What Are Climate Tipping Points, And How Likely Is It That Humans Might Trigger Them?

You're sat in front of a glass of water, precariously perched on the edge of your kitchen table. As you analyse your own, curved reflection in the glass and follow the golden light patterns refracted on the table surface, you let your intrusive thoughts take over: you nudge the glass, just a little. It rebalances. You push it off again, with the tip of your finger, a tiny bit more; about half of it is in suspension now. Surprised of how it kept its stability, you nudge it once more, testing its limits. Suddenly, the glass goes crashing to the floor, shattering and spilling all over the tiles! With that last push, you triggered a sudden, irreversible change, much bigger than your minute effort: you triggered a tipping point.

In climate science, a tipping point is defined as a critical threshold that, when exceeded, can lead to a significant change in the state of the system, often with an understanding that the change is irreversible. In terms of global warming, there are certain levels of temperature rise at which some very fast, significant and irreversible changes might occur in the world as we know it, just like a minuscule nudge can shatter a glass of water. Some examples of what this might look like around the world are the Amazon rainforest becoming a savannah, the collapse of coral reefs, and other worrying, undesirable consequences over the next few centuries. Although these may sound like very remote, purely theoretical possibilities, there is scientific evidence that we might be heading in this direction. How is this possible?

The answer to this question lies in the mechanism that triggers most tipping points: feedback loops. Take a swing in a park, for example. If untouched, the seat will obviously remain in its equilibrium position: still, and at the bottom of its swinging movement. However, as a child starts using it they drive themselves backwards, away from equilibrium. What will happen now? This example won't end in catastrophe: the child starts effortlessly swinging backwards and forwards. The swing always comes back down thanks to the force of gravity, which acts against its movement. This is an example of a negative feedback loop: the farther away from the equilibrium position, the stronger the restoring force which eventually allows the system to return to its original state. There is significant evidence that climate change is full of negative feedback loops, and this has allowed the Earth to maintain a fairly stable temperature for millions of years: whether it was swinging towards cold ice ages or warmer interglacial periods, negative feedback loops were always able to restabilise the Earth's equilibrium.

However, climate change is also full of positive feedback loops, that work in the opposite way: a movement away from equilibrium causes a chain reaction that culminates in further movement away from equilibrium. This is happening in the Arctic, where the white and shiny arctic sea ice has always been great at reflecting part of the sun's radiation away from the Earth to ensure that it doesn't heat up too much. Today, however, global warming is causing arctic ice to melt and retreat. This uncovers the sea beneath it, which absorbs the sun's radiation much better and so increases the amount of heat trapped on Earth. Recapping: global warming causes sea ice melting, which leads to more global warming and… more sea ice melting, at a faster rate than before! At a certain temperature, a tipping point may be reached: sea ice would start retreating very rapidly and the whole arctic, less and less able to reflect the sun's radiation, would find a new equilibrium at a much higher temperature.

The discovery of positive feedback loops and tipping points has made the world reconsider the importance of global warming as a global issue, since it reveals a potentially much bigger problem. But how likely is it that humans might trigger the planet's tipping points?

This depends on the type of tipping point considered, since some systems are more resilient than others. A system that is already on the verge of tipping is the Amazon rainforest: a combination of higher temperatures and deforestation are causing longer periods of droughts in a cycle that may start self-amplifying because as more trees die the forest loses moisture, making droughts even longer. Scientific estimates see the forest tipping at a temperature change of +1.5/2.0°C and deforestation of 20-25%; we currently stand at +1.2°C and 17-18%. Instead, the East Antarctic Ice sheet may only collapse at about +7.5°C, which is much less probable.

In the Paris Agreement, 194 countries agreed to implement policies aimed at keeping temperature increase under 2°C. Unfortunately, even if this goal is reached it's likely that 7 out of the 16 identified tipping elements will be triggered, raising concerns over the treaty's effectiveness. Further doubts are arising since the US, the second country with the most greenhouse gas emissions, is set to withdraw from the agreement.

On the other hand, there is enough evidence to hope that climate tipping points won't be fully triggered. Our scientific advances have finally indicated a clear path to stop global warming and all the necessary tools and resources to meet our current climate goals, such as green energy, are already accessible. In addition, most systems only find a new equilibrium decades or centuries after their tipping point has been triggered, potentially giving future human generations enough time to cool the Earth down and interrupt the feedback loops before the systems' transitions are complete. This may be achieved if we reach a negative value for net global emissions.

In conclusion, it is likely that human-induced global warming will trigger several tipping points, with destructive consequences. However, an increased awareness on such consequences has placed humanity on the right track to limit the damage and, hopefully, repair it before it is too late.

By Federico Fiorini, 16, Wellington College, Y12

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