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Leveraging key advances in building strong institutions and governance for climate action, focusing on clean energy transition

Effective governance for extreme heat: integrating institutional frameworks with the energy shift

Note by the Secretariat

The Secretariat has the honour to transmit to the Committee of Experts on Public Administration the paper prepared by Committee members Linda Bilmes and Mauricio Rodas, in collaboration with fellow Committee members Yamini Aiyar, Soonae Park, Aminata Touré and Lan Xue.

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Effective governance for extreme heat: integrating institutional frameworks with the energy shift

Summary

The warmest year on record was 2024, with climate change-induced extreme heat affecting billions of people and economies worldwide. Developing countries and vulnerable groups are particularly affected and at risk of being left behind. In this paper, the authors explore the significant threats posed by extreme heat to public health, economies and ecosystems, and the connection between extreme heat and the clean energy transition, with extreme heat increasing cooling demands and negatively affecting the functioning and scaling up of renewable energy systems.

The authors emphasize the essential role of strong institutions and robust governance structures at all levels in managing the dual challenge of tackling extreme heat and advancing a clean energy transition. Specific mitigation and adaptation strategies are explored, such as the development of national cooling and heat action plans that can be integrated into broader climate action plans. The importance of promoting global collaboration, policy coherence, intersectoral coordination, data and monitoring, and access to climate finance is also discussed.

The authors conclude with a set of recommendations on mitigating the impacts of extreme heat while fostering a clean energy transition and building resilience at all levels, with the larger aim of protecting people and economies and leaving no one behind while building strong institutions for climate action.

I. Background

1. Rising global temperatures and the intensifying global challenge of extreme heat, driven by climate change, present severe threats to public health, economies and ecosystems. Elevated temperatures and prolonged heatwaves exacerbate health risks, disproportionately affecting vulnerable populations, including children, older persons and individuals with pre-existing conditions. Furthermore, extreme heat events endanger food security, deepen socioeconomic inequalities and strain energy systems as rising cooling demands challenge grid stability and renewable energy integration. This underscores the urgent need for action and for robust and integrated governance frameworks.

2. Extreme heat events are prolonged periods of excessively high temperatures that significantly exceed average conditions for a specific region or time of year. These events are typically measured using metrics such as daily maximum temperatures, heat indexes or deviations from historical temperature norms. Extreme heat events are particularly hazardous when night-time temperatures remain elevated, offering little relief. The Intergovernmental Panel on Climate Change identifies heat extremes as one of the most observable impacts of climate change, driven primarily by global warming.

3. Human-induced greenhouse gas emissions have significantly increased global temperatures, intensifying the frequency and severity of heatwaves.[1] Changes in atmospheric circulation, including shifts in jet streams and high-pressure systems, also contribute to extreme heat by trapping heat over regions for extended periods of time.[2] In addition, land-use changes such as deforestation reduce evapotranspiration, a natural cooling mechanism, further increasing localized temperatures.[3] Natural climate variability, such as the El Niño/Southern Oscillation, can also exacerbate extreme heat events by altering global weather patterns.[4]

4. In 2024, the global average temperature broke records, surpassing 2023, which had been the warmest year since measurements began in 1850. For the first time, the planet's temperature exceeded 1.5°C above pre-industrial levels – a significant milestone set by the Paris Agreement of 2015. Worryingly, all 10 of the hottest years on record have occurred in the past decade (2014–2023). Since 1850, the planet's temperature has increased by approximately 2°F.[5] In August 2024, nearly 4.1 billion people, roughly half the world's population, experienced unusually hot temperatures.[6]

5. In response, the Secretary-General launched a Call to Action on Extreme Heat, urging countries to prioritize protecting vulnerable populations and workers and boosting the resilience of economies and societies using data and science, all while aiming to limit global warming to 1.5°C by phasing out fossil fuels and scaling up investment in renewable energy.

6. The World Meteorological Organization (WMO) warns that episodes of extreme heat will become more frequent, intense and prolonged, with this trend expected to

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[1] Intergovernmental Panel on Climate Change, *Climate Change 2021: The Physical Science Basis – Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, Cambridge University Press, 2021).

[2] Dim Coumou and Stefan Rahmstorf, "A decade of weather extremes", *Nature Climate Change*, vol. 2 (July 2012).

[3] Gordon B. Bonan, "Forests and climate change: forcings, feedbacks, and the climate benefits of forests", *Science*, vol. 320, No. 5882 (2008).

[4] United States of America, National Oceanic and Atmospheric Administration, "Global climate report: annual 2024", available at www.ncei.noaa.gov/access/monitoring/monthly-report/global.

[5] Ibid.

[6] Climate Central, "People exposed to climate change: June–August 2024", 18 September 2024.

persist until at least 2060.[7] The heatwaves experienced in 2024 are no longer exceptional and are projected to intensify, becoming more frequent and prolonged in the future, according to scientific assessments.

7. Going forward, effective governance based on a multilayered approach that bridges subnational, national and international strategies is required for addressing extreme heat. Coordination across these levels is essential to ensure alignment, maximize resource efficiency and promote equitable access to climate adaptation measures. The connection between extreme heat and the clean energy transition should also be taken into account, with extreme heat increasing cooling demands and negatively affecting the functioning and integration of renewable energies.

8. In this paper, the authors examine the institutional responses to extreme heat in the context of transitioning to sustainable energy systems, emphasizing the need for governance structures that integrate mitigation and adaptation strategies. Drawing on various reports, case studies and best practices, they highlight the importance of enhancing energy resilience, scaling up renewable energy, fostering intergovernmental dialogue, mobilizing climate finance and involving diverse stakeholders across sectors, while implementing efficient strategies and policies to tackle extreme heat events. By proposing recommendations to strengthen governance frameworks, the authors aim to contribute to the development of resilient, equitable and sustainable responses to the escalating challenges posed by climate change and extreme heat in a warming world.

II. Impacts of extreme heat events

Human health impacts

9. Extreme heat, often referred to as the “silent killer”, poses a severe threat to global public health as its effects are not immediately visible but have a cumulative impact, disproportionately affecting the most vulnerable populations. By 2070, it is estimated that 3.5 billion people will be severely affected by extreme heat, with 1.6 billion of them residing in urban areas.[8] A study conducted across nine countries suggests that 356,000 deaths were associated with extreme heat in 2019 alone.[9] Thus, there is an urgent need to address the risks associated with rising temperatures, particularly as extreme heat is already more lethal than all the other climate-related threats combined, including hurricanes, floods and droughts.

10. Extreme heat can initially cause mild symptoms, such as dizziness and fatigue, but prolonged exposure can lead to more severe conditions, such as heat stroke, a potentially fatal medical emergency. This gradual progression makes early identification of risk challenging, often resulting in inadequate preparation and a lack of preventive measures. Furthermore, extreme heat can exacerbate pre-existing health conditions, leading to, for example, heart attacks, respiratory failure and complications in individuals with diabetes, thereby increasing heat-related morbidity and mortality. Many of these aggravated conditions may not immediately be attributed to heat, contributing to an underestimation of its impact on human health.

11. Economically disadvantaged groups, including migrants, are particularly at risk of heat-related illnesses and fatalities. Their heightened vulnerability is driven by

[7] WMO, *State of the Global Climate 2023* (Geneva, 2024).

[8] Chi Xu and others, “Future of the human climate niche”, *Proceedings of the National Academy of Sciences*, vol. 117, No. 21 (2020).

[9] Katrin G. Burkart and others, “Estimating the cause-specific relative risks of non-optimal temperature on daily mortality: a two-part modelling approach applied to the Global Burden of Disease Study”, *The Lancet*, vol. 398, No. 10301 (2021).

various factors, such as substandard housing, limited access to air conditioning and occupations such as manual labour and waste collection, which involve prolonged exposure to extreme heat.[10]

12. According to the World Health Organization (WHO), extreme weather events, such as heatwaves and floods, can also directly influence disease transmission and morbidity. In addition, climate change and its effects, in particular heatwaves and humidity, have altered the behaviour of the anopheles mosquito, the vector for malaria, increasing its survival rate.[11] During extreme heat conditions, cities become "heat islands" as they experience significantly higher temperatures than surrounding rural areas, due mainly to the built environment trapping heat from buildings, roads and other impervious surfaces, leading to potentially dangerous heatwaves with increased health risks for residents. This is called the urban heat island effect.

Economic and infrastructure impacts

13. Extreme heat has far-reaching impacts on labour productivity, urban infrastructure and key economic activities. It exacerbates social and economic inequalities by disproportionately affecting vulnerable groups and imposes places significant economic pressure on communities due to increased demand for public services and rising healthcare costs.

14. The International Labour Organization (ILO) reports that at least 2.41 billion workers worldwide (71 per cent of the working population) are exposed to excessive heat, resulting in 22.85 million injuries and 18,970 deaths annually.[12] By 2050, extreme urban heat is projected to reduce global labour capacity by 20 per cent during hot months.[13] In 2020 alone, 295 billion work hours were lost globally due to extreme heat.[14] In the United States of America, associated labour productivity losses could double to nearly $200 billion by 2030 and reach $500 billion by mid-century.[15]

15. Key sectors, such as agriculture, construction, manufacturing and tourism, are particularly vulnerable to extreme heat. In agriculture, for example, extreme heat can significantly reduce crop yields for staples such as corn, soybeans and wheat, with annual losses in the United States projected to rise from $720 million to $1.7 billion by 2030, threatening food security and export capacity.[16] In India, heatwaves have significantly reduced wheat production, with studies indicating that a mere 1°C increase in temperature could cause a 4 to 5 per cent decline in yields.[17] These agricultural impacts are further exacerbated by erratic rainfall patterns linked to climate change, jeopardizing the livelihoods of millions who rely on farming. The Intergovernmental Panel on Climate Change warns of potential crop failures in staple-growing regions, which may lead to increased food prices and a heightened risk of famine in vulnerable communities. Projections indicate that, without substantial

[10] See for example, Matthew F. Chersich and Caradee Y. Wright, "Climate change adaptation in South Africa: a case study on the role of the health sector", *Globalization and Health*, vol. 15, No. 22 (2019).

[11] WHO, *World Malaria Report 2023* (Geneva, 2023).

[12] Andreas Flouris and others, eds., *Heat at Work: Implications for Safety and Health – A Global Review of the Science, Policy and Practice* (Geneva, ILO, 2024).

[13] David Dodman and others, "Cities, settlements and key infrastructure", in *Climate Change 2022: Impacts, Adaptation and Vulnerability – Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Hans-Otto Pörtner and others, eds. (Cambridge, Cambridge University Press, 2022).

[14] Sustainable Energy for All, *Chilling Prospects: Tracking Sustainable Cooling for All* (2022).

[15] Adrienne Arsht-Rockefeller Foundation Resilience Centre, *Extreme Heat: The Economic and Social Consequences for the United States* (2021).

[16] Ibid.

[17] Ridhima Gupta, E. Somanathan and Sagnik Dey, "Global warming and local air pollution have reduced wheat yields in India", *Climate Change*, vol. 140 (2017).

mitigation efforts, global food production could drop by as much as 30 per cent in certain regions by 2050, intensifying poverty and hunger issues.[18]

16. In addition, urban infrastructure is often ill-equipped to handle the intensifying effects of extreme heat. Roads, power lines and buildings face structural damage and system failures, while energy infrastructure struggles to meet the increasing demand for air conditioning during heatwaves. Heat-induced infrastructure failures could have cascading effects on health and economic activity, particularly in urban areas already suffering from the urban heat island effect.

Environmental impacts

17. Extreme heat exerts profound impacts on ecosystems, natural resources and air and water quality. For example, it elevates the risks of drought and wildfires by depleting soil moisture and places severe stress on terrestrial ecosystems, thereby threatening biodiversity and disrupting ecological balance. Extreme heatwaves contribute to ocean warming, which can significantly disrupt marine ecosystems, affecting fisheries, coral reefs and other marine life, while potentially influencing weather patterns, such as the intensity of hurricanes.[19]

18. Water resources will face significant strain due to extreme heat, particularly in drought-prone areas. According to the United Nations Children's Fund (UNICEF), 1.42 billion people, including 450 million children, are already living in areas of high or extremely high water vulnerability. Freshwater accounts for less than 3 per cent of the world's water resources and is growing increasingly scarce. Various regions worldwide are experiencing more frequent and severe droughts driven by elevated temperatures, leading to increased competition for water resources.[20] This can also lead to conflicts and force communities to adjust to shifting environmental conditions. In addition, this trend places stress on freshwater ecosystems and raises salinity levels, adversely affecting aquatic life.

19. Extreme heat has a negative impact on air quality through the increased formation of ground-level ozone, a pollutant that exacerbates respiratory ailments and other health issues. In urban environments such as Los Angeles and Beijing, elevated temperatures catalyse the chemical reactions responsible for ozone smog, putting millions of residents at risk.

Impacts of extreme heat in Africa

20. The recent rise in global temperatures poses a severe threat to Africa, affecting its already fragile and insufficient electricity and water infrastructure. According to a WMO report,[21] the infrastructure in many African cities, which are characterized by growing urban populations and inadequate services, cannot adapt promptly to extreme weather conditions or adequately deal with spiking cooling and water demands. In Cape Town, for example, the 2018 heatwave underscored critical vulnerabilities in the city's energy infrastructure, highlighting age-related deficiencies and an inability to cope with extreme weather events. Strengthening such infrastructure requires significant investment, a daunting challenge in resource-limited contexts, where budget constraints often hinder development efforts.

21. Agricultural productivity and labour capacity in Africa are particularly vulnerable to extreme heat. A study conducted in sub-Saharan Africa suggests that

[18] Intergovernmental Panel on Climate Change, *Climate Change 2021: The Physical Science Basis*.

[19] Alex Sen Gupta and others, "Drivers and impacts of the most extreme marine heatwave events", *Scientific Reports*, vol. 10, No. 19359 (2020).

[20] UNICEF, "Reimagining WASH: water security for all", March 2021.

[21] WMO, *State of Climate in Africa 2021* (Geneva, 2022).

rising temperatures have already contributed to a significant decline in crop yields of critical staples.[22] The increased thermal stress on workers also leads to lower productivity and economic output in agricultural sectors that are essential for the livelihoods of millions. As a result, the food supply in regions reliant on these sectors dwindles, contributing to a vicious cycle of poverty and food scarcity that plagues many African nations.

22. Worsening drought conditions, intensified by extreme heat, drive food insecurity across the continent, leading to price increases and lower dietary intakes, primarily affecting poorer populations. According to the Food and Agriculture Organization of the United Nations, droughts driven by heat are expected to increase over the coming decades, causing significant food price inflation and reducing overall access to nutritious foods.[23]

23. The impacts of extreme heat on water supply and quality are equally critical, with heatwaves compounding existing water scarcity issues. During periods of extreme temperatures, the demand for water for drinking, cooling and irrigation rises sharply, but the supply dwindles. Research indicates that, during severe heat events, many regions in Africa experience accelerated depletion of water sources, leading to inadequate drinking water quality and access.[24]

III. Connection between extreme heat and the energy transition

24. One of the main consequences of extreme heat is significant spikes in electricity usage due to increased demand for cooling, including from air conditioning, fans, ventilation systems, evaporative coolers, heat pumps, refrigerators and other devices. This is exacerbated by the fact that air conditioning and other cooling devices require more energy to run as the air temperature increases because they need to work harder to maintain cool indoor temperatures and function less efficiently. These effects are compounded in buildings with poor insulation, which are widespread in many countries.

25. Such spikes in demand can strain the energy grid and create risks of blackouts, power shortages and instability in the grid. Typically, electricity demand peaks in the hottest hours of the day, which can strain power grids to their breaking point. Most electricity grids were built decades ago and are not designed to withstand such prolonged high demand. Extreme temperatures can cause power lines to sag, reducing their carrying capacity and efficiency. They can also place stress on transformers and other equipment, which decreases their lifespan.

26. To address these issues, the Republic of Korea, under an emergency power-saving demand response programme managed by the Korea Electric Power Corporation, provides financial incentives to large electricity consumers, including businesses and educational institutions, to voluntarily reduce their energy usage during peak demand periods. The programme has proved to be an effective tool for stabilizing the grid, minimizing reliance on fossil fuels and managing electricity demand during heatwaves.

27. Heatwaves can reduce the efficiency of certain renewable energy sources. For instance, extreme temperatures can lower the performance of solar panels, while water scarcity during droughts can limit hydropower generation. These challenges

[22] Diogo Baptista and others, *Climate Change and Chronic Food Insecurity in Sub-Saharan Africa*, (Washington, D.C., International Monetary Fund, 2022).

[23] Hugh Turral, Jacob Burke and Jean-Marc Faurès, *Climate Change, Water and Food Security* (Rome, Food and Agriculture Organization of the United Nations, 2011).

[24] See for example, UNICEF, “Water crisis in the Horn of Africa”, 2022.

underscore the importance of analysing the resilience of energy infrastructure to withstand extreme heat. In addition, energy storage systems must be adapted to manage demand fluctuations effectively during peak heat periods.

28. Thus, the transition to renewable energy is intertwined with efforts to mitigate extreme heat. Countries can directly address the root causes of rising temperatures by decarbonizing the energy supply and adopting renewable energy sources, such as solar, wind and hydropower. This will reduce the carbon footprint of power generation and may lead to less frequent extreme heat events. In addition, innovative solutions will need to be found to tackle increased electricity demands.

IV. Effective governance for addressing extreme heat and accelerating the energy transition

29. Although extreme heat poses a significant and increasing challenge in the era of climate change, it also presents an opportunity to build strong and resilient public institutions at all levels of government and to foster global, national and subnational collaboration.

A. Effective governance at the national level

30. The role of national Governments in tackling extreme heat and accelerating a clean energy transition should be centred around strategic guidance and coordination. National Governments play a pivotal role in the effective and cohesive implementation of strategies and policies aimed at combating extreme heat, enhancing energy resilience and promoting renewable energy, such as renewable energy mandates and heat action plans.[25]

31. Robust national policies and national action plans can provide a structured framework to guide local governments in developing and executing initiatives tailored to their specific contexts. For instance, renewable energy mandates not only promote the transition towards cleaner energy sources but also help to alleviate the strain on energy systems during extreme heat events by diversifying energy portfolios.

National cooling action plans

32. National cooling action plans are emerging as a crucial framework for addressing the growing demand for cooling solutions in a warming world. These plans align cooling policies with national development goals, addressing gaps in cooling access and ensuring that energy efficiency, environmental sustainability and equitable access to resources and cooling technologies are prioritized. By integrating these plans into broader climate adaptation strategies, Governments can enhance institutional coordination and close gaps in policy implementation.

Promoting renewable energy solutions

33. To scale up renewable energy, it is essential to develop national energy efficiency standards, such as minimum energy performance standards, which can reduce energy consumption by improving the energy efficiency of cooling appliances. In addition, energy efficiency measures, such as retrofitting buildings with better

[25] Grace Wickerson and Autumn Burton, “Building a whole-of-government strategy to address extreme heat: comprehensive recommendations from +85 experts to enable a heat-resilient nation”, Federation of American Scientists, June 2024.

insulation, adopting regulations to require adequate insulation and employing smart grid technologies, can help to reduce demand during heatwaves and peak hours of heat. These measures can prevent surges in electricity demand despite the growing need for cooling. Regulations that prioritize sustainable infrastructure are key to long-term resilience.

34. Multi-stakeholder collaboration can contribute to more effective policy frameworks for renewable energy solutions. Inclusive dialogues among Governments, research institutions and the private sector can help to align interests, pool resources and streamline the large-scale deployment of renewable technologies. Such collaborative efforts can significantly reduce costs and accelerate the adoption of renewable energy solutions.[26]

Infrastructure investment

35. To effectively address the challenges posed by extreme heat, national Governments need to prioritize the expansion of large-scale renewable energy infrastructure, particularly utility-scale solar farms and wind power installations. Research indicates that diversifying energy portfolios enhances reliability and reduces vulnerability to climate-related disruptions.[27] This proactive approach is essential for establishing a robust energy framework capable of withstanding climate-induced and extreme heat-related challenges. Investments in high-efficiency cooling systems also remain critical, as they reduce energy consumption and enhance public access to cooling during heatwaves.

36. Efforts should be strategically directed towards the regions most vulnerable to extreme heat events to promote equitable energy distribution and access. Such an approach not only supports the immediate energy needs of at-risk populations but also contributes to long-term sustainability goals by reducing reliance on fossil fuels.

Advancing new technologies

37. Policies should actively encourage the adoption of advanced technologies, such as passive cooling systems and thermal insulation, to minimize energy consumption during peak heat periods.[28] The implementation of these technologies not only enhances comfort for residents but also contributes to more effective energy management strategies and significant energy savings, thereby alleviating pressure on power grids during high-demand situations and improving overall community resilience.

38. The adoption of new cooling methods and technologies is inherently a context-specific process influenced by the local environment, community needs and infrastructure. It is therefore essential for local actors to be part of developing and implementing these solutions. At the same time, technological adaptation necessitates a whole-of-government approach, taking into account the needs and challenges of vulnerable population groups, as adaptation and mitigation strategies intersect with economic sectors of national interest, including energy, health and labour. Integrated planning across government entities can be critical in fostering the coordination and cooperation needed for effective implementation.

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[26] Mission Innovation, “Mission Innovation beyond 2020: challenges and opportunities”, 2019.

[27] International Atomic Energy Agency, *Climate Change and Nuclear Power: Financing Nuclear Energy in Low Carbon Transitions* (Vienna, 2024).

[28] European Environment Agency, “Cooling buildings sustainably in Europe: exploring the links between climate change mitigation and adaptation, and their social impacts”, 10 November 2022.

B. Effective governance at the subnational level

39. Local governments are at the forefront of implementing climate adaptation strategies, combating extreme heat and pushing forward the green energy transition. Extreme heat events exhibit highly localized effects, resulting in different vulnerabilities that require targeted responses tailored to the needs of diverse demographic groups and occupations.

40. Effectively coping with the impacts of extreme heat therefore requires Governments to make decentralized efforts guided by a whole-of-government approach. While national Governments can play an important role in establishing guiding principles through national action plans or other mechanisms, it is incumbent upon local governments to execute and adapt those policies and strategies, while defining and implementing context-specific and community-based solutions. Through collaboration between municipal authorities, community organizations and private actors, local initiatives can be tailored to better address the unique vulnerabilities and needs of local communities.

41. A balanced approach that combines mitigation and adaptation strategies is crucial at the local level. Mitigation efforts are aimed at addressing the root causes of extreme heat (e.g. reducing greenhouse gas emissions), while adaptation measures are aimed at managing the impacts of already occurring extreme heat events by taking steps to reduce heat-related illnesses (e.g. creating cooling centres). In addition, an evidence-based approach is essential for allocating resources efficiently, with a focus on policies that yield the highest return on investment, such as targeted support for vulnerable groups.

42. Dynamic modelling and policy simulations conducted in the Republic of Korea highlighted the potential benefits of allocating budgets to both mitigation and adaptation efforts in terms of reducing the risks of heat-related illness. The findings were as follows:

(a) A mitigation-only budget allocation approach, whereby KRW 440 billion were allocated to policies related to high-efficiency air conditioners and eco-friendly vehicles, reduced cases of heat-related illness by 56.2 per cent;

(b) An adaptation-only budget allocation approach with the same budget, focused on support for vulnerable groups, green area expansion and heatwave shelters, achieved a reduction rate of 61.5 per cent;

(c) Optimized budget allocation covering both mitigation and adaptation efforts resulted in a 78.0 per cent reduction in cases of heat-related illness. Under this approach, 81.5 per cent of the budget was allocated to vulnerable groups, 16.7 per cent to high-efficiency air conditioners, 0.91 per cent to heatwave shelters, 0.82 per cent to green area expansion and 0.09 per cent to eco-friendly vehicle expansion.[29]

43. By adopting a data-driven approach and prioritizing effective strategies, policymakers can maximize the impact of urban heatwave policies while addressing the challenges of extreme heat. Long-term planning is necessary to ensure the integration of heatwave strategies, such as heatwave shelters, cooling and misting stations, and green area expansion, into broader climate resilience plans. Long-term planning can also ensure sustainable and equitable resource allocation.

44. Although local governments play an essential role in implementing heat adaptation strategies, they are often insufficiently empowered in terms of functions,

[29] Cheol Hee Son, Young Eun Ryu and Yong Un Ban, “Dynamic modeling and policy simulation to reduce heat-related illness risk from urban heatwaves in Seoul, South Korea”, *City and Environmental Interactions*, vol. 21 (January 2024).

financial resources, human capacities and specialized skill sets to effectively respond to extreme heat events. To do so, local governments need financial and technical assistance from higher levels of government, as local budgets are designed to meet only short-term annual needs. In addition, higher levels of government play a vital role in helping local governments to prepare for such events, including by providing training, building capacities, setting guidelines for coordination in advance, developing regulations, and convening stakeholders to agree on emergency responsibilities and debriefing with these stakeholders after events. A whole-of-government approach to subnational action can enable the achievement of the overarching objective of enhancing community resilience to heat, leading to more effective heat management strategies across geographical areas and population groups within a country.

45. If appropriately designed, subnational interventions can effectively leverage existing sectoral schemes and programmes. For instance, integrating passive cooling strategies into State-funded low-cost housing initiatives can enhance community resilience to heat while maximizing the use of limited financial resources. Such reforms are fundamental for empowering local governments to effectively carry out their crucial roles in climate adaptation.

Local-level instruments

46. As witnessed repeatedly during extreme heat events, the worst consequences are not uniform but rather tend to afflict some neighbourhoods more than others. Local governments are the only institutional player working on the ground and are thus able to quickly assess and prioritize the needs of communities and to monitor compliance. Local governments should therefore be encouraged and funded to adopt policies that will improve resilience in certain locations, such as including requirements for green roofs or urban tree planting in zoning regulations, expanding bus routes to minimize walking distances in hot temperatures, installing misting stations, modifying school hours, monitoring air quality and building fountains. Cooling centres and water distribution points have also proved effective.

47. Adapting urban infrastructure is also essential to mitigate the impacts of extreme heat and ensure the well-being of city dwellers. This can be achieved by: (a) reducing the cooling demand through passive cooling strategies, such as insulation and reflective surfaces, and integrating passive cooling into building codes and urban planning; and (b) developing climate-resilient buildings and green infrastructure, for example by using reflective building materials and expanding green spaces to reduce surface temperatures and enhance urban liveability.

48. Cities such as Barcelona have been pioneering climate-resilient building initiatives, focusing on enhancing urban greenery and installing cool roofs.

49. Integrating energy transition into urban design by embedding renewable energy systems, such as solar microgrids, green roofs and cool roofs, into city planning can mitigate the urban heat island effect. Financial incentives need to be provided to encourage the adoption of renewable energy in new construction and retrofitting projects, thereby increasing resilience to peak demand periods.

50. Empowering communities for resilience by implementing targeted education programmes and community-based energy initiatives can foster the widespread adoption of energy-efficient technologies. Special focus should be placed on ensuring that vulnerable populations have access to cooling technologies and renewable energy resources.

51. Improving transportation and housing resilience by developing renewable energy-powered cooling solutions needs to be made a priority. For example, installing

solar-powered cooling units in public transit shelters and providing subsidies for energy-efficient cooling systems to low-income households can ensure protection during extreme heat events.

52. Localized innovations also play a vital role in addressing extreme heat. For instance, “cool pavements”, in which reflective materials are used to lower surface temperatures, have been installed in Phoenix, Arizona. This measure is aligned with broader climate goals while providing immediate relief to urban populations. In Athens, innovative resilience measures (e.g. reflective surfaces) paired with public awareness programmes have been implemented. The city’s resilience strategy also includes partnerships with local non-governmental organizations and private sector entities to enhance community engagement and resource mobilization.

Heat action plans

53. Effective heat action plans, which outline preventive measures and response strategies during heatwaves, are important for ensuring that local communities and vulnerable populations receive the necessary protection and resources and build resilience. These plans are essential components of a larger governance framework that integrates adaptation and mitigation strategies, which are crucial for responding to the effects of climate change, especially in the context of extreme heat scenarios.

54. By conducting holistic, evidence-based risk assessments, national Governments can provide invaluable insights to local authorities as they formulate their heat action plans. Local governments also need to be provided with the necessary resources and training to avoid the production of substandard heat action plans.

55. The designation of dedicated chief heat officers has proved instrumental in advancing heat action plans, enabling the implementation of targeted, innovative solutions and strengthening local responses to extreme heat. Drawing from the experiences of various cities, chief heat officers play a pivotal role in coordinating multisectoral efforts, ensuring that resources and policies are effectively aligned to address the multifaceted challenges of extreme heat. In Santiago, for example, the chief heat officer led efforts to embed heat resilience into urban planning and public health frameworks, fostering a comprehensive approach to mitigating heat impacts.

56. Cities worldwide have demonstrated the efficacy of heat action plans in reducing heat-related mortality and improving resilience. In Ahmedabad, India, for example, a heat action plan comprising various measures, including early warning systems, public awareness campaigns and the establishment of cooling centres in vulnerable areas, has significantly reduced heat-related mortality.[30]

C. Effective governance at the global level

International frameworks and initiatives for addressing extreme heat

57. The Paris Agreement provides a framework for climate action. Central to its mandate is the integration of adaptation strategies into nationally determined contributions. Such strategies include measures to mitigate the risks posed by extreme heat through enhanced urban planning, public health interventions and infrastructure resilience.

[30] Kim Knowlton and others, “Development and implementation of South Asia’s first heat-health action plan in Ahmedabad (Gujarat, India)”, *International Journal of Environmental Research and Public Health*, vol. 11 (2014).

58. The Sendai Framework for Disaster Risk Reduction 2015–2030 calls for the integration of climate risk assessments into national and local development plans to ensure that populations are better equipped to handle heat-related emergencies.

59. WHO has also played a pivotal role in addressing extreme heat by developing heat-health action plans. These plans provide a road map for governments to implement public health strategies aimed at reducing heat-related mortality and morbidity. Key components of the plans include early warning systems, public awareness campaigns and targeted interventions for vulnerable populations.[31]

Global collaboration and partnerships

60. International collaboration is vital for addressing the transboundary nature of climate change and extreme heat while simultaneously advancing a sustainable energy future. Frameworks such as the Paris Agreement and the European Green Deal provide a platform for countries to align their adaptation strategies and share best practices. The importance of international coordination in managing heat-related risks was further underscored in the Sendai Framework for Disaster Risk Reduction. By fostering global collaboration, these frameworks can enable countries to pool resources and expertise, enhancing their collective capacity to address extreme heat.

61. Heat adaptation efforts need to be informed by scientific guidance from institutions such as the Intergovernmental Panel on Climate Change. By integrating global recommendations into national and subnational adaptation plans, countries and cities can effectively prepare for the impacts of rising temperatures. Collaborative approaches that combine local innovation with global best practices ensure that nations and cities remain resilient in the face of climate change.

62. Encouraging collaborative research on renewable energy technologies is essential for effectively addressing the challenges posed by extreme heat. Global partnerships can harness diverse expertise, resources and innovations, enabling the development of advanced solutions for sustainable energy use. For instance, the International Solar Alliance has facilitated cooperation among countries to expand access to affordable solar energy, particularly in heat-prone regions.[32]

63. Promoting collaborative research on heat-resilient urban designs is equally critical. As cities increasingly grapple with rising temperatures, collaborative research can support the implementation of innovative designs that integrate green infrastructure, sustainable building materials and urban planning strategies to reduce urban heat island effects and build climate-resilient cities and communities.[33] International partnerships among research institutions can enable the exchange of knowledge and the adoption of cutting-edge technologies that have been successfully applied in various global contexts.

64. Effective partnerships between Governments and the private sector can drive innovation in sustainable infrastructure and cooling technologies. Such partnerships can also leverage private investment and expertise to complement public sector efforts, creating a more robust and comprehensive response to extreme heat.

65. The establishment of a permanent platform for intergovernmental dialogues on energy at the United Nations, as suggested by the technical advisory group on Sustainable Development Goal 7, would offer a significant opportunity to enhance global governance in the context of climate-related challenges, including extreme heat. Such a platform could facilitate the exchange of best practices among countries,

[31] Franziska Matthies and others, eds., *Heat-Health Action Plans: Guidance* (Geneva, WHO, 2018).

[32] International Solar Alliance, *Annual Report 2023* (2023).

[33] United Nations Human Settlements Programme (UN-Habitat), *Cities and Climate Action: World Cities Report 2024* (Kenya, 2024).

allowing them to learn from each other's experiences and strategies. It could also serve as a coordination mechanism for actions aimed at strengthening climate resilience and equity in climate finance distribution. By promoting dialogues that bridge diverse sectors and stakeholders, the platform could help to ensure that robust policies addressing the multifaceted nature of climate change impacts are developed and implemented effectively. Empowering countries to collaborate closely could yield more responsive and holistic strategies for combating extreme heat and a smoother transition to sustainable energy systems.[34]

D. Focusing on the clean energy transition

66. Combating extreme heat will require institutions to prioritize the clean energy transition, facilitating a shift away from fossil fuels to renewable energy. Reducing carbon emissions and prioritizing renewable energy sources is essential to mitigating global warming and extreme heat events while meeting the rising demand for energy to manage these conditions effectively. The decarbonization efforts seen in some countries, such as Costa Rica and Germany, highlight how the large-scale adoption of renewable energy can effectively reduce carbon footprints and accelerate the transition to a sustainable future.

67. Promoting energy efficiency and managing demand-side pressures are integral to the clean energy transition, particularly in the context of extreme heat. To that end, the Global Cooling Prize highlights innovations in energy-efficient air conditioning that reduce energy consumption during peak demand while minimizing the impact on the environment. Smart grid systems and decentralized energy solutions allow for more efficient energy management during heatwaves while bolstering grid resilience.

68. Renewable energy integration is another critical pillar of the clean energy transition. Decentralized solar energy systems, such as the rural electrification programmes in India, ensure reliable energy access during heatwaves. Solar mini-grids and off-grid systems enhance resilience in areas with limited grid access or vulnerable infrastructure, enabling rural communities to better adapt to extreme heat.

69. The electrification of transportation systems provides a key strategy within the clean energy transition. Shifting from carbon dioxide-emitting vehicles to electric vehicles in urban centres can significantly reduce emissions that contribute to extreme heat events. Lessons can be learned from the successful implementation of such programmes in Japan and Norway, which demonstrate how electrification can be aligned with climate goals and support adaptation to rising temperatures, thus underscoring the potential of clean transportation systems to play a transformative role in addressing extreme heat challenges.

E. Financing climate action and heat resilience

70. Countries need to prioritize financing the transition to clean energy to reduce greenhouse gas emissions that drive climate change and extreme heat. They also need to support measures that help populations to adapt and build resilience. By investing in renewable energy, Governments can lower the reliance on fossil fuels. Financing such projects will also help to promote the development of energy-efficient cooling systems, improved building designs and smart grids that reduce the strain on power systems. However, this effort requires action by all actors. For example, central banks can assist the transition by integrating climate risks into monetary policies and

[34] *Ensuring Universal Energy Access and Advancing Just, Inclusive and Equitable Energy Transitions* (United Nations publication, 2023).

financial regulations, while institutional investors can direct a certain percentage of capital towards clean energy initiatives. Civil society institutions play a critical role in advocating equitable and sustainable solutions and ensuring that resources reach vulnerable communities. Together, these efforts can help to mitigate extreme heat and to provide communities with some of the tools they need to adapt effectively.

71. Developing countries and subnational and local governments face particular challenges, including the need to address high capital costs while often having limited access to financing. Moreover, weak governance structures and insufficient capacities to plan and monitor projects often undermine the effective use of resources. These challenges need to be urgently addressed. By expanding financial support mechanisms and integrating them into broader climate action plans, Governments can foster the development of resilient energy infrastructure that meets the dual challenges of extreme heat and the clean energy transition.

72. Access to international climate finance is essential for building institutional capacity and facilitating the transition to sustainable energy in the regions most vulnerable to extreme heat. Developing countries and subnational governments could benefit significantly from climate finance, as it provides the resources needed to address climate and extreme heat-related challenges. However, current access to such funding remains limited and insufficient to meet the scale of interventions required for both mitigation and adaptation efforts. Scaling up financial instruments such as green mortgages, risk-sharing mechanisms and concessional financing is necessary to address these gaps. In addition, adopting innovative models such as the cooling-as-a-service model offers a viable path towards sustainable and energy-efficient cooling systems, particularly in areas facing frequent heatwaves.

73. Financial incentives and subsidies can also help to accelerate the adoption of renewable energy. Countries such as Brazil and China have achieved rapid growth in solar and wind capacities through energy compacts and just energy transition partnerships. These initiatives align with the United Nations objective of advancing the adoption of renewable energy globally.

74. To instil confidence and provide clear guidance to investors, Governments must implement robust regulatory frameworks and consistent policies. The existing uncertainty regarding clean energy investments, compounded by regulatory barriers and political instability in many countries, significantly hampers long-term commitments in this sector. Moreover, climate risks are often overlooked in financial regulations in many regions, which further hinders access to clean energy financing. By addressing these obstacles and fostering a stable policy environment, Governments can attract and sustain investment flows into clean energy initiatives, paving the way for a more sustainable and resilient energy future.

75. There are several mechanisms that can be used to assist in securing climate financing. Public-private partnerships can play a critical role in scaling urban heat mitigation projects by mobilizing private sector investment and driving innovation. International initiatives such as the United Nations Green Climate Fund and the World Bank climate investment funds can act as catalysts, driving investment in clean energy and resilience-building efforts. Although these sources are not sufficient to cover the entire energy transition, in most cases some funding is available for well-structured projects. Cities should actively identify and solicit funding sources, including national and international grants, while exploring innovative financing mechanisms, such as green bonds, for specific measures to address extreme heat.

76. To encourage private sector participation, Governments can adopt carbon pricing and offer targeted incentives for investments in renewable energy and energy efficiency. For example, feed-in tariffs encourage the development of renewable energy by providing long-term contracts to renewable energy producers, offering a

guaranteed price for renewable energy based on the cost of generation. The price is paid to producers for the total amount of kilowatt-hours of renewable electricity that they produce.

F. Promoting cross-sectoral coordination and collaboration

77. Policy coordination and integration are essential for managing the complex and interconnected challenges posed by extreme heat. By fostering coordination and collaboration across different sectors and governance levels, Governments can implement more effective, comprehensive and sustainable climate adaptation measures. When this is paired with integrated planning, aligned policies at all levels, enhanced local capacity and global cooperation, the impacts of extreme heat can be mitigated, safeguarding communities, economies and ecosystems.

78. Research suggests that comprehensive coordination is key to enhancing national resilience against extreme heat events.[35] National Governments are responsible for creating overarching frameworks to guide and support local actions. Integrating extreme heat adaptation into national climate strategies can ensure that different levels of government, such as states and cities, align their efforts to combat heatwaves, leading to a more cohesive, consistent and coordinated approach across regions. This is particularly important given that the effective management of extreme heat requires policy integration at both the local and the national levels.

79. Extreme heat has impacts on multiple sectors, including urban planning, energy, health and agriculture. A siloed approach to policy development risks overlooking the interconnected nature of impacts across sectors, leading to fragmented and inefficient solutions. Urban planning, for example, plays a pivotal role in mitigating the urban heat island effect. Policies promoting urban greening, the use of reflective building materials and the design of shaded public spaces can significantly reduce heat exposure in cities. However, these measures must be aligned with energy policies that prioritize efficient cooling technologies and renewable energy sources, thus reducing the carbon footprint of adaptation strategies. In the health sector, coordinating health policies with urban planning and energy strategies ensures that public cooling centres, heat health action plans and early warning systems are integrated into broader adaptation efforts. Cross-sector collaboration and coordination are therefore required in order to ensure that climate resilience is integrated into diverse policy areas, enabling a more holistic response. In this context, the European Green Deal provides a framework for aligning different sectors to achieve sustainable and resilient urban development.

80. The national climate adaptation strategy of Germany is a prime example of a comprehensive approach that integrates climate risk assessments into urban planning and infrastructure development. Measures such as urban greening, the use of heat-resistant materials in construction and the expansion of shaded public spaces have been instrumental in reducing heat-related vulnerabilities. Singapore offers another exemplary model with its integrated resource management strategies. Its approach combines water management, energy efficiency and disaster preparedness to create a holistic response to climate risks. Initiatives such as the Active, Beautiful, Clean Waters Programme and the deployment of smart cooling systems in urban areas underscore the commitment of Singapore to combating extreme heat events and promoting sustainable adaptation.

[35] World Bank, *Urban Overheating and Adaptation Measures: An Analysis at EU, National, and Local Level* (Washington, D.C., World Bank Group, 2024).

81. By fostering collaboration among various sectors, Governments can create cohesive strategies that leverage innovative solutions to better prepare communities to face the impacts of rising temperatures, all while promoting the sustainable use of resources. To foster cross-sectoral coordination, national Governments must establish cohesive policies that align energy initiatives with urban planning and disaster management frameworks. This requires Governments to coordinate with and regulate utility companies, whether owned publicly, privately or by hybrid means. Such companies may be owned at the federal, state or local level, but in most cases they are important stakeholders involved in providing electricity, water and other critical resources to the public. Centralized oversight mechanisms can ensure the alignment of renewable energy strategies with climate adaptation strategies, particularly those aimed at heat mitigation and energy efficiency.

G. Leveraging data and monitoring systems

82. Data and monitoring systems are indispensable tools for managing the impacts of extreme heat. By leveraging real-time insights and integrating local efforts with broader frameworks, countries and cities can enhance their adaptive capacities, protect vulnerable populations and build resilience against future heat events. The success of data-driven strategies in Australia and Spain, for example, highlights the potential for replication and scaling, providing a road map for global climate adaptation.

83. Strategic data collection is focused on several key variables to inform targeted interventions. First, tracking heat patterns allows for the identification of temperature fluctuations and the pinpointing of heat hotspots. Second, mapping national and local factors, such as green cover, building density and surface heat, provides insights into how these factors contribute to national and subnational heating. Third, monitoring energy consumption is critical for understanding cooling demands and the capacity of existing infrastructure to meet these demands. Lastly, analysing demographics, including population distribution and growth, helps to predict future vulnerabilities among various communities. Data-driven frameworks, such as the Global Framework for Climate Services developed by WMO, can enhance the ability of cities to use this information effectively.

84. For example, detailed heat maps can identify neighbourhoods in cities in urgent need of cooling solutions, ensuring that interventions are applied where they are most needed. Similarly, data on energy consumption inform infrastructure upgrades and developments, allowing municipalities to adapt to surging cooling demands during extreme heat events. By leveraging these insights, cities can enhance their resilience to climate-induced temperature extremes, safeguarding vulnerable populations and improving overall public health and safety.

85. Integrating local monitoring efforts into national and international initiatives fosters a cohesive approach to climate adaptation. Collaborative platforms ensure that data are standardized and shared across regions, enhancing the capacity of cities to respond effectively. For example, linking municipal data with global climate models improves predictions of extreme heat events, enabling better preparation and response.

V. Conclusions and recommendations

86. Extreme heat and related events, such as fires, droughts and power grid failures, have become more frequent and far more deadly due to the increase in global

temperatures. Effective governance for extreme heat at the international, national and subnational levels is required in response.

87. Governments would be well-advised to start preparing for extreme heat events with the same sense of urgency and rigour as that associated with disaster preparedness for hurricanes, severe storms, blizzards and earthquakes. Vulnerable population groups with more limited access to cooling, ventilation and water face the highest level of risk during extreme heat events and should be prioritized in extreme heat policies and interventions in order to leave no one behind.

88. In addition to endangering human health and safety, a direct consequence of extreme heat is an increased demand for electricity and a consequent strain on power grids. Many power grids continue to rely largely on fossil fuels such as coal, oil and natural gas to generate electricity, which in turn contributes to climate change and an increased risk of extreme heat events. Rising temperatures and related impacts therefore make it essential to accelerate the transition to renewable energy.

89. The fragmented landscape of institutional responsibility for mitigating and adapting to extreme heat is cause for further concern. Preparing for rising temperatures will require strengthened collaboration and coordination among all stakeholders, including policymakers and regulators at all levels of government, as well as academia, civil society and private sector actors such as insurance companies, banks and investors.

Strategies to prepare for and respond to extreme heat events

90. Effective heat action plans that outline preventive measures and response strategies during heatwaves are required in order to ensure that vulnerable populations receive the necessary protection and resources. Chief heat officers need to be designated to lead interdepartmental task forces to design such action plans. The plans need to include various measures, such as identifying triggers and warnings for extreme heat events, identifying populations at highest risk, designing targeted programmes to provide cooling shelters and providing financial support to ensure access to efficient cooling for low-income households.

91. To design adequate and effective extreme heat response plans, Governments need to work with other institutions, particularly utility companies, emergency services, builders (e.g. to adapt building codes for better insulation), energy and healthcare providers.

92. Reliable electricity access in public institutions, including health centres and schools, is crucial for providing essential services, such as healthcare and education, during extreme heat events. These institutions may also be able to serve as cooling centres for vulnerable populations.

93. Targeted awareness campaigns can be useful to educate the public and other stakeholders about available cooling measures (e.g. cooling centres).

Enhancing energy resilience

94. Investment in grid modernization, including smart grids, advanced energy storage and robust transmission systems, is required to manage increased cooling demand.

95. Decentralized energy systems need to be promoted by developing microgrids and community-level solar installations to enhance local energy autonomy.

Scaling up renewable energy

96. Increased investment in solar, wind and battery storage can reduce fossil fuel dependence.

97. Adopting energy-efficient cooling systems, including by developing new technologies, can reduce cooling energy demand.

Financing climate action and heat resilience

98. Access to international climate finance is essential for building institutional capacity, increasing resilience and facilitating the transition to sustainable energy in the countries and regions most vulnerable to extreme heat. Developing countries and subnational governments require particular support to be able to implement context-specific adaptation measures.

99. Governments, banks, institutional investors and other actors need to develop partnerships that make it easier to finance renewable energy investments. Governments can assist directly by lowering regulatory barriers, providing concessionary funds, explaining benefits to the public and otherwise incentivizing investment in renewables.

Enhancing coordination and collaboration

100. To promote international collaboration, global frameworks need to be leveraged to share best practices and resources, thus enhancing collective resilience.

101. Given the interconnected nature of the impacts of extreme heat across sectors, cross-sectoral coordination is crucial, leading to coherent and sustainable solutions and facilitating national resilience-building.

102. Governments can use participatory approaches to engage local communities and other actors to ensure that energy transition and extreme heat strategies meet local needs and build resilience.

103. Public-private partnerships can drive innovation and investment in sustainable solutions aimed at combating extreme heat.

104. Targeted awareness campaigns are needed to educate the public and stakeholders about sustainable urban cooling.

Leveraging data and monitoring systems

105. Data and monitoring systems are indispensable tools for managing the impacts of extreme heat. Collected data can be used for public alerts, early warning systems, community response plans, health surveillance and climate change research.