Global Challenges Foundation

Tipping points

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The Thwaites Glacier is a giant river of ice, more than a kilometer deep at its base and covering an area roughly the size of Britain, that is slowly flowing from the interior of the West Antarctic Ice Sheet to the Amundsen Sea in the South Pacific Ocean.

Right next to it is the Pine Island Glacier, another enormous ice flow, transporting ice masses formed in the interior of West Antarctica over millennia towards the ocean. Together the two glaciers hold enough frozen water to raise the global sea level by more than a meter if they melt. And melting they are.

Due to global heating, the Thwaites and Pine Island Glaciers have been shrinking for decades, losing billions of tons of ice every year, with a combined net ice loss currently corresponding to a 0.3 mm global sea level rise per year.

Now, 0.3 mm per year may not sound too alarming, and if glacier melting was a linear process, it could take hundreds or thousands of years before the two glaciers would cause any serious trouble for the world. Unfortunately, that is not how things work.

The Thwaites and Pine Island glaciers are both grounded at bedrock deep below the surface of the sea, and as the glaciers slowly shrink, they become increasingly exposed to the ocean, causing accelerating melting from below, undermining the glaciers and causing them to slide faster into the ocean.

At some point, this process of disintegration from below could become self-sustaining and continue to escalate, even if the man-made global heating that triggered it was halted. Eventually the ice shelves, and then the entire glaciers, may collapse and, in turn, destabilize the entire West Antarctic Ice Sheet.

The critical threshold where glacier decay turns into a self-reinforcing process, with ice loss triggering further ice loss in an accelerating spiral towards large scale ice sheet collapse, constitutes what scientists have identified as a climate tipping point.

The existence of such tipping points in the Earth's climate system has caused increasing alarm among climate scientists, since it means that disastrous and irreversible consequences of global heating could occur much faster and with less heating than previously thought.

A particularly important, and scary, insight is that the tipping point is not the point when the glacier collapses; it is the point when the self-sustaining process that may eventually lead to glacier collapse is set in motion. This could happen decades before the collapse and perhaps without anyone noticing.

The generalized tipping point concept involves

- A system with multiple possible, qualitatively different, alternative states, that is stable in the sense that some external force is required to push the system out of its incumbent state.
- A positive feedback mechanism that, beyond the tipping point, becomes strong enough to continue to move the system away from its initial state even if the external forcing is removed.

In physics – where the concept has its origins – a tipping point is the maximum angle to which you can tilt an object before it tips over. Within a certain range – as long as the center of gravity stays within its support base – an object that is tilted remains stable. But – as some of us have experienced as school children – if you lean backwards on your chair beyond a certain angle, it will tip over and you end up flat on your back at the floor.

The concept has gained a much wider use and is today applied to explain change dynamics in a variety of scientific disciplines: sociology, game theory, economics, epidemiology, ecology. In climate science, the concept is used to identify dangerous thresholds where anthropogenic global warming could trigger dramatic, self-reinforcing and possibly irreversible changes in vital, life supporting systems of the earth.

In addition to the West Antarctic Ice Sheet, potential tipping elements in the climate system include the Amazon, where deforestation, droughts and fires may cause a massive loss of forest, causing further forest loss in a vicious spiral, turning one of the world's largest carbon sinks into a giant carbon source. It also includes ocean circulation systems, dying coral reefs and thawing permafrost in arctic regions that could release vast amounts of stored carbon to the atmosphere, making climate change continue, and accelerate even if human emissions would go to zero.

In the case of a tilted chair, the positive feedback mechanism is gravity; in the case of thawing permafrost, it is the fact that the carbon released from frozen organic material will add to and accelerate global heating, thus causing additional thawing, releasing even more carbon to the atmosphere. Positive feedback mechanisms typically generate exponential change, starting off slowly but then accelerating. This means we may at first underestimate the magnitude of an emerging problem grossly and fail to react adequately while we still have time to make a real difference.

To give an idea of the power of exponential change, suppose you had a choice between 10 million USD today, or 10 cents to be doubled every week. What would you

choose? Well, if you choose the 10 cents, you will at first see your small fortune grow very slowly, almost unnoticeable, for many weeks. After five weeks you could perhaps buy a cappuccino. After 15 weeks your money will have started to grow, but you will still be lagging far behind with around 3,000 USD on your account. But within less than a year your initial 10c will have turned into an amount exceeding global GDP.

Understanding that neither global heating nor the impacts of it are linear processes, but characterized by complex feedback mechanisms, exponential change and critical tipping points, comes with some important policy implications. First and foremost, it means that action is extremely urgent; it is before tipping points are crossed that we can change the course of history, not when the effects of crossing them unfold before us.

But it also means that we may have more power to change our destiny than we realize. The existence of "positive tipping points" in social and economic change may provide us with powerful opportunities for rapid changes of human behavior, technologies and patterns of production and consumption that are needed for a transition towards a sustainable future.

"If it was a matter of hunting a deer, everyone well realized that he must remain faithful to his post; but if a hare happened to pass within reach of one of them, we cannot doubt that he would have gone off in pursuit of it without scruple…"

Social tipping points occur in human interaction problems where people have incentives to behave in the same way as others. In 'A Discourse on Inequality', Jean Jacques Rousseau tells a much cited, brief anecdote about an imaginary hunter society where people can choose to collaborate to hunt deer, or to hunt hare on their own:

Suppose that catching a deer together brings more meat to the table for all than each catching a hare by themselves, and that the chance of catching a deer increases with the number of hunters who collaborate. The situation has two equilibrium outcomes: a collaborative one where all hunt deer, and a non-collaborative one where all hunt hares. In game theory, this type of interaction problem is known as the Stag Hunt.

Since the collaborative equilibrium is better for all, deer hunting might seem to be the obvious choice. However, deer hunting is also risky; if you hunt deer and everyone else leaves their posts to go hare hunting, you will go to sleep hungry. If you live in a society where everyone hunts hare, you better do the same. A society can therefore be trapped in a non collaborative equilibrium that is bad for all.

The problem illustrated by the Stag Hunt game is how a society can transition from a bad equilibrium to a better one. The tipping point is where a critical mass of hunters start working together, making it beneficial for others to join them, which increases the attraction of collaboration further.

Right now, humanity is facing a giant challenge with a similar structure: How can we collectively move from the current state, trapped in fossil fuel dependence, overconsumption of resources and unsustainable take-make-waste production models towards a future of renewable energy, and sustainable modes of consumption and production?

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Many aspects of this necessary transition have a Stag Hunt-structure. We start from a state of deep dependence on fossil fuels, where the incumbent fossil-based solutions benefit from economies of scale, sunk costs and infrastructure – roads, grids, fueling stations – that have been built around and adapted to the existing fossil solutions for decades.

Any alternative technology – renewable energy, electric vehicles or circular production – will start off at a disadvantage. But as the market share of the alternative solution grows, costs will go down, infrastructure will be built to support it, and it will become more and more competitive both in terms of cost and availability. At some point, the alternative solution may become cheaper and more easily available than the incumbent one.

That is the tipping point. That is the point where the market starts to transform by itself at an accelerating pace, without policy interventions. There are signs that some tipping points have been passed; on many markets, wind and solar power is already less expensive than new – or even existing – coal power.

This means that well targeted, well-designed and timely policy interventions can have much more impact than we acknowledge. One important role of policy interventions is simply to push potentially viable sustainable solutions beyond the hilltop, where the carriage starts rolling by itself.

Understanding the power of exponential change and tipping points thus should make us both scared and determined: the situation is likely much worse than we can currently see, but our power to do something about it is also much greater than we realize.