EHF is measuring is shown in Figure 2. The EHF calculation itself:

- includes maximum and minimum temperature over a period of three days. Three days has proved to be more effective than a shorter or longer span of days in assessing how heat builds up over time and results in impacts for people, environments, and systems;
- compares maximum and minimum temperatures to the 95th percentile mean temperature[21]. The 95th percentile means the excess heat factor is only calculated when temperatures are unusually high; and
- incorporates an ‘acclimatisation index’ based on the average temperature for the previous 30-day period. The acclimatisation index adjusts for whether heat has been slowly building over time and people and infrastructure have had a chance to get used to it, or if the heat is sudden onset and comes as a more of a shock.

Globally, meteorological departments calculate heatwaves differently, so some factors may be left out of calculations in certain areas that are included in others. Ideally, calculations will include both maximum and minimum temperatures, look at a series of days, not just a single day, and include a period of previous temperatures to reflect acclimatisation.

Meteorological departments sometimes work with other agencies to provide recommended actions in the event of extreme heat. For example, the BoM only warns for the hazard itself - ‘severe’ and ‘extreme’ heat - but not its impacts. Instead, in South Australia the BoM relies on their partnership with South Australia State Emergency Services (SA SES) to warn of impacts and recommend specific actions for staying safe.

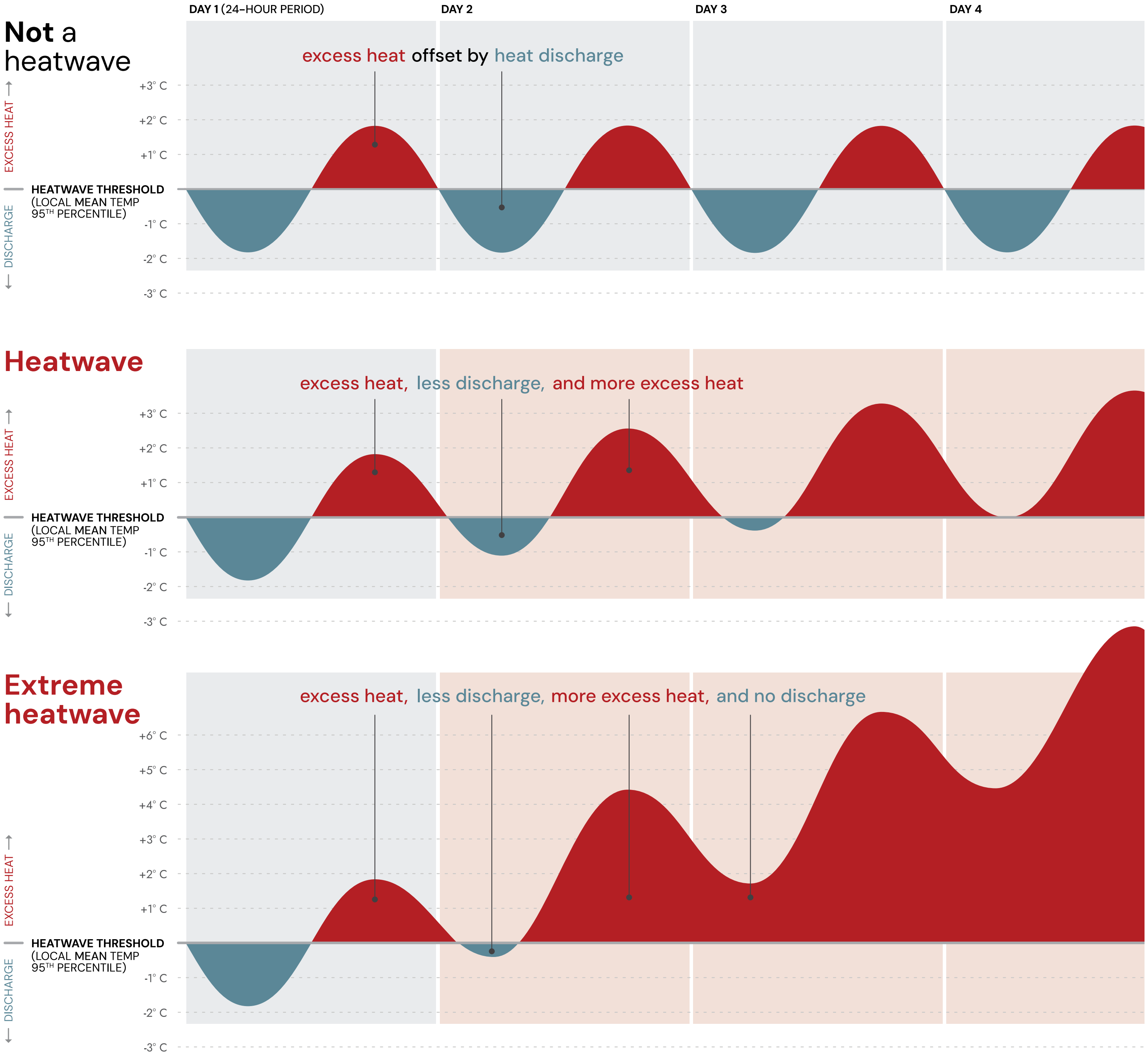


Figure 2: Understanding Heatwaves: Beyond Extreme Temperatures, John Nairn, Global Heat Health Information Network, January 2026.

Heatwaves are caused by 'local cumulative excess heat over a sequence of unusually hot days and nights'. The daily cycle of temperature warms during the day and cools at night, with excess heat measured around the 95th percentile-based threshold.

When daytime heating (red) is offset by overnight cooling (blue), it is not a heatwave, even when daytime temperatures are unusually high.

The middle panel illustrates increasing daytime and overnight temperatures - the heat discharge (blue) is much smaller than the excess heat (red) during the day, which is cumulative over the sequence of days. In this instance, cumulative excess heat over the sequence of consecutive days (red) results in a heatwave.

The bottom panel shows a sharp increase in both daytime and overnight temperatures - again, heat discharge (blue) is much smaller (or non-existent) than the cumulative excess heat (red). This is also a heatwave, but one that is more intense, possibly extreme.

3. Heat risk

Heat risk manifests through the combination of hazard, exposure, vulnerability, and capacity, which all play a role in influencing the point at which heat transforms from bearable to uncomfortable to catastrophic. When it comes to heat, the distinctions between these risk variables are often blurred; it is not always clear when heat is a hazard. In particular, heat exposure can be modulated by the same factors (e.g., access to cooling) that also play a role in vulnerability/capacity (e.g., affordability of cooling). Heat is a problem for people, ecosystems, and critical systems when it overwhelms their capacity to cope with or adapt to heat impacts, which is why heat risk is varied for different people and groups, and is exacerbated when vulnerabilities and exposure are unrecognised and unplanned for or heat warnings do not reach the right people[22].

3.1 Hazard

The point at which heat becomes a hazard is less clear than for other hazards like flooding and bushfire because when it becomes a hazard is a function of temperature, duration, and timing.

- **Temperature:** The absolute temperatures to which people, systems, or assets are exposed is a core consideration. However, when temperatures become a problem is only partially understood. For example, research is finding that heat mortality is occurring at temperature thresholds much lower than had previously been considered problematic[23].
- **Duration:** The length of time people, systems, or assets are exposed to heat can influence when heat becomes a problem. If heat is only brief - for a few hours or a day - then it typically also needs to be more extreme to be damaging. Conversely, a series of even just moderately hot days paired with warm nights that don't cool down, can lead to a build-up of excess heat over time that can be as damaging as short-duration extreme highs. This is true for people, ecosystems, infrastructure, and assets. For people, there is also growing evidence that chronic exposure to heat at levels that don't present as immediate health threats can nonetheless contribute to chronic health issues over time[24].
- **Timing:** Heat may be disproportionately impactful depending on its intensity, the season, its location (i.e. if heat is unusual for the context) or if it is sudden onset. This is why heat indices often include temperatures from the previous 30 days as a way to help identify how acclimated or unacclimated people, ecosystems, and infrastructure are to the heat. It is a common perception that people, ecosystems, and infrastructure in hot climates are accustomed to high temperatures and are therefore immune to the most serious impacts of extreme heat.

  While this is true to some extent, acclimatisation varies significantly, and or people, plants, and animals is subject to absolute physiological limits. Acclimatisation also takes time to develop, and it wanes in the absence of prolonged heat exposure. This means that it affords less protection against abrupt and unusual changes in temperature and humidity.

3.2 Exposure

Heat exposure is the extent to which people, ecosystems, infrastructure, or assets come into contact with high temperatures. For people, exposure is determined by a variety of factors including:

- **Cooling:** access to cooling is the primary way people mitigate exposure. This can be active cooling, like fans, evaporative cooling, or refrigerated air. It also includes seeking out shade or naturally cool areas like areas near water or where there is a breeze.
- **Ability to shed heat:** high humidity, lack of air flow, and heavy or occupationally protective clothing limit the ability of people, plants, and animals to respond to excess heat. Humidity and lack of airflow limit the body's ability to cool down through sweating or for plants to cool off via transpiration. For people, heavy or protective clothing both traps body heat further increasing heat load, and prevents sweating from operating to cool the body.
- **Occupational factors:** people in outdoor and informal workers and those who work in poorly ventilated spaces often face higher heat exposure because they can't seek out cooler areas, shade, or breezes, and are often subject to prolonged heat exposure, increasing the heat hazard itself.
- **Urban heat island (UHI) effect:** UHI increases heat exposure by trapping and amplifying existing heat. Lack of green spaces, tree cover, and heat absorbed by buildings and roads make urban areas significantly hotter, often hotter than the weather forecast.

3.3 Vulnerability and Capacity

In disaster risk reduction, vulnerability and capacity are related, with capacity reducing vulnerability. Heat vulnerability is the susceptibility of individuals, communities, or systems to the adverse effects of heat. Capacity is the combination of strengths and resources available to individuals, communities, or systems that help to reduce the adverse effects of heat[25].

People may be vulnerable due to:

- Physiological factors (such as being elderly, pregnant, a child, or having pre-existing health conditions and disabilities);
- Socio-economic conditions (such as poverty, inadequate housing, limited access to safety nets, healthcare, cooling, or social isolation); and/or
- Occupational factors, such as outdoor and informal workers often having few workplace protections.

Vulnerability factors often intersect and compound, meaning individuals may face multiple risk factors (such as a construction worker, with an underlying health condition, living in poorly ventilated housing).

Additional factors that increase people's vulnerability is the likelihood of unexpected exposure to heat (e.g., due to power system failure), individual circumstances (e.g., needing to work outside or being unable to afford to not work outside), and behaviour (e.g., not drinking enough water, playing sports outdoors, etc.).

Capacity to adapt to heat, for people, includes:

- Safety nets (both informal and formal) such as knowing and being able to call on neighbours for help, access to cooling centres/community spaces, and wellness checks on socially vulnerable people;
- Financial resources (i.e. the ability to pay for air conditioning);
- Heat risk awareness and knowledge on how to manage heat stress, such as seeking out shaded or cooled areas, staying hydrated, avoiding alcohol, and limiting heat exposure;
- Employer accommodations such as provision of water, cooling breaks, shaded and cooled rest locations, changes in working hours, and paid time off during extreme heat;
- Accommodations for clothing, provision of 'cooling clothes'[26], or recognition that if protective or heavy clothing is mandatory additional cooling time is needed.

Ecosystems and infrastructure[27] can also be vulnerable to heat. Some plants and ecosystems are more adapted to heat than others. In Adelaide, temperature increases are already stressing and killing plants and trees, ironically the same vegetation that is needed for cooling. Many urban foresters and parks staff are actively working to build the capacity of ecosystems by experimenting with more heat- and drought-adapted plants. For ecosystems near the edge of their heat tolerance, extra watering can increase the capacity of plants to survive hot weather.

Power systems, building materials, and construction practices are typically based on expected conditions the infrastructure needs to withstand, which leaves them vulnerable if those conditions are exceeded. Extreme temperatures or extended periods of high temperatures can exceed design thresholds, resulting in poor performance of systems and failure of various system components. For example, in very hot weather, transformers fail, roads and rails buckle, water infrastructure is damaged, car dashboards melt, and electrical distribution system components fail.

However, just as the vulnerability of infrastructure is a function of design, so too is capacity. Energy redundancies including connections to microgrids, solar power, battery backups, and generators can provide critical power during outages. For infrastructure, actions like increasing insulation in buildings, installing back-up power and cooling systems, shading buildings with vegetation or shade structures, and replacing parts with more heat resilient components can be ways to build capacity to withstand heat.

Critical system impacts from extreme heat

Weakening or failure of critical systems that underpin community wellbeing and functioning creates an additional burden for at-risk communities and increases overall heat risk.

Critical system impacts from extreme heat include:

- **Power systems:** transmission lines lose efficiency and transformers overheat while demand for cooling spikes, sometimes triggering blackouts. Power underpins other key systems. Power failures can cause cascading impacts to households, business, and other core services including cooling, water provision, transportation, and health care.
- **Water systems:** face demand increases. At the same time they are challenged by increased evaporative losses, overheating of pumps, heat-related impacts on treatment plants, and warmer water supplies that reduce cooling efficiency and affect water quality.
- **Housing and infrastructure:** building materials degrade, roofs and insulation fail, and cooling systems overload, raising risks of fire and unsafe indoor temperatures.
- **Transportation infrastructure:** roads buckle, rails warp, vehicles and aircraft require more energy to operate, and waterways shrink from evaporation.

Health impacts from extreme heat:

- **Health** is directly threatened by heat stress, over-exertion, dehydration, and worsening air quality; existing health conditions are exacerbated by high temperatures.
- **Healthcare facilities** typically experience demand surges; at the same time they may face equipment failure or power outages which limit the ability to provide services.
- **Secondary health impacts** may result from heat-sensitive medications that denature at high temperatures or when physical and mental well-being decline with prolonged heat exposure.

Secondary impacts also cascade through systems:

- **Livelihoods** are undermined as outdoor work and work in poorly ventilated spaces becomes unsafe, agriculture suffers from crop and livestock losses, and machinery overheats or breaks down causing reductions in economic output and productivity.
- **Education** is disrupted when heat begins to disrupt sleep and impact focus, schools become too hot for learning, cooling and power systems fail, or heat-related health risks keep students home.
- **Ecosystems** experience biodiversity loss as species reach thermal limits, water bodies warm and deoxygenate, and habitats degrade - weakening the natural systems people rely on for resilience.

Case study: Adapting heat warnings for heat vulnerability in South Australia

One of the challenges with heat is that - unlike flooding or bushfire where if you are exposed to floodwaters or fire the problem is clear - how much heat is too much may not be evident until after impacts have already occurred, and those impacts will vary depending on people's and systems' exposure and vulnerability and capacity. As a result, different populations need different heat warnings based on their underlying exposure and vulnerabilities and capacities.

Based on BoM heatwave forecasts, SA SES uses a three-tier system for heatwave warnings, with specific messaging for the public on what actions to take to stay safe:

Advice - Low-intensity Heatwaves: these are common during summer and most people are able to cope well, but the very young, older people, or those with medical conditions should take care.

Watch and Act - Severe Heatwaves: these are less frequent and are especially challenging for babies and young children, older people, pregnant women, and those who are already unwell, but even healthy people should take care. Separate warning messages are issued for each area in which a Severe Heatwave is forecast.

Emergency Warning - Extreme Heatwaves: these are rare, but are dangerous for anyone who does not take precautions to keep cool, even those who are fit and healthy. People who work or exercise outdoors are particularly at risk. The reliability of infrastructure, like power and transport, can also be affected. A separate warning message is issued for each area in which an Extreme Heatwave is forecast.

Some sectors in Australia have clear policies or guidelines for appropriate response during heatwaves, whether they follow BoM heatwave forecasts or have set their own thresholds. In South Australia, for example, a heatwave declaration by the BoM activates the Australian Red Cross' TeleRedi service, which provides calls to at-risk households that have registered with the Red Cross. In extreme heatwaves, many sporting matches are cancelled, outdoor construction workers at some construction sites have cease work policies and are given paid leave at defined thresholds, and South Australia Power cancels all non-emergency outdoor work.

The challenge is for the huge number of people for whom there are no clear policies or guidelines; many sectors have weaker policies or lack them altogether. For example, there is no national or state policy for what schools should do during heatwaves, though some school districts implement their own, and while some sports associations have heat policies and set thresholds for game cancellation and added water breaks, others do not. Nuanced messaging to the general public on best-practices is also weak. Lacking clear guidance, individuals are unsure what measures they need to stay safe; for example whether they would be safer staying inside their home or seeking relief from the heat at the beach. This situation is likely replicated in cities and towns across the world.

3.4 Compounding and cascading events

As the planet continues to warm there is increasing risk of compounding and cascading events. For heat, in addition to known vulnerabilities, there is the potential for impacts to be amplified, either further damaging a single system or causing widespread disruption across multiple systems. Because of the multi-faceted nature of compound risk, single hazard approaches will likely be insufficient; instead, comprehensive, multi-hazard approaches are needed.

Compound events[28] are when two or more weather or climate events occur at the same time, in close succession, or concurrently in different regions (e.g., bushfire and heat or storms and heat), exacerbating the impacts of either hazard alone and complicating response and recovery.

Cascading events[29] occur when a hazard contributes to the occurrence of another hazard (i.e. extreme heat contributing to drought and then wildfire) or a system failure (i.e. extreme heat causing a power system failure) that result in cumulative impacts greater than the impact of any one hazard or failure alone.

For heat, one of the greatest risks from a heatwave or chronic heat event is failure of the power system, as power failures cause cascading impacts to other systems. High electricity demand during extreme heat, often coupled with weakening of power system components due to heat and limited ability to have outdoor workers at work on the lines, can cause power outages which in turn can cause other systems to fail. The most immediate failure is typically cooling. In an extended blackout, communications systems and transportation (for both filling petrol and recharging electric vehicles) are often also impacted. All of these can rapidly create an environment in which people immediately move from unaware of and unaffected by the heat to highly exposed to the heat, in ways that they did not anticipate or may not be appropriately prepared for.

Case study: Compounding and cascading hazards - heat and bushfire in Australia

The risks of compound and cascading events are increasing across Australia, and will continue to worsen in the future[30]. Already, Australia has seen the impact of prolonged heat and low rainfall over several years lead to a 'tinderbox' effect that drove Australia's devastating megafires of 2019-2020. These fires occurred while some areas were already experiencing drought and heatwaves. Further, because the megafires left the soil unable to absorb water, rainfall in early 2020 resulted in erosion and surface runoff that polluted nearby rivers, degrading water quality.

One PERC interviewee described a grim but possible scenario of the impacts of compounding hazards based on their experience with the 2019-2020 heatwaves and megafires. In a combined heatwave and bushfire event, power workers (electricians, technicians, etc.) would not be able to safely address power systems failures. At the same time, greater demand for cooling would place increasing amounts of stress on the power system, but bushfire and smoke could limit the ability to work outdoors safely. The power system could quickly become overwhelmed, triggering a widespread blackout that could persist for several days.

Without active cooling, people's health and wellbeing would rapidly decline. Health services like emergency departments, ambulances, and emergency phone lines would be overwhelmed. In some communities, with strong social capital, groups of people would come together to support one another, ferrying elderly neighbours to public buildings with generator-powered refrigerated air; sharing ice, water, and cooler homes; and gathering on the beach overnight to take advantage of natural cooling. In other communities, with less social connection, many more would struggle with the heat alone, and overall the mortality and morbidity would spike as systems were unable to keep up with added demand. Such a scenario would also lead to longer recovery times, and ongoing social and health impacts.

We need to imagine and plan for worst-case scenario like this now to ensure they don't come to pass. Action taken now can prevent future disasters.

4. Heat's invisibility

Despite being the deadliest weather-related hazard, compared to other hazards, heat remains largely overlooked in terms of preparedness, response, and adaptation. Though other types of disasters are officially recognised by governments through disaster declarations, often triggering funding and access to other critical resources, extreme heat remains an exception. Like many other countries, Australia has never issued an emergency declaration in response to an extreme heat event.

The reasons for this are manifold: extreme heat is a largely invisible, silent, personal, and uninsured disaster, and cultural norms about coping with heat relegate it to the realm of something that you just "deal with"[31].

While the impacts of heat are widespread, the differing exposure, vulnerability, and capacity of people and systems results in highly varied impacts. Whereas a heat event might be merely an inconvenience for an indoor worker who has access to water and air conditioning, and thus might not be talked about, it may be devastating for an outdoor worker with limited breaks and no air conditioning at home.

Unlike floods or bushfires, which leave behind highly visible impacts, heat's impacts are largely invisible. Heat impacts are often felt only days into or even following the event. Heat impacts are rarely measured and what little data there is is often not available until months later. Heat-related illnesses and deaths are underreported and misattributed (see case study: Heat impact data in South Australia) making the true scale of damage unknown and weakening the evidence base that drives public concern and policy response. As a result, taking action to prepare for the next heatwave is especially challenging. Once a heatwave is over, attention quickly shifts to other more pressing challenges and its impacts are quickly forgotten.

Case study: Heat impact data in South Australia

It is difficult to recognise the extent of impacts from extreme heat because they are less obvious than other hazards, which makes accurate data collection essential. However, heat-impact data collection has yet to be established across many domains. In the Adelaide PERC, interviewees pointed to a lack of data on mortality, health system overwhelm, heat-related school and work absences, costs of business impacts, missed doctor appointments, incidents of family violence, impacts on wildlife, impacts on wellbeing, and sports cancellations, to name just a few.

There are substantial challenges to collecting good data, including defining heat - especially if it is chronic heat or an extreme day that occurs outside an identified heatwave period[32]. For example, the issue of underreporting of heat-related mortality has been identified in research[33]. with studies suggesting that the actual number of deaths in Australia could be 50 times higher than those currently attributed to heat[34] One key issue is that for many heat-related deaths, the primary cause of death is often attributed to a pre-existing condition like heart disease or stroke. This is what is recorded on death certificates, without documenting the contributing impact of heat.

Interviewees noted that the lack of data collected on heat impacts also makes it difficult to prioritise and plan heat resilience building actions. More consistent and accurate data on heat impacts from across domains is crucial for understanding risk and tracking changes over time to guide responses, policies, and actions.

5. Entry points for action

Extreme heat impacts everyone differently; what is a disaster for some is simply considered "usual weather" for others. As a result, heat is often viewed as an individual problem, and the responsibility to "deal with it" thus falls on individuals. Continuing to treat it as an individual's burden to bear, however, risks societal level consequences including increasing mortality and morbidities, livelihood impacts and economic disruptions, interrupted schooling, increasing mental health impacts, and overloaded systems. The breadth of potential society-wide impacts necessitates a broadening in how to think about heat and how to adapt to extreme heat from the individual to the collective.

Broadening how to think about and adapt to heat requires learning from past events to understand what worked well and what did not, and considering both short and long-term heat action planning for future, more extreme events. Especially given heat's invisibility and the tendency for the focus to shift to more visible events such as bushfires, learning from heat events needs to be captured as soon as possible following the event. Lessons should be integrated into updated heat action plans and shared both vertically (within departments and across city-state-national stakeholders) and horizontally between municipalities and across sectors.

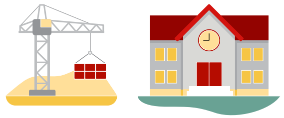
This PERC study revealed actions that worked well in past heat events and identified needs for future actions across eight components of the Adelaide Heat Resilience System[35]. Lessons from Adelaide relative to each of these components are listed briefly below and are further explored in "Strengthening resilience to extreme heat: an Adelaide case study."

Housing and urban development, including heat-informed urban planning, climate-resilient building codes, heat resilient housing and construction, and planning that addresses the Urban Heat Island effect.

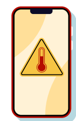
Urban greening and the natural environment, including increasing the urban tree canopy, incorporating green space in existing and new development, using water for cooling, and diverse, heat resilient ecosystems.

Heat health, including heat aware healthcare, social protection, heat morbidity and mortality data, and mental health support.

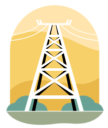
Safety of at-risk populations, including identifying at-risk populations and reaching them via heatwave response planning and cool spaces activation.



Heat at work and school, including heat risk in workplaces and erosion of education due to heat.



Heat warnings and disaster management, including heat forecasting, impact-based alerts, tailored heat messaging, and compound heat and wildfire risk.



Energy and critical infrastructure, including continuity of electrical power, utility management for heat resilience, the transportation network, and infrastructure maintenance, repair, and replacement.

Community awareness and cultural norms, including heat risk awareness and Australian cultural norms that limit heat risk action.

1 Venkateswaran, K., MacClune, K., Keating, A., Szönyi, M. (2020). *The PERC manual – Learning from disasters to build resilience: A guide to conducting a Post-Event Review* 2020. Institute for Social and Environmental Transition – International. https://www.i-s-e-t.org/publications-and-resources-1/the-perc-manual-%E2%80%93-learning-from-disasters-to-build-resilience%3A-a-guide-to-conducting-a-post-event-review-2020

2 Australian Climate Service (2025). *Heatwaves and temperature extremes.* https://www.acs.gov.au/pages/hazards-heatwaves

3 Australian Climate Service (2025). Australia's National Climate Risk Assessment. https://www.acs.gov.au/pages/national-climate-risk-assessment

4 Commonwealth of Australia (2023). *Intergenerational Report 2023 Australia's future to 2063.* https://treasury.gov.au/sites/default/files/2023-08/p2023-435150.pdf.

5 United Nations Environment Programme (2021). *Beating the Heat: A Sustainable Cooling Handbook for Cities.* Nairobi. https://www.unep.org/resources/report/beating-heat-sustainable-cooling-handbook-cities

6 ibid.

7 Statista (2025). Australia: *Urbanization from 1960 to 2024.* https://www.statista.com/statistics/260498/degree-of-urbanization-in-australia/ Accessed 23 October 2025

8 Marghidan, C.P., Proietti, C., Izquierdo, K., Roop Singh, R., et al. (2025). *"Understanding extreme heat: a shared language for action."* Zurich Climate Resilience Alliance.

9 UNDRR (2025). Extreme Heat Risk Governance Framework and Toolkit. https://www.undrr.org/publication/documents-and-publications/extreme-heat-risk-governance-framework-and-toolkit

10 US Environmental Protection Agency. What are heat islands. https://www.epa.gov/heatislands/what-are-heat-islands, referenced 6 December 2025.

11 Kontor et al., (2025). Climate Justice and Heat Inequity in Poor Urban Communities: The Lens of Transitional Justice, Green Climate Gentrification, and Adaptation Praxis. https://www.mdpi.com/3357126

12 Artificial turf can reach temperatures of 80C, making it one of the hottest surfaces in urban environments. From Belperio, M.J., January 2025. Rethinking artificial lawns: The impact on Adelaide urban heat, University of Adelaide, https://www.adelaide.edu.au/environment/news/list/2025/02/11/rethinking-artificial-lawns-the-impact-on-adelaide-urban-heat

13 Marghidan, C.P., Proietti, C., Izquierdo, K., Roop Singh, R., et al. (2025). "Understanding extreme heat: a shared language for action." Zurich Climate Resilience Alliance.

14 World Meteorological Organization (2025). Heatwave. https://wmo.int/topics/heatwave

15 United Nations Office for Disaster Risk Reduction (UNDRR), & International Science Council (ISC) (2025). UNDRR–ISC Hazard Information Profiles – 2025 Update: MH0501 Heatwave United Nations Office for Disaster Risk Reduction; International Science Council. https://www.undrr.org/terms/hips/MH0501

16 Cruz, M., et al. (2025). Where heat does not come in waves: A framework for understanding and managing chronic heat. Environmental Research: Climate, 4, 023002. https://iopscience.iop.org/article/10.1088/2752-5295/adc827

17 Keating, A., Campbell, K., Mechler, R., Magnuszewski, P., Mochizuki, J., Liu, W., ... & McQuistan, C. (2017). Disaster resilience: what it is and how it can engender a meaningful change in development policy. Development Policy Review, 35(1), 65-91. https://onlinelibrary.wiley.com/doi/abs/10.1111/dpr.12201

18 ESCOSA (2006). Inquiry into ETSA Utilities' Network Performance and Customer Response January 2006 Final Report, The Essential Services Commission of South Australia, Adelaide, SA. https://www.escosa.sa.gov.au/ArticleDocuments/992/060907-NetworkPerformanceHeatwave2006-FinalReport.pdf.aspx?Embed=Y

19 Nairn, J. R., & Fawcett, R. G. (2013). Defining heatwaves: heatwave defined as a heat-impact event servicing all community and business sectors in Australia. Centre for Australian Weather and Climate Research.

20 Nairn, J. R., & Fawcett, R. J. (2014). The excess heat factor: a metric for heatwave intensity and its use in classifying heatwave severity. International journal of environmental research and public health, 12(1), 227–253. https://www.mdpi.com/1660-4601/12/1/227

21 The '95th percentile' temperature is a temperature higher than 95 percent of recorded temperatures in a given dataset. Different meteorological departments use different percentile cutoffs, but the 90th percentile and 95th percentile are quite common. Different departments may also use maximum, maximum and minimum, or mean temperatures for these cutoffs. Regardless of the exact numbers used, applying a percentile cutoff means the index selects for periods that are abnormally hot (e.g. in the top 5 or 10 percent).

22 Rubenstein, N., Keating, A., MacClune, K. and Norton, R. (2024). "Measuring community heatwave resilience: a comprehensive framework and tool" Climate Risk Management 46, https://www.sciencedirect.com/science/article/pii/S2212096324000792

23 Perkins-Kirkpatrick, S., et al. Forthcoming. Non-survivable heat stress conditions are already occurring. Nature Portfolio. https://www.researchsquare.com/article/rs-6124063/v1

24 Oppermann, E., Kjellstrom, T., Lemke, B., Otto, M., & Lee, J. K. W. (2021). Establishing intensifying chronic exposure to extreme heat as a slow onset event with implications for health, wellbeing, productivity, society and economy. Current Opinion in Environmental Sustainability, 50, 225-235. https://www.sciencedirect.com/science/article/pii/S1877343521000634?via%3Dihub

25 IFRC. Enhanced Vulnerability and Capacity Assessment, Draft Version for Consultation Annex: Key concepts: determinants of risk. (2023). https://preparecenter.org/wp-content/uploads/2023/08/Key-concepts-risk-determinants.pdf

26 For example, the South Australia Police Department provides an undershirt that is a bamboo-mix fabric blend that provides cooling as long as the wearer is moving, and is switching from baseball caps to broad-brimmed hats.

27 For a more in-depth overview of the impacts of system failure, please see "Strengthening Resilience to Extreme Heat: An Adelaide Case Study." https://www.redcross.org.au/stories/2026/heatwave-research/

28 Singh, R., & Marghidan, C. P. (2025). Double jeopardy: Addressing compound flood and heatwave events. Red Cross Red Crescent Climate Centre, Zurich Climate Resilience Alliance. https://preparecenter.org/resource/double-jeopardy-addressing-compound-flood-and-heatwave-events/

29 National Academies of Sciences, Engineering, and Medicine (2022). Resilience for compounding and cascading events. https://www.nationalacademies.org/read/26659/chapter/1

30 Australian Climate Service (2025). https://www.acs.gov.au/pages/national-climate-risk-assessment

31 See the section on cultural norms and heat in Australia in "Strengthening Resilience to Extreme Heat: An Adelaide Case Study for more information". https://www.redcross.org.au/stories/2026/heatwave-research/

32 Coates L, van Leeuwen J, Browning S, et al (2022) Heatwave fatalities in Australia, 2001–2018: An analysis of coronial records. Int J Disaster Risk Reduct 67:102671. https://www.sciencedirect.com/science/article/pii/S2212420921006324

33 Coates L, Haynes K, O'Brien J, et al (2014) Exploring 167 years of vulnerability: An examination of extreme heat events in Australia 1844-2010. Environ Sci Policy 42:33–44. https://www.sciencedirect.com/science/article/pii/S1462901114000999?via%3Dihub

34 Longden T, Quilty S, Haywood P, et al (2020). Heat-related mortality: an urgent need to recognise and record. Lancet Planet Heal 4:e171. https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(20)30100-5/fulltext

35 These sectors are aligned with the heat management strategies presented in the 2024 UN Heat Governance meeting report. https://www.undrr.org/publication/documents-and-publications/extreme-heat-risk-reduction-towards-common-global-framework

This report presents a snapshot of heat events and responses in Adelaide, South Australia. It is not comprehensive – much more could be said on the degree of resilience of South Australia during heat events. What this report does provide is a collection of short, field-tested examples of resilient systems and actions, and a discussion of what it is that makes those resilient. It also describes factors that limited the ability of people and systems to respond effectively, and highlights what we can learn from this to increase our resilience moving forward.

For a downloadable PDF of this report, please visit: https://www.redcross.org.au/stories/2026/heatwave-research/

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