The threat of extreme heat waves and human 'survivability' in South Asia

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The adverse effect of anthropogenic climate change on human health, especially for populations in the low-income agricultural regions is a topic of grave concern for scientists and policy makers. A new study warns that fatal heat waves in the future may cause high human mortality in the hugely populated and economically vulnerable South Asia, unless measures are taken to mitigate climate change[1].

Following a previous study that analysed the human limitation of adaptability to heat stress in a changing climate[2], the new study[1] uses the metric 'wet bulb temperature (T_W)', which is defined as the temperature that an air parcel would attain if cooled at constant pressure by evaporating water within it, until saturation. Thus, T_W is a combination of both air temperature (T, the dry bulb temperature) and moisture content (humidity) in the air and is always less than T. T_W values are large when both temperature and humidity are high. Uncomfortable conditions are reached when T_W approaches 30°C.

The normal human core body temperature is maintained at around 37°C, and the skin temperature is regulated at or below 35°C because the skin must be cooler than the core body in order for metabolic heat to be conducted to the former. When $T_W \geqq 35$°C, the human body can no longer conduct or dissipate heat produced by metabolism to the environment. Instead, the body will absorb heat from the environment, which leads to hyperthermia and eventual death in a few hours in natural conditions. Commonly observed T_W values across the globe are in the range 25–26°C or less, with highest T_W values recorded globally in the recent decades near 30°C.

The previous modelling study[2] showed that while T_W never exceeds 30°C anywhere on the planet, it would begin to occur when global mean warming is about 7°C which is possible by the end of the century under the 'business-as-usual (BAU)' scenario of unabated CO_2 emissions. It further showed that with 11–12°C global mean warming, such 'unlivable' regions would spread to encompass the majority of the human population, as currently distributed.

The new study[1] is focused on the South Asian region. It identifies the following regions in South Asia where T_W values exceed 28°C in present-day conditions: Pakistan, Nepal, India, Bangladesh and Sri Lanka. The study projects the effects of climate change on T_W values in these regions in the future. It is noteworthy that these regions have a recorded history of increasing frequency of heat waves and related calamities in recent decades.

High-resolution regional climate model simulations for two possible future climate scenarios used by the Intergovernmental Panel on Climate Change are performed in the new study[1]. These simulations project the regional-level changes in climate by the end of the 21st century (year 2100). One of these scenarios is RCP8.5, in which the radiative forcing due to greenhouse gases in the atmosphere increases to 8.5 Wm^{-2} by 2100, relative to the pre-industrial period. The RCP8.5 scenario is also referred to as the 'business-as-usual' scenario, where fossil-fuel emission is unabated. In this scenario, a multi-model average global mean temperature increase of ~4.5°C, relative to the present is predicted. The other scenario – RCP4.5 – is a stabilization scenario with moderate mitigation efforts to curb global warming. For this scenario, a multi-model-mean global warming of ~2.25°C by 2010 is projected.

The new study[1] simulates daily maximum T_W values above the survivability threshold of 35°C by 2100 in various parts of South Asia, notably in Chota Nagpur Plateau, the Ganges river valley, North East India, the eastern coast of India, Bangladesh, northern Sri Lanka and Indus Valley of Pakistan in the no-mitigation RCP8.5 BAU scenario. Daily maximum T_W values much close to this survivability threshold are predicted over most of South Asia. Additionally, many urban metro regions in South Asia are projected to experience T_W values around 31°C, considered dangerous to most humans. It is concluded that 'The most intense hazard from extreme future heat waves would be concentrated around densely populated agricultural regions of the Ganges and Indus river basins.' 'Livable conditions' in India are likely to prevail only in the Deccan Plateau and Himalayas by 2100 in this scenario.

For the moderate-mitigation RCP4.5 scenario, daily maximum T_W values above the survivability threshold of 35°C in South Asia are not projected by this modelling study. However, many of the regions could be under the threat of health hazards with T_W values reaching 31°C. The study projects an increasing frequency of maximum T_W occurrences, from a once in 25-yr event at present to almost every year for RCP8.5 and every two years in RCP4.5.

It should be emphasized that countries in South Asia have lower per capita income, higher population density and large dependence on agriculture for livelihood, that further adds to the vulnerability of the population to climate change, as they may have to expose themselves more to the thermal stress outdoors and may not be able to afford air-conditioning or such amenities to fight the heat indoors. For high-density urban population exposed to poor living conditions, the urban heat island effect may increase the risk level of extreme heat.

Though both studies predict a grim future, the differences in T_W values between the moderate mitigation scenario and the BAU scenario show the importance of mitigation efforts to curb the effects of anthropogenic climate change in the most vulnerable geographical locations such as India. Human survivability in the South Asian region would be better served by sticking to the Paris Agreement and limiting the global mean warming to 2°C.

1. Im, E-S., Pal, J. S. and Eltahir, E. A. B., *Sci. Adv.*, 2017, **3**(8).
2. Sherwood, S. C. and Huber, M., *Proc. Natl. Acad. Sci. USA*, 2010, **107**, 9552–9555.

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