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Recovery under consecutive disasters: how recovery dynamics shape societal resilience

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Abstract. Consecutive disasters, where two or more disasters occur in succession before recovery from the first event has been completed, can have non-linear impacts on societies that can surpass the effects isolated events. Drawing on empirical examples and insights from scientific literature, we explore how consecutive disasters affect societal recovery across four interconnected pillars of society: human settlements, human health, economic systems, and socio-political systems. We identify pathways through which repeated disasters can either erode a community's ability to effectively respond to and recover from disasters or provide opportunities for social learning and positive change. By examining both immediate and long-term effects, we show how societies might be pushed towards critical tipping points, resulting in either a systemic breakdown of societal resilience, or transformative adaptation and improved capacity to manage future risks. Recognising these dynamics underscores the need for a long-term, multi-hazard approach to disaster risk reduction. Recovery planning must move beyond short-term, reactive measures toward integrated, forward-looking strategies, supported by reliable, proactive, and equitable financing mechanisms. Addressing the complexity of recovery under consecutive disasters is essential for both research and policy to enable adaptive, resilient societies in a future of increasingly frequent and intense hazards.

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

1 Introduction

Recent events have demonstrated how societies face heightened recovery challenges when they are faced with multiple disasters within a short period of time. In 2017, the small island of Puerto Rico was struck by two consecutive hurricanes during an exceptionally active Atlantic hurricane season. Hurricanes Irma and Maria hit only two weeks apart, leaving the island with limited time to recover between events. Irma already caused significant damage and left nearly a million people without power, after which Maria exacerbated the damage, ultimately affecting nearly every municipality and leading to a death toll of over 4,600, worsened by indirect effects such as prolonged power outages and limited healthcare access (FEMA, 2018; Kishore et al., 2018).

Such events, where two or more disasters occur in close succession, while recovery of the first event has not yet been completed, are defined as consecutive disasters (de Ruiter et al., 2020). Recent studies have provided insights into the global frequency of events where multiple disasters occur simultaneously or consecutively (Claassen et al., 2023; Ridder et al., 2020). When recovery between disasters is incomplete, interaction between multiple disaster impacts can result in impacts that are greater than the sum of the individual disasters (Kappes et al., 2012; Marzocchi et al., 2012). As a result of climate change, the frequency and intensity of many climate-related hazards are projected to increase, subsequently altering the likelihood of experiencing successive disaster events with limited recovery time (IPCC, 2023). For example, hurricane seasons similar to the 2017 Atlantic season, which featured 17 named storms and 10 tropical cyclones, with six escalating to major status, are, for example, expected to become more frequent as a result of climate change (NOAA National Centers for Environmental Information, 2025). By the end of the century, rising sea temperatures and sea levels, alongside shifts in storm patterns, are projected to reduce their occurrence interval from once every 10–92 years to every 1–3 years (Xi et al., 2023). Additionally, population growth and economic expansion will increase exposure, placing more people and assets at risk (Tellman et al., 2021).

The UNDRR (2016) defines recovery as “The restoring or improving of livelihoods and health, as well as economic, physical, social, cultural, and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and “Building Back Better”, to avoid or reduce future disaster risk”. While in the disaster risk management (DRM) cycle recovery is a distinct phase that follows response and predates prevention, mitigation, and preparedness, in practice the phases of DRM are not as clearly separated. Recovery can, for instance, already commence alongside immediate response and relief activities and, in the case of consecutive disasters, recovery demands from a second event can add to those from an earlier disaster (de Ruiter et al., 2020; Mohammadi et al., 2023; Terzi et al., 2022). The “Build Back Better” principles emphasise that recovery is *not* solely about returning to pre-disaster conditions, but also about improving preparedness and resilience through the implementation of disaster risk reduction (DRR) measures (UNDRR, 2016).

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

While it is evident that recovery plays a role in shaping the impacts of consecutive disasters, recovery processes in the context of such events remain one of the least-explored areas in disaster science (Drakes & Tate, 2022). Recent studies have advanced our understanding of how multiple hazards interact when they coincide or occur in short succession (Gill & Malamud, 2016; Tilloy et al., 2019), but the socio-economic impacts of consecutive disasters remain understudied (Drakes & Tate, 2022; Jäger et al., 2024; Lee et al., 2024). Moreover, the standard risk framework, which conceptualises risk as the product of overlapping hazard, exposure, and vulnerability (UNDRR, 2016) is generally used in a static manner, rather than exploring changes over time. Recent studies have underscored that dynamic exposure and vulnerability conditions following a first disaster can significantly influence people's ability to respond to and recover from subsequent events (de Ruiter et al., 2020; De Ruiter & van Loon, 2022).

In addition to disaster risk, recovery is also connected to the concept of resilience, as resilient societies are characterised by their ability to recover quickly and adapt effectively to shocks, thereby reducing vulnerability over time (UNDRR, 2022; Zobel & Khansa, 2014). When a consecutive disaster disrupts recovery, this may affect a society's resilience over time, slowly pushing it towards critical thresholds, known as tipping points, where a relatively small change to the system can trigger non-linear and irreversible shifts in the system (Milkoreit et al., 2018). The new state can either be less favourable, marked by a long-term reduction in resilience, or more favourable, reflecting transformative adaptation and enhanced capacity to manage future disasters. Even when recovery is completed between events, decisions made during the recovery process, such as how and where to rebuild, can fundamentally shape a society's resilience to subsequent events. Spaiser et al. (2024) identified four subsystems within a society (i.e., human settlements, the social-psychological system, financial markets, and the political system) as potential elements where non-linear transitions and ultimately social tipping can occur.

Here, we explore societal recovery under consecutive disasters along an adapted version of the four subsystems identified by Spaiser et al. (2024), including human settlements, human health, the economic system, and the socio-political system (Fig. 1). Rather than focusing solely on financial markets, we broaden this pillar to encompass the entire economic system, including disruptions in economic supply chains, allowing us to consider also impacts on the global food system. Additionally, we argue for the inclusion of human health as a distinct pillar, as health considerations are currently insufficiently integrated into DRM practices, while health crises and disasters resulting from natural hazards are known to be mutually reinforcing (UNDRR, 2022; WHO, 2019).

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

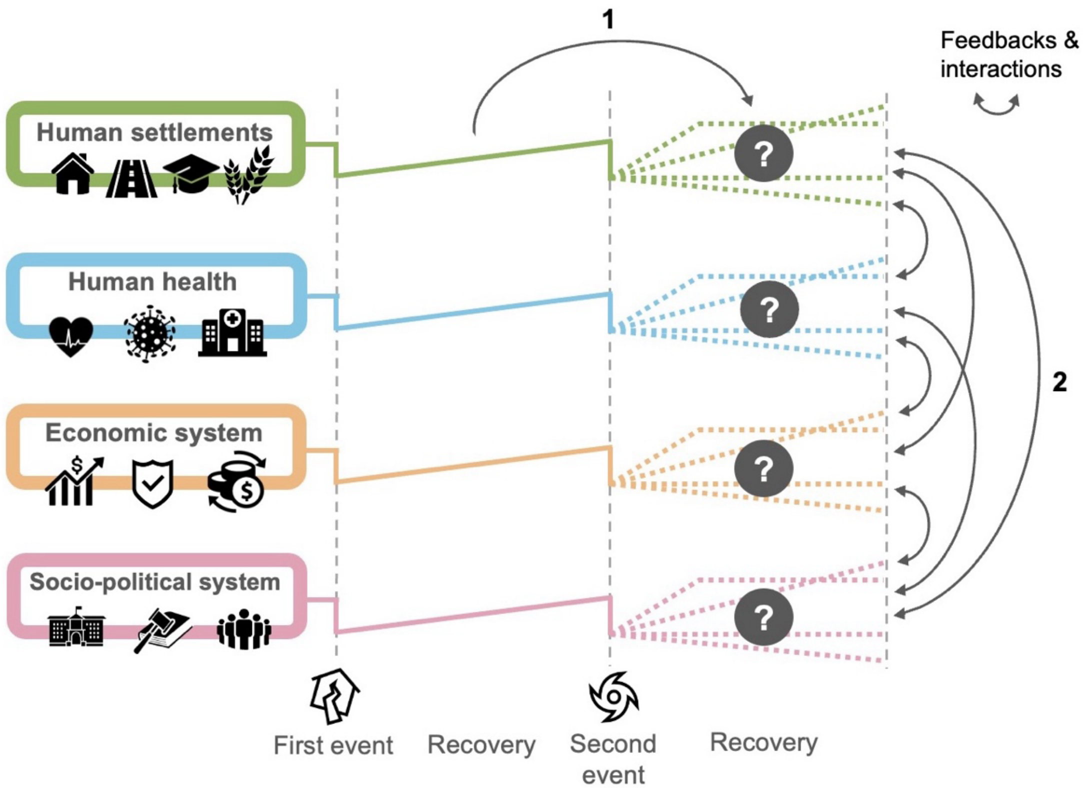

Figure 1. Conceptual framework, illustrating the four interconnected societal sub-systems (human settlements, human health, economic system, and socio-political system) and a simplified representation of their recovery trajectory under consecutive disasters. We highlight the uncertainty in the recovery process after a consecutive event and how this affected by 1) the recovery outcome from a previous event and 2) the recovery trajectory of other parts of society.

In this paper, we bring together empirical examples and insights from scientific literature to explore how consecutive disasters influence societal recovery and how recovery processes, in turn, can shape a society's resilience to cope with future events. We highlight various pathways through which non-linear impact interactions can emerge across four interconnected societal domains: human settlements, human health, economic systems, and socio-political systems (Fig. 1). Each chapter focuses on one of the four pillars, showcasing processes through which recovery can be affected in the context of consecutive events, after which we discuss the potential long-term implications for societal resilience. By addressing both immediate effects and indirect, long-lasting effects that can potentially lead to irreversible social tipping, we offer a broad perspective on how consecutive disasters shape societal recovery. While the paper does not aim to provide an exhaustive review, the provided examples highlight the importance of accounting for the complex dynamics that are involved with disaster recovery. The paper concludes with practical recommendations for better integration of recovery dynamics into research and policymaking, to support societies with effective management of consecutive disasters in the face of increasingly frequent and intense hazards.

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

2 Impacts within human settlements

Human settlements refer to the places where people live, and the critical systems they depend on, such as housing, education, public transport, and food(Newman et al., 1996). Disasters can repeatedly disrupt the structural functionality of human settlements, causing cumulative damage to buildings, infrastructure, and ecosystems, as well prolonged displacement and loss of life (IPCC, 2023). This section explores how recovery within these settlements can become a prolonged struggle rather than a linear process when efforts to rebuild homes, infrastructure, and livelihoods are repeatedly disrupted, and how inadequate recovery can increase vulnerability and exposure to future risks (Sargeant et al., 2020). A summary of the pathways discussed in this chapter can be found in Fig. 2.

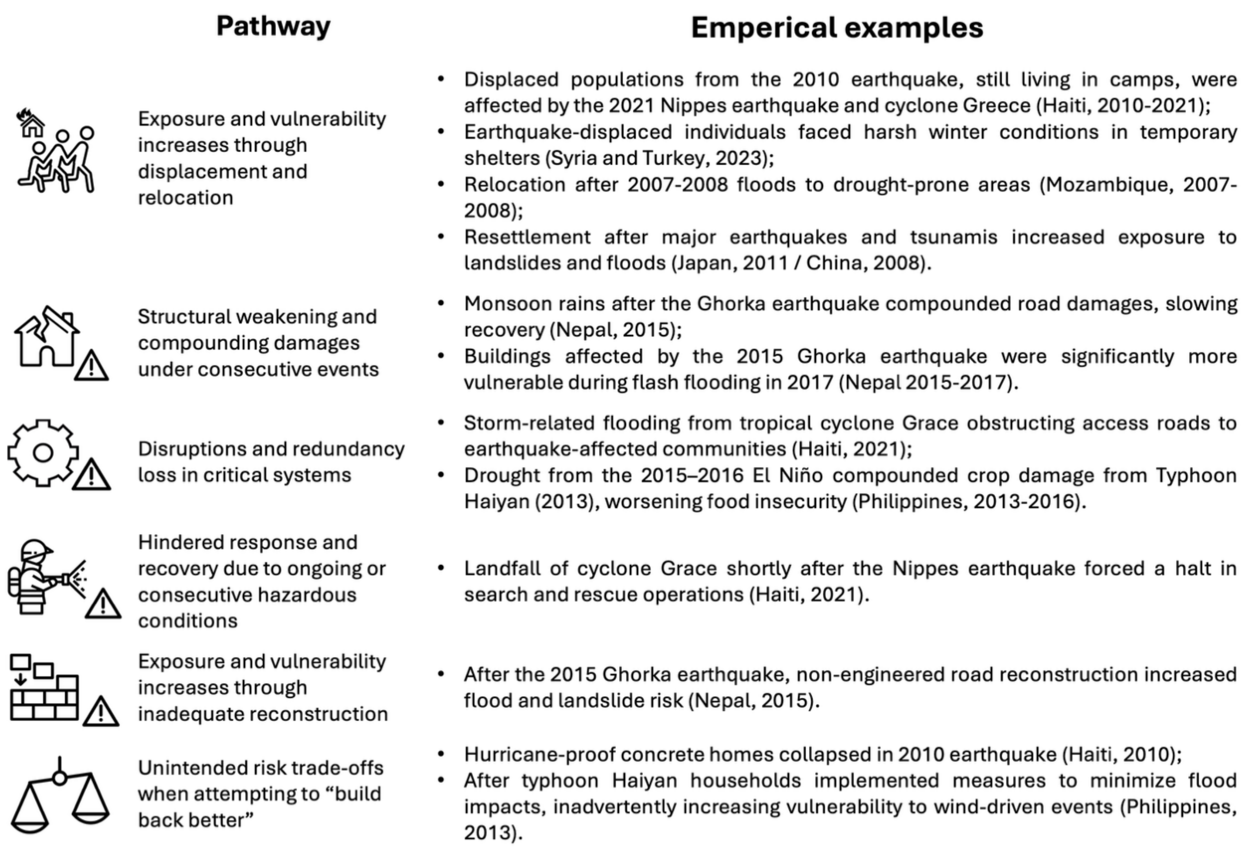

Figure 2. Summarizing figure showcasing main recovery pathways and examples discussed in chapter 2 (human settlements).

2.1 Exposure and vulnerability increases through displacement and relocation

Each year, over 20 million people are displaced by disasters, forcing them into temporary shelters or informal settlements (IDMC, 2021). Regaining stable housing is vital to restore individuals' wellbeing, yet only about 30 percent of affected individuals receive international aid within the first year, most of which is directed toward temporary shelters (Peacock et al., 2017; Twigg et al., 2017). Long-term support for livelihood resilience remains mostly absent, leaving recovery efforts to individual households (Twigg et al., 2017).

Displaced individuals are often more exposed to subsequent disasters, particularly in hazard-prone areas (IDMC, 2021). Following the 2010 earthquake (7.0 Mw) in Haiti, displaced residents migrated across the country, away from affected urban areas into flood- and landslide-prone areas with high seismic risk. Camps were established based on NGOs presence in the area, with minimal consideration of geographic appropriateness or disaster risk. Over a decade later, 33,000 victims of the 2010 earthquake were still living in camps, making them vulnerable to the major 2021 Nippes earthquake (7.2 Mw), followed just days later by tropical cyclone Grace (Cabas et al., 2023). While displacement could theoretically also reduce exposure if communities relocate to safer areas, empirical evidence remains lacking (Stalhandske et al., 2024). Even planned relocations frequently overlook meteorological and agronomic conditions (de Waal, 1991; Ferris, 2011). Relocation sites are often chosen without considering current and future exposure to other hazards. In Mozambique, flood-safe resettlement centres were built after floods and tropical cyclones in 2007/2008. However, droughts were not considered, and water scarcity forced people to grow crops in flood-prone areas again (Ferris, 2011). Similarly, after the 2008 Wenchuan earthquake (7.9 Mw) in China and the 2011 Great East Japan earthquake and tsunami, resettlement in mountainous areas increased exposure to landslides and floods (Kondo & Lizarralde, 2021; Tang et al., 2020). Even when risks are explicitly considered in relocation strategies, finding suitable, safe land for rebuilding can be challenging, due to limited availability of low-risk land, especially in hazard-prone regions. This search for safe land to rebuild is further exacerbated by unclear property rights and land claims (Jahn et al., 2016).

Displacement also heightens vulnerability. People staying in poorly constructed temporary shelters, or on the streets without any shelter at all, can become more susceptible to impacts from severe weather. After severe earthquakes (7.8/7.6 Mw) in Syria and Turkey (2023), displaced individuals were, for example, living in tents when they were confronted with harsh winter weather, making the earthquake victims vulnerable to medical issues such as hypothermia (Bayram et al., 2023; Orak, 2024). Moreover, people staying in displacement camps and temporary shelters often lack adequate access to critical services, such as WASH infrastructure, increasing their susceptibility to health-related impacts (further discussed in Sect. 3.1 on emerging and aggravated health risks in post-disaster contexts) (IDMC, 2021). Although intended as a short-term solution, shelters often unintendedly become permanent or semi-permanent over time, resulting in long-term vulnerabilities (Askar et al., 2019). Regaining stable housing can take years, or even decades, even in high income countries such as the U.S. and Japan (Action Aid, 2010; Merdjanoff et al., 2022).

2.2 Structural weakening and compounding damages under consecutive events

Even when disasters do not fully destroy houses and critical structures, it can leave these structures and the overall system significantly more vulnerable to subsequent disasters. Consecutive disasters compound earlier impacts, amplifying existing

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

damage and undermining reconstruction efforts (Kim & Choi, 2013; Puri et al., 2024). After the 2015 Gorkha earthquake (7.8 Mw) in Nepal, monsoon rains further degraded the road network, slowing the delivery of materials and aid, and forcing communities to divert efforts from rebuilding homes to address the new infrastructure impacts (Twigg et al., 2017).

When structures have not been able to fully recover from a preceding event, they can also become more vulnerable to later impacts, with increased risk of collapse or sustaining disproportionately large impacts from subsequent events (Gautam & Dong, 2018; Korswagen et al., 2019). Empirically estimated damage functions from the Gorkha earthquake illustrate this, showing that buildings affected by the earthquake in 2015 were significantly more vulnerable to subsequent flash flooding in 2017. In some cases, damage was aggravated up to 300 percent when buildings had suffered earthquake damage prior to the flood (Gautam & Dong, 2018).

2.3 Disruptions and redundancy loss in critical systems

The essential systems that human settlements rely on, such as energy, water, healthcare, transport, and food, also become increasingly affected when impacts accumulate. Access to critical facilities, such as shelters and hospitals, after a disaster plays a key role in accelerating recovery (Alam et al., 2024). When access to such facilities is disrupted, or when key systems transport and communication systems are affected, this can significantly slow down the overall recovery process (Ade Bilau et al., 2018; Sospeter et al., 2020; Suppasri et al., 2024). For example, In Haiti (2021), storm-related flooding obstructed access to earthquake-affected communities, making it difficult for humanitarian workers to reach those in need of help (OCHA, 2021b).

To be able to maintain functionality under shocks, critical systems are typically designed with redundancy of critical components and functions (Nowell et al., 2017; Urlainis et al., 2022). However, when such systems, such as roads, hospitals, or the power grid remain unrepaired, the system's vulnerability to subsequent events is increased through a redundancy reduction (Argyroudis et al., 2020; Fereshtehnejad & Shafieezadeh, 2018). Recovery time depends on initial damage, system interdependencies, and spatial distribution of critical components (Der Sarkissian et al., 2022; Jeddi et al., 2022). However, effective preparedness, recovery planning, and prioritization can help accelerate restoration (Koks et al., 2022; Urlainis et al., 2022).

Food system redundancy is also threatened under consecutive disasters. In the Philippines, drought-related crop failures caused by prolonged dry spells and reduced rainfall during the strong 2015-2016 El Niño event compounded earlier damage from typhoon Haiyan (2013) to coconut and banana trees (which take about 1-2 years to fully recover) (Sargeant et al., 2020). Similarly, Mozambique faced widespread food shortages after cyclones Idai and Kenneth (2019), worsened by prior droughts (IFRC, 2019; UNICEF, 2019). Crop diversification can improve resilience, but its effectiveness is limited when multiple hazards affect different food sources simultaneously (Bacon et al., 2017).

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

2.4 Hindered response and recovery due to ongoing or consecutive hazardous conditions

Recovery can also be slowed due to physical hazard conditions that create unsafe, inaccessible, or unworkable environments for emergency responders, even when systems remain functional. After the 2021 Haiti earthquake, storm Grace halted efforts to search for survivors for several critical hours (Cavallo et al., 2021). Similarly, the harsh winter weather after the 2023 Syria and Turkey earthquakes, accompanied by ongoing aftershocks, not only worsened the suffering of displaced and injured individuals, but also created a difficult working environment for emergency personnel (Aljazeera, 2023; Mavrouli et al., 2023). In New Mexico (2024), wildfires were immediately followed by flash floods, forcing firefighting crews to temporarily evacuate (Anguiano, 2024).

Hazard conditions can also decrease the availability of essential resources. The availability of labour for reconstruction can, for instance, be reduced significantly under certain hazard conditions such as extreme heat (Alshebani & Wedawatta, 2014). Similarly, droughts can restrict the availability of water, essential for firefighting (de Hoop et al., 2022). Resource depletion is further discussed in the context of the economic system in Sect. 4.

2.5 Exposure and vulnerability increases through inadequate reconstruction

For displaced populations, regaining stable housing and restoring critical systems is key. However, when reconstruction is rushed, and poorly planned or implemented, this can result in an increase in exposure or vulnerability to future hazards, even when recovery is completed between events. Non-engineered road reconstruction in Nepal after the 2015 Gorkha earthquake, for instance, caused a diversion of water flows, heightening flood risks and making areas more susceptible to succeeding landslides (McAdoo et al., 2018; Rieger, 2021). In addition to technical shortcomiyessngs or skill and resource constraints, inadequate reconstruction can also stem from political instability. Corruption, for example, may undermine the enforcement of building codes during the reconstruction period, resulting in sub-standard structures that are more vulnerable to damage in subsequent events (Cifuentes-Faura, 2024; Mannakkara & Wilkinson, 2013). The link between disaster recovery and political instability is further explored in Sect. 5.1.

2.6 Unintended risk trade-offs when attempting to "Build Back Better"

Unintended negative consequences can even occur when reconstruction is well-executed and attempting "Build Back Better". Ideally, during reconstruction, the aim is not to rebuild everything back to pre-disaster conditions, but to incorporate long-term planning and comprehensive DRR strategies (UNDRR, 2016). When done properly, long-term planning and implementation of such strategies can help a society to, over time, reduce vulnerability to disasters, as is discussed in Sect. 5.3. However, when DRR efforts in the post-disaster phase are too focused on the most recently experienced event, without adequate integration of long-term and multi-hazard considerations, this can increase a society's exposure and vulnerability to future disasters. A clear

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

example of this is again provided by Haiti, where prior to the 2010 earthquake the focus of DRR was on hurricane prevention and response, and to a lesser extent on floods and droughts, as the last major earthquake had been in 1962. While the seismic risks were known, concrete hurricane resistant houses were built, without using an earthquake resistance norm. During the 2010 earthquake, these heavy buildings collapsed, significantly exacerbating the earthquakes' impacts (Hou & Shi, 2011). Similarly, after typhoon Haiyan (2013) in the Philippines, some households build features to minimise flood impacts, such as raised flooring or an extra storey to their house, which inadvertently increased the structural vulnerability to subsequent wind-driven events (Twigg et al., 2017).

This type of unintended outcome is referred to as an asynergy, where a measure that is designed to reduce the risk of one hazard inadvertently increases vulnerability to another (Stolte et al., 2024). There are many more examples of such asynergies across a range of hazard-combinations and contexts, well documented for example for floods and earthquakes (de Ruiter et al., 2021), and floods and droughts (Ward et al., 2020). In addition to adaptation asynergies, there is also the risk of maladaptation, where measures are implemented with the intention of reducing risk but ultimately increase vulnerability or transfer it elsewhere (Schipper, 2020; Stolte et al., 2024).

3 Impacts within the human health system

Recovery from disasters is often complicated by health-related crises that compound disaster impacts (WHO, 2019). The relationship between climatic disasters and health crises is mutually reinforcing: extreme weather exacerbates existing health burdens and can create new ones, while ongoing health crises can weaken the ability of a society to respond to and recover from disaster impacts (Hariri-Ardebili et al., 2022). In this section, we discuss the feedback that exist between health crises and disasters, and how they can prolong humanitarian crises, complicating disaster recovery. A summary of the pathways discussed in this chapter can be found in Fig. 3.

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

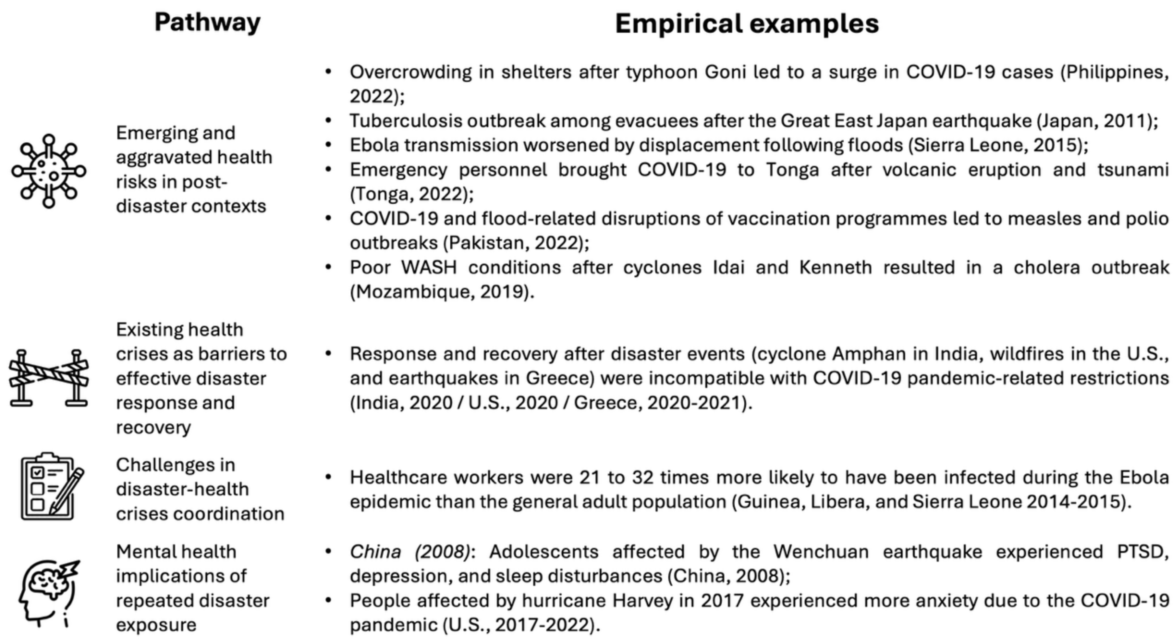

Figure 3. Summarizing figure showcasing main recovery pathways and examples discussed in chapter 3 (human health).

3.1 Emerging and aggravated health risks in post-disaster contexts

One of the most immediate ways in which disasters and health crises interact is through the emergence or intensification of health risks in the aftermath of hazard events. Post-disaster conditions can foster the spread of communicable diseases, for example due to overcrowding of displaced people in emergency shelters, or when mass evacuations are required (Hariri-Ardebili, 2020). This was seen after typhoon Goni in the Philippines in 2022 with a surge in COVID-19 cases (Rocha et al., 2022), Japan's 2011 earthquake with a tuberculosis outbreak (Kanamori et al., 2013), and Sierra Leone's 2015 floods, which worsened Ebola transmission due to strained resources in overcrowded shelters (Ratto et al., 2016). Natural hazards can also contribute to the spread of vector borne diseases such as dengue and malaria, for example when long standing water after a flood creates breeding grounds for mosquitoes (Coalson et al., 2021).

In addition to fostering disease spread, natural hazards can place significant additional pressure on healthcare systems by increasing demand for medical services and occupying hospital capacities (Hariri-Ardebili, 2020). Moreover, disaster-related movement, such as evacuations and humanitarian deployments, can introduce new health risks. This was exemplified during the COVID-19 pandemic, for example after the 2022 Tonga volcanic eruption and tsunami, when emergency personnel entering the affected area inadvertently brought the virus to the island, resulting in a major outbreak (IFRC, 2022).

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

Related to the disruptions in critical systems (Sect. 2.3), damaged or disrupted critical infrastructure in a post-disaster context can contribute to increased health risks for affected populations. For example, through damaged hospitals or hospital access roads and disruption of vaccination programmes (Ali & Hamid, 2022; Hariri-Ardebili, 2020; Salam et al., 2023). In Pakistan, disruptions to vaccination programs initially caused by the COVID-19 pandemic and later compounded by the 2022 "super floods," led to outbreaks of diseases such as polio and measles (Ali & Hamid, 2022). Hassan & Mahmoud (2021) evaluate different patient demand management strategies under a combined impact of a wildfire and pandemic and find that losing access to medical care is a direct function of the relative occurrence time between the two events. Specifically, the availability and accessibility of adequate water, sanitation, and hygiene (WASH) infrastructure can play a crucial role in post-disaster health outcomes. Following cyclone Kenneth in Mozambique early April 2019, less than six weeks after cyclone Idai, poor WASH conditions contributed to a cholera outbreak with over 6,700 deaths (Lequechane et al., 2020).

There are also indirect health effects that can arise, for example when disasters affect food security by disrupting agriculture and supply chains. As discussed in Sect. 2.3, food system resilience is vulnerable under consecutive disasters. The repeated destruction of cropland, loss of livestock, and ongoing displacement leave communities with little time to recover, gradually exacerbating food insecurity, particularly among vulnerable populations, as food scarcity drives up prices and limits access to essential nutrition (FAO, 2023). Especially for children, this can have significant health implications. Hossain et al. (2020) found that children exposed to multi-hazard risks were significantly more likely to be stunted and underweight compared to those in low-risk districts.

3.2 Existing health crises as barriers to effective disaster response and recovery

While extreme climatic events may contribute to new health emergencies, ongoing health crises may, in turn, complicate response and recovery after natural hazard occurrences by introducing significant physical and organizational barriers. The COVID-19 pandemic underscored how health crises can complicate efficient disaster management. Various studies examined disaster events that occurred at the height of the pandemic, such as earthquakes in Greece (2021-2022), wildfires in the U.S. (2020), and cyclone Amphan in India (2020) (Izumi & Shaw, 2022; Mavrouli et al., 2023). They found that response and recovery actions were often incompatible with pandemic-related restrictions, such as quarantine and social-distancing measures, resulting in restricted humanitarian aid delivery, reduced capacity for safe evacuations and sheltering, and a decline in volunteer numbers

3.3 Challenges in disaster-health crises coordination

Governments and responding agencies face the difficult task of balancing multiple, often conflicting priorities, such as preventing disease transmission while coordinating disaster relief efforts (Quigley et al., 2020). The co-occurrence of disasters during a health crisis, or vice versa, can further strain already limited financial and humanitarian resources, particularly in vulnerable, low-income communities that are disproportionately affected by climate change (Hochrainer-Stigler, 2021). In

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

addition, authorities must safeguard emergency personnel and military workers from health risks during ongoing crises, while ensuring effective disaster response (Hadeed et al., 2023). That this can be challenging was demonstrated in Guinea, Libera, and Sierra Leone, where healthcare workers were found to be 21 to 32 times more likely to have been infected with Ebola than other adults during the ongoing epidemic in 2014-2015 (WHO, 2015). These challenges illustrate the broader issue of increased DRM complexity under consecutive disasters, which will be further explored in Sect. 5.2.

3.4 Mental health implications of repeated disaster exposure

Disasters are known to have adverse effects on mental health and wellbeing, with impacts such as post-traumatic stress disorder (PTSD), anxiety, depression, and increased health risk behaviours (Keya et al., 2023; Zenker et al., 2024). For example, adolescents affected by the 2008 Wenchuan earthquake experienced prolonged sleep disturbances and elevated risks of PTSD and depression (Fan et al., 2017). Mental health effects may also extend to those indirectly exposed to disasters, such as through close connections to affected individuals or via media coverage (Garfin et al., 2022).

When people experience repeated exposure to disasters, mental health issues such as PTSD, acute stress disorder (ASD), and depression are exacerbated. This has been found for different hazard types and in a wide range of regions and socio-economic contexts, including exposure to multiple hurricanes in the US (Garfin et al., 2022), repeated earthquakes in China (Geng et al., 2018), and multiple weather-related disasters in Australia (Mitchell et al., 2024). Similar findings emerge when examining the intersection of the COVID-19 pandemic with natural hazards. Callender et al. (2022) register that during the COVID-19 pandemic, people who had been significantly impacted by hurricane Harvey (2017) had higher odds of experiencing severe anxiety. Children are particularly vulnerable to mental health impacts from disasters, as early disaster exposure increases the risk of mental health and substance use issues later in life (Maclean et al., 2016). Particularly when children are repeatedly exposed to disasters, their mental health impacts can be long-lasting, persisting for months or even years (Save the Children, 2023).

4 Impacts within the economic system

Another important aspect of society is the economic system, which encompasses the structures, institutions, and decision-making processes involved in the production, allocation, and distribution of goods, services, and capital within and across communities. Like human settlements and health systems, the economy is increasingly subject to multiple stressors, including extreme weather events, pandemics, and economic conflicts, which collectively create compounding challenges for recovery and growth (Middelanis et al., 2023; Townend et al., 2023). In this chapter we explore how the recovery and long-term resilience of the economic system are affected by consecutive events, as overlapping shocks gradually deplete financial resources, shift investment behaviours and risks, and trigger cascading effects within a highly interconnected global system. A summary of the pathways discussed in this chapter can be found in Fig. 4.

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

Figure 4. Summarizing figure showcasing main recovery pathways and examples discussed in chapter 4 (economic system).

4.1 Gradual depletion of financial resources at different scales

Financial resources are a core element of healthy economies that can become increasingly constrained because of consecutive events. This affects recovery, and eventually long-term financial resilience at different scales, from large-scale impacts at supra- and (inter)national levels down to individual households.

At the national level, recurrent disasters create compounding costs that deplete government funds to financially support their economies and fund disaster recovery (Miao et al., 2019; Skertich et al., 2012). In Mozambique, for instance, a resettlement program to relocate 30,000 families to higher ground after the 2007 floods was disrupted by recurrent flooding in 2008. The additional costs of relocating 21,000 more displaced families further strained financial resources, delaying the project's completion for several years (Ferris, 2011). Internationally, repeated disasters stretch donor resources, potentially leading to so-called donor fatigue (Maçon & Alexander, 2022; OCHA, 2021a). Signs of donor fatigue were observed after the 2021 consecutive earthquake and hurricane event in Haiti, where the lack of DRR improvement and the additional social conflicts seen in Haiti discouraged donors to keep investing (Maçon & Alexander, 2022). Similar dynamics can take place on a

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

supranational scale. A counterfactual storyline study covering 2002–2018 demonstrated that the succession of tropical cyclones in the Caribbean territories of EU countries, combined with earthquakes in Italy, could deplete the European Union Solidarity Fund (EUSF), leaving insufficient funds for recovery from other extreme weather events (Ciullo et al., 2021). This illustrates how the recovery capacity of one country can also be shaped by disaster events that occur in other regions, effectively raising the likelihood that disaster impacts and recovery needs will overlap in time, thus increasing the chance of experiencing consecutive disaster impacts.

At the household level, financial resilience similarly erodes under recurrent shocks. Those who take on debt to recover from an initial disaster, or who lose their income, face increased hardship under additional shocks, making it increasingly difficult to fund disaster recovery of subsequent events and to repay loans (Bacon et al., 2017; Sargeant et al., 2020). In the Philippines, the compounding agricultural losses from the consecutive typhoon Haiyan (2013) and El-Niño induced drought (2015-2016) events not only threatened food security (as discussed in Sect. 2.3) but also severely reduced agricultural income, forcing many households to take on loans (Sargeant et al., 2020; Twigg et al., 2017). These impacts were compounded by typhoons Koppu (2015) and Haima (2016), which forced households that were still struggling after the previous disasters to take on additional loans, deepening their pre-existing debts (Sargeant et al., 2020). Simulations of household recovery after recurrent shocks show that even middle-income households, which are likely to recover quickly from an individual shock, risk falling into poverty when exposed to successive disasters (Sauer et al., 2025).

4.2 Shifting financial risks and market instability

Repeated disasters can also place growing pressure on financial markets and risk-sharing mechanisms such as insurance and banking. Insurance is thought to improve disaster resilience by promoting and supporting fast recovery and by providing incentives for "Building Back Better" (Eriksen et al., 2020; Kousky, 2019). Especially under consecutive events, increases in economic growth-losses could be effectively mitigated by effective insurance coverage and recovery outcomes are significantly improved as insurance speeds up recovery (Cookson et al., 2025; Kousky, 2019; C. Otto et al., 2023). In contrast, positive effects of insurance on promoting precautionary measures to create long-term resilience are limited (Kousky, 2019).

Insuring disaster damages with fat-tailed risks is challenging, as these involve a relatively high likelihood of rare but extremely large losses that often exceed annual revenues in disaster-prone years. Consequently, insurance companies need to have access to enough capital, which needs to be build-up as reserves during years with lower claims or by means of reinsurance solutions. Successive events can deplete available funds in the private insurance and reinsurance markets and drive the risk beyond what is commonly insurable, resulting in elevated premium prices or even the complete withdrawal of insurance providers from high-risk regions (Sastry et al., 2024). This has already been observed in the U.S., where after repeated extreme events like major wildfires in 2018 and 2020, insurance companies withdrew from California (Brenna, 2024; Clark et al., 2024). Higher

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

premiums may further marginalise vulnerable low-income groups. Cookson et al. (2025) found, for instance, that for the 2021 Marshall fire in the U.S., lower-income households were less likely to be insured than higher-income households.

Erosion of financial resources (Sect. 4.1) at the household level can also affect banking stability, through a deterioration of outstanding loans. A study of rural credit cooperatives in China showed that borrowers' ability to repay declined after repeated disaster events, increasing credit risks for banks (Deng et al., 2025). Similar patterns have been observed across parts of Europe, where extreme weather has been found to contribute to higher insolvency rates in France, Italy, Portugal, and Spain (Pastor-Sanz et al., 2025). As these financial pressures accumulate, they may surpass the shock-absorbing capacity of financial systems, contributing to broader market instability (Mahalingam et al., 2018).

4.3 Exacerbated resource and labour constraints

Beyond financial constraints, consecutive disasters can create bottlenecks in the availability of resources required for recovery. Scarcity of construction materials and skilled labour can delay reconstruction and escalate costs when demand accumulates, especially in regions already facing structural shortages (Acharya et al., 2022; Ade Bilau et al., 2018; Sospeter et al., 2020). Chang-Richards et al. (2017), for instance, found that the 2010/2011 earthquakes in Christchurch exacerbated the existing skill shortage in the construction sector, creating significant obstacles to resourcing disaster recovery projects. General resource constraints in materials, equipment, and labour are amongst the most reported challenges in post-disaster recovery (Puri et al., 2024). These limitations become more pronounced when disasters occur consecutively, as resources are further strained, and recovery is prolonged due to competing demands for limited resources (Puri et al., 2024; Sargeant et al., 2020).

4.4 Cascading disruptions and resource depletion in a globalised system

The impacts of extreme events on recovery are not limited to the directly affected areas (Hallegatte, 2014; Mühlhofer et al., 2023; I. M. Otto et al., 2017). In a globally interconnected economy, disruptions in one region can ripple through supply chains, affecting the availability and cost of critical resources, such as construction materials, fuel, and food, in other parts of the world (Middelanis et al., 2023). A modeling study for hurricane Sandy in the U.S. (2012) showed that longer recovery times in the directly affected area significantly increases economic losses across other economically interconnected countries. Countries already incurring losses under short recovery periods would have faced significantly greater losses with prolonged recovery (Middelanis et al., 2021). Modeling exercises show that socio-economic ripple effects from disasters in trade-connected regions can result in substantial consumption losses, even in countries where direct losses are minimal (Kuhla et al., 2021; Middelanis et al., 2023).

These global interconnections are also evident in the food system. As discussed in Sect. 2.3, consecutive disasters can erode the redundancy of local and regional food systems, which can temporarily make communities more reliant on international food trade while they are still recovering. However, the increasingly centralised nature of the global food market makes it particularly vulnerable to systemic shocks (Clapp, 2023). In the same way that recurrent disasters can overwhelm local food production, consecutive events in geographically distant but interconnected regions can affect food system redundancy on a global scale, as their impacts propagate through interconnected systems. In 2020 in Vietnam, for instance, local rice production was affected by a severe drought, while rice prices globally sharply increased due to COVID-19 related food stockpiling (Fox et al., 2020). The risk for a simultaneous decrease of maize, wheat, and soybean yields in major food producing regions (breadbasket failures) has increased over the last decades due to the growing frequency of climate extremes in major crop producing areas (Gaupp et al., 2020) and is projected to increase further under future global warming, putting food security at risk (Hunt et al., 2021; Kornhuber et al., 2023). Countries highly dependent on imports are particularly vulnerable to supply shocks and price changes induced by crop failures in distant regions, with severe poverty implications (Bren D'Amour et al., 2016).

4.5 Positive economic feedback and business adaptation opportunities

Disasters may also stimulate increased economic activity in specific sectors or regions, leading to "Build Back Better" or "positive destruction" (Hsiang et al., 2014). Economic ripple effects can benefit firms outside of the affected area through reconstruction demand or reallocation of production and trade during the recovery period, as unaffected businesses substitute for disrupted suppliers and producers (Fatica et al., 2024; Koks & Thissen, 2016). While disasters generally have a negative impact on medium- to long-term economic growth (Berlemann & Wenzel, 2018; Felbermayr & Gröschl, 2014; Hsiang et al., 2014), potential for positive effects has been found in the case of moderate disasters, depending on disaster type and economic sector. For instance, moderate storms can have a beneficial effect for industrial growth during the recovery period due to increased reconstruction demand. In contrast, severe disasters are consistently associated with negative growth outcomes (Loayza et al., 2012).

Businesses may also pivot their business models to adapt to disaster-induced shifts in supply and demand (Guckenbiehl & Corral de Zubielqui, 2022). The COVID-19 pandemic, for example, created resource voids that enabled disaster entrepreneurship (Doern et al., 2019). Certain sectors, such as the healthcare sector, benefitted from increased demand, although it is unclear whether this turned into long-term benefits (Bachmann et al., 2022). The pandemic also illustrated how adaptability can help firms navigate rapidly changing economic environments (Krammer, 2022). The ability to adapt and seize opportunities are key characteristics of business resilience. Scarinci et al. (2016) studied small business disaster preparedness after superstorm Sandy in 2012 and found that disasters can encourage business owners to develop better contingency and recovery plans, enhancing their subsequent disaster preparedness. Businesses adopting digitization early during the pandemic were similarly better equipped for subsequent disruptions (Seetharaman, 2020; Shaikh et al., 2022).

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

5 Impacts within the socio-political system

The socio-political system, comprising the institutions, governance structures, and societal dynamics that influence decision making, plays a central role in how societies prepare for, respond to, and recover from disasters. Disaster impacts are shaped not only by physical hazard characteristics but also by underlying socio-political structures and pre-existing vulnerabilities (UNDRR, 2024). In this chapter we explore how socio-political systems both shape and are reshaped by repeated disaster impacts, and how underlying vulnerabilities and governance structures affect recovery trajectories and long-term resilience under consecutive events. A summary of the pathways discussed in this chapter can be found in Fig. 5.

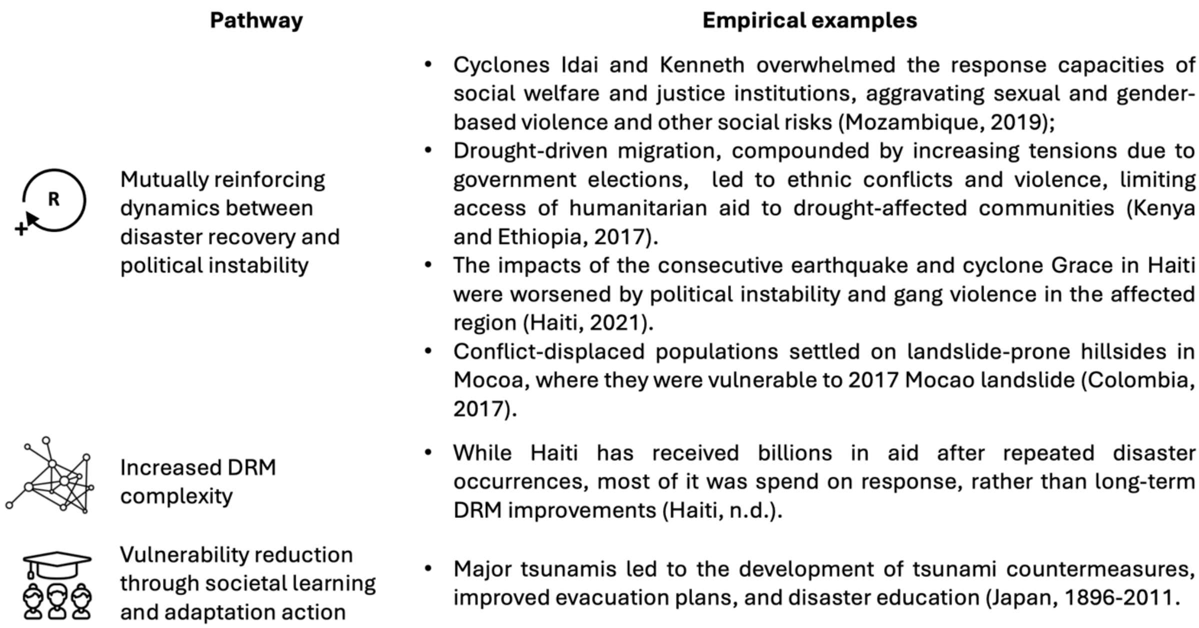

Figure 5. Summarizing figure showcasing main recovery pathways and examples discussed in chapter 5 (socio-political system).

5.1 Mutually reinforcing dynamics between disaster recovery and political instability

When political crises and natural hazards co-occur, they can be consecutive disasters due to the overlapping impacts and increased recovery complexity (Hariri-Ardebili et al., 2022). Reflecting this recognition, various societal hazards, such as civil unrest, armed conflict, and violence have been included in the UNDRR's Hazard Information Profiles (HIPs), alongside environmental and technological threats (UNDRR, 2021). The simultaneous occurrence of conflicts and disasters can hinder both immediate response and long-term recovery, creating cycles of instability and heightened vulnerability. The relationship is mutually reinforcing; while disasters can contribute to political crises, political instability can also exacerbate disaster impacts (Rosvold, 2023).

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

Disasters can further destabilise already fragile socio-political systems, for instance, by overwhelming the capacity of state institutions. For example, after Idai and Kenneth hit Mozambique six weeks apart in 2019, the response capacities of social welfare and justice institutions were significantly weakened. This aggravated risks related to child safety, loss of personal documentation and property rights, and sexual and gender-based violence (UNICEF, 2019). Social disorder post-disaster is also linked to large-scale displacement, particularly in low-income countries lacking resources to manage sudden population shifts (Castells-Quintana et al., 2022). In Kenya and Ethiopia, for example, a drought in 2017 affected pastoralist migration, causing resource conflicts and ethnic tensions, worsened by election-related violence and unrest in Kenya (Matanó et al., 2022). Moreover, recurrent disasters can contribute to existing inequalities, as the poorest and most vulnerable populations sustain disproportionate disaster impacts and have the most difficulty fully recovering between events (Sauer et al., 2025). Particularly for countries with weak institutions and high levels of inequalities, the risk of conflict increases in post-disaster settings (Ide et al., 2020).

Political conflict before or during disasters also increases vulnerability and hinders effective disaster response and recovery (Matanó et al., 2022; Rosvold, 2023). Ethnic conflicts and violence after the drought-driven migration in Kenia and Ethiopia (2017), for instance, significantly hindered the access of humanitarian aid to drought-affected communities (Matanó et al., 2022). Similar access limitations arose in Haiti (2021), where impacts of an earthquake and tropical storm were exacerbated by highly unstable political situation, which created additional challenges for disaster response and recovery. Accessibility to affected areas was already low due to road damage caused by landslides and rockfalls and was further restricted by escalating gang violence, which obstructed aid delivery and movement along key transport routes (Cabas et al., 2023).

Volatile political circumstances can also drive displacement, which can, similarly to disaster-driven displacement (Sect. 2.1) force vulnerable people into high-risk environments. In Colombia, for instance, people displaced by conflict in Bayo Putumayo settled on landslide-prone hillsides in Mocoa, leaving them exposed to the deadly 2017 Mocoa landslide (Siddiqi et al., 2019). Similarly to repeated disasters, political crises can reinforce inequalities. Displaced populations, for example, often face marginalisation and are systematically excluded from formal disaster preparedness and recovery efforts (Few et al., 2021). In the case of the 2017 Mocoa landslide, it was shown that internally displaced people and indigenous groups living in Mocoa were largely left out of disaster preparation activities and rehabilitation planning (Siddiqi et al., 2019). Unsurprisingly, it was estimated that 80 percent of the landslide victims had also been victims of prior conflict. Social inequalities can also shape access to support provided by response and recovery programs (Emrich et al., 2022). Effective distribution of recovery support and aid in conflict scenarios can also be hindered by a loss of trust as a result of an unstable political situation. People fleeing conflict have been shown to show more resistance to accepting help from military personnel after a disaster when they provide recovery and relief assistance (Siddiqi et al., 2019).

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

5.2 Increased DRM complexity

After a disaster, even without a political crisis, decision-makers must balance trade-offs between immediate response and recovery and long-term planning. While investing in DRR provides substantial benefits in terms of avoided losses (Hugenbusch & Neumann, 2019), consecutive disasters often divert resources to immediate response and relief efforts, limiting the capacity for long-term planning and preparedness (Finucane et al., 2020). Additionally, there is a tension between rapid recovery, focused on quickly replacing losses, and adopting a deliberate recovery approach that aligns with the "Build Back Better" principles (Olhansky, 2018). Haiti, hit by frequent disasters, has received billions in international aid, making up 20 percent of its annual government budget. Most funds have been directed toward immediate humanitarian response, with minimal investment in reconstruction and long-term development (Cabas et al., 2023; Fischer & Levy, 2012). Prioritizing short-term needs over long-term preparedness can ultimately trap disaster-affected communities in cycles of loss and dependence on external aid (Norton et al., 2023). A long-term reliance on international aid discourages local governments from taking ownership of DRM and sidelines local initiatives (Hendriks & Boersma, 2019). Additionally, poorly planned recovery without adequate integrations of long-term and multi-hazard considerations can lead to maladaptation and risk trade-offs, as discussed in Sect. 2.6.

5.3 Vulnerability reduction through societal learning and adaptation action

While the overlapping phases of DRM can intensify conflicting demands and trade-offs between immediate response and long-term planning, repeated disaster exposure may also be a trigger for social learning and adaptation action, potentially leading to a reduction in vulnerability over time (Di Baldassarre et al., 2018; Kreibich et al., 2022). There are various historical cases that exemplify how repeated disaster exposure can serve as a catalyst for transformative adaptation. In Japan, for instance, the 1896 Meiji Sanriku and 1933 Showa Sanriku earthquakes and tsunamis initiated early tsunami countermeasures, such as relocating residences to higher ground and constructing seawalls (Koshimura & Shuto, 2015). The 2011 Great East Japan earthquake and subsequent Fukushima nuclear disaster revealed remaining vulnerabilities, leading to improved evacuation plans, disaster education, and international policy shifts, including Germany's decision to phase out nuclear power (Kim & Choi, 2013).

As with positive economic feedback (Sect. 4.5), successful policy learning mainly occurs under moderate disaster conditions. Velev & Hochrainer-Stigler (2025) note that moderate manageable floods can encourage learning, while extreme or chronic exposure stalls progress. This is related to the availability of the human capital necessary to accelerate change, as big shocks can drain these financial funds, limiting abilities for forward looking DRM. Additionally, Kreibich et al. (2022) show that positive effects are most pronounced for recurrent hazards of the same type and similar or lower intensity than previously experienced events. This is consistent with patterns seen in floodplain settlements, where societies adapt to frequent, low-intensity, or nuisance floods but remain vulnerable to rare, high-intensity events (Devitt et al., 2023; Moftakhari et al., 2018).

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

Adaptation success can also vary significantly per region. After the 2004 Indian Ocean tsunami, the Indian Ocean Tsunami Warning and Mitigation System (IOTWMS) was established. While the IOTWMS successfully reduced tsunami vulnerability in some regions, limited vulnerability reductions were achieved in areas where post-tsunami recovery was slow (Stephan et al., 2017). Sauer et al. (2024), who assessed vulnerability reduction after flood impacts on a global scale, concluded that lower-developed regions often face significant challenges in reducing vulnerability.

Lessons learned from major disasters are not restricted to directly affected regions, potentially influencing policies, risk management strategies, and resilience-building efforts on a global scale (Nohrstedt et al., 2022). In addition to policy learning, social learning and adaptation after experiencing disasters can also take place at the individual level, for example through increased education, and capacity and awareness building (see also Sect. 4.5 on positive economic feedback and business adaptation) (Cerulli et al., 2020; Ivčević et al., 2021).

6. Long-term implications and tipping points

While many of the examples provide insights into recovery dynamics at short- to medium-term timescales, several processes highlighted in this review also have the potential to induce long-term societal transitions (Fig. 6). When such shifts in a dynamic social system are abrupt, irreversible, and triggered by external pressures, they can be considered social tipping points (Spaiser et al., 2024; Winkelmann et al., 2022). Tipping points refer to critical thresholds, indicated with an asterisk in Fig. 6 (panel A), where small changes in system variables cause an abrupt qualitative change in the social system from one state to another. Tipping is generally driven by self-reinforcing feedback loops, where a small change in the system triggers further reinforcing changes. Once the tipping threshold is crossed, the shift in the system can be difficult to reverse, even if the original stressors are removed (Spaiser et al., 2024; Winkelmann et al., 2022).

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

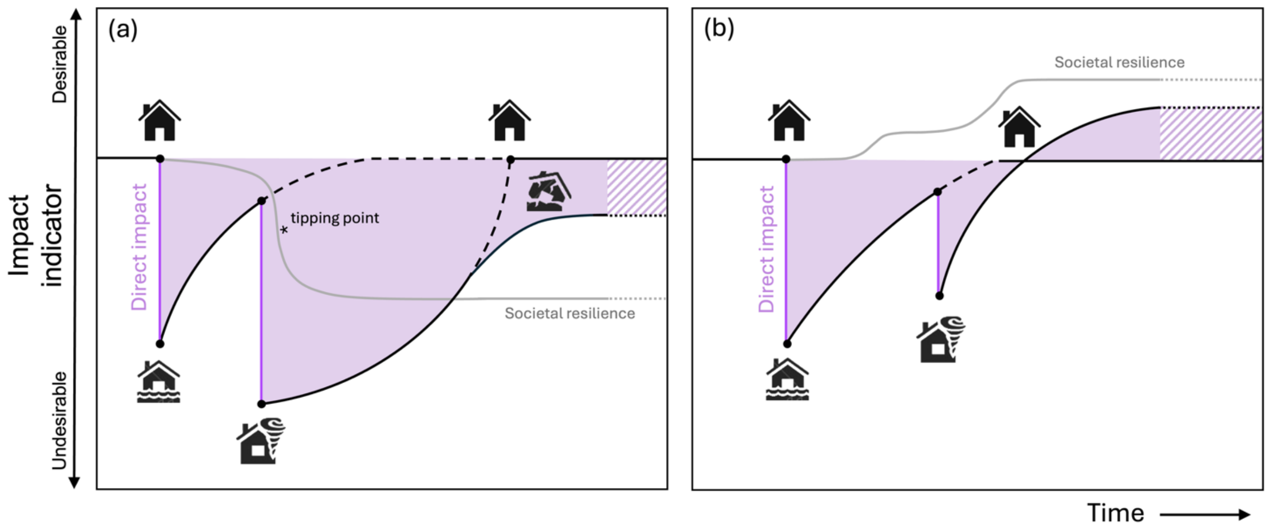

Figure 6. Stylised example of how recovery dynamics under consecutive disasters can shape long-term societal resilience. A) Development towards a less resilient society, characterised by compounding negative impacts that erode a society's capacity to respond to and recover from new disaster events, with negative tipping towards a less resilient society that might not be able to fully recover to pre-disaster conditions. B) Development towards a more resilient society, characterised by gradual "Building Back Better". While immediate physical destruction still causes undesirable direct impacts, positive indirect impacts (e.g., improved adaptation and disaster response policies) support faster recovery and reduce future disaster impacts.

Spaiser et al. (2024) identify several negative social tipping processes across four defined tipping elements, namely displacement (human settlements), financial crises (financial markets), conflicts (political system), and anomie, radicalization, and polarization (social psychological system). While their work focusses on mapping these tipping elements and their associated feedback under climate change, our analysis specifically highlights disaster recovery dynamics under consecutive events as a potential amplifier of these processes.

Our findings show, for instance, that insufficient or incomplete recovery following consecutive disaster events can contribute to reinforcing negative feedback over time (as shown in panel A of Fig. 6). Displaced populations face increased vulnerability and exposure to future events, as each new disaster interrupts ongoing recovery efforts, prolonging the time needed to restore stable housing, critical infrastructure, and related public services, which are important determinants for the return of people to their disaster-affected origins after displacement (Ahsan & Özbek, 2022; Merdjanoff et al., 2022). Moreover, safe land becomes increasingly difficult to find as a result of increasing event frequencies and intensities. Over time, these compounding vulnerabilities, combined with decreasing options for safe resettlement, can result in communities no longer being able, or willing, to return to or rebuild in the same area.

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

These observed dynamics align with the negative social tipping processes identified by Spaiser et al. (2024), who describe how feedback mechanisms such as disrupted livelihoods, cultural heritage loss, and weakened social networks can trigger prolonged displacement and eventually outmigration after disasters. Similar reinforcing feedback mechanisms are present in the other societal systems, where we have shown how repeated disaster events can erode economic capital or institutional capacities over time, creating conditions where recovery is systematically slowed down or under-resourced. This erosion can initiate negative feedback loops, such as outmigration or exacerbated inequalities, that reinforce vulnerability and reduce adaptive capacity, ultimately resulting in a persistent reduction of societal resilience.

Our examples also show that there are strong interdependencies between societal domains. For instance, the depletion of financial resources can restrict the reconstruction of housing and critical infrastructure, prolonging displacement and compounding vulnerability. In such cases, prolonged recovery in the economic domain directly undermines the progress in others, amplifying systemic risk. This can not only accelerate the movement of one of the societal domains towards a tipping point, but could also trigger so-called tipping cascades, where destabilization in one system cascades into others (Klose et al., 2021; Liu et al., 2023). Another clear example of these interdependencies in the context of increasing disaster frequency and intensity is supply chain failure. Disruptions in the production or distribution of basic goods, such as food and essential reconstruction materials, can lead to acute shortages, especially when compounded by pre-existing system vulnerabilities. Breadbasket failures, in particular, pose a risk, as they may escalate into severe humanitarian crises such as famine, with ripple effects on social and political stability (Gaupp et al., 2020; Janetos et al., 2017).

In addition to negative tipping, we also identify processes that may contribute to tipping or transforming a society positively, towards a more resilient state (as shown in panel B of Fig. 6): i) positive economic feedback and ii) vulnerability reduction through social learning and adaptive action. Especially under certain conditions, such as frequent but moderate events, positive feedback like business adaptation and the implementation of “Building Back Better” principles can emerge. While increasing disaster intensity and frequency poses challenges to adaptation, there remains potential for positive abrupt increases in societal resilience (e.g., the rapid development of new vaccines during health crises) (Garschagen & Solecki, 2017; Pandey et al., 2022).

7. Implications for science and policy making

Our research has demonstrated that consecutive hazards can result in non-linear impacts and long-lasting implications for societal resilience. Yet, current scientific and policy frameworks often fail to adequately address the complexity of the recovery dynamics driving these impacts. To support forward-looking comprehensive policymaking, a better and more explicit consideration and implementation of recovery dynamics into disaster risk studies is required.

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

An essential first step toward a more nuanced and accurate representation of recovery dynamics in disaster risk analyses is to critically reflect on what constitutes the "recovered state", acknowledging that a societal system might not return to pre-disaster conditions. Instead, the recovery process might extend over a long period (i.e., several years or even decades) or involve tipping points where communities shift toward entirely new, stable system states that differ fundamentally from those before the disaster. A well-defined recovered state enables clearer measurement of recovery duration and can help disentangle recovery feedback and interactions across societal domains in the context of consecutive disasters.

The effect of incomplete recovery between events is rarely considered in risk assessments, even when they explicitly address multiple events. For example, in infrastructure systems analysis, existing approaches to assessing life cycle consequences of multiple disasters often rely on overly simplistic binary assumptions, in which damages are either immediately repaired or permanently unresolved (Otárola et al., 2023). A critical shift is needed, from reliance on single, probabilistic, or average-based impact estimates, to metrics that reflect evolving conditions, such as the quantity of damaged units at a given time or dynamic best- and worst-case values across storylines (Hariri-Ardebili et al., 2022; Stalhandske et al., 2024). This shift also requires a more dynamic approach towards the concepts of vulnerability and exposure, which are key risk-determinants that can change rapidly in a post-disaster context. Despite growing recognition of their dynamic nature (De Ruiter & van Loon, 2022; Ward et al., 2022), most impact assessments still treat these risk determinants as static, overlooking how they can evolve during the recovery process and ignoring the residual impacts that can shape risk in subsequent events (De Angeli et al., 2022). Adopting a dynamic perspective highlights not only the acute impacts of single events but also allows for a focus on long-term regime changes. While this is well-studied in the context of disturbance regimes to ecosystems (Johnstone et al., 2016; Kropf et al., 2025; Turner & Seidl, 2025), this approach needs more attention in relation to human systems.

Recovery assessments must also carefully consider which indicators are used and over what time horizon. The apparent speed or completeness of recovery can vary greatly depending on the chosen proxy. While indicators such as electricity outages, housing reconstruction, and business reopening rates can provide valuable insights, these indicators might fail to capture dimensions such as political stability, inequality, and psychological well-being. Hence, it is important to carefully select appropriate proxies or indicators and to acknowledge their limitations when drawing conclusions about the state of recovery, considering the potential implications of the dimensions left out of the analysis.

Moving forward, disciplines that have traditionally lacked explicit representations of recovery could benefit from cross-disciplinary learning by drawing on approaches developed in fields with more established recovery frameworks, such as disaster studies, infrastructure systems modeling, public health, or research related to socio-economic resilience studies. Assessment frameworks that analyse recovery in the context of consecutive events have, for example, been developed for household well-being (Sauer et al., 2025), critical infrastructure (Argyroudis et al., 2020; Jeddi et al., 2022; Otárola et al., 2023), and supply chains (Juhel et al., 2024; Koks & Thissen, 2016). To capture the full range of interdependencies and cascading effects over time and across societal domains research needs to go beyond sector-specific or single-domain analyses and develop shared conceptual or modeling frameworks that bridge disciplinary siloes (De Ruiter et al., 2021). Future studies could build on recent examples, such as the combining of pandemic and natural hazard scenarios using storyline-based assessments (Hariri-Ardebili et al., 2022) or the development of quantitative epidemiological models that incorporate disaster scenarios (Hadeed et al., 2023; Hassan & Mahmoud, 2021; Quigley et al., 2020).

Improved scientific understanding alone, however, will not be sufficient to support more resilient recovery. Policy and financing mechanisms must also evolve to address the challenges of incomplete recovery between consecutive events. Current approaches to managing disaster impacts and recovery are not well adapted to a future characterised by increasingly frequent and intense natural hazards. As highlighted, long-term planning is often undermined by the need to repeatedly divert resources to immediate response and relief. To reduce the risk of negative societal transitions and to achieve long-term increases in societal resilience under consecutive disasters, a shift is needed, from reactive, short-term planning toward comprehensive, forward-looking DRM. This means also considering all relevant hazards and their potentially interconnected impacts, rather than focusing on only a specific subset of relevant hazard types, to minimise the risk of inadvertently implementing maladaptive practices or asynergies.

A key step is rethinking how recovery is financed. Looking into climate and health, Borghi et al. (2024) find that disaster financing is often passive, with funding arriving only after an event has occurred. They note opportunities to expand more strategic funding strategies that include the implementation of pre-emptive measures to reduce risks and enhance resilience (Borghi et al., 2024). To support efficient and equitable recovery after disasters, countries need more reliable and proactive financing solutions. These may also include pre-arranged recovery financing mechanisms such as forecast-based financing, where funds are automatically released for humanitarian actions that are agreed upon in advance (IFRC & RCCC, 2020) or parametric insurance, which offers rapid, flexible payouts based on pre-defined parameters such as certain rainfall or wind speed, ensuring rapid payments in post-disaster settings (Ocampo & Moreira, 2024). Current financing structures that try to diffuse risk, such as sovereign risk pooling, are also valuable tools as they help to distribute the financial burden of disasters and reduce a country's dependence on slow and uncertain foreign aid after a disaster (Ciullo et al., 2023). However, their effectiveness relies on the assumption that different regions or sectors will not be simultaneously affected by extreme events. As we have shown that disaster impacts often cascade through societal systems, these assumptions may not hold. Recognising and accounting for such interdependencies is critical to designing robust financing solutions.

In addition to being proactive, disaster financing should also be integrative, moving beyond isolated, sector-specific financing approaches to achieve co-benefits across multiple sectors or societal domains (Borghi et al., 2024). Examples of integrative co-financing strategies in the health sector include adaptive social protection schemes and the European Solidarity Fund, which

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

was expanded in 2020 to cover losses from major public health emergencies, transforming it into a multi-hazard, multi-risk financing instrument (Borghi et al., 2024; Hochrainer-Stigler et al., 2023).

The previously mentioned notion of "rethinking the recovered state" also extends to recovery funding mechanisms themselves, which should allow for transformative recovery, rather than simply restoring pre-disaster conditions. Yet in practice, reconstruction funding often does not sufficiently support building back better. Birkmann et al. (2023) report, for instance, after close monitoring of the reconstruction process in Germany after the 2021 floods, that reconstruction funding schemes are mainly focused on compensating losses and damages, not covering further improvements or resilient developments. They stress the need for the development of financing frameworks that allow for resilience gains in the medium- and long-run, moving beyond loss compensation to actively enable and incentivise building back better, supporting innovation and resilience gains in the long run.

Lastly, equity should be a central consideration in the design of disaster recovery financing and adaptation strategies. We have illustrated that as repeated disasters erode financial reserves, marginalised or low-income groups are often least able to recover and most exposed to cycles of loss and vulnerability. Without targeted support, these communities are at risk of falling into cycles of loss and vulnerability. Recovery financing and DRM that specifically accounts for these inequities, addressing equitable adaptation of minorities, are key to breaking this cycle and building a more resilient and equitable society (Haer & De Ruiter, 2024).

8. Conclusion

This paper illustrated how recovery plays a pivotal role in shaping the cumulative impacts of consecutive disasters. We have highlighted how delayed or incomplete recovery can escalate vulnerabilities, trigger feedback loops, and in some cases even trigger negative tipping to a less resilient societal state. At the same time, we showed the potential for societal learning and adaptive action, potentially increasing societal resilience over time (Fig. 6).

Recovery processes are highly interconnected across societal pillars such as housing, health, economy, and governance. Delayed or under-resourced recovery in one domain can cascade into others, amplifying systemic risk. Understanding these interactions demands that we move beyond static, single-event analyses toward integrated, interdisciplinary approaches that account for dynamic exposure, vulnerability, and recovery trajectories over time. To meaningfully incorporate recovery dynamics into disaster risk assessments, future research must develop and adopt suitable time-sensitive metrics and long-term data series that capture the evolving nature of vulnerability and resilience.

https://doi.org/10.5194/egusphere-2025-3200
Preprint. Discussion started: 22 August 2025

We call for a shift in both research and policy to recognise recovery as a central component of disaster risk management, and in the light of our findings, recommend several priorities to support positive societal transitions towards greater resilience under consecutive disasters, including:

i) adopting a multi-hazard perspective to avoid maladaptation and negative synergies;
ii) recognizing and addressing recovery dynamics and interactions between societal pillars, which are often studied in isolation;
iii) shifting disaster risk reduction (DRR) efforts toward long-term planning rather than short-term responses; and
iv) rethinking recovery funding by expanding pre-arranged financing mechanisms to enable rapid and equitable recovery.

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