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A discussion of resilience and sustainability: Land use planning recovery from the Canterbury earthquake sequence, New Zealand

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ABSTRACT

The term 'resilience' is increasingly being used in a multitude of contexts. Seemingly the latest 'buzz' word, it can mean many things to many people, in many different situations. In the natural hazard context, the terms 'sustainable planning', and 'resilience planning' are now being used, often interchangeably. But from a natural hazard perspective, is a resilient community a sustainable one? In order to be sustainable, does a community need to be resilient? The purpose of this paper is to answer these two questions, and stimulate discussion on how the two terms are being used. The paper provides an overview of resilience and sustainability within a land use planning and natural hazard context, and discusses how they are interrelated. The New Zealand legislative requirements for resilience and sustainability are outlined, followed by the presentation of an example from the earthquake impacted city of Christchurch, New Zealand. This example outlines the planning response to the earthquakes, and the sustainable and resilient planning options being implemented. The discussion shows that a resilient community should also be a sustainable community, in order to meet legislative requirements, and – more importantly – to ensure the needs of future generations are met, economically, socially, culturally, and environmentally.

1. Introduction

The term 'resilience' is increasingly being used in a multitude of contexts, from physical, psychological, ecological, social, city, community to individual resilience [23,29,33,44,66]. 'Resilience' is also now being used in a land use planning context with the term 'resilience planning' bandied about, often interchangeably with sustainability [61,6,24,26]. But questions remain over what resilience actually means for land-use planning, and the relationship that such a concept actually has with sustainability. Is a resilient community a sustainable one? In order to be sustainable, does a community need to be resilient?

The purpose of this paper is to stimulate discussion on how the two terms are being used, and to provide examples of their usage in a land use recovery context from natural hazard events. First, the paper will provide an overview of the terms 'sustainability' and 'resilience' to ascertain the similarities and differences between the two terms. The overview will also cover how these terms are used in the New Zealand legislative setting. Second, the paper will provide some discussion and thought about the relationship between sustainability and resilience. Third, recovery can provide a useful framing of the relationship between sustainability and natural hazards, and assist in setting the context for sustainability and resilience. Exploring the roles of recovery, pre-event planning and insurance as drivers for resilience and sustainability, this paper will draw upon a case study of the 2010–11 Canterbury earthquakes in order to prompt discussion around two questions: Is a resilient community a sustainable one? And, in order to be sustainable, does a community need to be resilient?

2. Sustainability and resilience

2.1. Overview of sustainability

While the term 'sustainable development' has many definitions and is the subject of much debate e.g. [1,5,6,10,28,31,34,45], the widely accepted definition is from the Brundtland Commission, which has defined it as "… meets the needs of current generations without compromising the ability of future generations to meet their own needs" [8, p. 23]. Much of the debate around this definition includes the term being too vague, therefore reconciling the different dimensions of sustainable development remains elusive, with a tendency for economic considerations to override other considerations e.g. [31,53,63]. This brings into question whether sustainable development, or sustainability, is the objective [53].

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For example, Robinson [53] states that:

> … development is seen as synonymous with growth, and therefore that sustainable development means ameliorating, but not challenging, continued economic growth. On this view, the preferred term 'sustainability' focuses attention where it should be placed, on the ability of humans to continue to live within environmental constraints.

More recently in 2014, suggested guiding principles for the Hyogo Framework for Action included that "The sustainability of development depends on its ability to prevent new risk creation and the reduction of existing risk" [60, p. 4]. Sustainability is integral to managing natural hazard risks, and recovery from natural hazard events.

Three key elements underpin the concept of sustainable development: economic, environmental, and social well-beings [10,31,6]. The interaction and reconciliation of these three well-beings is critical to the pursuit of sustainable development. A healthy economy provides for people's health, wealth, and happiness. A healthy, productive and diverse environment supports life and improves living standards. And social (or human) well-being is key to providing an acceptable standard of living [45,50]. In New Zealand, cultural well-being also requires consideration under legislation. Trade-offs between the well-beings is often required, and political will is a key input into the success of sustainable development. Reconciling these often contending dimensions lies at the heart of the sustainability challenge.

Sustainable recovery from a natural hazard event ensures that existing risks are reduced and any new risks are managed. The term 'holistic disaster recovery' from natural hazard events is used within the context of 'sustainable redevelopment' [40], to mean that sustainability principles are incorporated into the redevelopment of an area. After an event, communities are suddenly more aware of the risks they face from hazards, and decision makers have more political will and support to address complex problems and encourage innovative ideas to promote sustainability [40].

2.2. Overview of resilience

The term 'resilience' has become so popular in recent times it is now referred as the 'buzzword' of the decade [35,41]. With individuals and communities seeking to become resilient to adversities such as natural disasters, it has become important to define resilience, as it can mean many things to many people. Associated with this definition should be key indicators to measure resilient within society, and to assist in determining whether it is sustainable or not.

In the past, resilience has often been described as the ability to 'bounce back' after a disaster [33,39,48]. This implies a short term phenomena, whereby resilience mostly relates to the immediate response and recovery phases of a disaster. More recent literature suggests that resilience is not just about 'bouncing back' but is more of an 'adaptive capacity' held by individuals and/or communities [29,44]. Within a disaster context, Paton and Johnston [46] have defined resilience as the ability to adapt to the demands, challenges and changes encountered during and after a disaster. Having an adaptive capacity means that individuals, communities and institutions are able to readily adapt to adverse circumstances when dealing with the impact of a disaster. The adaptation that occurs during the recovery from a disaster may mean that they do not 'bounce back' to their former state as such, but evolve to deal with the changing circumstances. To adapt and evolve people need to draw upon personal, collective and institutional competencies and resources [47]. Such competencies and resources can be

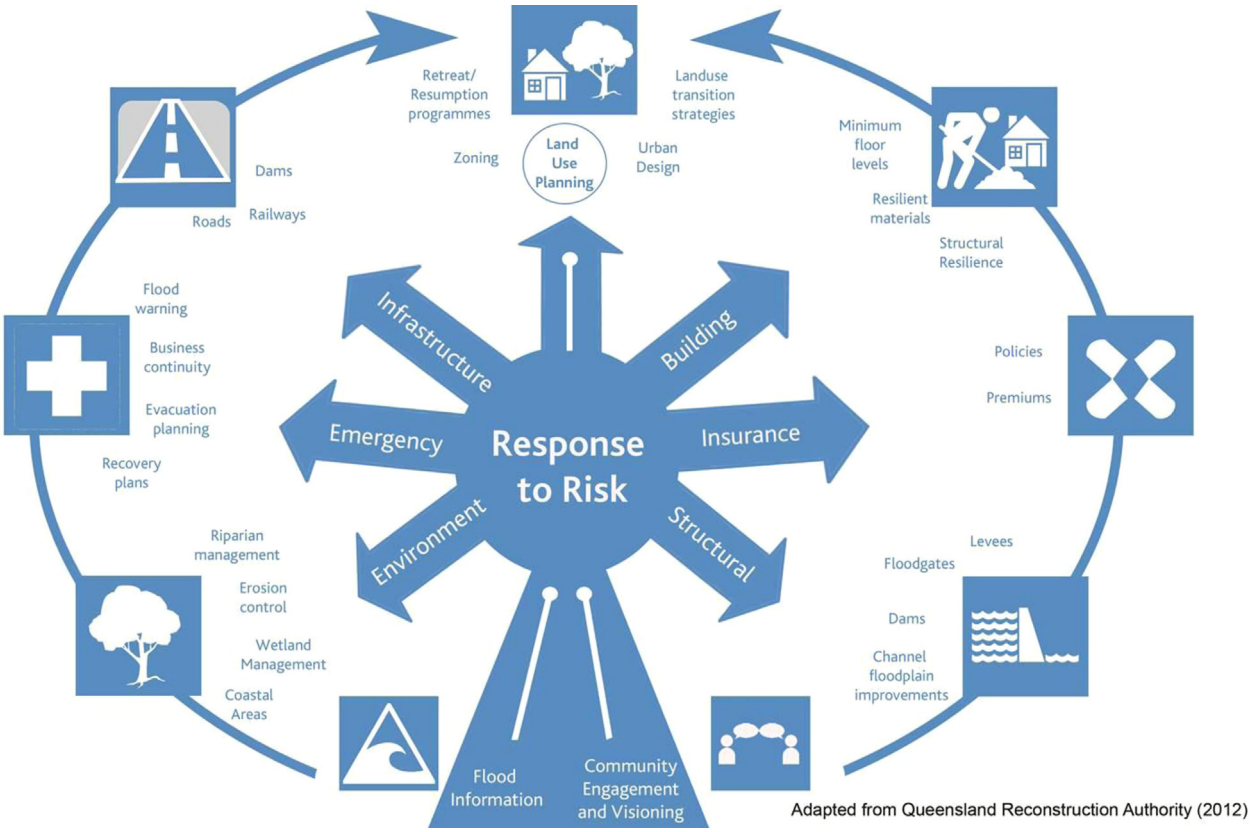

Fig. 1. Measures that contribute to resilience in the floodplain context [2,51].

applied to a variety of contexts. Fig. 1 presents a number of key contexts within which resilience must be considered including emergency management, the environment, infrastructure, land use planning, building, insurance and engineering. The figure shows the measures that could be undertaken to enhance resilience within each context. While the figure is depicted for floodplain management, the basic principles are transferable to other hazards.

As shown in Fig. 1, land use planning is one of the measures that contribute to resilience. This is supported by Paton et al. [49], who suggest that planning (including land use and emergency planning) is an integral part of creating a resilient society. It is important to involve citizens in the land-use planning process, and to create plans with risk reduction policies that can be implemented and evaluated [47,49]. Taking a risk-based approach to land use plans is becoming increasingly common [55]. When undertaken with an engagement strategy to include communities in determining levels of risk, risk-based planning provides a decision making framework that is robust, transparent, and acceptable to the community. Within a New Zealand context, recommendations have been made to improve the quality of land use plans, so as to ultimately improve risk reduction [56].

Following a disaster there are two typical timeframes that affect resilience. The first is the short term period immediately following a disaster, where people must be resilient in the face of their response to the disaster [57]. This may be the period where people are focussed on surviving an event itself, and in looking after themselves or their communities in the days immediately afterward.

The second timeframe is much longer and encompasses the recovery period which may stretch out from days to weeks and years [57]. The long term recovery period is a challenging time for resilience. It is this period where resilience and sustainability become intertwined, as people seek to recover their communities to become more resilient (e.g. more adaptable to future adverse events) and also sustainable (e.g. ensuring future generations can survive and thrive) over the long term.

Building resilience and long term sustainability can be challenging when recovery is protracted. A typical scenario for a protracted recovery could be something like this: a natural hazard event occurs (e.g. flood, earthquake), that requires some form of recovery. Insurance claims provide the financial means for a landowner to rebuild/do repairs to their house; the council repairs the infrastructure; life slowly returns to 'normal'. Within a small period of time, a similar event occurs, and recovery is required again. Being resilient, the landowner 'bounces back' once more, with another insurance pay-out. The council repairs damaged infrastructure. A short time later, a similar event occurs again. In a circumstance like this you can start to see differences between short term resilience and long term sustainability. When communities adapt after one small event, they often draw on their short-term resilience to 'bounce back'. However, if events keep occurring and impacts start compounding, then short term adaptive measures (e.g. insurance, rebuilding) may not address the hazard problem effectively. Instead a community may need to employ a set of adaptive measures that are more useful in longer term (e.g. retiring land, zoning) – something that is more in line with the concept of sustainable development.

Table 1
Explanations of sustainable and resilient communities.

Definition
Sustainable and resilient communities are defined as societies which are structurally organised to minimise the effects of disasters, and, at the same time, have the ability to recover quickly by restoring the socio-economic vitality of the community [61, p. 13].
Communities with a coherent land-use plan and hazard-mitigation strategy are able to build settlements that will be resistant to natural disasters, able to recover quickly from a natural event, and able to last for many years with little cost in dollars or lives to their inhabitants. These are resilient, sustainable communities [6, p. 104].
Sustainable development seeks to meet present needs without compromising the ability of future generations to meet their needs, but it cannot be successful without enabling societies to be resilient to natural hazards and ensuring that future development does not increase vulnerability (UN commission on sustainable development, 2002 [24, p. 3]).

2.3. Reconciling sustainability and resilience

So is a resilient community a sustainable one? In order to be sustainable, does a community need to be resilient? To assist in answering these questions, first we must understand what a resilient *and* sustainable community is. Table 1 provides several examples from the literature to assist with this understanding.

The definitions given here suggest that sustainability and resilience are not one and the same; rather they are interdependently linked. The definitions also imply that a sustainable community can only be sustainable if it holds some degree of resilience. This is particularly reflected in the definition by the UN Commission on Sustainable Development [24] which suggests that "Sustainable development… cannot be successful without enabling societies to be resilient to natural hazards". The definitions do not suggest the alternative idea which is that a resilient community can only be resilient if it is sustainable. This would imply that a resilient community of sorts could possibly exist in an unsustainable environment. This concept seems to make sense when considering disasters across the decades in developed countries. In a world where natural events can be expected to change how we live, resilience enhances the likelihood of sustaining development into the future [22].

In 2012, 17 sustainable development goals were developed through Rio+20 [62]. One goal – Sustainable Goal 11 – has a focus on resilience and sustainability. The goal is to "Make cities and human settlements inclusive, safe, resilient and sustainable". This is supported by the aim to "increase … the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, develop and implement in line with the forthcoming Hyogo Framework holistic disaster risk management at all levels" [62].

At a central government level, the New Zealand Treasury has produced a Higher Living Standards Framework (see Fig. 2) in which risk management, sustainability, and resilience are key. Treasury acknowledge that there is an increasing complexity of issues as there is a move from managing risk, to supporting resilience, and ultimately enabling sustainability [7]. Fig. 2 reconcile the three concepts of resilience, sustainability and risk management. The Treasury diagram implies that resilience should be focussed on short and long term adaptability, while sustainability takes a longer term 'future generations' stance.

But care is needed when striving for sustainability and resilience, particularly within large urban cities, as sustainability and resilience goals can contradict each other if not managed as complementary outcomes [35]. The initiatives that progress sustainable cities often include the need to reduce redundancy – a key aspect of a resilient system.

3. Legislative framework for sustainability and resilience

Sustainability forms the underpinning philosophical base for various statutes in New Zealand, particularly those that contribute

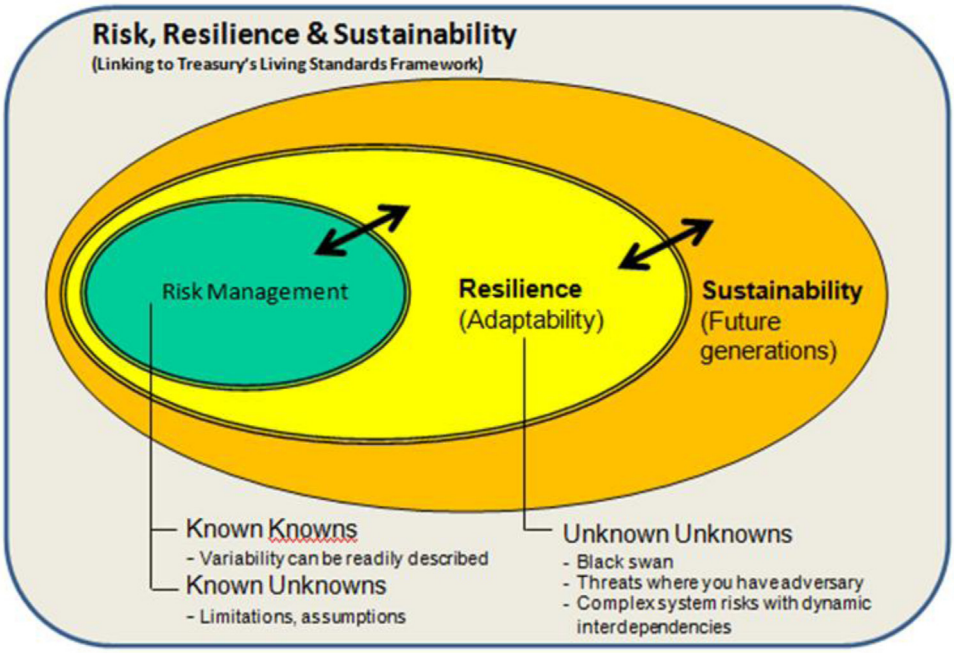

Fig. 2. How resilience is related to both risk and sustainability [7, p. 6].

to natural hazard management – the Resource Management Act (RMA) [52], the land use planning and environmental legislation; the Civil Defence Emergency Management Act (CDEMA) [18], with a focus on reduction, readiness, response, and recovery; the Building Act [9], which sets the standard for building construction; and the Local Government Act (LGA) [32], which outlines the duties and responsibilities of local government. While these four statutes refer to sustainability, only the RMA defines sustainable management. Table 2 provides a summary of the key areas in these statutes where sustainable management and development is included. It is evident that sustainability provides a link between statutes – a common goal to achieve and maintain a consistent sustainable approach to hazards [54].

Within the RMA, sustainable management is defined as:

> *… managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while—*
>
> (1) *sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations;*
> (2) *safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*
> (3) *avoiding, remedying, or mitigating any adverse effects of activities on the environment.*

Other commonalities between the legislation include references to social, economic, cultural, environmental well-being, and health and safety. These well-beings are not defined within the legislation, and so provides an opportunity for councils to determine their own measures for these. It is also interesting to note that health and safety is an RMA issue, and is not just the responsibility of the Building Act and CDEM Act. Often these latter Acts, rather than the RMA, are relied on for life safety.

In contrast to sustainability, the concept of resilience is advocated by one statute only – the CDEM Act. Administered by the Ministry of Civil Defence and Emergency Management (MCDEM), resilience is the core focus of the National Strategy, required under the CDEM Act. The Strategy's vision is "… to build a resilient and safer New Zealand with communities understanding and managing their hazards and risks" [38, p. 1]. While the Strategy does not specifically define resilience, it shows linked components of a Resilient New Zealand, being (p. 7):

- Individuals looking after their families and loved ones.
- Communities managing their hazards.
- Businesses providing services to support the continued functioning of communities.
- City, district and regional authorities ensuring the safety of

Table 2
New Zealand legislation which contains references to sustainability (emphasis added).

Statue	Purpose
Resource Management Act [52]	Promote the *sustainable management* of natural and physical resources … managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their *social, economic* , and *cultural wellbeing* and for their *health and safety.*
Civil Defence Emergency Management Act [18]	Improve and promote the *sustainable management* of hazards in a way that contributes to the *social, economic* , *cultural* , and *environmental well-being* and *safety* of the public and also to the *protection* of property.
Building Act [9]	Buildings are designed, constructed, and able to be used in ways that promote *sustainable development* … to safeguard people from injury from critical failure .
Local Government Act [32, Part 1 Section 3]	Provides for local authorities to play a broad role in promoting the social, economic, environmental, and cultural well-being of their communities, taking a *sustainable development* approach.

their communities;
- Emergency services providing critical services.
- Central government ensuring the security and well-being of their citizens.
- Utilities providing essential services.

To assist in achieving resilience, the CDEM Act and National Plan[1] focus on ensuring the "4R"s of reduction, readiness, response and recovery are addressed at a national and local level [18,37]. Within the National CDEM Strategy, it is also acknowledged that through the CDEM Act, a sustainable management approach needs to be adopted, thus showing some acknowledgement of links that may be present between resilience and sustainability.

The New Zealand Coastal Policy Statement (NZCPS) is required to achieve the purpose of the RMA in relation to the coastal environment of New Zealand (i.e. sustainable management). The term 'resilience' is included once within the NZCPS, via Objective 1, which is "To safeguard the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems, including marine and intertidal areas, estuaries, dunes and land …" [42, p. 9]. Again, resilience is not defined.

4. Christchurch – a resilient and sustainable city?

Recovery provides a useful context in which to explore the interactions between resilience and sustainability. Christchurch provides a case study of a protracted recovery process that illustrates the challenges and co-benefits of creating sustainable, resilient communities.

4.1. Description of the Canterbury earthquake sequence and effects

The Darfield earthquake of magnitude 7.1 occurred on 4 September 2010 at 4.35 a.m., causing damage to the immediate Darfield area, and as far away as the nearby city of Christchurch and the Kaiapoi township. Significant building damage occurred mostly from ground shaking, liquefaction and fault rupture. Unreinforced masonry buildings suffered damage, as did residential houses located in areas of liquefaction and lateral spread [65]. Transport, electricity, water and sewerage systems were disrupted, with the most notable damage occurring to sewerage systems (anticipated 18 month restoration times for some areas). No lives were lost, only two major injuries occurred, and the majority of injuries (over 2250) were minor [27].

The main Darfield earthquake was followed by a series of aftershocks, many of which occurred close to Christchurch City. On 22 February 2011 at 12.51 p.m. a shallow aftershock of magnitude 6.3 occurred near Lyttleton and Christchurch (known as the 'Christchurch Earthquake'). This aftershock caused severe ground shaking resulting in the collapse of a number of unreinforced masonry buildings and two multi-storey office buildings, and caused structural and non-structural damage to other buildings. Unfortunately, this severe midday aftershock resulted in185 people losing their life [43], and in many serious injuries. Much of the CBD was severely damaged in the earthquake and was cordoned off for months and years afterwards. Infrastructure was hit hard, with transport, electricity, water and sewerage systems disrupted. Rock falls occurred in the Port Hills. Liquefaction and lateral spread was more widespread than in the 2010 earthquake. This proved a problem in both residential and commercial areas, with properties and streets affected by thick layers of water and silt. Severe damage occurred to homes from liquefaction and ground shaking, and many residents were displaced.

Aftershocks continued to occur after 22 February, with aftershocks on 13 June and 23 December 2011 again causing issues with liquefaction [19], bringing home the realisation that the earthquake impacts experienced in Canterbury were severe and potentially long-lasting. This extended to other hazards, such as flooding. There was a marked increase in flood events due to the changed ground levels from ground tilting and subsidence as a result of liquefaction.

4.2. Recovery from the earthquakes

Following the initial Darfield earthquake on 4 September 2010 the recovery process began. In the following days and weeks, people re-engaged with their social networks at a local level to help each other through the effects of the earthquake. People provided emotional support, shared meals and assisted each other in the clean-up [12]. Liquefied material was swiftly cleared into piles by volunteer community members (e.g. Student Army, Farmy Army) and taken away to dumping sites by the city services [64]. Damaged buildings were identified by building assessors [25], and decisions were made about whether to demolish or repair these buildings. Insurance companies began assessing damaged property and possessions and starting to settle claims. Local authorities held discussions about what the earthquake had meant for settlements and began to think about planning for the future. For the most part the recovery was focussed on reinstating the status quo (with some minor improvements if possible) and getting everyone back to normal as quickly as possible. There was much discussion about how the region was a resilient one, and that people and infrastructure had stood up well to the earthquake [58,65]. People vowed to work together to recover the affected towns and city.

The Darfield recovery process was thwarted by the Christchurch Earthquake on 22 February 2011. The damage and disruption to Christchurch was so severe that a new recovery trajectory was required for the city. This new recovery direction also influenced communities located further afield, such as Kaiapoi which was still recovering from the Darfield earthquake but had fewer impacts after the Christchurch earthquake. It was evident that even though Christchurch had considered itself resilient in the face of the Darfield earthquake [58,65], and had worked tirelessly to 'bounce back' from that event, subsequent events had overwhelmed it. Many of the resilient adaptations that people had employed following the Darfield earthquake (e.g. removal of liquefaction, repairs to buildings and infrastructure) were rendered useless by the impacts of the Christchurch earthquake, and were not able to be translated into a long term sustainable future.

In a land-use planning sense, effects were most profoundly felt in terms of the destruction of the Christchurch CBD, and liquefaction and rock falls in residential areas. The CBD was heavily damaged and would require an entire rebuild. Liquefaction (and associated lateral spreading of the land) had damaged a large portion of the residential areas of Christchurch [20], which meant that people were unable to return to their homes. Additionally, liquefaction was still occurring every time a significant aftershock was felt [19]. Rock falls in the Port Hills area had either damaged homes already, or had the potential to damage homes in the future, meaning many properties were likely uninhabitable [13]. To ensure a sustainable future, new land use planning solutions were required to be implemented to deal with these impacts in an effective way – it was not business as usual.

What is clear from Christchurch is that: "Recovery is not simply restoring what we had before the earthquakes, but making an

[1] The National CDEM Plan sets out the hazards and risks to be managed at the national level, and the civil defence emergency management necessary to manage those hazards and risks. It sets out the roles and responsibilities of central government, Civil Defence Emergency Management Groups and other agencies such as lifeline utilities, emergency services and non-government organisations.

even better city – which includes improving the social, economic, cultural, and environmental wellbeing of greater Christchurch and its communities" [11,p. 2]. This statement captures the very idea of the city building back, but improving upon the past, and becoming more sustainable and resilient at the same time.

The following Section 4.3 describes examples of land-use planning that are contributing to future sustainability (and consequently also enhancing resilience). This includes the role of zoning, pre-event recovery planning, and insurance, in re-building a resilient and sustainable Christchurch.

4.3. Examples from Christchurch of land-use planning that contribute to sustainability and resilience

Examples of land use zoning, pre-event recovery planning and the role of insurance are presented. Each of these contributes to resilience and sustainability in differing ways.

Due to the amount of liquefaction and land instability (i.e. rockfall and cliff collapse) that occurred in parts of Christchurch as a result of the earthquakes – and likelihood of continuing susceptibility to future events-planning initiatives were developed. These included the introduction of the residential red-zone system, the development of a recovery plan or 'Blueprint' for the Central Business District (CBD), and using insurance pay-outs to improve upon people's previous living or work situations.

Red and green zones were developed for residential properties. Red zones were developed for the flat land subject to liquefaction, and for areas in the Port Hills susceptible to cliff collapse and boulder roll; green zones were developed for areas generally considered to have a sufficiently low risk to life, and the land could be remediated independently of surrounding properties. This response has created both a sustainable and resilient approach to land use planning, as discussed below.

4.3.1. Red zoning-a sustainable approach?

Areas in the flat land residential red zone had area-wide land and infrastructure damage, and an engineering solution to repair the land was considered to be uncertain, costly, and likely to be highly disruptive [15]. Properties that were within the red zone were financially settled by insurers and the government, and residents received a pay-out for forfeiting their property. Once settlement had been accepted by the land owner, houses were removed from the site, and reinstatement of the land began.

The criterion for defining an area as a residential red zone was [16]:

- significant and extensive area wide land damage;
- success of engineering solutions may be uncertain in terms of design, its success and possible commencement, given ongoing seismic activity; and
- any repair would be disruptive and protracted for landowners.

In the Port Hills, red zone areas were identified as those which were either:

- affected by cliff collapse and there were immediate risks to life, land remediation was not considered viable and infrastructure was difficult and costly to maintain, or
- affected by rock roll and the risk to life was considered unacceptable, was unlikely to reach an acceptable level in a reasonable timeframe, and protective works to mitigate the life safety risk were not considered practicable [15].

A total of 714 properties were zoned red in the Port Hills [13].

This zoning of residential land provides an example of a sustainable management response to the land use recovery process. If the decision to red zone areas had not been made, residents (and infrastructure providers) would have been required to rely on their own adaptations to aid their recovery following each earthquake event. While the residents may have been able to adapt to their surroundings and to how they responded to future events (e.g. removing liquefaction material; living in tilted houses; perhaps not being able to insure their property), in the long term this was not deemed a sustainable response, in that people, communities and infrastructure providers were unable to provide for their ongoing social, economic, and cultural well-being, and for their health and safety. The sustainable approach was to remove residential land use, and retire the land until a time in the future when it may be reinstated. In contrast, the green zone land can be inhabited with engineering solutions.

4.3.2. Green zoning – a resilient response?

Green zones were used for residential land in both the Port Hills for land instability, and on the flat land for liquefaction. Land in the flat green zone was divided into three technical categories: TC1 (grey), TC2 (yellow) and TC3 (blue), shown in Fig. 3. These categories describe how the land is expected to perform in future earthquakes, and also describe the foundation systems most likely to be required in the corresponding areas [17]:

- Technical Category 1 (TC1, grey) – future land damage is unlikely. You can use standard foundations for concrete slabs or timber floors.
- Technical Category 2 (TC2, yellow) – minor to moderate land damage is possible in future significant earthquakes. You can use standard timber piled foundations for houses with lightweight cladding and roofing and suspended timber floors or enhanced concrete foundations.
- Technical Category 3 (TC3, blue) – moderate to significant land damage is possible in future large earthquakes. Site-specific geotechnical investigation and specific engineering foundation design is required.

In contrast to the red zone - which requires the complete retirement of land - the green zones allow for adaptive measures to be completed so the land use can remain. By adapting engineering practises for foundations, resilience is improved (i.e. foundation requirement solutions) as is people's adaptive capacity. By adapting building and consent requirements, residential property owners can adapt to the new ground conditions and continue to live in these locations.

4.3.3. Pre-event recovery planning

Linking the complementary objectives of hazard mitigation, sustainable development and disaster resilience can be achieved through pre-event planning for post-disaster recovery [59]. Pre-event recovery planning is a type of planning to assist with sustainability that can be undertaken before a disaster happens [3,57,59]. An organisation can think through what might happen in a disaster, and then what might need to happen in terms of response and recovery after the event. They can then put specific plans in place prior to an event occurring to reduce the impacts of a disaster, or can make pre-event plans that will assist with the response and recovery phase. Pre-event recovery planning can be undertaken within, and co-ordinated between, many sectors including land-use planning, emergency management, insurance providers, and more. Becker et al., [4] have developed a methodology for land use pre-event recovery planning in New Zealand. In the case of Christchurch, limited pre-event planning had been undertaken, but during the recovery process, many initiatives have provided pre-event planning for the next future event. Table 3 provides examples of pre-event land use planning considerations, and how they have been implemented during the recovery of

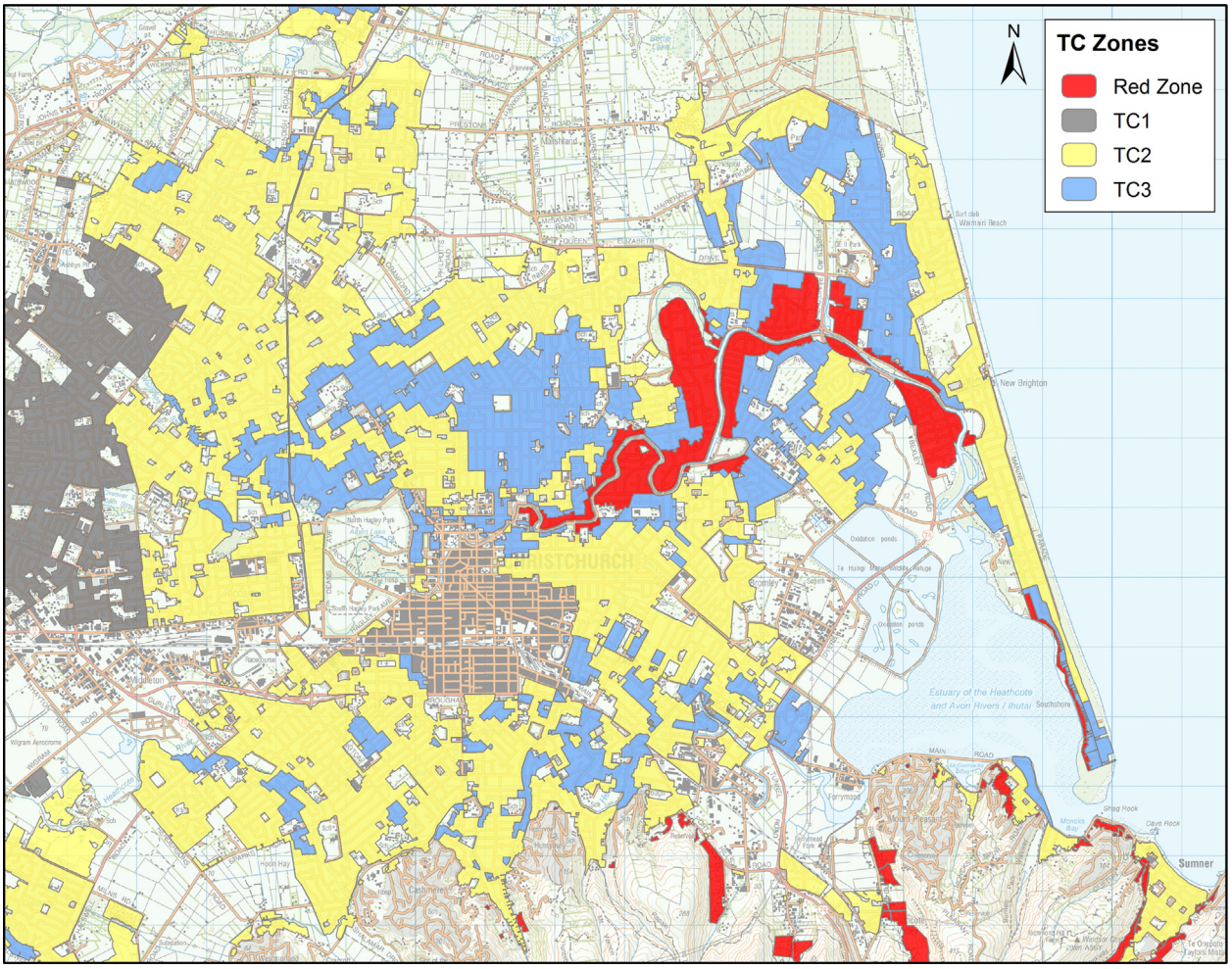

Fig. 3. Map of greater Christchurch area showing red and TC zones developed for residential properties [14].

Christchurch.

Pre-event recovery planning can be one way of boosting long term sustainability and overall resilience, instead of relying on short term resilience to see a community through a disaster period. Christchurch has undertaken many of these pre-event planning suggestions after the earthquake sequence. However, in doing so it has still attempted to focus on longer-term adaptation and sustainability in its forward planning.

Table 3
Pre-event planning considerations and their relevance to Christchurch recovery [4, 57]:.

Pre-event consideration	Christchurch EQ recovery outcome
A development moratorium, whereby development decisions are halted for a period of time after a disaster.	Moratorium in the central city area to allow time to develop a Central City Blueprint Plan to and confirm anchor projects
Temporary repair permits/consents	EQC-managed
Emergency consents (e.g. for removal of debris)	Emergency consents granted under RMA
Regulations which deal with demolition issues	Managed through CERA demolition team
Zoning for temporary housing	Managed through CERA
Setting priorities for infrastructure repair	Stronger Christchurch Infrastructure Rebuild Team (SCIRT) established to manage infrastructure repair
Identification of sites for emergency operations	Emergency management planning
Historic preservation (i.e. what to do with a historic building that has been damaged?)	A number of historic buildings which may have been able to be repaired were quickly demolished for life safety considerations
Acquisition of property in hazardous zones	Red zoning
Infrastructure development and management policies	SCIRT led, influenced by zoning
Hazard management plans	Flooding revised post-earthquake due to altered ground levels
Zoning tools (e.g. to prevent development in hazard areas)	Red and green zoning; land use recovery plan established; district plan review
Subdivision control and design	Green zone requirements, district plan review
Design controls placed on the landscape	Natural environmental recovery programme established
Re-planning of areas which may be stricken	Red and green zoning, district plan review, land use recovery plan
Examination of street patterns for access	Central city recovery plan reviewed one-way system
Debris disposal	Clean fill used for Port reclamation
Financial tools	Insurance

4.3.4. The role of insurance in promoting resilience and sustainable development in post-earthquake Christchurch

Resilience can reinforce both sustainable and unsustainable development [35]. Insurance – a key aspect of resilience – can fulfil this dual outcome. Insurance is a primary driver for recovery and resilience, as it provides a funding mechanism to repair and rebuild. It allows for the reinstatement of properties with little economic cost to the policy holder (as long as not under-insured), and ideally provides an opportunity to incorporate risk reduction measures into the recovery process. However, insurance can mask unsustainable land uses-providing 'resilience' by resinstating land uses (i.e. 'bouncing back'), that may be subject to future hazard events, and future claims. Insurance policies are typically based on 'like for like' replacement, allowing any risk reduction activities to be borne by the policy holder. Often such initiatives – such as raising a floor level above a flood level if it has been flooded previously – is beyond the financial means of the policy holder, and so the floor level is reinstated at the pre-existing level. This approach achieves no risk reduction, is not sustainable, and creates a false positive of resilience, as the original hazard and risk has not changed.

Promoting investment in cost-effective, sustainable risk reduction measures, while placing the burden of recovery on those who suffer losses from a natural event, is a challenge [30]. Insurance provides a tool for enabling people to bear the loss of an event [21], and therefore tolerate risks knowing that insurance can assist in the recovery process. In theory, insurance is one of the most effective policy tools for achieving risk reduction and risk-based pricing, as it rewards risk reduction investment with lower premiums and provides payment if an event occurs [30]. However, in practise, insurance does not adequately fulfil this role. Typically, and for various reasons, insurers do not charge premiums that encourage risk reduction measures [30]. This is true for New Zealand, which has a somewhat unique insurance system where the government-owned Earthquake Commission (EQC) provides natural disaster insurance for all residential property up to a specified dollar amount (www.eqc.govt.nz). Private insurance companies then provide 'top up' insurance. Whilst the scheme has contributed to high levels of insurance in New Zealand, it lacks some features like risk-based pricing and encouragement of mitigation [36].

In Canterbury, insurance policies provided replacement of like with like – the opportunity to include risk reduction or environmentally sustainable features that were previously non-existent, were not able to be incorporated. However, two years into the recovery insurers allowed home owners to install insulation to their previously non-insulated homes, to make them warmer, as part of the replacement. This will reduce their heating requirements and improve general health and wellbeing – that is, be more sustainable in a holistic sense. In the areas with liquefiable soils there are engineering remedies to enable foundations to be built. However, insurance companies may not include the significant cost of these additional foundation requirements in current claims settlements. Owners of buildings requiring foundation improvements may have difficulty obtaining affordable insurance, and if lenders insist on insurance as a condition for advancing loans, a vicious circle has been formed. Economically unsustainable, homes that are built on improved foundations will be over-capitalised, with the owners being unable to recoup the cost in the market value of the property [36].

5. Summary

A resilient community should also be a sustainable community, for two reasons: to meet legislative requirements, and – more importantly – to ensure the needs of future generations are met: economically, socially, culturally, and environmentally. The ability to recover from an event, and in the process improve sustainable practises and adaptive capacity, is a positive outcome for communities.

It is evident from literature that legislative definitions and conceptual framework concepts are interlinked. Sustainability and resilience both have the ultimate aim of developing strong communities and creating places that are enjoyable and safe to live in over time. However, there are still some current definitions and frameworks that focus on resilience as a shorter term phenomena, whereby people are expected to adapt in immediate response to a disaster, or in the short term recovery phase. Sustainability is often related to longer term aspirations where the consideration of future generations is important. The differences between resilience and sustainability become most evident where recovery from a disaster is protracted – for example, where communities get hit by multiple events or recovery is long and hard. It is in such a context that short-term adaptations can actually lead to unsustainable practises in the long term, and a more strategic overview on resilience and sustainability is required.

In Christchurch City during the Canterbury earthquake sequence, the dynamics between resilience and sustainability were certainly evident. People considered themselves adaptable and resilient after the Darfield earthquake, and undertook repairs with the aim of recovering to a 'normal' state as quickly as possible. In a land use context this meant clearing away the liquefaction, repairing existing buildings, and thinking about reconstructing seriously damaged buildings in a similar way and in the same area.

It was only after the Christchurch earthquake that people realised this short term view of resilience was not in fact sustainable in the long term. Far more visionary land-use planning solutions were required to achieve long term sustainability and greater resilience. Thus projects such as the red and green zoning, Christchurch CBD recovery plan [11], and insurance initiatives were undertaken to try to tackle this. The red zoning and retirement of areas of liquefiable land and land in the Port Hills will ensure that risks are reduced in the future, and that communities do not continue to live there in an unsustainable way. In a land use sense, the remaining communities are then considered sustainable in the long term.

Christchurch provides examples of resilient (i.e. TC area zoning), and sustainable (i.e. red zoning), redevelopment during the recovery process. In order to be fully resilient and sustainable, a community also needs to incorporate other measures to accompany land use initiatives, such as providing engineering solutions for foundations, i.e. adapting to the changed environment so that communities can continue to live in green zone areas. Another important contributor to resilience is ensuring that communities are engaged and empowered to take part in the land use planning process, so that they can effectively contribute to reducing their own risks before and after a disaster.

Given that resilience and sustainability are so interlinked, a wider recognition of the variety of factors that contribute to resilience would be useful. For example, as Paton et al. [49] suggest, a number of personal, community and institutions processes affect resilience, with planning being a key, but often overlooked, element. Recognising and accounting for a wider array of resilient factors may bring resilience closer to the concept of sustainability, and as a consequence, the goals of sustainability and resilience may become more closely aligned.

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