Climate tipping might not always be disastrous

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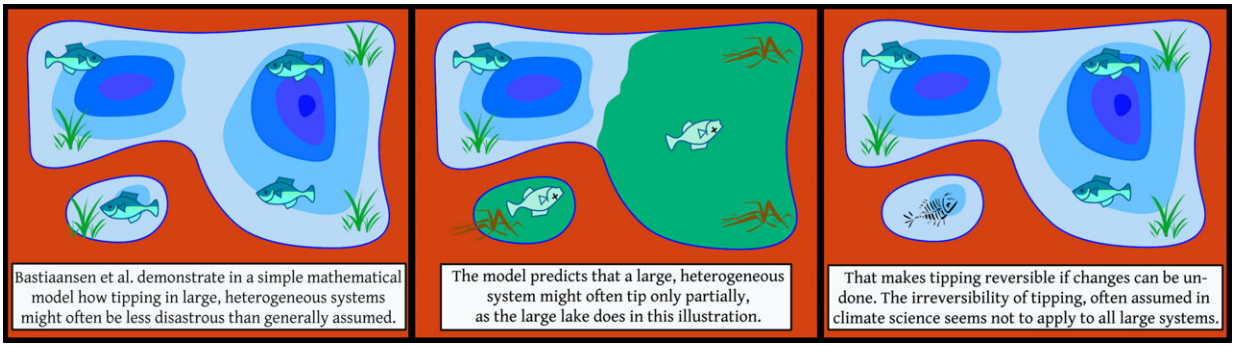

Passing a tipping point is less critical in the large lake than in the small one. A new model reveals this will be the case in many large, heterogeneous systems. Credit: TiPES/HP

The consequences of crossing a tipping point might often be much more subtle and less severe than generally assumed. That is the conclusion of a mathematical analysis of tipping in large, spatially heterogeneous systems, which natural systems like ice sheets, lakes, and forests often are. The study by dr. Robbin Bastiaansen et al. from Utrecht University, The Netherlands is published in *Environmental Research Letters*.

In most scientific works on tipping points in the Earth system, as well as in public discussions, it is often assumed that tipping leads to catastrophic and irreversible changes for the whole system. But in the paper, titled "Fragmented tipping in a spatially heterogeneous world,"

the researchers argue that such a view is based on simplistic modeling.

The real world is heterogeneous

The authors reveal that when spatial heterogeneity is added to the simulations, the severity of hitting a tipping point seems to strongly depend on the spatial size and heterogeneity of the system. This means that in large, heterogeneous, systems tipping might often instead lead to minor, stepwise, and even reversible changes. Many climate sub-systems, such as ocean current systems, ice sheets, and large biotopes like rain forests, are indeed large and spatially heterogeneous.

The finding can be illustrated with a pair of lakes of different sizes. In a small pond, there is only little variation (little heterogeneity) within the system and consequently, nutrient pollution can induce tipping in which excessive growth of algae makes the full pond turbid. In a larger lake, however, tipping might not involve the whole lake. Parts of the lake might avoid turbidity because of the sheer size of the system which makes it more heterogeneous.

Passing a tipping point is, therefore, less critical in the large lake than in the small one. Indeed, the heterogeneity also makes tipping more easily reversible in the large system. In small lakes, restoration via an improvement of the nutrient balance is often very difficult as the system is trapped in a turbid state. In larger lakes, however, even the removal of small amounts of nutrients can immediately lead to an expansion of the clear parts of the lake.

Moreover, because species may survive in the clear parts of the lake and later reinhabit the turbid areas as they once again might clear up, also the impact of tipping on the ecosystem can be much less severe if parts of the system maintain their original state.

Still worried

Generally, the study from Bastiaansen et al. informs us that what comes after the crossing of a climate tipping point is still very much an open question. The study, however, does not make Bastiaansen think we should simply relax about climate tipping.

"I am still worried about tipping points. Because I can imagine critical things might happen especially as climate change persists. But I am not as worried that once we cross a tipping point, everything is going to hell immediately. I think it is going to be much more subtle than the kind of narrative that has been painted in some papers about planetary boundaries: that once we cross over one tipping point everything just collapses simultaneously. I don't think that is the case," concludes Robbin Bastiaansen.

More information: Robbin Bastiaansen et al, Fragmented tipping in a spatially heterogeneous world, *Environmental Research Letters* (2022). DOI: 10.1088/1748-9326/ac59a8

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