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Interconnected Disaster Risks

Risk Tipping Points

2023

Contents

Executive Summary

Introduction
Humans often think of processes as being simple and predictable. When we need water, we turn on the tap and water comes out. However, we do not give much thought to where the water came from in the first place, and we are often unaware of the many underlying processes that occur before it reaches us. This leaves us with little understanding of the effect of our usage on others in the system, or the risk that one day the source of our water could be gone.

Systems are all around us and closely connected to us. Water systems, food systems, transport systems, information systems, ecosystems and others: our world is made up of systems where the individual parts interact with one another. Over time, human activities have made these systems increasingly complex, be it through global supply chains, communication networks, international trade and more. As these interconnections get stronger, they offer opportunities for global cooperation and support, but also expose us to greater risks and unpleasant surprises, particularly when our own actions threaten to damage a system.

When our life-sustaining systems, such as those for our water or food, deteriorate, it is typically not a simple and predictable process. A tower made of building blocks might remain standing at first if you remove one piece at a time, but instability slowly builds in until you remove one block too many and it topples over. Like the stack of blocks, when a certain threshold of instability is reached in a system, it might collapse or fundamentally change. We open the tap, and suddenly nothing comes out. This is called a tipping point, and tipping points can have irreversible, catastrophic impacts for people and the planet.

Risk tipping points
There are different kinds of tipping points. Climate change has so-called “climate tipping points”, specific thresholds after which unstoppable changes occur, influencing the global climate. When the increasing temperatures push vast systems around the world, like the Amazon rainforest or the Greenland Ice Sheet, past certain thresholds, they will enter a path towards collapse.

But tipping points are not always physical, and climate change is just one of the many drivers of risk. Many new risks emerge when and where our physical and natural worlds interconnect with human society. Some tipping points trigger abrupt changes in our life-sustaining systems that can shake the foundations of our societies. This is why the 2023 edition of the Interconnected Disaster Risks report proposes a new category of tipping points: risk tipping points. A risk tipping point is the moment at which a given socioecological system is no longer able to buffer risks and provide its expected functions, after which the risk of catastrophic impacts to these systems increases substantially.

Pushed towards a cliff edge
Today, we are moving perilously close to the brink of multiple risk tipping points. Human actions are behind this rapid and fundamental change to the planet. We are introducing new risks and amplifying existing ones by indiscriminately extracting our water resources, damaging nature and biodiversity, polluting both Earth and space, and destroying our tools and options to deal with disaster risk.

One example of such a risk tipping point is the depletion of groundwater needed for agriculture (**Groundwater depletion**). Groundwater is an essential freshwater resource stored in underground reservoirs called “aquifers”. These aquifers supply drinking water to over 2 billion people, and around 70 per cent of withdrawals are used for agriculture. However, more than half of the world’s major aquifers are being depleted faster than they can be naturally replenished. As groundwater accumulates over thousands of years, it is essentially a non-renewable resource. The tipping point in this case is reached when the water table falls below a level that existing wells can access. Once crossed, farmers will no longer have access to groundwater to irrigate their crops. This not only puts farmers at risk of losing their livelihoods, but can also lead to food insecurity and put entire food production systems at risk of failure.

This is not a theoretical threat. Some regions, like Saudi Arabia, have already surpassed this groundwater risk tipping point. In the mid-1990s, Saudi Arabia was the world’s sixth-largest wheat exporter, based on the large-scale extraction of groundwater for irrigation. But once the wells ran dry, Saudi Arabian wheat production dropped and they had to rely on wheat imported from elsewhere. Other countries, like India, are not far from approaching this risk tipping point, too.

In an interconnected world the impacts of risk tipping points such as this are felt globally, as they cause ripple effects through food systems, the economy and the environment. They affect the very structure of our society and the well-being of future generations, and they also affect our ability to manage future risks. Groundwater, for instance, is relied upon to mitigate half of the agricultural losses caused by drought, a scenario we can expect to occur more often at many places in the future, due to climate change. If the groundwater has been depleted, this is an option we will no longer have.

Analysing risk tipping points
The 2023 Interconnected Disaster Risks report analyses six interconnected risk tipping points, selected for their representation of large global issues, which are changing lives across the world:

- **Accelerating extinctions**: A chain reaction to ecosystem collapse
- **Groundwater depletion**: Draining our water, risking our food supply
- **Mountain glaciers melting**: Running on thin ice
- **Space debris**: Losing our eyes in the sky
- **Unbearable heat**: Living in the unliveable
- **Uninsurable future**: With rising risks, insurance becomes unreachable

For **Mountain glaciers**, the risk tipping point is called “peak water” — it is when a glacier produces the maximum volume of water run-off due to melting. After this point, freshwater availability will steadily decline. Peak water has already passed or is expected to occur within the next 10 years for many of the small glaciers in Central Europe, western Canada or South America. In the Andes, where peak water has already passed for many glaciers, communities are now grappling with the impacts of unreliable water sources for drinking water and irrigation.

For **Uninsurable future**, the risk tipping point is reached when increasingly severe hazards such as storms, floods or fires drive up the costs of insurance until it is no longer accessible or affordable. Once insurance is no longer offered against certain risks, in certain areas or at a reasonable price, these areas are considered “uninsurable”. In Australia, for example, approximately 520,940 homes are predicted to be uninsurable by 2030, primarily due to increasing flood risk. Once this point is passed, people are left without an economic safety net when disasters strike, opening the door to cascading socioeconomic impacts in high-risk areas.

These diverse examples illustrate that risk tipping points extend beyond the single domains of climate, ecosystems, society or technology, but rather are inherently interconnected across them. They share similar root causes and drivers which are embedded in our behaviours and actions that increasingly put pressure on our systems until they change and stop supporting human lives and livelihoods. The impacts of these risk tipping points are not isolated to the places where tipping points are crossed but, through their interconnections with other systems, cascade through to other places around the world, influencing those to tip as well. For example, **Unbearable heat** threatens not only human lives and health, but also wildlife, which is increasing the risk of **Accelerating extinctions**, putting the ecosystems we depend on in peril.

More and more risk tipping points on the horizon
The six risk tipping points analysed in this report offer some key examples of the numerous risk tipping points we are approaching. If we look at the world as a whole, there are many more systems at risk that require our attention. Each system acts as a string in a safety net, keeping us from harm and supporting our societies. As the next system tips, another string is cut, increasing the overall pressure on the remaining systems to hold us up. Therefore, any attempt to reduce risk in these systems needs to acknowledge and understand these underlying interconnectivities. Actions that affect one system will likely have consequences on another, so we must avoid working in silos and instead look at the world as one connected system.

Creating the future we want
Luckily, we have a unique advantage of being able to see the danger ahead of us by recognizing the risk tipping points we are approaching. This provides us with the opportunity to make informed decisions and take decisive actions to avert the worst of these impacts, and perhaps even forge a new path towards a bright, sustainable and equitable future. By anticipating risk tipping points where the system will cease to function as expected, we can adjust the way the system functions accordingly or modify our expectations of what the system can deliver. In each case, however, avoiding the risk tipping point will require more than a single solution. We will need to integrate actions across sectors in unprecedented ways in order to address the complex set of root causes and drivers of risk and promote changes in established mindsets.

A new framework for solutions
The 2023 Interconnected Disaster Risks report proposes a new framework to classify and discuss the effectiveness of solutions that can help us address risk tipping points. Broadly, solutions fall into two main categories: **Avoid** solutions are those that target root causes and drivers of risk to avoid crossing risk tipping points altogether. Meanwhile, **Adapt** solutions are those that help us to prepare or to better address the negative impacts of risk tipping points in case they cannot be avoided, and seek to adapt to the resulting changes in an attempt to live with them.
Within each category, there are two options for actions: **Delay** actions work within the existing “business as usual” system and seek to slow down the progression towards risk tipping points or possible worst impacts. **Transform** actions involve a fundamental reimagining of the system itself.

The resulting framework has four categories:

1. **Avoid-Delay**
2. **Avoid-Transform**
3. **Adapt-Delay**
4. **Adapt-Transform**

Understanding which of the four categories a solution falls into helps to assess what kind of outcomes it can produce and which trade-offs it may have. For example, in the case of **Unbearable heat**, there are weather stations that have already recorded temperatures beyond the tipping point for what a human body can survive in. If this threshold is crossed for more than six hours, a person's body will be unable to cool itself down, and may experience organ failure and brain damage. It is human-induced climate change that is causing a global rise in temperatures, leading to more frequent and intense heatwaves with severe impacts, so an **Avoid-Transform** solution would be one that transforms our society in such a way that we achieve strong and sustained reductions in emissions of greenhouse gases to halt climate change. This involves a societal change towards low-carbon ways of living, so that these tipping points can be avoided. Meanwhile, an **Adapt-Delay** solution would be one where we install air conditioners in all buildings in hot climates. The air conditioners will delay when the risk tipping point is reached for the people in these environments, but they will not prevent us from reaching the risk tipping point eventually, particularly if the air conditioners are powered with fossil fuels, which would contribute to further global warming.

Need for transformation

Most solutions being implemented at present focus on **Delay** rather than **Transform**, although increasing focus is being put on transformative change to achieve global goals on transitioning to a more sustainable future. Out of the different categories, it is transformative solutions that have the potential to move us away from a future of multiplying risk tipping points, but they also require the most societal and personal change. If we deploy solutions in collaborative, integrated packages, and are innovative with our current solutions to develop them with long-term, transformational change in mind, we can start to move from **Delay** to **Transform**.

Because risks are interconnected, so are most potential solutions. Therefore, the report highlights overall changes we can make to our behaviours and values that would transform the way we use our systems and reduce overall risk. These include a shift towards zero waste, a closer connection to nature, global cooperation and trust, consideration for future generations and shifting to an economic model that is less focused on growth and more on human well-being within planetary boundaries.

Avoiding or adapting to risk tipping points requires us to fundamentally change how we perceive and value the world around us in a way that gives us the responsibility to care for it. We must design our systems to work in a way that recognizes how much we need the world and all its systems working together for our survival; otherwise we will find ourselves in a future where risks continue to multiply. The choice is ours. We have the power to act now to create the future we want.

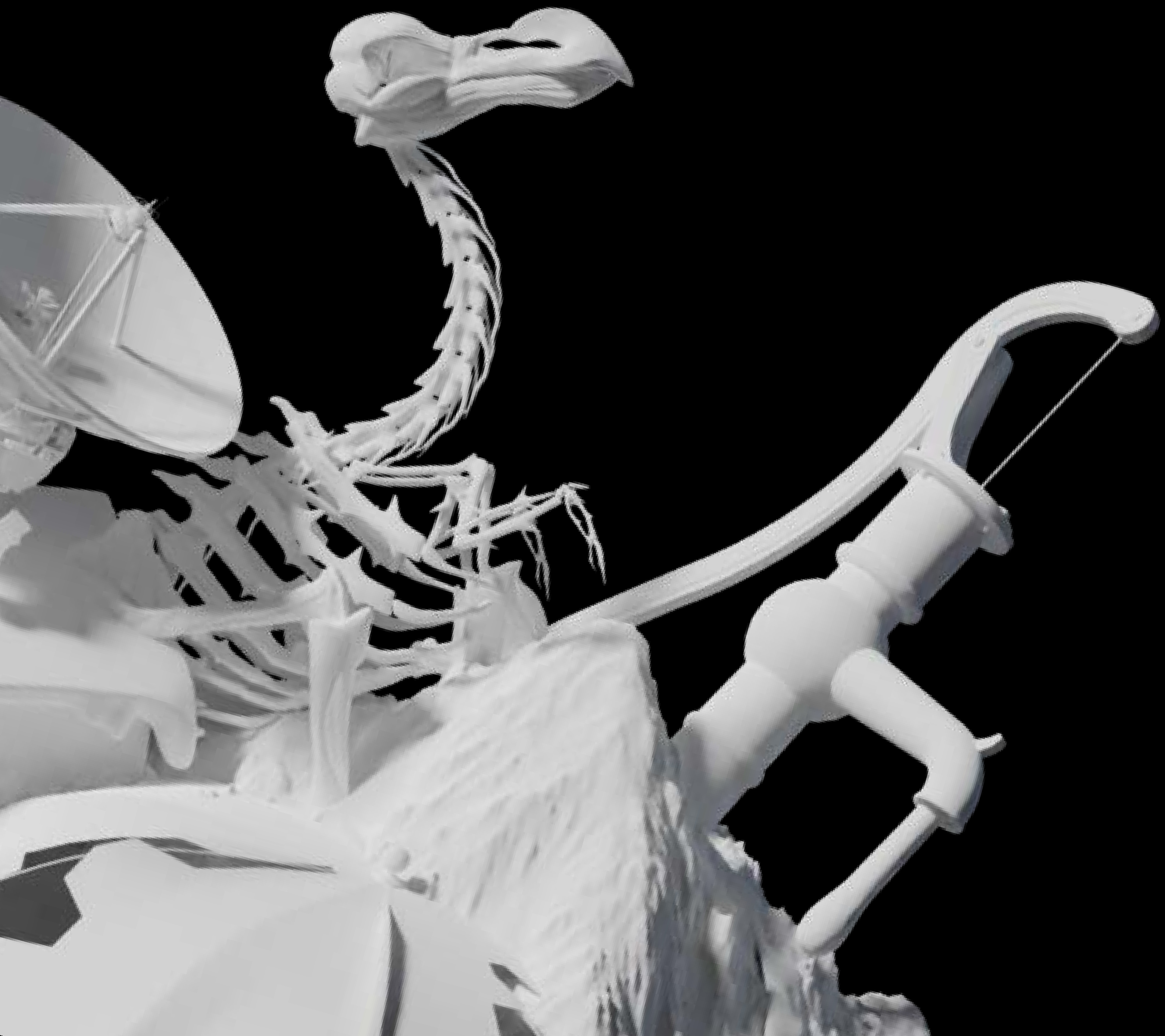
Abbreviations

ESA	European Space Agency
FWC	Florida Fish and Wildlife Conservation Commission
GDP	Gross Domestic Product
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IRP	International Resource Panel
NASA	National Aeronautics and Space Administration
ppm	Parts Per Million
USNPS	United States National Park Service
UCS	Union of Concerned Scientists
UNDRR	United Nations Office for Disaster Risk Reduction
UNU-EHS	United Nations University – Institute for Environment and Human Security
USGS	United States Geological Survey
WMO	World Meteorological Organization

Chapter 1

Introduction

Our world is inextricably interconnected, intertwining us as individuals but also the global community in a web of intricate relationships. This interconnectivity, spread through our world by the rise of globally interconnected systems, including global supply chains, communication systems and economic markets, offers us remarkable advantages and opportunities. However, it also presents existential challenges that reverberate across the globe. As these systems expand in their scale and complexity, so do their vulnerabilities and potential points of failure. In other words: as we become increasingly interconnected, so do the risks we share.



The convergence of societal and ecological challenges, such as environmental degradation, resource depletion, a warming climate, technological pressures, governance instability and a crisis of multilateralism, threatens to push us into an uncertain, risky future. We are teetering on the precipice of multiple tipping points that can trigger abrupt and often irreversible changes to the systems we rely upon, casting ripple effects through the fabric of our society and the ecosystems around us. Importantly, since our Earth systems are interconnected, a risk for one can be a risk for all. To build a more resilient, safe and equitable future for all, we need to understand how we got to this point in the first place, truly think about what kind of future we want to live in and build a bridge between the two, before it is too late.

In this edition of the *Interconnected Disaster Risks* report, we focus on three key themes:

We are fast approaching several risk tipping points.
Our critical life-supporting systems, such as the climate as we know it which supported the development of human life and societies, hydrological cycles, natural ecosystems, our food production, knowledge systems and risk management tools, are all being fundamentally challenged. While these systems have been continually reshaped throughout human history, the speed of change and the multitude of simultaneous changes occurring today is unprecedented. We are facing more severe impacts not only from known risks, such as more intense and frequent storms and wildfires, but also from new and emerging risks that society has yet to fully understand how they develop, let alone devise possible ways to respond to them. This poses a new challenge to society to not only keep up with these changes but also to positively shape the future while not leaving anyone or anything behind. This report showcases how and why we are approaching the limits to what our current systems can take. It also highlights how, if we do not start making better decisions, we will drive ourselves off the edge into a riskier future with potentially catastrophic impacts for people and the planet.

These tipping points are interconnected.
The looming tipping points directly result from the way our choices and priorities interact with various complex systems in which human societies are embedded in nature, such as our food production, which is dependent upon climate and availabilities of water resources, nutrients or pollinators. In these socioecological systems, our social, economic, technological and cultural systems interact with environmental or physical systems. These systems are interconnected in many ways, such as having the same root causes and drivers, which causes pressure on multiple systems at once. When one system passes a tipping point such that fundamental changes are inevitable, it increases the overall risk across systems and may actually accelerate tipping in another system. Feedback loops between systems amplify the impacts of risks and can create self-reinforcing dynamics that increase the speed of change. The impacts of these manifesting risks may accumulate over time, causing us to reach multiple critical tipping points simultaneously. This will result in amplified impacts compared to just one system being affected, leading to more drastic consequences that are difficult to predict and recover from. Therefore, any attempt to reduce risk in these systems must acknowledge and understand these underlying pressures as well as their interconnectivity. Actions that affect one system will likely have consequences on another, so we must avoid working in fragmented silos and instead look at the world as one beautiful, intricate system. This report helps us to understand the interconnectivity of different systems approaching tipping points and the consequences for the risks we share.

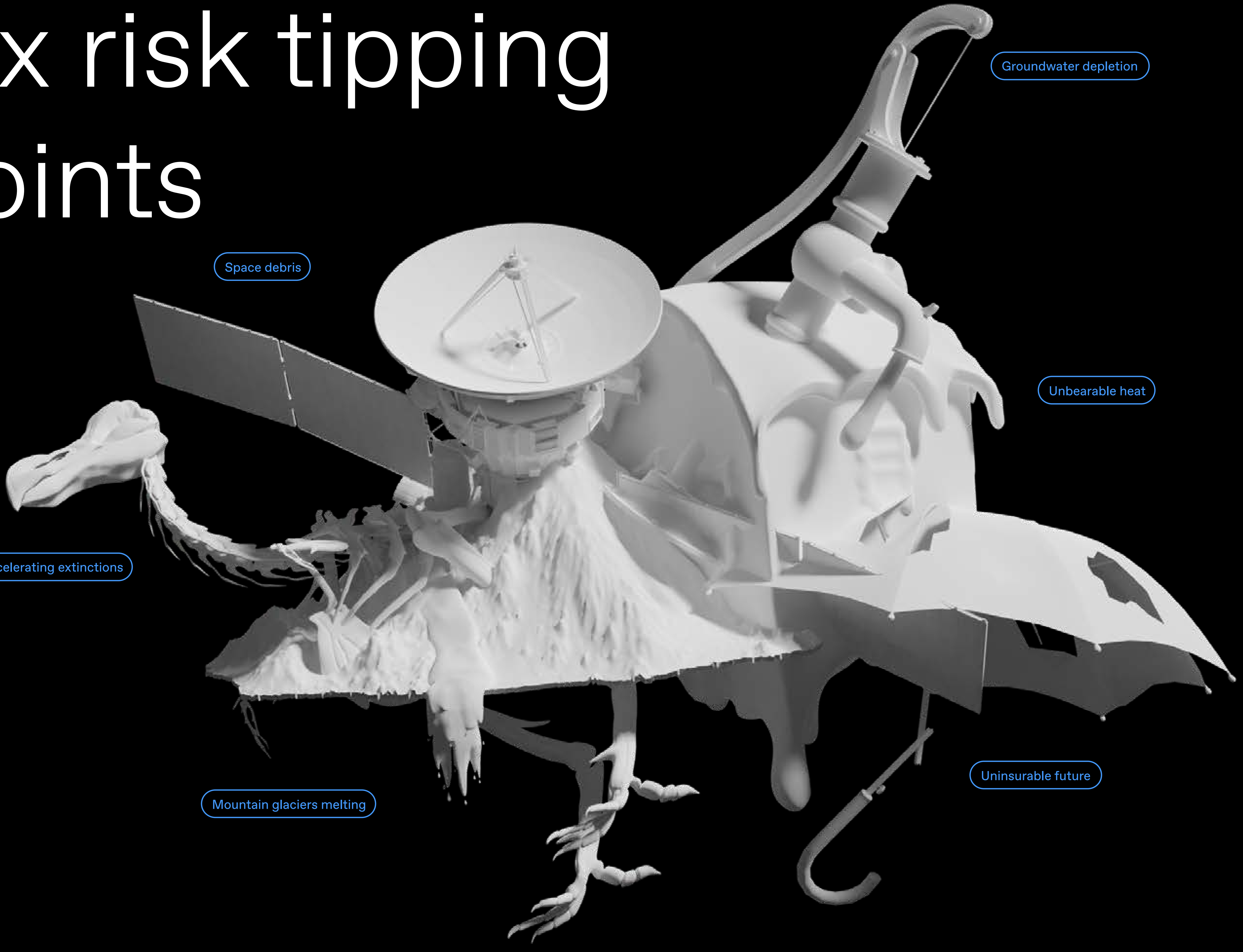
We have a choice about the future we want to live in.
Even as we head down a dangerous path into a risky future, we fortunately have the research, knowledge and tools to see these tipping points coming and can adjust our trajectory. In many cases and places, we can still act to avoid the tipping points and to reduce or prevent losses and damages to the systems we value and rely on. Human agency can influence the time we have before we reach these tipping points, giving us critical space for developing adaptation strategies. It can even prevent us from reaching these points altogether if we make deliberate choices and take decisive actions to steer us towards a desirable future. Having this agency means that we have not only the ability but also the duty to influence the direction society is heading towards. The trajectory of increasing risk in different systems paints a clear picture that without substantially changing what is considered "business as usual", crossing these tipping points is inevitable. This report highlights choices we can take to change our collective behaviours and priorities for the benefit of the planet and everyone on it.

About the report
The 2023 Interconnected Disaster Risks report analyses six key risks with approaching tipping points: the accelerating extinctions of species, the depletion of groundwater resources, the retreat of mountain glaciers, the growing number of places facing uninhabitable temperatures, the rise in uninsurability and the growing amount of space debris. These tipping points are representative of globally relevant trends pushing our socioecological systems to the brink. They represent a diverse selection across thematic categories worldwide to better explore the consequences of their global interconnectivity for both the changing risk landscape and the possible solutions.

The six risk tipping points are introduced in **Chapter 2** in individual fact sheets that show the overarching risk to certain systems these tipping points represent, outlining the points when the systems tip and what impacts we might see now and in the future. The six fact sheets also show the interconnectivity between these tipping points, highlighting how risks across systems are intertwined. The concept of "risk tipping points" is further outlined in **Chapter 3**, explaining their similarities and differences with other types of tipping points, along with definitions and the methodology for tipping point selection. **Chapter 4** discusses the interconnectivity of these tipping points, from their root causes and drivers to their similar trajectories in the future if we do not start to make better choices. **Chapter 5** outlines different paths for either adapting to or avoiding risk tipping point impacts, by moving away from our current thinking around solutions for isolated problems and towards transformative change and a more resilient future.

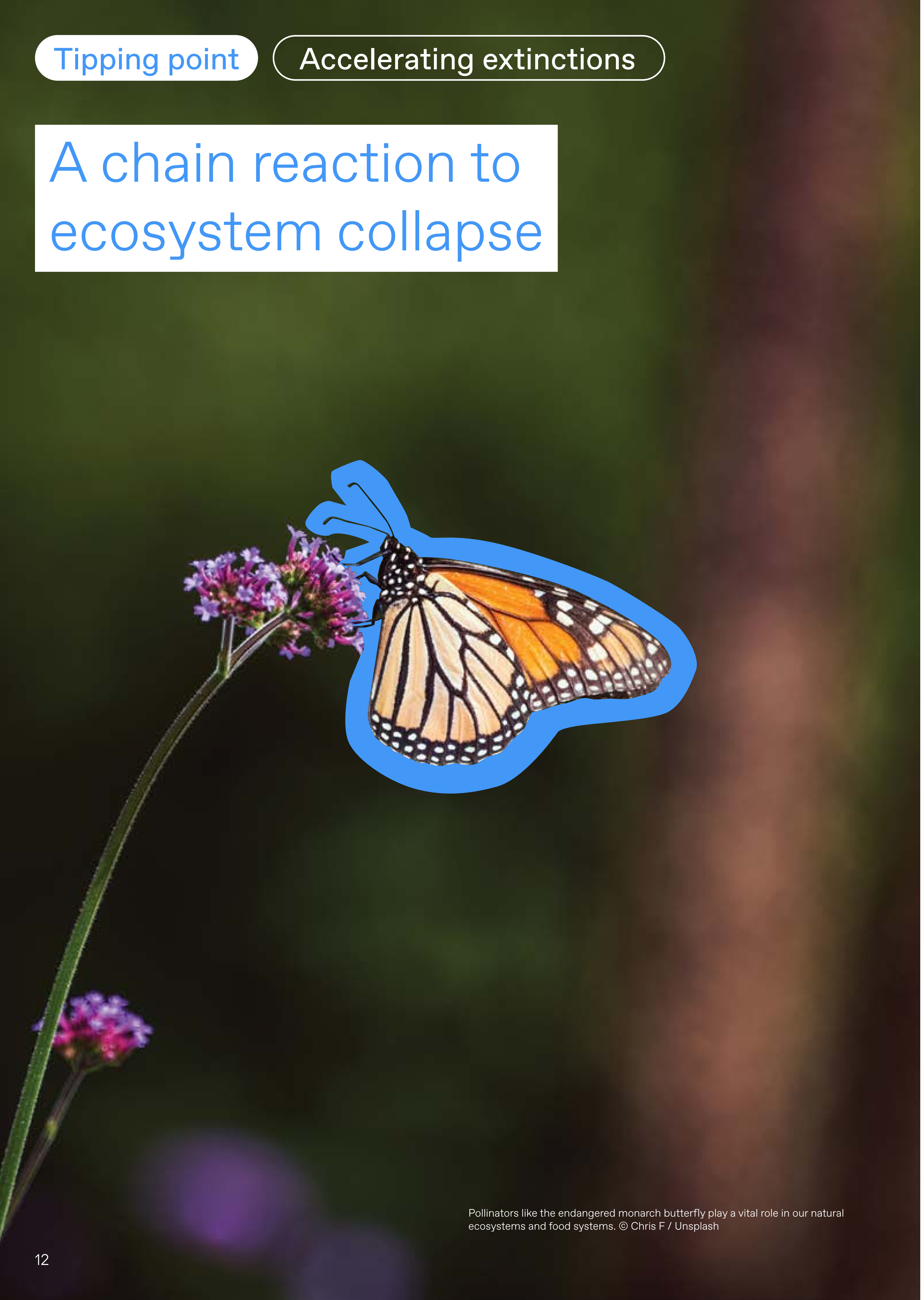
Chapter 2

Six risk tipping points



Tipping point | Accelerating extinctions

A chain reaction to ecosystem collapse



Pollinators like the endangered monarch butterfly play a vital role in our natural ecosystems and food systems. © Chris F / Unsplash

Throughout Earth's history, many species have gone extinct. Extinction is a part of the evolutionary process that has shaped life on the planet, but often proceeds slowly over thousands to millions of years[1]. Unfortunately, through intense human activities such as land use change, overexploitation, climate change, pollution and introduction of invasive species, we have put our foot on the extinction accelerator. The current rate of species extinction is at least tens to hundreds of times higher than usual due to human influence[2] [3], with drastic consequences for all life on our planet.

Ecosystems are built on intricate networks of connections between different species. As such, the real risk of extinction may be much greater than we realize, especially as many species are highly interconnected and form strong, unique bonds with other species. The disappearance of such an organism has ripple effects throughout the ecosystem and could trigger a "co-extinction" — the extinction of dependent species — setting off a chain reaction of extinctions that could end in the ecosystem's collapse. In short, extinction breeds extinction.

Thus, with almost 1 million plant and animal species currently threatened with extinction[3], it is not "just" about the loss of a single species but of countless others. For example, the gopher tortoise, which is threatened with extinction, digs burrows that are used by more than 350 other species[4] for breeding, feeding, protection from predators and avoiding extreme temperatures. The critically endangered dusky gopher frog, which helps control insect populations and prevent pest outbreaks in longleaf pine forest ponds, relies extensively on these burrows for survival. If the gopher tortoise goes extinct, the dusky gopher frog will likely follow, affecting the entire forest ecosystem. Similarly, predators like sea otters, a locally endangered species due to overhunting, help balance Pacific kelp forests by feeding on sea urchins. Without otters, the urchins overgraze the kelp, creating "urchin barrens" or patches where the kelp forest is invaded and essentially wiped out. The shelter, food and protection provided by kelp would be lost for over 1,000 species[5], including sharks, turtles, seals, whales, birds, fish and more, with a cascade of extinctions likely to follow.

In the vast web of life, the extinction of one species cuts multiple threads that hold the world together. As these links become fewer and thinner, the reduced resilience of ecosystems can lead to a state of instability, in which even minor changes can cause a catastrophic collapse. Our current approach to conservation is often single-species focused, ignoring the intricate interrelationships among species and the fragility of dependent species and ecosystems. As a result, the true impact of extinction on our critical life-support systems is vastly underestimated. We must intensify efforts to conserve not only target species, but also dependent species. We must act quickly and decisively to protect and conserve ecosystems and the biodiversity they support. Nature should also be reintegrated into our culture, to understand that its value goes beyond our desire for money and development. This approach will maintain the resilience of ecosystems and ensure the survival of our planet's living webs.

Tipping point: The extinction of a strongly connected species in a given ecosystem can trigger cascading extinctions of dependent species, which can eventually lead to ecosystem collapse.

Key numbers:

400+
vertebrate species extinct in the last 100 years[1]

32 million ha
of primary or recovering forest lost between 2010 and 2015[3]

1 million
plant and animal species threatened with extinction, many of them within decades[3]

[1]Ceballos and others, 2020
[2]De Vos and others, 2015
[3]IPBES, 2019
[4]FWC, 2023
[5]USNPS, 2023

Tipping point

Accelerating extinctions

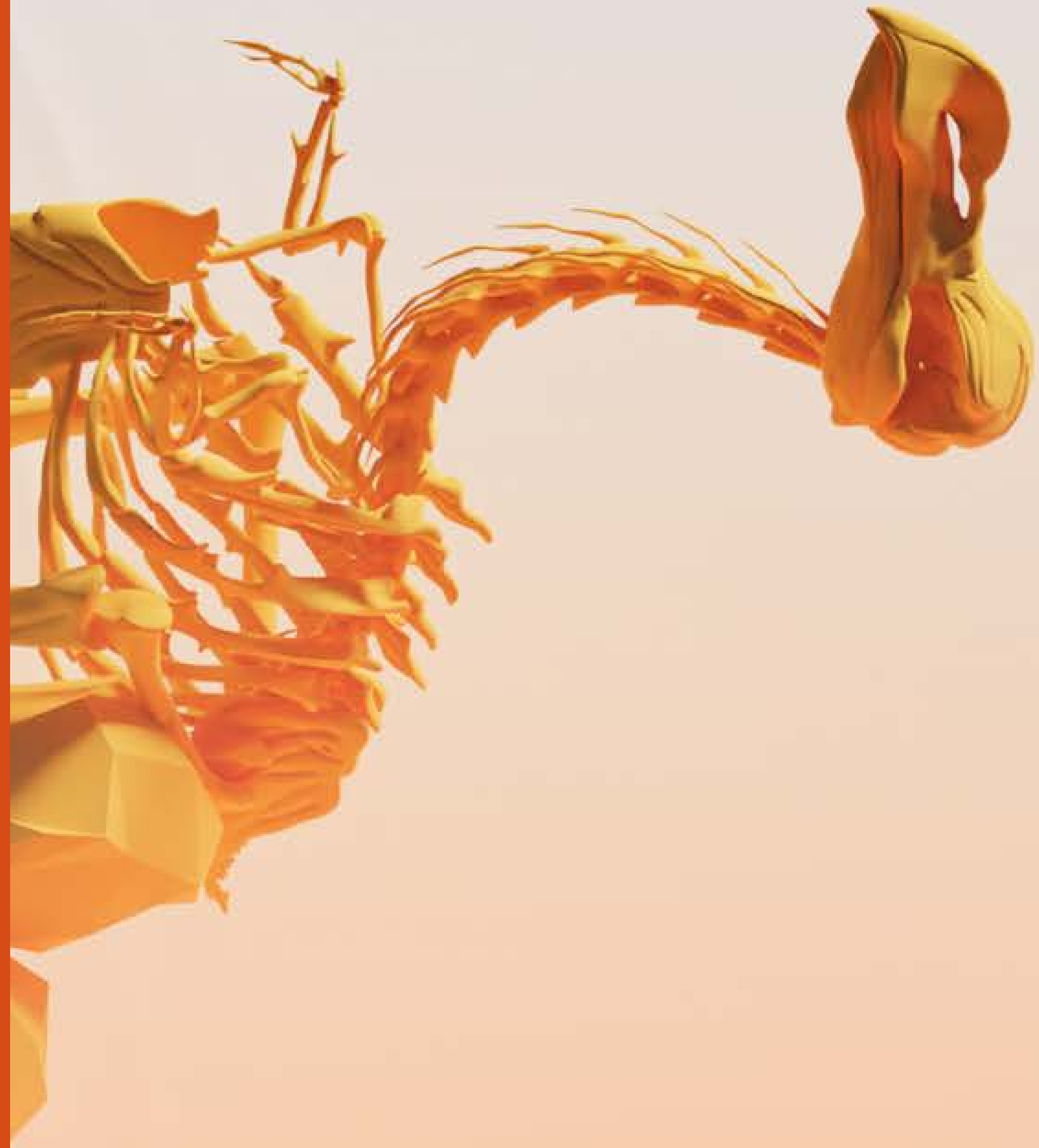
Drivers

- Insufficient future planning
- Risk-intensifying land use
- Lack of regulations/enforcement
- Atmospheric/ocean warming
- Lack of information
- Pollution

Root causes

- Insufficient risk management
- Human-induced greenhouse gas emissions
- Global demand pressures
- Colonialism
- Undervaluing environmental costs

Increasing risk =
Increasing environmental degradation and habitat loss



Tipping point =
Extinction of a strongly connected species

Impacts

- Livelihood loss
- Food insecurity
- Water insecurity
- Ecosystem damage and biodiversity loss
- Cultural heritage loss
- Loss of opportunities

Tipped =
Resulting cascading extinctions leading to ecosystem collapse

Key interconnections:

Shared root cause with:

Space debris

Colonialism

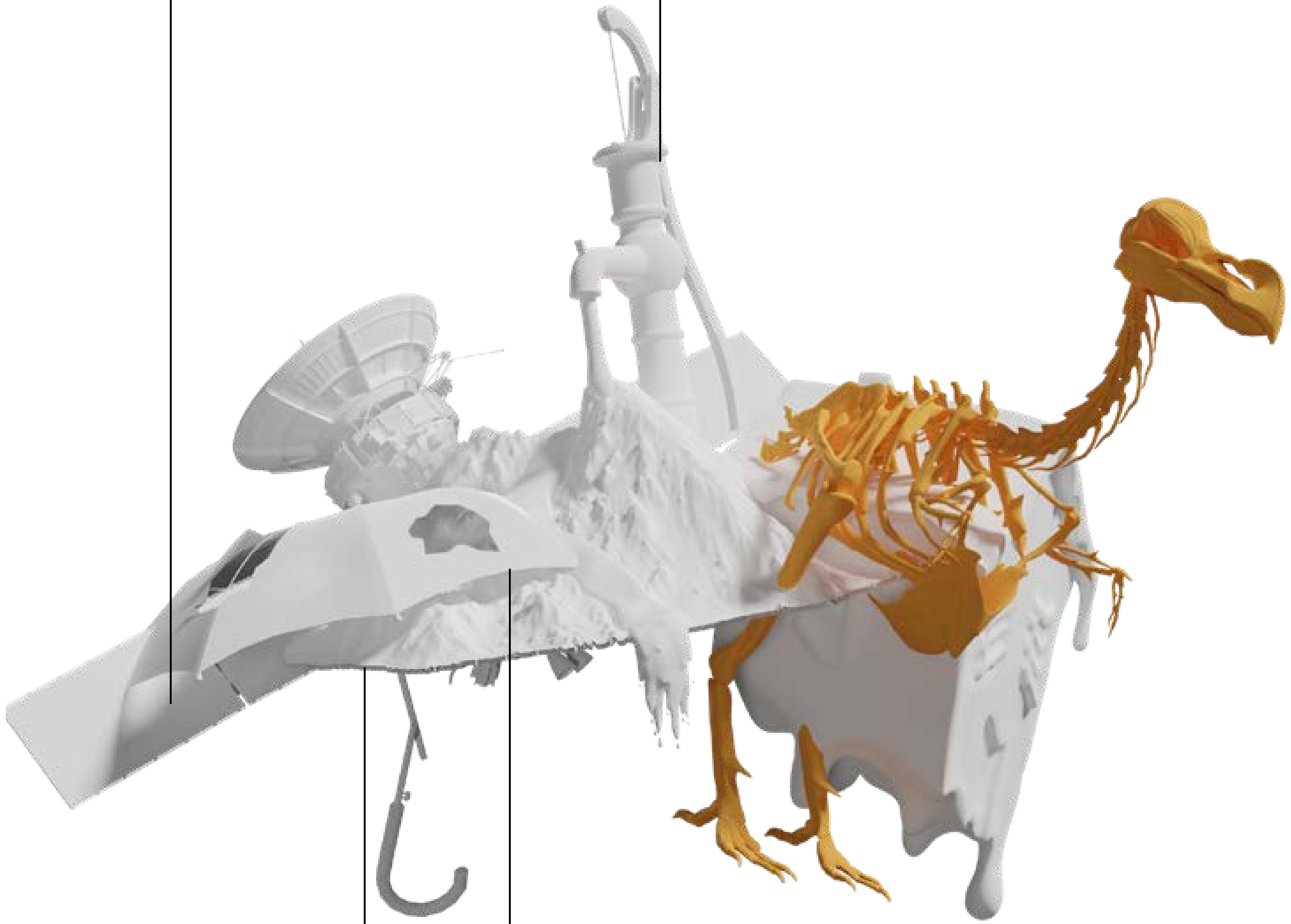
Expanding over an area for economic or strategic exploitation that leads to degradation of Earth's environment and orbits

Shared driver with:

Groundwater depletion

Risk-intensifying land use

Agricultural intensification and expansion increases risk to groundwater resources and vulnerable species



Shared impact with:

Groundwater depletion

Mountain glaciers melting

Unbearable heat

Ecosystem damage and biodiversity loss

Habitat fragmentation, environmental degradation and other physical disturbances compromise ecosystem health, triggering both species decline and landscape transformations

Direct influence on:

Uninsurable future

As cascading extinctions lead to degraded ecosystems, we lose services that can be valuable for disaster protection, raising risk and exacerbating uninsurability

Flowers from the botanical park "Library of Trees" appear below the Vertical Forest (Bosco Verticale) high-rise complex in Milan, Italy. © Miguel Medina / AFP

Tipping point | Groundwater depletion

Draining our water, risking our food supply

A tractor kicks up dust as it plows a dry field in May 2021, California, USA. As the state enters an extreme drought emergency, water is starting to become scarce in California's Central Valley, one of the most productive agricultural regions in the world. © Justin Sullivan / Getty Images / AFP

Groundwater is an essential freshwater resource stored in underground reservoirs called "aquifers". These aquifers supply drinking water to over 2 billion people and around 70 per cent of withdrawals are used for agriculture. However, 21 out of 37 of the world's major aquifers are being depleted faster than they can be replenished[1]. The water stored in aquifers often has accumulated over thousands of years and would equally take thousands of years to fully recharge, making it essentially a non-renewable resource. In these at-risk aquifers, lives and livelihoods are put on the line as the water level drops further and further out of reach.

Some places in the world have already extracted significant amounts of their groundwater resources. For example, Saudi Arabia once sat atop one of the world's largest aquifer systems and, in the 1970s, used it to make the desert a productive oasis. By the mid-1990s, farmers were pumping around 19 trillion litres per year, and Saudi Arabia became the world's sixth-largest wheat exporter[2]. This vast overextraction is estimated to have depleted over 80 per cent of the aquifer[3], prompting the Saudi government to announce the 2016 wheat harvest as its last. Now, to feed the country's 30+ million people, Saudi Arabia must rely on crops imported from other countries.

A strong relationship between groundwater and global food production means that local problems can quickly have far-reaching consequences. For example, the High Plains aquifer in the United States supplies one third of all groundwater for irrigation used in the country and supports over $35 billion worth of crops such as wheat and soy. However, as unsustainable groundwater extraction continues, around 40 per cent of the aquifer's area will not support irrigation by the year 2100[4]. Since the United States exports almost half of its groundwater-dependent crops to other countries, places like Mexico, China and Japan will also suffer the impacts. Additionally, India is the world's largest user of groundwater, exceeding the use of the United States and China combined. The north-western region of India serves as the breadbasket for the nation's growing 1.4 billion people, with the states of Punjab and Haryana producing 50 per cent of the country's rice supply and 85 per cent of its wheat stocks[5]. However, 78 per cent of wells in Punjab are considered overexploited[6], and the north-western region as a whole is predicted to experience critically low groundwater availability by 2025.

Agricultural intensification combined with new technologies and policies that make groundwater cheaper to use has accelerated extraction rates, leading to alarming levels of aquifer depletion. We can no longer consider groundwater as a boundless source of easily-accessible freshwater. Instead, we can now see that it has limits and is becoming increasingly inaccessible, with worrying implications for its use as a coping mechanism when rains fail. We need drastic changes in our global agricultural system to be mindful of the limits of groundwater systems and our ability to access this water. We need regulations and technologies to ensure the sustainable use of groundwater and preserve this resource for when we need it most.

Tipping point: When the water table in a given aquifer drops consistently below the well depth, access to groundwater will become problematic, increasing the risk for farmers to be unable to irrigate their crops.

Key numbers:

21 of 37
of the world's largest aquifers being depleted faster than they can be replenished[1]

70%
of global groundwater withdrawals used for agricultural production

2 billion
people relying on groundwater as a primary source of freshwater

[1] Richey and others, 2015
[2] Halverson, 2015
[3] Novo, 2019
[4] Haacker and others, 2016
[5] Shiao and others, 2015
[6] Ministry of Jal Shakti, 2021

Tipping point

Groundwater depletion

Drivers

- Insufficient future planning
- Risk-intensifying land use
- Lack of information
- Lack of regulations/enforcement

Root causes

- Insufficient risk management
- Global demand pressures
- Insufficient cooperation
- Prioritizing profits

Tipping point =
Water table drops consistently below well depth

Impacts

- Livelihood loss
- Migration/displacement
- Ecosystem damage and biodiversity loss
- Loss of safety
- Food insecurity
- Water insecurity

Increasing risk =
More groundwater is extracted than is able to be recharged

Tipped =
Access to groundwater is unavailable

Key interconnections:

Shared driver with:

Accelerating extinctions

Risk-intensifying land use

Agricultural intensification and expansion increases risk to groundwater resources and vulnerable species

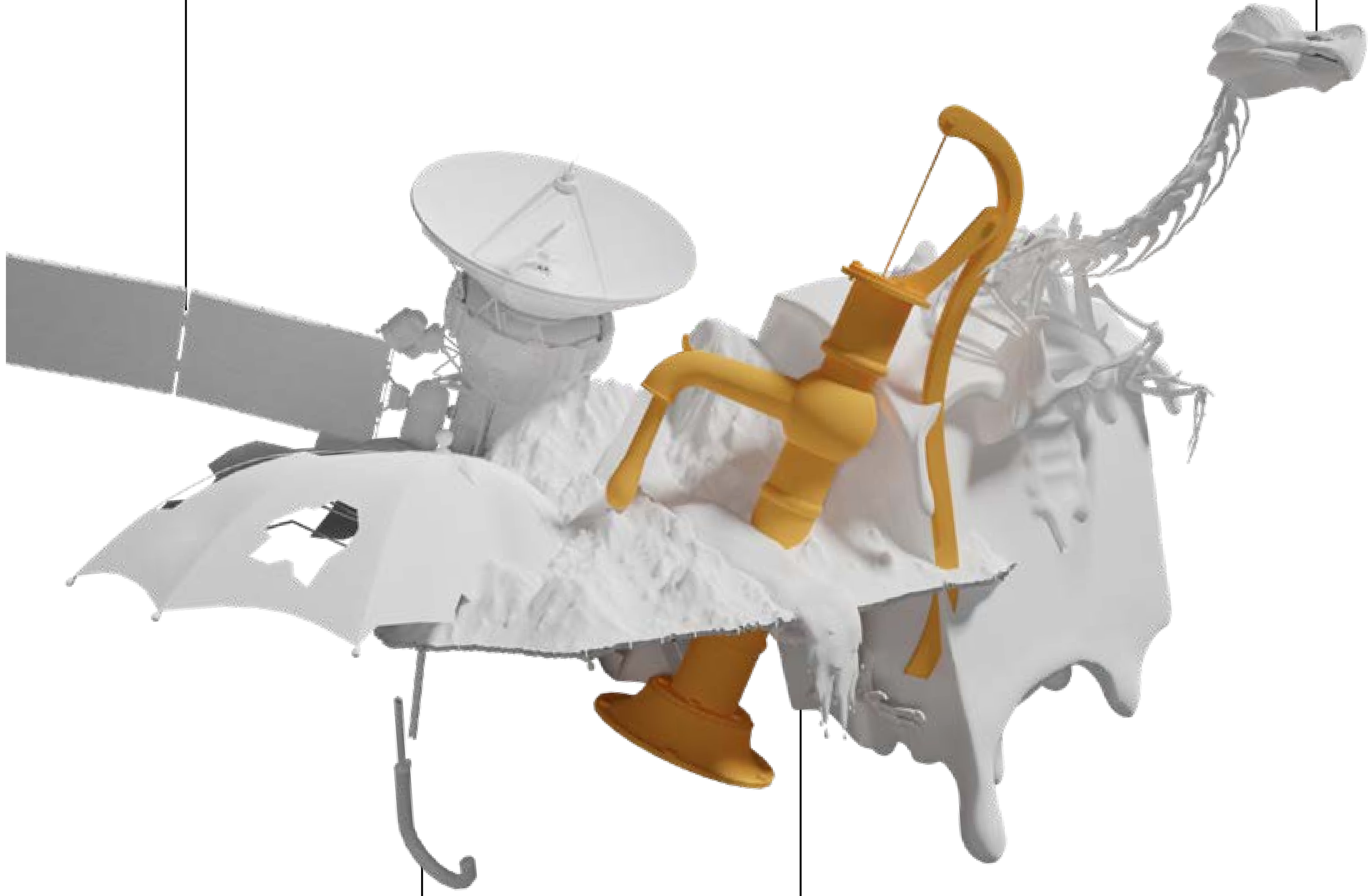
Shared root cause with:

Accelerating extinctions

Space debris

Global demand pressures

Increasing demand for resources and goods increases risk for species and our satellite and irrigation infrastructure



Shared impact with:

Space debris

Mountain glaciers melting

Uninsurable future

Loss of safety

Loss of risk management or monitoring tools leads to loss of safety and security

Direct influence on:

Unbearable heat

Groundwater has a cooling effect on land and the atmosphere, but its moderating effect during a heatwave is decreased as the groundwater table falls

An eco-friendly check dam is used to to harvest rain water for irrigation in Rajasthan, India. © Govindasamy Agoramoorthy / Shutterstock

Tipping point

Mountain glaciers melting

Running on thin ice

A mountain glacier in the Himalayan region.
© Chirag-Saini YuJui / Unsplash

On top of the world's highest mountains, glaciers act as "water towers" by storing fresh water. Meltwater from glaciers and snow supplies water for drinking, irrigation, hydropower and ecosystems to entire regions. Glaciers retreat when the ice mass that formed many years ago melts faster than snow can replace. Due to global warming, the world's glaciers are melting at double the speed they had in the past two decades. Between 2000 and 2019, glaciers lost 267 gigatons of ice per year[1], roughly equivalent to the mass of 46,500 Great Pyramids of Giza. In a warming world, we are projected to lose around 50 per cent of glaciers (excluding Greenland and Antarctica) by 2100, even if global warming can be limited to 1.5°C[2].

As a glacier begins to retreat, its ice gradually melts and increases the amount of water flowing to the river basin. With more meltwater, the risk of flooding downstream increases. In some cases, this can lead to "glacial lake outburst floods", in which a natural dam fails and suddenly releases meltwater with devastating consequences. Eventually, the glacier experiences its highest amount of melting and produces the maximum volume of water run-off, known as "peak water". After this point, freshwater availability will steadily decline. Peak water has already been passed or is expected to occur within the next 10 years in basins dominated by small glaciers like those in Central Europe, western Canada or South America. Even the glaciers on the highest peaks, such as those in the high mountains of Asia, are predicted to reach peak water around the middle of this century. As such, the 90,000+ glaciers of the Himalayas, Karakorum and Hindu Kush mountains are at risk, and so are the nearly 870 million people that rely on them[3].

Meltwater is often used to compensate for the lack of rain during dry seasons. As glaciers shrink, this potential is diminished, meaning that mountain communities and their downstream counterparts will have to radically shift how they manage water resources. In the Andes, where peak water has already passed for many glaciers, communities are grappling with the impacts of unreliable water sources from both the glaciers and climate change-induced difference in rainfall. For example, the Quelccaya glacier in Peru was once the world's largest tropical ice cap, but it has shrunk by 31 per cent in the last 30 years[4], contributing to periodic water scarcity in the dry season and widespread impacts. Villagers living at the foot of the Quelccaya glacier, for instance, lost up to one third of their alpacas during a drought in 2021. The loss of glaciers is also a loss of iconic features in many mountain areas that has several tangible and intangible negative consequences for livelihoods, economies and heritage.

Glacier retreat is a call for action to take urgent measures to reduce greenhouse gas emissions. These glaciers are natural wonders and are essential for the survival and well-being of many communities who will have to adapt to a warmer and more unpredictable climate with direct consequences for their livelihoods and their access to water.

Tipping point: When glaciers retreat, long-term ice storage melts and is gradually released as meltwater. Initially, the volume of water released increases until a maximum is reached, known as peak water. After this tipping point, glacier meltwater volume decreases as the glacier continues to shrink with effects on freshwater availability for humans and other species.

Key numbers:

267 gigatons
of ice lost from glaciers between 2000 and 2019[1]

50%
of world's glaciers projected to be lost by 2100[2]

1.9 billion
people at risk of negative effects due to glacier retreat[5]

[1] Hugonnet and others, 2021
[2] Rounce and others, 2023
[3] Nie and others, 2021
[4] University at Albany, 2018
[5] Immerzeel and others, 2020

Tipping point Mountain glaciers melting

Drivers

- Insufficient future planning
- Atmospheric/ocean warming
- Lack of information

Root causes

- Insufficient risk management
- Human-induced greenhouse gas emissions

Increasing risk =
Increasing global temperatures melt glaciers faster than they can grow back

Tipping point =
Glacier meltwater maximum known as "peak water"

Impacts

- Ecosystem damage and biodiversity loss
- Loss of safety
- Migration/displacement
- Cultural heritage loss
- Livelihood loss
- Food insecurity
- Water insecurity
- Infrastructure damage
- Loss of opportunities

Tipped =
Glacier meltwater will steadily decrease, reducing freshwater availability

Key interconnections:

Shared root cause with:

- Unbearable heat
- Uninsurable future
- Accelerating extinctions
- Human-induced greenhouse gas emissions

Continued anthropogenic greenhouse gas emissions increase global temperatures, accelerating unfavourable conditions for physical, natural and human systems

Shared driver with:

- Accelerating extinctions
- Groundwater depletion
- Uninsurable future
- Lack of information

Insufficient or inaccurate data and models to estimate the true extent of the risk species, water systems or human settlements are facing

Shared impact with:

- Space debris
- Accelerating extinctions
- Cultural heritage loss

Loss or damage to physical or intangible attributes that provide cultural meaning, knowledge and belonging

Direct influence on:

- Accelerating extinctions

Glacier retreat will change ecosystems in ways that threaten various species and increase the risk of extinctions

An ice stupa, which acts as an artificial glacier, stands in the middle of the cold desert of Ladakh, India. © Naveen Macro / Shutterstock

Tipping point | Space debris

Losing our eyes in the sky

Hurricane Ian moves through the Caribbean Sea in September 2022, just south of Cuba. © NASA via Getty Images / AFP

Thousands of satellites orbit the Earth, gathering and distributing vital information for weather monitoring, disaster early warning systems and communications. Recent technological advancements have made it easier and more affordable for countries, companies and even individuals to put satellites into space. Satellites make our lives safer, more convenient and connected, and represent critical infrastructure that is now essential for a functioning society. However, as the number of satellites increases, so does the problem of space debris, which poses a threat to both functioning satellites and the future of our orbit.

Space debris consists of various objects, from minuscule flecks of paint to massive chunks of metal. Out of 34,260 objects tracked in orbit, only around 25 per cent are working satellites while the rest are junk, such as broken satellites or discarded rocket stages[1]. Additionally, there are likely around 130 million pieces of debris too small to be tracked, measuring between 1 mm and 1 cm[1]. Given that these objects travel over 25,000 kilometres per hour[2], even the smallest debris can cause significant damage. Each piece of debris becomes an obstacle in the orbital "highway", making it increasingly difficult for functional satellites to avoid collisions.

The danger is more than just theoretical. In 2009, a collision between a defunct satellite and an active communications satellite created thousands of debris pieces that still orbit Earth today. This debris can impact other objects, such as the International Space Station, which conducts manoeuvres around once per year to avoid such debris[3]. Satellites can be warned of impending collisions; in fact, the European Sentinel-2 satellite registered more than 8,000 alerts between 2015 and 2017[4]. Collision avoidance even between active satellites can also be difficult since agencies often need to communicate and quickly come to agreements. For example, in 2019, a European Space Agency satellite had to perform an emergency manoeuvre to avoid colliding with a communications satellite after an agreement with the operator could not be reached.

More than 100,000 new spacecraft could be launched into orbit by 2030[5], compared to the approximately 8,000 we have now. As more satellites are launched, the orbit becomes more crowded, increasing the risk of collisions. Each collision creates millions more pieces of debris, which can then collide with other debris or satellites, creating even more shrapnel. Eventually, this will reach a point where one crash sets off a chain reaction, causing our orbit to become so dense with shrapnel that it becomes unusable. The existing space infrastructure would eventually be destroyed and future activities in space could become impossible.

Space is the final frontier, and with countries and companies racing to stake their claim, we must consider what kind of future we want to create. If we continue on the current trajectory, we risk sacrificing Earth's orbits and the opportunities they offer to society now and in the future. Importantly, we must regulate space launches more strictly and ensure that satellites and other spacecraft are disposed of responsibly, while also investing in technologies for tracking and removing orbital debris. By coming together as a global community to treat Earth's orbits as a precious common good, we can safeguard our future in space before it is too late.

Tipping point: When there is a critical density of objects in orbit around Earth, such that one collision between two objects can set off a chain reaction, it will cause our orbit to become so dense with shrapnel that it becomes unusable. This would threaten our ability to monitor, for example, the weather and environmental changes, and to receive early disaster warnings.

Key numbers:

8,300
functioning satellites in orbit[1]

34,260
tracked objects in orbit[1]

25,000 km/hr
travel speed[2]

[1] ESA, 2023
[2] Mukherjee, 2021
[3] NASA Orbital Debris Program Office, 2022
[4] Undseth and others, 2020
[5] Pardini and Anselmo, 2021

Tipping point

Space debris

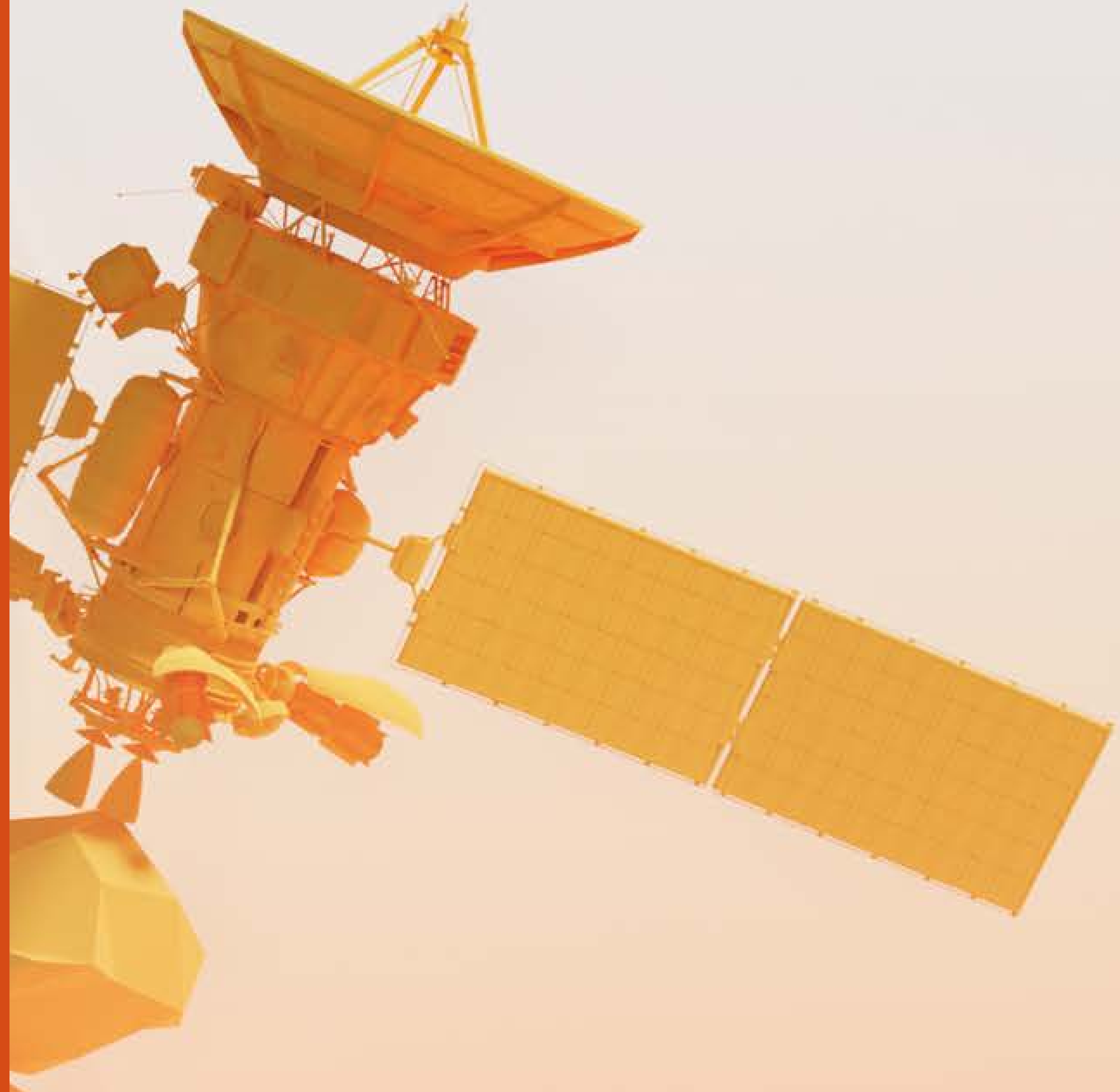
Drivers

- Insufficient future planning
- Lack of regulations/enforcement
- Pollution

Root causes

- Insufficient risk management
- Global demand pressures
- Insufficient cooperation
- Prioritizing profits
- Colonialism

Increasing risk =
Increasing number of objects in orbit around Earth



Tipping point =
Critical density of objects in orbit causing a chain reaction of collisions

Impacts

- Loss of safety
- Cultural heritage loss
- Infrastructure damage
- Loss of opportunities

Tipped =
Collisions result in a large number of fragments, rendering the orbit unusable

Key interconnections:

Shared driver with:

Accelerating extinctions

Pollution

Increasing amounts of pollutants in our environment puts pressure on both species and satellite infrastructure

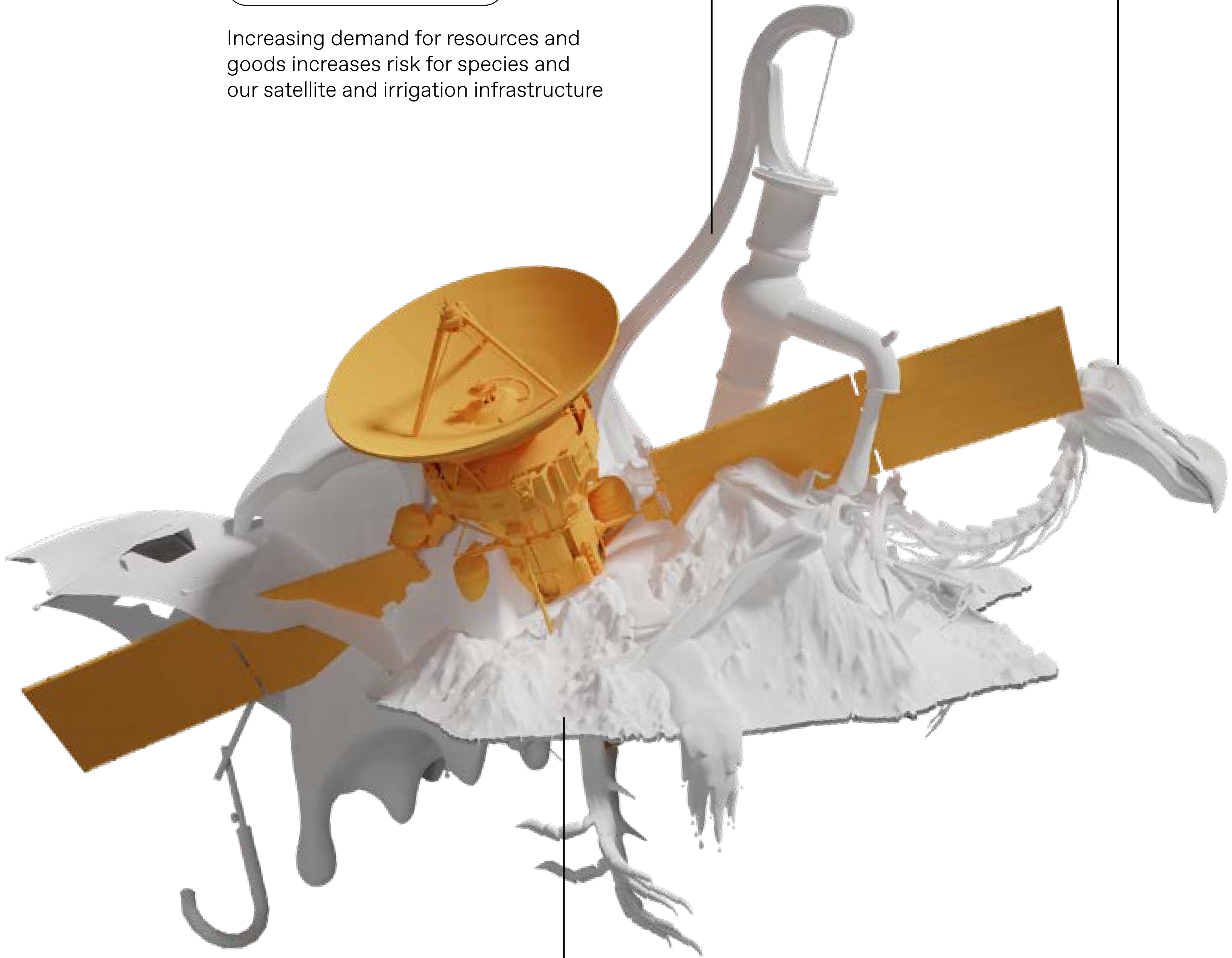
Shared root cause with:

Groundwater depletion

Accelerating extinctions

Global demand pressures

Increasing demand for resources and goods increases risk for species and our satellite and irrigation infrastructure



Shared impact with:

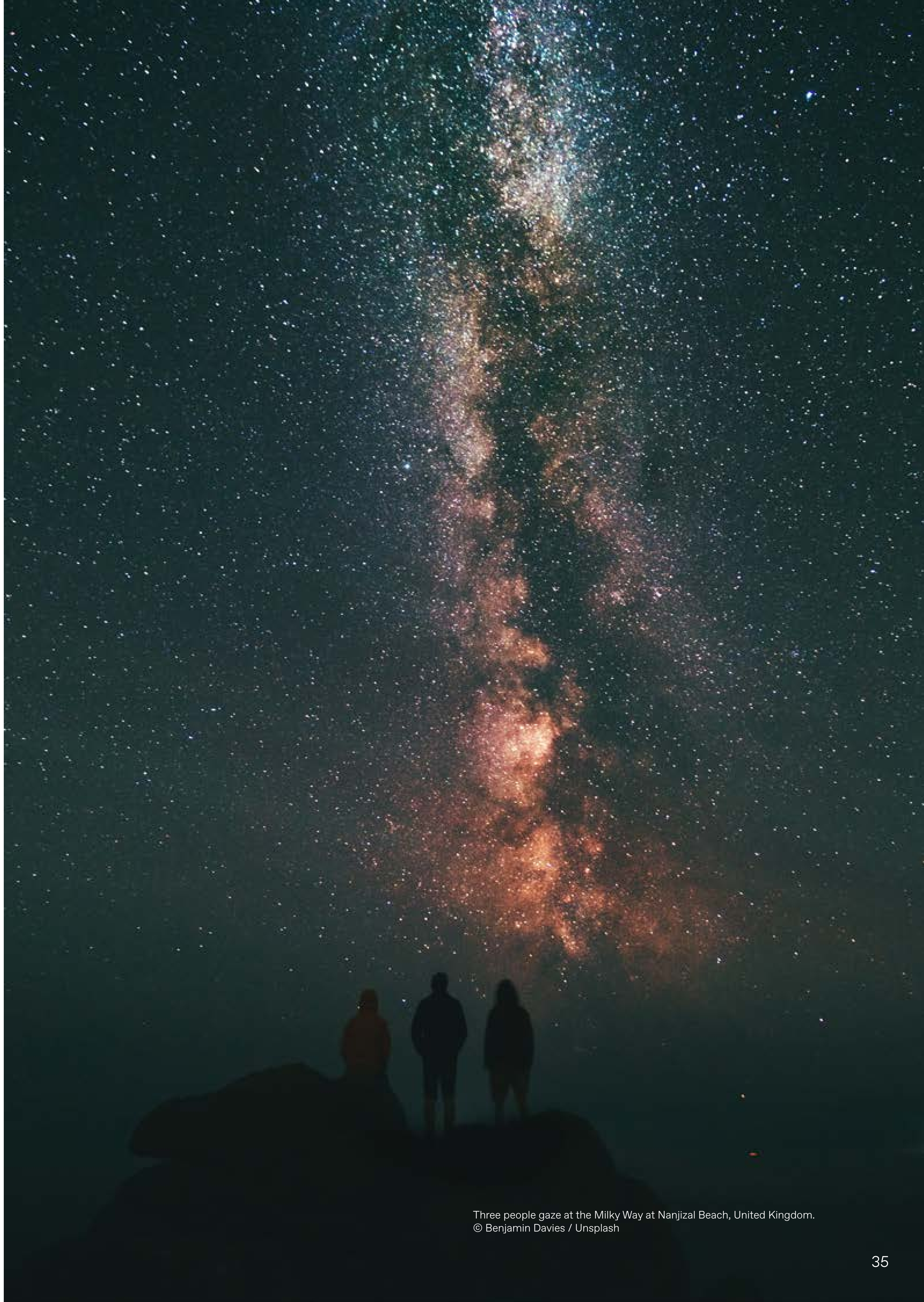
Groundwater depletion

Mountain glaciers melting

Uninsurable future

Loss of safety

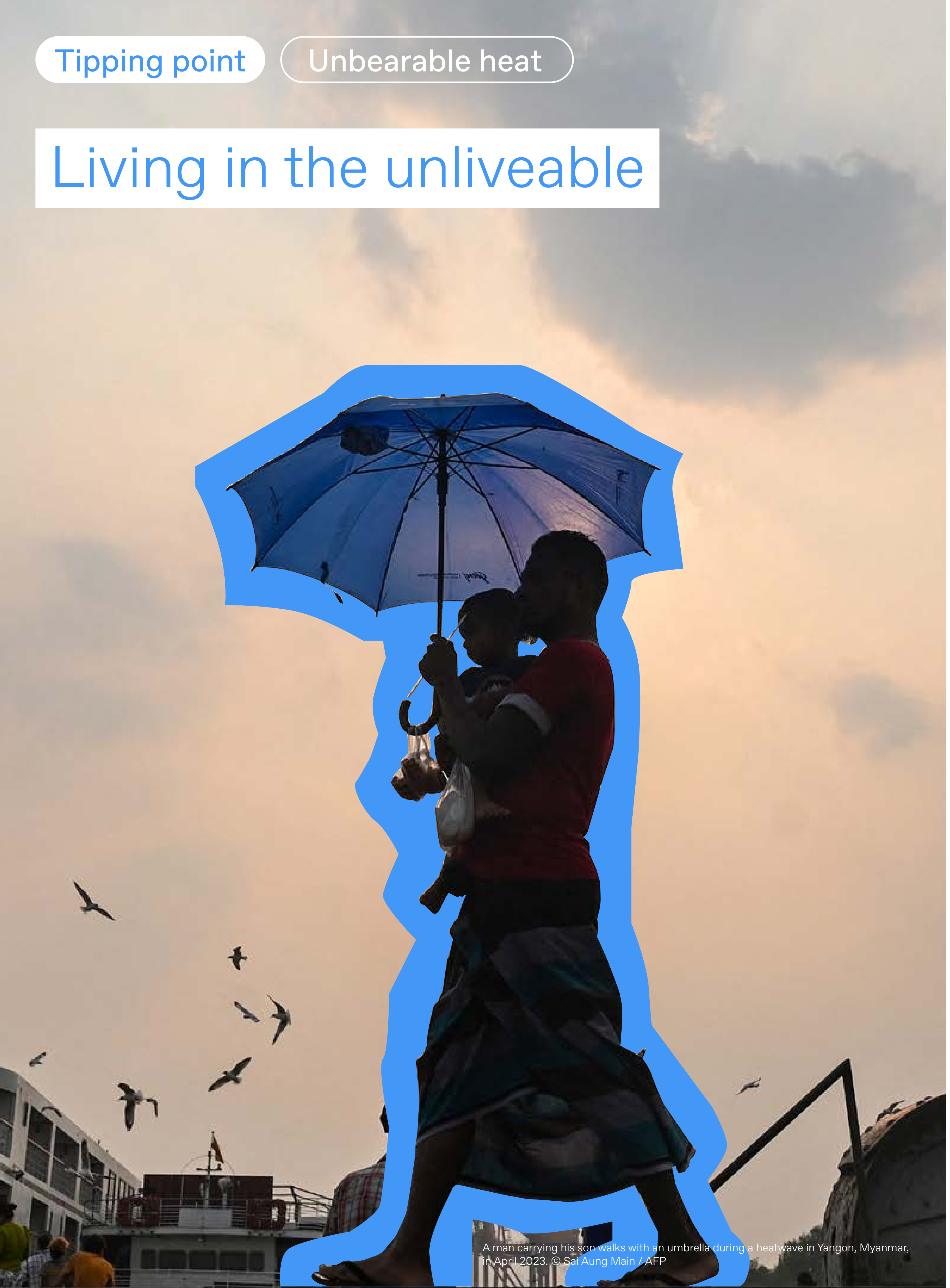
Loss of risk management or monitoring tools leads to loss of safety and security



Three people gaze at the Milky Way at Nanjizal Beach, United Kingdom.
© Benjamin Davies / Unsplash

Tipping point | Unbearable heat

Living in the unliveable



A man carrying his son walks with an umbrella during a heatwave in Yangon, Myanmar, in April 2023. © Sai Aung Main / AFP

Human-induced climate change is causing a global rise in temperatures, leading to more frequent and intense heatwaves with severe impacts. Extreme heat was already responsible for an average of 500,000 excess deaths annually in the last two decades[1], disproportionately affecting the most vulnerable. High humidity exacerbates heat impacts by hindering the evaporation of sweat, which is the body's mechanism to cool off. To understand these high heat stress conditions, scientists use a measurement called wet-bulb temperature, which combines temperature and humidity. If the wet-bulb temperature exceeds 35°C (95°F) for more than six hours, the average person's body will be unable to cool itself off by evaporating sweat and maintain a stable core body temperature. This can result in organ failure and brain damage if the situation is not improved.

Currently, wet-bulb temperatures have crossed this critical threshold in at least two weather stations, one in the Persian Gulf and one in the Indus River Basin. Jacobabad, Pakistan, known as one of the hottest cities on Earth, has experienced this occurrence at least twice since 2010[2]. Although these instances have been limited to only a few hours each, their frequency is increasing. For example, during a 2023 heatwave in India, wet-bulb temperatures went above 34°C[3]. Research indicates that by 2070, parts of South Asia and the Middle East will regularly surpass this threshold. Currently, around 30 per cent of the global population is exposed to deadly climate conditions for at least 20 days per year, and this number could rise to over 70 per cent by 2100[4].

Importantly, 35°C wet-bulb temperature is the upper limit of what humans can survive. Impacts can be felt at much lower temperatures, varying greatly depending on who people are, where they live and the work they do. For example, the 2021 heatwave that registered over 600 heat-related deaths in British Columbia reached a wet-bulb temperature of just 25°C[5]. Older adults, young children and individuals with specific medical conditions are more susceptible to the effects of extreme heat. Occupations such as construction work, farming or working in hot kitchens expose individuals to additional heat from the environment or physical activity. Similarly, socioeconomic conditions can affect vulnerability: in the same city on the same day, the difference between an air-conditioned room and living quarters under a tin roof can be fatal.

Solutions to this problem are not easy, and while cutting greenhouse gas emissions is key, it will not be enough. The reality is that we are quickly approaching a tipping point past which people will not survive. Much of the discussion on the topic has focused on how people will move away from unbearably hot areas. However, many people will not be able to escape these conditions and will be trapped due to work or social obligations, financial or political limitations or disabilities. Consequently, adaptation solutions must also be implemented where people live now, including changing our environments, homes and behaviours. It is crucial for people, communities and governments to prepare and provide support to help take care of individuals who are trapped in the unliveable.

Tipping point: Being exposed to above 35°C wet-bulb temperature for longer than six hours will result in a healthy, young, resting adult in the shade and wind suffering extreme health consequences. This threshold becomes far lower as other factors are considered, such as age, medical conditions or activity level.

Key numbers:

500,000
excess deaths annually attributed to heat from 2000–2019[1]

35°C
maximum wet-bulb temperature from which humans can survive[2]

30%
of global population exposed to deadly climate conditions at least 20 days per year[4]

[1] Zhao and others, 2021
[2] Greenfield and Dickie, 2022
[3] Travelli and Kumar, 2023
[4] Mora and others, 2017
[5] Buis, 2022

Tipping point Unbearable heat

Drivers

- Insufficient future planning
- Risk-intensifying land use
- Atmospheric/ocean warming
- Living and working in at-risk areas

Root causes

- Insufficient risk management
- Human-induced greenhouse gas emissions
- Inequality of development and livelihood opportunities

Increasing risk =
Environmental conditions becoming increasingly hot and humid

Tipping point =
35°C wet-bulb temperature for longer than 6 hours

Impacts

- Livelihood loss
- Migration/displacement
- Ecosystem damage and biodiversity loss
- Health impacts
- Loss of life

Tipped =
Human body is unable to regulate internal temperature

Key interconnections:

Shared root cause with:

- Mountain glaciers melting
- Uninsurable future
- Accelerating extinctions
- Human-induced greenhouse gas emissions

Continued anthropogenic greenhouse gas emissions increase global temperatures, accelerating unfavourable conditions for physical, natural and human systems

Shared driver with:

- Uninsurable future
- Living and working in at-risk areas

People move to or remain in places that expose them to increased risk due to social or economic pressures

Shared impact with:

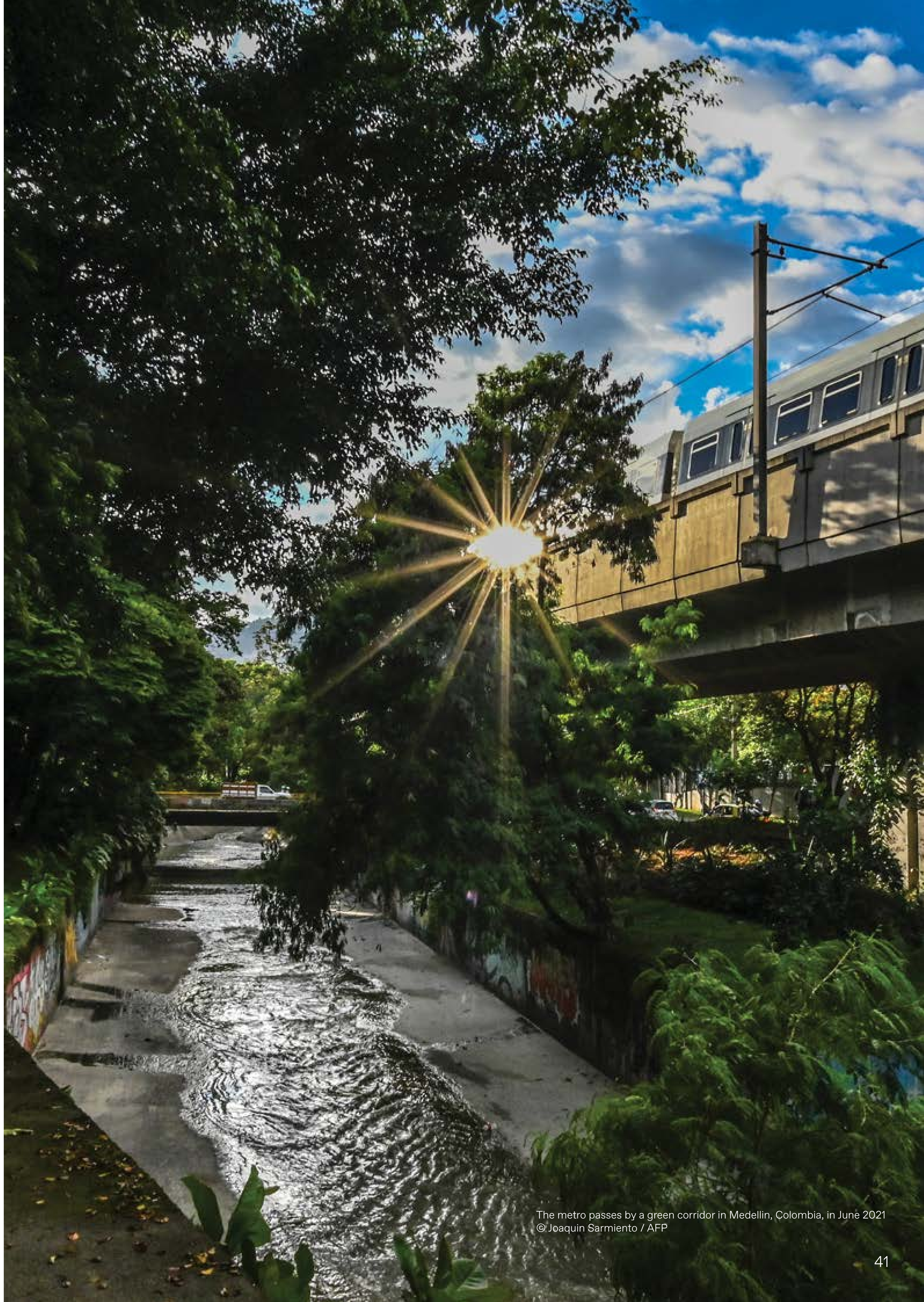
- Groundwater depletion
- Mountain glaciers melting
- Uninsurable future
- Migration/displacement

Some people may choose or are pushed to move temporarily or permanently to new, ideally less risky, locations

Direct influence on:

- Accelerating extinctions

Increasing heat and humidity not only impacts humans, but many other species who may be unable to survive extreme conditions



The metro passes by a green corridor in Medellin, Colombia, in June 2021
© Joaquin Sarmiento / AFP

Tipping point | Uninsurable future

With rising risks, insurance becomes unreachable

Woman standing outside her house that was destroyed during the floods in the New South Wales town of Lismore, in May 2022. © Patrick Hamilton / AFP

As extreme weather events around the world become more frequent and severe, so too has the cost of the damage they inflict. Since the 1970s, damages as a result of weather-related disasters have increased sevenfold, with 2022 alone seeing $313 billion in global economic losses[1]. Insurance is used to safeguard people against the risk of losses as a result of damages during disasters, with the cost based on the probability of such losses occurring. Climate change is dramatically shifting the landscape of risks, with the number of severe and frequent disasters forecast to double globally by 2040[2], causing insurance prices to rise. In places where extreme weather events increasingly wreak havoc, homeowners have seen prices climb by as much as 57 per cent since 2015[3], and people are struggling to afford coverage. Meanwhile, in the face of rising losses, some insurance companies in at-risk areas have decided to limit the amount or type of damages they can cover, cancel policies or leave the market altogether. Once insurance is no longer offered against certain risks (accessibility), in certain areas (availability) or at a reasonable price for homeowners (affordability), these areas are considered “uninsurable”. In Australia, for example, approximately 520,940 homes are predicted to be uninsurable by 2030, primarily due to increasing flood risk[4].

Despite this precarious situation, population growth and development continue in risky areas, as social and economic pressures influence more people to flock to places along the coasts, rivers, floodplains and wildland-urban interfaces. Such areas are increasingly prone to extreme weather events, putting more people and property in harm’s way. At the same time, the number and size of at-risk areas are predicted to expand as climate change shifts the range of hazards like wildfires and storms into new areas.

Without the ability to access insurance, people are exposed to drastic financial losses, and may also find it difficult to buy or sell uninsurable homes, affecting the stability of housing markets. The impacts go far beyond economic risk, however. The risk of rising inequality grows as people who are able to will likely move away. Those already vulnerable will be forced to stay and, in addition to those who come seeking cheaper housing in these areas, will face increasingly extreme events without insurance coverage. While efforts to address the issue of uninsurability have traditionally looked to economic solutions, such as government subsidies, to support affordability, relatively little attention has been given to reducing the underlying risks that have been escalating unchecked. Insurance can be a valuable tool to manage our risk when hazards strike; however, it has limits when the risks are too high. As such, insurance is most useful when used in combination with other risk reduction measures, and should not be perceived as a license to live in hazardous situations. Transformative approaches to tackle the underlying social and environmental drivers of risk are needed before we lose access to a valuable safety net when we need it most.

Tipping point: Increasingly severe hazards drive up the costs of insurance until it is no longer accessible or affordable. Once this point is passed, people are left without an economic safety net when disasters strike, opening the door to cascading socioeconomic impacts in high-risk areas.

Key numbers:

7-fold
increase in the cost of disasters globally since the 1970s[5]

$313 billion
in global economic losses from disasters in 2022[1]

520,940
homes predicted to become uninsurable by 2030 in Australia alone, due to climate change impacts[4]

[1] AON plc, 2023
[2] Swiss Re Institute, 2021
[3] Kamin, 2023
[4] Hutley and others, 2022
[5] WMO, 2021

Tipping point | Uninsurable future

Drivers

- Insufficient future planning
- Risk-intensifying land use
- Atmospheric/ocean warming
- Lack of information
- Living and working in at-risk areas

Root causes

- Insufficient risk management
- Human-induced greenhouse gas emissions
- Inequality of development and livelihood opportunities

Increasing risk =
Reducing access to coverage and rapidly escalating prices in at-risk areas

Tipping point =
Availability, accessibility and affordability of insurance coverage no longer feasible

Impacts

- Migration/displacement
- Loss of safety

Tipped =
Homeowners and businesses without options for coverage to offset their risk to increasing hazards

Key interconnections:

Shared driver with:

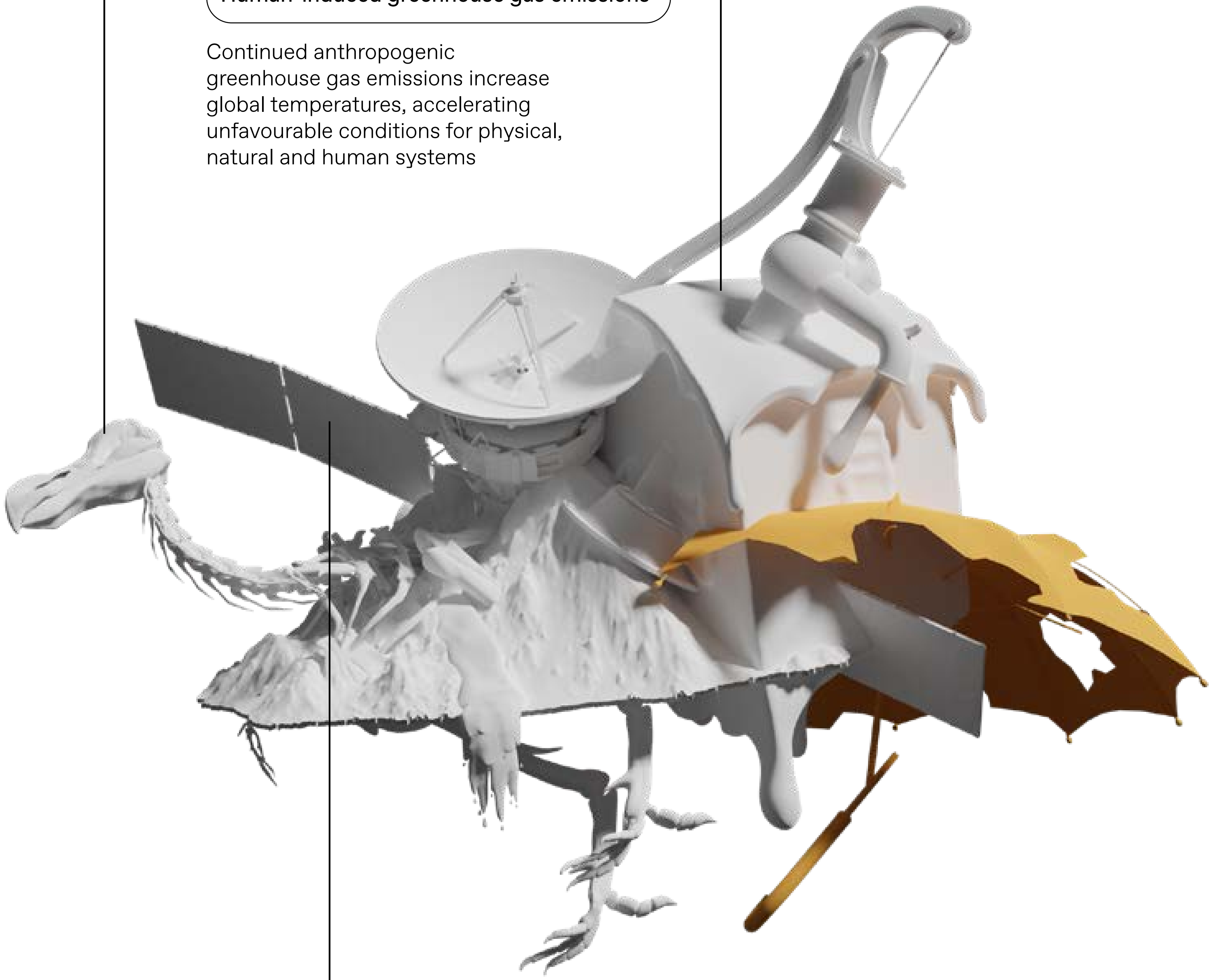
- Unbearable heat
- Living and working in at-risk areas

People move to or remain in places that expose them to increased risk due to social or economic pressures

Shared root cause with:

- Unbearable heat
- Mountain glaciers melting
- Accelerating extinctions
- Human-induced greenhouse gas emissions

Continued anthropogenic greenhouse gas emissions increase global temperatures, accelerating unfavourable conditions for physical, natural and human systems



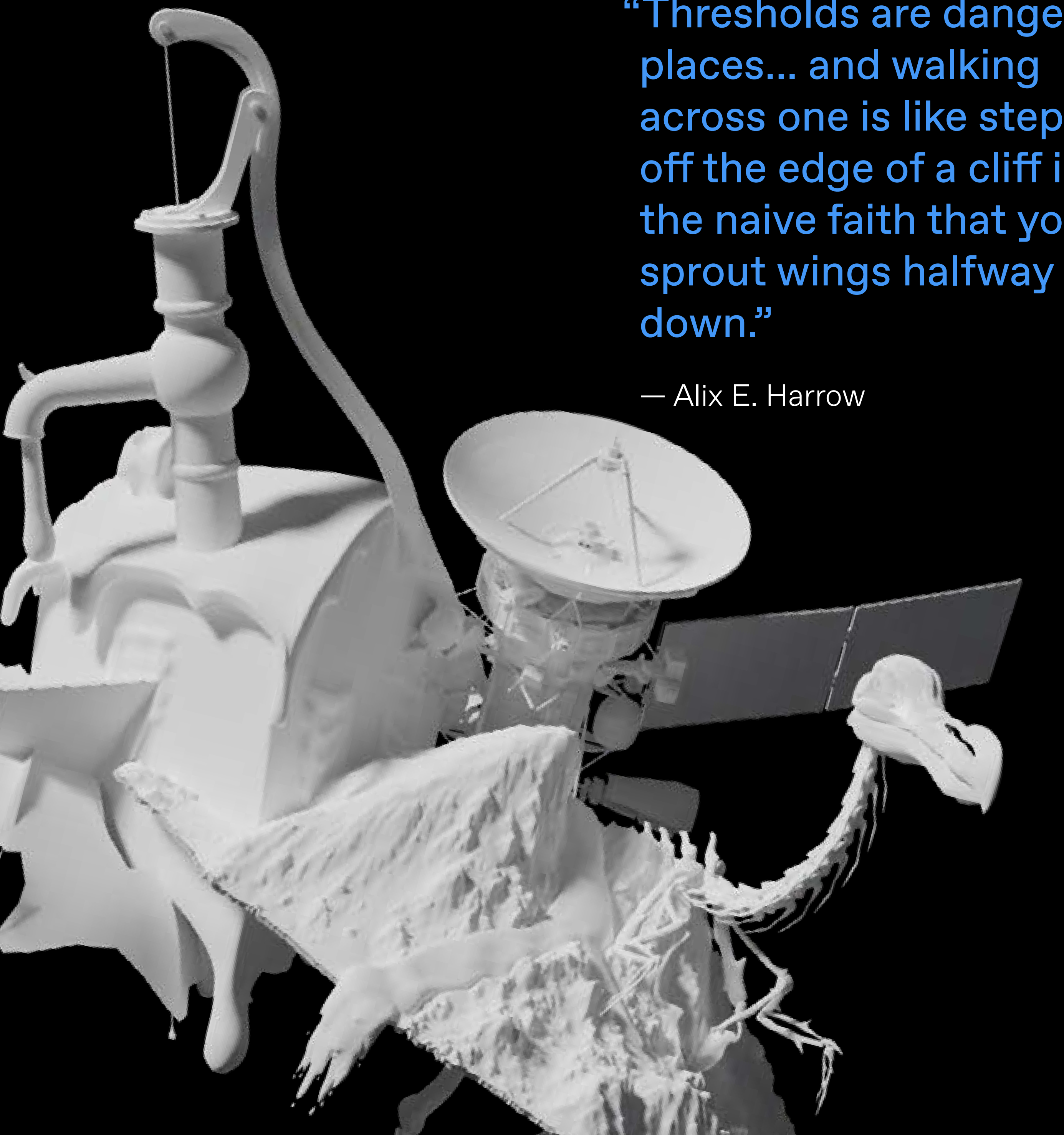
Shared impact with:

- Groundwater depletion
- Space debris
- Mountain glaciers melting
- Loss of safety

Loss of risk management or monitoring tools leads to loss of safety and security

Grazing goats are used as an environmentally friendly way to clear away dry grass and brush to reduce fire danger on properties in Walnut Creek, California. © Justin Sullivan / Getty Images / AFP

Risk tipping points



"Thresholds are dangerous places... and walking across one is like stepping off the edge of a cliff in the naive faith that you'll sprout wings halfway down."

— Alix E. Harrow

Background

The concept of tipping points has been used across disciplines for decades, from ecology and sociology to chemistry and climate science. As such, multiple definitions and terms describe the concept, including "critical transitions", "regime shifts" and "ecological thresholds". In general, these different fields of study examine abrupt changes in the state of a system after crossing a certain threshold (Milkoreit and others, 2018). Ecological thresholds, or ecological tipping points, refer to rapid regime shifts in ecosystems through small perturbations over time or a large-scale shock to the system (van Ginkel and others, 2020). One such well-documented example is a regime shift in lakes and ponds resulting from the excessive input of nutrients, such as phosphorus or nitrogen, which transforms the ecosystem from a clear-water state, in which aquatic plants dominate, to a turbid state, in which microalgae dominate (Scheffer and others, 1993; Gilarranz and others, 2022). Climate tipping points apply to elements of Earth's climate system, including the Greenland Ice Sheet and the Amazon rainforest, that transition to a different state through minor disruptions that impact the state of global climate (Lenton and others, 2008; Armstrong McKay and others, 2022). The "tipping point" is the corresponding threshold at which the state of the system is fundamentally altered, such as when the Greenland ice sheet melts or when the Amazon rainforest transitions to a dryland savannah (Lenton and others, 2008). Moreover, these effects are not confined to a single system due to the interconnectivity and feedback loops between various systems. When one system tips, it is likely to have cascading effects, potentially destabilizing other systems that share interconnected elements (Steffen and others, 2018; Klose and others, 2020; Liu and others, 2023). It is important to highlight that our climate and ecological systems are inseparable from our society, emphasizing the unity of humans and nature in our socioecological systems (Berkes and others, 1998) and the role of human agency in influencing climate and ecological systems (Graham and others, 2023).

Additionally, there are substantial impacts on human well-being after a system has tipped. For example, when the extinction of a species leads to ecosystem collapse, people may lose key food sources or other ecosystem services they depend on (Halpern, 2017). While much of the existing literature examines physical tipping points, social systems have also recently been shown to undergo "tipping" behaviour. However, they do not act in the same way as physical systems, and are much more unpredictable as people's choices and behaviours are diverse across time and space (Juhola and others, 2022). Social tipping points have often been discussed in the context of social movements, where a new idea or technology shifts from being taken up by a minority to a majority of the population (van Ginkel and others, 2020). However, more relevant here is the discussion of thresholds and limits in social systems. An adaptation limit, for example, represents the point at which an intolerable risk prevents a stakeholder from securing a valued objective through adaptive action (Juhola and others, 2022). Relatedly, the concept of adaptation tipping points or turning points are used in the climate science field to define the conditions under which a policy or management strategy is no longer sufficient to address the magnitude of the effects of climate change, and corrective action is required (Werners and others, 2015; van Ginkel and others, 2020).

A young Tibetan woman carries her baby at the Nojin Kangsang glacier, Tibet Autonomous Region of the People's Republic of China, in February 2007.
© Peter Parks / AFP

In this report, we expand on these concepts to define **risk tipping points**. A risk tipping point is defined as the point at which a given socioecological system ceases to buffer risks and to provide its expected functions, after which the risk of catastrophic impacts to the system increases substantially. Risk in a given socioecological system increases in such a way that once a certain physical or social threshold is passed, it leads the system, often irreversibly, into a riskier state, likely with immediate, severe consequences for the environment and human security. The new, riskier state is functionally very different from the previous state in which known, proven risk reduction strategies may no longer apply.

To understand risk tipping points, we first need to look at the increasing **risk** in a certain, defined **system** undergoing change, the **tipping point** at which a system shift occurs and the actual **changes** that take place in the system after surpassing the tipping point. In this context, our **risk** can be defined as the potential for adverse consequences to our socioecological systems, determined by the severity of the threat and our level of exposure and vulnerability to it (IPCC, 2021). Once we pass certain critical tipping points, the threat becomes more severe or there is an increase in the exposure and vulnerability of individuals, ecosystems or societies to be affected. In the case of **Groundwater depletion**, the risk of overexploitation of groundwater resources increases as we extract water from aquifers faster than it can be replenished, until eventually water can no longer be extracted for irrigation. This depletion results in the increased potential for impacts on our food production systems that rely on that groundwater.

Different from the classic definition of a tipping point, the **systems** undergoing change are not necessarily Earth systems themselves, such as hydrological cycles or climate patterns, but the socioecological systems dependent on their functioning. For instance, there may be a biophysical limit when the depletion of an aquifer causes the hydrological system to undergo tipping behaviour. However, when discussing the **Groundwater depletion** risk tipping point discussed in this report, the **system** that tips is the socioecological system reliant on groundwater resources — in this case, our groundwater-dependent agricultural irrigation system.

Tipping points are identified as critical points at one part of the socioecological system at which these systems cease to provide their expected functions. Past a certain point, a system can no longer maintain the current expectations without undergoing significant change to either the system or to the expectations. With **Groundwater depletion**, the point at which the irrigation-based agricultural system stops functioning as expected would be when the water is no longer reachable by the existing irrigation infrastructure. This tipping point is likely to be crossed by different people or places at different times. In fact, in some cases, the tipping point has already passed in one area but not yet in others.

The **changes** that occur after reaching the tipping point are not only physical changes, but also changes primarily to the level of risk in our system. Beyond the tipping point, given our current trajectory, risk to the system becomes substantially higher, increasing the likelihood of cascading effects and adverse impacts for people and the planet. In the case of **Groundwater depletion**, after crossing the tipping point, a farmer would be unable to irrigate their crops with groundwater. As such, crops would either fail completely or rely on other means of irrigation, such as rain, a much riskier proposition with the unpredictability of future weather patterns under climate change conditions. Either way, past this tipping point, there is an increased risk of crop failure, and the people dependent on those crops could lose their livelihoods or food security. Importantly, the riskier future after the tipping point is experienced not only by those directly affected by its impacts, in this case farmers, but also by the social and environmental systems they are interconnected with. The risks would cascade through food systems, economies, health systems, ecosystems and communities that are forced to contend with the drastic changes to agriculture without groundwater.

These components can be seen in each of our six risk tipping points. For example, in the case of **Space debris**, the **system** at risk is our space-based infrastructure, including weather forecasting, climate monitoring, disaster early warning, satellite internet and telecommunications (Undseth and others, 2020). Once our orbits become so congested and polluted with satellite and rocket debris, we will reach a **tipping point**, a critical density of objects in orbit around Earth, such that one collision between two objects can set off a chain reaction. This would mean that objects and debris crash into each other, creating more debris that crashes into more objects until our satellite infrastructure will eventually be completely destroyed (Kessler, 2000). After this point, our orbits would **change** to become unusable, filled with millions of shards of debris that could damage or destroy any future object launched into space, eliminating our ability to gather and distribute information from space (Greenbaum, 2020; Clormann and Klimburg-Witjes, 2022).

Importantly, many of these risk tipping points do not necessarily represent a final, irreversible point of no return. Though irreversibility is a key component of many tipping point definitions, this characteristic cannot always be interpreted literally. For example, it is not impossible for groundwater aquifers to sufficiently recharge to be reachable again by existing irrigation infrastructure. However, considering our current trajectory, under a business-as-usual lens, it is unlikely that these changes will be reversed in a policy- or intervention-relevant timescale (Lenton and others, 2008; Milkoreit and others, 2018). For **Groundwater depletion**, in some shallow aquifers, it may take less than a decade to recharge naturally, while for others it may take thousands of years (Little, 2009; Schreiner-McGraw and Ajami, 2021). For other tipping points, the eventual changes may only potentially be irreversible. In the case of **Space debris**, if we were to pass the tipping point and our orbit became unusable from the amount of debris, we currently have no means to reverse it. There is some indication that future technology could be developed to clean up our orbit, but it is not yet possible (Boag, 2019). However, considering that large-scale Earth system changes, such as climate change, are driving some of these tipping points, reversing them will likely be impossible without comparable large-scale changes (Reyers and others, 2018). For example, getting to an environment where **Melting mountain glaciers** grow instead of shrink would necessitate a return to a planetary glaciation cycle, the next of which has been postponed thousands of years beyond its natural occurrence due to human-induced global warming (Ganopolski and others, 2016; Steffen and others, 2018). Even if we did manage to counteract the global-scale processes in motion, we would likely not return to the same state as before and would therefore still experience some sort of irreversible loss. With **Accelerating extinctions**, we should do everything in our power to reduce the anthropogenic pressures on species and their habitats, but we will likely never get those species back once they go extinct. While removing the pressures could prevent some vulnerable species from going extinct and create an environment for new species to evolve, the loss of the species that came before would still haunt us.

Luckily, even if we pass a risk tipping point, there are likely still some options for risk to be reduced. However, it is important to keep in mind that not everyone will be able to access these options equally, particularly those that are most vulnerable. Fundamentally, the tipping point represents an obstacle that some may have the means to overcome, while others face constraints that limit their ability to minimize risk. In the case of **Groundwater depletion**, some people may have the capacity to dig deeper wells, supplement irrigation with other water sources or pursue other livelihood options. In the case of **Unbearable heat** or **Uninsurable future**, some will have the capacity to move to less risky areas or obtain sufficient tools to manage their risk. Others who may not have this capacity will have to shoulder the risk completely and suffer the consequences as they occur. As we approach the risk tipping point, the magnitude of the risks will increase while the potential impacts will worsen. Additionally, implementing interventions to mitigate these risks will become increasingly difficult. We do not have to wait until the tipping point is upon us to change. We can do so now to reduce risk and avert the worst impacts.

Flames crest a hill threatening homes in Santa Clarita in Los Angeles County, California, in October 2003. © Robyn Beck / AFP

To select the risk tipping points for this report, we started with the question: What are some of the biggest risks facing our environment and human security? We considered these risks in broad categories, including unsustainable resource use, increasing frequency of environmental hazards, inequality in distribution and access to resources and failing risk management systems. We then examined systems that are subject to these risks, such as our agricultural system, human health and well-being, hydrological systems, ecosystems and other similar systems. We then performed extensive research to answer the fundamental question: At what point would the pressure from these risks cause the systems to stop functioning as expected? Once we identified these tipping points, it was also important for us to be able to communicate tangible, realistic impacts beyond the tipping points, as well as being able to convey interventions and solutions that we can implement to reduce our risk, both before and after reaching each tipping point. After making a repository of potential risk tipping points to discuss, we made the final selection, aiming for a diverse thematic spread, a wide range of impacted areas and timely relevance of the topic.

The concept of risk tipping points (**Figure 1**) shows how we are being pushed to the edge by an undercurrent of **drivers**, or trends and patterns in our global socioecological systems, including deforestation, atmospheric warming and lack of regulations. These drivers originate in our underlying behavioural patterns, policies, attitudes, beliefs and morals that we call **root causes**. These root causes and drivers have brought our systems to the point we are at today, with vulnerabilities built on the resulting systemic faults (see Chapter 4.1). If we choose to do nothing, we are headed over the tipping point and down a dangerous path into a riskier future, with likely severe and immediate impacts, particularly for the most vulnerable (see Chapter 4.2). However, we have the benefit of being able to see the tipping point coming and can choose to steer away from the tipping point toward a brighter, more sustainable path leading to a less risky future (see Chapter 5).

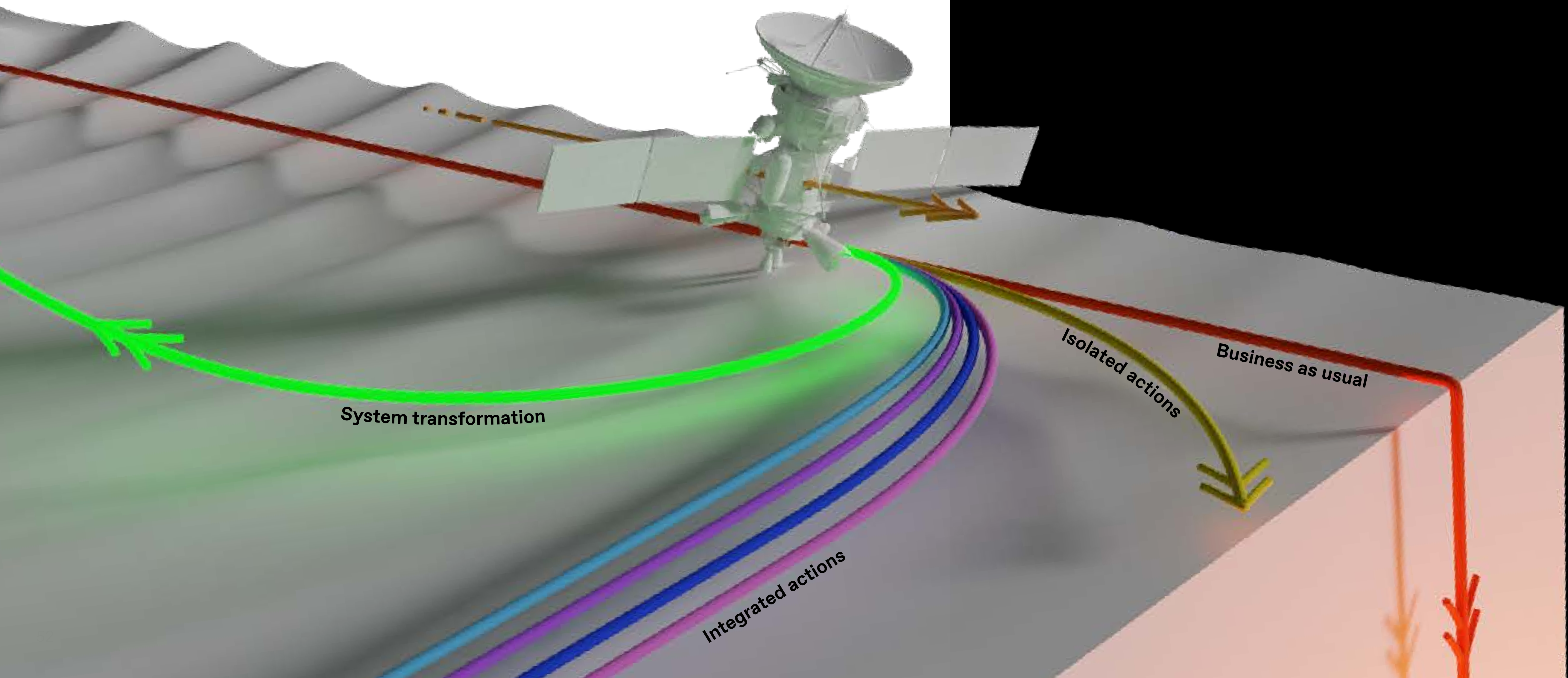


Figure 1: Risk tipping point — The path we are on now involves increasing risk until our systems reach tipping points, but taking alternative actions can delay or prevent this tipping point from being passed.

Connecting the dots

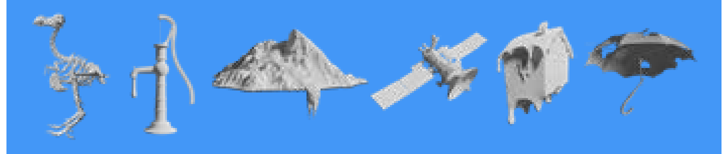
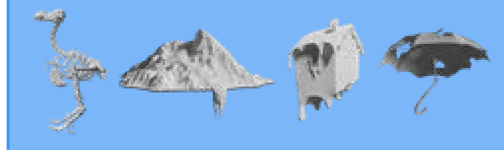
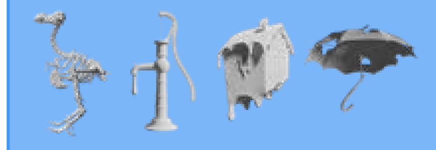
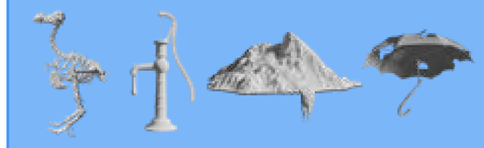
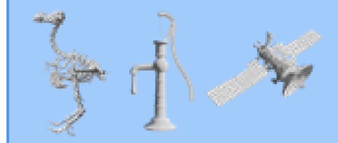
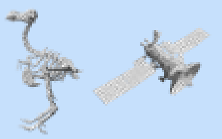
Section 4.1 How did we get here?

The six risk tipping points described in this report are the manifestation of broad patterns of emerging risks that the world is facing in many places, now or in the near future. Importantly, while we can somewhat easily recognize these patterns of risk as they occur in different places, they are just the tip of the iceberg. We must look below the surface to see the underlying conditions that created these risk tipping points in the first place. Importantly, though each risk tipping point represents a unique problem, they are interconnected through these common underlying conditions.

"The world is a place that is so interconnected that what happens in another part of the world will impact us."

— Anthony Fauci

The proximal causes of risk tipping points reveal trends and patterns in their **drivers** — the more immediate factors that push us towards a tipping point, such as pollution or atmospheric warming.

Table 1	Shared drivers 2023	Shared tipping points
(6/6)	**Insufficient future planning** (Lack of foresight to act on an oncoming problem)	
(4/6)	**Atmospheric/ocean warming** (Greenhouse gases trapping sunlight and warming the planet)	
(4/6)	**Risk-intensifying land use** (Ways of using land that intensifies an associated risk)	
(4/6)	**Lack of information** (Insufficient monitoring or inadequate models to estimate the extent of the problem)	
(3/6)	**Lack of regulations/enforcement** (Absence or ineffective enforcement of regulations connected to other risk drivers)	
(2/6)	**Pollution** (Any product or substance in a concentration harmful for human or environmental health)	
(2/6)	**Living and working in at-risk areas** (Exceptionally high exposure to risks as a result of a certain behaviour)	

As shown in **Table 1**, some risk tipping points share similar drivers, illustrating how these specific patterns can manifest different outcomes depending on their different contexts. For example, increasing atmospheric and ocean warming not only drives **Mountain glaciers melting** and glacier retreat, but also causes more frequent and intense hazards, like storms or wildfires, that increases the likelihood of a place becoming **Uninsurable**. The way each of these drivers is related to the specific risk tipping points is explored further in their respective **technical reports**.

Among these interconnected drivers, several common themes emerged. First, by looking into the driver *Risk-intensifying land use*, we can clearly see that the way we use and modify our landscapes is pushing us towards greater risk. For example, agricultural intensification, such as farmland expansion, increases groundwater withdrawals, exacerbating **Groundwater depletion** (Ao and others, 2021), while also disrupting the relationships between strongly-connected species, leading to the risk of **Accelerating extinctions** (Morrison and others, 2020).

Urban expansion also contributes to habitat loss, which is the dominant threat for the extinction of species (Kehoe and others, 2021), while also contributing to **Unbearable heat**, as increasing infrastructure built from concrete and asphalt in cities absorbs and retains more heat than the surrounding environment (Qian and others, 2022). Occasionally, this urbanization or other development can take place in risky areas, such as in the wildland-urban interface where wildfire risk is high (Radeloff and others, 2018), further exacerbating the likelihood that some homes will be **Uninsurable** (Flavelle and others, 2023).

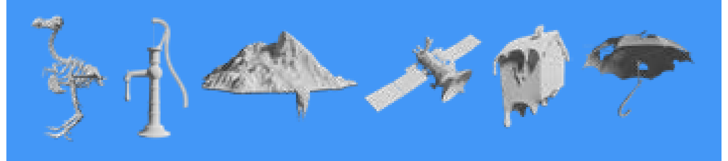
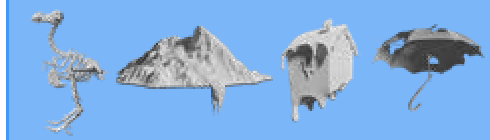
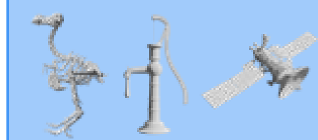
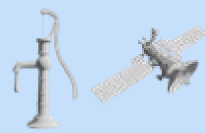
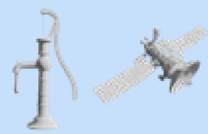
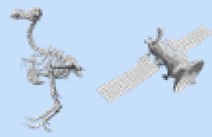
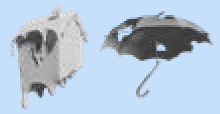
Additionally, the commonalities found in *Insufficient future planning* as a driver for multiple risk tipping points indicates a fundamental issue of risk perception, or people's judgment about the characteristics and severity of a risk, made based on their personality, political orientation, cultural biases and level of knowledge (Douglas and Wildavsky, 1983). Risk perception can be seen as an outcome of the interaction between certainty and consent. When individuals are certain about the knowledge they have on a given topic as well as consent from the larger group that this is the complete amount of knowledge, then the only issue left is how to efficiently design a solution (Douglas and Wildavsky, 1983). However, if either the certainty or the consent around the knowledge of the problem is in question, then solutions to address the risk and plan for the future will be difficult to implement, unless there is more research on the topic or coercion of the group towards consensus. The *Lack of information* about a given risk can lead to either an unawareness that the risk exists, or an assumption that the risk is non-existent or not important. These two drivers, *Insufficient future planning* and *Lack of information* often combine with a tendency to avoid the **precautionary principle** when assessing risk. The precautionary principle, applied in this context, means that performing a certain action of which the effects are unknown should be resisted. Importantly, this does not mean that the action should be avoided at all costs, but should rather be undertaken cautiously. As such, the lack of information could inform our activities to proceed with caution. However, it seems that many systems operate under the "no news is good news" idea, and advance full steam ahead. For example, in many places, there is little to no monitoring of **Groundwater depletion**, meaning that often we do not know how much groundwater is actually available. This favours the practice of overextraction as it makes developing sustainable water management efforts more difficult (Vasco and others, 2019).

Other times, we do have ample evidence that there is an oncoming danger, but the danger is too far removed from us in space or time and we would need to bear the cost now for benefits that would only be seen by others or in the future. For **Space debris**, as the continued pollution of our orbits puts satellite infrastructure at increasing risk of collisions, we are not sufficiently taking precautionary measures to limit that possibility because the measures to do so are quite expensive, would need to be implemented by many stakeholders and, importantly, deemed not immediately necessary (Undseth and others, 2020). This avoidance of precaution can be especially prevalent when it comes to privilege, as more affluent individuals often have more to gain from taking a certain risk and are often shielded from potential negative impacts (Tiller and others, 2022). Similarly, this is one of the reasons shared resources may quickly decline (see Chapter 4.1.2), as the gains from using the resource are private, but the losses are shared.

A man stands behind a borewell drilling machine in a crop field in Punjab, India, in May 2023. © Polina Schapova / UNU-EHS

Section 4.1.2 Root causes

While the drivers are pushing us towards the tipping points, the reasons why our systems are fundamentally at risk are rooted one layer deeper and are formed by our economic and political structures as well as our value systems. As shown in **Table 2**, the six tipping points are rooted in eight main **root causes**. Some of them are shared across most tipping points such as *Insufficient risk management* and *Human-induced greenhouse gas emissions*, highlighting how often these lead to risk and thus how important it is to recognize and address them.

Table 2	Shared root causes 2023	Shared tipping points
(6/6)	**Insufficient risk management** (A lack of perception, awareness or preparation in governance relating to risk management and response)	
(4/6)	**Human-induced greenhouse gas emissions** (Gases released into the atmosphere by human activities contribute to increasing global warming and climate change)	
(3/6)	**Global demand pressures** (Pressure related to increasing consumptive demands for goods and services, such as food, energy and industrial materials)	
(2/6)	**Insufficient cooperation** (Lack of coherent national/global governance, unregulated exploitation of low- and middle-income countries, limited governmental capacity)	
(2/6)	**Prioritizing profits** (Maximization of profits is prioritized over other social concerns, causing increased risk, such as a lack of effective regulation and accountability along global value chains)	
(2/6)	**Colonialism** (Expansion over an area for economic or strategic exploitation and control)	
(2/6)	**Inequality of development and livelihood opportunities** (Unequal distribution of economic opportunities and limited livelihood options)	
(1/6)	**Undervaluing environmental costs** (Pursuit of economic or developmental interests with a lack of consideration for impacts on the environment)	

A lack of sufficient perception, awareness and preparation in risk management and response is summarized in the root cause *Insufficient risk management*, which pushes all six life-sustaining systems towards a tipping point. For example, while insurance-based solutions are designed to help people and communities to recover after a hardship such as a disaster, with increasing disaster risk impacting more and more people and places, it becomes more challenging to sustain access to affordable insurance coverage (Mills and others, 2005). *Insufficient risk management* leads to an **Uninsurable future** as it does not sufficiently reduce the exposure and vulnerability of people and places to different hazards. If we do not address the increasing underlying risk, we will not be able to sustain insurance as a valuable tool to manage our risk when hazards strike (Surminski and others, 2016). The way each of these root causes is related to the specific tipping points is explored further in their respective **technical reports**.

Importantly, reaching these risk tipping points is caused by not just one root cause, but the combination of many root causes at once. For example, **Unbearable heat** and related severe health impacts are rooted in *Human-induced greenhouse gas emissions* and resulting land and ocean warming. It is, however, also influenced by *Insufficient risk management* in the form of lack of heat plans, lack of heat early warning systems and lack of perception of heat as a serious threat (Li and others, 2022; Eberle and others, 2022; Pillai, 2023). Additionally, **Unbearable heat** has a very strong equity component, as the *Inequality of development and livelihood opportunities* highlights how socioeconomic conditions strongly influence heat-related vulnerability as under same heat conditions, the difference between housing opportunities, work conditions or access to an air-conditioned room may mean the difference between life and death (Gronlund, 2014; Kjellstrom and others, 2020; Benz and Burney, 2021).

Other root causes are more specific to a few or single tipping points, such as *Undervaluing environmental costs* leading to **Accelerating extinctions**. Often, this means that economic development is pursued in a way that ignores critical environmental impacts, which directly or indirectly increases the risk of extinctions (Zabel and others, 2019). The root cause *Undervaluing environmental costs* is intertwined with the root cause *Global demand pressures* as the increasing consumptive demands for goods, such as food, energy and industrial materials, often lead to land-use change decisions. These are harmful not only for biodiversity and ecosystem integrity (Johnson and others, 2017), but also for water resources (Dalin and others, 2017; Bierkens and Wada, 2019), contributing to **Groundwater depletion**.

Colonialism was one of the root causes for the steep increase in human activities in space, leading to a sharply increasing amount of **Space debris** in the orbit (ESA, 2023a). Resulting power structures have long-lasting impacts and often reinforce and support systemic inequalities across the globe, contributing to the interlinked root cause *Inequality of development and livelihood opportunities.* Access to space is not evenly distributed, as currently only 10 countries and one intergovernmental organization have the capacity for orbital launches, with the United States in particular emerging as the dominant player (UCS, 2005; Koop, 2022). As only a select few countries and individuals are able to afford direct access to space, they disadvantage the rest of the planet by damaging our outer space environment (Venkatesan and others, 2020), crowding out other nations that may want to use the orbit and potentially destroying the usability of the orbit in the future (Clormann and Klimburg-Witjes, 2022). The impacts of *Colonialism* also have put a strain on biodiversity, contributing to **Accelerating extinctions**. For colonizers, the "new" territories were places of infinite resource extraction with little regard for the long-term consequences. This leads to habitat destruction through mainly deforestation and mining, overexploitation of species by unsustainable hunting, fishing, logging, the indiscriminate trade of species and the intended or unintended introduction of invasive alien species across the world pushing away native endemic species (Winter and others, 2009; Sodhi and others, 2009; McQuade, 2019; Lenzner and others, 2022).

A common theme across the tipping points **Accelerating extinctions**, **Groundwater depletion** and **Space debris** is the challenge of the management of common-pool resources to which — at least theoretically — everyone has access. The *tragedy of the (unmanaged) commons* metaphor (Hardin, 1968; Hardin, 1998) describes that individuals with access to common-pool resources tend to use it according to their personal benefits, without acting in the best interest of others. The depletion of the resource is inevitable unless sufficient regulations or self-organization of the community for the sustainable use of the resource are put in place. Importantly, the gains are private while the costs and consequences of this exploitation are shared and felt by all those who directly or indirectly rely on the resource. In the end, everybody loses but the most vulnerable and most resource-dependent parts of society suffer the most. Sustainable management is needed for all resources that cannot be sustained if the rate of consumption is higher than the rate of replication (animals, plants) or replenishment (soil, water). It also means that not just the organisms themselves but also their habitats and ecosystems need to be preserved, while other source materials need to be recycled (Montgomery and Tipton, 2019).

In the case of **Groundwater depletion**, the resource itself is hidden below ground, so its exploitation is not immediately visible to the individual user. The same groundwater resource is accessed by many users simultaneously for agricultural irrigation, drinking water and industrial production. Additionally, the consumers of the produced goods, such as food or fodder, also rely on the resource. In many cases, use of groundwater is not sufficiently governed by either local or governmental rules, with some regulations even incentivizing overuse to secure personal gain. For example, for the High Plains aquifer in the United States, one of the world's largest groundwater resources, water-use rights are often determined based on "beneficial use" (Hockaday and Ormerod, 2020). If farmers are allocated a certain amount of water and consistently underutilize their full allocation, then their water rights may be curtailed. This policy can incentivize inefficient irrigation strategies by encouraging farmers to use all water that is allocated, independent of the current need, leading to overuse and depletion (Aiken, 1988). Resource depletion can also be driven by distant users who benefit from the common resource without directly suffering the consequences of depletion. For instance, groundwater-dependent agricultural products are often exported to other parts of the world, and the water used to grow the product is called "virtual water". The trade of crops resulting from groundwater depletion by the top crop exporters (Pakistan, the United States and India) has steeply increased from 2000 to 2010 (D'Odorico and others, 2019), increasing the trade of virtual water and reinforcing the global interconnectivity in groundwater depletion. This trend also highlights the high degree of decoupling between the visible impacts of groundwater depletion from demand and use of the resource.

A specific case of common resources are the *global commons*, areas and resources beyond the sovereignty of any state, which include the high seas, the seabed, Antarctica, the atmosphere and outer space. All nations have the right to access to these global commons, but none have the right to claim sovereignty over them. Importantly, this concept only works when all states agree to recognize an area or resource as a global commons. For example, one of the issues contributing to the **Space debris** tipping point is that there is no international agreement designating our orbits and outer space as a global commons. In fact, the United States issued an executive order in 2020 stating explicitly that "the United States does not view [outer space] as a global commons" (Venkatesan and others, 2020). The underlying assumption of infinite use of resources of the global commons (Schrijver, 2016) has led to a widespread decline in global resources, such as the overfishing of the high seas and related loss of biodiversity (Neeman and others, 2018), greenhouse gas emissions into the atmosphere and resulting climate change (IPCC, 2023) and the increasing use of the outer space by states, enterprises and even individuals (Venkatesan and others, 2020). All imperil planetary and human health, and lead to risk tipping points such as **Accelerating extinctions**, **Unbearable heat**, **Mountain glaciers melting** or **Space debris**.

Another common theme across several tipping points is the profound impact of human activities on our large-scale planetary systems as a consequence of the "Great Acceleration", which describes a period of unprecedented increase of human activities since the 1950s and its impacts on the Earth system such as population growth, energy use, water use, damming of rivers, greenhouse gas emissions, surface temperature increase, deforestation and species extinction (Steffen and others, 2005). It also points to a planetary-scale coupling between the socioeconomic system and the Earth system via globalization (Steffen and others, 2015). In the past, Earth's history has been divided into geological epochs defined by dominant large-scale changes, such as meteor strikes, volcanic eruptions or continental movements. However, with the "Great Acceleration", human activity has become the dominant, global cause of environmental change, leading some scholars to suggest that a new geological epoch should be defined: the Anthropocene (Crutzen and Stoermer, 2000; Lewis and Maslin, 2015). Indeed, humans have pushed the planet outside of the previous Holocene epoch's range of variability, testing the limits of what people and the planet can endure (Rockström and others, 2009). There is ample evidence that human actions driven by societal or economic needs, such as pollution or deforestation, influence physical tipping points (Filatova and others, 2016; Brovkin and others, 2021; Rockström and others, 2023). Although humans have always changed their environment and species have always gone extinct as part of natural evolution or some catastrophic events, the "Great Acceleration" documents an unprecedented rate and magnitude of change. The fast rate of change, for example in biodiversity loss or resource overexploitation, means that we are approaching tipping points, such as **Accelerating extinctions** or **Groundwater depletion**. The Earth's systems cannot sustain this kind of growth anymore. An example is the essentially stagnating marine fish capture since the 1980s due to the exhaustion of fish populations (Steffen and others, 2015). On a global scale, planetary boundaries represent these limits in various Earth systems, outlining the safe operating space for humanity, such as limits for climate change (CO_2 concentration less than 350 ppm) or biodiversity loss (less than 10 extinctions per million species annually) (Rockström and others, 2009). When we pass these boundaries, we destabilize and undermine our critical life-support systems with often devastating results.

A farmer holds a plant from his rice crop in Punjab, India, in May 2023, where groundwater levels are declining. © Polina Schapova / UNU-EHS

Section 4.1.3 Influence across systems

The increasing risks described in each of the six risk tipping points in this report are not only a concern for individual systems but, in our interconnected world, can also cascade through other systems worldwide. In other words, when one system passes the tipping point, it risks further unbalancing others (**Figure 2**). Such influences are expected to occur between so-called tipping elements of the Earth, where the melting Greenland Ice Sheet and ocean circulation cycles can impact each other (Steffen and others, 2018; Liu and others, 2023). Importantly, this threat of a "tipping cascade" is not limited to one field or sector, such as climate tipping points, but cuts across social, environmental and economic sectors. Certain systems passing risk tipping points have the ability to accelerate each other, as the impacts of passing one tipping point can raise risk in interconnected systems pushing them further towards their own tipping points, even across distant spatial scales.

In addition to being interconnected by shared root causes and drivers, the six risk tipping points in this report are interconnected through their influence on each other; as one system approaches the tipping point, it can push others towards the edge as well. For example, **Mountain glaciers melting** and **Groundwater depletion** will change aquatic and terrestrial ecosystems in ways that threaten various species and further increase the risk of **Accelerating extinctions**. Although responses will likely vary depending on the type of organism, local extinctions are predicted to follow glacier retreat, particularly in cold-adapted plant and aquatic invertebrate species, which have already seen their habitats shrinking in recent years (Giersch and others, 2017; Anthelme and others, 2022). As conditions and ecosystems change with shifts in temperature and availability of food and water, mountain species could find themselves on the "escalator of extinction", where they must either continually move up the mountain to stay in their preferred conditions or risk being outcompeted by other species moving into their range (Losapio and others, 2021). Meanwhile, the organisms living in underground aquifers are vulnerable to shocks that change their habitats (Devitt and others, 2019), and the depleting groundwater will further impact biodiversity on the surface as river and lake habitats literally dry up. This shift of environmental conditions pushing sensitive species towards **Accelerating extinctions** could also be influenced by **Unbearable heat**, as many animals, particularly mammals, share similar thermal limits as humans and thus similar health risks above the 35°C wet-bulb temperature threshold (Sherwood and Huber, 2010). Even if the primary extinction was set in motion as a result of natural evolutionary processes, the resulting reduced diversity will reduce the number of ecological interactions between species and raise the risk of cascades if an extinction takes place (Dunne and Williams, 2009; Kehoe and others, 2021).

Some risk tipping points influence each other more indirectly further down the impact chain. For example, if the amount of **Space debris** in low Earth orbit passes a critical point and sets off a destructive cascade where satellites are destroyed and future use of the orbit is no longer viable, we lose a critical tool that helps us reduce risk in various other systems. Satellite monitoring is an important tool for monitoring groundwater and aquatic systems and predicting areas of water stress (Richey and others, 2015). If these satellites are destroyed by a catastrophic collision, we would be left without the ability to monitor groundwater resources from above, limiting our ability to manage **Groundwater depletion** and increasing the risk of crossing that risk tipping point as well. Similarly, satellites provide data to model and predict hazard risks, important for avoiding an **Uninsurable future**. If we lose our capacity for remote sensing and monitoring weather cycles, this will increase the uncertainty that is driving unaffordability in at-risk areas (Norwood, 2021). Given the key role of satellites in early warning systems, losing our "eyes in the sky" can result in delayed, inaccurate or absent information about an oncoming hazard, increasing the likelihood of adverse impacts and increasing damages (Frąckiewicz, 2023). Additionally, the rising risk of collisions of **Space debris** in low Earth orbit is making insurance for satellites increasingly unobtainable as insurers no longer offer coverage or limit cover for the hazard of collisions, mirroring the situation of increasing **Uninsurability** on Earth (Hussain and Cohn, 2021).

Adding to the complex nature of interconnections between risk tipping points is their ability to reinforce one another as risks rise. Crossing **Unbearable heat** tipping points will have far-reaching effects on risk in different systems beyond human and ecosystem health. For example, rising wet-bulb temperatures change precipitation patterns and in some mountain regions reduce snowfall that glaciers depend on to maintain their size, further accelerating the risk of **Mountain glaciers melting** (Tamang and others, 2020). As glaciers melt away, they can no longer play their role in recharging groundwater aquifers, some of which rely on glacial meltwater for more than half of their recharge, increasing the risk of **Groundwater depletion**, particularly in mountain areas (Ó Dochartaigh and others, 2019). Global warming combined with groundwater-based irrigation can lead to increased occurrence of humid heat above ground (Ambika and Mishra, 2022), and thus rapidly intensifying groundwater irrigation not only increases risk of depletion but can also raise wet-bulb temperatures and the risk of **Unbearable heat**.

As these examples indicate, managing one risk alone without recognizing the influence of interconnectivity and feedbacks with other risks would not account for many important drivers of the risk in question and could limit the effectiveness of efforts to reduce it. The more we understand the interconnected nature of risk tipping points, the more critical it becomes to avoid crossing them.

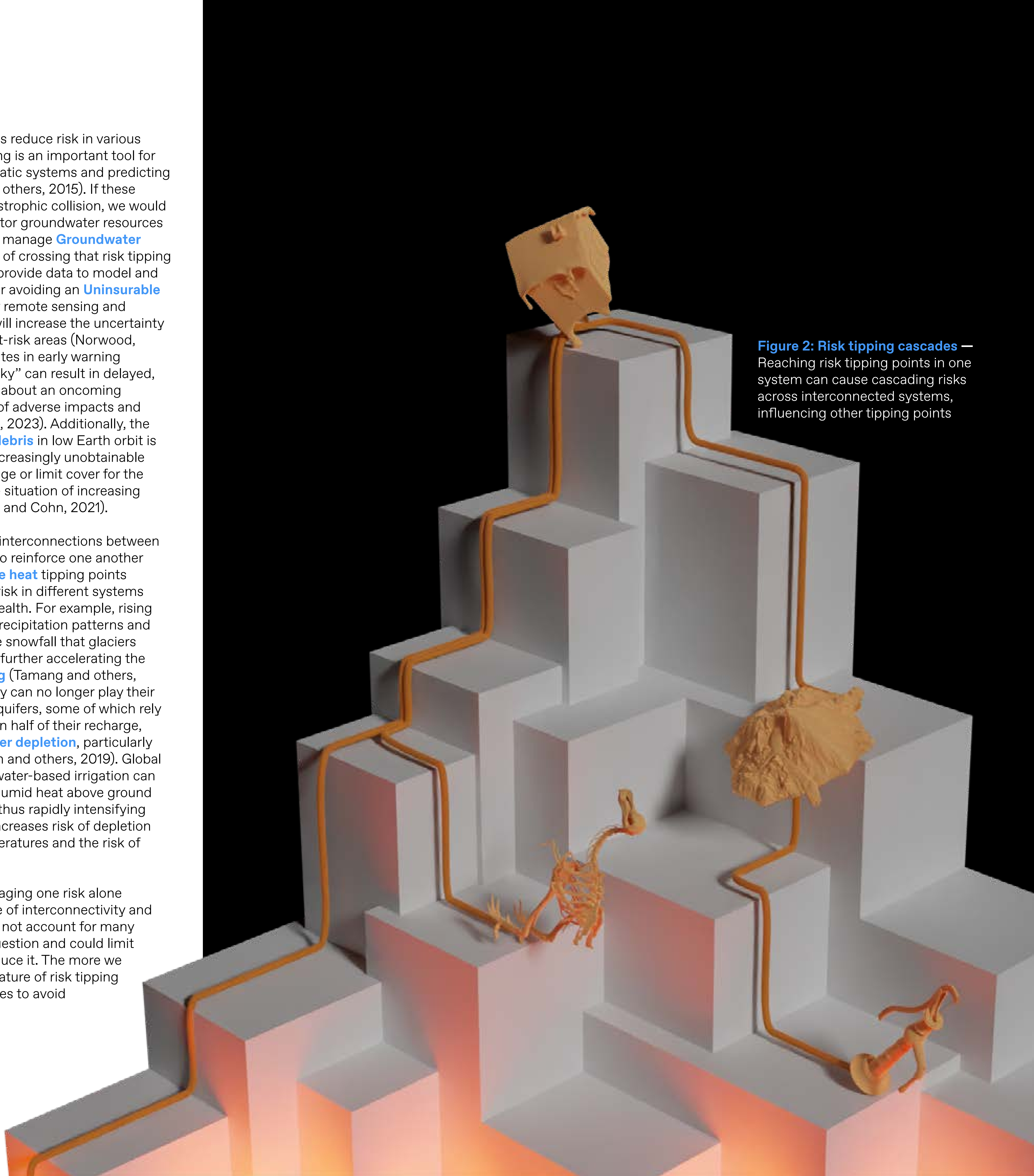


Figure 2: Risk tipping cascades — Reaching risk tipping points in one system can cause cascading risks across interconnected systems, influencing other tipping points

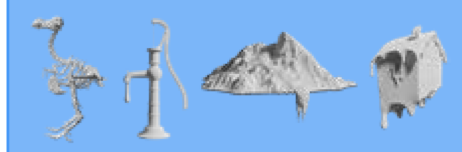
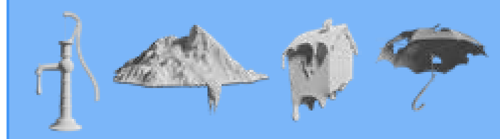
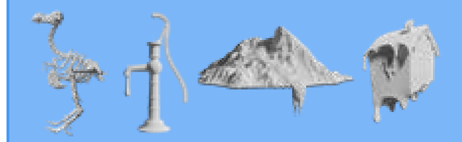
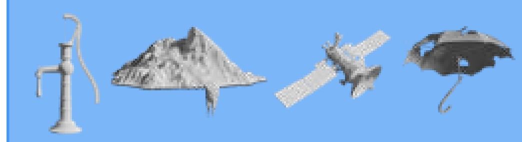
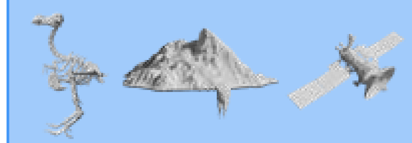
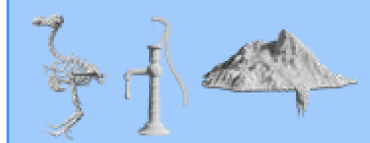
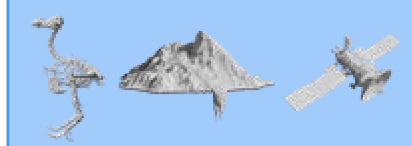
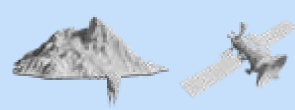
Section 4.2

Where are we headed? Current and future impacts

The underlying factors discussed in the previous chapter have put us on a trajectory towards a riskier future. Like a boat on a river, we are being carried by the current of **root causes** and **drivers** past the tipping point into a future fraught with danger and the potential for severe impacts for people and the planet. Many of these risk tipping points have not been crossed yet, and the future is still uncertain. For example, the risk of runaway or cascading collisions from increased **Space debris** has not materialized and turned to impacts at the time of writing. However, models and research suggest the risk of this occurring in the future is very high, and how soon it happens depends on our actions now and in the next few years (Kessler, 2000; ESA, 2023a). Unfortunately, for some of the risk tipping points analysed in this report, many places have already crossed the tipping point and are facing a riskier future. They can illuminate how the future could look in other parts of the world in which we have not crossed the tipping point yet. For example, as of 2017, peak water has already passed for around 45 per cent of **Mountain glacier** basins worldwide (Huss and Hock, 2018). The tropical Andes are a particularly affected region, as more than 80 per cent of glaciers have passed peak water as of 2019 (McDowell and others, 2022). This means that many of the impacts we see in the tropical Andes, such as water insecurity, livelihood loss, ecosystem damage, migration or displacement and cultural heritage loss, may also be felt in other communities as they reach peak water in the future.

> "We are a profoundly interconnected species, as the global economic and ecological crises reveal in vivid and frightening detail. We must embrace the simple fact that we are dependent on and accountable to one another."
>
> — Parker Palmer

A local resident inspects a damaged house in the Blue Mountains, Australia, in December 2002. Cooler conditions have helped firefighters contain more than 70 fires which have destroyed 48 homes in the areas surrounding Sydney. © William West / AFP

Table 3	Shared impacts 2023	Shared tipping points
(4/6)	**Livelihood loss**	
(4/6)	**Migration/displacement**	
(4/6)	**Ecosystem damage and biodiversity loss**	
(4/6)	**Loss of safety**	
(3/6)	**Loss of opportunities**	
(3/6)	**Food and water insecurity**	
(3/6)	**Cultural heritage loss**	
(2/6)	**Infrastructure damage**	

Several risk tipping points are interconnected through similar impacts, both potential and already occurring, as shown in **Table 3**. Reaching a tipping point in relation to **Unbearable heat** could result in migration or displacement out of that area (Chazalnoël and others, 2017). Similarly, migration or displacement can occur as a consequence of **Groundwater depletion** and **Mountain glaciers melting**, as people also lose livelihoods or water security (Fishman and others, 2013; Raoul, 2015). Additionally, people may move if their home becomes **Uninsurable**, as they look for a new place with more peace of mind (Siders, 2019).

A common thread emerging from the analysis of risk tipping points and their cascading risks is the progressive loss of safety nets, or the tools we have at our disposal to help buffer our vulnerability or help us to bounce back after various system shocks and extreme events. Each of the systems subject to our six risk tipping points supports functions critical for reducing risk. When we reach risk tipping points, that system ceases to function as expected. In many cases, not only do we lose the direct functions of the system, but we also lose diversity or redundancy in systems that are able to provide a certain service, reducing the resilience of our entire society (UNDRR, 2023).

For instance, we partially rely on satellite infrastructure for disaster early warning systems. If we were to reach a **Space debris** risk tipping point, these services would be unavailable, leaving us to only rely on terrestrial early warning systems. This would significantly increase risk in places with fewer ground-based systems, such as the Southern hemisphere (Undseth and others, 2020), or with limited reach, especially in rural communities (Venkatesan and others, 2020). Having a more diverse set of options usually means more resilience to shocks, as there is usually an alternative to fall back on if a certain tool fails (Narvaez and others, 2022). This is the main reason why **Accelerating extinctions** are so devastating; as we lose more and more strongly connected species, the other species relying on them lose available options. For instance, the green-backed firecrown hummingbird (*Sephanoides sephanoides*) collects nectar from and pollinates 20 per cent of local plant species in the Patagonian grasslands, many of which have evolved to be pollinated solely by this specific hummingbird. This means that without the green-backed firecrown, many Patagonian habitats would collapse, since no other pollinator has adapted to pollinate these plants (Medel and others, 2022; National Geographic, 2023).

In some cases, we rely on only one element to provide the necessary system functions, without enhancing other available options. For example, groundwater is often used as a backup water source when surface water is unavailable during dry seasons or droughts (Taylor and Shamsudduha, 2022). Therefore, **Groundwater depletion** decreases the reliability of a backup water source, minimizing the amount of water available for the irrigated agriculture system. Similarly, as we approach an **Uninsurable future** tipping point, the increasing cost of damages is more than what insurance is able to cover alone. Without having other risk reduction or transfer mechanisms in place, insurance is likely to fail and leave people to bear the full brunt of the impacts on their own (Irfan, 2023).

Not only are we catastrophically impacting our socioecological systems today, but we are also markedly darkening our future and closing windows of opportunities. The loss and destruction of shared resources through **Groundwater depletion** and **Mountain glaciers melting** will leave little for future generations to benefit from (Rodella and others, 2023). Ever-warming global temperatures only increase the chances that future societies will contend with even higher levels of **Unbearable heat**. These impacts will resonate through time, but in addition to the impacts we know could occur, there is so much more we do not know — and we are losing the opportunity to explore those possibilities. For example, with increased activity in space, we have incredible opportunities to observe the universe and our place in it. We can learn about our neighbouring planets or far-away galaxies and hypothesize about the beginning and end of time. The knowledge we have generated so far is profound, but the possibilities of what we could learn in the future are beyond imagination. If we reach a tipping point of **Space debris** and our orbits become unusable, we will lose not only the opportunities to continue using existing infrastructure, such as the Hubble telescope or the International Space Station, but also any potential to send any replacements (Primack and Abrams, 2023). Something similar can be said for **Accelerating extinctions**: for every described species that goes extinct, roughly another four extinctions are estimated to happen that may go undiscovered (van Dooren, 2022). As such, many species may go extinct before we have the opportunity to study them, many of which could yield important instrumental benefits for humanity, including discoveries in medicine, evolutionary history or biology (Laurance and Edwards, 2011; Fischer and others, 2016).

The impacts described in this section are not only significant but also far-reaching. They affect not just our current systems, but also the very fabric of our society and the well-being of future generations. It is crucial to recognize that the consequences we face are avoidable, but only if we act with urgency. As human beings, we have a unique advantage of being able to see the risk tipping points ahead of us. This advantage provides us with the opportunity to make informed decisions and take decisive actions to avert the worst of these impacts, and perhaps even forge a new path towards a bright, sustainable and equitable future.

A man looks for belongings through the ashes of his family's home in the aftermath of a wildfire in Lahaina, western Maui, Hawaii, in August 2023. © Patrick T. Fallon / AFP

Chapter 5

The future we want to create

> "For better or for worse, our future is now closely tied to human creativity. The result will be determined in large part by our dreams and by the struggle to make them real."
>
> — Mihaly Csikszentmihalyi

In the previous chapter, we get a glimpse of what our future might look like if we allow current systems to progress on the trajectories they are on. By anticipating tipping points where the system will cease to function as known, we can adjust the way the system functions accordingly or modify our expectations of what the system can deliver. In each case, however, avoiding the risk tipping point will require more than a single solution. We will need to integrate actions across sectors in unprecedented ways to address the complex set of root causes and drivers of risk and promote changes in established mindsets. To go even further, if we want to change our trajectory away from a future of multiplying and cascading risks, we must move towards transforming our systems altogether for them to become more sustainable. We can act now to create the future we want.

In looking at solutions that can help us avoid risk tipping points, there are a few questions to consider: Is a solution targeting root causes and drivers of risk to **avoid** negative system changes or targeting **adaptation** to those changes? Is a solution working within the existing "business as usual" system, or driving a fundamental re-imagining of the system itself? Answering these questions is critical for understanding if and how different solutions move us towards certain goals to reduce risk, and what kind of outcomes we can expect by selecting different options, including potential negative consequences and trade-offs. Concordantly, when looking at solutions to address risk tipping points, we developed a framework to navigate these questions.

This framework, called **ADAT2**, classifies solutions into four categories:

1. **Avoid-Delay (AD)**
2. **Avoid-Transform (AT)**
3. **Adapt-Delay (AD)**
4. **Adapt-Transform (AT)**

While **Avoid** actions focus on changing the current system in ways that can help us to avoid crossing the risk tipping point altogether, **Adapt** actions focus on reducing exposure and vulnerability to oncoming impacts of a risk tipping point being crossed and on preparing for living sustainably with the changed system. Within each of these two categories, **Delay** actions can push back against drivers of risk to help slow down our progression towards risk tipping points so that reaching them is delayed (**Avoid-Delay**), or the worst impacts we are at risk of experiencing are delayed after crossing them (**Adapt-Delay**). Neither case removes the system's flaws and vulnerabilities that are driving underlying risk. **Transform** actions, meanwhile, recognize and address the underlying root causes and drivers of risk in the current state of the system and promote transformative shifts in both its structure and the mindsets and behaviours that underpin it by rethinking and reimagining how we operate. These solutions can either prevent crossing the tipping point completely (**Avoid-Transform**), or can facilitate transformative change to provide new options such that impacts can be avoided, "softened" or reversed once the tipping point is crossed (**Adapt-Transform**). Transformative solutions, however, require a greater scale of societal and personal change.

Ideally, the choice of actions we take should be embedded in written or unwritten societal agreements and goals that influence what level of risk is tolerable and acceptable, and what level of effort is taken to avoid crossing the limits of intolerable risk. Using this framework, we can clarify which solutions are best suited to reach the desired goals identified on different levels of society, from local to global. Most of the solutions implemented currently focus on **Delay** rather than **Transform**, although increasing focus is being put on transformative change to achieve global goals on transitioning to a more sustainable future (IPBES, 2019; IPCC, 2023). To get there, first we need to understand the difference between adapting to risk tipping points and avoiding them, and between actions that delay looming risks and those that move us towards transformation.

A woman uses an umbrella during a hot afternoon in New Delhi, India, in May 2022.
© Money Sharma / AFP

Avoid

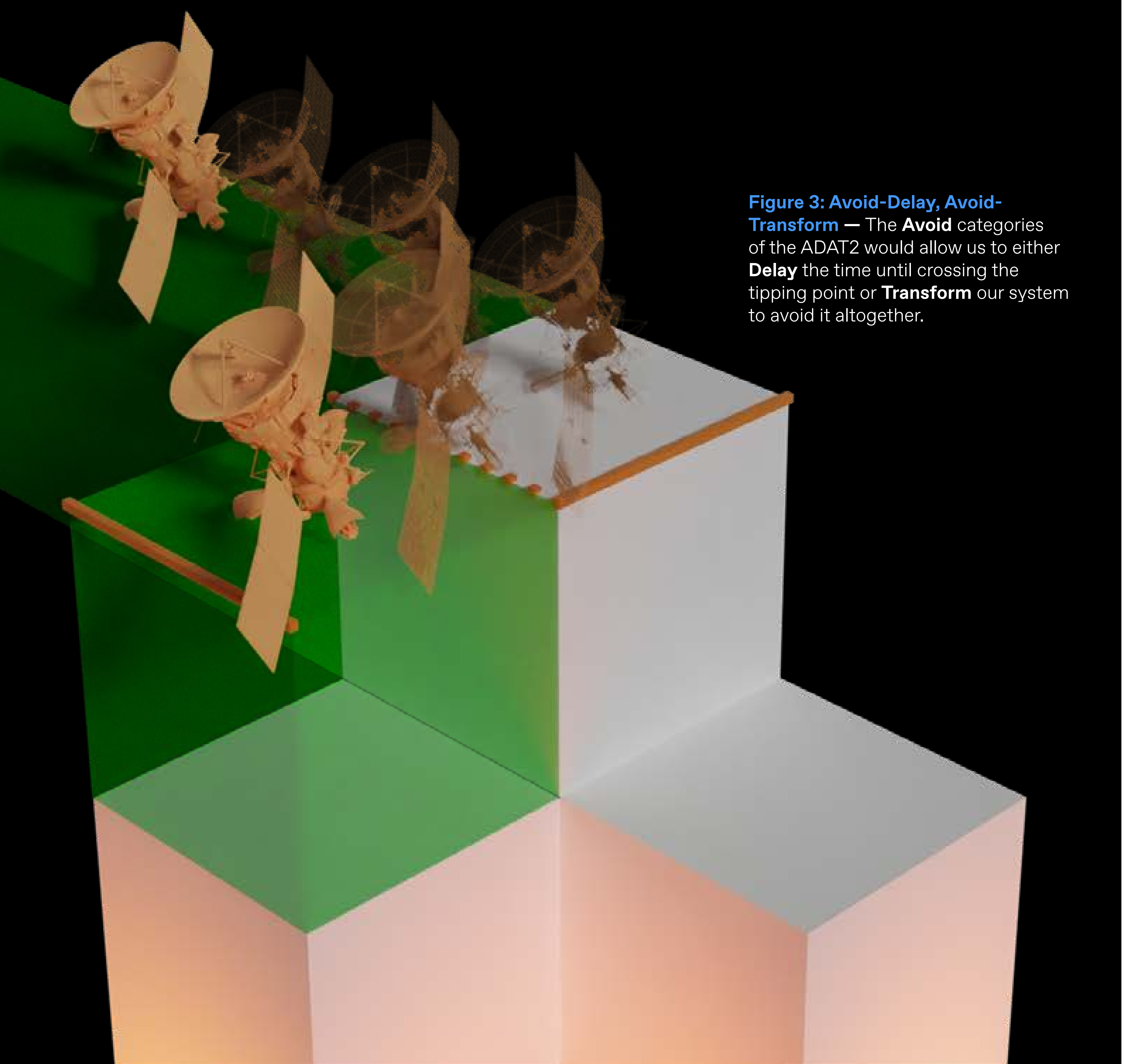


Figure 3: Avoid-Delay, Avoid-Transform — The **Avoid** categories of the ADAT2 would allow us to either **Delay** the time until crossing the tipping point or **Transform** our system to avoid it altogether.

Ideally, we would aim to avoid reaching risk tipping points by changing the way we interact with the system. For example, our trajectory towards **Groundwater depletion** is driven mainly by the fact that we are extracting water from aquifers at a much faster rate than they can be recharged. To restore this equilibrium and to ensure that the water table is still accessible for our irrigation infrastructure, we would need to change the way we use groundwater to minimize the amount of water we extract while maximizing the amount of water that can filter down to recharge the aquifer. Solutions can include stronger regulations for sustainable water usage, more efficient irrigation techniques, or creating natural or artificial recharge areas (Aeschbach-Hertig and Gleeson, 2012). This type of solution keeps us from reaching a tipping point (**Figure 3**), but whether this is temporary or permanent depends on how fundamental the intervention is or how much we reimagine the system. If we operate at the surface level by finding fixes for certain problems while keeping the underlying system the same, we may only delay reaching the oncoming risk tipping point.

To ensure we avoid the tipping point altogether, we need to be able to holistically address the **root causes** and **drivers** that have brought our systems to the brink in the first place; this is the first step to reimagining our systems in a more transformative manner (see Chapter 5.2). To prevent an **Uninsurable future** for example, the traditional approach has been a system of government programmes and subsidies to help maintain affordability in some cases. However, this approach is increasingly under pressure as the necessity of this "last resort" option is quickly becoming more common and cannot solve the problem alone since it does not address the root causes. One of the main issues that we are facing is an increase in the frequency and severity of extreme weather events that is making previously unexpected and infrequent occurrences increasingly common, overwhelming the capacity of what insurance can cover (Surminski and others, 2016). More transformative action that focuses on addressing this growing underlying risk not only involves reducing our greenhouse gas emissions, but also rethinking our approaches to planning climate-proof housing, settlements and cities to cope with extreme events, while reducing socioeconomic vulnerabilities to boost coping capacity. In other words, we need to address the underlying risks that cause disasters to develop in the first place, and only then can we ensure that insurance can remain a valuable risk transfer mechanism for all in the future.

Adapt

In some cases, trying to avoid crossing the tipping point is no longer realistic, due to the existing processes in motion that are driving the systems to the brink. In these cases, we need to prepare to adapt our systems or change our expectations of what the system can provide. For example, mitigating our greenhouse gas emissions is the only way to reverse the trend towards some risk tipping points, but this will not be enough to stop the impacts arising as a result of our historic emissions to date (Hausfather, 2021). Even if we are to limit our planetary warming to 1.5°C above pre-industrial levels, the world is predicted to lose more than half of its glaciers by 2100 (Rounce and others, 2023). Given that we have already hit 1.1°C as of 2020 and are on track to exceed 1.5°C during the twenty-first century (IPCC, 2023), it is inevitable that most **Mountain glaciers** will pass the tipping point within this century (Rounce and others, 2023). The same is true for **Unbearable heat**, as even with drastic reductions in greenhouse gas emissions, by 2100, almost half of the world's population could be exposed to life-threatening climatic conditions for at least 20 days per year (Mora and others, 2017). Though a deep, rapid and sustained reduction of our greenhouse gas emissions is imperative to prevent even worse impacts from occurring in the future, crossing these risk tipping points is already an inevitability in some places. This means we need solutions to adapt to them now. Additionally, risk tipping points have already been crossed in some places, and the people that still rely on these systems need options to not only survive but thrive in the new conditions. For example, most of Saudi Arabia and some areas in the High Plains aquifer in the United States or the Indo-Gangetic basin in India have already passed the **Groundwater depletion** tipping point, as some people are unable to consistently access the water stored in the aquifer given the current depth of the water table and existing wells (Parker, 2016; Kajal, 2022). There are still actions we can take to reduce risk, even if the system has passed the tipping point (**Figure 4**). However, just as with the solutions to avoid the tipping point, how effective the solutions are at preventing the worst impacts depends on how deep the interventions can go. If we operate only superficially, keeping the underlying systems the same, we may only prevent or delay some of the impacts and could be faced with another system-wide tipping point in the future. For example, designating protected areas for biodiversity can help prevent **Accelerating extinctions**, but it does not actively manage the external pressures threatening species, such as pollution flows or illegal poaching, and the societal drivers that enable them (O'Connor and others, 2022).
To be able to truly adapt to the impacts of a tipping point altogether, we have to address the **root causes** and **drivers** that drove us over the tipping point in the first place — to reimagine our systems in a more holistic way and avoid making the same mistakes in the future (see Chapter 5.2). We must change our expectations and adapt to the new, riskier state of the system. For **Mountain glaciers melting**, this could include changing our expectations of water availability from the mountains and finding alternative, reliable sources of water or less water-dependent livelihoods (Cullen, 2018). For **Unbearable heat**, we might need to shift the way we work and live to avoid the hottest parts of the day or year (Gale, 2023).

In some cases, we can try to avoid the tipping point while implementing adaptation measures as a precaution. For **Space debris**, we can limit the number of satellites we launch and clean up existing debris, while also investing in collision avoidance systems and boosting our terrestrial infrastructure (Undseth and others, 2020). In some cases, such as **Accelerating extinctions**, avoiding the tipping point is the only option we have to save ourselves in the long term. We are part of the ecosystem, so as one species after another goes extinct, it is only a matter of time before humans are next. We will have to protect other species, restore and conserve their habitats and work with the natural system rather than against it to protect the human species and our overall well-being (Crist and others, 2021).

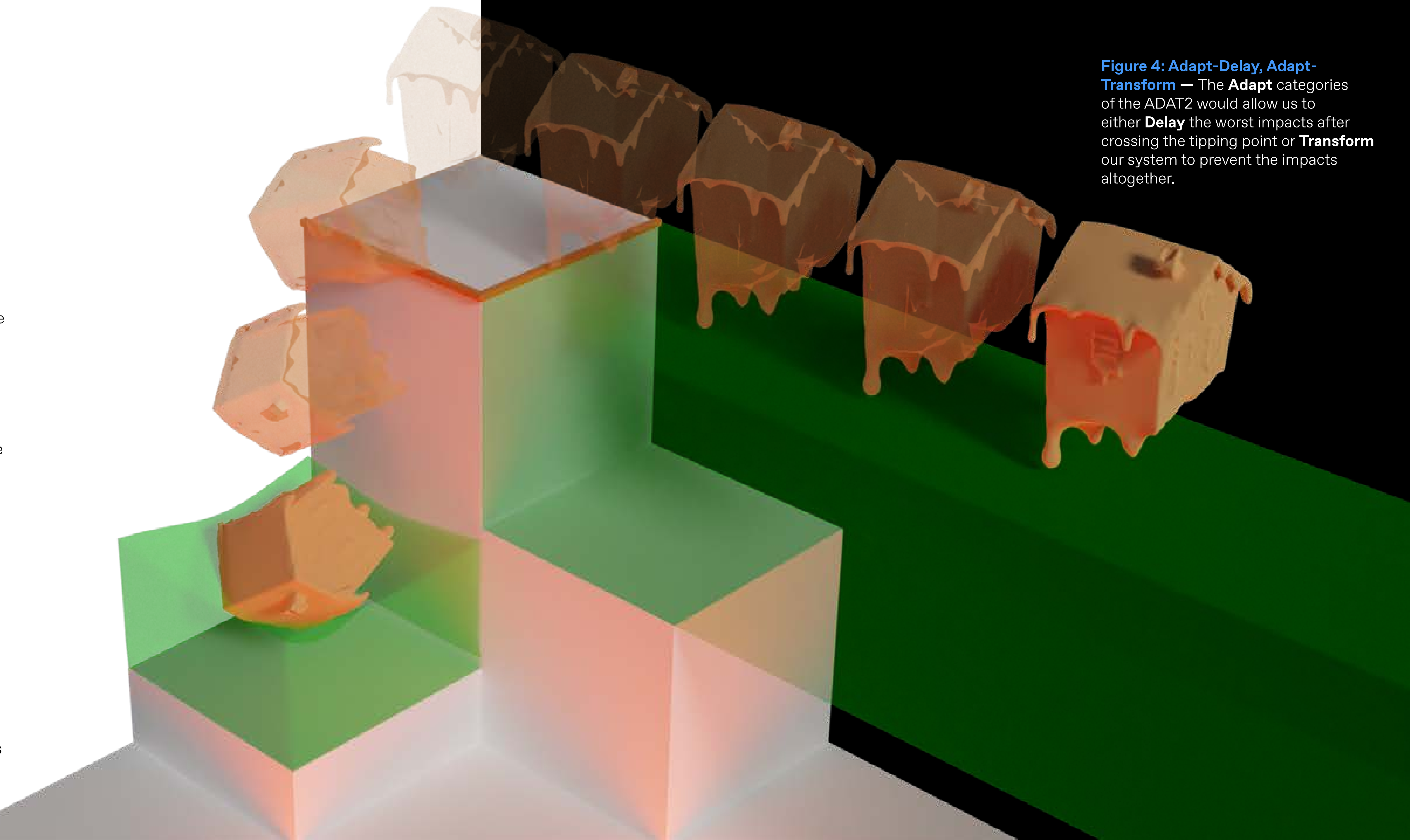


Figure 4: Adapt-Delay, Adapt-Transform — The **Adapt** categories of the ADAT2 would allow us to either **Delay** the worst impacts after crossing the tipping point or **Transform** our system to prevent the impacts altogether.

From Delay to Transform

Many solutions we choose to implement are beneficial in the short term, to **Delay** ourselves from reaching the tipping point or to delay the worst impacts that occur after passing it. However, they do not address the underlying problem and can create unintended consequences and new risk tipping points to contend with. For example, introducing air conditioning to places exposed to **Unbearable heat** would initially ease the problem for those who can afford it, but introduces new strains on energy supply and creates additional greenhouse gas emissions that will only make the heat problem worse in the long-term. Also, air conditioning becomes a critical infrastructure of which failure would lead to life-threatening situations. Thus, air conditioning can help to cope with the impacts, but there will be resulting trade-offs and dependencies on the technology. Additionally, it will not help us to fundamentally change the system, since it does not address the underlying factors that are driving heat risk in the first place. Instead, solutions should look at the interconnected problem of **Unbearable heat** as a whole, and find solutions that can balance the benefits and trade-offs. Transformative change would take this further by redesigning our system with this interconnectivity in mind, such as redesigning a city into a place full of green spaces, sustainable energy and water systems and equitable access to them all.

Similarly, one solution alone will not be enough; rather, it is one piece of a larger puzzle that must all fit together to make a positive and lasting difference. We must look at the problem from all angles and implement **solution packages** targeting social, economic, governmental and environmental aspects, as all of these systems are interconnected and influence each other (UNU-EHS, 2022). With these solution packages, we can take advantage of the interconnectedness of our various socioecological systems to also provide co-benefits to address multiple tipping points at once. For example, restoring wetland ecosystems in certain areas could provide natural recharge zones to combat **Groundwater depletion** and serve as water storage areas as **Mountain glaciers melt**, while also re-establishing habitats for certain species to prevent **Accelerating extinctions** (Conlisk and others, 2022). As long as we are able to think about our interconnected world as a whole, one solution can address multiple problems at once, rippling through our socioecological systems with cascading benefits (UNU-EHS, 2022). As such, these solution packages help to address risk tipping points in a more holistic way and can help us to change the system in such a way that risk tipping points are avoided. Solution packages may also lead to transformative change if the changes implemented in many parts of the system address the root causes and drivers, and lead to an overall shift and system change.

However, the desired transformation does not happen by chance but rather by design and deliberate effort. Those solutions that do not address the underlying factors of the risk tipping points can only take us so far. Like paddling up a river, these solutions will face relentless pressure, meaning we must work constantly, maintaining and adjusting strategies to keep up with the current. The slightest change can put us at risk of our capacities being overwhelmed, pushing us into an even riskier future despite our best efforts. These strategies can fail because we place the system itself as the object of observation rather than looking at the behaviours and values that underpin it. If we focus only on the ways in which the system is not working, all issues are regarded merely as a technical problem that can be addressed with technical solutions (Pelling, 2010). For example, if we look at the problem of **Space debris** as solely an issue of increasing pollution in orbit, then our solutions will focus on practical means to clean it up. The presence of debris is a fact of the world, and we will need to keep up with the rate of change, until our capacity to clean up the debris becomes overwhelmed and the risk tipping point is reached anyway. However, if we can look deeper at the root causes of why the debris is there in the first place, for example, *Global demand pressures* or *Insufficient risk management* (see Chapter 4.1), then we can see how the pollution of our orbit is part of wider societal processes. As such, the solutions to address the problem are more fundamental (Pelling, 2010). We need to reimagine our socioecological systems to create truly sustainable, resilient and equitable systems that work for people and the planet in the long term.

Transformative change can happen in several ways, across many different dimensions. While tangible actions that are readily visible tend to attract the most attention, they are only one part of the story. For tangible transformations to occur, they must be supported by transformations in larger societal structures and cultural norms. These transformations are essential because they redefine the boundaries of what is achievable within a society (O'Brien and Sygna, 2013). Since our societies, systems and structures are ultimately composed of individuals, the success of these transformations also depends on changes happening within the hearts and minds of people who constitute the collective society. This internal transformation leads to shifts in thoughts and values, which, in turn, influence how individuals perceive and interact with the world. As a consequence, this can shift our priorities, how we frame certain issues and which questions we ask or overlook (O'Brien and Sygna, 2013). For genuine and effective transformation to take place, it is crucial to address all of these dimensions in an interconnected way. Simply making practical changes without considering the personal values of the people involved may lead to reluctance or even conflicts, resulting in a lack of understanding or motivation to fully embrace a proposed solution. For example, we can work to restore a species' habitat to delay **Accelerating extinctions**, but if the collective values of society do not align with this action, then the intervention lacks support and would eventually be abandoned or undermined by contrasting actions. Conversely, focusing solely on changing hearts and minds may result in abstract ideals that cannot be translated into practical actions. Similarly, talking about the importance of biodiversity to curb **Accelerating extinctions** is key, although it would not mean anything unless it can filter down into actionable methods to protect species. The interconnectivity and interactions between the two determine the boundaries of what is possible in our systems and structures, facilitating the possibility of achieving significant, large-scale transformations.

Adopting this interconnected thinking does not only apply to these different dimensions of change, but also to different sectors and levels of society. The **solution package** approach not only involves different types of actions, but also many actors from different parts of society, working together to address a particular problem. Having such diverse ideas and approaches from a range of backgrounds and cultures gives us more opportunities to discover actions, behaviours and values that we had previously not considered possible, or to rediscover those which had been formerly used but discarded along the way. Different levels of society will be able to provide different elements and scales of change, according to their responsibility and capacity to do so. For example, it is easier for those in positions of power or privilege to undertake transformative actions at scale, especially actions that disrupt the system. However, challenging the system and calling out for change often comes from civil society or youth demanding change. A government official can more easily influence policies and their implementation than a regular citizen, and people with a wealth of time and resources can more easily spend them on desired outcomes. However, each individual action can serve as an important building block for a desired transformation, and every effort helps (**Figure 5**). Indeed, transformation is often triggered by changes starting in scales driven by niche innovations (Geels and Schot, 2007). Importantly, the power of setting a positive example to influence decisive action should not be undervalued (see Chapter 5.2). By moving from isolated, individual solutions to interconnected, collective solutions, we can build the pathway from **Delay** actions towards the **Transform** actions and mindsets we need to reduce risks for a better future.

In itself, a transformation is a regime shift that takes the state of the system now and fundamentally changes it to something new and, hopefully, improved. Transforming our systems will not be easy. This change can seem daunting and intimidating, particularly when charging into uncharted territory and experimenting with new and untried systems and structures. However, sticking to the status quo and remaining in our comfort zone is driving us perilously close to reaching risk tipping points on multiple fronts. To tackle this, we must imagine a better world and have faith in our ability to create it, then make every action count towards building it together.

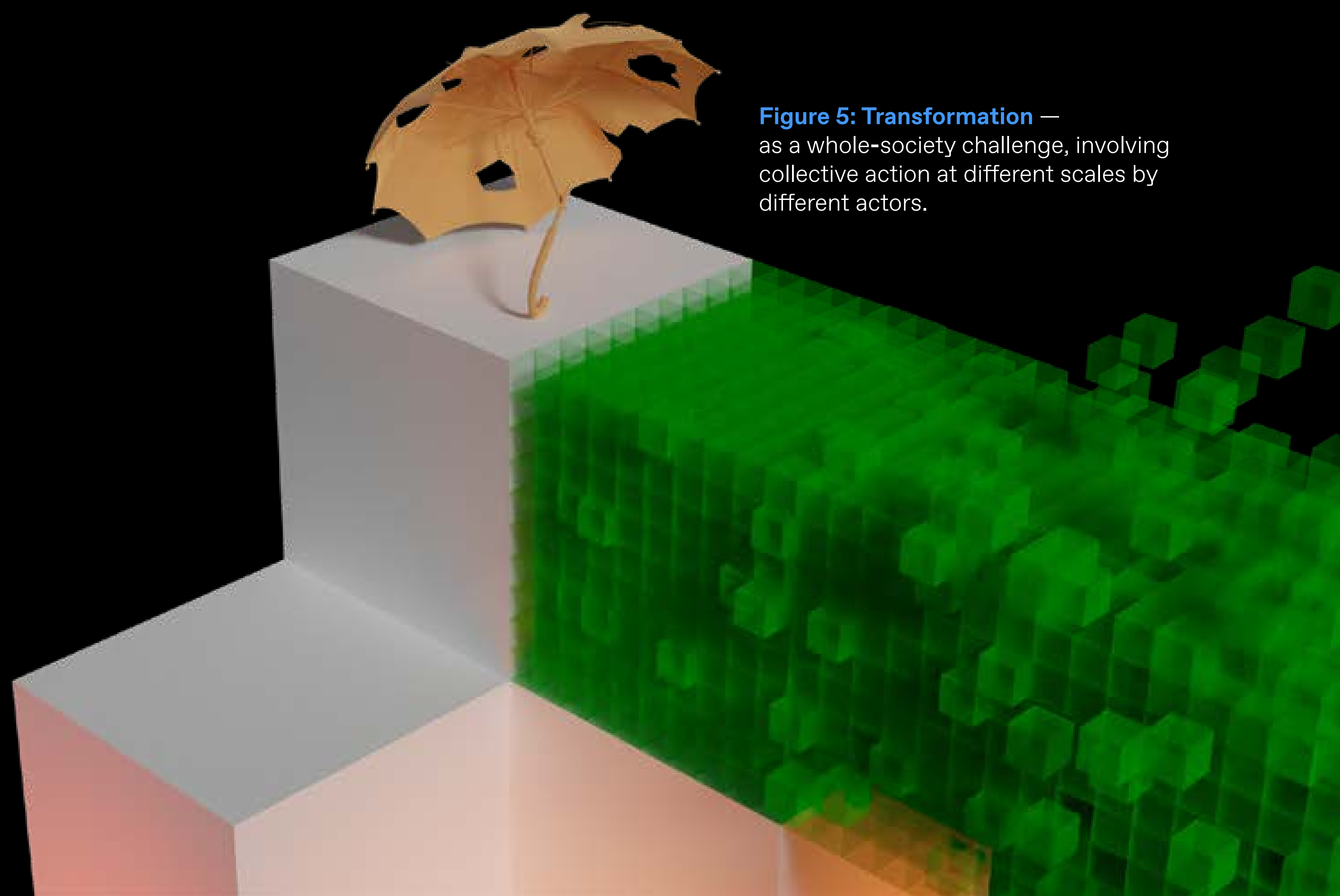


Figure 5: Transformation — as a whole-society challenge, involving collective action at different scales by different actors.

Workers do their part to reduce waste by reusing boots as planters at the Selayur Jaya Reduce, Reuse, Reduce (TPS 3R) Waste Disposal Site, in 2022.
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Section 5.1

How we can get there: Five changes we need to make

In this section, we outline five important changes we need to make to build towards a more sustainable, just and equitable future. These suggestions build on our analysis of root causes and drivers among the six risk tipping point cases as well as the common threads among the different solutions to address them. As such, they are targeted towards the transformation, both at a personal and societal level, leading us to reorganize our personal and collective thoughts, behaviours and values towards transformative change that can be applied to each of our risk tipping points, showing where practical transformation is possible (see **technical reports**). This is by no means an exhaustive list; instead, they represent the needed transformations necessary to counteract the underlying root causes and drivers pushing our systems to the brink. A greater personal and collective adoption of these values and behaviours opens more doors to what is possible, giving us new paths to explore and options to pursue.

> "Change is coming anyway. So I'd like it to be by design and not by disaster."
>
> — Maja Göpel

1. Creating a world without waste

Our systems of production for the things we all use every day operate linearly like a conveyor belt, producing significant waste. Once a product is used and no longer useful, it becomes "waste" to be disposed of, while new resources are tapped to create new products. This approach shows a lack of appreciation for the energy and time invested in these resources, as the system is designed against sustainability by favouring single-use items and planned obsolescence (Bocken and Short, 2021). However, because nature is not linear, this model disrupts the natural flow of energy and materials. To address this issue, we must adopt a circular model that recognizes the intrinsic value of all materials and be innovative about how we use them, effectively eliminating waste from the system. A circular model prioritizes efficient, renewable resources and respects the natural cycles of Earth systems (Ellen MacArthur Foundation, 2015). It involves valuing resources beyond human-use value and respecting all living and non-living things in their own right. Importantly, just because the dominant systems on our planet do not follow this model, it does not mean that this concept is untried. Respect for non-human things has a history in many cultures worldwide, notably in traditions of animism that ascribe spiritual essence and consciousness to objects, places and species. By recognizing the intrinsic value in other living and non-living things, the concept of "waste" will not exist.

Transforming towards circular thinking could revamp our systems that are currently at risk from the linear model. As resources become increasingly scarce, many risk tipping points could be avoided if we create a world without waste. For example, **Space debris** is primarily a waste issue, as satellites with predetermined lifespans are placed in "graveyard orbits" or discarded back to Earth's atmosphere or oceans (Werner, 2018; Boag, 2019). Imagine a world in which satellites and the resources used to make them were valued beyond their initial function. We would design them to last as long as they could, and have plans to repair them if they were broken or bring them home if we could not. We would appreciate the material and energy used to produce them, as well as the service they provided, and reuse or recycle their components to give them new life, starting the cycle over again. Similarly, approaching both **Groundwater depletion** and **Mountain glaciers melting** risk tipping points forces us to address irresponsible water waste. Climate change and human activities put incredible strain on our water resources, as we take, use and waste water resources without respect for the water cycle. Instead, we can choose to adapt our society and ourselves to build a world in which we decrease our overall water use, optimize use of the water we do use and retain or protect the water not currently in use (Morseletto and others, 2022). In essence, we need to change the way we value water from something inexhaustible and disposable into something precious and essential for life, which it is. By using water more efficiently and taking only what is necessary, we can ensure that anything we withdraw is replenished or restored to a better state than before. The linear model also puts us at risk of **Accelerating extinctions**, as more than 90 per cent of biodiversity loss occurs from the extraction and processing of natural resources (IRP, 2019). This includes habitat loss from clearing land for agriculture, industrial pollutants in our air and water, and overhunting or harvesting the species themselves (Ellen MacArthur Foundation, 2021) Here, even our words matter. Using words like "fish stocks" represents how we currently value fish. A *stock* of tuna, for example, identifies the animals as commodified objects rather than as individual subjects entitled to partake in the web of life. The logic of extractive use of resources renders fish as assets for possession and trade (Telesca, 2017). Instead of continuing this trend, we could stop viewing the living and non-living beings in our world as resources, and start viewing them as partners and gifts based on mutual respect and reciprocity like many indigenous peoples do. We would not own the land or the forest, the wheat or the timber. Rather, we would enter into a partnership with the land, the forest and their inhabitants, for the use of their space, ensuring that we impact them as little as possible and give it back to them in a better condition than we found it.

2. Being one with nature

Humanity's way to interact with nature stems from a mindset of dominance and separation. We clear-cut forests, bulldoze mountains, channelize rivers and change the climate, declaring human interest more important than the needs of the rest of the planet as we push nature out or subjugate it for our own use (Weston, 2022). Many human cultures regard humans as separate from nature, and therefore, separate all natural processes from human-made areas. The English language, for example, is not even in the position to express such oneness with nature, which is why we talk about a human-nature relationship. With these actions, we are sabotaging not only the planet, but also ourselves as a consequence. For example, in many areas, rainfall is naturally absorbed into the soil and stored in groundwater, while the rest runs off the land into streams and rivers. When these watersheds become urbanized, we cover the space in impermeable surfaces, such as concrete or asphalt, which disrupt the natural infiltration when it rains. Water is unable to be absorbed into the soil and recharge the aquifers, exacerbating the issue of **Groundwater depletion**. This also causes water run-off to occur more quickly, increasing the frequency and severity of flood hazards (USGS, 2018), exacerbating the issue of **Uninsurable futures**, making damages more likely and costly. Surface sealing also contributes to **Unbearable heat** as the built infrastructure absorbs and retains heat while the reduced green space does not provide shade and limits the amount of evapotranspiration, resulting in cities that are warmer than the surrounding environment (Chapman and others, 2017). Additionally, the separation of humans and nature leads to the exclusion, exploitation and detriment of various species on the planet, resulting in **Accelerating extinctions**. Habitat destruction and climate change push wild species out of their homes as we delineate conservation areas where they are allowed to exist. The rest of the planet is seen as belonging to humans, to take, alter, pollute or destroy as we please. Indeed, even describing the world in terms of "natural resources" supports an assumption that Earth is subject to human ownership (Crist and others, 2021). This only serves to drive our own risk, as this mindset ignores the idea that humans are a species that depends on other species to exist, for the air we breathe, the food we eat and the water we drink. There cannot be separate spaces for humans and nature, because humans *are* part of nature.

A paradigm shift is needed towards respecting the needs and well-being of nature as a global-scale system of interconnected pieces, of which, we as humans are just one. In addition to using resources more respectfully, as outlined in the previous section, we can combat climate change to prevent further detrimental impacts on ecosystems and simultaneously restore natural processes that we are currently disrupting. Rewilding is one such approach, bringing ecosystems altered by human activities back to their "wild" state, more closely in line with how they functioned before human intervention. This allows us to build conditions that support and embed human settlements in more resilient, complex ecosystems, giving humans the benefit of certain ecosystem services while giving space back to non-human entities to exist (Perino and others, 2019). We can create "sponge cities" full of permeable pavements and green spaces that absorb rainwater to prevent flooding and recharge groundwater, increase evapotranspiration to mitigate heat impacts and provide habitats for wild species to live and roam (Simon, 2022). We should designate human-use areas and constrain our overuse of space on the planet by default out of respect for the non-human inhabitants (Crist and others, 2021). We can move from a system of control and conflict to one of coexistence and cooperation with nature.

3. Cultivating a global neighbourhood

We have witnessed the remarkable power of global collaboration when the international community unites for a common purpose. An excellent example of this was during the 1970s when scientists discovered that chlorofluorocarbons were causing damage to Earth's ozone layer. In response, the world came together and devised the Montreal Protocol, a plan aimed at phasing out these ozone-depleting chemicals from production and consumption. The Montreal Protocol marked the first environmental treaty to be signed by all 198 United Nations member states with binding, time-targeted and measurable commitments. The interventions were successful, and it is expected that the ozone layer will fully recover by the middle of this century (WMO, 2022). No single actor, community or country can tackle this type of large-scale problem alone, making cooperation a necessity.

Although such success stories exist, the global community struggles often to reach or successfully implement global commitments. For example, countries have debated the need to combat climate change since the early 1990s and produced important accords, including the Kyoto Protocol and the Paris Agreement, to reduce greenhouse gas emissions. However, the amount of carbon dioxide in the atmosphere keeps rising, due to "broken climate promises", revealing a "yawning gap between climate pledges and reality" (Guterres, 2022). To achieve true transformative cooperation across the planet, global binding agreements and their implementation need to be based on a global civic

Sea otter in kelp forest, Glacier Bay National Park, Alaska. © Gerald Corsi / iStock mindset. We need to shift away from actions taken out of self-interest and towards actions based on common values (Derviş, 2020). Making this possible requires a foundation of trust and a common understanding of facts and risks, along with the ability to understand and empathize with other perspectives (Muggah, 2019).

Trust and binding agreements are critical to avoid increasing **Space debris**. Currently, satellite operators do not consistently share data on the number and characteristics of satellites in orbit, leading to inadequate knowledge for calculating collision risks (Undseth and others, 2020). Many actors are unwilling to release this data due to competition or national security concerns (Finkleman, 2017). Additionally, developing debris clean-up technology is limited because it could be interpreted as a potential "space weapon", so countries are reluctant to let others have that kind of power (Wall, 2021). Furthermore, national security and intellectual property rules limit the sharing of Earth-observation data gathered by satellites (Borowitz, 2017). This lack of cooperation, combined with a lack of binding agreements, not only hampers the global community's ability to tackle significant problems like climate change and disaster risk, but also could further contribute to an increase in the number of satellites in orbit, as each actor would need their own observation satellite to ensure reliable information.

Cooperation is also crucial to manage limited resources sustainably, as seen in the case of the tragedy of the unmanaged commons (see Chapter 4.1.2). To move away from a **Groundwater depletion** tipping point, we must establish a shared understanding of what constitutes the beneficial use and wasteful consumption of groundwater resources now and in the future, while ensuring efficient water use (Aiken, 1988), and not exceeding natural replenishment rates. Being on a finite planet means resources are already limited, and as we disrupt natural systems, we face scarcity and competition in meeting human needs. To address this, we need to restore natural cycles and foster a spirit of caring and sharing among our global community. This kind of change comes from shifting away from a competitive mindset that prioritizes individual gain and towards a recognition that the best path to a sustainable future is bringing benefits to all. As **Mountain glaciers melt**, we need to recognize the needs of people along the watershed, from source to sink, and make sure there is enough to go around for everyone, including those in downstream countries (Climate Diplomacy, 2023). Transboundary cooperation on water resources also helps to build trust, promote knowledge-sharing and enhance overall security (Shrestha and others, 2015). Similarly, countries need to make sure that their respective actions to adapt to climate change do not cause harm in other countries and do not constrain the adaptation options of others. This concerns not only the use of common resources, such as transboundary groundwater bodies, but also transboundary impacts of adaptation via global trade of food and virtual water embodied in products we trade. For example, citizens in wealthier nations consume more meat per capita, creating a wide array of environmental effects on less wealthy nations such as increasing greenhouse gas emissions, water use and biodiversity loss (Cumming and Cramon-Taubadel, 2018).

The discussion of transboundary cooperation and multilateral agreements may seem as though this shift in mindset can only be taken up by governments and international organizations. However, the truth is that the transformation needs to happen at all levels, including individuals showing trust, respect, empathy and compassion for others worldwide. For instance, during periods of **Unbearable heat**, we may need to adjust our expectations for services during the hottest parts of the day or year, considering the well-being of workers operating in those conditions. Enhancing neighbourhood support networks and social capital during extreme heat can significantly reduce health impacts (Wolf and others, 2010). Caring for and supporting those around us holds the power to bring about meaningful change in the world that reduces risks for all and saves lives.

A father imparts the invaluable lesson of environmental stewardship to his young daughter, teaching her to sow the seeds of a greener tomorrow.
© Nikki Sandino Victoriano / Transformative Urban Coalitions / UNU-EHS

4. Being a good ancestor

Future generations living on this planet are at the mercy of the choices we make today. As a result of our choices, entire populations of people could live their lives full of happiness or suffering, or could never live at all (Fenwick, 2023). This power of choice is great but as always, with great power comes great responsibility. As such, we, the people of today, have a moral responsibility to ensure that our actions better the lives of future generations. Again, this concept is not novel, but is present in many indigenous communities. For example, the Iroquois philosophy of the "Seventh Generation" dictates that each generation today is responsible for ensuring the survival of the seventh generation in the future (Clarkson and others, 1992). We can turn away from plundering the planet's resources for short-term gains, and rather interact with our world in a way that carefully considers a long-term future for our world (Slaughter, 1994). This can start with designing our systems with the recognition of potential future risks and acting out of precaution for negative impacts down the line rather than maximizing short-term gains over long-term losses (see Chapter 4.1.1). Planning for future conditions will help prevent an **Uninsurable future**, as it can make our communities more resilient through innovative and climate-ready urban design and nature-based solutions, reducing damages from future hazards (Shaw and others, 2007; Israeli and others, 2020). For example, in both the cases of **Mountain glaciers melting** and **Unbearable heat**, we have the reasonable foresight to see that our past and current greenhouse gas emissions will create unavoidable consequences in the future. Therefore, it is our responsibility to ourselves and generations in the future to build systems and cities to withstand and adapt to those future changes. This process needs to start now to minimize future suffering. We cannot wait until the impacts are on our doorstep before we choose to act. This also entails that present laws and political institutions need to ensure that future generations are not disadvantaged and do not suffer disproportionately from the impacts of today's decisions or inactions, which would push the burden of climate mitigation to future generations (Kotzé, 2021). Transforming to a mindset of intergenerational equity entails the adoption of certain principles already discussed but with a different perspective. For example, conserving natural and cultural resources can be done for the purpose of eliminating waste and strengthening our relationship with the natural environment, but should also be done with the intention of not restricting the options available to future generations. Halting **Groundwater depletion** will ensure that future generations are able to use aquifers to sustain their communities (Rodella and others, 2023). This concept of protecting future options and future freedom of choice not only relates to physical resources but also to opportunities for knowledge, learning, innovation and relationships. We can stop ourselves from reaching a **Space debris** tipping point to ensure that future generations can research and explore the cosmos freely and ensure that ancestral cultural traditions of the past, such as using stars for navigation or storytelling, can survive into the future (Venkatesan and others, 2020). Preventing **Accelerating extinctions** and preserving biodiversity will also help ensure humanity's access to critical ecosystem services and our survival on Earth (Raven and Wackernagel, 2020). Beyond this, preserving biodiversity enhances the future resilience of our ecosystems, as more diverse ecological communities are likely to be increasingly stable over time (Fischer and others, 2016; Wagg and others, 2022) so that they could provide more opportunities for new ecological relationships to be formed, expanding potential services and resilience for the world as a whole. Essentially, this transformation entails bringing in a consideration of being a good ancestor to future generations (Krznaric, 2021). It is an extension of the need to build community relationships not just across continents and oceans, but also across time and into the future.

5. Designing an economy of well-being

The global economy is currently based on the relentless pursuit of growth, so actors continuously increase production and consumption of resources at unsustainable rates. Humans use up ecological resources equivalent to 1.7 Earths (Lin and others, 2018), which is problematic considering we just have the one. If everyone on the planet lived like those in the United States or Australia, we would need four or five Earths to sustain such growth (Alexander, 2020). This means that many of us are living beyond our means and pushing the costs onto other beings, different places and future generations. For instance, economic growth and biodiversity loss are linked through the impacts of increased resource use (Otero and others, 2020). In fact, rapid economic development has been shown to push many species, especially large carnivores, to the brink of extinction (Johnson and others, 2023), increasing the risk of **Accelerating extinctions**.

The reality is that the prevailing growth-based economic model is destined to fail on a planet with finite resources. Eventually, we will reach its limits and the system will end (Görg and others, 2017; Alexander, 2020). For example, the Kingdom of Saudi Arabia used much of their **Groundwater** resources to grow wheat in the desert, taking out nearly 10 times more than could be recharged (Fienen and Arshad, 2016). As such, it is estimated that Saudi Arabia depleted over 80 per cent of their groundwater, prompting the government to announce that the 2016 wheat harvest would be their last (Plumer, 2015; Novo, 2019). However, this impending end can be met in two ways: either by disaster or by design. The preferred method would be to design and implement changes that take us away from the capitalist dictate of economic growth to limit the suffering of both society and the environment. We ultimately need to think of a different growth, replacing economic growth and the indicator of GDP to measure it. Instead, we need to build our idea of "growth" on advancing human and environmental well-being. For example, GDP accounts for the number of cars a country produces but ignores the negative impacts of their emissions on the environment and public health (Kapoor and Debroy, 2019). It fails to measure what we truly value — things such as happiness, security, community or the beauty of nature — which are truly priceless. They are intrinsic, intangible and incommensurable values that are unable to be captured by any economic indicator. Instead, we can decide to protect nature and implement nature-based solutions on a large scale, regardless of the economic costs involved, by taking a mission-oriented approach that unites society behind clear targets and a vision to transform our governance models, as well as decision pathways for large-scale positive changes (Sebesvari, 2022).

There has been an increasing desire to replace materialistic values centred on maximizing production and income with post-materialistic values of personal freedom and well-being (Jordaan, 2023) and the need to strive for human well-being within planetary boundaries (Raworth, 2017). This shift is evident in various demands for better healthcare, earlier retirement, shorter working hours and improved working conditions. It is also seen in the rising popularity of alternative measures of development, such as the National Happiness Index or the Genuine Progress Indicator. The concept of a "well-being" economy lies at the core of these ideas, aiming to improve the overall well-being of individuals and communities and encompassing aspects such as social, economic, environmental, physical and cultural well-being. Governments embracing this model strive to restore the balance between society and nature, ensure fair distribution of resources, promote collaboration among public entities and support the health and resilience of individuals and communities in the present and future (Chrysopoulou, 2020). In conclusion, many of the transformative actions proposed in this report align with this shift in mindset towards prioritizing well-being over relentless economic growth. By reorienting our goals and values, we can work towards creating a more sustainable and harmonious world for ourselves and future generations. This, by design, will address some of the most deep-seated root causes behind risk tipping points and allow us to work effectively towards a future with fewer risks for all.

"Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has."

— Margaret Mead

With risk tipping points, we can see how human actions can influence systemic change and increase the potential for negative impacts. Instead of allowing our actions to create risk tipping points that increase potential harm to people and the planet, we should strive to create positive tipping points for societal change. Collective human action is needed to steer us away from risk tipping points to avoid climate, social and ecological emergencies (Steffen and others, 2018). Practical action requires a fundamental shift in values, such as those outlined in the previous section, to be taken up as a new normal. Similar to other tipping points, positive tipping points have the potential to cascade through our interconnected socioecological systems. For instance, if plant-based proteins become as affordable and attractive as animal-based proteins, it can lead to reduced livestock farming and positive tipping in greenhouse gas emissions reductions and land conservation (Meldrum and others, 2023). In this way, the interconnectivity of the world can be used to our advantage, as we can use the momentum of one tipping point to influence other positive transformational changes as well.

This transformation often starts in small niche populations, but can quickly spread to larger groups through "social contagion". When one person adopts a behaviour, it makes it easier for the next person to follow suit by imitating and learning from the original person (Lenton and others, 2022). For positive changes to gain widespread adoption, they must be affordable, attractive and accessible (Meldrum and others, 2023). Eventually, enough people will adopt the behaviour that we reach a "critical mass", a tipping point after which the behaviour will become the new normal within the community (Lenton and others, 2022).

Individual behavioural changes play a significant role in influencing positive tipping points. We must recognize our role within interconnected systems and understand that our actions and choices matter, for better or for worse. We can choose to perpetuate a system that pushes us towards tipping points and crises, or we can choose to make positive changes wherever we can. Positive changes can be made without completely rejecting modern society, as transformative changes take time and start with small steps. Transformative change does not happen overnight, and simply doing what you have the capacity to do at every chance you get is already a transformation itself. This can be done through individual behavioural changes, such as reusing materials, checking in on a neighbour or by using our voices to demand large-scale change. The most difficult part of any journey is making the decision to start, and any effort that continues that journey is monumental. Making personal changes to behaviour and values may seem insignificant, but we are actually setting an example of what is possible, providing a vision of a better world for those around us. In fact, values endorsed by our friends and peers are often more influential in changing behaviours than facts or expert opinions (Lenton and others, 2022). We have the power to create positive tipping points, to "tip" the conditions in the original system towards something better and brighter. The journey towards positive change begins with us, and as we lead by example, the world will follow suit.

To protect their cities, people work hand in hand to plant mangroves, Sayung, Demak, Indonesia. © Bambang Wirawan / Transformative Urban Coalitions / UNU-EHS

Chapter 6

Conclusion

"I'm trying to free your mind, Neo. But I can only show you the door. You're the one that has to walk through it."

— Morpheus, The Matrix (1999)

We live in a world full of interconnected risks. With each passing day, the systems we rely on, such as the climate suitable for human life and societies, hydrological cycles, natural ecosystems and our food production, are heading further down a path towards imminent risk tipping points. The six risk tipping points analysed in this report offer us only a glimpse of the numerous risk tipping points we are approaching. If we look at the world as a whole, there are many more systems at risk that require our attention. It is crucial to understand that these risk tipping points are diverse and extend beyond climate, ecosystems, society or technology, and are inherently interconnected. They share the same root causes and drivers in our behaviours and actions that increasingly put pressure on our systems. The impacts of these systems tipping are not isolated to the system itself or the places where tipping points are crossed but can cascade through interconnected pathways to other systems and places around the world, pushing them towards tipping themselves. Each system acts as a string in a safety net, keeping us from harm and supporting our lives and livelihoods. As the next system tips, another string is cut, increasing the overall pressure on the remaining systems to hold us up.

In order to tackle complex, interconnected risks, we need integrated, inclusive approaches. The interconnectivity of our systems means we increasingly share the risks of other systems and places even far afield, greatly raising the importance of addressing risk tipping points wherever they are, and building resilience to proactively protect systems locally with a comprehensive approach that recognizes their interconnected nature. However, understanding risk in complex systems is not easy, and science has an important role to generate in-depth knowledge and understanding of these complexities, to issue warning signs of where we are headed if we keep going along a certain path. Yet, despite global scientific efforts and the warnings they are generating about how we are pushing our systems to the brink of tipping points, we continue our unsustainable practices. Something has to change.

Luckily, we can see the warning signs and the tipping points ahead of us, and the future is not set in stone. We have choices. To make the most sustainable choices, we need to take collaborative action across diverse sectors and from the level of international governance down to the individual person. As more of us work together towards the future we want, our actions can inspire others to begin to realize what is possible, giving them inspiration and agency to take positive actions of their own. In our interconnected world, these changes also have the power to permeate positive effects and reduce risk across different systems. Avoiding risk tipping points is therefore a shared responsibility of governments and companies around the world, along with every person on this planet. Collective transformative actions can fundamentally change how we perceive and value the world around us. Contributing to either a future of increasing risks or a future of sustainability and resilience comes down to our choices and the actions that follow. Changing established systems and behaviours is never easy, but this is the choice we must make if we want to avoid risk tipping points.

The question we face is simple, yet profound — what kind of future do we want?

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A vicuna roams at the foothill of the Chimborazo volcano in Ecuador's Central Andes in February 2019. © Pablo Cozzaglio / AFP

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