

# DEFINING RESILIENCE: A PREREQUISITE FOR EFFECTIVE FLOOD MANAGEMENT

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## ABSTRACT

In the realm of flood management, the pursuit of resilience remains elusive, hindered by a fundamental challenge: the absence of a shared understanding of what resilience entails and the benchmarks we aspire to achieve. Past flooding incidents in New Zealand and overseas serve as stark reminders of the repercussions of navigating preparedness, response, and recovery without a clear definition of resilience. Our cautionary tale is beginning to write itself.

This paper will explore differing definitions to seek alignment, including Judith Rodin's influential work focusing on the triple nature of resilience—asset management with its associated risk frameworks, psychological resilience, and systems thinking—each integral to comprehending the multifaceted landscape of resilience within the flood context.

At its core, resilience transcends mere asset protection; it embodies a symbiotic relationship between infrastructure resilience and human adaptability. Rodin's framework underscores the imperative of integrating asset management principles, risk management frameworks, with a profound understanding of human resilience—the ability to cope and recover from stressors inherent in natural hazard events.

Our definition of resilience must be flexible enough to stay relevant in an increasingly complex world, whilst staying pragmatic to be effectively applied in everyday use. Indicators and metrics are paramount for understanding the efficacy of our strategies. However can resilience be measured, and how do we differentiate risk from resilience? Simply put, high resilience communities can be described as those where impacts are not felt as deeply, and recover rapidly to be stronger post-event, providing metrics such as depth of impact (absorption) and speed of recovery (adaptability).

As we navigate the complexities of defining resilience within the stormwater and flood sector, it becomes evident that resilience is not a static endpoint but a perpetual journey—a moving goalpost that adapts to evolving challenges and aspirations.

## KEYWORDS

**Risk, resilience, social capital, flooding, systems thinking, human resilience**

## PRESENTER PROFILE

Alex is a chartered professional who focuses on helping clients understand and manage their risks associated with natural hazards and climate change. Technical Director of Resilience and Emergency Management, Alex seeks to support organisational change to increase their resilience. Alex has led numerous projects for regional councils and critical infrastructure organisations across New Zealand, Asia and the UK.

# 1 INTRODUCTION

In the realm of flood management, the pursuit of resilience remains elusive, hindered by a fundamental challenge: the absence of a shared understanding of what resilience entails and the benchmarks we aspire to achieve.

Resilience is a term thrown around the media and political circles, most-often post disaster, where political figures can often be seen to highlight community resilience in the face of adversity. Yet the cynic in you may say this is a distraction, shifting focus to communities and away from any perceived or actual lack of action that may have led to the event that just occurred. Christchurch provides a shining light for this example, with communities being described as resilient while surrounded by infrastructure that had not stayed standing.

Without an agreed definition, resilience continues to be the buzzword of deflection, a term used without need for quantification or justification. Of course, the challenges to define resilience are, in part, the reason that no agreed definition has stood the test of time. How is it possible to consider defining complex systems of systems such to measure resilience?

## 1.1 NAVIGATING WITHOUT A DEFINITION

Past flooding incidents in New Zealand and overseas serve as stark reminders of the repercussions of navigating preparedness, response, and recovery without a clear definition of resilience.

Cast your mind back. It's Friday 27 January 2023, the height of summer in Tāmaki Makaurau Auckland. The city is buzzing in anticipation of a long weekend and an Elton John concert for nearly 50,000 fans. At 7pm, less than 30 minutes before the concert was due to start, organisers call off the event due to significant rainfall.

Just 24 hours later, four people are dead. Auckland has experienced its wettest day on record. Damaged infrastructure was littered across New Zealand's largest city.

Two weeks later, Cyclone Gabrielle hit the top of New Zealand's North Island, causing widespread damage and killing 11 people. Over 10,000 people were estimated to have been displaced, and over 225,000 homes lost power.

Less than 50 days into 2023, the death toll stood at 15. Hundreds of thousands of people were impacted and 115,000 individual insurance claims were made. The insured losses for New Zealand from these weather events was costed near \$4bn New Zealand Dollars by mid-2023. The scale of the 2023 severe weather events was 10 times larger than previous recorded losses.

For a country known for its earthquakes and other geohazards, New Zealand was hitting the headlines globally for extreme weather. Reviews that followed would find a known lack of capability within the flood risk and emergency management sectors to respond to larger scale events, a lack of cross-agency coordination, and inadequate methods for communicating with the public.

Suddenly 2023 is in the spotlight, the year that could provide New Zealand its wake-up call for flooding. The need for recovery enables discussions around "resilience", "building

back better”, “a stronger tomorrow”. The desire to find hope from the ashes brings hyper-focus to resilience.

This post-event desire for hope is not new to New Zealand, nor is it new when we look internationally. Let’s consider the devastating 2007 UK floods. This saw the loss of 13 lives, and the largest peacetime rescue operation in British history to help the estimated 55,000 houses that were flooded and over 7,000 people rescued by emergency services. This was the wake-up call for the UK Government, the flood of change that highlighted the importance of effective flood risk management.

The response, one of the widest-ranging policy reviews ever conducted in the UK. In short, some of the key discoveries from the Pitt Review were that:

- existing approaches to flood risk management lacks coordination and structure;
- property owners received warnings after their property had already flooded or not at all;
- it is not surprising that the public are confused and that they wonder who is accountable;
- responders were surprised by the scale and duration of the emergencies and found themselves reacting to unexpected events.

Enter the Flood and Water Management Act in 2010, providing a new framework for managing flood risk, including greater clarity on roles and responsibilities, along with improved coordination across agencies. Beyond this, local authorities were required to improve public awareness of flood risk.

New Zealand’s population was one tenth of the UK’s in 2007, yet the 2023 events were comparable in deaths, with insured losses two thirds of the 2007 costs. The lessons identified in the Pitt Review 15 years ago are as applicable in New Zealand today. Was there a missed opportunity to learn from the lessons of others? How does this affect a discussion around resilience?

## **2 EXPLORING DEFINITIONS OF RESILIENCE**

Resilience is considered the ultimate objective in the context of hazard mitigation. There is a variety of definitions which have evolved as different disciplines have applied resilience thinking to their work, and adapted the definitions to meet their focus.

### **2.1 CHALLENGES IN DEFINING RESILIENCE**

Risk management standards are well documented internationally, including the ISO Standard 31000 – Risk Management. This provides a global benchmark for risk management, and often finds itself being used as people look to define resilience also.

While there is an ISO Standard for organisational resilience, this is lesser known, and often overlooked. Here organisational resilience is defined as

*"the ability of an organization to absorb and adapt in a changing environment to enable it to deliver its objectives and to survive and prosper."  
(ISO 22316: 2017)*

But what about infrastructure, human, and community resilience? The New Zealand Treasury's National Infrastructure Plan acknowledges that

*"the concept of resilience is wider than natural disasters and covers the capacity of public, private and civic sectors to withstand disruption, absorb disturbance, act effectively in a crisis, adapt to changing conditions, including climate change, and grow over time."*

This definition acknowledges that the service the infrastructure delivers will be disrupted, due to damage to the infrastructure; however, the service is able to reduce the possibility of failure, adapt and recover from a disruptive event and/or gradual external changes over time. It also implies transformation, so not only is the infrastructure service able to survive or recover but it can adapt to a changing environment in which it operates. Finally, the definition is broad enough to encompass more recent approaches that allow for 'unknown' as well as 'known' hazards.

While just one example, the Treasury is already showcasing the depth and breadth of a definition of resilience, including words such as: capacity, disruption, absorb, act, adapt. This aligns to a 2015 study into defining resilience, which found that of the 25 most frequently used words across 120 definitions of resilience, seven referred to an event. Over half of the definitions used the word "ability", with "adapt", "capacity" and "recover" all featuring in at least one quarter of the definitions ([Stevenson et al., 2015](#)).

One of the more comprehensive definitions of resilience has been provided by Judith Rodin in her book *The Resilience Dividend*. According to Rodin, resilience is the capacity of any entity – an individual, a community, an organisation, or a natural system – to prepare for disruptions, to recover from shocks and stresses, and to adapt and grow from a disruptive experience.

She suggests that the concept has three main roots:

- asset management with its associated risk management frameworks,
- psychological concepts of personal resilience as an ability to cope and recover from stress,
- and systems thinking.

So in relation to infrastructure, resilience really refers to the ability of the infrastructure networks to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event. There has been a growing recognition of the need to build more resilient and sustainable infrastructure networks, and the severe consequences of major infrastructure failures continue to remind us of this need.

But what about beyond infrastructure? At its core, resilience transcends mere asset protection; it embodies a symbiotic relationship between infrastructure resilience and human adaptability. Rodin's framework underscores the imperative of integrating asset management principles, risk management frameworks such as ISO 31000, with a

profound understanding of human resilience—the ability to cope and recover from stressors inherent in natural hazard events. While the focus here is on infrastructure, specifically flood infrastructure, the interaction of infrastructure, people and systems cannot be overlooked.

## **2.2 CONFLATING RISK AND RESILIENCE**

To further understand resilience, it is useful to consider its significance to both hazards and risk.

Recent natural and technological catastrophes have highlighted a) a failure to predict extreme events, and b) an inability to understand the complex systems involved and the potential range of failure possibilities.

Park et al (2013) emphasises our ignorance: ‘not the assumption that future events are expected, but that they will always be unexpected’.

Historically, a risk analysis approach has been used to identify risks and then develop management/ mitigation approaches. However, as many hazards and failure modes are unknown, risk analysis becomes inadequate, and arguably impossible (Park et al 2013). In short, risk analysis requires the hazards to be identifiable, and therefore, to prepare for the unexpected. An alternative (and complementary) approach is required to consider these unpredictable events.

Some key differences in a traditional ‘risk-based’ approach versus a ‘resilience’ approach are as follows:

- A risk-based approach looks to mitigate failure through probability and scenario-based analysis of known hazards. A resilience approach looks to minimise the consequences of failure through investigating scenarios with unidentified causes.
- A risk-based approach would involve incrementally modifying existing designs in response to emerging hazards, whereas a resilience approach would involve adapting to changing conditions, and potentially allowing controlled failure (‘safe-to-fail’ design) at a sub-system level to reduce the possibility of broader loss of function within the larger system (Park et al (2013) and Snowden (2011)).
- These ‘risk’ and ‘resilience’ approaches are considered complementary and applicable in different circumstances. They are not considered mutually exclusive, and their use will depend on the context of the analysis being undertaken and the understanding of the relevant hazard. This is discussed in section 5.1.

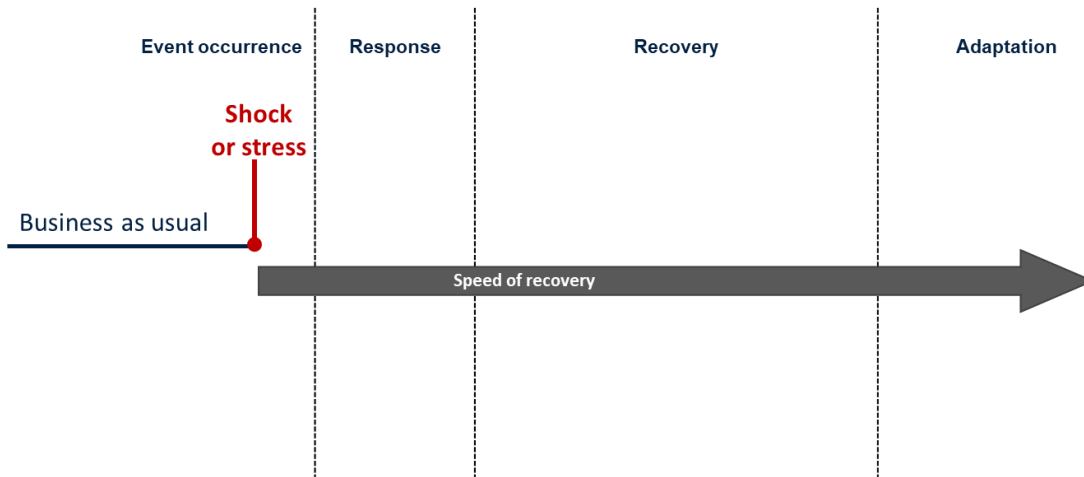
Each integral to comprehending the multifaceted landscape of resilience within the flood context.

## **2.3 WHAT DOES THIS TELL US?**

So what does the overlap with risk mean for measuring resilience in the infrastructure space. Well, current thinking is that resilience is all about actions needed to treat risks, to adapt, and build resilience. Through considering resilient approaches across all risk treatment activities, it is fair to say that reduction in underlying risk is one measure of resilience.

More broadly, what do all these words tell us about resilience though? They showcase that resilience is a word of numerous timeframes, or temporal categories. From the moment of an **event occurring** - the first phase of resilience, through **responding** to an event, **recovering** from an event, and then **adapting** to the future state - the new normal.

This begins to provide a structure to consider resilience within, a potential framing that could be used to aid measuring resilience - where the terms can collectively be classed as the **speed of recovery** (Figure 1).



## 2. SPEED OF RECOVERY ADAPTABILITY

*Figure 1: Considering the speed of recovery across four phases following an event shock or stress.*

One aspect that is not covered in this temporal view of resilience is the initial response at the event occurrence. This considers the words utilised by the Treasury, “withstand disruption”, “absorb disturbance”. Here we are considering a systems capacity to tolerate a perturbation, where the occurrence of an event does not cause material disruption or destruction. Here we can classify these terms as the **depth of impact** (Figure 2).

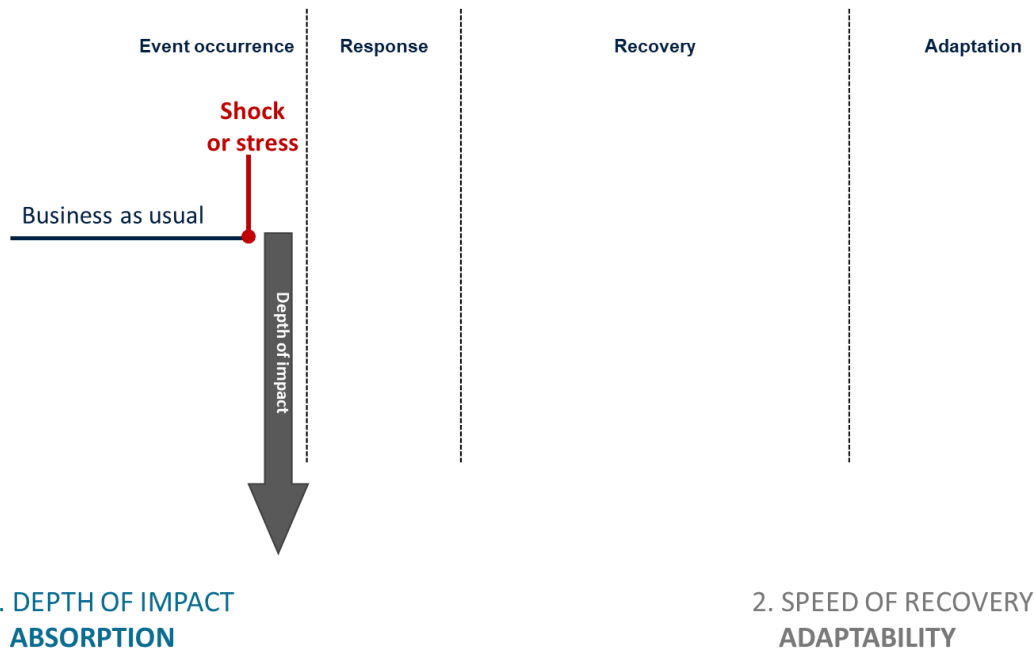


Figure 2: Considering the depth of impact following an event shock or stress.

When we combine these two variables together, we can conceptualise resilience on a temporal scale (Figure 3). Here we can see that following a shock or stress, depth of impact relates to how much an asset, person, or system feels the shock or stress; with speed of recovery looking along the temporal scale.

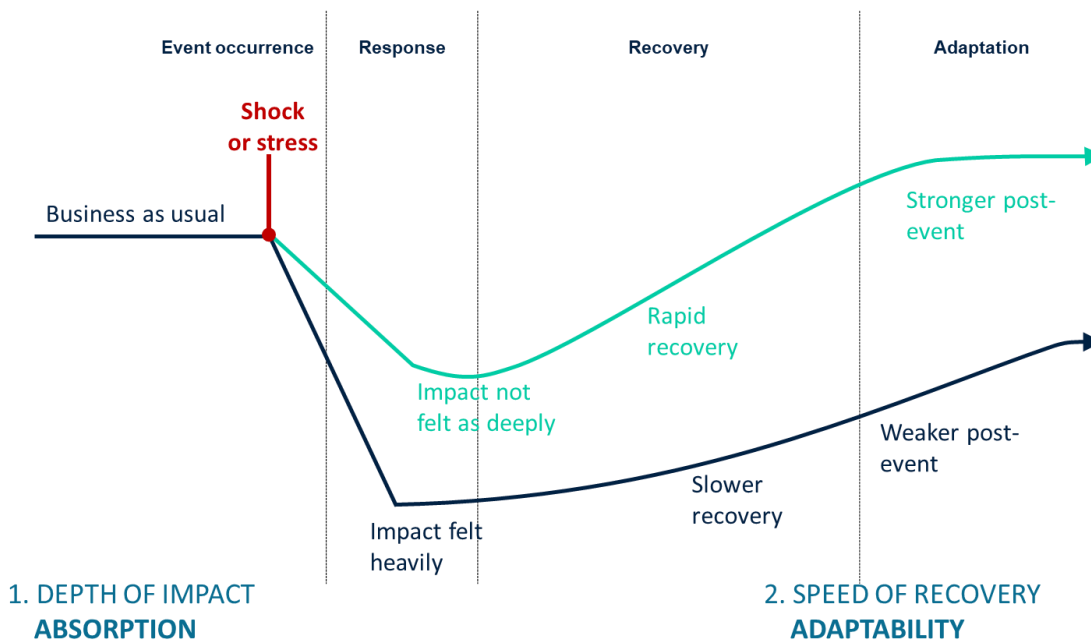


Figure 3: Demonstrating the relationship between depth of impact (absorption) and speed of recovery (adaptability)

### 3 CAN WE MEASURE INFRASTRUCTURE RESILIENCE?

Can we measure resilience? What do you think?

In reality, the answer is subjective, and varies with who you ask, and actually where their evolution of thinking is at too. The question also depends on what we could be measuring resilience of, be it: infrastructure, organisational or even a city's resilience.

In the early 2000's we can see numerous examples of tools, frameworks and techniques that seek to measure resilience. This aligned to the increasing focus on resilience through 2000s and early 2010s. In the last five years or so this focus has changed, looking more at building rather than measuring resilience.

A core document in asset management space is the International Infrastructure Management Manual (IIMM). Here the definition of resilience, including measuring resilience, has changed through various version updates. The 2020 version of IIMM highlights resilience as a subset of risk, strongly associated with risk treatment, although does provide some insights on measuring resilience.

The ultimate question when talking about measuring resilience however is resilience to what? With resilience focusing on the unpredictable, the ability to measure against this becomes tricky. While depth of absorption and speed of recovery provide direction toward metrics, without consistently measuring everything, how do we establish a baseline to measure resilience following an unpredictable event?

#### 3.1 METRICS FOR MEASURING RESILIENCE

Research conducted by Hughes and Healy (2014) for Waka Kotahi (New Zealand Transport Agency) looked to develop a framework to measure the resilience of the New Zealand transport system. This largely focused on providing a quantitative approach to measure resilience. Here principles of resilience were established, within both technical and organisational dimensions, with associated individual performance criteria.

The key technical principles included within the 2014 Research project included:

- **Robustness:** ability to withstand a given level of stress or demand without suffering degradation or loss of function.
- **Redundancy:** ability to be substitutable - capable of satisfying functional requirements in the event of disruption, degradation, or loss of functionality.
- **Safe-to-fail:** allowing controlled, planned failure during unpredicted events.

While these principles provide further granularity to measurable metrics, the question regarding a baseline to measure against still exists. Here is where performance criteria can be included, providing qualitative descriptors against which performance for specific principles can be measured against. Work by Bruneau et al (2003) shows an example of this for seismic resilience measures (Figure 4).



Performance criteria				
Performance measures	Robustness	Redundancy	Resourcefulness	Rapidity
Technical	Damage avoidance and continued service provision	Backup/duplicate systems, equipment and supplies	Diagnostic and damage detection technologies and methodologies	Optimising time to return to pre-event functional levels
Organisational	Continued ability to carry out designated functions	Backup resources to sustain operations (eg alternative sites)	Plans and resources to cope with damage and disruption (eg mutual aid, emergency plans, decision support systems)	Minimise time needed to restore services and perform key response tasks
Social	Avoidance of casualties and disruption in the community	Alternative means of providing for community needs	Plans and resources to meet community needs	Optimising time to return to pre-event functional levels

Figure 4: example Seismic resilience measures from Hughes and Healy (adapted from Bruneau et al)

### 3.2 A COMMUNITY LENS

It is often easy to consider infrastructure in isolation, the size of the road or the height of a stopbank. When we focus back to the purpose of a given piece of infrastructure however, we are reminded that infrastructure is only there for one purpose, to serve a community need. Therefore, focus on community needs to be at the forefront when trying to define resilience.

We often hear the term 'resilience' thrown around about communities immediately after occurrence of an event (disaster). Lianne Dalziel, Mayor of Christchurch during the Canterbury Earthquake Sequence, acknowledged this, stating that

*"resilience is not strength in the face of adversity—that is stoicism—it is the capacity to plan and prepare for, absorb, recover from, and adapt to the consequences of an adverse event. It is also about the capacity to co-create a new normal."*

It is the end of this quote that draws most attention, **the capacity to co-create a new normal**. Once again, we are straying into a space of the unknown, where measurement will only be possible after the fact. Quantitative approaches generally do not stack up in this space. Instead, qualitative statements provide a better ability to measure potential criteria when projecting into an uncertain future.

Considering a community lens provides interlinkage across Rodin's trifecta definition of resilience. Here it brings together asset management with human psychology, and the need for systems thinking to draw conclusions relevant to both infrastructure and society.

When this is considered in the context of flood risk management, it raises the question around whether it is appropriate to consider the resilience of a singular asset. If we have a highly reliable raised flood defence, one with suitable redundancy, it could be considered highly resilient. This resilience will be to a given design event, meaning that overdesign events will still result in flooding within the community. This flooding

occurring from what is classed as a highly resilient asset. While the asset may be seen as resilient, the community remain at risk of flooding, therefore likely to have a lower level of psychological resilience. Without wider measures, the system (community) is not resilient. This showcases the power of resilience, but also the pitfalls when defined too narrowly.

## **4 RESILIENCE AS A PERPETUAL JOURNEY**

While we are finding many metrics to measure performance of infrastructure, the pitfalls of focusing on only asset management are pronounced. Instead, we must look beyond asset management to include systems thinking and the human elements. Our definition of resilience must also acknowledge the capacity to co-create a new normal. But how?

If we step away from the desire to measure resilience, and focus instead on a desire to build resilience, we provide more flex. Here we can consider resilience as an ever-changing end state, the “holy-grail” that is chased but never achieved. Using Rodin’s trifecta definition of resilience provides a great starting framework, considering: asset management, human psychology, and systems thinking.

While this provides a framing, analysis against this framing is still required. Instead of focusing effort on establishing effective metrics for unknown outcomes, resilience could become a reflective commentary, based on experiences. Qualitative statements previously discussed for measuring resilience are still effective, however through a repurposed lens. Here they are used to provide a baseline for commentary on resilience, and areas of potential improvement. Experiences used for reflection could be direct or indirect, and help understand point in time resilience of an asset, a system, a community.

As we navigate the complexities of defining resilience within the stormwater and flood sector, it becomes evident that resilience is not a static endpoint but a perpetual journey – a moving goalpost that adapts to evolving challenges and aspirations. This view of resilience as a perpetual journey links closely to other journeys, such as sustainability. The shared principle being that focus should be on a positive journey, with both incremental and step changes for better, without a singular end metric in site. This drives a culture that is always chasing a more resilient future.

### **4.1 LESSONS AS THE KEY TO RESILIENCE**

A lack of transitioning lessons identified into lessons learned is a well-known struggle, more often leading to lessons lost (Glasse, 2015).

This mindset shift toward resilience as a reflective commentary drives forward the need for learning lessons, that is stepping beyond identifying lessons following events to implementing change. The lessons identified following the 2007 UK floods helped increase flood resilience in the UK. These same lessons were identified for New Zealand 15 years later following the 2023 floods.

While it is too early to say whether these lessons will enact change similar to that of the UK, this showcases the power of building resilience through reflective commentary. Without detailed metrics, it is possible to provide comparison to lessons identified elsewhere (indirect), and reflect on resilience of the focus area. When using this approach, it further highlights the need to learn from experience.

This approach is aligned to the United Nations Office for Disaster Risk Reduction Infrastructure Resilience Principles (Figure 5). The six principles focus on an ever-more socially engaged community that drive proactive and transformational change through shared responsibility and continuous learning.

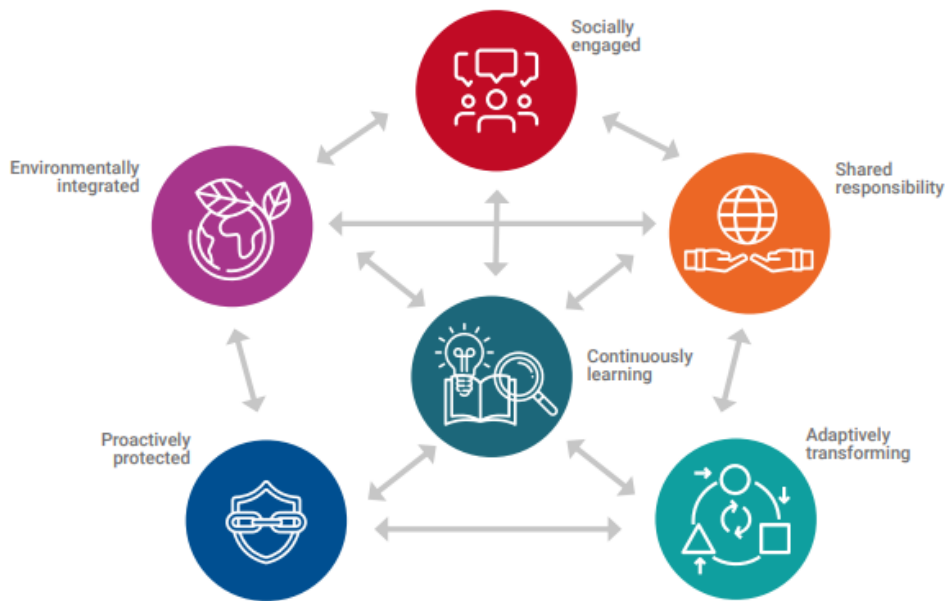


Figure 5: UNDRR Principles for Resilient Infrastructure

## 5 CONCLUSION

Ultimately, this paper advocates for a collective re-evaluation of our approach to resilience. The desire to constantly redefine resilience for individual purpose is put aside, instead looking to retain a broad and encompassing definition, focused around Rodin’s trifecta of resilience:

- asset management with its associated risk management frameworks,
- psychological concepts of personal resilience as an ability to cope and recover from stress,
- and systems thinking.

Here we look to step away from measuring resilience, and strive for building resilience from previous experiences. Resilience is not a static endpoint but a perpetual journey — a moving goalpost that adapts to evolving challenges and aspirations. Two key factors can be considered across this trifecta framing, the depth of impact, and the speed of recovery from a given event. This can be achieved in a qualitative manner, focused on capturing lessons that build resilience.

The need to look beyond direct experiences to those indirect experiences occurring on an international stage is critical. When considering the 2023 floods for New Zealand, we have an opportunity to build resilience moving forward across assets, people, and systems. These opportunities have existed since lessons were identified for similar events, such as floods 15 years previously. Resilience provides yet another reason to drive action from lessons identified elsewhere. This approach helps embark on a transformative journey towards a more resilient future, where storms will continue to disrupt, yet communities recover stronger.

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