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Briefing

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Emerging climate change-related public health challenges: the potential impacts of temperature rise on health outcomes in Dar es Salaam, Tanzania

In Dar es Salaam, climate model analysis strongly suggests that both day- and night-time temperatures will rise, with heat waves also expected to increase. Heat will likely aggravate many existing health and well-being risks in the city. Among other impacts, an increase in temperature can lead to: increases in infectious, vector-borne, and heat-related illnesses; rising levels of morbidity and mortality related to non-communicable diseases; and deteriorating mental and occupational health. This briefing outlines some potential interventions at multiple scales that could increase the resilience of Dar's communities.

Climate and climate projections for Dar es Salaam

Cities, particularly in the developing world, are very vulnerable to high temperatures and to the negative impacts of heat. High temperatures are common in Dar es Salaam and this can lead to the perception that people are 'used' to heat. However, research on human bioclimate in Dar shows that heat stress typically occurs during the hot season (October-March), peaking in December-February.[1,2]

Climate model analysis strongly suggests that both day-time and night-time temperatures will increase in the future.[3] By 2040, Dar will have more very hot days[4] in a year, and more very hot nights in particular, compared to the historical average.

The number of warm spells – or events where the highest daytime temperature is more than 34.6°C for three or more days in a row – is projected to increase in the future. The number of night-time warm spells – or events where the lowest temperature is above 24.5°C for three or more nights in a row – is also projected to increase by 2040 (Table 1).

Projections for annual average relative humidity are only available for six climate models. These models suggest no change from the historical average until the 2040s. After that, some models suggest there will be no change, and others that there will be a slight increase in average relative humidity, up to the end of the century.

The impacts of heat on health in Dar es Salaam

Several health risks linked to heat and rising temperatures are relevant to Dar's context, and

Policy Pointers

Governments should develop comprehensive heat and health adaptation and response plans, with the following elements:

- *Heat forecasting and monitoring* to warn local officials, planning agencies, health agencies and citizens of high temperatures or heat waves, and help prepare responses.
- *Improved disease surveillance, health data collection, and monitoring*, which would be strengthened by including private healthcare providers in reporting systems.
- *Health sector vulnerability and adaptation assessments* to identify current and future vulnerabilities, and develop interventions to avoid, prepare for and respond to risks.
- *Early/heat warning, education and awareness*, including measures to notify the public of high temperatures or heat waves, as well as conducting public health outreach.
- *High heat/heat wave responses* to: 1) increase the resilience of cities and citizens in general; and 2) respond to a particular heat wave, which may apply to different sectors (health, labour, local government, etc).

Table 1. Projections for the average annual number of very hot days, very hot nights, warm spells and night-time warm spells. The table provides the average annual figures for the present day, by 2040, and by the end of the century.

	At present	By 2040	By the end of the century
Average number of very hot days a year (days when the highest temperature is above 34.6 °C)	36	50-180	80-365
Average number of very hot nights a year (nights where the lowest temperature is more than 24.5 °C)	36	100-200	220-365
Average number of warm spells a year (events where the highest daytime temperature is more than 34.6 °C for 3 or more days in a row)	(just below) 5	6-12	6.5-16 *
Average number of night-time warm spells a year (events where the lowest temperature is above 24.5 °C for 3 or more nights in a row)	(just below) 5	6-13	4-8 **

*A number of models project a decrease in the frequency of warm spells towards the end of the century because the average length of these warm spells increases so much that separate events 'join up' into longer warm spells.
** By the end of the century there is a drop in the frequency of night-time warm spells because nights where the lowest temperature is above 24.5 °C become so common that the night-time warm spells join together, and become fewer but longer.

some of the most significant are briefly discussed below.[5] It is important to note that temperatures do not have to be extreme for heat to have an effect on health, even moderate increases in temperature can negatively impact health outcomes.

Heat strain or stress (including heat exhaustion and heat stroke): 'heat strain' (or stress) refers to a range of heat-related illnesses, that happen when the body cannot cool down enough to maintain its core temperature. Dehydration places people at greater risk, and symptoms of heat stress include: difficulty concentrating, confusion, dizziness, headache, muscle cramps, heat rash, fatigue, fainting and nausea. In the most serious cases, heat stroke can happen and may lead to unconsciousness and death.

Infectious diseases: rising temperatures could increase a variety of infectious diseases in different (and often complex) ways. However, there is a strong relationship between increased temperatures and diarrhoeal diseases like cholera, because cholera bacteria do well in warmer temperatures and in warmer water. Cholera is an important health threat in Dar.[6] Furthermore, heat can lead to changes in behaviour (for example, drinking or washing in contaminated water to keep cool) that could also increase infection rates.

Vector-borne diseases: temperature, along with rainfall and humidity, is a key driver of the rate of malaria transmission. It is difficult to predict what impact an increase in temperature would have on malaria in Dar. A small increase in temperature could mean an increase in transmission, but at relatively high temperatures, malaria could decrease. However, when it is hot, people's behaviour may change: for example, they may sleep outside more. These changes in behaviour would increase exposure to mosquitoes, and so increase the chances of getting malaria. Other vector-borne diseases that are linked to heat include dengue fever, yellow fever, tick-borne encephalitis, African trypanosomiasis, West Nile virus, schistosomiasis, and the plague.

Non-communicable diseases (NCDs): NCDs are diseases that are not passed from person to person. Some NCDs are related to heat/temperature rise, including cardiovascular disease, stroke, renal disease, diabetes, and respiratory disease. All these are increasingly contributing to Tanzania's national burden of disease.[7] People suffering from one or more of these NCDs are particularly vulnerable to heat, for different reasons. For example, diabetics are at greater risk of developing heat illnesses because their bodies cannot cool down as efficiently as people who don't have diabetes, and they lose water faster. People who catch infectious diseases are often already suffering from one or more NCDs, putting them at higher risk of heat-related health problems.

Mental and occupational health: heat/temperature rise leads to mental and physical fatigue, affecting people's concentration and ability to carry out work tasks. These effects can result in lowered productivity, which can negatively affect people's income. Furthermore, people working outside, or with a high physical load, are more susceptible to developing heat stress and related heat illnesses.

The vulnerability of Dar es Salaam residents to heat

Health vulnerability to heat varies noticeably across both individuals and populations. Typical vulnerable groups include women and children, older adults, pregnant women, persons with pre-existing illnesses (such as diabetes, cardiovascular disease), and people

Box 1. Some of the factors that affect the vulnerability of informal settlement residents in Dar es Salaam to the health impacts of heat.

Higher exposure to heat: residents of informal settlements and other low-income residents are more likely to be exposed to heat, because of: 1) living in low-quality housing structures (for example, houses made of heat-trapping materials with tin roofs); 2) lacking access to green spaces, trees and shade; and 3) working outside or in unventilated conditions.

Greater sensitivity or susceptibility to the health effects of heat: there are a number of factors that increase the sensitivity of informal settlement/low-income residents to the negative effects of heat on health. For example, these residents often don't have enough access to adequate water or sanitation, they live in crowded conditions, and often suffer from malnutrition and chronic medical conditions.

Fewer adaptation options available: informal settlement/low-income residents often have little capacity to adapt to high temperatures: they usually have little control over their home or work environments; cannot access reliable electricity, air conditioning, appropriate cooling facilities, or adequate healthcare; and receive little heat-related health information.

working outdoors. Particularly vulnerable populations in Dar include the poor and/or those living in informal settlements. Discussions (and direct observation) with residents in the informal settlement of Vingunguti, as well as discussions with policymakers and practitioners in Dar,[8] showed that many factors come together to give these groups and individuals higher exposure, greater sensitivity, and fewer adaptation options to heat (see Box 1). These factors are similar to those experienced by informal settlement residents in India.[9]

Discussions with Vingunguti residents did not focus specifically on different vulnerabilities, however, the following findings showed that: (1) residents are more uncomfortable from the heat at night than during the day; (2) sleeping outside can help people cool down at night time, but safety concerns mean that few people use this option, particularly women and children; (3) generally, children are most affected by the heat.

The Urban Heat Island (UHI) effect is worsening the effects of temperature increases in Dar. The UHI means that temperatures are often higher in cities than in surrounding rural areas for many reasons. For example: urban construction materials absorb more heat than natural land cover; and vegetation plays a large part in keeping an area cool, but vegetation is often removed in urban areas (including in informal settlements). Dar has an UHI of between 1 °C to 4 °C, as compared to a more rural area.[10]

Recommendations

Many interventions, at different scales and sectors, could increase the resilience of Dar's communities to the impacts of heat on health. A comprehensive heat and health adaptation and response plan (Heat-Health Action Plans)[11] can reduce the negative impacts of high/rising temperatures on health. The elements of such a plan might include:

- **Heat forecasting and monitoring**, which allow meteorological services to send out heat warnings so that city officials, citizens and others can prepare responses. It requires the development of heat thresholds, and defining a heat wave in Tanzania/Dar (there is no standard definition for heat waves).

- **Improved disease surveillance, health data collection, and monitoring**, including updated hospital admissions and emergency case records to track heat-related morbidity and mortality. This reporting system would be strengthened by including private healthcare providers. Health data can be broken down by social characteristics (such as by age, gender, occupation) and spatially (such as by neighbourhood) to understand who is most affected and where.

- **Vulnerability and adaptation assessments for the health sector**, which can identify current and future vulnerabilities to changing temperatures, and outline policies, programmes and projects to avoid, prepare for and respond to risks. For example, disease-specific national action plans could consider how temperature rise would affect future patterns of risks (also by specific locations, such as Dar).

- **Early/heat warning, education and awareness**, such as formal and informal systems for notifying the public of high temperatures or heat waves. Social media, SMSes, billboards, radio, newspaper, and television announcements can all be used. In informal settlements, community leaders can help to spread such information.

Public health outreach can help ensure the health and safety of city dwellers, especially the most vulnerable groups. Local officials can communicate information about:

- o The factors that put people at greater risk (such as very young or old residents, not having access to cool spaces, working outside).
- o Symptoms of excessive heat exposure (such as dizziness, nausea, muscle cramps).
- o Recommended response and treatment options (such as finding cool locations, staying hydrated, checking on family and friends).

- **Mapping of high-risk areas vulnerable to heat impacts**, taking into account the factors that influence vulnerability to heat, such as access to water, building materials, density, shade, etc.

- **High heat/heat wave responses:** responses to urban heat can be divided into those taken to increase the resilience of cities and citizens to heat and high temperatures in general, and those taken in response to a heat wave.

The following are all examples of possible broad responses to heat and high temperatures, divided into different sectors:

- *Health sector:* for example, capacity building among healthcare professionals so that professionals can better recognise and respond to heat-related illnesses; or keeping health facilities cool and comfortable, or at least providing designated cooling areas.
- *Urban planning and local government sector:* city officials can include strategies to reduce the UHI effect into long-term planning. For example, using cool or green roofs, and planting trees and vegetation, can help keep buildings and their surroundings cooler. These measures also reduce electricity demand. The importance of providing shade through trees is emphasised by a recent study for Dar.[12] Heat is often thought to be a greater problem in parts of a city dominated by high-rise buildings (because of the UHI effect), but the study shows that areas with low-rise buildings can be more stressful urban spaces than areas with high-rise buildings, because of the absence of shade. Planning permissions and building codes can be revised to consider adaptation to heat. Other strategies can include increasing the availability of cooling spaces such as parks, shaded open space or swimming pools, or creating 'cooling centres' in places such as schools, public libraries, places of worship, etc. In some cases, cooling spaces and centres might exist already, but access might need to be improved, for example, by extending opening hours or improving transport options. Public access to water could also be improved, for example, by offering safe drinking water fountains.
- *Labour sector:* trainings can be organised for employers, outdoor labourers and workers regarding the health impacts of heat and recommendations to protect themselves during high temperatures. Local businesses could be encouraged or required to provide fans, cool water, shade and rest periods to workers at risk, and change work hours to cooler times of day. It will be challenging to develop heat response strategies for the informal labour sector, given that this sector is unregulated.

The following are examples of heat wave responses:

- Providing emergency community cooling centres, particularly in areas with very vulnerable populations.
- Health centres, particularly those near informal settlements, could put in place staffing plans and protocols that increase capacity during heat waves.
- Establishing emergency efforts to distribute fresh drinking water, such as using water tankers during a heat alert.
- Encouraging employers to shift outdoor workers' schedules to cooler hours of the day during heat waves, and provide ventilation, water, shade and rest periods.

Authors

Lorena Pasquini – lorena.pasquini@gmail.com – African Climate & Development Initiative, and Climate System Analysis Group
Lisa van Aardenne – Climate System Analysis Group
Jessica Lee – Climate System Analysis Group
Christie Godsmark – School of Public Health and Family Medicine, Division of Environmental Health
Chris Jack– Climate System Analysis Group
University of Cape Town, South Africa.

Notes

1. Ndetto, EL and Matzarakis, A (2013) Basic analysis of climate and urban bioclimate of Dar es Salaam, Tanzania. *Theoretical and Applied Climatology* 114: 213-226.
2. Ndetto, EL and Matzarakis, A (2017) Assessment of human thermal perception in the hot-humid climate of Dar es Salaam, Tanzania. *International Journal of Biometeorology* 61: 69-85.
3. Climate model analyses were performed at the University of Cape Town and are available at www.urbanark.org/dar-es-salaam-climate-profile-summary-version and www.urbanark.org/dar-es-salaam-climate-profile-full-technical-version
4. 'Very hot' days are often described as those that are over the 90th percentile statistic. For Dar es Salaam, the 90th percentile is 34.6°C for daily maximum temperature, and so 'very hot' days are those in which the hottest daytime temperature is more than 34.6 °C. 'Very hot' nights are those in which the lowest night-time temperature is more than 24.5 °C. The 90th percentile is a statistic used to show the 10 per cent of most extreme events through time (eg the 10 per cent of days with the hottest temperature in the weather data record for Dar are those days hotter than 34.6°C).
5. It is important to note that there are other impacts of temperature rise/heat that are not covered in this briefing. For example, an important possible impact from heat in Dar concerns road safety: lowered concentration and fatigue under heat conditions can lead to increased road traffic accidents.
6. For example: McCrickard, LS *et al*. (2017) Cholera mortality during urban epidemic, Dar es Salaam, Tanzania, 16 August 2015–16 January 2016. *Emerging Infectious Diseases* 23(Suppl 1): S154-S157.
7. Mayige, M, Kagaruki, G, Ramaiya, K and Swai, A (2012) Non communicable diseases in Tanzania: a call for urgent action. T*anzania Journal of Health Research* 13(5: Suppl): 378-386.
8. The full analysis of interview results will appear in a forthcoming paper by Pasquini *et al*.
9. Mavalankar, D *et al*. (2013) Rising temperatures, deadly threat: recommendations for slum communities in Ahmedabad. *NRDC Issue Brief*. Natural Resources Defense Council, New York. Available online at: www.nrdc.org/sites/default/files/india-heat-government-officials-IB.pdf [accessed 14 August 2018].
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11. See www.euro.who.int/__data/assets/pdf_file/0006/95919/E91347.pdf
12. Yahia, MW, Johansson, E, Thorsson, S, Lindberg, F and Rasmussen, MI (2018) Effect of urban design on microclimate and thermal comfort outdoors in warm-humid Dar es Salaam, Tanzania. *International Journal of Biometeorology* 62: 373-385.

Urban Africa Risk Knowledge

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Contact: Mark Pelling
mark.pelling@kcl.ac.uk

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