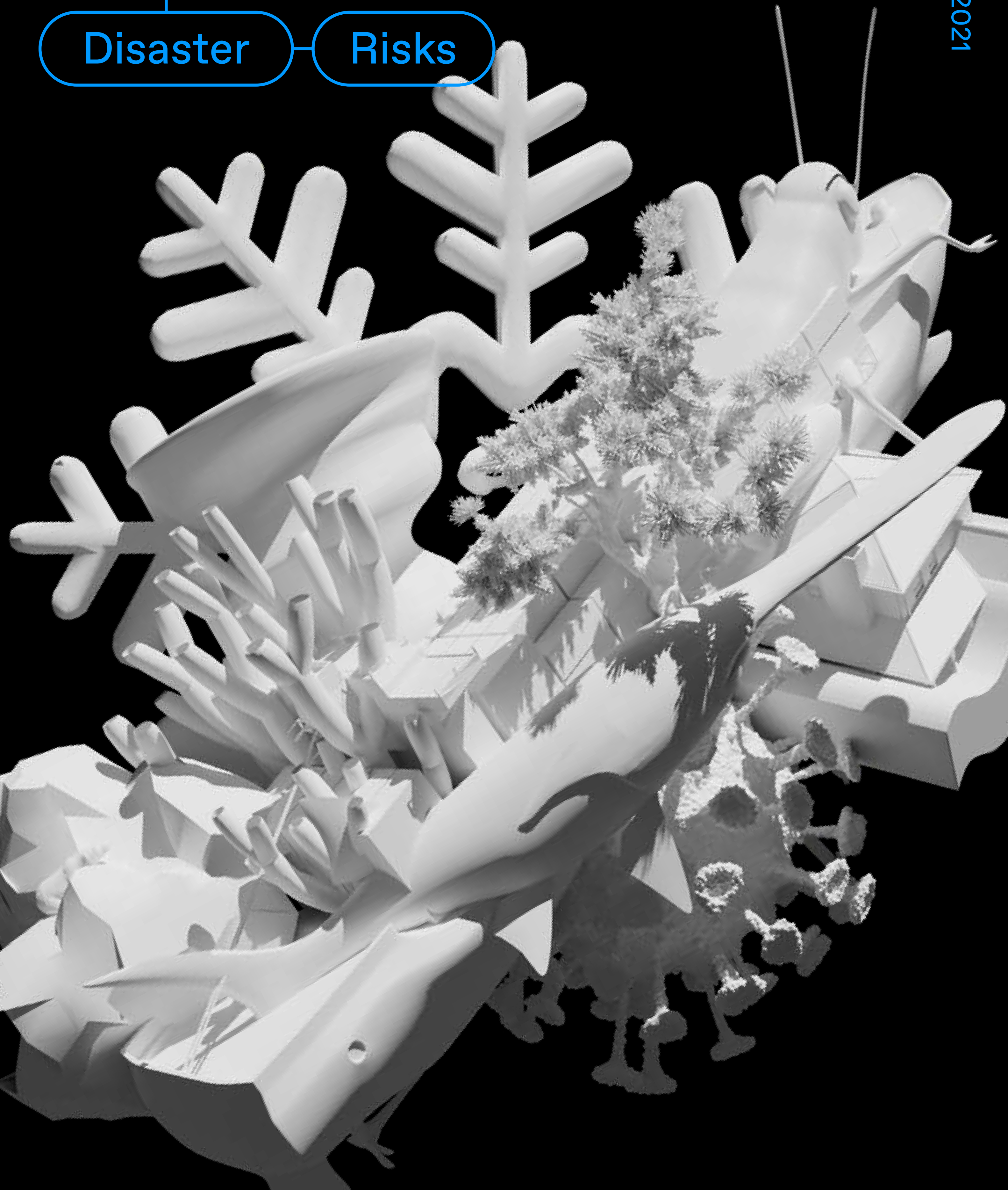
Interconnected Disaster Risks

2020/2021



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Nobody is an island. We are interconnected. Our actions have consequences – for all of us.

Executive Summary

Nobody is an island. We are interconnected. Our actions have consequences – for all of us. As we become ever-more interconnected, so do the risks we share. To manage these risks, we need to understand why and how they are interconnected. Only then can we find appropriate solutions.

Our world today is facing an unprecedented level of extreme events impacting people and nature, evident in the ever-increasing frequency of severe weather events, epidemics and human-made disasters. In 2020/2021, the world witnessed a number of record-breaking disasters that showed us clearer than ever before how interconnected we are, for better or worse.

Society will likely remember most of these disasters as tragic, but largely isolated events that affected certain parts of the world for a period of time. This report explains that these events are only the tip of the iceberg, by highlighting how these events are interconnected with each other, with other larger processes, as well as with our action or inaction. They can lead to future disasters or will worsen existing problems such as biodiversity loss or poverty.

The report analyses 10 interconnected disasters that took place in 2020/2021. They were selected for their notoriety and representation of larger global issues, which have changed or will change our lives across the world:

1. Amazon Wildfires – Wildfires fueled by global appetite
2. Arctic Heatwave – Spiraling into a climate disaster
3. Beirut Explosion – When the global community abandons ship
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The COVID-19 pandemic, which was facilitated or amplified by our hyper-connected society, demonstrated in the clearest form possible that there are no borders or boundaries that can contain disasters. While this interconnectivity has been globally recognized for COVID-19, it equally applies to many other large-scale disasters which took place in 2020/2021.

Disasters are interconnected

One example of this interconnectivity is the link between the Arctic heatwave and the Texas cold wave. In 2020, the Arctic experienced the second-highest air temperatures and second-lowest amount of sea ice coverage on record. These changes have impacts on the climate outside of the Arctic and can lead to intense cold spells and heatwaves in Europe and North America, such as the Texas cold wave in February 2021. During 86 hours, in temperatures below freezing in a state that is used to year-round warm weather, around 4 million people were without electricity as the power grid froze up, leading to the deaths of 210 people. The cold spell was likely influenced by increasing temperatures in the Arctic which destabilized the polar vortex, a spinning mass of cold air above the North Pole, allowing it to move southward into North America. If greenhouse gas emissions continue to be released at the current level, the Arctic will warm by 4°C year-round by 2050 and the cold wave in Texas will only be the beginning of more similar climate shocks.

Disasters co-occur

Interconnections of disasters are not limited to those between faraway locations; they can also compound each other, as happened with the COVID-19 pandemic and Cyclone Amphan in the border region of India and Bangladesh. In an area where almost 50 per cent of the population is living under the poverty line, the COVID-19 pandemic and subsequent lockdowns left many people without income options, including migrant workers who were forced to return to their home areas and were housed in cyclone shelters while under quarantine. On 20 May 2020, Super Cyclone Amphan hit the region causing over 100 fatalities, damages in excess of $13 billion and displacing 4.9 million people. Many people, concerned over social distancing, hygiene and privacy, avoided evacuating to shelters. While the pandemic made it more difficult to prepare for the cyclone, the cyclone in turn also worsened the conditions for pandemic response in its aftermath, as health centres were destroyed and COVID-19 cases spiked. The pandemic also influenced response capacities to the desert locust outbreak, for example by disrupting supply chains for pesticides. As the number of disasters per year continues to rise, co-occurring disasters will become much more frequent.

Disasters can be connected to individual and collective human behaviour

A high global demand for meat means that there is also a high demand for animal fodder, such as soy, which requires large plots of farmland. Combined with local political decisions and limited monitoring and enforcement, this has led to a record rate of deforestation and wildfires in the Amazon. Through the interconnections of global supply chains, meat consumption is one of the root causes contributing to the destruction of the Amazon. The impacts of forest fires and widespread deforestation are already felt globally as they exacerbate climate change and threaten biodiversity. Therefore the individual decision to eat meat and poultry can contribute to disaster risks.

Disasters share the same root causes

Root causes are the underlying factors that create conditions for disasters to occur. If we think of an event such as the Texas cold wave as an iceberg, the unusually freezing temperatures that led to power outages and suffering were just the tip of this iceberg. However, this tip is how we perceive disasters, and this is where the media and discussions usually tend to focus. Far below the tip, there are deeper systems and structures that allowed the disaster to occur, and they are surprisingly similar for many seemingly unrelated events. After identifying sets of root causes for each event, the three most commonly identified root causes shared between these 10 events are human-induced greenhouse gas emissions, insufficient disaster risk management and under-valuing environmental costs and benefits in decision-making. Human-induced greenhouse gas emissions were one of the reasons why Texas experienced the freezing temperatures to begin with, but they also contribute to the formation of cyclones such as Amphan or the Arctic heatwave, for example – entirely different disasters in entirely different parts of the world. Insufficient disaster risk management led to the large impacts of the Texas cold wave, where there was inadequate cold weather protection in place even though similar cold waves had already disrupted the delivery of electricity in 1989 and 2011, and there had been warnings of another cold winter. This same root cause also played a role in other events such as the Beirut explosion or the desert locust outbreak.

Disasters should no longer be viewed in isolation

When we recognize common root causes and emerging risks resulting from disasters like these and become aware of the interconnectivity between them, we will understand them better. This will also enable us to take collective actions at the global level that will change the larger, systemic processes behind them and ideally prevent similar events from occurring in the future.

Interconnected root causes call for interconnected solutions

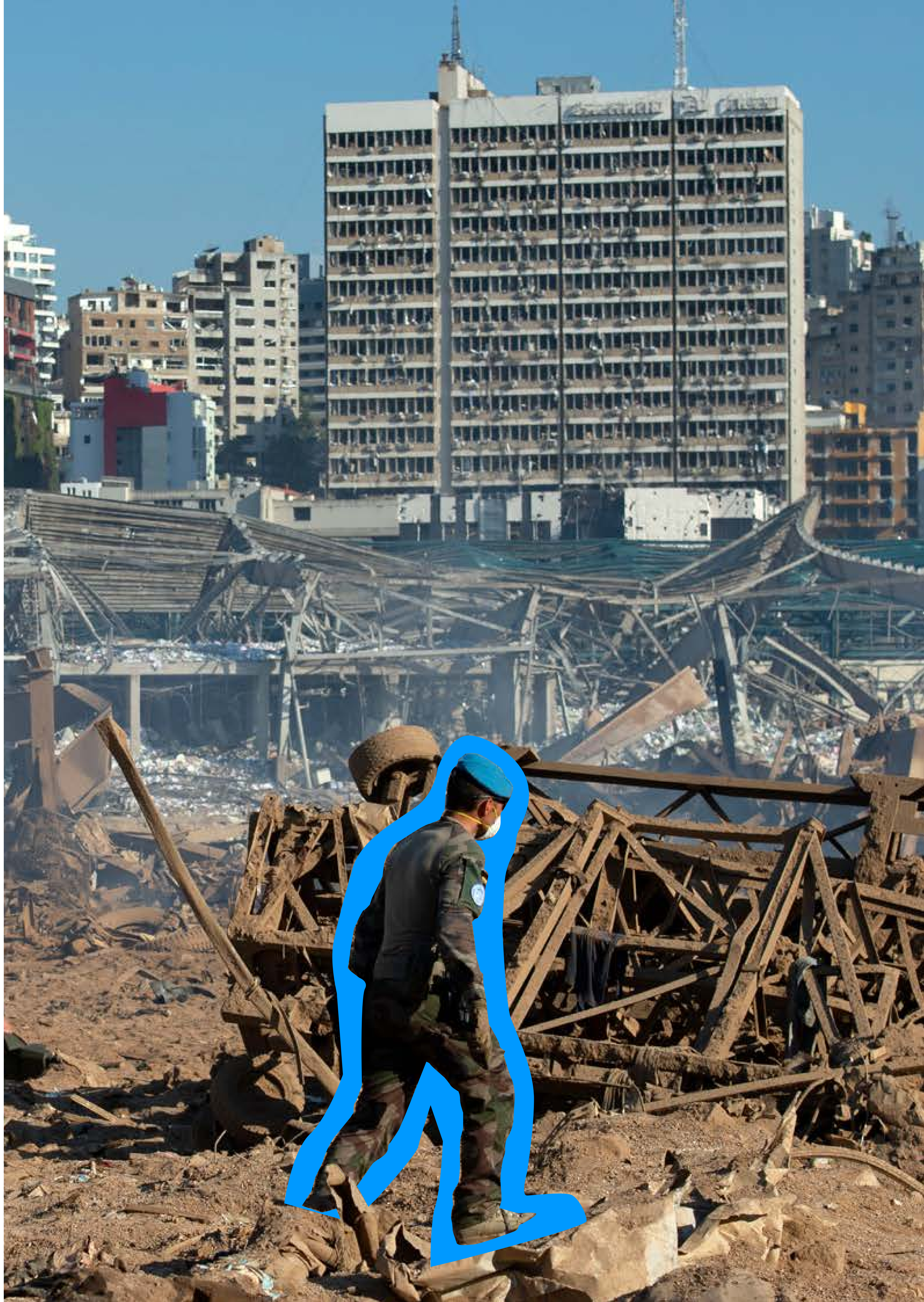
As the interconnected nature of events and their underlying root causes are increasingly creating emerging risks at all scales, it is time to recognize the shortcomings of fragmented responses. Ideally, the solutions we implement will have benefits across different dimensions. Cutting our greenhouse gas emissions, for instance, could eventually reduce the frequency and severity of hazards linked to atmosphere and ocean warming (such as the Central Viet Nam floods, driven by a series of tropical storms and cyclones), thus reducing risk in vulnerable areas. Additionally, slowing down climate change is beneficial for biodiversity and ecosystems as it gives more time for ecosystems and species to adapt to changing conditions. This would not only help to protect biodiversity, for example in the Great Barrier Reef, but would also allow us to maintain the benefits a healthy reef provides to society such as coastal protection, recreational value and fish for consumption. These types of solutions use interconnectivity to our advantage to reduce risks and the severity of impacts, and they also help to avoid a cascade of disastrous events and therefore the emerging risks they contribute to.

Addressing trade-offs

Solutions that address the tip of the iceberg rather than the underlying structures are not only bound to be less efficient, but they also bring with them additional risks. Actions designed to reduce risk in one system can have negative impacts on another. Addressing any potential trade-offs is important to ensure that implemented solutions don't become part of a further problem. For example, one solution to reduce disaster risk is to build sea walls or river dams that come with negative impacts on biodiversity and ecosystem health. A better solution would be to integrate ecosystem-based measures along with built infrastructure that can help reduce disaster risk, while also protecting biodiversity.

We as individuals can be part of the solution

While many of the solutions require actions on international, national or regional scale, individual actions or inactions also matter. Because disasters can be connected to individual and collective human behaviour, we can be part of the solution if we take action which supports solutions or avoids further risk creation. We can be agents of change if we learn about risks and adjust our own behaviours at the individual level, while also demanding change and action from the society we live in.



Chapter 1

Introduction

We live in an interconnected world. We see it every day: through increased transport, trade and technology, our lives are more intertwined than ever with societies, economies and ecosystems in distant parts of the world.

The year 2020 brought this interconnectivity into sharp focus with the COVID-19 pandemic, highlighting the risks increasing connectedness with our environment and fellow humans can have if left unchecked. While this pandemic has united the world in struggle as never before, it has also overshadowed the numerous record-setting disastrous events worldwide: from record-high temperatures on land and sea, to extreme cold waves, insect plagues, species extinctions and wildfires, and explosions in urban areas.

Although we are coming to think of disaster risks as being interconnected, the disastrous events themselves are still largely reported and perceived as being isolated incidents. To build more resilient communities and sustainable futures, we need to better understand how global disasters are connected and why they happened in the first place.

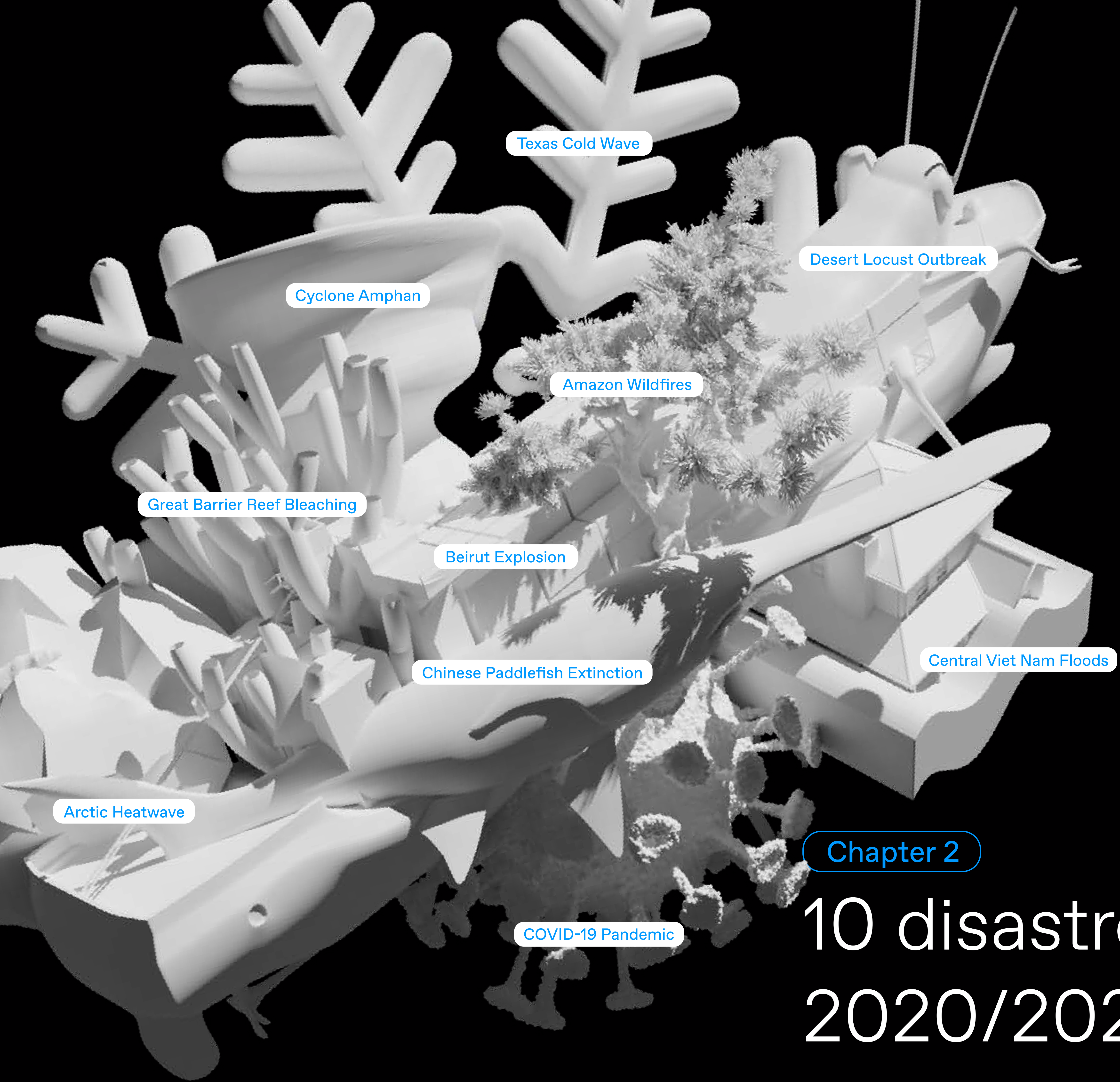
In this new report series, we focus on two key characteristics of disasters around the world:

These events may still be happening and will happen again. The modern media cycle is short and the disastrous events so frequent that as soon as we start to care about one issue another quickly replaces it (Schema and others, 2019). Critically, reporting often ends when the hazard itself (e.g. a cyclone, or a heatwave) stops, ignoring the cascading impacts which remain ongoing for the people and places affected and the importance of how recovery is achieved. Remember the Beirut explosion or the cold wave in Texas which made the global news headlines in the past year? Despite large-scale media attention at the time, little public focus has been given to these incidents since. Other events are ongoing but only receive attention as disastrous events when particularly notable impacts arise (e.g. wildfires in the Amazon or warming in the Arctic). This report revisits these major events with the benefit of hindsight to learn lessons about the systemic problems behind them in order to improve our ability to forecast and prepare for future risks.

These events don't happen in isolation. To prepare for disastrous events with foresight, we need a deeper understanding of the common root causes behind them, not just at the site of impact itself but wherever they may lie in the world. These root causes may relate to the **hazard** itself (i.e. the disastrous event causing the loss), the **exposure** to the hazard (i.e. the people, assets and places at risk of impacts from the hazard) or the **vulnerability** to the hazard (i.e. how susceptible people, assets and places are and what their capacity to cope with hazards is), and are influenced by social, economic and environmental factors. Here, we identify not only how disastrous events are linked to the behaviours and choices of people from the local to global levels, but also to each other. In this way, the solutions to reduce the impacts of these disasters must also come not just at the level of symptoms, but also at the root cause level through a transformative change of critical behaviours and policies that accounts for the interconnectivity of the systems they influence. In examining these events' global relevance and impacts, we ask what they will mean for our planet and humanity in the future, and we challenge readers to think why and how we need to act.

In the *2020/2021 Interconnected Disaster Risks* report, we have selected the following 10 case studies: the wildfires in the Amazon, the record-breaking Arctic warming, the explosion in the port of Beirut, consecutive tropical storms and flooding in central Viet Nam, the extinction of the Chinese Paddlefish, the global COVID-19 pandemic, Cyclone Amphan in the Bay of Bengal, the locust infestation in the Horn of Africa, the mass coral bleaching event on the Great Barrier Reef, and the Texas cold wave We selected these events for their suitability as emblems for a broader picture of interconnected global issues and their high profile (and therefore public awareness) through a media analysis. One event, however, was included as an 'overlooked' event (in this case the Chinese Paddlefish extinction) to highlight the importance of issues outside the mainstream media cycle and their interconnectivity to more visible events. To explore the core message of global interconnectivity more comprehensively we prioritised diversity in the selection process, with cases representing different types of extreme events selected from various regions around the world.

We will take you through these 10 disastrous events beginning in **Chapter 2**, which introduces them with particular narratives that connect them to the wider global picture, including summaries of how they developed, where their impacts may lead in the future, and how they are interconnected with other events in this report. **Chapter 3** constitutes a 'deep dive' into three critical aspects of disasters: 1) the **Interconnectivity** of the events and their causal factors, 2) primary **Root Causes**, and 3) **Emerging Risks** of major concern developing from these disastrous events and the systems that contributed to them. **Chapter 4** follows with a synthesis of possible solutions addressing the deeper level of root causes and vulnerabilities. As individual decisions matter, this chapter also provides choices and options for contributing to reducing risks in our interconnected world. This approach to the analysis of disastrous events gives a more systemic picture of the issues surrounding their occurrence in order to develop a greater understanding of the disaster-related risks we face now and will face in the future as a foundation for recognition and change.



Chapter 2

10 disastrous events 2020/2021

Event Amazon Wildfires

Wildfires fueled by global appetite

A high global demand for meat means that there is also a high demand for animal fodder, such as soy, which requires large plots of farmland. Combined with local political decisions and limited monitoring and enforcement, this has led to a record rate of deforestation and wildfires in the Amazon. In 2020 alone, an area of the Amazon forest burnt down that was larger than Fiji. ↳

Event Amazon Wildfires

While fire is often a natural process to manage vegetation, 9 out of 10 of the Amazon fires in 2020 followed the intention to convert tropical rainforest into commercially used land. The Amazon is the world's largest, most diverse tropical rainforest and Earth's largest carbon sink, covering an area of 5.5 million km2, and it is often referred to as the world's green lung.

However, an increase in meat consumption, particularly in the European Union and China, in combination with local political decisions and limited monitoring and enforcement, has led to a record rate of deforestation and wildfires. In the Amazon, wildfires are used as a tool for clearing land and converting forest vegetation into mostly agricultural land for livestock and soybean production. Around 77 per cent of these soybeans are then used for animal fodder, especially for poultry like the one in your chicken sandwich. Even if meat is not directly produced in the Amazon, through the interconnections of global supply chains, meat consumption is the root cause of the destruction of the Amazon. The deforestation of the Amazon, especially through the use of wildfires, strongly decreases local rainfall. The effect of this rainfall decrease has already been felt: in the year 2020 it caused human-made fires to go 'wild', leading to a vicious cycle which presents the very realistic threat of a tipping point being approached, after which parts of the rainforest will no longer be able to sustain themselves and will transform into grassland.

Today, the Amazon is in steep decline and as more and more trees are lost, there is increasing risk of the region changing from a net carbon dioxide capturer to a net emitter. The impacts of forest fires and widespread deforestation are already felt globally. They exacerbate climate change, threaten biodiversity and reduce many of nature's benefits that are central to the livelihoods of indigenous and local groups.

Event **Amazon Wildfires**

Key root causes:

- Insufficient disaster risk management
- Full environmental costs undervalued in decision-making
- Prioritizing individual profits
- Global demand pressures
- Insufficient national/international cooperation
- Human-induced greenhouse gas emissions

Wider picture / a symbolic event of:

From 2002–2019, 142,000 km² of Amazon rainforest was destroyed.

In 2020 wildfires raged in regions around the world, including Australia, Indonesia, United States (California) and Russia (Siberia).

Wildfires will most likely become more frequent, longer and more severe due to an increase in global meat demand, greater accessibility of untouched areas due to road expansions, the recent decline in commitment of national governments to forest protection, and the change in weather conditions due to climate change.

Location: Amazon rainforest

Category: Human-made wildfires

Date/duration: Perennial, season intensity from July – November

Key figures:

2,500
individual fires in 2020

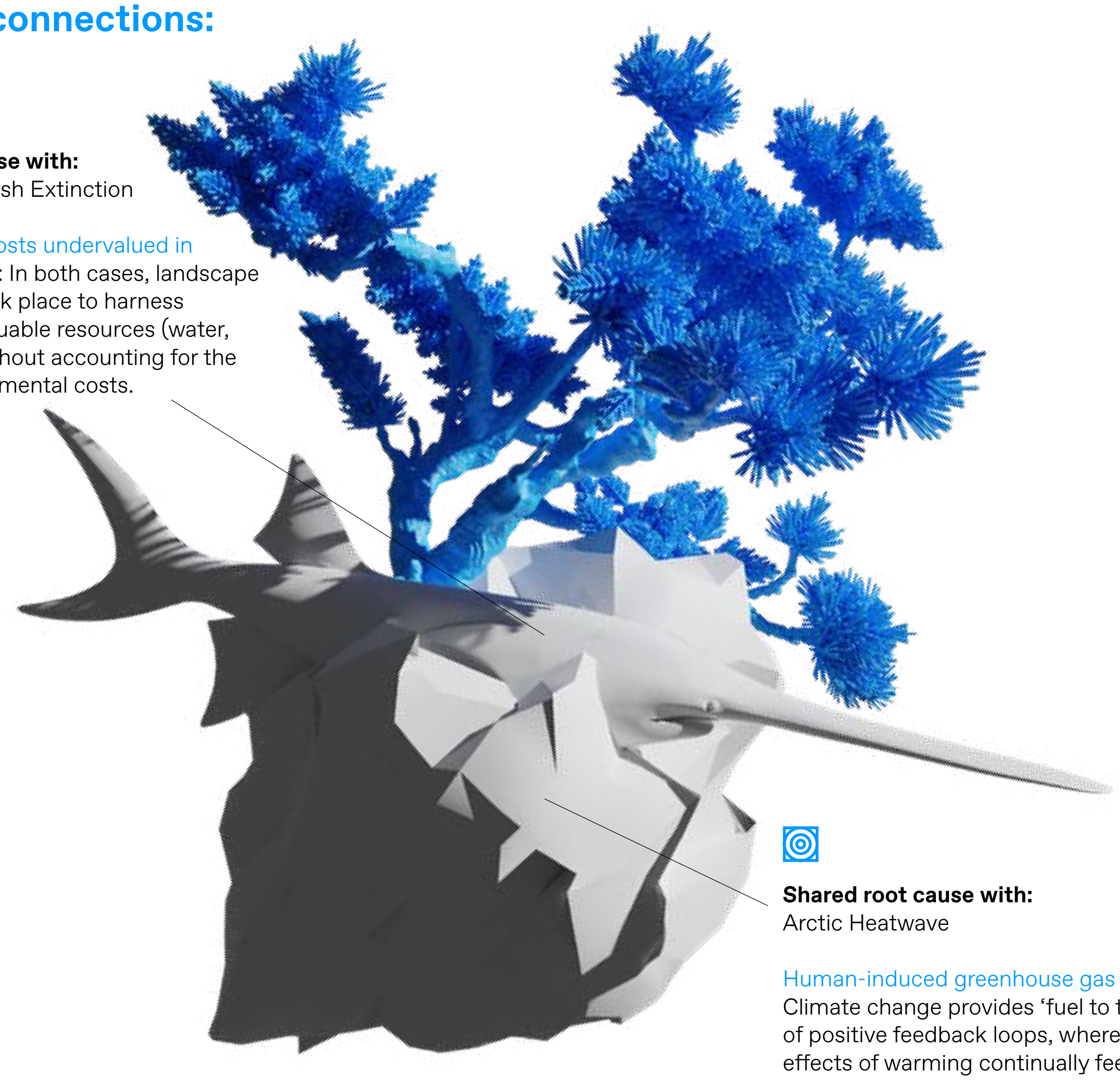
Key impacts:

$20,000\ km^2$
of primary forest loss

2,195
people were hospitalized due to respiratory illness in 2020

4.5 million
people have been affected by harmful levels of air pollution

Key interconnections:



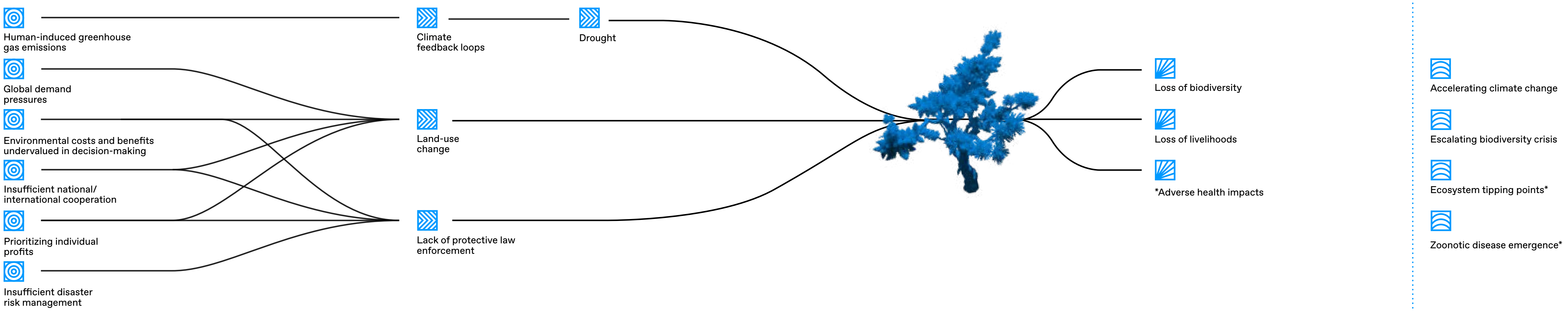
Shared root cause with:
Chinese Paddlefish Extinction

Environmental costs undervalued in decision-making: In both cases, landscape interventions took place to harness economically valuable resources (water, energy, food) without accounting for the resulting environmental costs.

Shared root cause with:
Arctic Heatwave

Human-induced greenhouse gas emissions: Climate change provides 'fuel to the fire' of positive feedback loops, whereby the effects of warming continually feed into each other, exacerbating the effects of climate change, reaching tipping points in both landscapes.

Root causes | **Underlying drivers** | **Amazon Wildfires** | **Impacts** | **Emerging risks**



*See Technical Report for more information

Event Arctic Heatwave

Spiraling into a climate disaster

In 2020, the Arctic had the second-highest air temperatures and second-lowest area of sea ice coverage on record. The Arctic is experiencing climate change with at least twice the speed of the rest of the planet, which has disastrous consequences not just for the immediate environment, but also for the whole world. ↱

Event Arctic Heatwave

2020 was one of the three warmest years on record, with the most notable warmth being observed in the Siberian Arctic, where temperatures reached 38°C in Verkhoyansk, provisionally the highest known temperature anywhere north of the Arctic Circle. This fueled the most active wildfire season in an 18-year-long data record, as estimated in terms of carbon dioxide emissions released from fires. In the past decade, Arctic temperatures have increased by nearly 1°C. If greenhouse gas emissions stay on the same trajectory, the North will have warmed by 4°C year-round by 2050. Projections point to an ice-free Arctic in the summer in the next 10-15 years, meaning that the once ice-covered white ocean will turn into a blue ocean. An important regulating mechanism in the Arctic is the albedo effect: when sunlight hits a white surface such as snow and ice, more of it is reflected back into space without warming its surroundings than when light hits a darker surface. When ice melts and uncovers darker land and water, more sun energy is absorbed, which warms the Arctic even further.

There is no aspect of life in the Arctic that will not be affected by these changes, from ecosystems' integrity to livelihood opportunities of the local population, to the stability of energy and transportation infrastructure. Close to 4 million people, many of them indigenous, will be forced to resettle or adjust to the new conditions. Animals, such as reindeer, polar bears, cod and seals, are all affected as their natural environment is changing faster than ever. With continued high greenhouse gas emissions, polar bears' reproduction and survival will steeply decline with projected extinction of nearly all subpopulations by 2100. What happens in the Arctic will affect the planet overall, through sea level rise caused by melting Greenland ice, and the impacts on the climate outside of the Arctic. Intense cold spells and heatwaves in Europe and North America are linked to the Arctic climate, and the rapid change in Arctic temperatures may affect their future patterns. The repercussions of these changes have the potential to affect climate stability worldwide: weather extremes around the world will be impacted by the change in oceanic and atmospheric currents, while the release of greenhouse gases stored in the thawing permafrost has the potential to strongly exacerbate climate change.

Event **Arctic Heatwave**

Key root causes:

Human-induced greenhouse gas emissions

Wider picture / a symbolic event of:

The changes in the Arctic have impacts globally: the melting of Greenland ice is one of the primary drivers of global sea level rise, and the Arctic climate contributes to cold spells and heatwaves in Europe and North America.

Potential ice-free summers in the Arctic by 2035; greenhouse gases that are currently stored in the permafrost could be released and exacerbate climate change further, and unique biodiversity will be lost.

Location: Land and sea above Arctic Circle (> 66.5° N)

Category: Extreme weather

Date/duration: Summer season 2020 (seasonal peak of multi-decade process)

Key figures:

2x
Arctic is warming twice as fast as the rest of the planet (Arctic amplification)

Key impacts:

2nd lowest
summer sea ice cover (3.74 million km2)

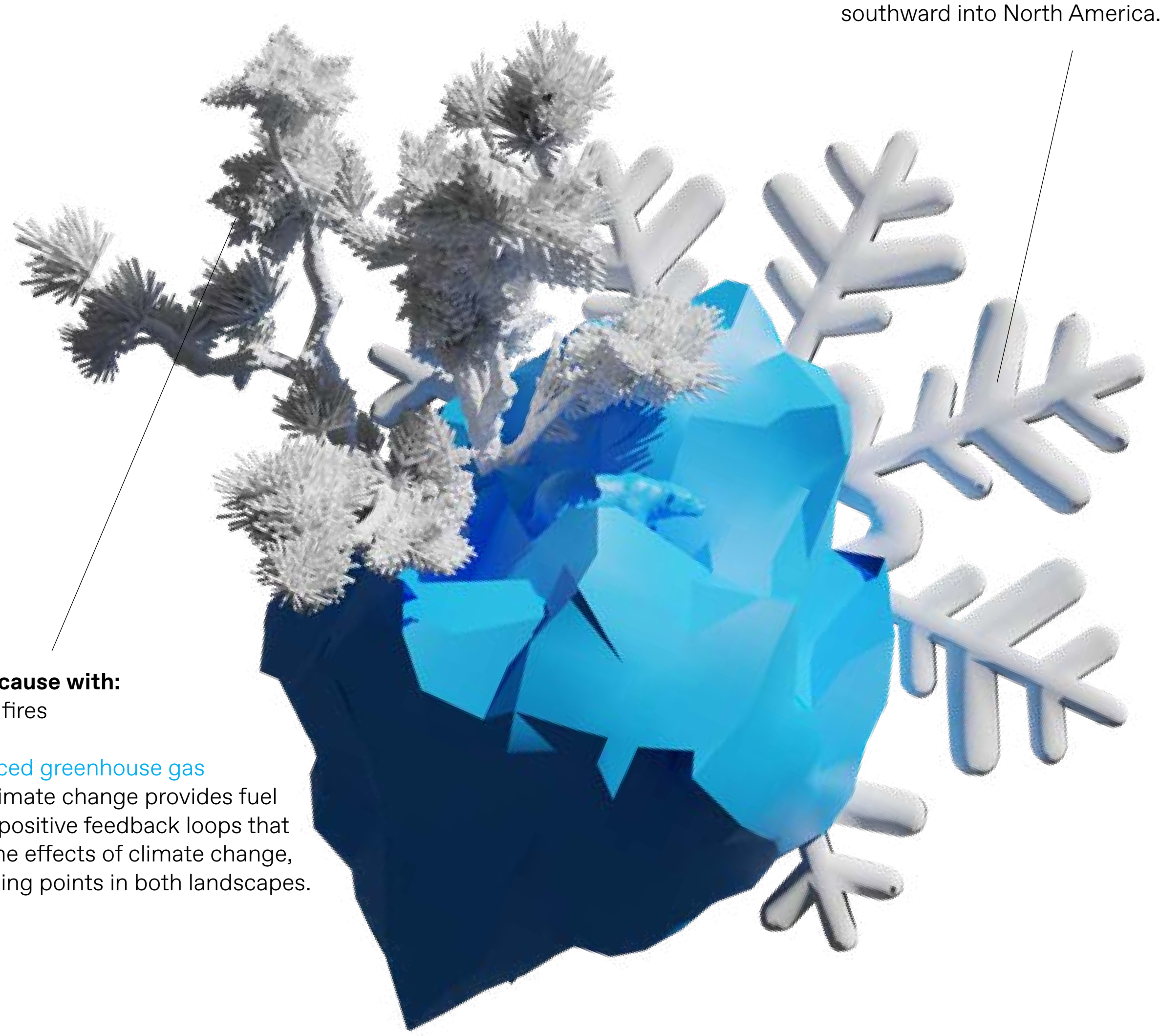
38°C
record air temperature recorded in Verkhoyansk, Siberia

14 million ha
of forests and peatlands burnt by wildfires in Siberia

Key interconnections:

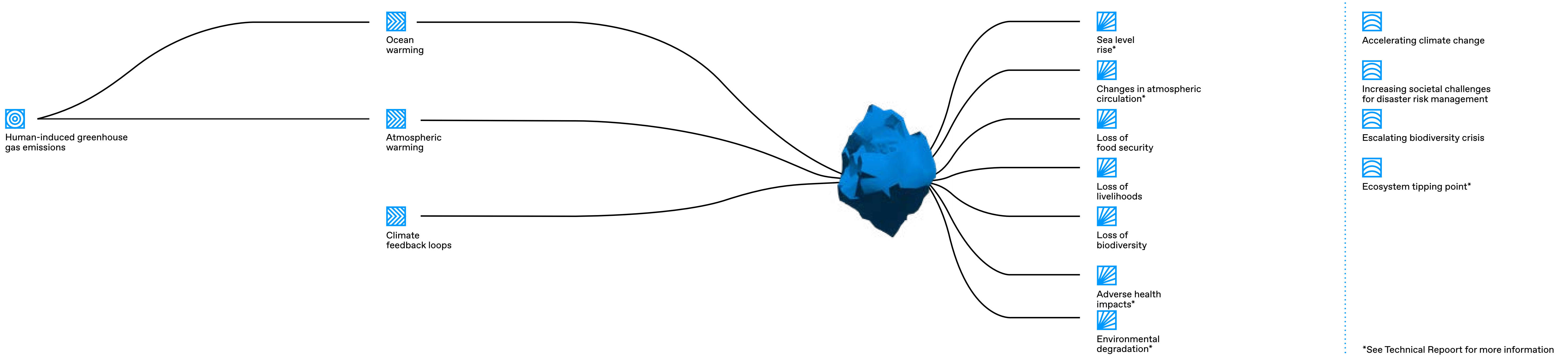
Direct influence on:
Texas Cold Wave

Increasing temperatures in the Arctic influence the stability of the polar jet stream, a spinning mass of air above the North Pole, allowing cold air to move southward into North America.



Shared root cause with:
Amazon Wildfires

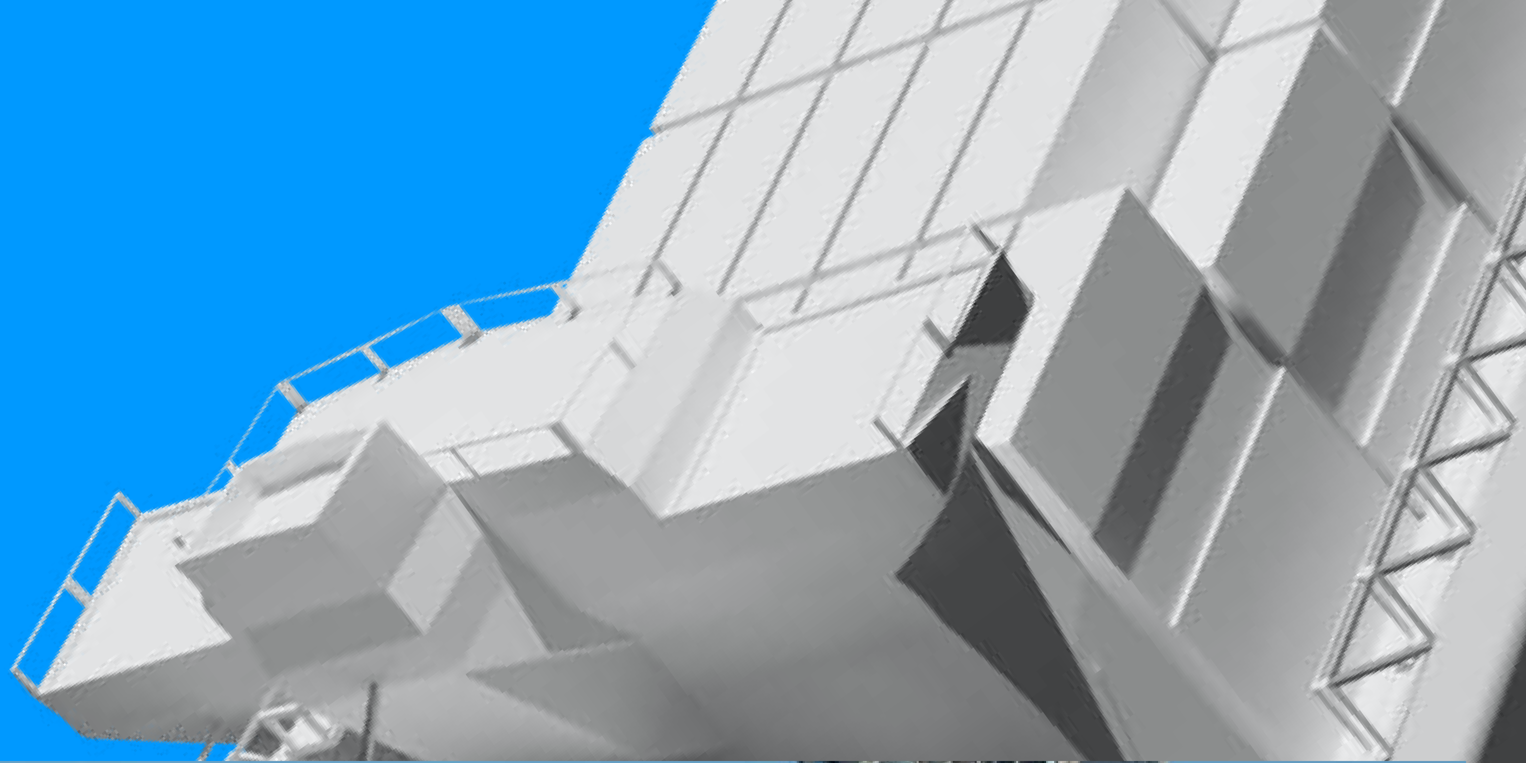
Human-induced greenhouse gas emissions: climate change provides fuel to the fire of positive feedback loops that exacerbate the effects of climate change, reaching tipping points in both landscapes.

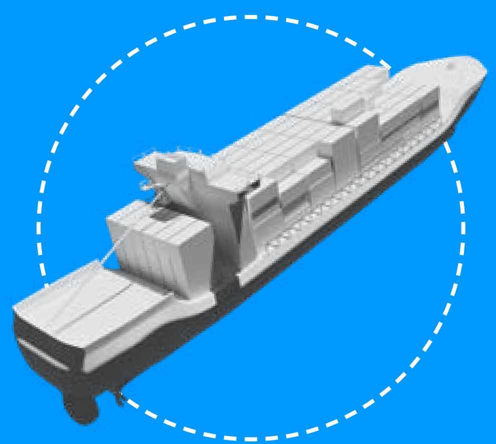


*See Technical Report for more information

Event Beirut Explosion

When the global community abandons ship





On 4 August 2020, more than 200 people lost their lives and more than 6,000 were injured when a massive explosion of ammonium nitrate destroyed much of the port area of Beirut. ↱

Event Beirut Explosion

However, the questions of how the ammonium nitrate ended up in the port of Beirut in the first place and why such hazardous material was stored inappropriately explains why Beirut is about more than one human tragedy: it is about lack of accountability in a global value chain, which – in the case of sea transport – leads to a poorly regulated shipping industry. All around the world, ships are abandoned once they become unprofitable, for example because they break down or are held by port authorities following safety inspections. The lack of binding international law enables ship operators to register their holdings in countries with 'open registries', which allows ships to fly a flag without having a connection to the chosen nationality. As a result, a majority of all vessels worldwide are registered in countries with the lowest fees and security standards, and fly so-called 'flags of convenience', allowing them to circumvent regulations and responsibility.

In the case of the Beirut explosion, a cargo ship carrying ammonium nitrate was abandoned in the port in 2013, and the explosive cargo was eventually brought to shore and incorrectly stored next to explosives in Beirut's harbour in a densely populated area for more than six years. Deeply rooted corruption and a weak governance structure contributed to a lack of action by those responsible. The explosion then affected a population which was already suffering under an over-stretched health care sector, struggling economy and the challenges of COVID-19, costing precious human lives and leaving behind traumatized families and communities. Following the explosion, COVID-19 cases spiked in Beirut, further stretching already scarce resources in the health sector. Between 2004 and 2018 the ILO registered 400 separate incidents of cargo ship abandonments with crew members on board. These abandonments are not only dangerous from the human rights perspective of the abandoned crews, but also because of the leftover fuel, hazardous cargoes and unattended ships that pose further risk for humans and the environment alike. The Beirut tragedy proves just how much disaster risk they carry.

Event | Beirut Explosion

Key root causes:

- Insufficient disaster risk management
- Prioritizing individual profits
- Insufficient national/international cooperation

Wider picture / a symbolic event of:

Since the assassination of former president Hariri, political instability has remained. The conflict in Syria starting in 2011 has led to an economic downturn in the region. Currently, Lebanon is facing a financial crisis which increased strongly in 2019.

Further issues of safety and security for ship operators and port areas will emerge as issues of regulation and enforcement continue to go unaddressed. Human security demands strong international cooperation and taking responsibility.

Location: Port of Beirut, Lebanon

Category: Human-made disaster

Date/duration: 4 August 2020 at around 6:07 PM

Key figures:

2,750 tons
of ammonium nitrate detonated. Loss of cultural heritage, threat of toxic gases and environmental contamination for roughly 2.4 million citizens of Beirut

Key impacts:

50%
hospital capacity of the city destroyed

$3.8
to $4.6 billion damage to the physical infrastructure alone

300,000
people homeless

+200
fatalities

+6,000
injured

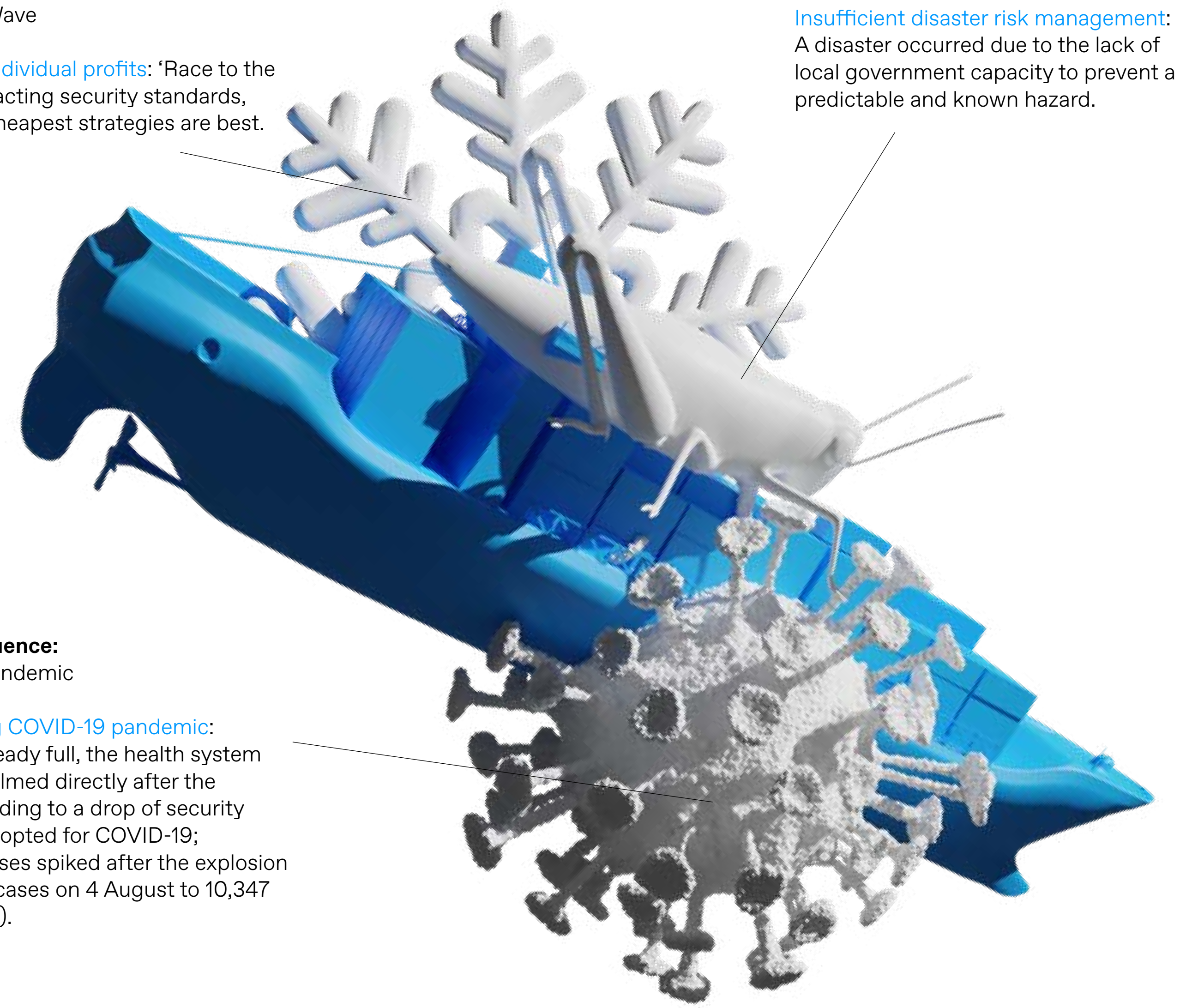
Key interconnections

Shared root cause with:
Texas Cold Wave

Prioritizing individual profits: 'Race to the bottom' impacting security standards, presuming cheapest strategies are best.

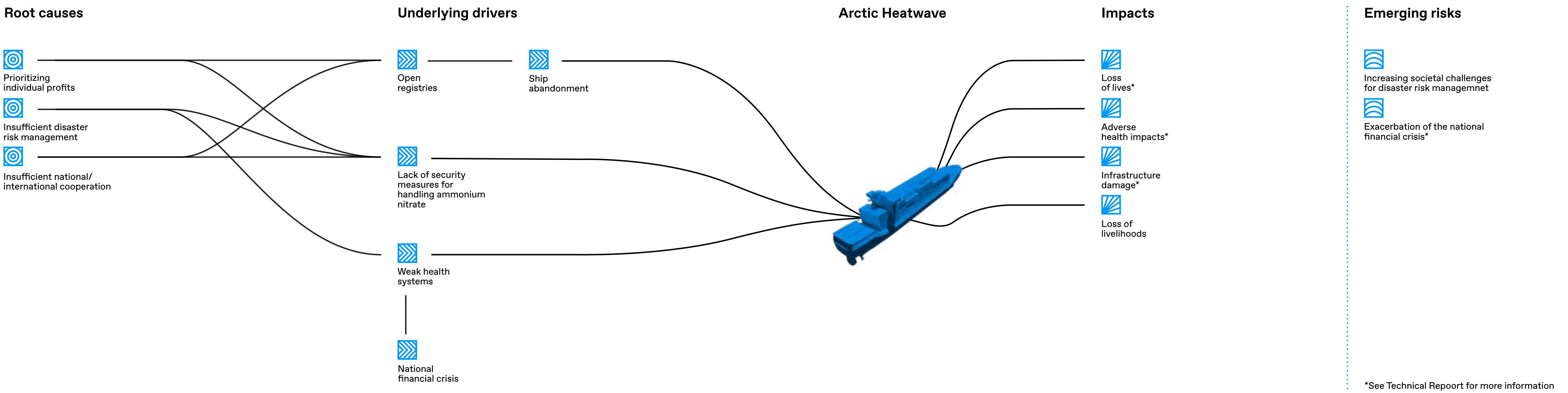
Shared root cause with:
Desert Locust Outbreak; Texas Cold Wave

Insufficient disaster risk management: A disaster occurred due to the lack of local government capacity to prevent a predictable and known hazard.



Indirect influence:
COVID-19 Pandemic

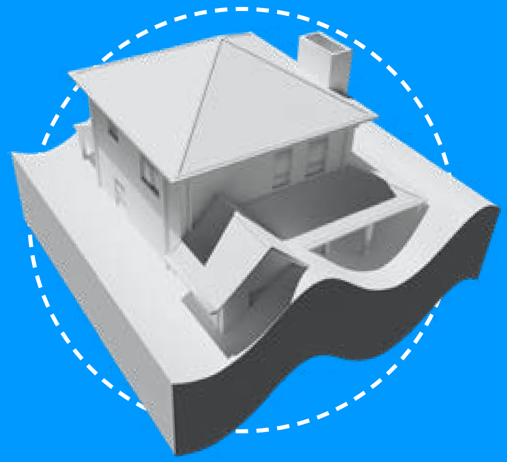
Exacerbating COVID-19 pandemic: Hospitals already full, the health system was overwhelmed directly after the explosion leading to a drop of security standards adopted for COVID-19; COVID-19 cases spiked after the explosion (from 4,022 cases on 4 August to 10,347 on 19 August).



*See Technical Repoort for more information

Event Central Viet Nam Floods

Nine storms, cyclones and heavy floods in 7 weeks – when being prepared is no longer enough



Viet Nam’s long coastline, geographic location and diverse topography and climate contribute to it being one of the most hazard-prone countries of the Asia-Pacific region. Almost all the provinces and cities in Viet Nam are affected by floods of varying intensity and duration. ↱

Event Central Viet Nam Floods

They are the country's deadliest hazard, having caused 69 per cent of all disaster-related casualties between 1990 and 2014. Despite long experience with such events, Viet Nam's disaster risk reduction measures and policies were still overwhelmed when nine storms and cyclones hit the central coast region within seven weeks. Storm Linfa, Storm Nangka, a tropical depression in the East Sea, Storm Saudel, Storm Molave, Super Typhoon Goni, Storm Astani, Storm Etau and Storm Vamco devastated Viet Nam from the beginning of October to mid-November of 2020 and caused widespread flooding in 10 regions. A combination of coastal flooding, urban flooding and heavy rains soon saturated the soils, leading to an unmanageable situation, even for a population and a government prepared to deal with these types of events.

As a result, a total of 7.7 million people were affected by the disruption to basic services (electricity, communications, transport, water, health, education and civil protection) and food supplies, and 291 lost their lives. Crops, livestock and lifeline infrastructure were severely damaged or completely lost, hampering the delivery of aid relief to the affected communities. Although Viet Nam is a country recognized as being exposed to recurring hazards, the magnitude and consecutive characteristics of the storms worsened the hardships caused by the ongoing pandemic and further plunged the affected people into poverty. Following the nine storms, the Government of Viet Nam introduced a new classification level for heavy rain in their weather warning system. Viet Nam has been listed by the World Bank as one of the five countries that will be worst-affected by climate change. Around 11.8 million people living in the coastal provinces of Viet Nam are exposed to intense flooding. The number of intense storms and cyclones is expected to increase with the changing climate, making these types of scenarios more likely in the future.

Event | Central Viet Nam Floods

Key root causes:

- Insufficient disaster risk management
- Human-induced greenhouse gas emissions
- Full environmental costs undervalued in decision-making

Wider picture / a symbolic event of:

In some provinces the flood levels broke historic records.

Increasing extreme events severity and flooding will challenge many tropical coastal locations globally.

Need to consider and prepare for new, unseen climate extremes.
The proportion of Category 4 and 5 tropical cyclones and associated average precipitation rates are projected to increase with a 2°C global temperature rise. Coastal hazards will be exacerbated by an increase in the average intensity and magnitude of storm surges, and precipitation rates of tropical cyclones.

Location: Central Viet Nam

Category: Extreme weather

Date/duration: Beginning of October to mid-November 2020

Key figures:

9 storms
in 7 weeks, torrential rains, heavy floods (coastal, urban and riverine) and resulting landslides

Key impacts:

$1.3 billion
in damages, loss of crops and livestock, losses in key economic sectors, damage to houses and lifeline infrastructure, disruption of basic services

7.7 million
people affected and 1.5 million people severely affected

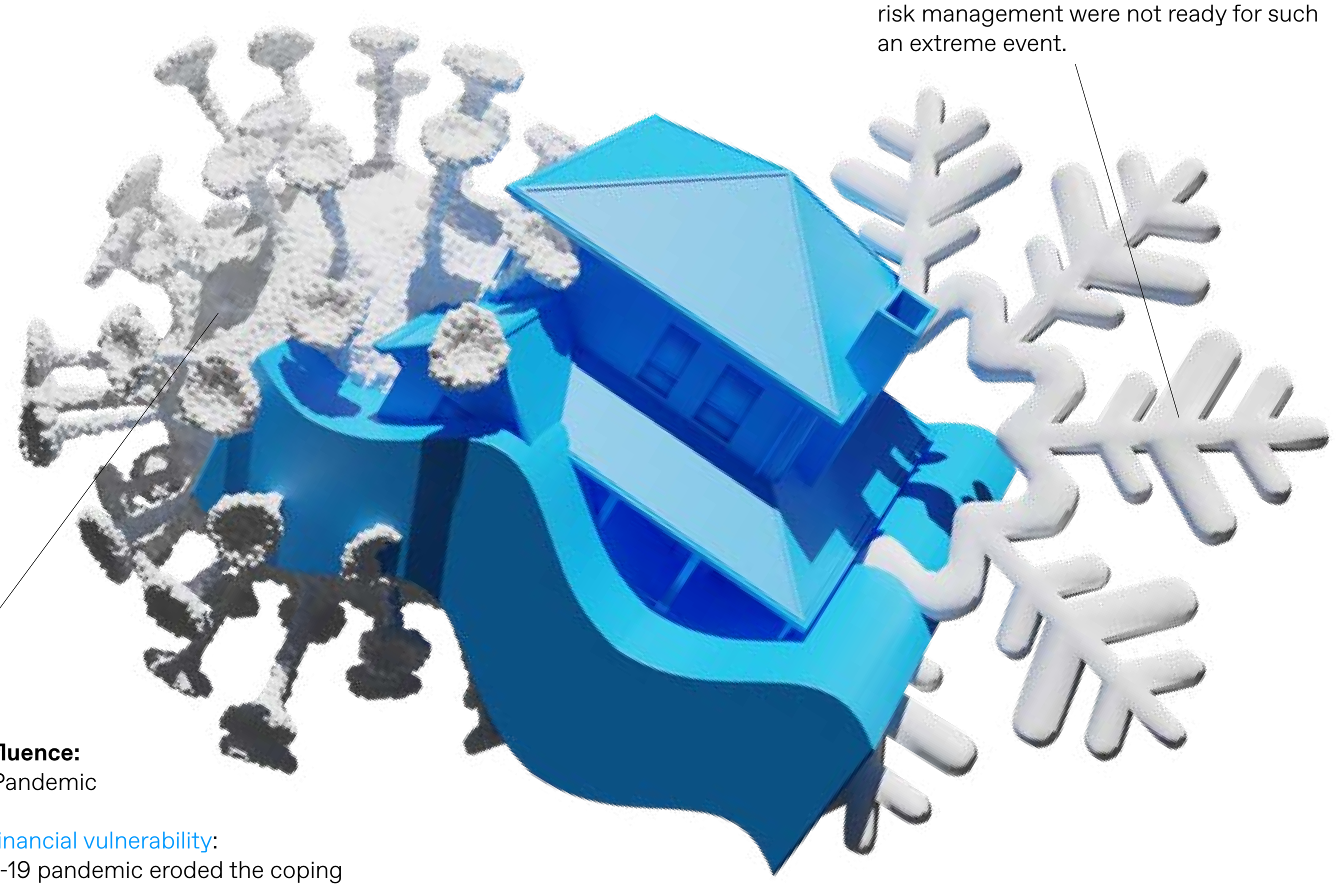
291
fatalities

66
missing people

Key interconnections:

Shared root cause with:
Texas Cold Wave

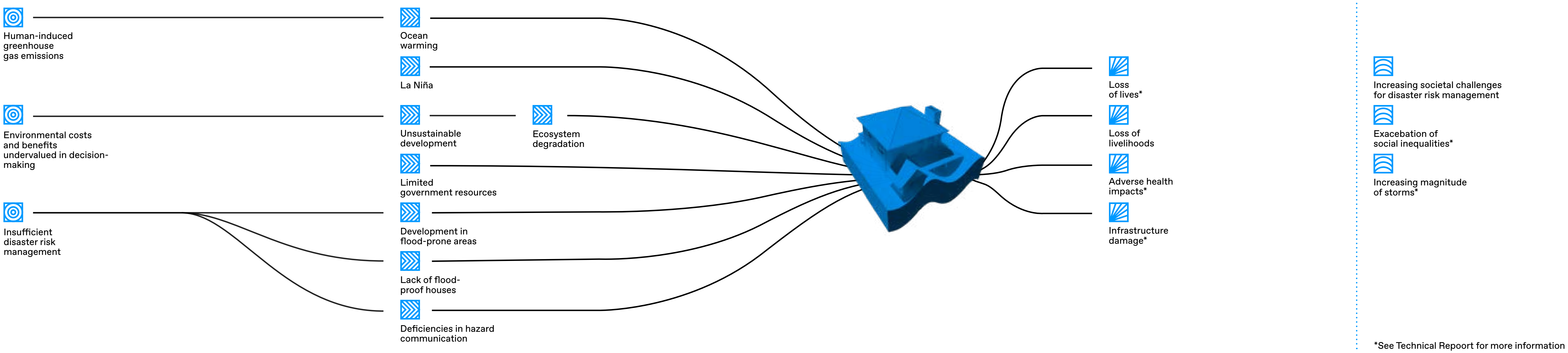
Insufficient disaster risk management: The structures and policies in place for disaster risk management were not ready for such an extreme event.



Indirect influence:
COVID-19 Pandemic

Increased financial vulnerability:
The COVID-19 pandemic eroded the coping capacities of vulnerable households, which led to them suffering harder impacts, employing negative coping mechanisms and increasing the risk of falling into extreme poverty.

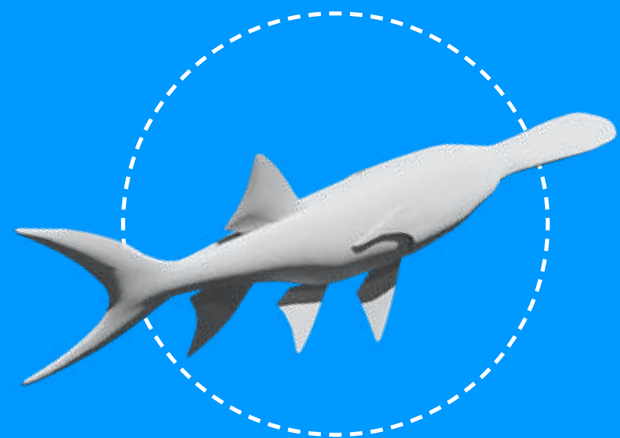
Root causes | **Underlying drivers** | **Arctic Heatwave** | **Impacts** | **Emerging risks**



*See Technical Report for more information

Event Chinese Paddlefish Extinction

The fish that survived the dinosaur extinction but not humankind



Chinese Paddlefish have been around for an estimated 200 million years, which means they already swam alongside the dinosaurs and survived their extinction. But they did not survive the overconsumption and intervention of humankind, and were declared extinct in 2020.
↱

Event

Chinese Paddlefish Extinction

While overfishing and pollution played an accelerating role, much of its demise can be attributed to the multiple dam constructions in the Chinese Paddlefish's natural habitat: the Yangtze River. The 'last nail in the coffin' was the construction of the Gezhouba Dam in 1981, which effectively cut the Chinese Paddlefish off from its only spawning ground, which was further upstream. While wild-caught freshwater fish provides food security and livelihoods for hundreds of millions of people across the world, the Chinese Paddlefish no longer can. In this, the Chinese Paddlefish is not alone: 16 species of freshwater fish disappeared in 2020, and another 115 have been classified as 'critically endangered, possibly extinct'. Aside from the loss of unique biodiversity, freshwater fish extinction has other long-term impacts. While freshwater makes up only 1 per cent of Earth's area, 51 per cent of known fish species can be found there, and they are an important source of nutrition and income for communities around the world. At least 43 per cent of the wild freshwater fish harvest comes from 50 low-income, food-deficient countries, where access to other forms of quality food is limited. Freshwater fish also play an important role in the food chain as they are eaten by larger animals (for example bears).

Dams are not the only reason why these fish go extinct, but they play an important role. Around the world, more than 40,000 large dams have been built since the 1950s, and 3,700 further dam projects are pending. Many of these projects are planned in areas that are considered biodiversity hotspots, including the Amazon, Congo and Mekong Rivers. It is estimated that these dams will alter 93 per cent of the river volume worldwide, which means they have an impact on almost all global habitats of freshwater fish.

Event — Chinese Paddlefish Extinction

Key root causes:

- Global demand pressures
- Full environmental costs undervalued in decision-making

Wider picture / a symbolic event of:

Freshwater ecosystems represent only 1 per cent of Earth's area but host more than 51 per cent of the known fish species, which provide the equivalent of the total animal protein consumption of 158 million people. IUCN declared at least 80 freshwater fish extinct, and one out of every three freshwater fish species is threatened by extinction. In the last 50 years, the population of migratory fish has fallen by 75 per cent; in the same time period the population of larger fish species has fallen by 94 per cent.

A world without freshwater fishes is a very concerning (and depressing) one, particularly for developing countries where fishing represents a major source of income and fish are part of the daily basic diet.

Location: Yangtze River, China

Category: Biodiversity loss

Date/duration: 'Functionally extinct' since 1993, officially declared extinct by the International Union for Conservation of Nature (IUCN) in January 2020

Key figures:

7 metres
maximum length. One of the largest freshwater fish

43%
of the wild freshwater fish harvest comes from 50 low-income, food-deficient countries

Every 3rd freshwater fish species is threatened by extinction

Key impacts:

Loss of biodiversity and ecological functions (e.g. relaxation of top-down control of prey populations)

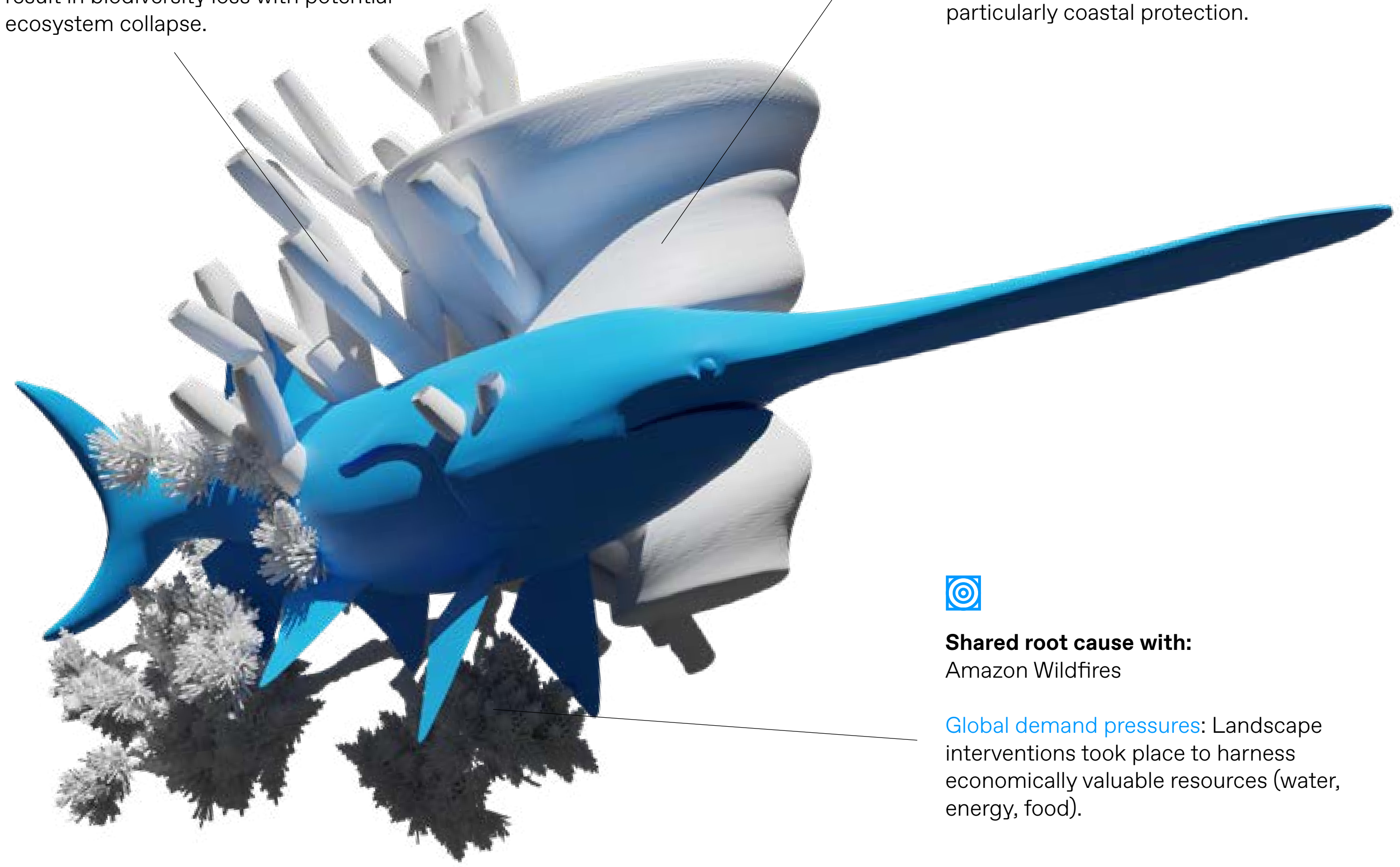
Key interconnections:

Shared emerging risks with:
Great Barrier Reef Bleaching

Biodiversity crisis: Coral bleaching and the Chinese Paddlefish extinction result in biodiversity loss with potential ecosystem collapse.

Shared root cause with:
Cyclone Amphan

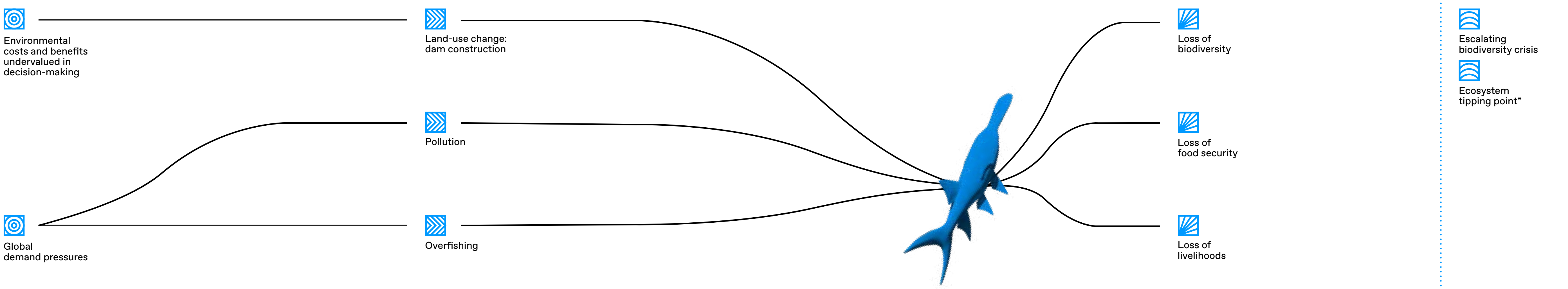
Environmental costs and benefits undervalued in decision-making: Dam construction leads to coastal erosion and loss of mangroves, which compromises ecosystem services, particularly coastal protection.



Shared root cause with:
Amazon Wildfires

Global demand pressures: Landscape interventions took place to harness economically valuable resources (water, energy, food).

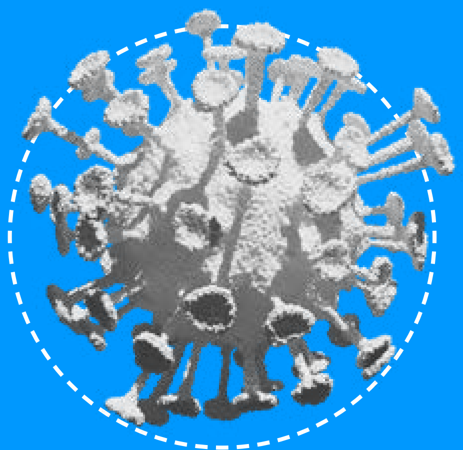
Root causes | **Underlying drivers** | **Arctic Heatwave** | **Impacts** | **Emerging risks**



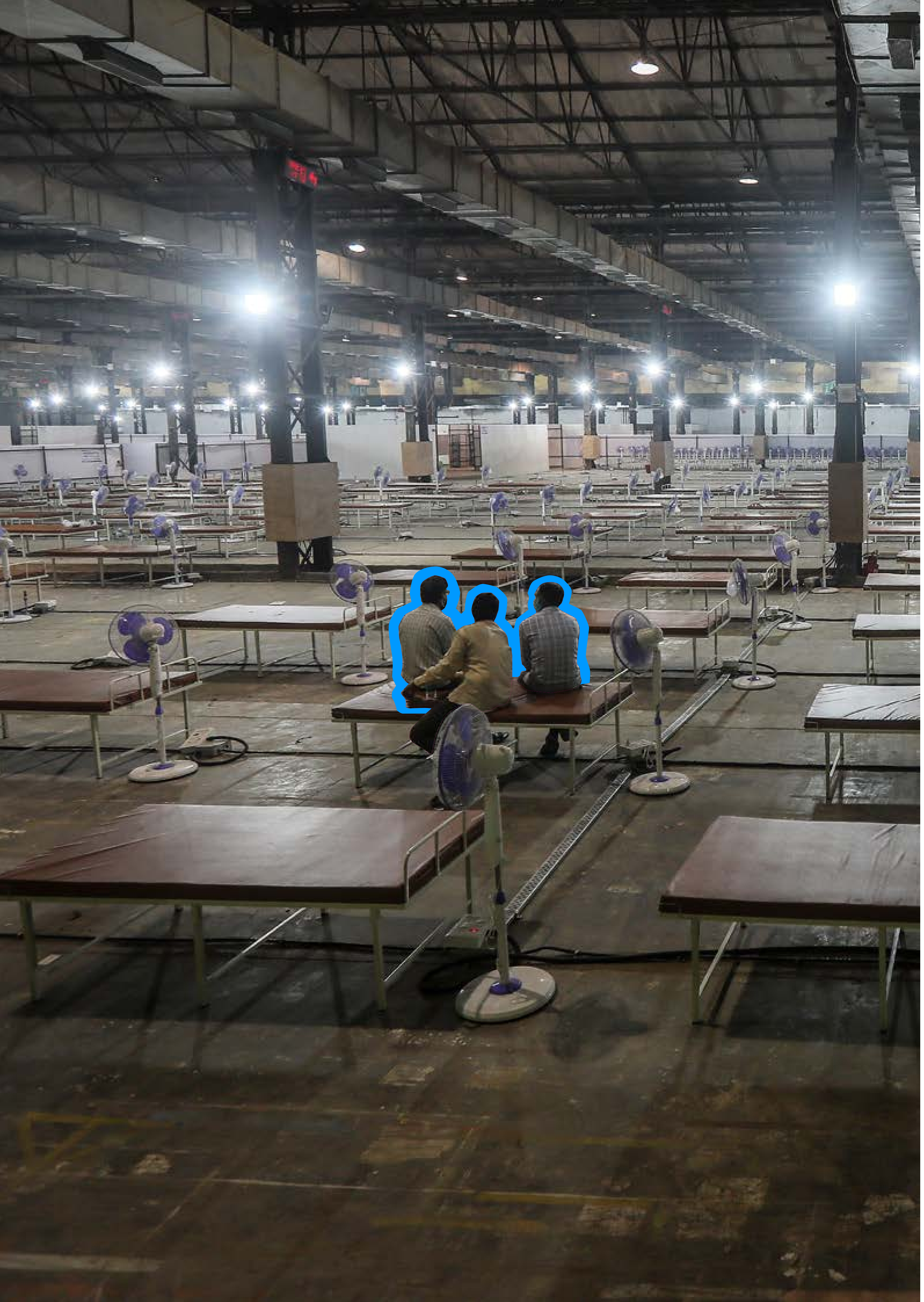
*See Technical Report for more information

Event COVID-19 Pandemic

How a pandemic is showing us the value of biodiversity



Human behaviour is largely to blame for the emergence of SARS-CoV-2 and for turning COVID-19 into a global pandemic that has so far caused over 4 million deaths globally and impacted the lives of millions more. ↳



Event COVID-19 Pandemic

When habitats are invaded or destroyed and exotic animals are hunted or traded, humans come close to animals in new ways, and they also come close to the diseases that these animals carry. SARS-CoV-2 is most likely a zoonotic disease, which means that it likely originated in wildlife and was transmitted to humans through close contact, possibly via animal markets[1]. Nearly every disease that has ever become a pandemic (influenza, Ebola, HIV/AIDS, SARS, etc.) was caused by zoonoses, and the frequency of these types of outbreaks has been increasing.

The increase in zoonotic diseases is not a coincidence. When humans destroy natural areas and habitats of animals, they also reduce biodiversity. As species disappear, the species that are able to persist in human-dominated landscapes are more likely to be zoonotic hosts, increasing the risk of spillover to people. In contrast, in less-disturbed areas with higher biodiversity, zoonotic hosts are less common as other species suppress their numbers. This means that biodiversity loss increases the risk of humans becoming exposed to zoonotic diseases.

But the impact of human behaviour did not end here: what makes COVID-19 particularly destructive is the unprecedented speed with which it spreads around the world. Despite the declaration of a Public Health Emergency by WHO in January 2020, governments did not implement effective containment measures for months; meanwhile humanity, in an age of globalization, moved faster. This allowed COVID-19 to become a disaster 'multiplier', which effectively amplifies the risk of current and future disasters. COVID-19 weakened the response capacity to any other disasters that took place simultaneously, and it is leaving behind people who are more vulnerable than before, be it because they are now poorer, have less food security, even greater gender inequality, or more. It is estimated that less than 0.1 per cent of the zoonotic viral risk has been discovered so far, hence there is great potential for future occurrences of zoonotic diseases. If humans continue to destroy biodiversity, keep increasing livestock farming and come closer to wild animals by intruding into habitats, the international community needs to better prepare, or COVID-19 will not be the last global pandemic in our lifetime.

[1] There is still a debate on whether SARS-Cov-2 could have also been first transmitted to humans in the Wuhan Institute of Virology, a laboratory researching bat coronaviruses. Still, even if this hypothesis turns out to be correct it remains essential to discuss the risk of zoonotic disease emergence.

Event COVID-19 Pandemic

Key root causes:

- Global demand pressures
- Full environmental costs undervalued in decision-making
- Insufficient disaster risk management
- Prioritizing individual profits
- Insufficient national/international cooperation

Wider picture / a symbolic event of:

This is the second outbreak of a SARS virus in the last 20 years – the first was successfully prevented to become a pandemic.

The risk of a new emergence of zoonotic diseases is increasing, as livestock farming and encroachment increases. Their development into pandemics will also become more likely due to increased global mobility and interconnectedness.

Location: Global

Category: Biological hazard

Date/duration: December 2019 - ongoing

Key figures:

200 million
confirmed cases

4 million
deaths

Key impacts:

Lockdown measures / travel restrictions, health system collapses

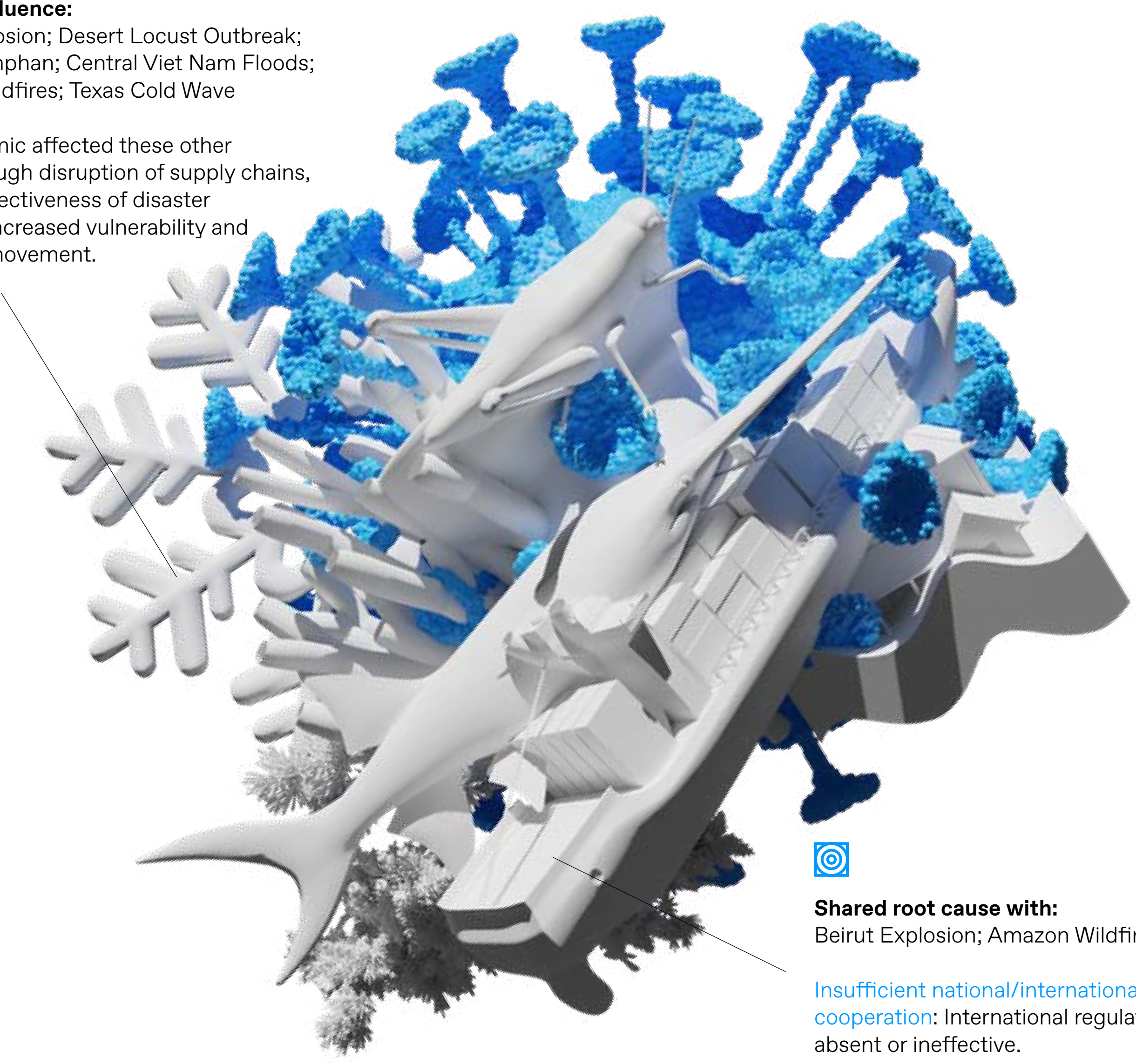
3.5%
decline in global economy

40%
rise in food prices from May 2020 to May 2021

Key interconnections:

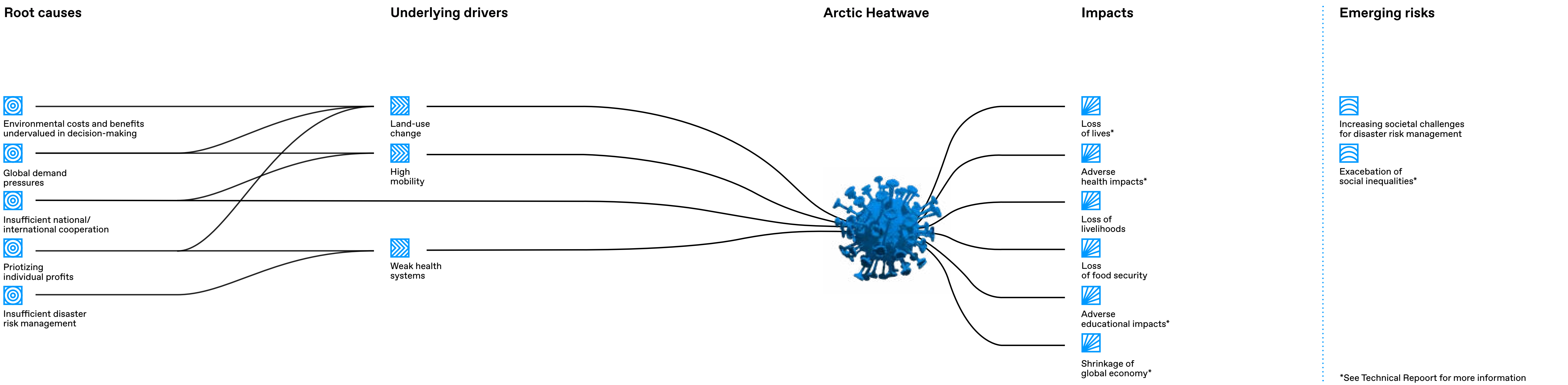
Indirect Influence:
Beirut Explosion; Desert Locust Outbreak; Cyclone Amphan; Central Viet Nam Floods; Amazon Wildfires; Texas Cold Wave

The pandemic affected these other events through disruption of supply chains, reduced effectiveness of disaster response, increased vulnerability and restricted movement.



Shared root cause with:
Beirut Explosion; Amazon Wildfires

Insufficient national/international cooperation: International regulations are absent or ineffective.



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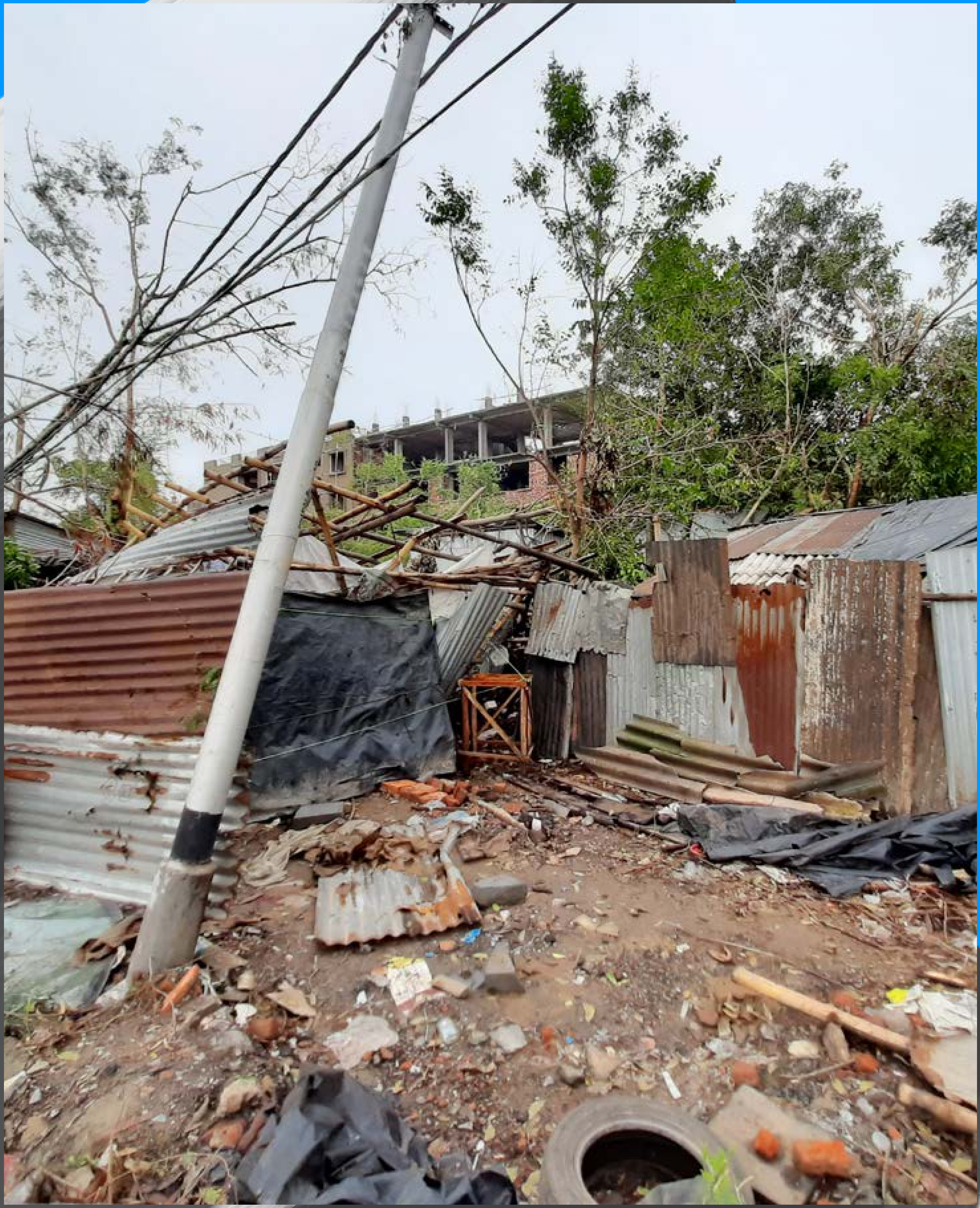


Event

Cyclone Amphan

When a cyclone and a pandemic combine

Super Cyclone Amphan is a lesson on the compounding effects that hazards, particularly novel (e.g. a global pandemic) or extreme (e.g. a super cyclone), can have when they co-occur, a scenario that is increasingly likely as the number of disasters per year continues to rise. ↱

Event Cyclone Amphan

The Sundarbans is a delta region characterized by one of the largest mangrove forests in the world that supports rich biodiversity, acts as a shelter belt from extreme weather and provides the livelihoods of millions of people, almost 50 per cent of whom are living under the poverty line. As an area that is struck by ever-intensifying storms and floods, and a combination of rising sea levels with damming of upstream rivers causing an increasingly eroded and saline coastline, the region's natural coastal defenses had already been weakened before Amphan hit.

When the COVID-19 pandemic struck, the subsequent lockdowns left many people without income options, including migrant workers who were forced to return to their home areas – including coastal rural areas like the Sundarbans – and housed in cyclone shelters while under quarantine. It was against this backdrop that Cyclone Amphan hit the area, a super cyclone that would have been devastating even without the ongoing pandemic. But the current situation was even more difficult for the population because the shelters were already crowded, and the local people largely avoided evacuating to them because they were concerned over social distancing, hygiene and privacy. While the pandemic made it more difficult to prepare for the cyclone, the cyclone in turn also worsened the conditions for pandemic response in its aftermath. It damaged close to 6,000 primary health centres and sub-centres, thereby exacerbating the strain on the existing health systems in the region. In addition, the cyclone had an impact on the pandemic spread. It destroyed homes where people had previously been able to distance themselves from others and it forced people into riskier behaviours because their livelihoods were destroyed. As a consequence, more people were put in the path of infection risk.

Event | Cyclone Amphan

Key root causes:

- Full environmental costs undervalued in decision-making
- Insufficient disaster risk management
- Human-induced greenhouse gas emissions

Wider picture / a symbolic event of:

Globally, there was a record-tying 103 named cyclones in 2020 alone, accounting for over 1,300 deaths and over $73 billion in damages. Of these cyclones, Amphan is notable for the severe impacts on vulnerable communities due to the compounding effect of the COVID-19 pandemic.

The likelihood of severe storms is set to increase, as are levels of population and development in vulnerable coastal zones, while ecosystem services and protection from coastal ecosystems are literally being eroded. Without integrated coastal zone management, loss and damage of coastal settlements due to storms is likely to increase in the future to a point where recovery is no longer feasible. In addition, however, as novel events and pandemics are predicted to increase in the future, multi-hazard events where different types of events co-occur (in this case a cyclone and a pandemic) must also be given more consideration in risk planning.

Location: Border region of India/Bangladesh (the Sundarbans)

Category: Extreme Weather

Date/duration: 20 May 2020

Key figures:

260 km/h
max wind speed. Category 5 (storm surge up to 5 metres high)

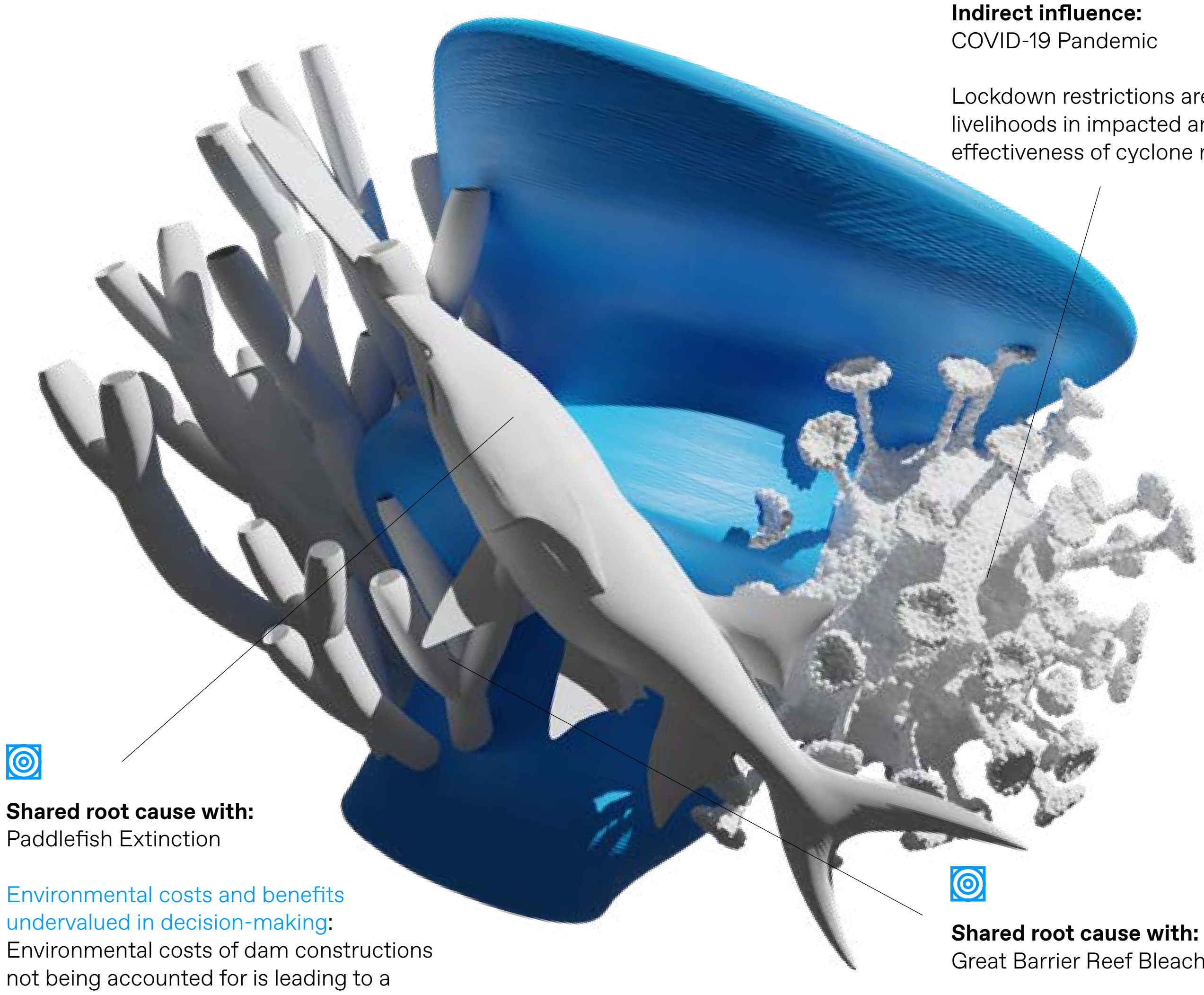
Key impacts:

$13 billion
cost of damages

4.9 million
people displaced

100+
deaths

Key interconnections:



Indirect influence:
COVID-19 Pandemic

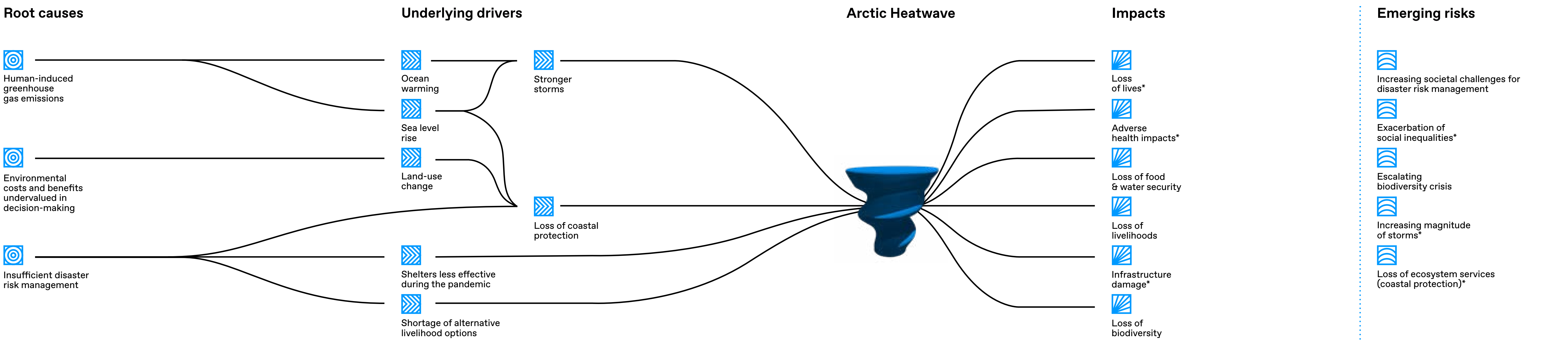
Lockdown restrictions are causing loss of livelihoods in impacted areas and reducing effectiveness of cyclone response options.

Shared root cause with:
Paddlefish Extinction

Environmental costs and benefits undervalued in decision-making: Environmental costs of dam constructions not being accounted for is leading to a loss of biodiversity in coastal mangroves, which compromises ecosystem services, particularly coastal protection.

Shared root cause with:
Great Barrier Reef Bleaching

Human-induced greenhouse gas emissions: Driving higher sea-surface temperatures are contributing to both coral bleaching and more intense cyclones.



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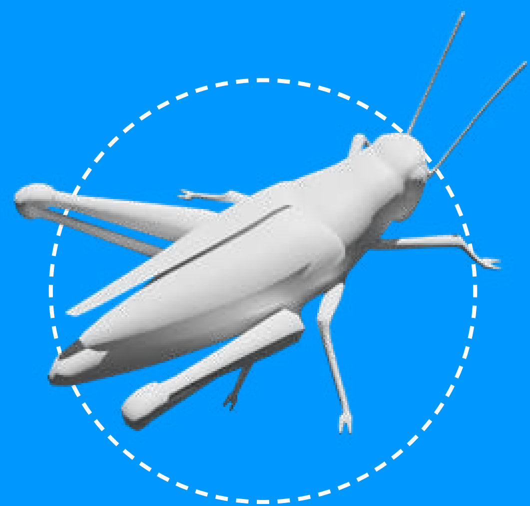
Event · Desert Locust Outbreak

How manageable risks spin out of control



Locust infestations have been considered a pest since antiquity, but in the past 120 years humans have generally become much better at managing locusts, having learned how to contain them before they turn into large infestations. ↱

Event Desert Locust Outbreak

However, despite having this knowledge, we frequently still fail at locust management. Starting in 2018, a series of unfortunate events unfolded that led to this opportunity being missed, allowing swarms of desert locusts to form and spread across 23 countries on multiple continents between 2019 and 2021, devouring their weight in vegetation every day. Desert locusts destroy vegetation extremely rapidly: a swarm covering 1 km^2 consumes as much food as 35,000 people in one day, and these swarms were often much larger. One mega-swarm alone, measured in Kenya in 2020, was the size of the country of Luxembourg.

It began with climate change and a series of cyclones that created favourable conditions for locust breeding in the Arabian Peninsula. Political conflict and insecurity in Yemen, and later in the course of the outbreak in Somalia, rendered some breeding areas inaccessible even after they had been identified, such that the initial outbreak was not curbed. The ongoing cyclones with their strong winds subsequently supported the migration of swarms far into Africa and Southeast Asia, where the locusts not only destroyed crops, but also fodder for farm animals to the point of leading to the starvation of animals. Ultimately, the large-scale vegetation loss directly threatened the livelihoods and nutrition of an estimated 42 million people already at risk from food insecurity.

In this way, missing crucial intervention points due to regional and local barriers to management led to 23 countries facing serious impacts over food security and livelihoods. Climate change predictions indicate that conditions favouring desert locust outbreaks will likely occur more frequently in the future.

Event | Desert Locust Outbreak

Key root causes:

- Full environmental costs undervalued in decision-making
- Insufficient disaster risk management
- Human-induced greenhouse gas emissions
- Insufficient national/international cooperation

Wider picture / a symbolic event of:

Wider context → Food insecurity, poverty and a comparatively high level of dependence on subsistence agriculture make the population of the most affected countries particularly vulnerable to crop losses, and lack of government funds and capacities hinder the implementation of adequate locust management.

Future context → Given their cyclic recurrence, desert locust outbreaks will continue to be a hazard in the future, and may become more frequent and severe as climatic changes, including ocean warming, foster weather conditions that are favourable for swarm emergence.

Location: 23 countries in total, 8 countries in the Horn of Africa most strongly affected (Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Uganda, Tanzania)

Category: Biological hazard

Date/duration: 2019 – present

Key figures:

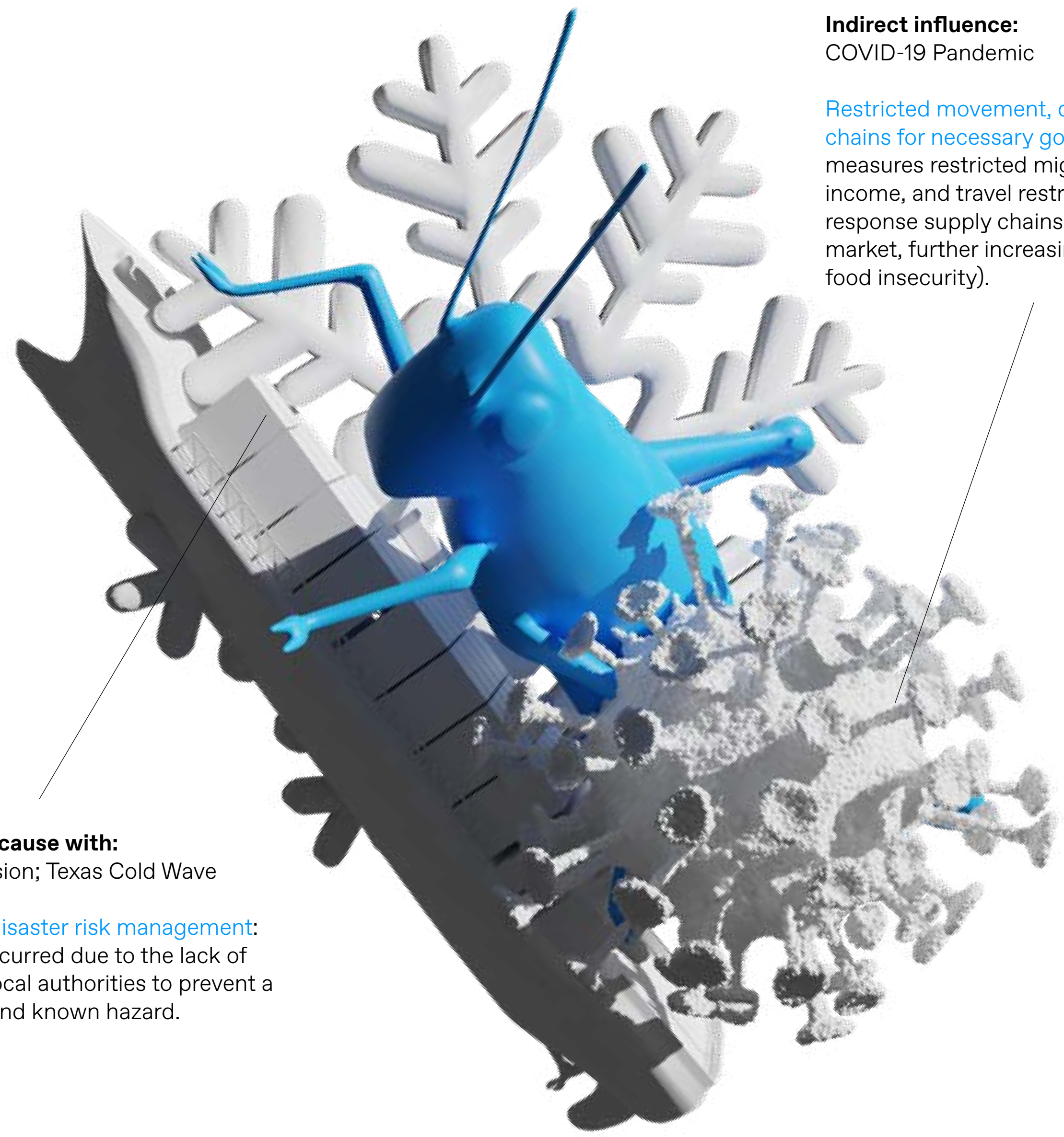
42 million
people at risk of food insecurity

$312 million
request from the Food and Agriculture Organization (FAO) in funding to fight the outbreak

2 million ha
of land in 10 countries targeted for treatment in 2020 and 2021

Key impacts:
Destruction of vegetation: harvest losses and loss of livestock fodder (livestock loss)

Key interconnections:

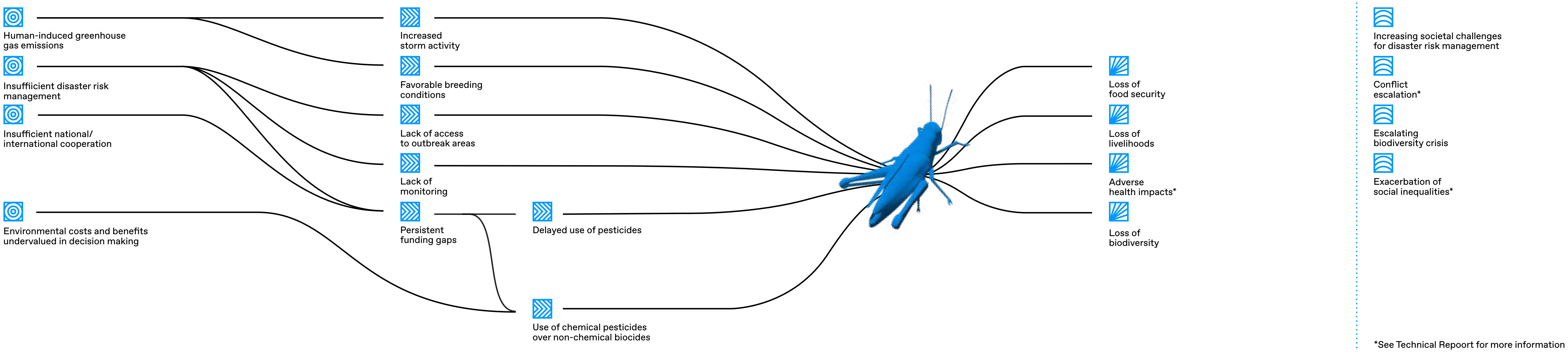


Indirect influence:
COVID-19 Pandemic

Restricted movement, disruption of supply chains for necessary goods: Lockdown measures restricted migration for alternate income, and travel restrictions disrupted response supply chains (including the food market, further increasing vulnerability to food insecurity).

Shared root cause with:
Beirut Explosion; Texas Cold Wave

Insufficient disaster risk management: A disaster occurred due to the lack of capacity of local authorities to prevent a predictable and known hazard.



*See Technical Report for more information

Event

Great Barrier Reef Bleaching

Losing more than a natural wonder

The Great Barrier Reef, a natural wonder, is usually associated with colourful fish and incredible beauty. But beyond its pretty looks, the Great Barrier Reef and coral reefs like it around the world provide essential services to ecosystems and local communities. ↱

Event

Great Barrier Reef Bleaching

Between a quarter and a third of all marine species spend a part of their lifecycle in coral reefs. Nearly a billion people depend on corals for their livelihood and food security, for example through related tourism business and fishing. Corals also protect coastlines and those living in close proximity to the coast. Reefs break waves and reduce current velocities and as such greatly contribute to coastal risk reduction. Approximately 200 million people are estimated to depend on coral reefs for protection from storm surges and waves. But currently we are losing our corals at an unprecedented level around the globe. The Great Barrier Reef experienced the most widespread amount of bleaching in 2020; and this for the third time in only five years. Increasing carbon dioxide emissions around the world have led to ocean warming with record sea surface temperatures that contribute to coral heat stress, resulting in bleaching. When water is too warm, corals expel the algae (zooxanthellae) living in their tissues, causing the coral to turn completely white. Corals can survive a bleaching event, but they are under more stress and are subject to mortality. If the ocean remains warm or turns even warmer, corals will no longer be able to recover and we would face a future without them. In a world where sea temperatures have risen 1.5°C, coral reefs will be seriously threatened; with a 2°C rise they will virtually no longer exist. At present rates, 60 per cent of coral reefs are expected to be endangered by 2030. Reefs are on a trajectory to collapse and could possibly be lost around the world by 2050, or soon after.

Event

Great Barrier Reef Bleaching

Key root causes:

- Global demand pressures
- Human-induced greenhouse gas emissions

Wider picture / a symbolic event of:

Third mass bleaching in five years. Global coral cover has declined 50–75 per cent over the past 30–40 years, and since the 1990s the number of corals on the Great Barrier Reef have already declined by more than 50 per cent. The last global bleaching event, 2014–2017, spread across the Pacific, Indian and Atlantic Oceans; it was the longest, most pervasive and destructive coral bleaching incident ever recorded.

Risk of a 'no-coral future'. Corals take about 10 years to recover fully from bleaching events and can't recover if they remain under continuous stress by e.g. ocean warming. We could lose these wonderful habitats as we know them, and all the essential services we derive from them, potentially leading to loss of food security and biosphere integrity.

Location: Great Barrier Reef, Australia

Category: Biodiversity loss

Date/duration: Australian summer, 2020

Key figures:

2,300 km

of reef system affected by bleaching, with one quarter of the Great Barrier Reef suffering severe bleaching

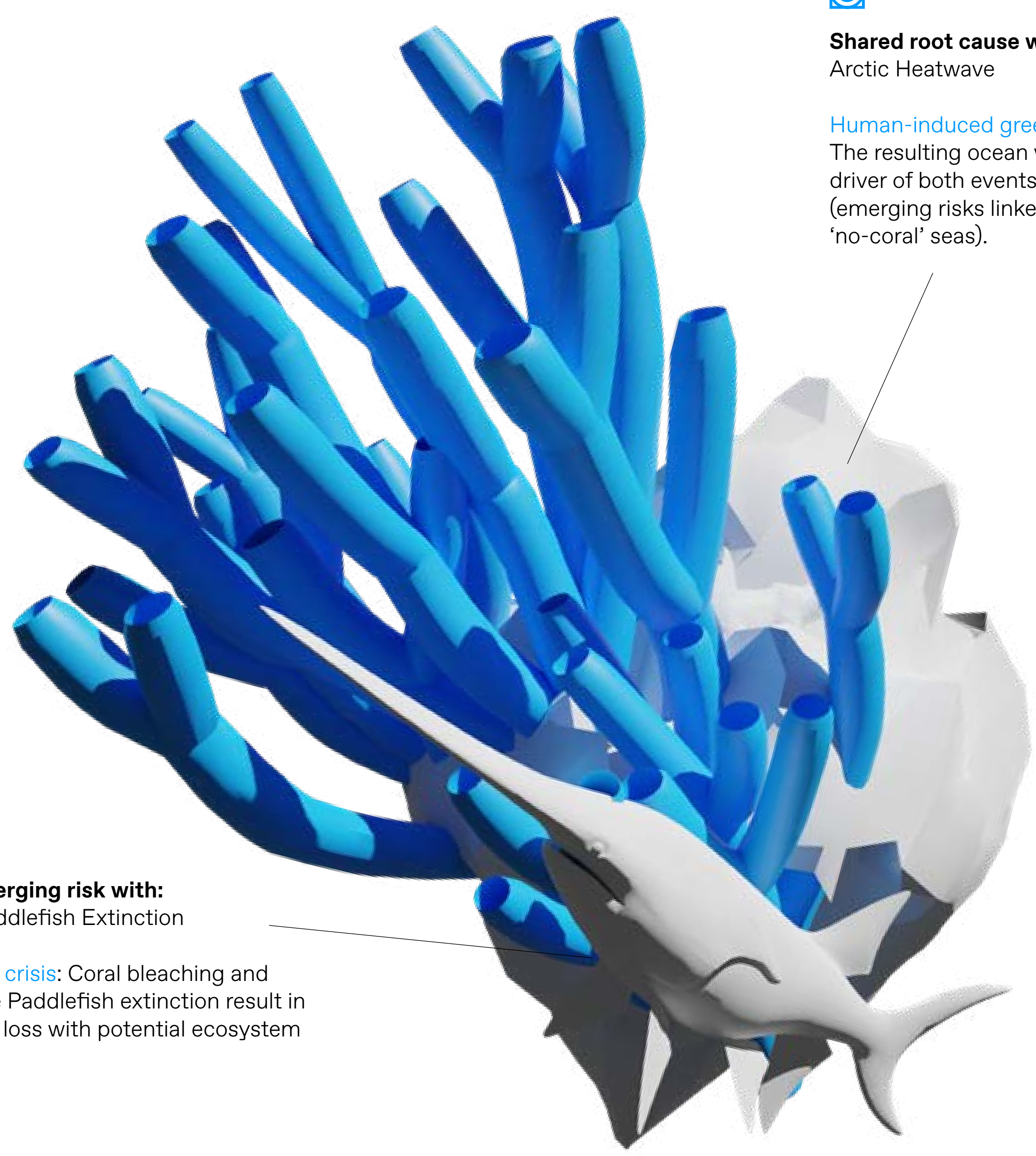
25%

of the Great Barrier Reef suffered severe bleaching

Key impacts:

Loss of biodiversity, coral mortality

Key interconnections:



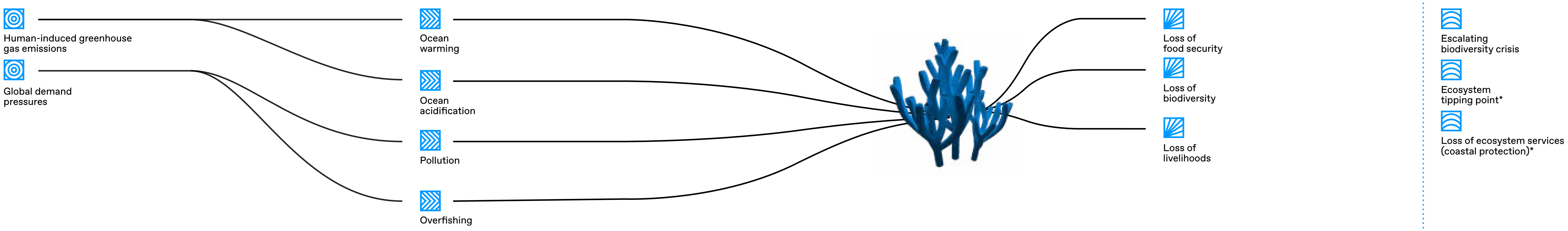
Shared root cause with:
Arctic Heatwave

Human-induced greenhouse gas emissions: The resulting ocean warming is the main driver of both events; grim future for both (emerging risks linked to 'no-ice' Arctic and 'no-coral' seas).

Shared emerging risk with:
Chinese Paddlefish Extinction

Biodiversity crisis: Coral bleaching and the Chinese Paddlefish extinction result in biodiversity loss with potential ecosystem collapse.

Root causes | **Underlying drivers** | **Arctic Heatwave** | **Impacts** | **Emerging risks**



*See Technical Report for more information

Event · Texas Cold Wave

A preventable catastrophe?

The powerful cold wave that swept over much of North America in February 2021 was a rare but not unprecedented event. In fact, similar cold waves occurred in 1989 and 2011, and the United States' state of Texas had encountered similar problems then. Still, when the cold wave hit in 2021, it found Texas poorly prepared. ↱

Event Texas Cold Wave

Texas is the only state of mainland United States that has its own electrical grid, which intentionally does not connect to the country's other power grids, to avoid federal regulations. This has resulted in the Texas energy supply being both isolated and largely deregulated. During previous winter storms, many generators failed, but in the Texas deregulated, market-based system, energy producers had barely any incentive to invest in cold weather protection; after all, in the average year they are much more affected by heat than by cold. In a state that prides itself on being independent and having freedom of choice, the free market and deregulation were prioritized over more disaster-resilient infrastructure.

As a result, when yet another winter storm hit in 2021, Texas found itself hardly better prepared than before. A number of power facilities went offline due to the freezing temperatures; in fact, at one time 48 per cent of power generation capacity was offline. With record cold temperatures and poorly insulated homes, there was also a surge in demand for electricity. Since the Texas electric grid is isolated from the rest of the country, power could not come from anywhere else other than within Texas. Because demand soon exceeded supply, the electric companies had to rely on rolling blackouts, which effectively cut power for around 3.5 million Texans. Without power to heat their homes, 210 people died, mostly from hypothermia.

Overall, the course of events was largely preventable: had power companies built in more resilience, most of the effects could have been prevented. But on a larger scale this is also a story of supply and demand. As long as Texans continue to demand a system that favours cheap electricity over safety and security, this disaster will be one of many.

Event | Texas Cold Wave

Key root causes:

- Insufficient disaster risk management
- Human-induced greenhouse gas emissions
- Insufficient national/international cooperation
- Prioritizing individual profit

Wider picture / a symbolic event of:

The same cold wave events also disrupted the delivery of electricity in Texas in 1989 and 2011, while jet stream disruptions in January/February 2021 caused energy crises in the European Union, China and Japan as Arctic temperatures moved south.

Emerging issues of critical infrastructure being caught unprepared for climate extremes.

Location: Texas, United States

Category: Extreme weather

Date/duration: February 11th – 20th 2021

Key figures:

86
consecutive hours below freezing

-22°C
colder than average in some areas

Key impacts:

3.5 million
people without electricity, infrastructure damaged / frozen

210
deaths

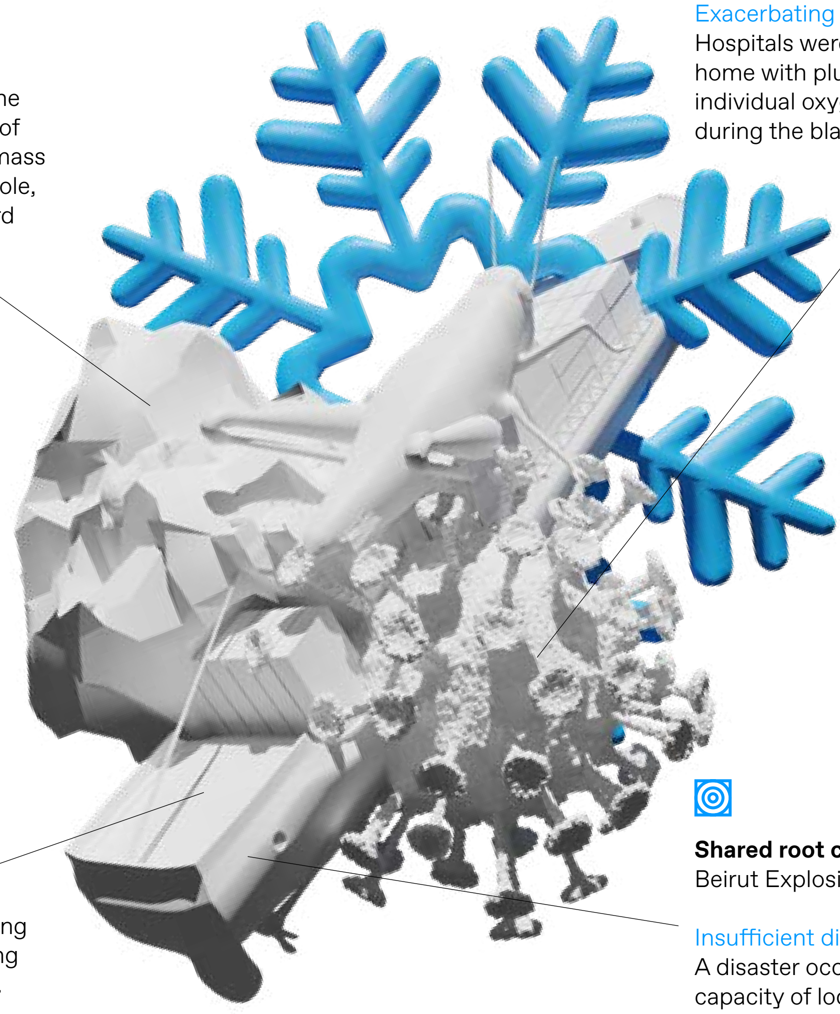
Key interconnections:

Direct Influence:
Arctic Heatwave

Increasing temperatures in the Arctic influence the stability of the polar vortex, a spinning mass of cold air above the North Pole, allowing it to move southward into North America.

Indirect Influence:
COVID-19 Pandemic

Exacerbating COVID-19 pandemic: Hospitals were at capacity, sending people home with plug-in breathing machines or individual oxygen canisters which failed during the blackouts.



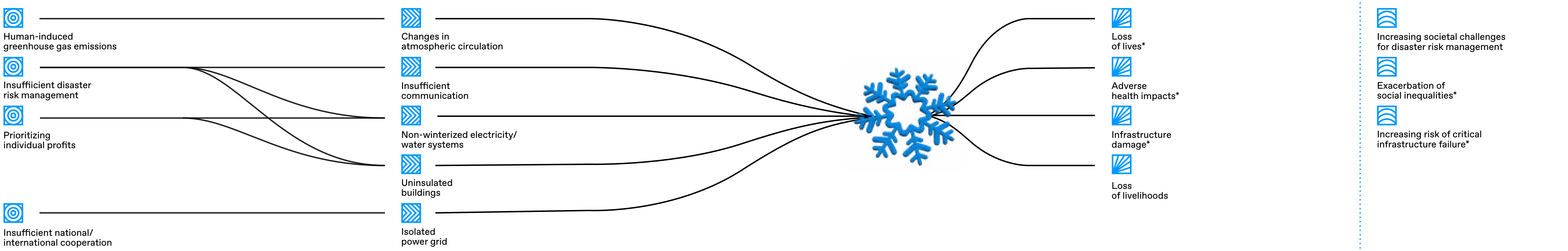
Shared root cause with:
Beirut Explosion

Prioritizing individual profits: 'Race to the bottom' impacting security standards, presuming cheapest strategies are best.

Shared root cause with:
Beirut Explosion; Desert Locust Outbreak

Insufficient disaster risk management: A disaster occurred due to the lack of capacity of local authorities to prevent a predictable and known hazard.

Root causes | **Underlying drivers** | **Arctic Heatwave** | **Impacts** | **Emerging risks**



*See Technical Report for more information

Chapter 3

Connecting the dots: Interconnectivity, root causes and emerging risks

"When we try to pick out anything by itself, we find it hitched to everything else in the universe."
John Muir

Section 3.1

Deep dive into the interconnectivity of 10 disastrous events

Globalization, the process of interaction and integration among people, companies and governments worldwide, has been accelerating since the 18th century due to advances in transport and communications, and as a result our world has become more interconnected than ever. This has created countless benefits and opportunities, but also increased the risk of cascading impacts when failures occur. The interconnected world we live in is a living, evolving system, and the disastrous events we see are often the results of systemic failures. Even more importantly, new risks emerge with the interconnections between different kinds of systems, such as between our energy, food and water systems, or ecosystems and climate (Helbing, 2013).

Once we start thinking in a systematic way, we become aware of the structures around us and that we are part of, and move from observing singular events to analysing patterns. The interconnections of root causes, drivers and impacts become easier to find, and it helps us see the bigger picture (Goodman, 2018). For example, what do Arctic ice melting, coral reef bleaching, a super cyclone forming, a United States city freezing and a swarm of locusts have in common? They can all, in part, be traced back to our continued emissions of greenhouse gases (GHG) and resulting global warming (see **Root Cause #2**). The following chapters will outline how each of the events in Chapter 2 is connected at multiple levels to each other and, in turn, to each of us.

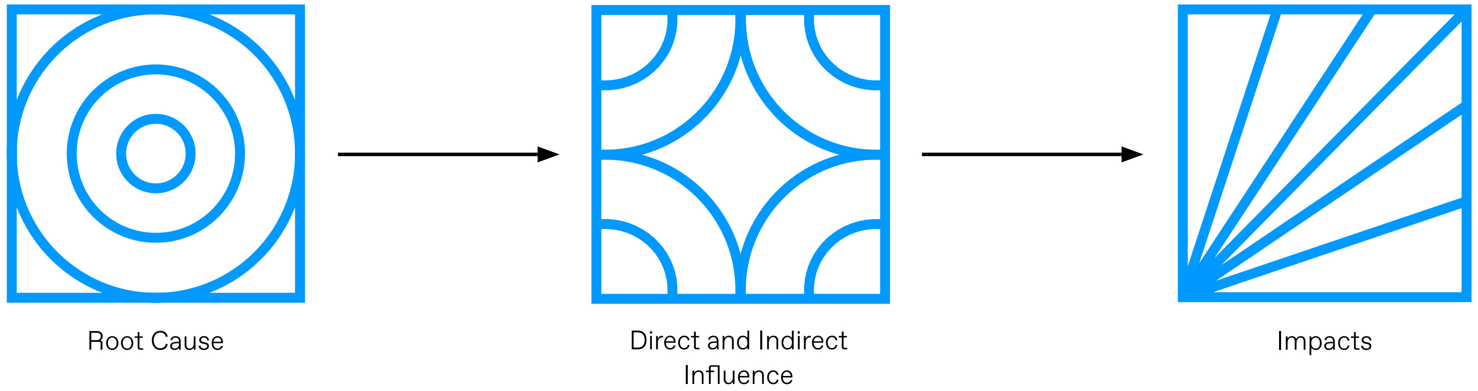
Section 3.1.1

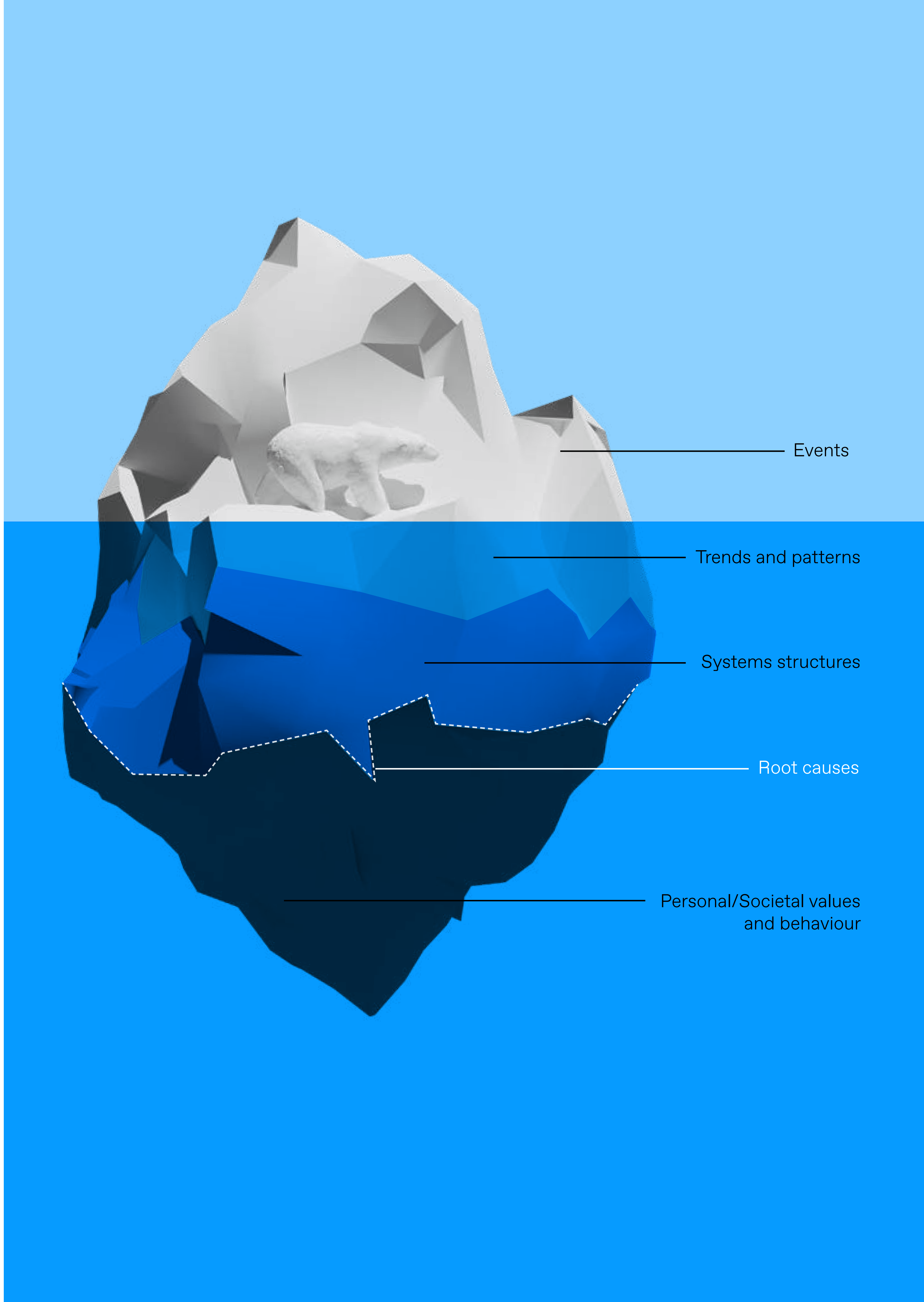
How disastrous events in 2020/2021 are interconnected

To investigate interconnectivity between the 10 diverse events of 2020/2021, we primarily looked at three levels of links between causes and effects for each event, and then looked for patterns in these levels across events where interconnections between them could be identified (Figure 1). The first analysis was at the level of root causes, identifying disastrous events that stem from the same underlying factors.

Then we analysed the level of influence between the disastrous events themselves, either where one event directly exacerbated the hazard of another (e.g. a cyclone creating conditions increasing the likelihood or severity of a locust swarm), or where an event had indirect influence on the exposure or vulnerability of people and/or places to another event. Lastly, we looked at shared impacts, where the disparate impacts of events line up to accelerate the same types of future risks.

Fig. 1: Levels of interconnectivity analysis for each event





Shared Root Causes - Intertwining Underground Roots

In order to identify root causes using a systems-thinking approach[2], we used an adapted version of the iceberg model, which uses the analogy of an iceberg to look below the surface of an event to search for the underlying root causes (Maani and Cavana, 2007). The events presented in **Chapter 2** represent the tip of the iceberg, only a small portion that we can see above the water. This is how we perceive disasters, and is where the media and discussions usually tend to focus.

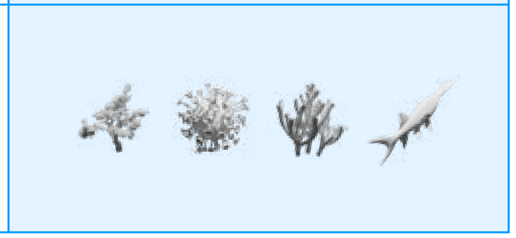
Just below the surface, we can see patterns emerging in underlying drivers that are common between different events, such as overfishing or deforestation. Diving deeper, we come to the systems and structures that cause the patterns we see and reveal how they relate and affect one another. These structures can be physical things (e.g. infrastructure), organizations (e.g. corporations or governments), policies (e.g. laws and regulations), or behavioural patterns (e.g. unsustainable consumption). At the very bottom of the iceberg, we find the attitudes, beliefs and morals that influence choices on both the personal and societal levels and underpin existing system structures. Here, at the boundary between systems and the behaviours that sustain them, we find the root causes.

Taking one example from outside our 10 disastrous events: in 2013 a building collapsed in Dhaka, Bangladesh, killing over 1,000 people (the tip of the iceberg). Despite risks due to poor building standards being identified previously, the economically-vulnerable workers were made to continue working in the garment factories located there (underlying pattern). These garment factories in developing countries serve a $2.4 trillion global fashion industry that employs about 40 million of the world's poorest workers, often in dangerous conditions (Rahman and Yadlapalli, 2021) (system structure). This system is underpinned by various factors, including our desire to buy clothes as cheaply as possible (root cause). By using 'umbrella terms' to encompass similar root causes, we identified the six most commonly shared root causes behind the 10 events presented in **Chapter 2**.

These shared root causes illustrate how seemingly disconnected events link back to the same sources but reveal themselves in different ways (figure 2). For example, the influence of human-induced GHG emissions on different systems lay behind 7 out of 10 events in either direct ways, by increasing the frequency or intensity of specific hazards, or in indirect ways, by increasing exposure or vulnerability to certain hazards. Through drivers such as ocean warming, drought conditions and positive feedback loops, human-induced GHG emissions have far-reaching consequences, and will contribute to disastrous events in the future unless swift, impactful action is taken. Insufficient disaster risk management was another one of the most common shared root causes, also linking 7 out of 10 events, and was related to issues of exposure and vulnerability – including issues of risk perception, risk governance, facing novel or extreme events and funding resources. Although different reasons and contexts were related to this root cause for each event, ultimately the events became disastrous as the measures put in place to minimize the impact were overwhelmed.

Importantly, this does not equate to wrongdoing on the part of risk managers, but should be viewed as an opportunity to identify ways to improve resilience for future events. Another root cause was related to governance and was found in 6 out of 10 events, namely that environmental costs were being undervalued in decision-making. This root cause connected events where decisions following economic or development priorities led to environmental impacts that again either directly caused the event, indirectly increased vulnerability to the hazard or exacerbated the impacts of the event. Each of these three most common root causes is explored in more depth in **Chapter 3.2**.

[2] A 'systems-thinking approach' is a way of problem solving by looking at how things interact in a system, rather than in isolation.

Table 1 Primary root causes 2020/2021 (featured in Chapter 3.2)		**Shared events**
(7/10)	**Human-induced greenhouse gas emissions** (Gases released to the atmosphere by human activities which contribute to increasing global warming and climate change)	
(7/10)	**Insufficient disaster risk management** (Cases in which a lack of perception, awareness or preparation in governance towards risk management and response resulted in exacerbated impacts to extreme or novel events)	
(6/10)	**Environmental costs and benefits undervalued in decision-making** (Pursuit of economic or developmental interests where a lack of consideration for the impacts on environmental services increaseed vulnerability to hazards)	
(5/10)	**Insufficient national/international cooperation** (Lack of coherent national/global governance, unregulated exploitation of low and middle-income countries, limited governmental capacity)	
(4/10)	**Prioritizing individual profits** (Cases where maximizing profit is prioritized over other social concerns, increasing risk, for example lack of effective regulation and accountibility along global value chains)	
(4/10)	**Global demand pressures** (Pressure related to increaing consumptive demands for goods, such as food, energy or industrial materials)	

Event key

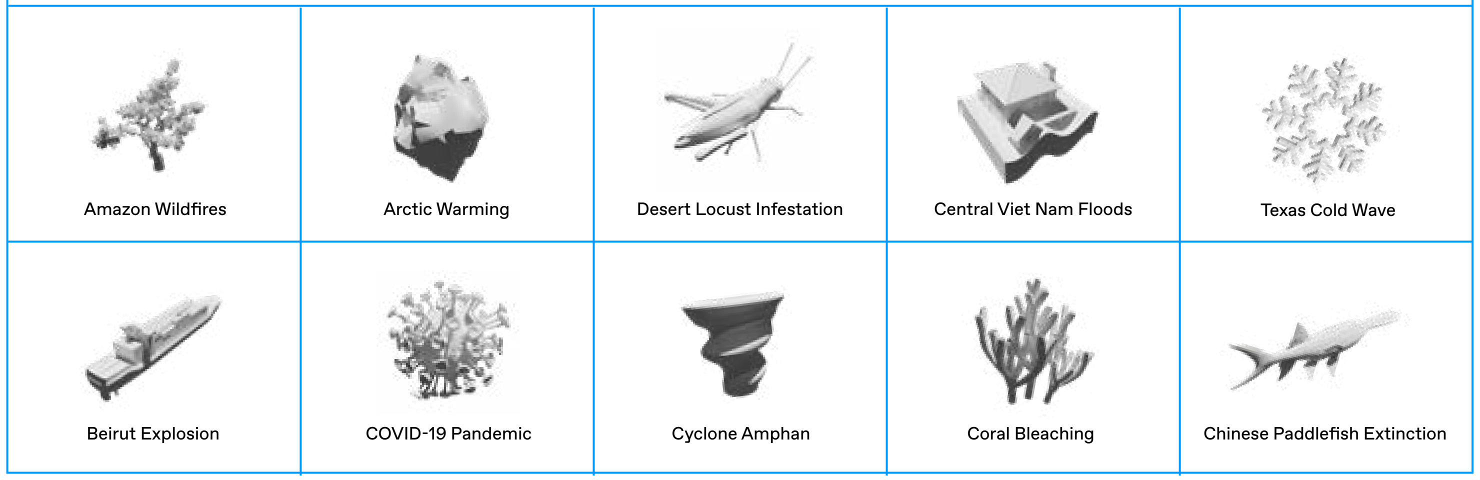
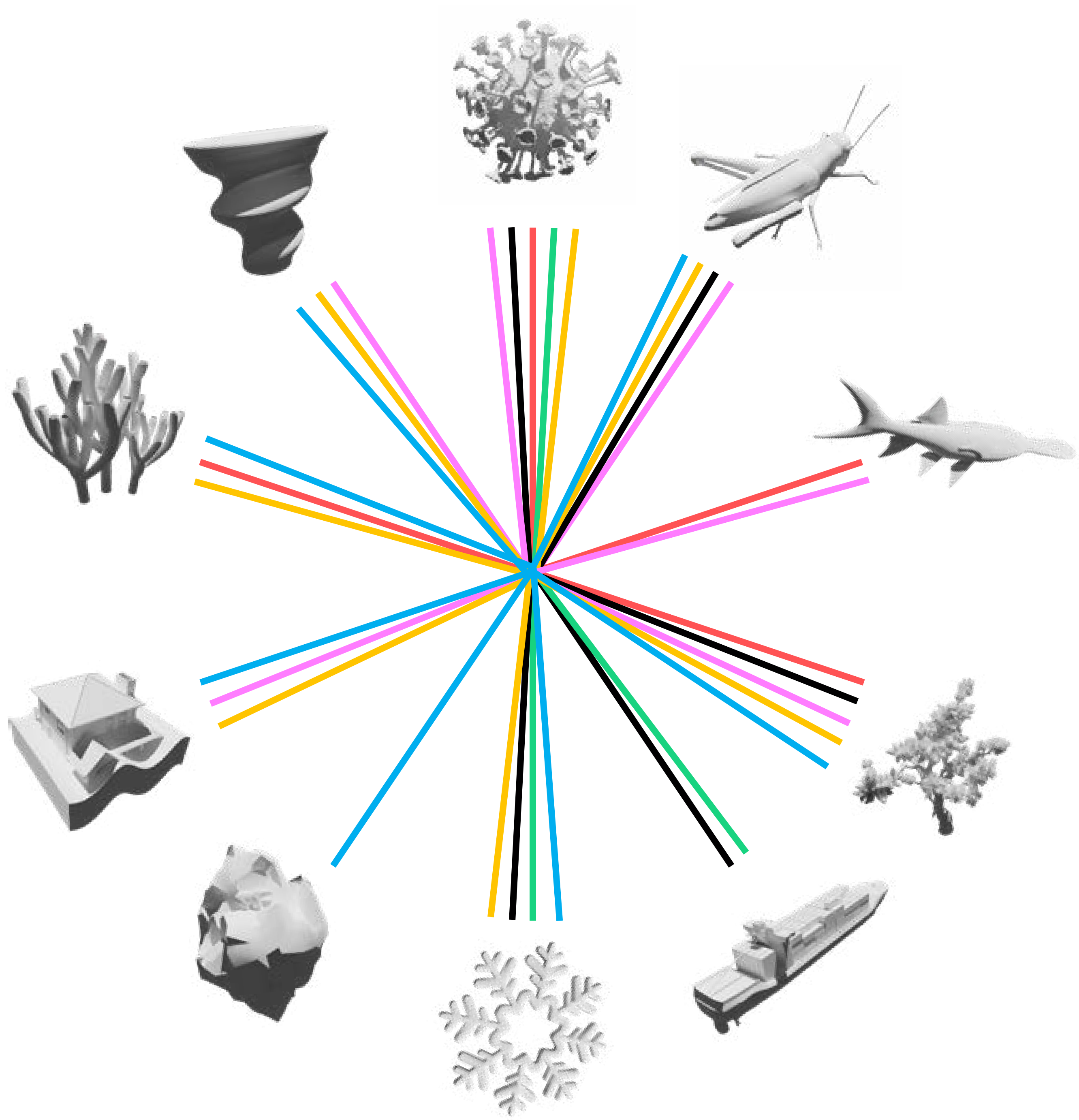


Fig. 2: interconnectedness of the 10 events with their root causes, which in turn have complex interactions



Root causes

Global demand pressures
Insufficient national/international cooperation
Prioritizing individual profits
Human-induced greenhouse gas emissions
Insufficient disaster risk management
Environmental costs and benefits undervalued in decision-making

Other prominent shared root causes determined from our analysis relate to insufficient national or international cooperation, where a lack of coherent policy, communication or enforcement between government bodies increased risk in areas where danger should have been manageable. This root cause manifested at both the national level (e.g. the isolation of the Texas power grid from the rest of the United States prior to the cold wave) and the international level (e.g. shortcomings in international governance contributed to increased risk behind the Beirut explosion, COVID-19 pandemic, Amazon wildfires and desert locust outbreaks). In many cases, the effectiveness of this cooperation may be undercut by another root cause – profit prioritization – which may discourage governments or corporations from sticking to committed cooperation. For some events, the prioritization of profits superseded security concerns, thus increasing risk in the lead-up to the event. Examples include the lack of 'winterization' regulations in Texas and the open registries used in international shipping, where profit maximization and regulation minimization for ship operators creates conditions for the abandonment of ships, such as in the case of the Beirut explosion (see Technical Report, **Beirut Explosion**). Driven by a growing population and increasing development, the global demand pressures for certain foods, energy types or industrial materials drove events such as the Chinese Paddlefish extinction and the Amazon wildfires. These demand pressures also increased the risk of the Great Barrier Reef bleaching, through overfishing of ecologically-important species, and the COVID-19 pandemic, by increasing land-use change that escalates the likelihood of diseases spreading from animals to humans.

Adding to the complexity of the interconnections of different disasters with their root causes are the inseparable ways the root causes themselves are interconnected. Different root causes can have similar manifestations in events, indicating that the root causes are not so easily separated from each other. For example, human-induced GHG emissions play a role in insufficient disaster risk management, because as GHG emissions continue unabated, the impacts of climate change make effective disaster risk management more challenging as more extreme and novel disasters occur in more widespread areas (Coronese and others, 2019). The predicted rise in GHG emissions is driven by a strong rebound in demand for coal and gas in electricity generation, as well as subsidies for their production, showing the link between human-induced GHG emissions with global demand pressures and profit prioritization (IEA, 2021). These examples of connectedness between the primary root causes discussed in this report shows that they, like the events they cause, should not be considered in isolation if solutions targeting them are to be effective.

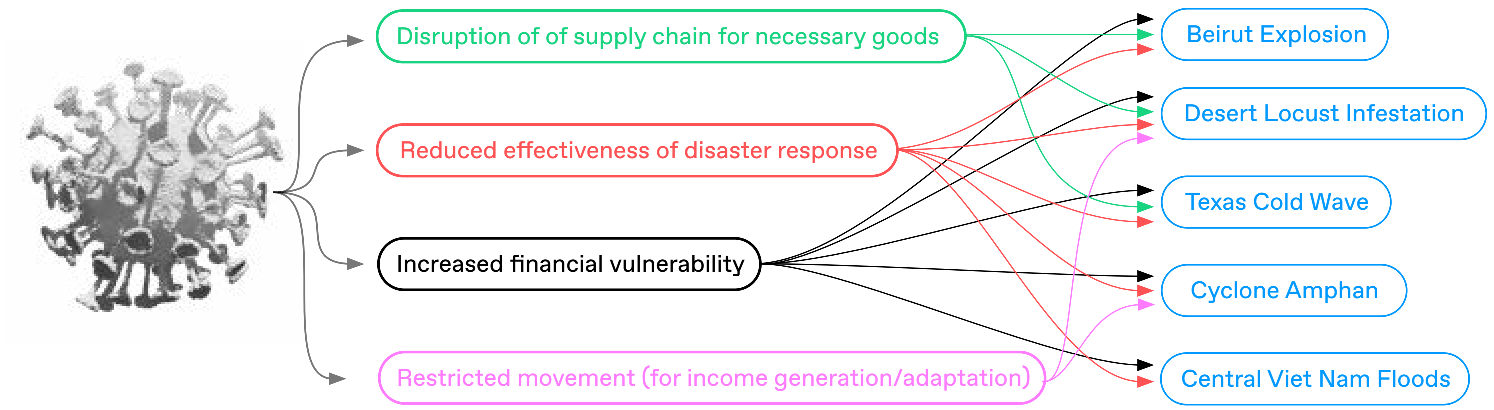
Direct and Indirect Influence -
When Extreme Events Combine

In addition to having shared root causes, disastrous events themselves can be interconnected either directly (one event directly influencing the formation of another) or indirectly (not causing the next event, but creating conditions which make its impacts more severe). An example of direct influence in the 10 events of 2020/2021 can be seen between the Arctic heatwave and the Texas cold wave. Driven by a process known as Arctic amplification, a feedback loop forms as sunlight-reflecting sea ice melts and more heat is absorbed by the ocean which, in turn, causes the sea ice to melt further. The heat exchange between ocean and atmosphere contributes to record high Arctic temperatures, often higher than the equivalent temperatures in Europe. The Arctic heatwaves can affect weather patterns in the mid-latitudes through changes in storm tracks, the jet stream and planetary waves (Cohen and others, 2014). Though debated in some scientific studies, this weakening of the jet stream may have allowed cold air to move down from the Arctic to create unusual and severely cold conditions in Texas (McSweeney, 2019).

In terms of interconnections where disastrous events compound the impacts of one another, 2020 saw a prime example in the COVID-19 pandemic. Through disruptions in the supply of necessary materials, reduced effectiveness of response, increased financial vulnerability and restricted movement, the COVID-19 pandemic exacerbated the impacts of several other co-occurring events in 2020/2021, creating compound events, or combinations of extreme events with underlying conditions that amplify each other's impacts (Seneviratne and others, 2012) (see **figure 3**). These exacerbated impacts hit hardest on the most vulnerable, putting these populations at an even higher risk (Phillips and others, 2020).

One of the ways in which the COVID-19 pandemic compounded disasters was by disrupting supply chains for necessary materials used in response to disasters, such as plumbing parts to repair homes in Texas (Agnew, 2021). During the desert locust outbreak, pandemic containment measures disrupted supply chains of equipment and pesticides, as well as response teams' ability to travel to affected regions to help combat the spread (Byaruhanga, 2020). The impacts on food supply chains also increased food insecurity, heightening the vulnerability of households to the impacts of locust swarms (Xu and others, 2021). Social distancing and travel restrictions from pandemic lockdowns also reduced the effectiveness of response to the other disasters, increasing their negative impact. Storm shelter capacity was reduced in both Cyclone Amphan and the Texas cold wave, limiting the number of people that could be protected without breaching social distancing regulations (Gordon, 2021; Mohanty and others, 2021).

Fig. 3: The COVID-19 pandemic as a 'disaster multiplier' for other disastrous events from 2020/2021



The COVID-19 pandemic also increased vulnerability to hazards by impacting the livelihoods of millions around the world and thus reducing their capacity to cope with extreme events. In Viet Nam, around 67 per cent of households reported a loss of income from the pandemic, decreasing their ability to cope and recover from the floods (Tran and others, 2020). Preceding Cyclone Amphan, for example, local workers in the Sundarbans, who predominantly rely on agriculture and aquaculture for their livelihoods, had their sources of income devastated when the pandemic caused lockdowns affecting local markets and trade. The extensive destruction and saltwater inundation of farming land during the cyclone further pushed people towards poverty and acute food insecurity (Ahammed and Pandey, 2021). This increased vulnerability links, also directly, to the effect of COVID-19 on freedom of movement, and its implications for disastrous events. For many affected by Cyclone Amphan and the desert locust outbreak, this was not the first time they had had to contend with such an event. Previously, a potential way to adapt when local livelihoods were destroyed was to temporarily migrate to other areas to work and send money back home. In 2020, however, the restrictions on movement due to COVID-19 narrowed the available options to respond to the disaster, which has implications for future disaster risk management (see **Chapter 3.2, Root Cause #2**).

Not only did the COVID-19 pandemic exacerbate the impacts of other events, but other events exacerbated the effects of the pandemic. For example, Lebanon had 4,022 COVID-19 cases before the blast, but two weeks later this number had increased to 10,347, partly due to mass protests and lowered precaution standards in hospitals and disaster response and recovery (El Sayed, 2020). Such a rise in cases of COVID-19 was also indicated in other events, such as areas affected by Cyclone Amphan, which showed an increase of ~70 per cent in cases between the periods before and after the storm (Kumar and others, 2021). Both the Beirut explosion and Cyclone Amphan destroyed health-care centres used to treat COVID-19 patients, highlighting the need for critical infrastructure to be made more resilient to extreme events (Meyers, 2020; IFRC, 2020). In addition to destroying infrastructure designed to prevent and treat COVID-19, some disasters also hindered recovery from the disease. Before the cold wave hit, Texas hospitals were so crowded that COVID-19 patients were often sent home with at-home, plug-in breathing equipment, which was unable to function in the power blackouts caused by the cold temperatures (Hixenbaugh and Trevizo, 2021).

The COVID-19 pandemic decreased individual, societal and governmental abilities to respond to other disasters, which had compounding impacts on lives and livelihoods. Such compounding impacts further heighten the vulnerability of our society to future disasters, particularly for the people least equipped to handle them (Kruczkiewicz and others, 2021).

“When viewed through the lens of interconnectivity, we begin to understand how each disastrous event builds on the impacts of the past and paves the way for the impacts of the future”

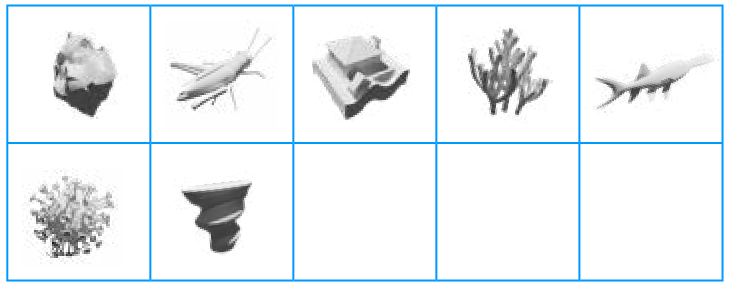
Shared Impacts -
Death by a Thousand Cuts

The disastrous events of 2020/2021 are linked not only by their causes, but also by their effects, and – as with root causes – we investigated patterns of common impacts stemming from each event. When thinking about the impacts of disastrous events in an interconnected way, it is important to consider cascading impacts as well as the ones immediately felt. For example, while the extent of pristine rainforest lost to wildfires in the Amazon region in 2020 is shocking, the cascading effect of this loss on biodiversity, freshwater provision and climate change will have broader implications for future risk. In other words: even when the flames are out, danger continues. This applies to all manner of disastrous events; the impacts we see in the media are just the beginning. In our analysis, we identified three primary types of shared impacts, namely loss of livelihoods, reduced food or water security, and loss of biodiversity.

Loss of livelihoods: **10/10**

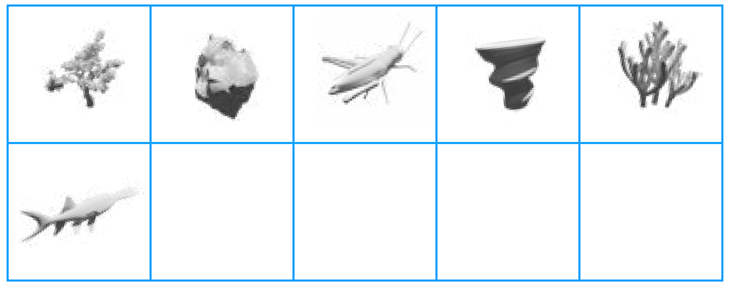
By far the most commonly shared impacts, found in 10 out of 10 events, were the loss of livelihoods as hazards damaged infrastructure and ecosystems essential for income generation, or otherwise removed or reduced the potential to earn a living. In some cases, the loss and damage inflicted by the events, and in turn the disruption to livelihoods, could take years to recover from, particularly in areas experiencing a greater frequency of recurring events (see Technical Reports, **Cyclone Amphan, Great Barrier Reef Bleaching**). In other cases, natural ecosystems are unlikely to ever return to their previous condition (see Technical Reports, **Amazon Wildfires, Arctic Heatwave**). For those with limited options for alternative livelihoods, the risk of poverty is heightened, and so in turn is their vulnerability to future events. Therefore, although disastrous events can strike anywhere, the poverty-disaster cycle is the most vicious in the most vulnerable regions (Hallegatte and others, 2018). Though many of the disasters harmed livelihoods in different parts of the planet, no event exemplified the vulnerability of people around the world to this cycle like the COVID-19 pandemic. It has contributed to a global economic recession that is driving unprecedented reversals of development gains for millions in developing countries, and increasing global inequality (United Nations, 2021).

Reduced food/water security: **7/10**



Several of the disastrous events in 2020/2021 contributed to reduced food and water security in impacted areas, either through damaging food production or water access infrastructure directly (see Technical Reports, **Desert Locust Outbreak, Cyclone Amphan**), or through increased financial vulnerability (see Technical Reports, **COVID-19 Pandemic**). Locust infestations in the Horn of Africa, the worst in 25 years, are causing significant crop and pasture losses affecting millions of people in countries already facing acute food insecurity due to recurrent conflicts and droughts (e.g. Kenya, Ethiopia and Somalia) (Integrated Food Security Phase Classification 2020). A world away, in the Arctic, subsistence hunters, who rely on the sea ice to access target species, are finding that disappearing ice is making hunting more dangerous and the abundance of prey declining, leaving a growing number of indigenous communities facing food shortages (Struzik, 2016). In addition to the extensive destruction of farmland and water infrastructure, flooding associated with Cyclone Amphan inundated thousands of square kilometres of coastal areas with seawater, exacerbating the problem of saltwater intrusion into groundwater reserves (driven also by sea level rise and a reduction in upstream water flow), and threatening the water security of people in the region (Kumar and others, 2020). COVID-19 impacts have led to severe and widespread increases in global food insecurity, with impacts expected to continue through 2021 and into 2022 (United Nations, 2020). Due in part to the disruption of food supply chains and local markets associated with pandemic restrictions, food prices are also surging, which – combined with the widespread loss of livelihoods – further exacerbates the threat to food security. The loss of food security is also interconnected with the next shared impact in this section: loss of biodiversity.

Loss of biodiversity: **6/10**



Humans are not the only ones who suffer the impacts of disastrous events. Extreme weather and climate change wreak havoc on the natural world also, as precious biodiverse habitats such as coral reefs, tropical mangroves and Arctic tundra feel the heat, many species lose their habitats and attempt to either adapt or move to new areas. In either case survival is not guaranteed. Humans also inflict habitat destruction (see Technical Reports, **Amazon Wildfires**), fragmentation (see Technical Reports, **Chinese Paddlefish Extinction**) and pollution (see Technical Reports, **Desert Locust Outbreak**), which impact biodiversity on various scales in various ways. The outlook for disastrous events and the biodiversity crisis is explored further in **Chapter 3.3, Emerging Risks**.

In addition to the 10 events having connected impacts, it is also important to remember that each event is symbolic of a bigger picture. So as fires continued to rage in the Amazon in 2020, fires also scorched many other parts of the world, such as California, Canada, Siberia and Australia, in unprecedented ways. Cyclone Amphan was only one of a record 103 named storms in 2020 (National Oceanic and Atmospheric Administration, 2021). While these events may have different root causes and drivers that play out in their individual contexts, their impacts are often similar. Therefore, in the big picture we must consider not only the loss and damage from Cyclone Amphan, or from the other 102 named storms that year, but also from the Amazon wildfires and the other record-setting wildfires all over the world – from Australia to Siberia – and the other disastrous events we see constantly in the media cycle. When viewed through the lens of interconnectivity, we begin to understand how each disastrous event builds on the impacts of the past and paves the way for the impacts of the future (see **Chapter 3.3**).

Section 3.1.2

We are all interconnected to disastrous events

Once we start thinking in terms of systems and interconnections, it is easy to see how seemingly isolated events are nestled into something infinitely more complex. Individual actions become a part of something bigger: your purchase is a part of a supply chain, your lightbulb is a part of the whole energy grid and your wearing of a mask is a part of ending a pandemic (Tooley, 2021). This applies also to the 2020/2021 events (see **Chapter 2**). Eating your chicken sandwich is linked through the supply chain to the Amazon wildfires. Using petrol emits GHGs which contribute to the bleaching of the Great Barrier Reef. As we illustrated in this section, the interconnectivity of these actions goes much deeper than that. Wherever we live on Earth, our choices, both conscious (e.g. what we buy) and unconscious (e.g. how we value the environment around us), are connected to structures that are creating increasingly dangerous events around the world. Naturally, individual action alone can rarely prevent disastrous events from happening, but changing the underlying systems that create disastrous situations can only begin when individuals recognize their part in the larger, whole iceberg, rather than just the tip (see **Chapter 4**).

“There are a thousand hacking at the branches of evil to one who is striking at the root.”
Henry David Thoreau

Section 3.2

Deep dive into the root causes of 10 disastrous events

The 10 events we focus on for 2020/2021 were not only disastrous in and of themselves, but they are also symbolic of more significant persisting problems in our world. In other words, these disastrous events are the visible symptoms of processes that are so entwined with our society, and the way it interacts with the natural world, that they are taken for granted. These underlying processes are often ignored due to their distance (be it in terms of time, emotional significance or physical distance) from the more visible disastrous event they contribute to, such as a cyclone or a pandemic (Wisner and others, 2004). We, therefore, define ‘root causes’ here as the factors that ‘drive’ the chain of interconnected elements behind the events highlighted in this report and the severity of their impacts. To prevent disastrous events like these from happening, we cannot rely on only addressing the immediate symptoms with costly, ad hoc responses; we must also focus on the root causes of these events, and direct management priorities towards addressing them. Otherwise, humanity will always have to contend with their recurrence. This section takes you on a deep dive into these root causes to provide a more holistic understanding so as to be better equipped to strike at the root rather than the branches.

Root causes contribute to disastrous events from many different angles through interconnected systems of causal chains. Some root causes influence the hazard itself, while others affect the amount of exposure a particular place or people have to a hazard or how vulnerable they are to its effects. As a result, most disastrous events we see can’t be attributed to one single root cause, but rather to an interconnected set of multiple root causes. Accordingly, not every possible root cause for each event is reported here, but rather the ones uncovered through our analysis of causal chains (see Technical Reports) that are the most prominent and prevalent among the events.

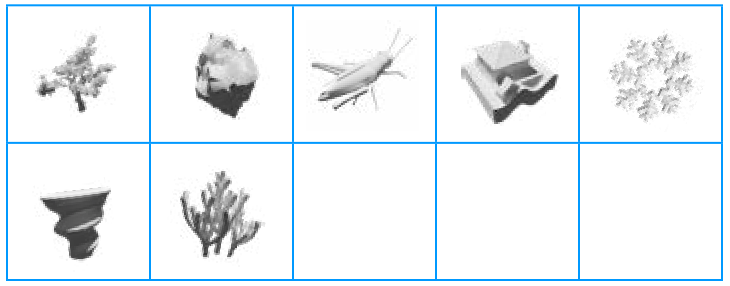
This chapter reports on a selection of key root causes identified in our analysis of the 10 cases from 2020/2021 due to their influence on chains of underlying factors (drivers) that eventually led to disastrous events (see Technical Reports). After identifying root causes linked to each event, we gather them into thematic categories (see **Table 1**) and rank them according to the number of connections between different events (see **Chapter 3.1**). Although all of the root causes we identify are important to address in this report (see **Table 1**), we take this deep dive into the **three root causes most commonly linked to the events** from our selection.

Section 3.2.1

Root cause 1

Human-induced greenhouse gas emissions

Human-induced greenhouse gas emissions: **7/10**



Human-induced greenhouse gas emissions sit at the root of 7 out of 10 disastrous events we selected this year. In May 2021, carbon dioxide levels in the atmosphere hit 419 parts per million, representing 50 per cent more than when the industrial age began (Gammon, 2021). Most of the world's GHG emissions come from a relatively small number of countries. China, the United States and the European Union are the three largest emitters on an absolute basis, while per capita GHG emissions are highest in the United States and Russia (C2ES, 2019). Globally, the average carbon footprint per person is around four tons, but this varies depending on where you live: per capita consumption emissions in the United States are approximately 17.6 tons, compared to 1.7 tons in India (Capstick and others, 2020). Meanwhile, persisting issues of social inequality ensure that adverse effects of climate change are more acutely felt in developing countries and by disadvantaged groups (Islam & Winkel, 2017).

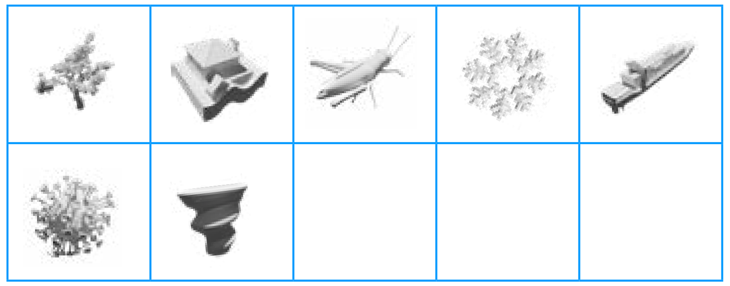
GHGs (such as carbon dioxide, methane and nitrous oxide) in the atmosphere absorb heat energy, keeping Earth's surface and lower atmosphere warm. As GHG concentrations in the atmosphere increase, more of the heat radiated from the Earth's surface is trapped, and the warming effect is enhanced. As a result, the rate at which the global annual temperature has increased since 1880 has more than doubled since 1981 (NOAA, 2021b). Most of this excess atmospheric heat is absorbed by the oceans (EPA, 2021; IUCN, 2017). In fact, oceans have absorbed 93 per cent of the excess heat from the effect of GHGs since the 1970s (IPCC, 2013). The average global sea surface temperature – the temperature of the upper few metres of the ocean – has increased steadily over the past 100 years, with the last three decades being consistently warmer (EPA, 2021). With an anomaly of 0.79°C, 2016 was the warmest year on record, followed by 2019 and 2020 (NOAA, 2021b).

Changes in ocean temperatures and currents also lead to changes in weather and climate patterns, such as the development of stronger storms in the tropics (EPA, 2021). Warmer ocean temperatures increase evaporation, and warmer atmospheric temperatures increase the amount of water vapour stored in the air, which adds fuel to power cyclones. Additionally, cool subsurface waters can slow and weaken cyclonic activity, but increased ocean temperatures reduce this effect significantly (Sun and others, 2017). All of this contributes to larger, more intense cyclones (see Technical Report, **Cyclone Amphan**). Warming-induced cyclones also contribute to other disasters in unexpected ways. Cyclones Mekenunu and Luban both created conditions favourable for locust breeding in the Arabian peninsula, the latter contributing to an 8,000-fold increase of the locust population (Stokstad, 2020). Cyclone Pawan also supported the migration of the locusts into East Africa (see Technical Report, **Desert Locust Outbreak)**. The rise in cyclone activity and weather and climate variability will likely increase and spread locust outbreaks (Salih and others, 2020).

As our emissions of GHGs continue to grow, rising global temperatures are creating positive feedback loops. For example, an increase in temperatures exacerbates drought conditions that intensify wildfire spread in the Amazon (see Technical Report, **Amazon Wildfires**). The subsequent loss of forest cover decreases the amount of water evaporating from the land entering the atmosphere (evapotranspiration), decreasing rainfall, lowering humidity and increasing ground surface temperatures. Smoke from the fires also reduces rainfall and cloud cover by trapping moisture and preventing raindrops from forming. These factors only exacerbate drought stress, creating a cycle that intensifies over time (Laurance and Williamson, 2001). The Arctic experiences these climatic positive feedback loops more intensely, warming more than twice as fast as the rest of the planet (Cohen and others, 2014). As human-induced GHGs warm the atmosphere and oceans, it melts the Arctic sea ice. This reduction in sea ice reduces the albedo effect, in which ice reflects solar energy back into the atmosphere, instead allowing it to be absorbed by the darker ocean water (see Technical Report, **Arctic Heatwave**).

Insufficient disaster risk management

Insufficient disaster risk management: **7/10**



Insufficient disaster risk management fueled drivers of 7 out of 10 disastrous events we chose from the past year by leaving infrastructure unprepared, hampering response efforts, and increasing vulnerability. In general, disaster risk management is meant to help prepare for a disastrous event through recognizing potential risks, mitigating the risks before they become problematic, preparing systems to respond to problems and coordinating effective responses that increase resilience to future events. Over the past few decades, disaster risk management has evolved and made an increasing difference: deaths attributed to disasters have been significantly reduced thanks to more effective early warning systems, more resilient infrastructure and better overall emergency preparedness (Ritchie and Roser, 2014). However, given the constantly evolving context of climate change and the increasing interconnectedness of our society, complex systemic risks are emerging, and the challenge of effectively reducing the impacts of disastrous events is also increasing.

Disaster preparedness plays a critical role in mitigating the impacts of disasters. As the frequency of climate-related hazards continues to grow with the effects of climate change (see **Root Cause #1**), the risks from both anticipated and extreme or novel events become more complex and they are more difficult to foresee and prepare for. Many of the 2020 floods in Viet Nam would not have been considered extreme individually, but nine consecutive storms in less than two months triggered severe impacts and challenged the country's disaster response capacity (see Technical Report, **Central Viet Nam Floods**). Additionally, the COVID-19 pandemic disrupted disaster responses, and by pushing millions of people back or further into extreme poverty, increased vulnerability to hazards on a global scale (World Bank, 2020), and created multi-hazard events which compounded the impact of disastrous events in ways that existing disaster risk management and pandemic response plans were not prepared for (Attanayake and others, 2020).

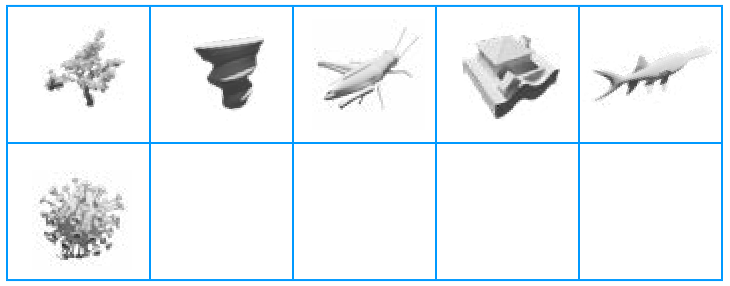
Commonly, it is only in the aftermath of a disastrous event that we reflect and identify shortcomings in disaster risk management. Indeed, understanding current and future disaster risks and their root causes is a critical factor in building resilience, and one of the common, essential elements often overlooked is how the risk is perceived. Risk perception depends entirely on psychological, social, historical and cultural factors, from individual common sense to media influence and political structures (Wachinger and others, 2010). When hazard risks are poorly understood, or addressing them is not perceived to provide economic benefits, planning decisions might be inappropriate or even harmful. These decisions are made using cost-benefit analyses in determining the probability of an event occurring and its potential impacts, especially when it comes to high-impact, low-probability events. However, far too often the possible social, environmental (see **Root Cause #3)** or economic costs are undervalued in these analyses, creating a division between the actual value of preparation, avoided costs and perceived justification for investment (Lee and others, 2012). For example, Texas has typically mild winters, so the cold wave in 2020 that brought ice, snow and below-freezing temperatures for over three days was an unusual occurrence. Though similar cold waves have swept through Texas before, notably in 2011, the perception of the cold wave risk was such that it occurred too infrequently for residents, officials or institutions to prepare for it. In other words, the potential cost of preparation outweighed the potential risks (Black and Veatch, 2013) (see Technical Report, **Texas Cold Wave**). In some cases, this decision also comes down to funding issues, since it can be challenging for officials to justify investing large portions of their budget for something that isn't an immediate concern. For example, locust outbreaks are sporadic and the perception of their importance can diminish with time. Therefore, funding for management of severe infestations gets crowded out of political agendas by topics deemed more urgent, such as poverty assistance (Meynard and others, 2020). Studies have even modelled a negative correlation between cyclic locust invasions and the level of interest that funding bodies show (Gay and others, 2018) (see Technical Report, **Desert Locust Outbreak).**

The level of political commitment of governments to disaster risk management, influenced by political agendas and funding priorities, also plays a role in its effectiveness when disasters strike. This was illustrated during the early phases of the COVID-19 pandemic. After the 2009 H1N1 pandemic, several panels and commissions were set up to recommend steps to improve preparedness, which were largely met with indifference by panel member states. The implementation of effective response measures was delayed until the last possible moment, when serious impacts were already apparent, rather than taking precautionary measures based on early data (The Independent Panel for Pandemic Preparedness and Response, 2021) (see Technical Report, **COVID-19 Pandemic**). Meanwhile, in the lead-up to the Beirut explosion, Lebanese officials were reportedly warned about the dangerous potential of ammonium nitrate at least eight times since 2014 (Trew and others, 2020) (see Technical Report, **Beirut Explosion**). The lack of political commitment to disaster risk management can also be seen in the Amazon case study. Deforestation and wildfires are not new to the Amazon region, but recent policies have contributed to an increase in wildfires, particularly in Brazil and Bolivia (Ramírez, 2019). Though the Government of Brazil claims to have a zero-tolerance policy for any illegal deforestation or forest burnings, in practice they cut the inspection budget of the federal agency in charge of regulating deforestation by 40 per cent (Fellet & Pamment, 2021). This lack of political commitment relates directly to prioritizing economic gains (see **Table 1**, **Prioritizing individual profits**) over environmental costs (see **Root Cause #3**).

Section 3.2.3 Root cause 3

Environmental costs and benefits undervalued in decision-making

Environmental costs and benefits undervalued in decision-making: **6/10**



Undervaluing the environmental costs of development and governance decisions was an underlying cause of 6 out of 10 disastrous events we selected this year, particularly in decisions relating to land-use change, such as deforestation and damming of rivers. Often, this undervaluing manifests as economic development being pursued in a way that ignores critical social or environmental factors and directly or indirectly increases risk from hazards. Though there are strong links between the environment and the economy (OECD, 2016), achieving higher economic growth often results in environmental degradation through natural resource exploitation, land-use change and increased emissions (Alvarado and Toledo, 2017; Chakravarty & Mandal, 2020). Environmental degradation has cascading effects on livelihoods and food security (see **Chapter 3.3**) and can thus negatively affect long-term development. Although poverty has been reduced in recent years, poor environmental quality is increasingly affecting people's health and well-being (OECD, 2016; Ekins and Zenghelis, 2021). For example, the COVID-19 pandemic has had devastating effects for already-disadvantaged populations and is expected to push millions back into extreme poverty (World Bank, 2020). Land conversion and habitat fragmentation increase the risk of disease spreading from animals to humans (Barbier, 2021), and though research is still investigating the origins of the COVID-19 pandemic, it likely originated from human interaction with wildlife (see Technical Report, **COVID-19 Pandemic**).

One reason why the natural and environmental costs linked to development decisions are often overlooked is due to the difficulty in calculating the value of nature. The benefits people receive from nature are encapsulated in the concept of ecosystem services, whereby valuable services are provided to people by the environment in four main categories: resources (e.g. food, water, raw materials), regulation of natural processes (e.g. water purification, erosion, pollination), support for the provision of all other ecosystem services (e.g. providing habitat that promotes biodiversity) and non-material benefits (e.g. recreation, well-being, cultural heritage). In fact, the economic cost of lost ecosystem services as a result of land-use change is estimated to be $4.3 trillion–$20.2 trillion a year (Costanza and others, 2014). For example, in addition to the coastal protection from cyclone storm surge given by constructed sea walls and embankments, mangrove forests can provide other benefits, including water purification, biodiversity support, erosion control, carbon storage, aesthetic appeal and cultural importance (Sutherland and others, 2018) (see Technical Report, **Cyclone Amphan**).

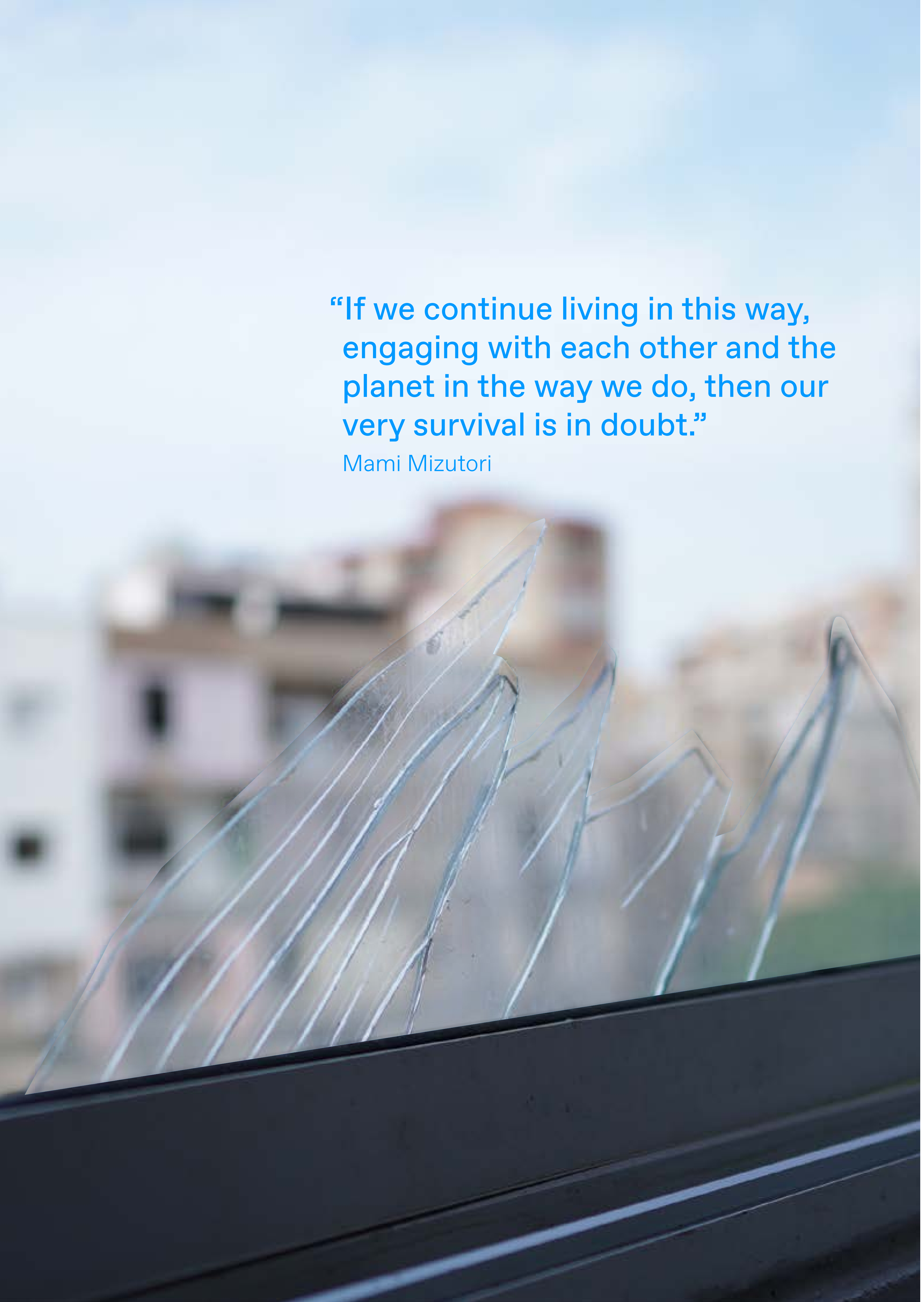
As with **Root Cause #1**, perception often plays a role in undervaluing environmental costs. Humans are naturally inclined to disregard problems that are not directly evident, where the detrimental impacts on the environment become an issue only when the consequences become clear (IIED, 2007). For instance, despite the ecological consequences of building dams on riverine ecosystems, the drive for development often seems more vital than the conservation of biodiversity (Vörösmarty and others, 2010). Dams support development through the provision of energy, agricultural irrigation and, in some cases, protection against floods (Barbarossa and others, 2020). However, they also represent one of the most intense human interventions on the environment, disrupting the hydrology of freshwater ecosystems, compromising their biodiversity and, consequently, the wellbeing of the communities which depend on them (Brown and others, 2009). For example, the Gezhouba Dam provides nearly 2,715 MW of power to the nearby city of Yichang, but also contributed to the extinction of the Chinese Paddlefish by shortening its spawning migration route by over 1,000 km (Green, 2020; Huang and Wang, 2018). Construction of the dam was completed in 1981, with no provisions for ensuring that fish habitats would remain intact, and as a result one more species disappeared

from the planet (see Technical Report, **Chinese Paddlefish Extinction**).

Sometimes even being aware of the importance of nature is not enough. Even where environmental perception is high, institutions are often under-resourced or not influential enough and struggle to promote the ecological agenda (IIED, 2007). In the case of locust outbreaks, such as the 2020 outbreak of the desert locust (see Technical Report, **Desert Locust Outbreak**), there has been extensive research into nature-based alternatives to chemical pesticides, which affect non-target species as well as humans (Lomer and others, 1997). These biocides are less readily available than more established chemical pesticides, and are most effective in the early stages of an infestation (Grzywacz and others, 2014; FAO, 2007). Since preventative control of locust outbreaks is often crowded out by other political agendas (see **Root Cause #1**), the lag in response time dealing with an outbreak makes the more environmentally-friendly biocides less attractive. Additionally, there are conflicts of interest with some actors purposefully overlooking nature's value for short-term gains (see **Table 1**: **Prioritizing individual profits**).

Summary

This chapter has shown that the 10 events featured in this report were not only disastrous for people and the environment but were also the symptoms of underlying processes ingrained in our society. Anyone working to combat future locust outbreaks or infrastructure failure from climate extremes must also address issues of risk perception and political commitment to disaster risk reduction. Reducing risk from cyclones or managing coral bleaching cannot be done effectively without working towards lowering GHG emissions. We will be fighting an uphill battle unless decision-making processes include provisions for protecting biodiversity and habitat. The root causes mentioned here are only a fraction of those that interconnect with our 10 events (see Technical Reports), and they themselves are inextricably linked. Understanding these interconnections is essential to applying solutions that will have meaningful and long-lasting effects, and in the next chapter we explore them in more detail.



> "If we continue living in this way, engaging with each other and the planet in the way we do, then our very survival is in doubt."
> Mami Mizutori

Section 3.3

Emerging risks

Though the 10 events described in this report are already a concern today, the three main root causes discussed in **Chapter 3.2** are all on a trajectory to accelerate, either exacerbating existing risk or creating more and new challenges for disaster risk management in the years and decades to come. The science behind climate change, biodiversity loss and societal developments that underpin the shortcomings we see in disaster risk management is clear. However, societal behaviours, such as attitudes towards international cooperation or risk perception, are more difficult to predict. Given the wide range of potential outcomes influenced by these complex variables, this chapter highlights the potential implications of the accelerating climate crisis and biodiversity crisis paired with increasing societal challenges to disaster risk management, with specific reference to the types of risks featured in the 10 events of this report.

Section 3.3.1

Accelerating climate change

Human-induced GHG emissions cause impacts on natural and human systems worldwide that go far beyond the events featured in this report. If we follow the current emission trajectory, global warming will likely reach 1.5°C above pre-industrial levels within the next two to three decades (IPCC, 2018). Meanwhile, many of the disastrous events detailed in this report (e.g. Amazon wildfires and Arctic heatwave) themselves reinforce climate change with positive feedback loops (see **Chapter 3.2, Root Cause #2**). Having already lost one-fifth of the Amazon rainforest to climate change and human-made fires, scientists fear the forest may dry beyond the point of human rescue, inviting more wildfires and further releasing carbon (The Climate Reality Project, 2020). A similar feedback loop emerges in the Arctic: research suggests that parts of the Arctic tundra are now already emitting more carbon dioxide than they absorb (Natali and others, 2019), and the region could turn into a net source of GHGs (Natali and others, 2021). This is particularly worrisome, given that the frozen Arctic soil holds an estimated 1,600 billion tons of trapped carbon – almost twice the amount of GHGs currently in the atmosphere (Turetsky and others, 2019) (see Technical Reports, **Arctic Heatwave**).

Continued emission of GHGs and the consequent positive feedback loops will inevitably cause long-lasting changes in the climate system with severe and irreversible impacts on people and nature. Climate change is a risk magnifier and will increase the frequency and severity of extreme events such as heatwaves, droughts, storms and flooding (IPCC, 2018, 2019b). With further GHG emissions, the sea level will continue to rise at an increasing rate. If we continue with the current emission scenario, we will face a one-metre sea level rise by 2100 and up to four metres by 2300 (IPCC, 2019a). In the absence of ambitious adaptation, risks due to sea level rise and extreme events are projected to increase significantly throughout this century, with annual coastal flood damages expected to increase by two to three orders of magnitude by 2100 compared to today (Intergovernmental Panel on Climate Change 2019a) (see Technical Reports, **Cyclone Amphan**). Climate change impacts on biodiversity and ecosystem functioning are projected to become stronger and will worsen with global warming (see Technical Reports, **Great Barrier Reef Bleaching**). Even under low emission scenarios (global warming of 1.5°C to 2°C), the ranges of most terrestrial species are projected to shrink dramatically (IPBES, 2019).

Section 3.3.2

Increasing societal challenges for disaster risk management

Disasters occur at the interconnection of environmental conditions and societal processes. Every disaster takes place in such contexts, so these drivers have the power to shape future risk together with the changing environmental conditions. Societal drivers (demographic, social, economic, political and cultural, etc.) can determine the exposure of people, assets, livelihoods and nature as well as the capacity of these to cope with hazardous events. The drivers can therefore help reduce or create risk depending on how they are managed. Given the infinite complexities and interconnections found in societies (see **Chapter 3.1**), the number of societal processes that can influence disaster risk management today is incalculable. When looking at the 10 events in this report, trends of key processes like urbanization and development, along with social inequalities and food insecurity, will create more challenges for disaster risk management in the future.

In general, development processes are essential in reducing drivers of vulnerability, such as poverty and economic instability, by providing economic opportunities and improving access to services (Hallegatte and others, 2018). However, occasionally development can also trigger the creation of risk. For instance, it can prompt or accelerate the accumulation of people and assets in hazard-prone areas (e.g. coastal zones), leading to an increase in exposure to future hazards (GFDRR, 2016). The rich resources and economic opportunities these locations offer often outweigh consideration of the hazard, especially for low-income groups (UNDRR, 2015). Examples of this can be observed in densely-populated, low-lying coastal areas such as central Viet Nam (see Technical Reports, **Central Viet Nam Floods**). Urbanization is steadily driving more people to resettle in cities (especially in Africa, Asia and Latin America) and is expected to result in 68 per cent of the global population being urban by 2050 (UN DESA, 2018). This process is particularly acute in low-elevation coastal zones, whose populations are projected to increase by at least 50 per cent between the years 2000 and 2030 (Neumann and others, 2015). In addition, rapid urbanization is expected to happen mostly in mid-size cities, which are, in general, less equipped to embark on large-scale and risk-informed urban planning because of their limited resources, thus creating conditions for future urban exposure to hazards (Birkmann and others, 2016; IPCC, 2014). Increased exposure is particularly concerning when it combines with additional poverty levels, which is widely considered to be a major driver of vulnerability: estimates suggest that there could be as many as 325 million extremely poor people living in the 49 most hazard-prone countries in 2030 (Shepherd and others, 2013). These developments are occurring now, and failure to tackle them through effective and risk-informed governance is likely to create new and long-term hotspots of risk in the future.

In addition to increasing the gravity of direct impacts, poverty is also responsible for further exacerbating vulnerability to future disasters. This is evidenced by the devastating effects of the COVID-19 pandemic, which were particularly cumbersome for already disadvantaged groups, and are expected to push millions of people deeper, or back, into extreme poverty (World Bank, 2020). For example, already financially devastated by the COVID-19 pandemic, low-income families in Texas were disproportionately affected by the power blackouts, and also lacked the financial capacity to cope with the cold the way some more affluent residents could (such as fleeing the state or renting a hotel room) (Dobbins and Tabuchi, 2021). Unfortunately, global trends show that inequalities in income distribution within countries are also rising or remain high. Gaps in access to equal opportunities for vulnerable social groups (e.g. children, persons with disabilities, etc.) are far from being closed (UN DESA, 2020). Social inequalities are also considered to be at the root of food insecurity, which is reported to have increased in recent years after a long period of decreasing trends (FAO and others, 2020). When combined with the possible environmental constraints to food production imposed by climate change, the number of people suffering from food insecurity could keep increasing, a trend that must be met with a proper response from governments (Candel, 2014).

Section 3.3.3

Escalating biodiversity crisis

The trend of environmental costs being undervalued in decision-making is leading the world into large-scale degradation and loss of the natural environment. Of particular concern are agricultural expansion, urbanization and infrastructure development at the expense of forests, wetlands and grasslands contributing to pollution, habitat degradation and fragmentation of land, freshwater and marine ecosystems (IPBES, 2019). Large-scale environmental changes, such as deforestation and river damming, threaten biodiversity by accelerating global species' extinction rates, which are already exponentially higher than the average over the past 10 million years (Benton and others, 2021). An average of 25 per cent of all plant and animal species are threatened with extinction (Intergovernmental Platform on Biodiversity and Ecosystem Services, 2019). The trend can be seen in the contribution of dams to the extinction of the Chinese Paddlefish (see **Chapter 2**, **Chinese Paddlefish Extinction**). IUCN have declared at least 80 freshwater fishes extinct to date, with 16 disappearing in 2020 alone, and 115 classified as 'Critically Endangered Possibly Extinct' (WWF, 2021). Almost half of living freshwater fish species are predicted to go extinct due to climate change by 2070, with a substantial decline in tropical river basins, particularly in Viet Nam and south-eastern China (Manjarrés-Hernández and others, 2021). Similarly, roughly half of the world's coral reefs have been lost since the 1870s, and 33 per cent of those remaining are threatened with extinction (IPBES, 2019) (see **Chapter 2**, **Great Barrier Reef Bleaching**). Species extinctions affect more than just biodiversity and ecosystem integrity. For example, freshwater fish decline and extinctions raise concerns about food security and poverty. Freshwater fish is a primary source of protein for 200 million people across Asia, Africa and South America, and provide jobs and livelihoods to 60 million people (WWF, 2021) (see Technical Reports, **Chinese Paddlefish Extinction**).

As we convert and fragment ecosystems, we lose biodiversity and, in turn, increase our own risk in various ways. Decreasing biodiversity increases the risk of diseases spreading from animals to humans, such as COVID-19. Some species such as rodents and bats are more likely than others to become disease reservoirs and are often present in higher numbers in human-dominated landscapes. In less disturbed areas, these hosts are less abundant, and non-risk species dominate. Thus, losing biodiversity increases the risk of human exposure to zoonotic pathogens (Keesing and Ostfeld, 2021) (see **Chapter 2**, **COVID-19 Pandemic**).

The loss of biodiversity and ecosystem integrity harms ecosystem services, such as food, water, clean air, flood protection or pollination. If ambitions to halt biodiversity decline do not ramp up, and the drivers of change do not deviate from the current trajectory, nature and the services it provides to people will continue to decline sharply (Díaz and others, 2019). With declining ecosystem services under future land use and climate change scenarios, up to 5 billion people will suffer from water pollution, and hundreds of millions of people will face increased coastal risk (Chaplin-Kramer and others, 2019).

The emergence and interconnection of increased societal exposure and vulnerability, and the acceleration towards tipping points in biodiversity loss and climate change, create complex issues that are difficult to foresee and prepare for. Impacts in one place trigger cascading impacts in other areas, meaning a future risk somewhere can be a future risk anywhere. These areas of societal challenges, biodiversity loss and climate change must be considered jointly if we aim for a future with less risk to our environment and our societies.

Chapter 4

Solutions

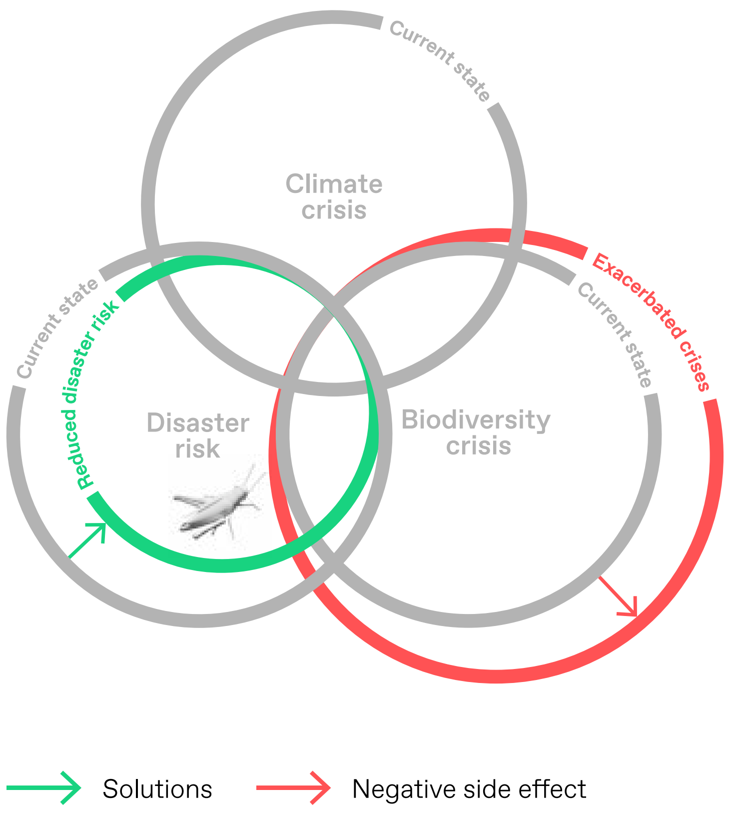
"If I had to select one sentence to describe the state of the world, I would say we are in a world in which global challenges are more and more integrated, and the responses are more and more fragmented, and if this is not reversed, it's a recipe for disaster."
António Guterres, UN Secretary General 2019

As the interconnected nature of events and their underlying root causes are increasingly creating emerging risks at all scales, it is time to recognize the shortcomings of fragmented responses (Turney and others, 2020). We explored the three most prominent root causes and emerging risks among the 10 disastrous events: i) human-induced GHG emissions driving the climate crises, ii) insufficient disaster risk management, which worsens with growing societal challenges, and iii) the undervaluation of the full environmental costs of decisions at all levels, leading to the biodiversity crisis – i.e. the rapid degradation of ecosystems and the accelerating loss of species. In our interconnected world, it is crucial to address these connected root causes and emerging risks in an integrated way.

Importantly, the window of opportunity is closing; while some impacts outlined in this report are irreversible, such as the extinction of the Chinese Paddlefish, others require swift intervention to avoid passing tipping points where long-term impacts can no longer be avoided. For instance coral reefs, which provide protection from storm surges to around 200 million people worldwide (WWF, 2018), are at risk of irreversible damage from the impacts of ocean warming and sea level rise driven by climate change (IPCC, 2019b) (see **Chapter 2**, **Great Barrier Reef Bleaching**). The sooner we act, the more solutions remain viable and at our disposal. We are learning, however, that if proper planning and foresight are not employed with care, then actions taken to reduce risk in one system can subsequently impact adversely on, or increase the vulnerability of, other systems, sectors or social groups (Barnett and O'Neill, 2010). With systems in our modern world being so interconnected (see **Chapter 3.1**), we can't afford to devote precious time and resources to such 'maladaptations' – solutions which not only are ineffective, but through cascading impacts, actively work against our risk reduction goals. Both trade-offs and synergies between different solution approaches must be identified to minimize negative impacts and maximize benefits for preventing disasters.

Fig. 4: Solutions addressing a single root cause with negative side effect

Pesticides help to control locust outbreaks but have negative effects on biodiversity.

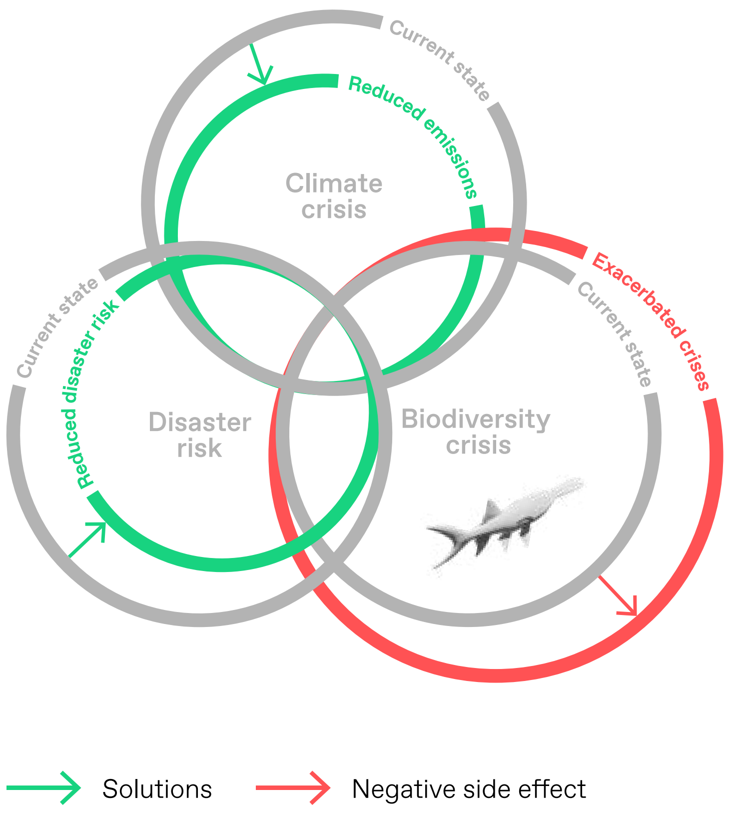


In Chapter 3, we identified root causes behind the 10 disastrous events of the past year, and how they are interconnected. This opens up important opportunities for a space to develop new solutions focused on the problems at the roots of disastrous events. However, here too we must also begin by considering interconnectedness in order to avoid maladaptation. Solutions that focus on a single root cause can result in negative impacts that increase other risks (see **Figure 4**). As the desert locust outbreak shows, some disaster risk management decisions can have negative effects on biodiversity. If we act only after the emergence of large locust swarms, toxic pesticides, which negatively affect biodiversity and human health, are used at a large scale. Acting earlier would facilitate a small-scale intervention using less harmful species-specific biocides. A no-regret, pre-emptive approach that is conscious of avoiding negative environmental impacts, like monitoring of locust emergence and cooperation, would thus not only be cheaper than emergency response actions, but it would also have avoided negative side effects that worsen the biodiversity crisis (see Chapter 2, **Desert Locust Outbreak**).

Negative consequences can also emerge from solutions that address more than one root cause (see **Figure 5**). Building hydropower dams increases the share of clean energy and addresses the climate crises, while also providing improved flood control opportunities and thus disaster risk reduction benefits. The price we pay is in the degradation of fish habitats (Barbarossa and others, 2020; Dudgeon, 2019; Barnett and O'Neill, 2010); Dudgeon, 2019; Barnett and O'Neill, 2010) leading to the extinction of many freshwater fish species globally, as seen in the case of the Chinese Paddlefish (see Chapter 2, **Chinese Paddlefish Extinction**). These trade-offs must be recognized and addressed in order to achieve a robust path to progress in limiting climate change and disaster risk while safeguarding biodiversity, and ensuring that our transition towards zero-carbon emissions is as sustainable as possible (IPBES and IPCC, 2021). Solutions designed to reduce one risk only can be helpful, provided there is a well-designed, thorough process to assess and avoid any negative impacts on other risk areas. Attempts must be made to find no-regret solutions, i.e. those with no side effects exacerbating other crises.

Fig. 5: Solutions for multiple root causes with negative side effect

Hydropower dams provide renewable energy and help to reduce disaster risk but have negative effects on biodiversity.



Section 4.2 Win-win-win

Given the interconnectivity of our world, it is not surprising that solutions can also have cascading effects. Ideally, the solutions we implement will not only be 'no-regret', but also 'win-win-win' solutions that have co-benefits across different dimensions. Evidence shows that solutions with multiple benefits and objectives are often the most cost-effective (Seddon and others, 2021). Addressing the climate crisis by drastically cutting our GHG emissions, for instance, could eventually reduce the frequency and severity of hazards linked to atmosphere and ocean warming (such as cyclones like Amphan), thus reducing risk in vulnerable areas and helping to address the challenge of insufficient disaster risk management. Additionally, slowing down climate change is beneficial for biodiversity and ecosystems as it gives more time for ecosystems and species to adapt to changing conditions. This would help reduce the pressure on natural habitats, and thus the environmental costs of our decisions and actions. In this way, combining no-regret and win-win-win solutions uses interconnectivity to our advantage to reduce the severity of impacts cascading from disastrous events and therefore the emerging risks they contribute to (see **Figure 6**).

Section 4.3 Examples of integrated approaches

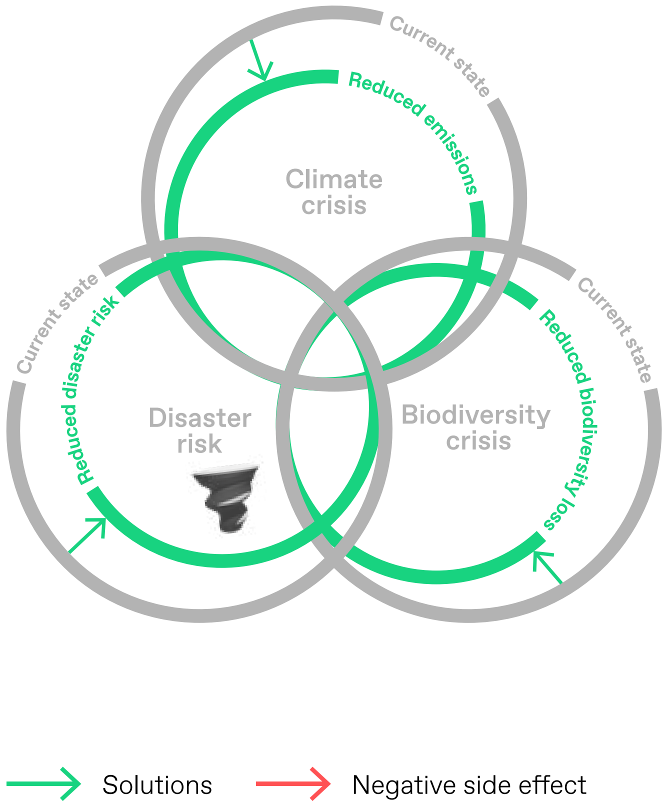
A good example of integrated approaches (i.e. win-win-win) that address the three most common root causes behind the 10 disastrous events of the past year (see **Chapter 3.2**) are nature-based solutions. Nature-based solutions aim to protect and restore ecosystems, while also addressing societal challenges, such as climate change and disaster risk. For example, reducing deforestation and actively fostering forest protection and reforestation contribute to reducing the risk of disease spreading from animals to humans, while also contributing to biodiversity protection and climate change mitigation (see **Chapter 2**, **COVID-19 Pandemic** and **Amazon Wildfires**). Conserving the mangrove forest in the Sundarbans protects a biodiversity hotspot home to a number of endangered species. It also protects the coasts of India and Bangladesh from storm surges, while also capturing and storing carbon and providing local livelihood opportunities (Menéndez and others, 2020). Reducing deforestation, in general, is one of only five climate mitigation responses without potential tradeoffs with sustainable development, as it can be linked with reducing poverty and hunger, enhancing health, and clean water and sanitation (IPCC, 2019b).

While the protection of biodiversity is beneficial to society by increasing the resilience of natural systems to deal with hazards and the adverse impacts of climate change, Adaptive Social Protection (ASP) directly helps to increase the resilience of societies. ASP links social protection programmes (such as health or unemployment insurance) with disaster risk management and climate change adaptation in order to reduce the negative impacts on households resulting from natural hazards and climate change, such as poverty and food insecurity. For example, severe flooding, as seen in central Viet Nam, can damage crops, buildings and infrastructure, resulting in food shortages or limiting access to food. To respond to this shock, households often apply negative coping strategies, such as selling livestock or other productive assets that provide short-term release but hamper long-term opportunities and might thus even reinforce food insecurity. By using ASP, through analysing the various perspectives of risk, inter-agency cooperation and an expansion of programmes such as food and financial assistance, these shocks and the negative coping strategies can be tackled. Institutions can use financial instruments to help enhance capacities while also addressing the climate crisis and environmental degradation. For example, a government can use climate finance to pay people to work on risk-reducing measures, such as implementing public works programmes for landscape restoration (Aleksandrova and Costella, 2021). These programmes help people increase their food and income security while also mitigating the impact and severity of disasters by financing prevention and preparedness measures. ASP can also be joined with market-based climate risk insurance schemes to protect individuals, businesses and cooperatives against climate shocks by acting as a buffer and safety net shortly after an extreme weather event. Integrating insurance solutions can thus promote opportunities by helping to lessen financial repercussions and can incentivize risk reduction behaviour and a culture of prevention (Schaefer and others, 2016).

It is important to remember that the capacity to respond to disasters and implement effective solutions varies widely across the globe, and also within societies and communities. Disproportionately affected by systemic injustices, such as racism and colonialism, histories of conflict and cycles of poverty, many countries and communities lack the financial capacity to effectively manage risks. In the United States, regions with a large minority population were more than four times more likely to have suffered a power outage during the Texas cold wave when compared to predominantly white neighbourhoods (Carvallo and others, 2021). On the national level, even though the solutions and knowledge are available to implement interconnected solutions, financial hurdles remain. For example, though some countries used environmentally-friendly, fungus-based biocides during the 2020 desert locust outbreak, they did not achieve widespread adoption since they are less readily available at short notice (Grzywacz and others, 2014; McConnell, 2021), and stockpiling them during recession years is a cost that some governments cannot absorb. Before the blast in Beirut, Lebanon was suffering from the impacts of a civil war and a financial crisis leading to hyperinflation. A mix of lack of capacities and corruption prevented proper inspection of the warehouse, which led to ammonium nitrate being stored inappropriately for more than six years until it exploded. In other places, impacts of climate change and future risks of disaster challenge the ability of vulnerable countries and communities to adapt and recover. Especially in the Arctic region, the forecasted impacts of climate change indicate a dramatic change in the ecosystem that is likely to alter the livelihood strategies of indigenous communities. In addressing the crises facing our world, we should specifically address these systemic issues to ensure effective and equitable solutions for the most vulnerable.

Fig. 6: Win-win-win and no regret solutions

Mangrove forest protection and restoration in the Sundarbans helps to reduce disaster risk, provides biodiversity benefits, while the forests also store and sequester carbon.



Tackling multiple root causes and emerging risks in an integrated way, while enhancing capacities to prepare and respond to future disasters, requires a combination of strategies across sectors and ensuring that any potential trade-offs are adequately assessed and dealt with. For example, the strategies analysed by the Intergovernmental Panel on Climate Change (IPCC, 2018) to achieve the level of net GHG emissions reductions that would allow the limiting of global warming to 1.5°C require rapid and far-reaching transitions in all systems such as energy, land use, urban development, infrastructure and industry. For instance, it would require that the share of renewables in the electricity matrix increases to 70–85 per cent by 2050. However, many renewable energies currently rely on mining for minerals on land and in the ocean, for example rare-earth metals used in the batteries of electric cars (Parajuly and others, 2020), and rarely have clean ways for disposal. This trade-off could be mitigated by the development of alternative batteries and an efficient recycling system, together with strong considerations for environmental impacts.

Renewable energy infrastructures such as hydropower dams are fragmenting river habitats and cutting off migratory species from their spawning grounds, leading to a reduction in abundances or extinction of migratory species (e.g. the Chinese Paddlefish). Selection of suitable sites for hydropower dams, and more broadly decisions about building or removing dams, needs to consider and mitigate the trade-offs for clean energy, irrigation, water supply, ecosystem quality and biodiversity, including the need for interdisciplinary, stakeholder-based methods that inform deliberations about these trade-offs.

GHG emission reduction strategies include options to restore the ecosystem. If reforestation is undertaken with monocultures, it can be detrimental to biodiversity and may not have clear benefits for adaptation or disaster risk reduction. For example, mangrove reforestation helps to capture and store carbon, and support biodiversity and local livelihoods. The latter two goals are, however, restricted if reforestation is undertaken with one mangrove species only. For the Sundarban mangrove forest, which shields West Bengal from the impacts of storms and cyclones (see Technical Reports, **Cyclone Amphan**), research shows that the area of forest cover will decrease and species distribution could be significantly impacted within 100 years in a business-as-usual scenario. One of the recommendations is that afforestation programmes should be planned in a way that the species diversity of the Sundarbans remains conserved as opposed to the current mono-species culture (Mukhopadhyay and others, 2018). Infrastructure measures that are narrowly focused on climate adaptation can have large negative impacts on ecosystems. For example, technical measures for managing floods and droughts, such as building dams, or protecting coasts from sea level rise, by building sea walls, frequently have large impacts on biodiversity. Planning with a combination of ecosystem-based and grey infrastructure[3] measures can optimize benefits and help to deal with the trade-offs.

Overall, solutions should be identified and accepted for producing multiple benefits, rather than maximizing performance on single indicators, such as GHG removal (IPBES and IPCC, 2021).

[3] 'Grey infrastructure' generally refers to human-engineered infrastructure for water resources.

Despite having solutions available that could have helped address the disastrous events of 2020/2021, there were a number of aspects that could have either encouraged or hindered their implementation. Enablers, i.e. factors that encourage action, play an important role in providing the foundation for the implementation of solutions. A key enabling aspect is raising awareness, since knowledge encourages action. Awareness can drive public group and individual acts by increasing interest and enthusiasm around a topic and, through that, stimulate mobilization and action. Environmental education, for instance, can enhance values such as connectedness and care, and encourage people to support actions and initiatives to protect the environment (IPBES and IPCC, 2021). At the same time, public awareness exerts pressure on policymakers to act on an issue, and can thus influence policy and result in the mobilizing of resources. Awareness raising is therefore fundamental to stimulate action and encourage the implementation of both large-scale and individual solutions.

Behaviour can also be significantly influenced through incentives, encouraging people to engage in or refrain from certain behaviours or actions. Financial incentives are an excellent example of something that motivates behaviour, either directly or indirectly, by removing financial obstacles to change (Cherry, 2020; Samson, 2019). Positive incentives, such as direct forest-protection payments, could encourage people to refrain from habitat fragmentation (in the case of the Amazon wildfires and COVID-19), while taxing fossil fuels could discourage the emitting of GHGs and enable the transition to climate neutrality[4]. Positive incentives could encourage early interventions, as in the case of locust outbreaks, while negative incentives on fishing could encourage alternative livelihood sources and discourage overfishing, which would have helped in the case of the Paddlefish extinction.

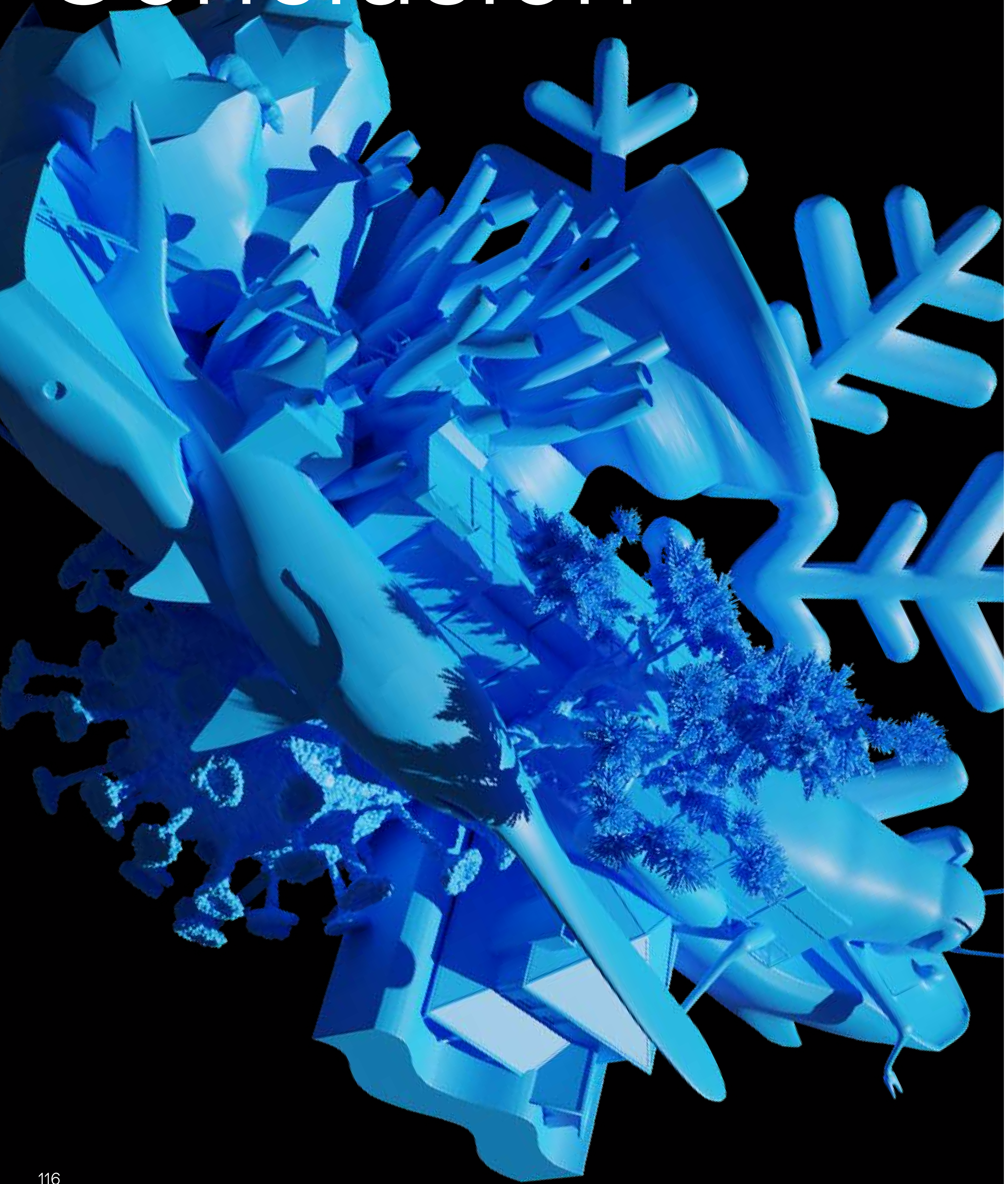
Inclusive governance can also enable the implementation of solutions. Participatory approaches that involve all groups in society, such as the private sector, indigenous groups, women and youth, and civil society, include different perspectives and tend to reduce conflict at all stages of decision-making and implementation of solutions (IPBES and IPCC, 2021). In an increasingly interconnected world, there is an especially strong need for international collaboration that builds on an environment of transparency and trust. The COVID-19 pandemic has again demonstrated the crucial role of international collaboration. Reactions involving nationalism and racism were counter-productive to ending the pandemic (Bump and others, 2021). These governance solutions must not be only top-down, but must also represent an equitable partnership, enabling us to push for joint implementation of solutions for the greater good.

The most important thing to remember is that we, as individuals, are part of this system and no one is too small to make a change. With our lifestyles and our everyday choices, we have profound impacts on our planet: we can be the change we want to see in the world. Though often we are not responsible individually for the damages we see, we are a part of the larger system and our actions and behaviours have influence. When viewed in isolation, an individual action presents a very minor change; but when viewed as a part of a larger whole, individual action can be huge with cascading effects and future impacts. Our collective actions can create lasting, meaningful and positive change, and this 'butterfly effect' can start with you.

[4] 'Climate neutrality' is where a net-zero carbon dioxide emission balance is achieved between what is emitted to and removed from the atmosphere.

Chapter 5

Conclusion



Our world is a living, dynamic system interconnected on multiple scales. While these interconnectivities are not new, they are affecting and accelerating changes across scales in increasingly unexpected ways. Widespread environmental change combined with the global exchange of people, ideas, living organisms and goods exposes individuals and societies to new types of risks with new types of interconnectivities. The past is no longer a reliable source in planning for future development or risk reduction.

The failure to address interconnected root causes and emerging risks is accelerating the climate crisis, creating new and more intense extreme events, increasing societal vulnerabilities and leading us to tipping points including mass extinctions and loss of ecosystem services. The solutions we conceive of as a global society must confront these systemic issues and allow for interconnected ways of solving multiple problems at once. We must try to maximize risk reduction and adaptation benefits across multiple sectors, and for different members of society locally and globally to avoid the rise of inequalities.

The way we understand and perceive risks influences our ability to respond to them. Since the risks associated with these disastrous events are interconnected, thinking in fragmented, isolated and insular ways is no longer tenable. We must instead think of ourselves and our actions as part of a set of interconnected systems. Though this world is bigger and more complex than we can even begin to comprehend, our actions and our voices matter, and collectively we can change these systems for the better.

Works Cited

Agnew, Duncan (2021). Plumber shortage and supply chain issues are delaying storm recovery efforts in Texas. The Texas Tribune, 26 February 2021. www.texastribune.org/2021/02/26/texas-plumber-shortage-winter-storm/

Ahammed, K.K. Basheer, and Arvind C. Pandey (2021). Characterization and Impact Assessment of Super Cyclonic Storm AMPHAN in the Indian Subcontinent Through Space Borne Observations. In Ocean & Coastal Management, Vol. 205, p. 105532.

Aleksandrova, Mariya, and Cecilia Costella (2021). Reaching the Poorest and Most Vulnerable: Addressing Loss and Damage Through Social Protection. In Current Opinion in Environmental Sustainability, Vol. 50, pp. 121–28.

Alvarado, Rafael, and Elisa Toled (2017). Environmental degradation and economic growth: evidence for a developing country. In Environment, Development and Sustainability, Vol. 19, Issue 4, pp. 1205–1218. doi: 10.1007/s10668-016-9790-y

Attanayake, Januka, and others (2020). The dual risks of natural disasters and COVID-19. Pursuit. University of Melbourne. https://pursuit.unimelb.edu.au/articles/the-dual-risks-of-natural-disasters-and-covid-19

Barbarossa, Valerio, and others (2020). Impacts of Current and Future Large Dams on the Geographic Range Connectivity of Freshwater Fish Worldwide. In Proceedings of the National Academy of Sciences of the United States of America, Vol. 117, No. 7, pp. 3648–3655.

Barbier, Edward (2021). Habitat loss and the risk of disease outbreak. In Journal of Environmental Economics and Management, Vol. 108. doi: 10.1016/j.jeem.2021.102451

Barnett, Jon, and Saffron O'Neill (2010). Maladaptation. In Global Environmental Change, Vol. 20, No. 2, pp. 211–213. www.researchgate.net/publication/220041300_Maladaptation

Benton, Tim, and others (2021). Food system impacts on biodiversity loss: Three levers for food system transformation in support of nature. Research Paper. https://action.ciwf.org/media/7443992/food-system-impacts-on-biodiversity-loss.pdf

Birkmann, Joern, and others (2016). Boost Resilience of Small and Mid-Sized Cities. In Nature Climate Change, Vol. 537, No. 1, pp. 605–08.

Black & Veatch. (2013). Long-Term Assessment of Natural Gas Infrastructure to Serve Electric Generation Needs Within ERCOT. www.ercot.com/content/committees/other/lts/keydocs/2013/BV_ERCOT_Gas_Study_Appendix_A.pdf

Brown, Philip, and others (2009). Modeling the costs and benefits of dam construction from a multidisciplinary perspective. In Journal of Environmental Management, Vol. 90, Issue 3, No. S303-11. doi: 10.1016/j.jenvman.2008.07.025

Bump, Jesse B., and others (2021). Political Economy of COVID-19: Extractive, Regressive, Competitive. In The BMJ, Vol. 372, No.73.

Byaruhanga, Catherine (2020). How do you fight a locust invasion amid coronavirus? BBC News, 25 April 2020. www.bbc.com/news/world-africa-52394888

Candel, Jeroen (2014). Food security governance: a systematic literature review. In Food Security, Vol. 6, No. 4. www.researchgate.net/publication/263747877_Food_security_governance_A_systematic_literature_review

Capstick, Stuart, and others (2020). Bridging the gap – the role of equitable low-carbon lifestyles. In UNEP Emissions Gap Report 2020, pp. 62–75. doi: 10.18356/9789280738124c010

Carvallo, Juan Pablo, and others (2021). Frozen Out in Texas: Blackouts and Inequity. www.rockefellerfoundation.org/case-study/frozen-out-in-texas-blackouts-and-inequity/

Center for Climate and Energy Solutions (C2ES) (2019). Global Emissions. www.c2es.org/content/international-emissions/

Chakravarty, Devleena, and Sabuj K. Mandal (2020). Is economic growth a cause or cure for environmental degradation? Empirical evidences from selected developing economies. In Environmental and Sustainability Indicators, Vol. 7, No. 100045. doi: 10.1016/j.indic.2020.100045

Chaplin-Kramer, Rebecca, and others (2019). Global modeling of nature's contributions to people. In Science, Vol. 366, No. 6462, pp. 255–58. https://science.sciencemag.org/content/366/6462/255

Cherry, Kendra (2020). The Incentive Theory of Motivation. In Verywell Mind, 4 March 2020. www.verywellmind.com/the-incentive-theory-of-motivation-2795382

Cohen, Judah, and others (2014). Recent Arctic amplification and extreme mid-latitude weather. In Nature Geoscience, Vol. 7. www.nature.com/articles/ngeo2234

Coronese, Matteo, and others (2019). Evidence for sharp increase in the economic damages of extreme natural disasters. In Proceedings of the National Academy of Sciences of the United States of America, Vol. 116, No. 43, pp. 21450–21455. www.pnas.org/content/116/43/21450

Costanza, Robert, and others (2014). Changes in the global value of ecosystem services. In Global Environmental Change, Vol. 26, pp. 152–158.

Díaz, Sandra, and others (2019). Pervasive human-driven decline of life on Earth points to the need for transformative change. In Science, Vol. 366, No. 6471. https://science.sciencemag.org/content/366/6471/eaax3100

Dobbins, James, and Hiroko Tabuchi (2021). Texas Blackouts Hit Minority Neighborhoods Especially Hard. New York Times, 16 February 2021. www.nytimes.com/2021/02/16/climate/texas-blackout-storm-minorities.html

Dudgeon, David (2019). Multiple Threats Imperil Freshwater Biodiversity in the Anthropocene. In Current Biology, Vol. 29, No. 19, R960–R967.

Ekins, Paul, and Dimitri Zenghelis (2021). The costs and benefits of environmental sustainability. In Sustainability Science, Vol. 16, Issue 3, pp. 949–965. doi: 10.1007/s11625-021-00910-5

El Sayed, Mazen J. (2020). Beirut Ammonium Nitrate Explosion: A Man-Made Disaster in Times of the COVID-19 Pandemic. In Disaster Medicine and Public Health Preparedness, pp. 1–5.

Fellet, Joao, and Charlotte Pamment (2021). Amazon rainforest plots sold via Facebook Marketplace ads. BBC Brasil. www.bbc.co.uk/news/amp/technology-56168844?

Food and Agriculture Organization (FAO) (2007). Review of the efficacy of Metarhizium anisopliae var. acridum against the Desert Locust. Desert Locust Technical Series, No. AGP/DL/TS/34. www.fao.org/ag/locusts/common/ecg/1295/en/TS34e.pdf

Food and Agriculture Organization, and others (2020). The State of Food Security and Nutrition in the World 2020: Transforming Food Systems for Affordable Healthy Diets. Food and Agriculture Organization of the United Nations: Rome, Italy.

Gammon, Katharine (2021). Global carbon dioxide levels continued to rise despite pandemic. The Guardian. www.theguardian.com/environment/2021/jun/08/carbon-dioxide-levels-pandemic-emissions

Works Cited

Gay, Pierre-Emmanuel, and Michael Lecoq (2018). Improving preventive locust management: insights from a multi-agent model. In Pest Management Science, Vol. 74, Issue 1, pp. 46–58. doi: 10.1002/ps.4648

Global Facility for Disaster Reduction and Recovery (GFDRR) (2016). The making of a riskier future: How our decisions are shaping future disaster risk. Global Facility for Disaster Reduction and Recovery. www.gfdrr.org/sites/default/files/publication/Riskier%20Future.pdf

Goodman, Michael (2018). Systems Thinking: What, Why, When, Where, and How? https://thesystemsthinker.com/systems-thinking-what-why-when-where-and-how/

Gordon, Scott (2021). Fort Worth Opens Emergency Homeless Shelters During Cold Spell. NBC, 9 February 2021. www.nbcdfw.com/news/local/fort-worth-opens-emergency-homeless-shelters-during-cold-spell/2547285/

Green, Kelvin (2020). Extinction is Forever: The End of the Chinese Paddlefish. Global Preservation Society. https://globalpreservationsociety.org/uncategorized/extinction-is-forever-the-end-of-the-chinese-paddlefish/

Grzywacz, David, and others (2014). The Use of Indigenous Ecological Resources for Pest Control in Africa. In Food Security, Vol. 6, No. 1, pp. 71–86.

Hallegatte, Stephane, and others (2018). Poverty and Climate Change: Introduction. In Environment and Development Economics, Vol. 23, No. 3, pp. 217–33.

Helbing, Dirk (2013). Globally networked risks and how to respond. In Perspective, Vol. 497, pp. 51–59. www.nature.com/articles/nature12047/

Hixenbaugh, Mike, and Perla Trevizo (2021). Texans recovering from COVID-19 relied on machines to help them breathe. Then the power went out. The Texas Tribune, 9 March 2021. www.texastribune.org/2021/03/09/texas-covid-power-outages/

Huang, Zhenli, and Luhai Wang (2018). Yangtze Dams Increasingly Threaten the Survival of the Chinese Sturgeon. In Current Biology, Vol 28, Issue 22. doi: 10.1016/j.cub.2018.09.032

Integrated Food Security Phase Classification (IPC) (2020). East & Horn of Africa: IPC Food Security Phase Classification, Desert Locusts & COVID-19. www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC_ECA_DI_COVID19_May2020_Snapshot.pdf

Intergovernmental Panel on Climate Change (IPCC) (2013). Climate change 2013: the physical science basis. Stocker, Thomas, and others, eds., Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press: Cambridge, U.K. and New York, U.S.

Intergovernmental Panel on Climate Change (IPCC) (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change: New York, U.S.

Intergovernmental Panel on Climate Change (IPCC) (2018). Global warming of 1.5°C: An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Intergovernmental Panel on Climate Change.

Intergovernmental Panel on Climate Change (IPCC) (2019a). Climate Change and Land: Summary for Policymakers. Intergovernmental Panel on Climate Change.

Intergovernmental Panel on Climate Change (IPCC) (2019b). IPCC Special Report on the Ocean and Cryosphere in a Changing Climate: Summary for Policymakers. Intergovernmental Panel on Climate Change.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2019). Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Intergovernmental Platform on Biodiversity and Ecosystem Services – Secretariat: Bonn, Germany.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and Intergovernmental Panel on Climate Change (IPCC) (2021). Biodiversity and Climate Change: Scientific Outcome. www.ipbes.net/events/launch-ipbes-ipcc-co-sponsored-workshop-report-biodiversity-and-climate-change

International Energy Agency (IEA) (2021). Global Energy Review 2021: Assessing the Effects of Economic Recoveries on Global Energy Demand and CO2 Emissions in 2021. https://iea.blob.core.windows.net/assets/d0031107-401d-4a2f-a48b-9eed19457335/GlobalEnergyReview2021.pdf

International Federation of Red Cross and Red Crescent (IFRC) (2020). India: Cyclone Amphan Operation Update Report: DREF N MDRIN025. https://reliefweb.int/report/india/india-cyclone-amphan-final-report-dref-n-mdrin025

International Institute for Environment and Development (IIED) (2007). Environment Inside – Lack of environmental awareness, skills and institutional capacity. www.environmental-mainstreaming.org/Environment%20Inside/Chapter%205/chapter5-2-f.html

International Union for Conservation of Nature (IUCN) (2017). Ocean warming. www.iucn.org/resources/issues-briefs/ocean-warming

Islam, Nazrul, & John Winkel (2017). Climate change and social inequality. UN Department of Economic and Social Affairs (DESA) Working Papers, No. 152, UN, New York. doi: 10.18356/2c62335d-en

Keesing, Felicia, and Richard S. Ostfeld (2021). Impacts of Biodiversity and Biodiversity Loss on Zoonotic Diseases. In Proceedings of the National Academy of Sciences, Vol. 118, No. 17.

Kruczkiewicz, Andrew, and others (2021). Opinion: Compound risks and complex emergencies require new approaches to preparedness. In Proceedings of the National Academy of Sciences of the United States of America, Vol. 118, No. 19. www.pnas.org/content/118/19/e2106795118

Kumar, Pankaj, and others (2020). Socio-Hydrology: A key approach for adaptation to water scarcity and achieving human well-being in large riverine islands. In Progress in Disaster Science, Vol. 8, p. 100134. www.sciencedirect.com/science/article/pii/S2590061720300715

Kumar, Shubham, and others (2021). Influence of Super Cyclone "Amphan" in the Indian Subcontinent Amid COVID-19 Pandemic. In Remote Sensing in Earth Systems Sciences, pp. 1–8.

Laurance, William, and Bruce Williamson (2001). Positive Feedbacks among Forest Fragmentation, Drought, and Climate Change in the Amazon. In Conservation Biology, Vol. 15, Issue 6, pp. 1529–1535. https://conbio.onlinelibrary.wiley.com/doi/epdf/10.1046/j.1523-1739.2001.01093.x

Lee, Bernice, and others (2012). Preparing for High-impact, Low-probability Events: Lessons from Eyjafjallajökull. The Royal Institute of International Affairs (Chatham House): London, U.K. www.chathamhouse.org/sites/default/files/public/Research/Energy%2C Environment and Development/r0112_highimpact.pdf

Lomer, C., and others (1997). Development of Metarhizium spp. for the Control of Grasshoppers and Locusts. In Memoirs of the Entomological Society of Canada, Vol. 129 (Supplement S171), pp. 265–286. doi:10.4039/entm129171265-1

Works Cited

Maani, Kambis, and Robert Cavana (2007). Systems Thinking, System Dynamics: Managing Change and Complexity, 2nd edition. New Zealand.

Manjarrés-Hernández, Ana, and others (2021). Predicting the Effects of Climate Change on Future Freshwater Fish Diversity at Global Scale. In Nature Conservation, Vol. 43, pp. 1–24.

McConnell, Tristan (2021). A locust plague hit East Africa. The pesticide solution may have dire consequences. National Geographic, 24 March 2021. www.nationalgeographic.com/environment/article/locust-plague-hit-east-africa-pesticide-solution-may-have-dire-consequences

McSweeney, Robert (2019). Q&A: How is Arctic warming linked to the'polar vortex'and other extreme weather? Carbon Brief, 31 January 2019. www.carbonbrief.org/qa-how-is-arctic-warming-linked-to-polar-vortext-other-extreme-weather
Menéndez, Pelayo, and others (2020). The Global Flood Protection Benefits of Mangroves. In Scientific Reports, Vol. 10, No. 1, p. 4404. www.nature.com/articles/s41598-020-61136-6

Meyers, Talya (2020). Super Cyclone Amphan Bears down on India and Bangladesh: The First Super-Cyclonic Storm to Hit the Region in over 20 Years, Amphan Is Slow-Moving but Highly Dangerous. Direct Relief. www.directrelief.org/2020/05/super-cyclone-amphan-bears-down-on-india-and-bangladesh/

Meynard, Christine, and others (2020). On the relative role of climate change and management in the current desert locust outbreak in East Africa. In Global Change Biology, Vol. 26, Issue 7, pp. 3753–3755. doi: 10.1111/gcb.15137

Mohanty, Sujit, and others (2021). Shelter Management During Pandemics: Lessons from Cascading Risks of Cyclones and COVID-19. In International Journal of Disaster Resilience in the Built Environment, Ahead-of-print.

Mukhopadhyay, Anirban, and others (2018). Dynamics of the Sundarbans Mangroves in Bangladesh Under Climate Change, in Ecosystem Services for Well-Being in Deltas, Nicholls, Robert, and others, eds., Palgrave Macmillan. doi: 10.1007/978-3-319-71093-8_26

Natali, Susan M., and others (2019). Large loss of CO2 in winter observed across the northern permafrost region. In Nature Climate Change, Vol. 9, No. 11, pp. 852–57. www.nature.com/articles/s41558-019-0592-8

¬Natali, Susan M., and others (2021). Permafrost carbon feedbacks threaten global climate goals. In Proceedings of the National Academy of Sciences, Vol. 118, No. 21. www.pnas.org/content/pnas/118/21/e2100163118.full.pdf

National Oceanic and Atmospheric Administration (NOAA) (2021a). State of the Climate: Tropical Cyclones – Annual 2020. www.ncdc.noaa.gov/sotc/tropical-cyclones/202013

National Oceanic and Atmospheric Association (2021b). Global Climate Report – Annual 2020. www.ncdc.noaa.gov/sotc/global/202013

Neumann, Barbara, and others (2015). Future Coastal Population Growth and Exposure to Sea-Level Rise and Coastal Flooding – a Global Assessment. In PloS one, Vol. 10, No. 3, e0118571.

Organisation for Economic Co-operation and Development (OECD) (2016). Conference Proceedings: Towards Quantifying the Links Between Environment and Economic Growth. Global Forum on Environment and Economic Growth, OECD Conference Centre, Paris. www.oecd.org/economy/greeneco/global-forum-on-environment-2016.htm

Parajuly, Keshav, and others (2020). The Future of Electric Vehicles and Material Resources: A Foresight Brief. UNU/UNITAR – SCYCLE: Bonn, Germany, and UNEP-IETC: Osaka, Japan.

Phillips, Carly, and others (2020). Compound climate risks in the COVID-19 pandemic. In Nature Climate Change, Vol. 10, pp. 586–588. www.nature.com/articles/s41558-020-0804-2

Rahman, Shams and Aswini Yadlapalli (2021). Years after the Rana Plaza tragedy, Bangladesh's garment workers are still bottom of the pile. In The Conversation, 22 April 2021.https://theconversation.com/years-after-the-rana-plaza-tragedy-bangladeshs-garment-workers-are-still-bottom-of-the-pile-159224

Ramírez, Enrique (2019). Amazon wildfire crisis: Need for an international response. European Parliamentary Research Service. www.europarl.europa.eu/RegData/etudes/BRIE/2019/644198/EPRS_BRI(2019)644198_EN.pdf

Ritchie, Hannah, and Max Roser (2014). Natural Disasters. Our World In Data. https://ourworldindata.org/natural-disasters

Salih, Abudakr and others (2020). Climate change and locust outbreak in East Africa. In Nature Climate Change, Vol. 10, Issue 7, pp. 584–585. doi: 10.1038/s41558-020-0835-8

Samson, A. (2019). How Incentives Can Build Good Habits. Psychology Today, 30 July 2019. www.psychologytoday.com/us/blog/consumed/201907/how-incentives-can-build-good-habits

Schaefer, Laura, and others (2016). Making Climate Risk Insurance Work for the Most Vulnerable: Seven Guiding Principles. https://collections.unu.edu/eserv/UNU:5830/MCII_ProPoor_161031_Online_meta.pdf

Schema, and others (2019). The Lifespan of News Stories. https://newslifespan.com/

Seddon, Nathalie, and others (2021). Getting the Message Right on Nature-Based Solutions to Climate Change. In Global Change Biology, Vol. 27, No. 8, pp. 1518–1546.

Seneviratne, Sonia I., and others (2012). Changes in Climate Extremes and their Impacts on the Natural Physical Environment. www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap3_FINAL-1.pdf

Shepherd, Andrew, and others (2013). The geography of poverty, disasters and climate extremes in 2030. Research Report. Overseas Development Institute. https://odi.org/en/publications/the-geography-of-poverty-disasters-and-climate-extremes-in-2030/

Stokstad, Erik (2020). In Somalia, an unprecedented effort to kill massive locust swarms with biocontrol. Science. www.sciencemag.org/news/2020/02/somalia-unprecedented-effort-kill-massive-locust-swarms-biocontrol

Struzik, Ed (2016). Food Insecurity: Arctic Heat Is Threatening Indigenous Life. Yale Environment 360, 17 March 2016. https://e360.yale.edu/features/arctic_heat_threatens_indigenous_life_climate_change

Sun, Yuan, and others (2017). Impact of Ocean Warming on Tropical Cyclone Size and Its Destructiveness. In Scientific Reports, Vol. 7, Article No. 8154. www.nature.com/articles/s41598-017-08533-6

Sutherland, Ira, and others (2018). Undervalued and under pressure: a plea for greater attention toward regulating ecosystem services. In Ecological Indicators, Vol. 94, pp. 23–32.

The Climate Reality Project (2020). How Feedback Loops Are Making the Climate Crisis Worse. www.climaterealityproject.org/blog/how-feedback-loops-are-making-climate-crisis-worse

Tooley, Christian (2021). What 'systems thinking' actually means – and why it matters for innovation today. www.weforum.org/agenda/2021/01/what-systems-thinking-actually-means-and-why-it-matters-today/
Tran, Bach Xuan, and others (2020): Impact of COVID-19 on Economic Well-Being and Quality of Life of the Vietnamese During the National Social Distancing. In Frontiers in psychology, Vol. 11, p. 565153. doi: 10.3389/fpsyg.2020.565153.

Trew, Bel, and others (2020). The seven years of neglect, and 13 minutes of chaos, that destroyed Beirut. The Independent. www.independent.co.uk/news/world/middle-east/beirut-explosions-lebanon-deaths-ammonium-nitrate-government-resign-a9665566.html

Works Cited

Turetsky, Merritt R., and others (2019). Permafrost collapse is accelerating carbon release. In Nature, Vol. 569. https://media.nature.com/original/magazine-assets/d41586-019-01313-4/d41586-019-01313-4.pdf

Turney, Chris, and others (2020). Urgent need for an integrated policy framework for biodiversity loss and climate change. In Nature Ecology & Evolution, Vol. 4, No. 8, p. 996. www.nature.com/articles/s41559-020-1242-2

United Nations (2020). The Impact of COVID-19 on Food Security and Nutrition. Policy Brief. www.un.org/sites/un2.un.org/files/sg_policy_brief_on_covid_impact_on_food_security.pdf

United Nations (2021). Financing for Sustainable Development Report 2021: Inter-Agency Task Force on Financing for Development. https://developmentfinance.un.org/fsdr2021
United Nations Department of Economic and Social Affairs (UN-DESA) (2018). World Urbanization Prospects: The 2018 Revision. United Nations Department of Economic and Social Affairs, Population Division. https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf

United Nations Department of Economic and Social Affairs (2020). World Social Report 2020: Inequality in a Rapidly Changing World. United Nations Department of Economic and Social Affairs. www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2020/02/World-Social-Report2020-FullReport.pdf

United Nations Office for Disaster Risk Reduction (UNISDR) (2015). Global Assessment Report on Disaster Risk Reduction: Annex 4: Future Challenges for Disaster Risk Management. United Nations Office for Disaster Risk Reduction. www.preventionweb.net/english/hyogo/gar/2015/en/gar-pdf/Annex4-Future_challenges_of_disaster_risk_management.pdf

United States Environmental Protection Agency (EPA) (2021). Climate Change Indicators: Oceans. www.epa.gov/climate-indicators/oceans

Vörösmarty, C. J., and others (2010). Global Threats to Human Water Security and River Biodiversity. In Nature, Vol. 468, No.334. doi: 10.1038/nature09549

Wachinger, Gisela, and others (2010). Risk perception of natural hazards. CapHaz-Net WP3 Report. DIALOGIK Non-Profit Institute for Communication and Cooperative Research: Stuttgart, Germany. www.researchgate.net/profile/Tracey-Coates-2/publication/228827276_Risk_perception_of_natural_hazards/links/00b49519f2905da3f5000000/Risk-perception-of-natural-hazards.pdf

Wisner, Ben, and others (2004). At risk: Natural hazards, people's vulnerability and disasters. 2nd Edition, Routledge: London, U.K.

World Bank (2020). Poverty and Shared Prosperity 2020: Reversals of Fortune. https://openknowledge.worldbank.org/bitstream/handle/10986/34496/9781464816024.pdf

World Wide Fund for Nature (WWF) (2018). Living Planet Report – 2018: Aiming Higher. https://coral.org/wp-content/uploads/2018/11/lpr2018_full_report_spreads.pdf

World Wide Fund for Nature (2021). The World's Forgotten Fishes. World Wide Fund for Nature: Switzerland. https://wwfint.awsassets.panda.org/downloads/world_s_forgotten_fishes__final_april9_.pdf

Xu, Zhitao, and others (2021). The Compounded Effects of COVID-19 Pandemic and Desert Locust Outbreak on Food Security and Food Supply Chain. In Sustainability, Vol. 13, No. 3, p. 1063. https://doaj.org/article/86cc923b44064413a6f912a006194f1e

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