Speed of approach to critical levels of climate change as dangerous to our survival as reaching those critical levels

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The rate at which Earth approaches critical levels of climate change could be as dangerous to our future as reaching these levels themselves, researchers have determined.

A recent paper by mathematicians at University College Cork and the University of Exeter in England has found that our ability to adapt to

global warming will be impaired if the rate of change is too rapid. Approaching critical levels at a too fast rate of change will create new rate-induced tipping points, researchers have found.

This, in turn, will impact our capacity to meet the challenges posed by tipping points since tipping will occur earlier than expected. The study has been published in the journal *Earth System Dynamics*.

Until now, critical levels have been assumed to be a point of no return, but the new study concludes that dangerous rates of change could trigger irreversible shifts in human and natural systems even before these critical levels are reached.

The new study highlights the dangers associated with rate-induced tipping, which is triggered not by a critical level of change but instead by how quickly that level is approached.

For example, a slower or more gradual approach towards a critical level of climate change will allow humans, animals, and ecological systems more time to adapt and survive the outcomes once this level is reached. However, a more disruptive rapid approach risks the survival of species even before a critical level is reached. This disruption to ecosystems will, in turn, create new challenges and new tipping points in socio-ecological networks through so-called domino effect.

The research team say the rate of change in anthropogenic forcing is often more important to control, than the peak change, if we are to avoid triggering tipping points.

Joint lead author, Dr. Hassan Alkhayuon, from the School of Mathematical Sciences, University College Cork, said, "The phenomenon of rate-induced tipping is not restricted to climate systems. Using mathematical modeling we observe similar effects in ecosystems

and human-made systems."

Another example of rate-induced tipping was the near-miss blackout in England during the 1990 World Cup semi-final, as Dr. Alkhayuon explains.

"When England played West Germany, the National Grid was prepared for a surge in demand at full time. What they didn't prepare for was the game going to extra time, then penalties. So, when the equivalent of one million kettles were turned on all at once there was a huge surge in demand on the grid and a near miss. It wasn't that the capacity wasn't there—the problem was that at that moment in time the grid was not prepared for a sudden surge."

Professor Sebastian Wieczorek from the School of Mathematical Sciences, University College Cork, added, "Rate-induced tipping captures a ubiquitous and potentially dangerous instability—failure to adapt to changing external conditions—and thus requires deeper understanding and recognition by climate policy makers."

Joint lead author Dr. Paul Ritchie, of Exeter's Global Systems Institute and the Department of Mathematics and Statistics, said, "While the latest Intergovernmental Panel on Climate Change 6th Assessment Report rightly highlighted the urgency to limit global warming levels, it fell short of identifying the rate of warming as a key risk factor for climate tipping points."

"This rate-induced tipping may be of even greater concern because of the unprecedented rates of global warming and heat wave intensity we are currently experiencing."

More information: Paul D. L. Ritchie et al, Rate-induced tipping in natural and human systems, *Earth System Dynamics* (2023). DOI:

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