



HAL
open science

Resilience after an earthquake: a focus on Kumamoto, Japan and Christchurch, New Zealand

Laura Renaud

► **To cite this version:**

Laura Renaud. Resilience after an earthquake : a focus on Kumamoto, Japan and Christchurch, New Zealand. Architecture, space management. 2020. dumas-02965630

HAL Id: dumas-02965630

<https://dumas.ccsd.cnrs.fr/dumas-02965630>

Submitted on 13 Oct 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Laura RENAUD

Thesis master 2 « Urbanisme et aménagement »

Mention: « Urbanisme et coopération internationale »



DISASTER RESILIENCE

EARTHQUAKE

A focus on Kumamoto, Japan and Christchurch, New Zealand

Project tutor: Jean-Christophe DISSART
Academic year: 2019-2020

UGA
INSTITUT
URBANISME
GÉOGRAPHIE
ALPINE **Université**
Grenoble Alpes

Notice bibliographique

Projet de Fin d'Etudes Master Urbanisme et aménagement

Auteure : Laura RENAUD

Titre du Projet de Fin d'Etudes : Resilience after an earthquake, a focus on Kumamoto, Japan and Christchurch, New Zealand.

Date de soutenance : 07/09/2020

Organisme d'affiliation : Institut d'Urbanisme de l'Université Grenoble Alpes

Organisme dans lequel le stage a été effectué : Stage annulé - coronavirus

Directeur du Projet de Fin d'Etudes : Jean Christophe DISSART

Collation : Nombre de pages : 111 / Nombre d'annexes : 02 / Nombre de références bibliographiques : 97

Mots-clés analytiques : *resilient city, resilience, earthquake, natural hazard*

Mots-clés géographiques : *New Zealand, Christchurch, Japan, Kumamoto*

1^{er} résumé dans la langue principale du mémoire

How does a city and its people recover from a shock? This is the question that this thesis is based on. The shock here is the earthquake and in order to answer this question 2 cities are chosen and compared: Kumamoto, a Japanese city that experienced a destructive earthquake in 2016 and Christchurch in 2011. The Japanese country is known for its mastery in risk and disaster management. The aim is to look at the failures and successes of both countries to draw inspiration from them in the event of natural disasters, including earthquakes.

2^{ème} résumé dans une autre langue

Comment une ville et ses habitants se relève après un choc ? C'est sur cette question que ce mémoire s'inscrit. Le choc ici est le tremblement de terre et afin d'y répondre 2 villes sont choisies et comparées: Kumamoto, ville japonaise ayant connu un séisme destructeur en 2016 et Christchurch en 2011. Le pays nippon est réputé pour sa maîtrise dans la gestion des risques et des catastrophes. L'objectif est de s'intéresser aux échecs et réussites des deux pays afin de s'en inspirer en cas de catastrophes naturelles et notamment de tremblements de terre.

Acknowledgements

I would like first to thank Valérie Lalbin for her benevolence, even if I didn't get the chance to do my internship with her at Shawinigan in Canada due to the global pandemic which put an end to this before it could start.

Thanks to my parents for their support and the good framework during the confinement period. Thank you to Kim Keryann Manea for helping me to understand a little bit more about Japan, its language and culture. Thanks to Yannick Demba for his unfailing support throughout the process of writing the thesis.

I would like to thank Mr. Jean Christophe Dissart for his time and advice in the preparation of this thesis

Table of content

INTRODUCTION	10
1. JAPAN AND NEW ZEALAND IN EARTHQUAKE RISK MANAGEMENT	22
1.1. ASSESSMENT	23
1.1.1. EARTHQUAKE CLASSIFICATION	23
1.1.2. JAPAN AND NEW ZEALAND, TWO CULTURES FACING NATURAL DISASTERS	27
1.1.3. AN ASSESSMENT RESULTING FROM PREVIOUS DEVASTATING EARTHQUAKES	31
1.1.3.1. The Hanshing-Awaji earthquake (1995)	31
1.1.3.2. The Canterbury earthquake (2010)	34
1.2. ADAPTATION	37
1.2.1. NEW ZEALAND AND JAPANESE ADMINISTRATIVE SYSTEM	37
1.2.1.1. New Zealand administrative system	37
1.2.1.2. Japan administrative system	45
1.2.2. EARTHQUAKE PREVENTION	49
1.2.2.1. Prevention on infrastructures	49
1.2.2.2. Public prevention	52
2. JAPAN AND NEW ZEALAND IN EARTHQUAKE DISASTER MANAGEMENT	56
2.1. RESPONSE	59
2.2. RECOVERY – BUILD BACK BETTER	67

2.2.1. BUILD A NEW CENTRAL BUSINESS DISTRICT IN CHRISTCHURCH – A SUSTAINED CONSTRUCTION	68
2.2.2. CREATIVE RECOVERY IN KUMAMOTO	74
3. IS JAPAN THE WORLD REFERENCE?	79
3.1. JAPAN: THE WORLD REFERENCE IN DISASTER RESILIENCE	80
3.2. WHAT CAN WE LEARN ABOUT DISASTER RESILIENCE FROM THOSE TWO CASE STUDIES	83
CONCLUSION	91
ANNEX	95
TABLE OF FIGURES	99
TABLE OF PHOTOS	100
TABLE OF TABLES	100
BIBLIOGRAPHY	101
SITOGRAPHY	110



Introduction

On Thursday, 14 April 2016 at 9:26 p.m., a first earthquake of magnitude 6.5 occurred in Kumamoto, Japan, west of Kyushu Island, followed by a second tremor on 16 April of 7.3 magnitude.

The same year, on 14 November, the small town of Kaikoura, nearly 180 km North of Christchurch in New Zealand, experienced a 7.8 magnitude earthquake. This disaster is reminiscent of the 6.3 magnitude earthquake in Christchurch on 22 February 2011, which killed 185 people, and the 7.0 magnitude earthquake on 4 September 2010.

These disasters raise questions about the resilience of Kumamoto and Christchurch, which regularly face destructive and deadly earthquakes

In Latin, resilience *resilire* means to bounce, to spring back. The idea of "resilience" has been integrated into many disciplines. There is physical resilience, which refers to the ability to withstand a shock or to return to one's original shape. We find this notion in the social, natural, biological and economic sciences.

In psychology, resilience is a way of being *ordinary* rather than *extraordinary*: "Psychologists define resilience as the process of adapting well in the face of adversity, trauma, tragedy, threats or significant sources of stress — such as family and relationship problems, serious health problems, or workplace and financial stressors. As much as resilience involves "bouncing back" from these difficult experiences, it can also involve profound personal growth" (American Psychological Association, 2020 p.1). This explains why people suffering from trauma generally have the ability and desire to bounce back over time. It then becomes normal to be resilient. But in psychology another point is also very important. It is the capacity of the individual to mobilize external resources, to adapt his or her behaviour in order to cope with the difficulties encountered.

Resilience from an ecological perspective differs from psychology in that resilience in ecology is defined as a state of vulnerability to surprise and shock, rather than a response to such stresses (Foster, 2007). Resilience is therefore associated with low vulnerability with a high capacity for reorganization, growth and innovation.

The difference between resilience in psychology and resilience in ecology lies in three points. First of all, forecasting and intentionality. It is therefore the possibility of reacting to an alert. This reduces surprise, thereby increasing resilience. Second, communication. Indeed it allows us to learn from our experiences and past mistakes in order to have a better response to the situation. Communication allows us to ask for help. And finally, the last point of difference lies in technology and innovation that allows a better control of the environment and management of the territory. (Foster, 2007).

What about resilience in urban planning and geography?

There are three reasons why these disciplines have become interested in the notion of resilience.

First of all, there is the succession of environmental disasters that have affected local communities. What has been noticed is the way in which these populations have managed to bounce back locally in the face of these disasters. Secondly, urban planners and geographers have been interested in the notion of resilience in other disciplines (especially in ecology) and in the way ecosystems and socio-ecological systems respond to disturbances. Finally, the third reason is the growing interest in economic geography (Martin, 2012). In addition, the increasing pressures, instabilities and stresses caused by climate change at the global level have brought the issue of "resilience" to the forefront.

It is possible to give three definitions of "resilience" although it is difficult to give a comprehensive definition accepted by the disciplines (Martin and Sunley, 2012):

- Resilience as the ability to "bounce back" after a shock: the system returns, "bounces back" to the state or trajectory it was in before the shock. The focus here is on the speed and the scope of the recovery.
- Resilience as the "capacity to absorb" shocks. It is then the stability of the structure, function and identity of the system that responds to shocks.
- Resilience as "positive adaptability" in anticipation of or in response to shocks. It is then the ability of a system to maintain its basic performance in the face of shocks by adapting its structure, functions, and organization. The idea of "bouncing back".

Resilience can then be defined as the ability of a region to anticipate, prepare for, respond to and recover from a disturbance. The territory has to be resistant in shock, to be able to absorb it and bounce back.

❖ *Resilience: two states to be distinguished*

Two states can therefore be distinguished, the "preparation" of resilience to the "performance" of resilience (Foster, 2007).

Preparedness involves assessing a system, its infrastructure and vulnerabilities. These assessments will allow a better analysis of the territory and give another reading on how vulnerabilities can be worked on and adapted upstream in order to offer the most appropriate response to potential future shocks. When the shock occurs, there is first the immediate response and then the recovery. This is the moment when the territory is rebuilt. This cycle is then represented by the diagram below which presents the 2 states of resilience and the different stages.

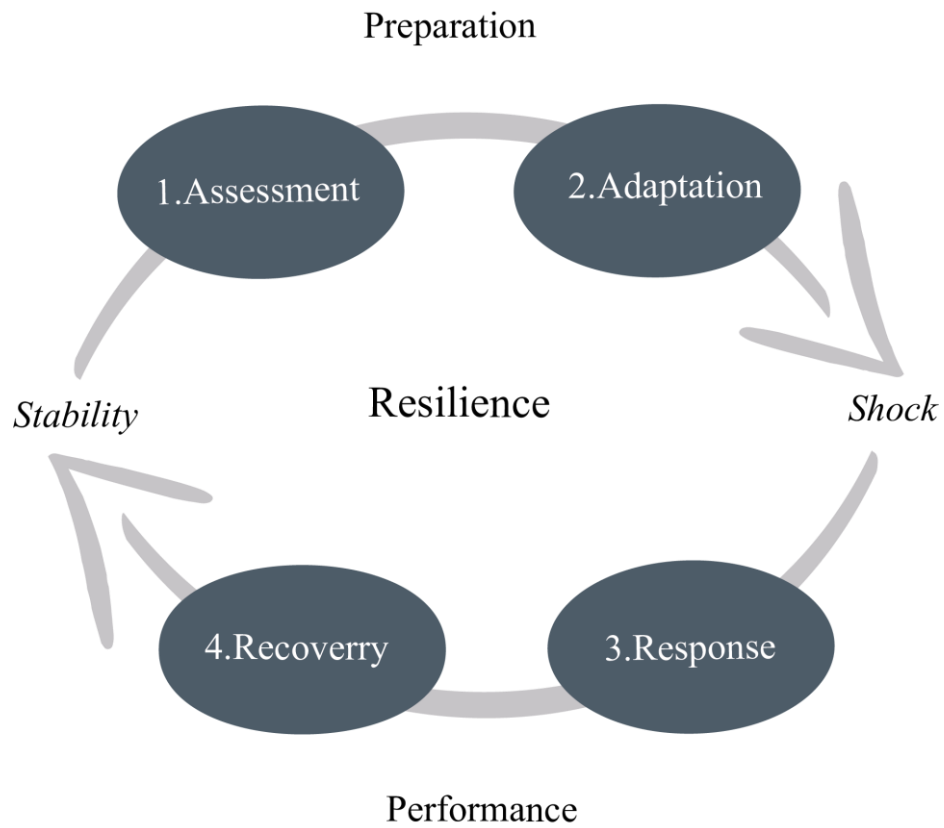


Figure 1: The two states of resilience
Author
Source: Foster, 2007

Resilience is not just at the time of recovery, it is throughout the process.

This thesis will follow the different steps to study how Kumamoto and Christchurch were resilient after the earthquakes.

❖ *Earthquake resilience*

An earthquake can occur:

- Strong ground-shaking
- Fault rupture
- Landslides
- Liquefaction
- Tsunami
- Fire
- Water pollution

These potential consequences of an earthquake on a territory can add vulnerabilities.

The objective is to reduce the probability and consequences of failures and reduce the recovery time. "There is no explicit set of procedures in the existing literature that suggests how to quantify resilience in the context of earthquake hazards, how to compare communities with one another in terms of their resilience, or how to determine whether individual communities are moving in the direction of becoming more resilient in the face of earthquake hazards." (Bruneau et al, 2003 p734). Research is heavily focused on human and financial losses and on the different possible scenarios to be put in place to limit them. Nevertheless, all research remains very important because it contributes to the acquisition of new insights that can thus reduce seismic risks.

Resilience is also measured by the capacity of local communities to mobilize their resources in order to reduce risks, human losses and to be able to restart business as soon as possible.

It is also necessary to know the meaning of natural hazard, vulnerability, risk, and disaster as well as their translation and equivalents in Japanese.

The definitions in English are taken from the United Nations International Strategy for Disaster Reduction (UNISDR, 2009) and in Japanese by the author Jean-François Heimburger (Heimburger, 2018 p.21-22).

Natural hazard is defined as a natural process or phenomenon that can cause loss of life, injury or other health effects, damage to property, loss of livelihoods and services, socio-economic disruption, or damage to the environment. In Japanese, natural hazard has no translation of its own, the closest term is *shizen genshō* (自然現象) which translates as "natural phenomenon". *Hazādo*, modelled on hazard, is used only in the sense of *hazādo mappu*, i.e. "hazard map" or "map of dangers".

Vulnerability is the characteristics and circumstances of a community or system that make it susceptible to the hazard effects. The Japanese equivalent is *Seijakusei* (脆弱性), which indicates a fragile and weak character.

Risk (here disaster risk) is defined as the potential for disaster, in terms of human lives, health, livelihoods, goods and services, to occur in a community or society in the future. Risk is then the result of the combination of hazard and vulnerability. In Japanese the equivalent is *kiken* (危険) which we can translate as "dangerousness". Like *hazādo*, Japan uses another Anglicism to talk about risk, *risuku* (リスク) *Sangai risuku* 災害リスク means "disaster risk". It is interesting to note that both "risk" and "dangerousness" are translated by the same word, *kiken*.

Finally, a disaster is a serious disruption in the functioning of a community or society involving significant human, material, economic or environmental impacts and losses that the affected community or society cannot overcome with its resources alone. This term has its exact equivalent in Japanese *saigai* (災害) which is a misfortune that happens unexpectedly. It is interesting here to take a closer look at the ideogram 災. This one is composed of 2 parts: first of all at the top "<<" which means dam, at the bottom "火" it is fire. The whole means therefore a fire coming to disturb life.

❖ *Japan and New Zealand*

The Kumamoto earthquake in Japan in 2016 caused the death of 50 people, with another 197 people dying later, indirectly. This event, far from being isolated, is a continuing threat to this country. Located along the firewall, Japan is the leading country in terms of measured earthquakes. It is located in an area where 4 lithospheric plates (Eurasian, North American, Pacific and Philippine plates) meet and move continuously in relation to each other, causing regular earthquakes in the Japanese archipelago.

Twenty-five years ago, the city of Kobe experienced a devastating earthquake in which more than 6,000 people lost their lives. The disaster cost the equivalent of about 10% of the state budget that year.

Often marked as a turning point for Japan, the country is then considered an exemplary seismic and urban state on an international scale.

But Japan is not the only country experiencing devastating earthquakes. Nearly 9 000 km away, New Zealand also regularly experiences violent earthquakes. New Zealand is highly vulnerable to natural hazard risks. It is one of the most vulnerable economies in the world to the impact of natural disaster (Lloyd's Global Underinsurance Report, 2012). This country, composed of 2 main islands and nearly 600 islands in all, is located at the junction of the Pacific and the Australian plates. The city which will then interest us for the rest of this thesis is the city of Christchurch (the third most populated city in New Zealand and the most populous of the South Island).

In order to better compare these two countries, the thesis focuses mainly on the city of Christchurch and the earthquakes the city experienced in 2011. Indeed, both Kumamoto and Christchurch, two medium-sized coastal cities, experienced a devastating earthquake in a very short period of time. Japan and New Zealand are both advanced economies and are located on the Pacific Ring of Fire which runs from New Zealand to the southern tip of South America. The choice of these two case studies will allow us to answer the following question:

How is Japan a model of seismic and urban resilience for New Zealand?

Three hypotheses can be formulated regarding this problem:

- It is possible to assess the resilience of a city before the disaster occurs;
- The earthquake becomes the key to a major restructuring of the affected city;
- Japan is an exemplary country in risk and disaster management.

In the first part we will see Japan and New Zealand in earthquake risk management. In the second part we will see how Japan and New Zealand are managing the earthquake disaster. Finally, we will discuss whether Japan is really a model to follow. These parts will focus on the issue of seismic risk and urban resilience. Resilience does not only concern urban functions, it also affects, among others, the field of education and health, which will also be discussed but deliberately not developed to focus on the field of urban planning. The purpose of this thesis is not to propose a development plan or projects for these cities, but rather to see how they have reacted and adapted to these natural disasters. What lessons can be drawn from them, their potential externalities.

The context in which this thesis was written requires an adaptation of the methodology used. As it was impossible to carry out field studies, the documentation comes from studies already carried out. The objective is to diversify the sources as much as possible in order to have both qualitative and quantitative data which are from scientific literature, news articles, testimony, government and organizations and also from documentaries and films. I interviewed a Christchurch inhabitant but unfortunately none from Kumamoto.

Two case studies are then carried out to address the issue. This also has a twofold objective: to see if Japan is really an example and thus be able to compare two communities with each other.

A few figures to start with

JAPAN

377 915 km²



126,5 MILLIONS

334,23 inhabitants / km²



Constitutional Monarchy

47 PREFECTURES / 8 REGIONS



**20% OF THE LARGEST EARTHQUAKES
OCCUR IN JAPAN**

423 ISLANDS

Tokyo

KUMAMOTO



739 556 INHABITANTS



**LOCATED ON THE KYŪSHŪ
ISLAND**

Thursday 14 April 2016 9:26pm

Earthquake precursor of magnetism 6,5

ECONOMIC IMPACT 56 BILLION EUROS



170 000 PROPERTIES DAMAGED AND 8 373 DESTROYED

50 VICTIMS & 2 700 WOUNDED

NEW-ZEALAND

268 021 km²



4 886 MILLIONS

18,23 inhabitants / km²

600 ISLANDS



Parliamentary Monarchy

12 REGIONS

Wellington



In the last 365 days the country has experienced



9 earthquakes of a magnetism greater than or equal to 6



CHRISTCHURCH



Canterbury region
capital



381 500 INHABITANTS

Tuesday 22 Febryary 2011, 11:51pm

Precursor earthquake of magnetude 6.6

AFTERSHOCKS OF MAGNETUDE 5.9

185 VICTIMS AND 2 000 WOUNDED

COST: 23 BILLIONS OF EUROS





1. Japan and New Zealand in earthquake risk management

1.1. Assessment

The assessment is part of the resilience cycle. It lies in the study of a system, its infrastructures and its vulnerabilities.

1.1.1. Earthquake classification

First of all, it is important to understand how an earthquake is measured. Seismic magnitude scales are used to describe the overall strength of an earthquake. Different magnitude scales exist. There is a misunderstanding about the “Richter” magnitude scale. It is not the one that it is actually used. In fact, Charles Richter is the first person who developed the idea of a logarithmic earthquake in the 1930s. But as more seismograph stations were installed around the world, it became apparent that his method was strictly valid only for certain frequency and distance ranges. Because of the limits of the “Richter” magnitude scale, a new method is developed by the United States Geological Survey. It is called the “moment magnitude scale” (Mw). This is the one that it is still used today and employed in this thesis. The following table presents the “moment magnitude scale”:

Description	Moment magnitude scale	Effects	Average frequency - world
Micro	Under 1,9	Micro earthquake, not felt	8,000 per day
Very minor	2,0 to 2,9	Generally not felt but detected / recorded	1,000 per day
Minor	3,0 to 3,9	Often felt without causing damage	50,000 per year
Light	4,0 to 4,9	Notable shaking of objects inside the house, rattling noises. Damage remain very slight	6,000 per year
Moderate	5,0 to 5,9	May cause significant damage to poorly designed buildings in restricted areas	800 per year
Strong	6,0 to 6,9	May cause serious damage over tens of kilometers. Only resistant buildings can stand near the centre.	120 per year
Very strong	7,0 to 7,9	May cause severe damage in large areas; all buildings are affected near the centre	18 per year
Major	8,0 to 8,9	May cause very severe damage in areas hundreds of kilometers away. Major damage to all buildings, including tens of kilometers from the centre	1 per year
Devastating	9,0 and more	Hundreds of kilometers around are devastated. Damage over more than 1 000 km	1 to 5 per century

Table 1: Moment Magnitude Scale

Author

Source: Vaselenko, Amy. 2015

The following figure exposes the magnitude and energy release to better understand the strength of an earthquake and its damage. The left side of the chart shows the magnitude of the earthquake and the right side represents the amount of high explosive required to produce the energy released by the earthquake. The middle of the chart shows the relative frequencies.

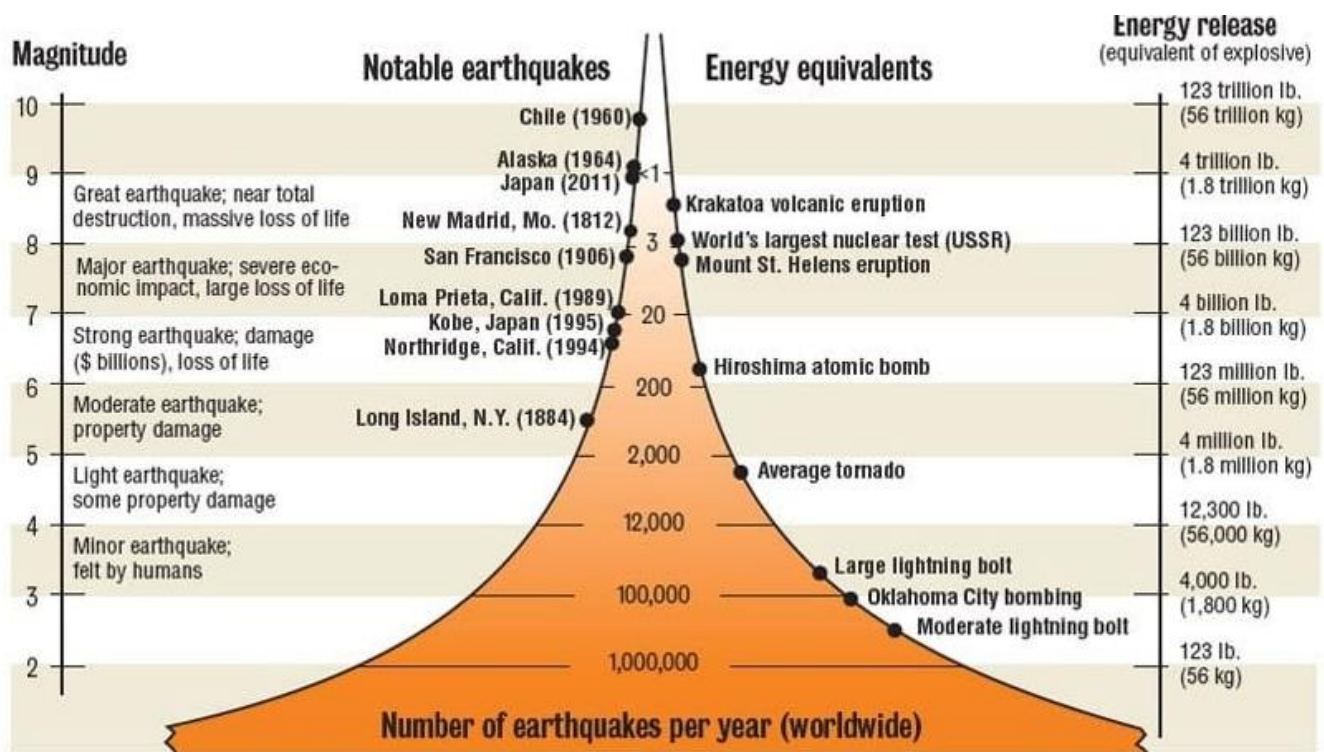


Figure 2: Magnitude, energy release and shaking intensity
 Source: Hayes, Gavin. Incorporated Research Institutions for Seismology, 2011

Japan has its own system to measure seismic waves and categorize the intensity of local ground shaking. It is the Japan Meteorological Agency (JMA) seismic Intensity Scale (known in Japan as the Shindo seismic scale (震度, "seismic intensity")). Contrarily to the Moment Magnitude Scale that is concentrated on the low frequencies of seismic waves, the Shindo scale focuses on how much ground shaking takes place at measurement sites distributed throughout an affected area.

Below, the Shindo scale according to the Japan Meteorological Agency:

Degree of intensity	Human perceptions and reactions	Indoor location	Outdoor location
0	Imperceptible shocks		
1	Rarely sensitive shocks indoors		
2	Sometimes sensitive shaking indoors	Balancing suspended objects	
3	Sensitive shocks indoors	Vibration of the dishes	Slight swaying of power lines
4	Sensitive shocks while walking; surprise	Strong swinging of suspended objects	Strong swaying of power lines
5-	Need to hold on to a stable element; fear	Danger of falling dishes and books, or even furniture tipping over	Movement of power poles, risk of road degradation
5+	Hard to move	Increasing risk of furniture tipping over	Collapse of unconsolidated walls
6-	Difficult standing position		Damage to weakly resistant houses
6+	Standing position impossible to hold		Increasing risk of damage to resistant houses and collapse of non-resistant houses
		Tilting or even projecting furniture	

Table 2: The Shindo Scale

Author

Source: Japan meteorological agency, 2018

Being able to measure universally the power of earthquakes provides a global basis for assessment. It is then possible to compare data from all over the world and to speak the same language.

In addition to the importance of being able to understand each other and share data today, the two countries have developed a culture of risk.

1.1.2. Japan and New Zealand, two cultures facing natural disasters

More than 700 years ago, Polynesian populations discovered and colonized New Zealand, which was then called Aotearoa ("country with the long white cloud"). They developed a specific culture, the Maori culture. The country was first discovered in 1642 by the Dutch navigator Abel Tasman. The territory is then named New Zealand after a Dutch province of the same name. In 1769, James Cook arrived and claimed the territory on behalf of the British Crown. Today the population of New Zealand is 64% European and 14% Maori.

The Maori have developed, among other things, a knowledge of the territory, their environment, the climate and natural hazards. They passed on this knowledge orally from generation to generation. It is called "Maori Environmental Knowledge" or Matauranga taiao. This information and knowledge include the observation and recording of changes in the environment, the nomination and classification of risk areas and the prediction of environmental disturbances (Goff et al., 2007 p60).

The diagram below indicates the several steps before reaching the Indigenous Knowledge. In our case study, Maori knowledge about natural hazards have attained the level 4 so we can assume that the expertise accumulated by the Maori people are Indigenous Knowledge.

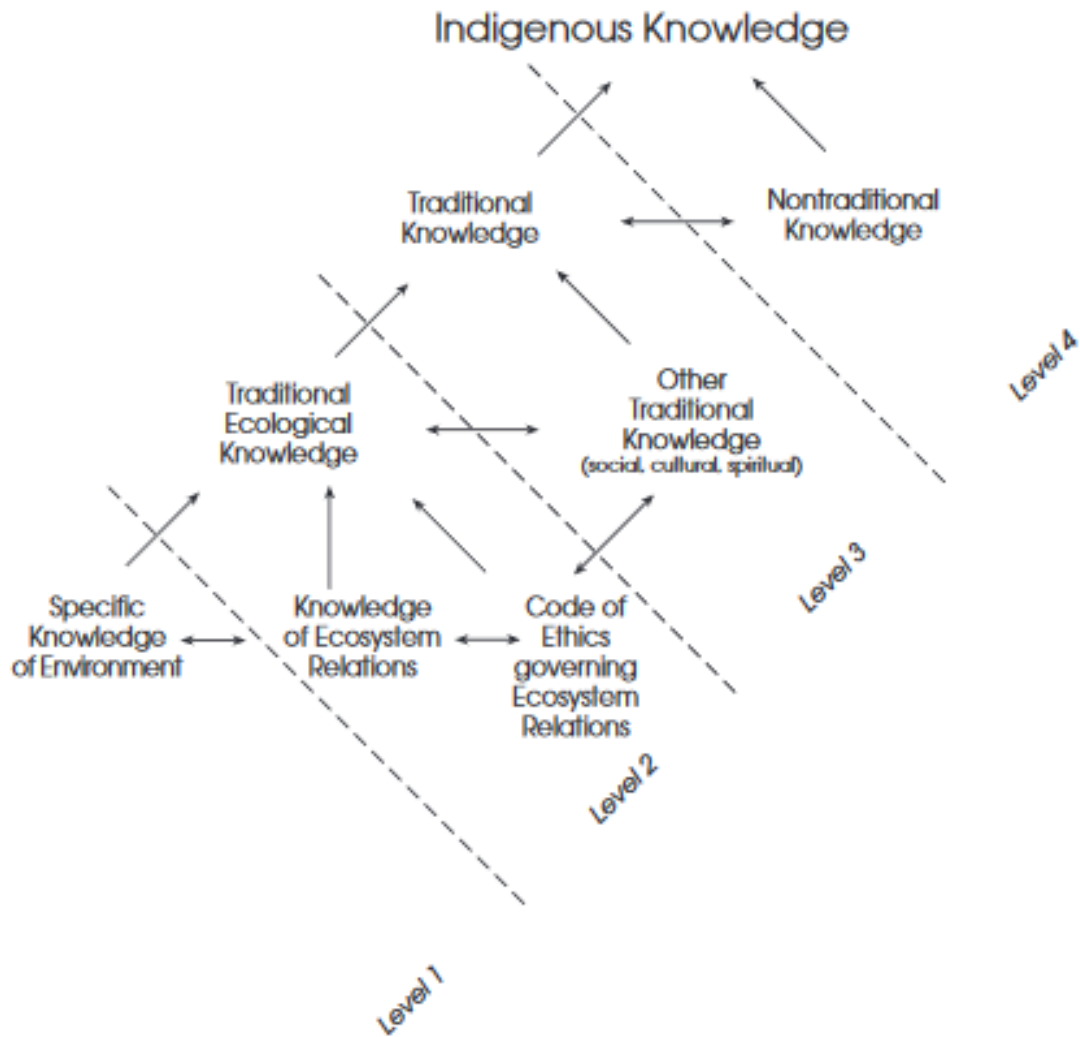


Figure 3: Structural components of Aboriginal knowledge, at different levels of incorporation in environmental assessment and management
Source: Stevenson, 1996 p.280

Before the arrival of Europeans on what would become Christchurch in 1848, the area was occupied by Maori hunters of Mōa (now extinct). The city was then built entirely by European settlers. Today Christchurch is the capital of the Canterbury region located in the centre-east of the South Island with a total population of 628,600.

There is currently no written record of an earthquake that occurred in this territory before the arrival of the settlers. This can be explained in particular by the virtual absence of Maori who lived mainly on the North Island. As can be seen on this map below, the main Maori accounts of natural hazards are largely based on events that took place in the North Island.

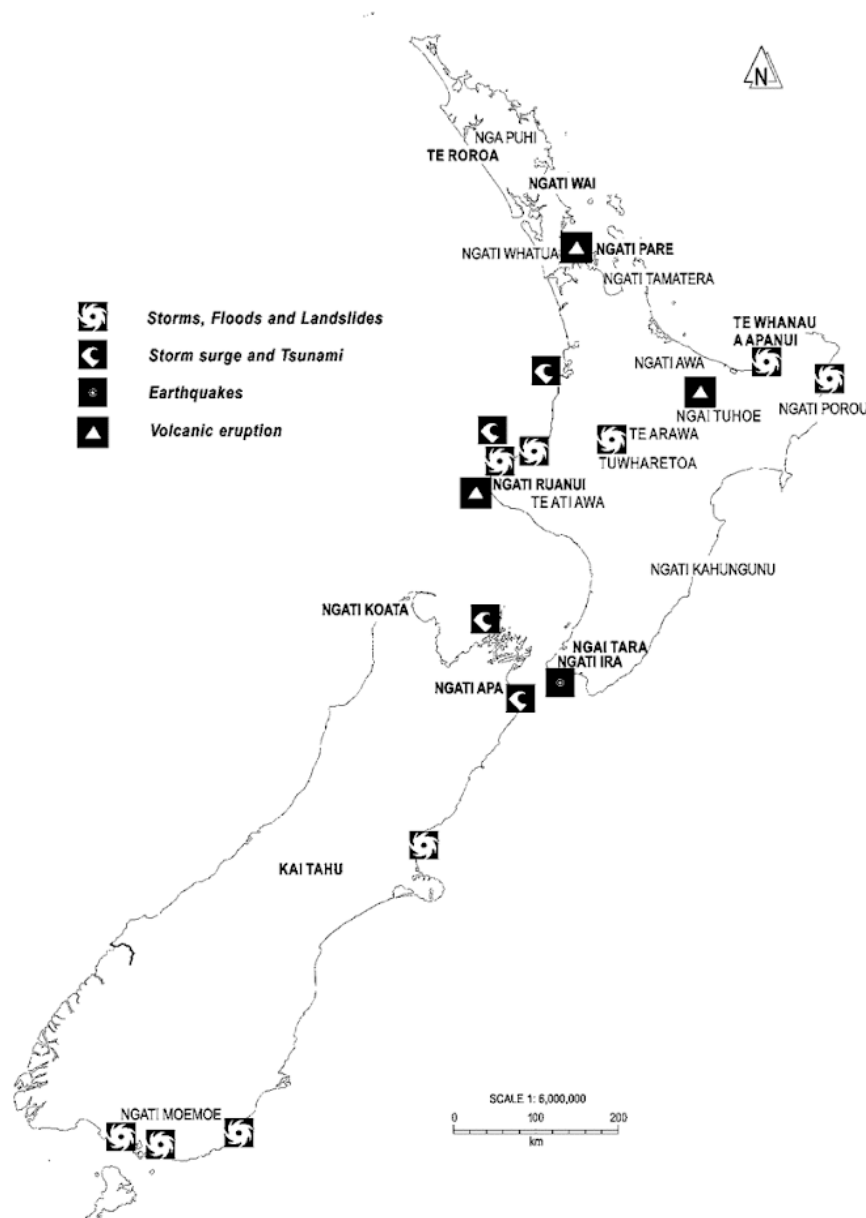


Figure 4: Map showing events recorded orally by tribal groups in New Zealand

Source: King et al. 2007 p.63

Despite the significance of this subject, it is still necessary to remain cautious about interpreting oral narratives that have been handed down over several generations. However, it is important to highlight the value of this knowledge, particularly for planners who have sought to integrate this vision into local resource management, biodiversity conservation, land use assessment and sustainable development (Stevenson, 1996).

Japan, for its part, has been occupied by humans since 40,000 BC. The term "indigenous people" or *senjumin* is associated with foreign people (American Indians, Australian Aborigines, Maori etc.). However, within Japan, this term is also used to refer to the Ainu of Hokkaido, in the northern island of Japan. They proclaim themselves as indigenous and aboriginal. However, the Ainu never received official recognition from the government.

The choice is then not to consider that there are indigenous peoples in Japan. However, it does not negate strong regional cultures and communities.

Japan has always faced multiple natural disasters (such as earthquakes, typhoons, tsunamis, volcanic eruptions, etc) due to its climate and topography. A Nippon legend tells that a huge dragon slumbers under Asia and that by stirring it creates earthquakes. Its burning mouth (located precisely under Japan) is the origin of volcanoes. Another legend says that Japan is based on a very turbulent *namazu* catfish (鯰) which is the origin of earthquakes. Strangely, catfish seem to be particularly sensitive to the warning signs of an earthquake, sometimes up to 24 hours in advance (Motoji Ikeya, 2004).

In the Maori tradition, Rūaumoko, God of earthquakes, causes rumbles and earthquakes by walking.

Unlike Christchurch, which has a recent history, the island of Kyushu where Kumamoto is located has been inhabited since the arrival of the first humans in Japan. Prior to their arrival, the island experienced four major volcanic eruptions which led to structural changes on the island and the appearance of stone materials produced by the lava which were used for construction.

These two countries, which are subject to natural hazards that can cause disasters, have developed over the years a knowledge of their territory and environment.

1.1.3. An assessment resulting from previous devastating earthquakes

1.1.3.1. The Hanshing-Awaji earthquake (1995)

25 years ago, 17 January 1995, the 7.2-magnitude temblor Hanshin-Awaji earthquake, better known as the Kobe earthquake is often shown as the disaster that changed Japan.

“This modern city had suddenly become dysfunctional, engulfed by confusion and chaos, and shaking with fear”

Wu Zun Min, 1995 (Kobe inhabitant)

To really understand the consequences of this major earthquake, Kobe is often compared to the one that happened in Los Angeles 17th January 1994. The following table exposes the differences between those two cities:

	Kobe	Los Angeles
Date	17 January 1995	17 January 1994
Magnitude	7.2	6.7
Dead	6 434	72
Wounded	43 792	9 000
Homelessness	45 000	x
People moved out in evacuation centres	316 700	125 000
People who left the city after the earthquake	50 000	x
Buildings damaged or destroyed	127 000	82 000
Cost	USD 114 billion	USD 20 billion

Table 3: Kobe and Los Angeles earthquake facts
 Author
 Source: Heimburger, 2020. Fonseca, 2019

The management of the Kobe earthquake was strongly criticized due to the number of victims. A densely populated area, a lack of attention and poor preparation explain the severity of the damage (Heimbürger, 2020).

“Because most of the roads were broken up, and many people were walking into the city, it took me three hours to travel the distance which can usually be covered in less than twenty minutes.”

Wu Zun Min, 1995 (Kobe inhabitant)

So what happened? Why did Kobe seem overwhelmed while the city of Los Angeles managed to control the earthquake consequences? The gas, electricity and water were cut. When fires started it became difficult to put them out. France and Switzerland sent help but it took days before they arrived in Kobe. Inhabitants were not prepared and the infrastructure not yet adapted.

“Kobe, let’s do our best !” (神戸で頑張ろう) was the slogan after the disaster.

Today, the actual mayor considers that the works are over. Kobe’s goal is to rebuild, not just the same, but better. At the same time, it is a question of improving the actions intended to reduce the damage in the event of a new disaster. This is how this modern city has become a place of seism research and promoted a risk prevention policy. After the disaster, the Headquarters for Earthquake Research Promotion was created in order to release every 10 years a guideline of earthquake research. Its role:

- Planning of comprehensive and basic policies
- Coordination of budgets and other administrative work with related governmental organizations
- Establishment of comprehensive survey and observation plans
- Collection, arrangement, analyses and comprehensive evaluation of survey results by related governmental organizations, universities, etc.
- Publication based on the above evaluations

One of their significant works is the following map. It shows the probability of ground motions equal to or larger than seismic intensity of 6- (according the Japan Meteorological Agency), occurring within 30 years into the future. The base date is 01 January 2018.

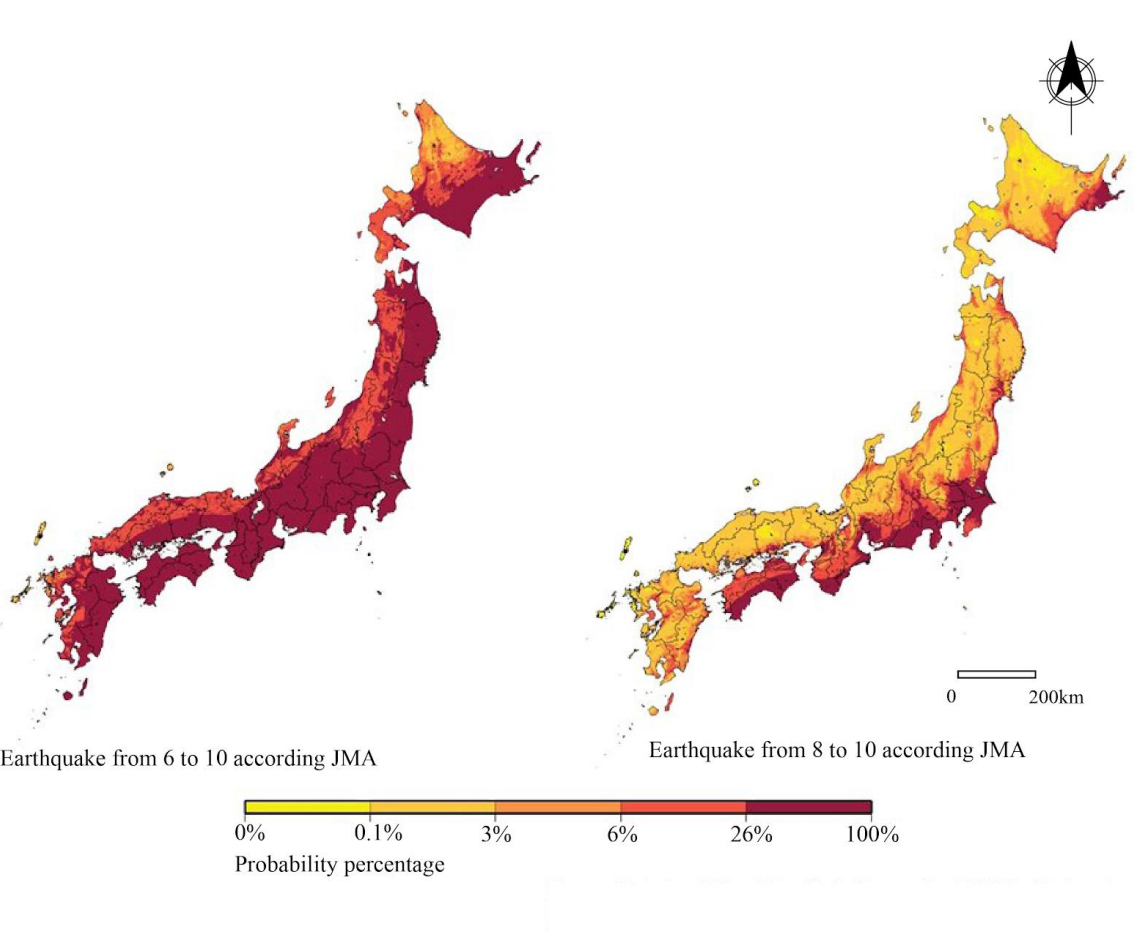


Figure 5: Probability of experiencing an earthquake of 6- intensity of above in the next 30 years
Source: The Headquarters for Earthquake Research Promotion, 2018

This work indicates how high is the risk of suffering a major earthquake in the years to come and how vitally important it is to be able to prepare the country and its inhabitants for this likely shock. Which brings us to the question of prevention.

The word *bôσαι* is made by *bô* means “prevention” and *sai* “disaster”. Professor Yoshiaki Kawata¹ uses the term *shukusai*. It means how to anticipate potential damage and how to think not only of its reduction but also be able to create a society capable of quickly carrying restoration and reconstruction after a disaster. This is the closest Japanese word for *resilience*.

1.1.3.2. The Canterbury earthquake (2010)

Like Japan, New Zealand suffered a major earthquake that changed the approach of seisms in the country. Saturday 4 September 2010 at 4.35 am, a magnitude 7.1 earthquake occurred near Christchurch, in Darfield. Scientists named it the Darfield earthquake but it is better known as the Canterbury earthquake. It is the largest earthquake to affect a major urban area since the Hawke's Bay earthquake in 1931. Fortunately, most people were at home sleeping, and the streets were empty. Thanks to that, there were few serious injuries. The lack of casualties was also due to strict building regulations² and partial strengthening of many older buildings. But the worst damage was for pre-1940s buildings constructed using masonry and bricks that fall on the streets.

Scientists discovered that the earthquake of February 2011 is a replica of the 2010 earthquake.

¹ Faculty of Safety Science Department of Safety Management - Kyoto University

² Building regulations are developed in the section “adaptation”.



Photo 1: Christchurch earthquakes of 2010
Source : Blundell, S. 2018

As of June 2011, the earthquakes had cost the city council \$3.6 billion. The Canterbury earthquake cost \$10 billion (5 714 507 672€). In 2018, \$2.3 billion was founded. Christchurch city council has to pay \$7.7 billion. But according to Deloitte³ a further \$4 billion of earthquake-related capital investment is necessary over the next 30 years to return assets to the level the territory had. Resilience refers to the notion of "rebound" as a rubber band which after a shock returns to its initial shape. There are 3 types of response after a negative economic shocks (Hill et al., 2008):

- Economically resilient: regions that have returned to (or exceeded) their previous growth path
- Shock resistant: regions that have not been thrown off their growth path
- Non-resilient: regions that have not been able to rebound

³ Global provider of audit and assurance, consulting, financial advisory, risk advisory, tax and related services in New Zealand

As the following figure shows, in 2018, Christchurch has returned to growth despite the shocks.

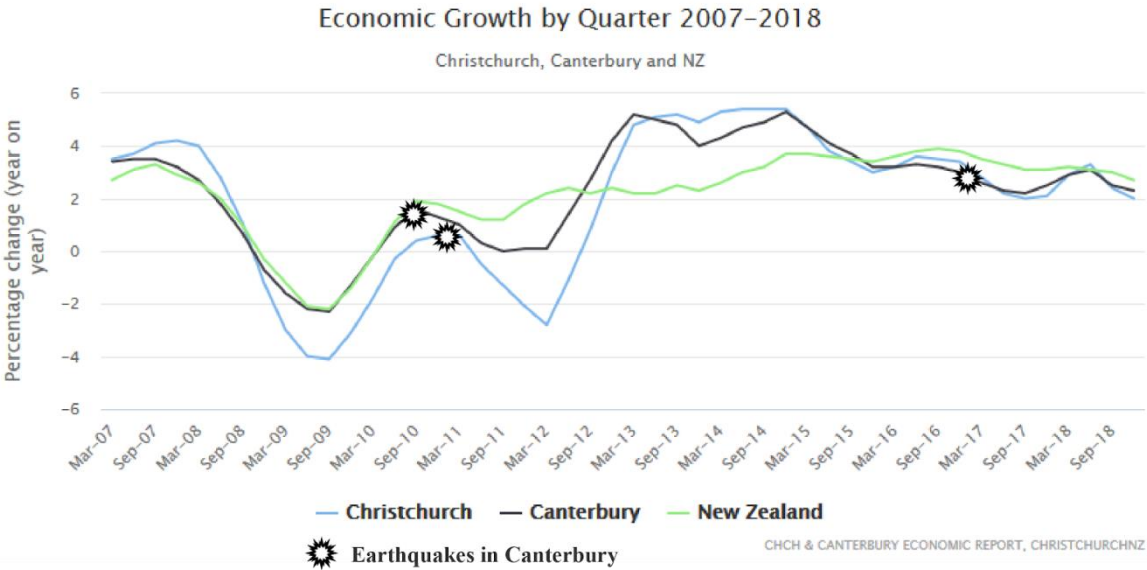


Figure 6: New Zealand Economic Growth
 Source: Greater Christchurch, 2018

Earthquakes of 2010 and 2011 resulted in an Economic Growth decrease of 2.2% until March 2012. 20% of total tourist arrivals in New Zealand land in Christchurch.

But an area's ability to return to its pre-shock level of growth is no longer a sufficient criterion to qualify whether the city has been resilient or not. This is one indicator among others developed in the thesis.

For the first time in New Zealand, the internet was used notably through social media (Twitter and Facebook) to share information to Canterbury citizens. GeoNet (which is the result of a partnership between the Earthquake Commission, GNS Science and Land Information New Zealand) posts the location and magnitude.

For both countries, mostly after these two major earthquakes but also because of all the disasters and knowledge they collected over the time, risk management and disaster prevention became a real part of New Zealand and Japan resilience.

Assessment is one of the two most important elements to prevent and react from a disaster. This is a part of the preparation. The other one is adaptation.

1.2. Adaptation

Assessment is the first step for a system to be resilient. The other step in the preparation phase is adaptation. This stage includes building regulations and prevention.

Before starting, a quick overview of the New Zealand and Japanese administrative systems is required to understand the different administrative scales in planning and who is competent in risk and disaster prevention.

1.2.1. New Zealand and Japanese administrative system

1.2.1.1. New Zealand administrative system

The political system of New Zealand is a parliamentary Monarchy. This means that Queen Elizabeth II of the United Kingdom is the head of the state. The prime minister of New Zealand (Jacinda Ardern, elected in 2017) is the head of government. With Cabinets, they form the Central Government.

In the 1980s, New Zealand knows a big shake-up of local government. The country is divided into two types of councils:

- Districts or city councils, which are responsible for: roads, urban facilities, housing and development, footpaths, water, sewerage, libraries, park, building consents and dog control.
- Regional councils: they cover a larger area than city councils and are responsible for: air and water quality, flood protection, harbors, public transport. Regional councils also act as a kind of environmental watchdog.

Another layer exists instead of the traditional city councils and regional councils. It is called the unitary authority. It is a single council doing the jobs of the city council and regional council. There are 6 unitary authorities in the country but none cover the Christchurch territory. In this thesis, an unitary authority layer is deliberately undeveloped because it does not concern the studied territory.

The city council of Christchurch and the Canterbury region are the area of study.

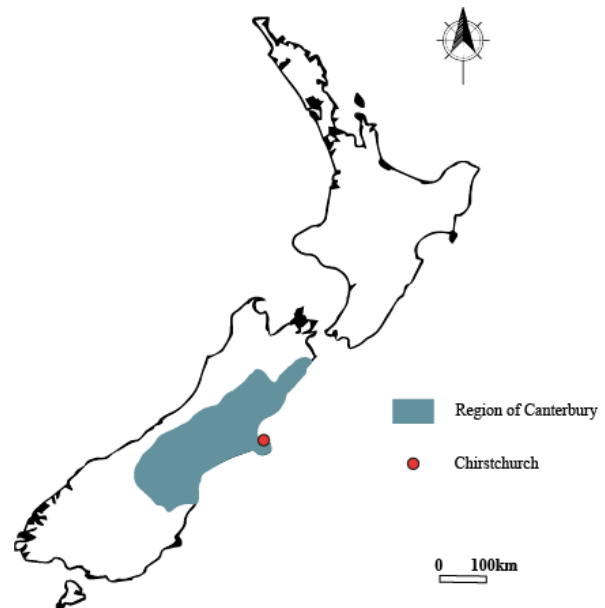


Figure 7: Region of Canterbury - New Zealand
Author

Relating to the national spatial policy:

- National Policy Statements and National Environmental Standards are managed by the Ministry of the Environment
- The National Infrastructure Plan by The Treasury: The Plan is designed to reduce uncertainty for businesses by outlining the Government intentions for infrastructure development over a 20-year timeframe. “The Plan is directional rather than directive. It provides a framework for infrastructure development rather than a detailed list of projects. The Plan sets out a vision that, by 2030, New Zealand infrastructure is resilient, coordinated and it contributes to economic growth and increased quality of life.

Its overall message is that New Zealand infrastructure is performing well, but there are areas where improved performance would accelerate economic performance. The Plan sets out six guiding principles to respond to these infrastructure challenges. It also outlines infrastructure issues in five key sectors (transport, telecommunications, energy, water and social infrastructure).” (New Zealand Planning Institute, 2011).

- Land Transport Funding and New Zealand Transport Strategy by the Ministry of Transport

- National Land Transport Programme by NZ Transport Agency

Before talking about Christchurch city council and the Canterbury region, it is first necessary to look at what is happening at the national level about building regulations and urban planning to prevent earthquake consequences.

The diagram below shows the 6 factors that are taken into account:



Figure 8: Earthquake prone building framework
Source: Building performance, 2018

The government has to ensure the management of buildings in anticipation of future earthquakes by finding the right balance between the protection of people from harm in an earthquake, the costs of strengthening or removing buildings and the impact on the heritage of New Zealand. The national system is not the only stakeholder: territorial authorities, engineers and building owners have also important roles to play. These are set out in the Building Act 2004 that can be summarized as:

- Territorial authorities identify potentially earthquake-prone buildings
- Owners who are notified by their territorial authority must obtain engineering assessments of the building carried out by suitably qualified engineers

- Territorial authorities determine whether buildings are earthquake prone, assign ratings, issue notices and publish information about the buildings in a public register
- Owners are required to display notices on their building and to remediate their building.

This legal document divides the country into 3 seismic risks area (below):

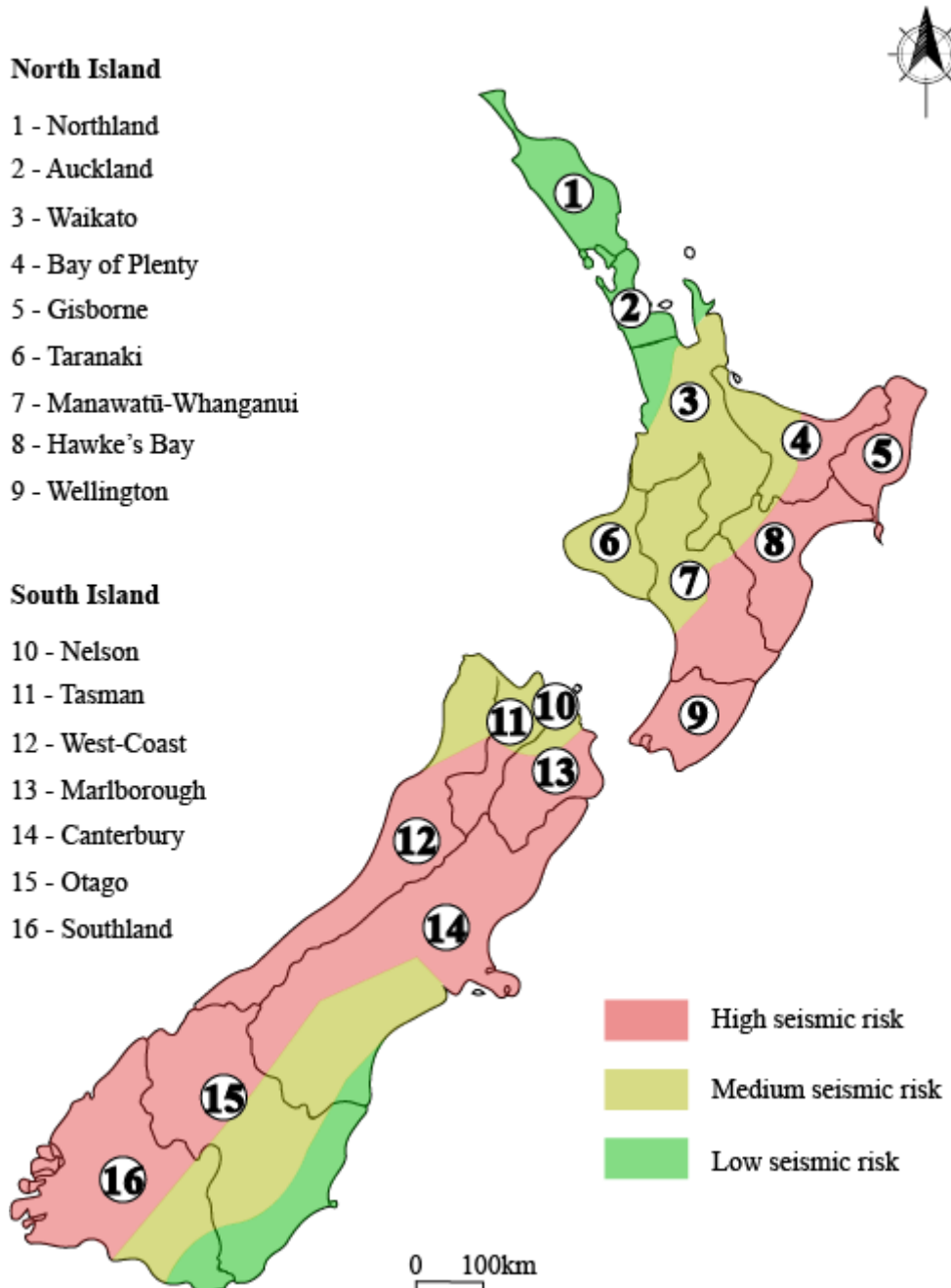


Figure 9: Seismic risk area of New Zealand regions

Author

Source: Building Act 2004

According to the area, different timeframes are granted to territorial authorities to identify potentially earthquake-prone buildings and for building owners to remediate it.

Regarding Christchurch, which is in the high seismic risk area, technical assistants have until 1 July 2022 to identify potential earthquake-prone buildings and owners, once their buildings are identified, have maximum of 15 years (7.5 years if the building is a priority) of the date of the original notice to carry out seismic work (to complete remedial work or demolish the building).

The section 133 AE of the Building Act 2004 defines what a priority building is:

- “Hospital buildings that are likely to be needed to provide emergency medical and ancillary services in an emergency;
- Buildings likely to be needed as an emergency shelter or an emergency centre in an emergency; or that enable emergency response services to carry out their jobs in an emergency;
- Buildings used for education purposes that are regularly occupied by at least 20 people;
- Parts of unreinforced masonry buildings that could fall in an earthquake onto thoroughfares with sufficient vehicular or pedestrian traffic to warrant prioritisation;
- Buildings that could impede transport routes of strategic importance (in terms of an emergency response) if they were to collapse in an earthquake.”

The following map indicates the distribution of earthquake-prone buildings per region in New Zealand.⁴

⁴ See annex 1 page 91 to access the spreadsheet containing the data collected on: <https://epbr.building.govt.nz/>

5

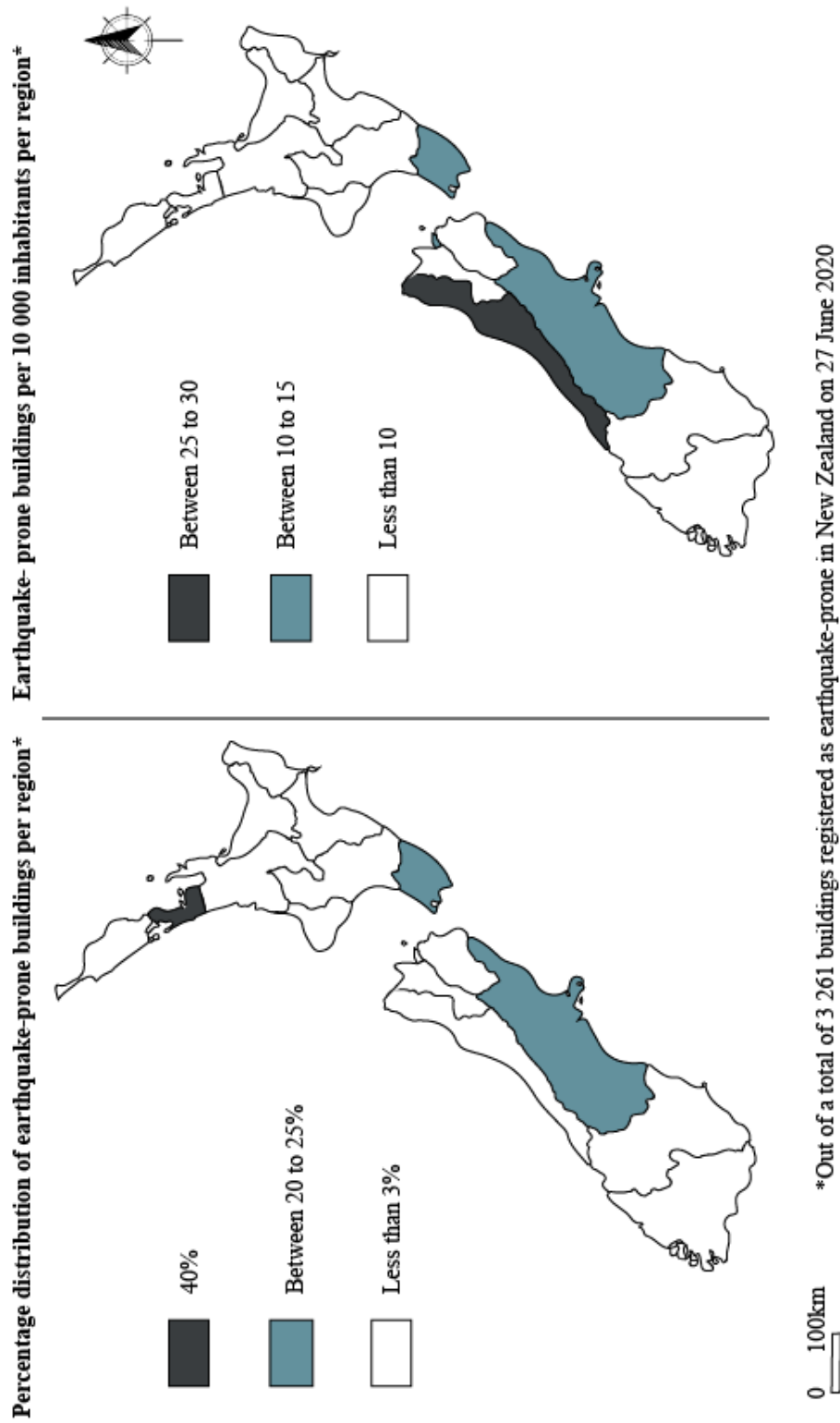


Figure 10: Distribution of earthquake-prone buildings in New Zealand on 27 June 2020

Author

Source: Ministry of Business, Innovation and employment

The previous map shows several interesting things:

- It would be possible to believe from a first reading that the region of Auckland would be the most vulnerable territory in New Zealand as 40% of the buildings registered as earthquake-prone are located in this area. However there are 8 vulnerable buildings per 10,000 inhabitants.
- Auckland is located in the most populated area of New Zealand which may explain the amount of data on this region but has a low seismic risk and has no buildings considered to be a priority.
- West Coast is the region with the most earthquake-prone buildings of New Zealand (27 per 10,000 inhabitants). It is located in a high-risk area and on the mountain range of the Alps (named Southern Alps). However, it is a sparsely populated region that has not been affected recently.
- Canterbury and Wellington are the two regions that together account for almost half of the buildings registered as more vulnerable.

What about Christchurch?

Of the current total number of buildings identified as earthquake-prone, 1/4 is in the Canterbury region.

To be more specific, 791 earthquake-prone buildings are currently identified in the region of Canterbury. Of the 791, 676 relate to Christchurch only (i.e. 85%). At this point, it is possible to assume that Christchurch is the most vulnerable city of New Zealand. But the city of Kaikoura, nearby Christchurch and hard hit by the earthquake of 2016 has not yet catalogued its fragile buildings in the online register hosted by the Ministry of Business, Innovation and employment. So for now, the registration of earthquake-prone buildings is still in progress and has not yet been completed. It is therefore necessary to take this data with a pinch of salt and to integrate the fact that in reality it concerns a much larger number of infrastructures.

But in response to the Canterbury earthquakes, on 14 March 2011, the Cabinet agreed to establish a Royal Commission to inquire into the Canterbury Earthquakes chaired by Justice Mark Cooper, a sitting High Court judge. This Commission has the role to examine issues around the built environment in the Christchurch central business district (among others). It is also needed to inquire about the adequacy of the relevant building codes and standards into the future. The Commission must take into account, but not be limited by a technical investigation undertaken by the Department of Building and Housing.

Different reports will follow the next year. 3 volumes have been published:

- Volume 1: summary and recommendation in volumes 1-3, seismicity, soils and the seismic design of buildings
- Volume 2: the performance of Christchurch CBD buildings
- Volume 3: low-damage building technologies

“A Royal Commission is the most serious response to an issue available to the New Zealand Government. It investigates matters of great importance and difficulty. It is engaged in fact-finding and preventing future recurrences. It investigates why the situation came about and then recommends policy or legislative changes to prevent it happening again. The Government establishes terms of reference, which set out what subjects are to be investigated. However a Royal Commission is independent from the Government and reports to the Governor-General. The way the inquiry is conducted and the Commission is run is decided by the Chair and Commissioners. The Government cannot interfere in the direction taken by an inquiry or influence the findings. A Royal Commission can inquire into any matters it sees fit in order to determine the cause of the issues. Chaired by a High Court judge who is appointed by the Governor-General, it has the powers of compulsion in regard to witnesses, documentation and awarding costs. This enables the Royal Commission to uncover information which might otherwise be difficult to obtain. Evidence is gathered from a range of different places and sources, including from participants and through the Commission's own investigations. Public hearings are one important part of the inquiry process. They provide an opportunity to clarify matters, test disputed material and ensure that key evidence is discussed in public.

A Royal Commission is not able to determine legal rights and liabilities. Findings and recommendations are not binding upon any party, including the Government.” (Canterbury Earthquake Royal Commission, 2011 p.1).

Also New Zealand established a statute “Canterbury Earthquake Response and Recovery Act 2010” in order to assist the reconstruction after the earthquake. This element will be developed in the second part because after the earthquake of 2011, the “Canterbury Earthquake Response and Recovery Act 2010” changes to “Canterbury earthquake recovery acts 2011”. In 2016, a new plan was adopted after the Kaikoura earthquake.

1.2.1.2. Japan administrative system

Japan is also a constitutional monarchy. The Emperor is the ceremonial head of state and the Prime Minister (Shinzō Abe) is the head of government and the Cabinet.

Japan administration is divided into 3 levels: national, prefectural and municipal.

According to the Article 6 (1) of the National Spatial Planning Act “The national government shall formulate a National Spatial Strategy for all districts in the nation as a policy guideline for the comprehensive spatial development.”.

A simplified scheme of spatial organization in Japan follows:

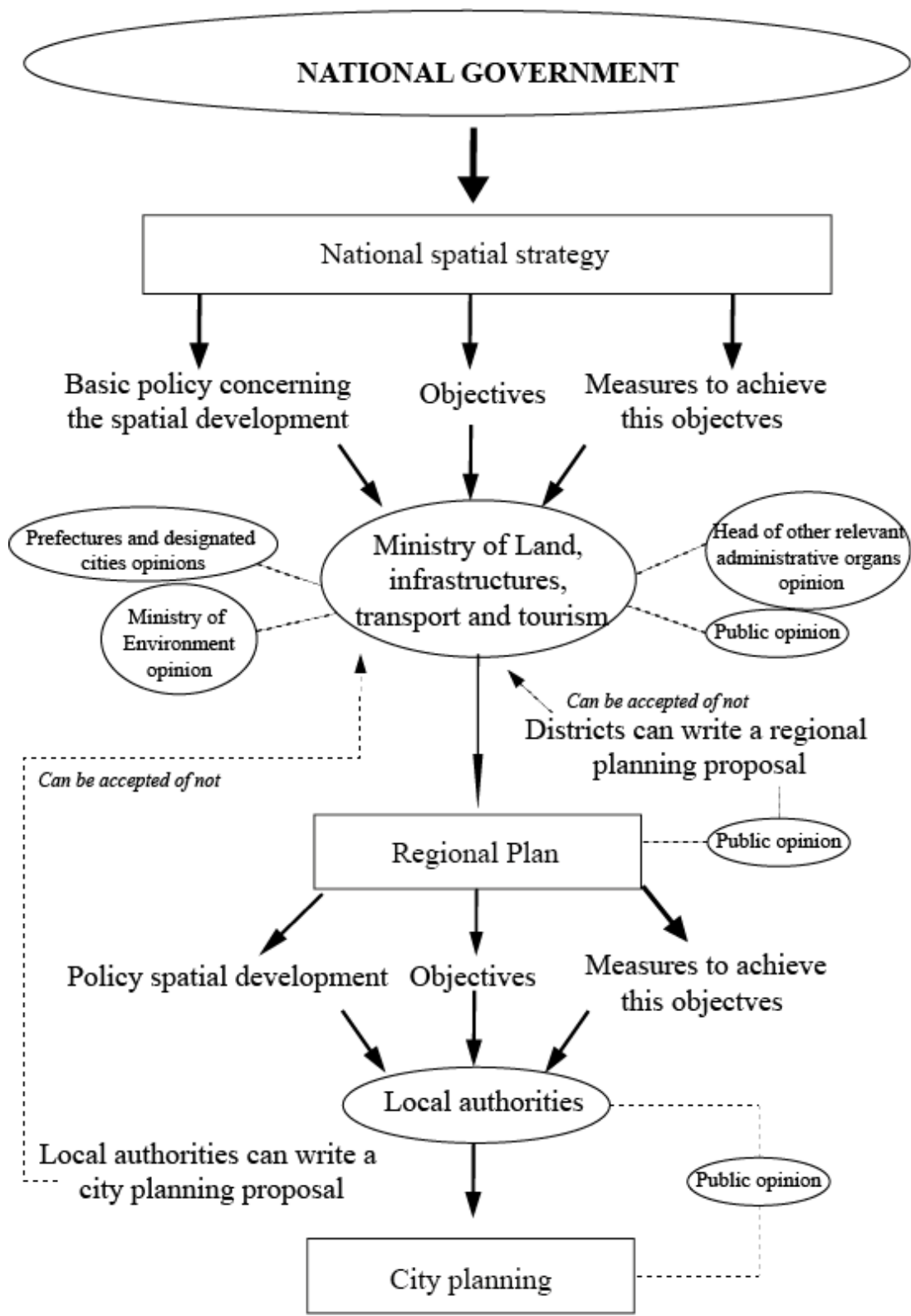


Figure 11: Spatial organisation in Japan

Author

Source: *The spatial planning platform - National Spatial Policy Documents - Ministry of Land, Infrastructure, transport and tourism*

Japan is a unitary State. The central government delegates many functions (such as education and the police force) to the prefectures and municipalities, but retains the overall right to control them.

The Local Autonomy Law establishes most of Japan's local government structures and administrative divisions (prefectures and municipalities).

The National Plan through the Regional Plan gives basic policy concerning the spatial development, objectives and measures to achieve these objectives.

The municipalities are autonomous regarding:

- Building regulation
- City planning projects
- Land use
- Improvement of urban facilities

In 1950, Japanese government enacted the Building Standard Law. It started in 1919 with the Urban Building Law. In 1923 a massive earthquake led to a revision of Law Enforcement Regulations in 1924 which introduced for the first time a seismic design force. After the World War II, the country defined several laws:

- Construction Trade Law (1949): “to improve the quality of those engaged in construction trade and to promote fair construction contacts”
- Architect Law (1950): “to define the qualification of engineers who can design buildings and supervise construction work”
- Building Standard Law (1950): “to safeguard the life, health and property of people by providing minimum standards concerning the site, structure, equipment and use of buildings”

To make all structures earthquake-resistant as much as possible, the Building Standard Act (BSA) is reviewed every time the country experiences a large earthquake. This adaptation is the result of previous evaluations and experiences.

The BSA divides Japanese buildings into “generations”. It depends on the date they were constructed. At the beginning, the BSA was focused on the way to reinforce the structure. Then, in 1981, after the Miyagi earthquake of 1978, the government introduced a new anti-seismic design code. All buildings built after 1981 must conform to this new anti-seismic structure standard. This time, it is not only about the structure but also a way to secure the safety of people inside a building. From then on, buildings must be able to resist an earthquake of Japan Meteorological Agency seismic scale upper 6 or higher.

In 1995, the Kobe earthquake led to tighter regulations, particularly for large buildings. A few years later, ground investigations became virtually mandatory.

In the 1960s, the share of the national budget devoted to disaster reduction in the global budget was about 8%. After a continuous decline until the mid-1990s, it has been on a downward trend, with two peaks, one in 1995 following the Kobe earthquake and the other in 2011-2013 following the East Japan earthquake. In 2016, the disaster reduction budget amounted to the equivalent of 5.05% of the total budget, with a further increase following the Kumamoto earthquakes (Heimbürger, 2018).

What about Kumamoto?

8,373 residential structures completely collapsed, 32,593 partially collapsed and 139,637 were partially damaged. As shown previously, the country adapts and evolves as disasters strike. The Kumamoto City Plan indicates that 69,9% of Kumamoto prefecture buildings comply with seismic standards. It is 87,7% in Kumamoto city. In 2016 more than half of the people who died in crashes lived in homes built before 1981. This proves the importance and quality of the standards imposed.

The history of these two countries with natural disasters has led them to implement measures to protect their inhabitants and prevent damage as much as possible. This process evolves as disasters occur, progress, innovations and research are made. Today, Kobe is an important place in seismological research and Christchurch is becoming the most advanced New Zealand city in the assessment and adaptation that the city can do to prevent risk and manage disaster. But Kobe seism has taught Japan that its infrastructures are not efficient enough to support a natural hazard that destructive, as well as the 2010 Christchurch earthquake in New Zealand. Which brings us to the second part, public prevention.

1.2.2. Earthquake prevention

1.2.2.1. Prevention on infrastructures

As mentioned earlier, the Hanshin-Awaji earthquake is a crucial event. Most of the buildings that collapsed were built before the New Anti-Seismic Design Standard came into effect.

But it is not only a matter of buildings, it is also a matter of infrastructures. Some facilities are considered important for the life of individuals and the functioning of society. Those are electricity, gas, water supply and transport networks. If these services were to be interrupted for any length of time, certain basic needs would no longer be met, which would represent a danger from a human and economic point of view. The protection of these vital infrastructures against natural disasters has thus become crucial in Japan.

Since the mid-1980s, the Japanese government has enacted initiatives to replace existing poles with underground lines. However, the political will remain weak, notably because of the costs (30 to 60 times more expensive than an overhead electrical installation). For gas, the share of the shock-resistant low-pressure network rose from 73.5% in 2004 to 85.9% 10 years later. The Ministry of Economy and Industry set a target of 90% by 2025. However, it is not the same situation for the country's water system. Only 37.2% of the 98,341 km of water pipes in the country were earthquake-resistant in 2015. From one region to another the disparities are very important.

Japan is also known for its high-speed lines (*shinkansen*), it is important to be able to secure them. Their emergency shutdown system is ineffective near the epicenter of an earthquake. Following the Kobe earthquake, prevention measures are being put in place. New techniques are being used to reinforce railway viaducts. It seems urgent that the country improves its infrastructures. Cost is the main obstacle to achieving these transformations.

An important point is the country's energy policy. Before the earthquake and tsunami of Fukushima in 2011, Japan had 54 nuclear reactors in operation supplying 30% of the electric power. It was expected to increase to at least 40% by 2017. But after the disaster, the new government elected in 2012 adopted in 2014 the Fourth Strategic Energy Plan with a 20 years perspective. The goal is now for 20% by 2030 and to decommission 21 reactors. Also, Japan wants to improve its renewable energy. Currently, 10% of its electricity is produced by renewable sources. The Fourth Strategic Energy Plan set the objective of 24% by 2030.

In Kyushu, there are 2 power plants and 6 reactors. 2 are decommissioned and 4 are in resumed operation.

In brief, clear progress has been made in this area: more than 90% of public institutions, such as schools and hospitals (which serve as a basis for disaster prevention) are now earthquake-resistant (Twice as many as 20 years ago). However, some cities or prefectures are lagging behind in bringing their establishments up to standard. With regard to housing, if the average of resistant houses was 82% in 2013, the target of 95% in 2020 seems too difficult to achieve. The cost of compliance, which is hard to bear, especially for the elderly and people on low incomes, is a major obstacle to the achievement of the target (Heimbürger, 2020).

In New Zealand, measures about earthquake prevention do not concern the whole territory. Within the next decade (starting 15 November 2017), the probability for a large seism (M7.0 or greater) in the large central of New Zealand is 30% (according to Geological hazard information of New Zealand).

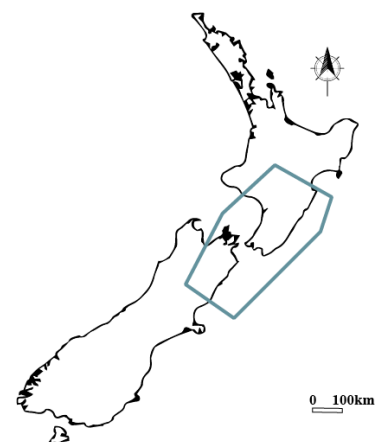


Figure 12: The large central of New Zealand
Author
Source: GeoNet: Geological hazard information of New Zealand

In contrast to Japan where seismic measures affect the entire territory and all buildings, New Zealand focuses on regions who most likely to be seriously affected and is doing work to identify the most fragile buildings. After this work, the building is judged on its priority and depending on who the owner is, the obligation to carry out renovation work is more or less long (see above). The Canterbury Earthquakes Royal Commission had also an important role to play. Even if its power was limited, its influence was significant and so were its recommendations and diagnosis. They worked on:

- Any measures necessary or desirable to prevent or minimise the failure of buildings in New Zealand due to earthquakes likely to occur during the lifetime of those buildings;
- The cost of those measures; and
- The adequacy of legal and best-practice requirements for building design, construction, and maintenance insofar as those requirements apply to managing risks of building failure caused by earthquakes.

The Canterbury Earthquakes Royal Commission is part of Christchurch resilience. It was created after a disaster in order to prevent future catastrophic seism. It used the assessment to enable better adaptation in order to manage the risk of the disaster and to do prevention work. Once it occurred, this work allowed better management, preparation of the disaster by the authorities with the aim of limiting human losses and material damage while being able to restart the activity quickly. As the Royal Commission has now delivered its full report, it has ceased to exist, as it has completed the task set out in its terms of reference.

One of its prerogatives is the awareness-raising and preparation of the inhabitants. It is also a major point for Japan.

1.2.2.2. *Public prevention*

Carrying out building alterations, research and acting on infrastructure is an essential variable for the resilience of Kumamoto and Christchurch cities in the face of earthquakes. But in these tools, it is important to integrate the human element, and in particular the inhabitants, in order to include them in this process of prevention and resilience.

Earthquake drills are mandatory in every elementary school in Japan since the Kobe earthquake in 1995. Children learn to get under their desks, head first, and to hold on to the legs of the desk until the quake is over. Japanese regulations require schools with two or more floors to install drainage chutes. The local fire department also has a prevention role. They take groups of children into earthquake simulation machines in order to familiarize them with the sensation. They also want to develop training for adults. 100,000 individuals are registered as head of disaster prevention at their workplace. The government wants to increase this figure. Children of New Zealand do not have evacuation drills for earthquakes this severe. Schools are required to have preparedness plans and evacuations schemes in place for a range of emergencies (which includes seisms among other emergencies). If children are not prepared, it is also the same for adults. According to the National Emergency Management Agency, only 50% of New Zealand adults would be able to take the right safety precautions in an earthquake. For decades, the message has stayed the same: “drop, cover, hold” (see right) and if someone is near the coast the message is “long, strong, get gone”.



Figure 13: "Drop, cover, hold"
Source: National Emergency Management Agency, 2012

These messages built on the same format are intended to be simple and easy for citizens to remember.

Both countries use the media to send information as quickly as possible. Every smartphone in Japan is installed with an earthquake and tsunami emergency alert system. In New Zealand inhabitants have to sign up for “ShakeOut” created by the government to get information about their living zone, alerts and information about how to react when a tsunami or seismic occurs. This application gives advice depending on whether the person registers as an individual/family, business or school. In order for this application to work, a massive registration of the inhabitants is necessary.

Currently 353,763⁶ New Zealanders have registered (7% of the total population). The information is therefore passed on to people who are already aware of the issue and who take the initiative themselves.

It is possible to get earthquake survival kits stocked with water, first aid equipment, food rations, gloves, face masks, insulation sheets, survival tools and copies of important Identity Documents (ID).

Memorials and quake anniversaries are also a reminder to these countries of the threat that exists and how to respond.

Japan municipalities or prefectures use maps as a prevention measure as well. They published hazard maps (*hazâdo mappu*), the most widely used to indicate the precise areas where natural hazards may occur. While disaster, there are prevention maps (*bosai mappu*) or evacuation maps (*hinan mappu*)⁷.

But the vast majority of the maps are in Japanese. A foreigner may find it difficult to access these maps. However, it is interesting to highlight some initiatives to conceptualize maps that are accessible to all. In Nara, high school students have developed a map in English with tourist information as well as evacuation sites and hospitals. On the back, instructions are written to indicate the steps to follow in case of soaking, strong wind and heavy rain.

But only 37% of Japanese use these maps (Heimbürger, 2018 p87). Another issue with these maps, particularly the one about the probability of experiencing an earthquake of 6- intensity of above in the next 30 years (see above) is that people living in the red zone might be too scared to react while those living in less exposed areas may not feel concerned.

⁶ As of 22 July 2020

⁷ Ministry of Land, Infrastructure, Transport and Tourism of Japan offers a portal with links to local authority hazard maps. Available at: <http://disaportal.gsi.go.jp/index.html>

So another device is also being used: signage. But for Japan and New Zealand, signage mainly concerns tsunamis and volcanic hazards.

Both countries rely on civic responsibility. They employ assessment and adaptation in order to prepare the territory and inhabitants to any natural hazards and their potential destruction. They work mainly on two aspects; the hard (buildings, infrastructures, planning) and the human (education, prevention, awareness dimension). Over the years following various events, they have adapted by changing legislation, investing in research, learning from the past and from their territory.

In the following part, the management of the disaster will be studied in terms of how each country reacted and rebuilt.



**2. Japan and
New Zealand in
earthquake disaster
management**

There are three steps in disaster management (National research council - Committee on Disaster Research in the Social Sciences: Future Challenges and Opportunities, 2006):

- The first step is **crisis management**, which involves implementing emergency measures such as rescue, caring for victims in evacuation centres, assessing damage and needs, and restoring access routes to disaster areas.
- The second is **general restoration**, which consists mainly of relocating disaster victims to temporary accommodation and restoring all vital networks.
- The third is the **reconstruction** of all damaged infrastructure, after which people can move into permanent housing.

Before starting, a quick comparison of the two cities at the time of the disaster:

	Kumamoto	Christchurch
Date and hour	Thursday 14 April 2016 9:26 pm	Tuesday 22 February 2011 12:51 pm
Magnitude	M6.5 7 (JMA)	M6.6
Aftershocks	16 April 2016 1:26am M7.3	22 February 2011 2:50 pm M5.9
Dead	50	185
Wounded	2,700	3,129
Homeless	*	67,500
People moved out in evacuation centres	200,000	*
Buildings damaged or destroyed	170,000 properties damaged and 8,373 destroyed	100,000 properties damaged and 10,000 destroyed
Cost	56 bn€	23 bn€
Superficie	1,426 km ²	390 km ²
Population	739,556	381,500
Population density	1,893 inhabitants per km ²	755 inhabitants per km ²

Table 4: Comparison between Christchurch and Kumamoto earthquakes

Author

Source: Christchurch City Council, Kumamoto City, Wikipédia

This table shows that despite the same magnitude these two cities experienced, there are many disparities that are developed below.

2.1. Response

“The first earthquake was very early in the morning. We woke to the whole room shaking violently. I got up and called to my daughters, to get under a door frame. It was very hard to walk and the whole house moved uncontrollably. My wife tried to run but kept hitting the wall as she was being thrown around. I woke my eldest daughter and held her under the door frame. When it stopped we ran outside. We were quite confused and didn’t really know what was happening.

The second big quake was 1pm in the afternoon. The building in which I worked in was in the city. The CTV building was across the road from us and this building fell down, with many deaths. The whole of the CBD was cordoned off afterwards as the authorities searched for bodies. When we got home, we had damage to our house as well. Not uninhabitable but damage to the foundations”

Paul P. - New Zealander and Christchurch inhabitant, 2020

115 out of 185 people died in the CTV building in Christchurch. This building became the symbol of the disaster (see right).

50% of the Central Business District (CBD) have been destroyed (Raven, 2016). 2,200 people had to live in temporary housing, 1/5 migrated from the city. According to economists, it will take 50 to 100 years for the New Zealand economy to recover.



Photo 2: CTV building - Christchurch 2011
Source: Mark Mitchell

Right after the disaster, \$7 million of international aid was provided. 3 days after, 300 Australian police officers fly into Christchurch as well as other rescue crews from the UK, USA and Taiwan. Chemical toilets were distributed to 30,000 inhabitants. 600 servicemen and 380 police patrol from the country operated. The city was in a state of emergency for 5 days. 2 operations conducted: get people trapped and alive in buildings. The other was to get out the dead bodies. There was neither power nor water in the city but no fires started. The disaster hit the city that hard also because it happens a Tuesday at lunch time.

“I don’t think we can go past the fact that we may well be witnessing New Zealand darkest day”

John Key (Prime Minister of New Zealand), 2011

70% of the Christchurch centre buildings have to be demolished and replaced.

Many shops were closed for weeks and 5 rugby world cup matches cancelled. According to the New Zealand Parliament, this impact on Christchurch economy was about NZD20 billion (i.e. €12 billion).

In the words of Doctor Chris Leathart, injuries after an earthquake are traumas and pain chests. But the main issue remains psychological stress. Dr Leathart “separates those experiencing stress into three categories:

- Children, especially those aged under ten years, who are traumatised by aftershocks and frightened to sleep in their own beds;
- Elderly people (particularly women) and those living alone, who are frightened and anxious;
- People with pre-existing mental health problems. Alcohol consumption among patients has increased, along with associated problems such as domestic conflicts and violence” (Leathart, 2011, p.2). Also there are diseases, as respiratory illness that develop months later because of the earthquake effects. The seisms occurred in February (which is summer time in New Zealand), but when winter came things were getting worst to live in a sub-standard housing.

“Many houses are leaking, cracked or with no heating and those with sound houses may find that they are now facing an overcrowded environment with relatives and friends [living together]” (Leathart, 2011, p.2). The dust from debris caused exacerbations in people with asthma and chronic obstructive pulmonary disease (COPD).

As mentioned in the introduction, health issues will not be further developed in this thesis, but it is still important to communicate this.

For Kumamoto, things were different. The magnitude of shaking was the same as that experienced during the 1995 Hanshin-Awaji earthquake but with less loss of life. This can mainly be explained by three reasons:

- Most of people were at home
- The epicentres were not in Kumamoto City
- 21 years separate the two disasters and, as seen previously, many changes were initiated after the Kobe earthquake including building standards (among others)

The Kumamoto disaster was caused by multiple cascading geological hazards. The primary damage was due to the shaking and ground deformation. The secondary damage was related by landslides and liquefactions (it happens when the soil loses strength and stiffness. It becomes soft). In addition to the impact on the reconstruction of houses (including those built before 1981 and the laws on building standards), the impact on the territory economy was even greater. (Kumamoto is Japan's main center regarding the semiconductor industry). The total economic loss was estimated to be €21 to 40 billion (Cabinet Office of Government of Japan, 2016).

The evacuation process during the earthquake involved the displacement of more than 180,000 people in nearly 885 established shelters. However some decided to live in their private vehicles for more privacy risking the “economy-class syndrome” (an increased risk of blood clots in the legs).

Kumamoto and Christchurch have shown perfect examples of solidarity.

Both cities' symbols have been badly damaged, see below.



Photo 3: Kumamoto Castle damaged during the 2016 earthquake
Source: Shinichi Saoshiro, 2016



Photo 4: Christchurch Cathedral damaged during the 2010 and 2011 earthquake
Source: Greater Christchurch, 2011

The Kumamoto Castle was built in the 16th century and is “designated as an important cultural property in Japan” (Asian Disaster Reduction Center, 2016 p7). It is also a main tourist attraction. A special plan of rehabilitation and reconstruction was made to restore the grandeur of the Castle and reopen it to the public.

The Christchurch Cathedral built in 1864 had a much sadder fate. The damages from 2011 led to its demolition and to its replacement by a temporary edifice in 2013 *The Cardboard Cathedral* by the architect Shigeru Ban (see right). It is designed to last fifty years.



Photo 5: The Cardboard Cathedral
Source: Wikipedia, 2014

Even in the chaos and destruction, those cities managed an immediate response to limit damage. As it is possible to see on the map below, the Central business district of Christchurch was the main area that was hit by the earthquake.

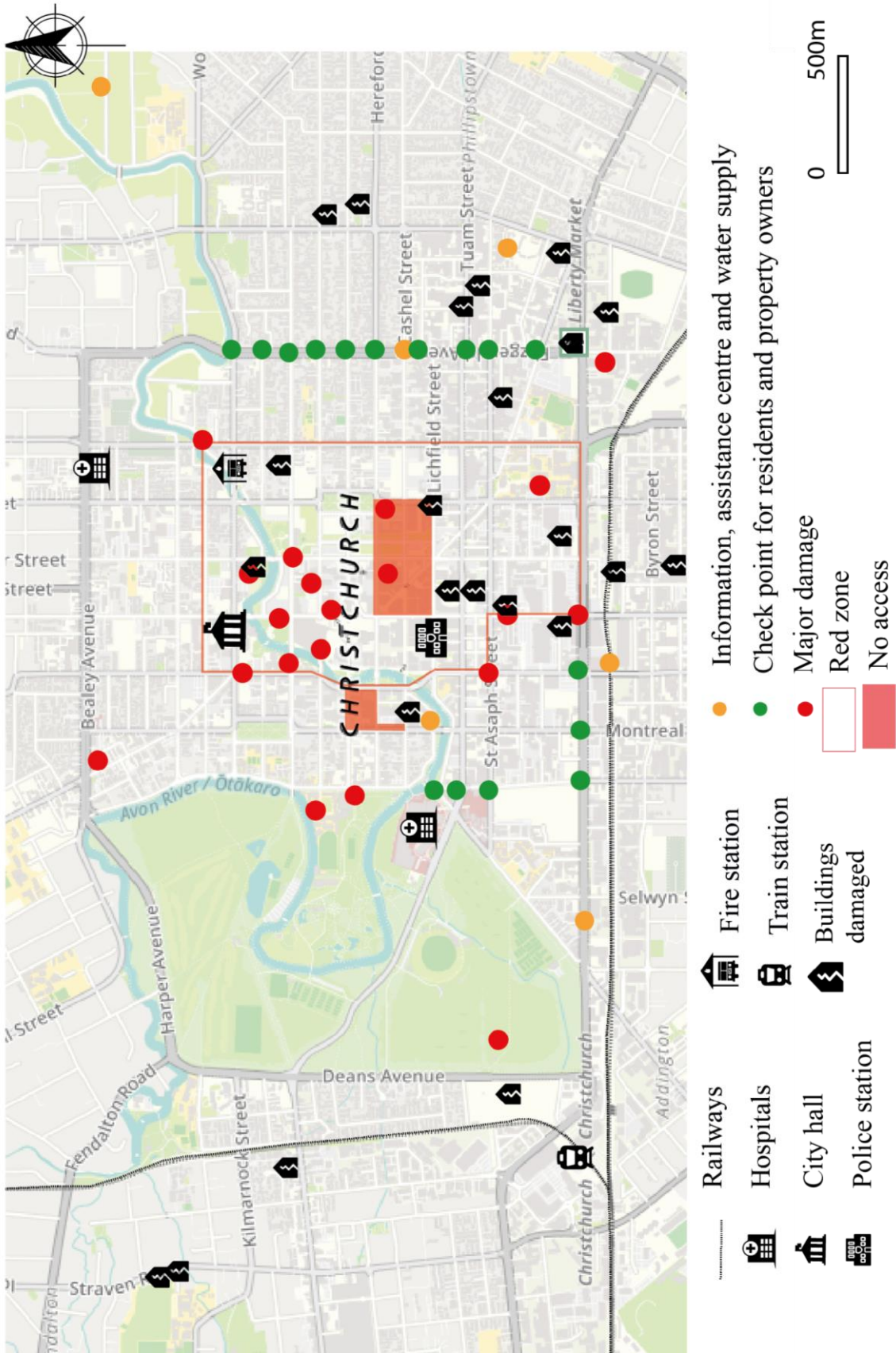
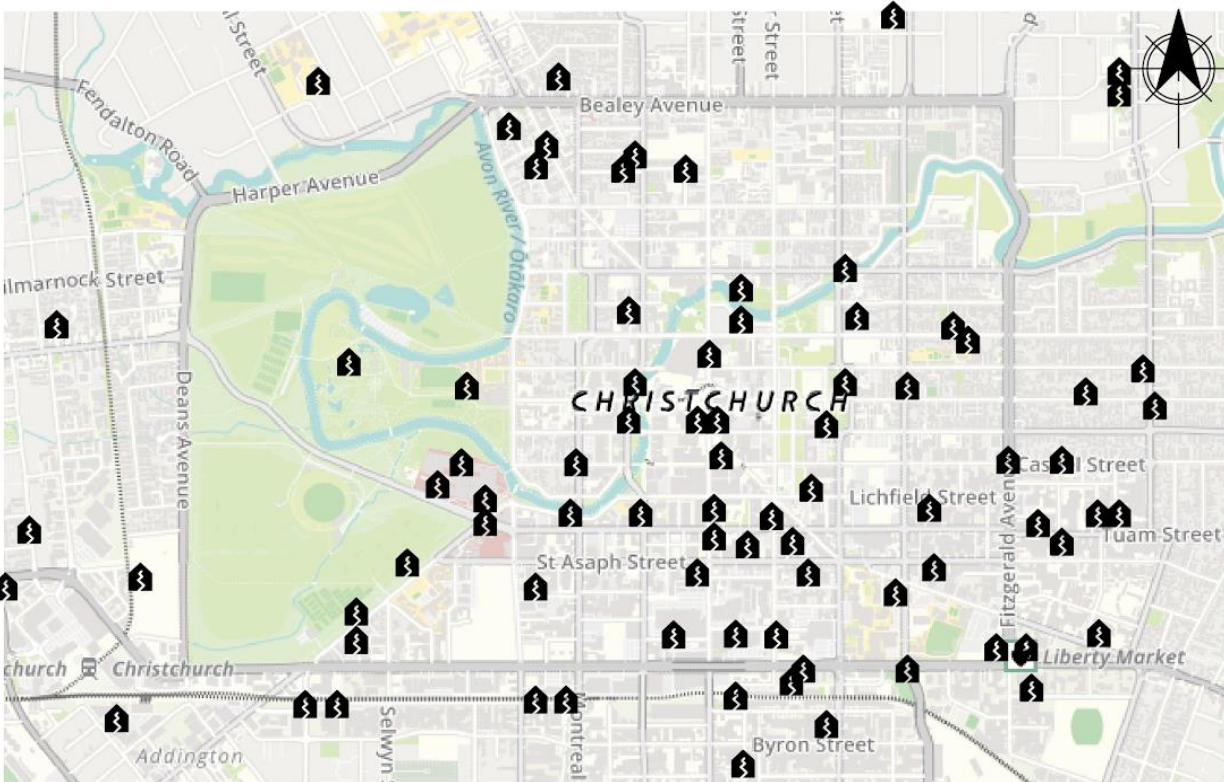



Figure 14: Christchurch damage and infrastructures
 Author
 Source: google map, NBR

There are 755 inhabitants/km². The CBD has a surface of 6km². This area concentrates two hospitals, one fire and police station. Those infrastructures were the closest from the scene of the tragedy and were on the front lines of helping people. A red zone was set up to limit access to people. Also two zones were considered as restricted. The furthest East concerns the location of the Christchurch Cathedral and the CTV building.

As the previous map demonstrated, main damage is concentrated in the CBD. It is the heart of Christchurch where buildings were the most vulnerable. As the below map exposes, there are a lot of earthquake prone buildings in Christchurch, especially in the CBD⁸.



 Earthquake prone-buildings

0 500m

Figure 15: Christchurch earthquake-prone buildings
Author

Source: Ministry of Business, innovation and employment

⁸ As of 28 June 2020

In Kumamoto there are 1,893 persons per km² for a total of 739,556 inhabitants, more than twice the population and density of Christchurch.

Evacuation sites and wide evacuation areas are designated by the Kumamoto City. This might be schools, universities, gymnasium, athletic ground, large squares etc.

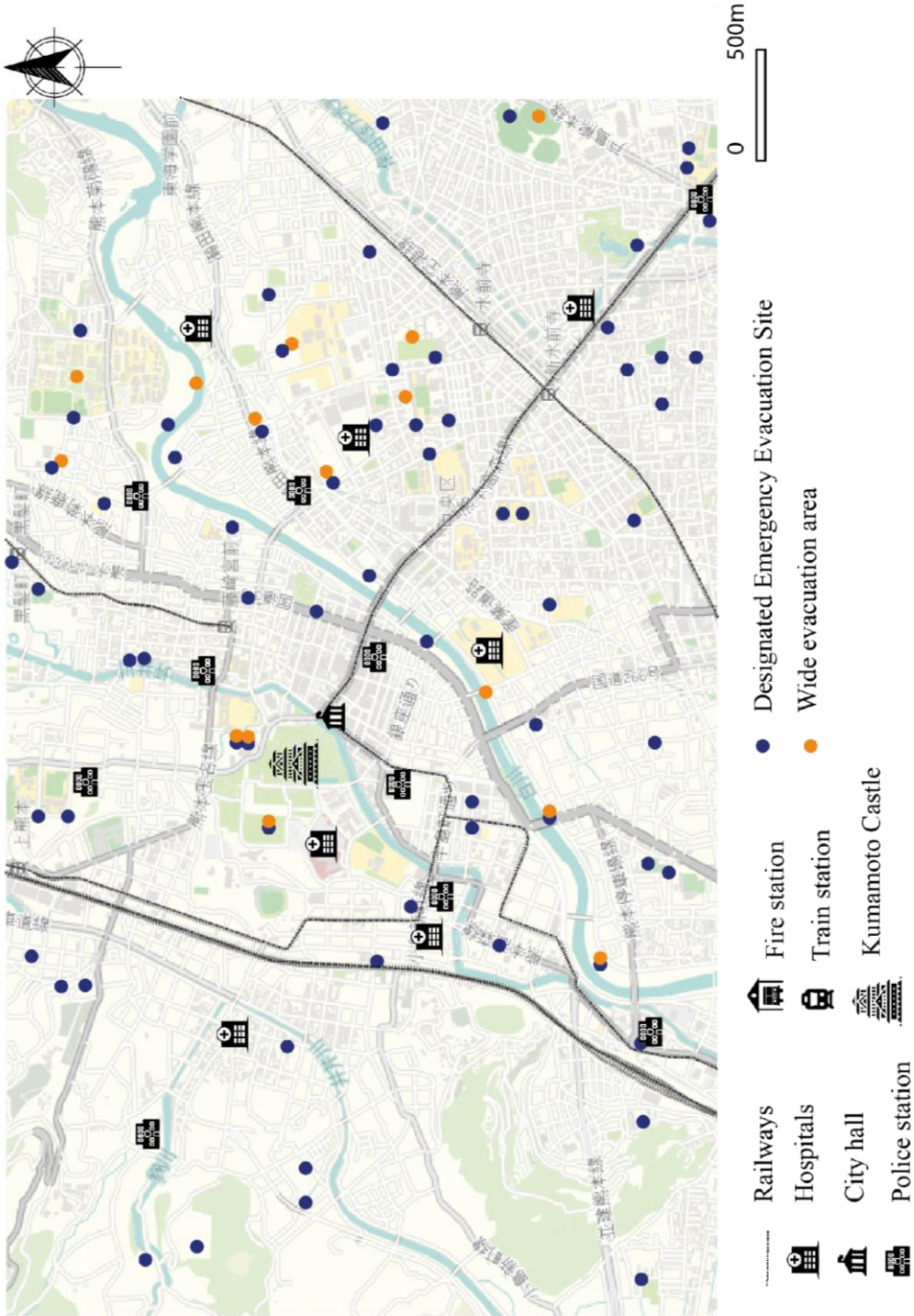


Figure 16: Kumamoto damages, infrastructures and evacuation centres

Author

Source: google map, Kumamoto city

The two maps do not indicate the same thing. Christchurch is more focused on its vulnerabilities, on what the city has to work on. For Kumamoto and Japan in general, vulnerability potentially resides in all buildings constructed before 1981. It is in fact on these pre-1981 buildings that most of the damage was caused by the 2016 earthquake. Kumamoto identified its strength points, where inhabitants can find a shelter. Both maps cover an area of 12km². The Japanese city has more infrastructures (such as hospitals or police stations) than the New Zealand city, where those are fewer in number but cover a larger area. But the difference in population density is such that this may explain the large difference in the number of public establishments. Indeed, it is assumed that the map of Kumamoto covers about 23,000 people. For Christchurch it is around 10,000 people. Nevertheless, Kumamoto has many more establishments that can intervene directly in the event of a disaster than Christchurch. Proximity becomes an important asset whether it is to find shelter or to get help quickly in several areas.

Identifying shelters is important, but only if the inhabitants are aware of their presence in their neighborhood. For Christchurch, evacuation centres were set up after the earthquake. It was organized by the Civil Defense (organization run by the government) that supplied food and clothes.

After the destruction, come the reconstruction and the opportunity to rebuild differently. The recovery identifies if the city is resilient by being able to regain its stability and restart its activity.

2.2. Recovery – Build Back Better

As Christchurch, Kumamoto was left without water, gas, oil and power. It took two weeks for a full restoration of electricity and gas and a month for water and oil. Highways, national roads, railways, airports and ports were also badly damaged. It took between two weeks and a month to rehabilitate the transportation system (Asian Disaster Reduction Center, 2016).

On May 16th, 1,700 temporary houses were planned to be built in the Kumamoto prefecture. By mid-June this number had risen to more than 2,700 and the first temporary houses were built. In the end, 4,224 houses were built to temporarily relocate the victims. It took four months.

Christchurch was facing the same issues that Kumamoto but on a smaller scale. After the earthquake of 2010, was created the Canterbury Earthquake Temporary Accommodation Service (CETAS) to develop the Temporary Housing Issues Project in order to provide on-the-ground support to the decision making process. While waiting for a temporary house, the CETA offered financial assistance: \$180 a week for a one-person household, \$275 a week for a two-person household and \$330 a week for households for three or more people to cover rental costs for those who were displaced from homes due to earthquake damage. Unlike Kumamoto which had identified evacuation centres, Christchurch improvised evacuation sites for residents who had gathered in schools or gymnasiums but there is no official figure on how many people it concerned. As an example, 700 individuals gathered at the welfare centre at Burnside High School gymnasium the night of the earthquake. Also, Housing New Zealand (a Crown Agency in order to provide public housing services for New Zealanders in need) used the Housing Emergency Lease Programme (HELP) to allocate temporary housing (campervans included) support to people whose homes became unlivable. For that, they requisitioned vacant homes usually leased from private property owners and rented to inhabitants in need.

CETAS reported that in August 200 people were assisted into rental accommodation.

But temporary housing can have a negative social impact: “international experiences (e.g. pre 1980, post-earthquake temporary housing management in Italy) have demonstrated that temporary settlements, conceived for medium-term use (6 months to 2 years), used to last for decades with negative social consequences for the displaced population and negative economic, social and environmental consequences for the hosting communities” (Giovinazzi, Sonia (et al.), 2012 p8). To avoid this situation, Christchurch followed 4 steps:

- Evacuation centres
- Campervans
- Medium-term temporary housing
- Repair/reconstruction of permanent housing

However, many people did not accept short or medium term solutions (such as campervans or temporary housing) preferring to share accommodation with other families or even to stay in their damaged house.

Apart from the regulatory changes previously studied, these 2 traumatic events for these cities then began a process of novelty in the reconstruction with a view to recovery.

Recovery includes restoration and enhancement. It does not concern only the “solid” but the wellbeing of communities as social, cultural, economic and environmental aspects. (Canterbury Earthquake Recovery Authority)

2.2.1. Build a new Central Business District in Christchurch – a sustained construction

The New Zealand parliament established the “Canterbury Earthquake Recovery Act 2011” in order to:

- “Provide appropriate measures to ensure that greater Christchurch and the councils and their communities respond to, and recover from, the impacts of the Canterbury earthquakes;

- To enable community participation in the planning of the recovery of affected communities without impeding a focused, timely, and expedited recovery;
- To provide for the Minister and [Canterbury Earthquake Recovery Authority] CERA to ensure that recovery;
- To enable a focused, timely, and expedited recovery;
- To enable information to be gathered about any land, structure, or infrastructure affected by the Canterbury earthquakes;
- To facilitate, co-ordinate, and direct the planning, rebuilding, and recovery of affected communities, including the repair and rebuilding of land, infrastructure, and other property;
- To restore the social, economic, cultural, and environmental well-being of greater Christchurch communities;
- To provide adequate statutory power for the purposes stated in paragraphs (a) to (g);
- To repeal and replace the Canterbury Earthquake Response and Recovery Act 2010”.

(Parliamentary counsel office, part 1 preliminary provisions, 2011).

As mentioned, the CERA was established as a government department on 29 March 2011 to lead and coordinate the Government response and recovery efforts following the earthquakes of 2010 and 2011 in Canterbury. It was disestablished on 18 April 2016 and replaced by the “Greater Christchurch Regeneration Act 2016”.

These measures illustrate the capability of the country to adapt itself in response to natural hazards notably seisms.

“Rebuilding central Christchurch is one of the most ambitious projects in New Zealand history. The post-earthquake recovery gives us the chance to make a new, even better central city, and the Government is fully committed to realising this vision in partnership with local government, iwi, businesses, investors, non-governmental organisations and the community. Solid progress has been made to date in responding to the earthquakes: now it is time to extend our horizons and plan for the long term”

Hon Gerry Brownlee Minister for Canterbury Earthquake Recovery, July 2012

The disaster then becomes an opportunity for the city to rethink its centre and go beyond the replacement of lost infrastructure and buildings.

The following map exposes the new urban plan for the centre and the areas that will be impacted by the new plan:

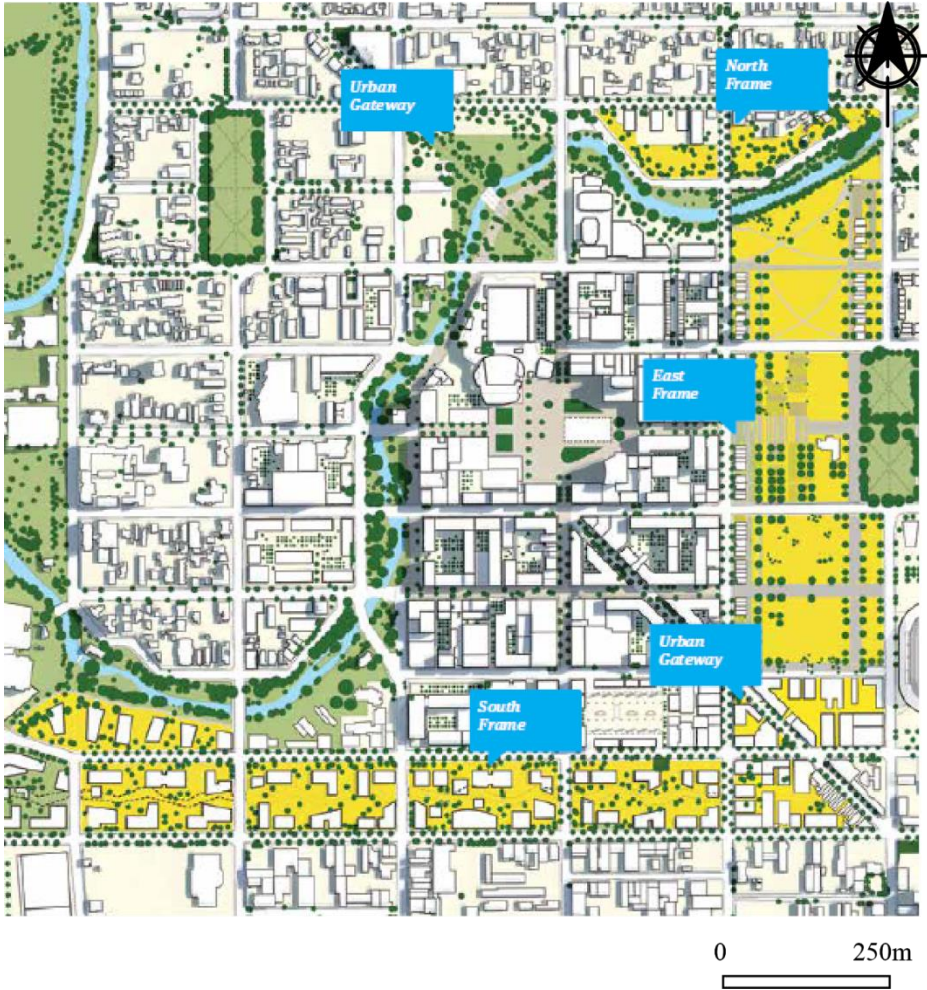


Figure 17: Christchurch central plan
Source: Canterbury Earthquake Recovery Authority Christchurch, 2012

The construction of roads, buildings and bike lines now comply with the Building Act 2004. One of the recurring wishes in planning documents and city policy is the desire for “sustainable buildings” and “resilient buildings” (Canterbury Earthquake Recovery Authority Christchurch, 2012 p61).

Christchurch City Council intends to encourage green buildings using renewable energy.

The waste (as wood) from the demolition of buildings damaged by earthquakes is also used as a source of energy. The transition between the disaster and a functioning central city is noticed as a way to test new ideas and concepts and also to involve local communities is the reconstruction process.

The civic opened an online platform to allow inhabitants to expose their desires for the new centre. 6 points are then identified:

- “Green city
- Stronger built identity
- Compact CBD
- Live, work, play, learn and visit
- Accessible city
- Embrace cultural values”

(Canterbury Earthquake Recovery Authority Christchurch, 2012 p.23)

“The new CBD will be great but it is taking a long time. It is completely new with better facilities, more precincts and better for biking/walking as the planning could do anything”

Paul P.

In the process of recovery, the CERA has also an important role to play. It gives clear orientation and ensures that this recovery plan complies with its recovery program. The CERA lead and be accountable for:

- “Overall implementation of the Recovery Plan
- Acquisition of land for the anchor projects
- Scheduling and coordination of construction
- Facilitation as required of private sector-led development”

(Canterbury Earthquake Recovery Authority Christchurch, 2012 p.99)

This plan was conceived in 2012 but what really happened after several years and a new strong earthquake in 2016 nearby?

The will of having a sustained construction is still on. But questions and dissatisfactions arise. Inhabitants feel dismissed and excluded from the process (Cretney 2016). It started with the Canterbury Earthquake Response and Recovery Act 2010. It permitted Government ministers to suspend or make exemptions to almost any New Zealand law by Orders in Council, transferring vast lawmaking power from the legislature to the government executive.

This Act and those that followed, have collected criticism from New Zealand and international academics specializing in constitutional law who claimed that it lacks constitutional safeguards and set a dangerous precedent for future natural disasters. From that point on, many criticisms were formulated at the government's management of the crisis (Cretney 2016). Some projects normally managed locally are taken over at the national level. For example, it is not the municipality of Christchurch that is in charge of the development of the city centre but the CERA.

But popular initiatives are worth highlighting. As an example, after the 2010 Canterbury earthquake was created “The Green Lab”. The purpose is to green rubble sites with temporary landscaping and planting projects to bring people back into the city. This initiative at first volunteer-driven, became in 2013 a Registered Charitable Trust. Another initiative was really helpful for the inhabitants. A crowdsourced information has been created “The Christchurch Recovery Map”. It became a major source of public information. Unfortunately, the map is today unfindable.

Today Christchurch is still recovering. The “garden city” eternally under construction continues to heal its wounds. To avoid the need for further expansion of peripheral areas, the city seeks to consolidate existing urban settlements. The aim is to minimise the adverse effects of travel for work, school or leisure purposes. Some intensification of centres of smaller adjacent towns is also expected to encourage new, more local practices and limit travel.

Despite the dramatic consequences of the earthquakes in the city, the destruction of houses and buildings allowed the redefinition of some blocks and to densify and increased the range of housing types that provides more choices.

A cultural impact appeared resulting from the consequences of the earthquakes. A number of Maori have sought to return to and live on the Maori Reserves set aside by the Crown in the XIXth Century. This would lead to new development opportunities for those reserves. It is over the long term that the effects of this reappropriation of reserves will be measured.

To help inhabitants in their renovation works, the government set up the Earthquake Commission (EQC). It is a New Zealand Crown entity investing in natural disaster research, education and providing insurance to residential property owners. There have been many insurance problems with the EQC:

“There are still a lot of people fighting their insurance companies to agree to fix or rebuild their houses. The insurance industry was not very moral in many cases. The EQC who were in charge of repairs to houses also tried to fix very cheaply and save money but this resulted in poor workmanship and bad repairs to people’s houses”

Paul P

EQC publicly apologized for its failings in 2019. Being fortunate enough to have a government-backed natural disaster insurance scheme has been marred by the many problems experienced by the city's inhabitants. Even today, not all of them have been solved yet (Williams, D. 2020).

In order to make the recovery process complete, the country is integrating the importance of knowing how to manage natural hazards (not only earthquakes but also tsunamis, landslides, floods, intense rainfalls or liquefactions). To respond to it, in 2013 the Canterbury Regional Policy Statement was created in order to focus on the availability of information and guidance, and on defining and delineating areas susceptible to natural hazards. The Ministry of Business, Innovation and Employment develops guidelines for the geotechnical investigation and suggests solutions.

This brings us back to the first phase of resilience (and also the first part of this paper): assessment.

2.2.2. Creative recovery in Kumamoto

For Kumamoto, “recovery” had a totally different meaning. It mostly concerned the reconstruction of the Kumamoto Castle. As mentioned above, the work on the Castle is being given special attention in order to speed up and facilitate its reopening to the public. 4 years later an elevated walkway opens to allow tourists to view selected areas of the inner Castle grounds without impacting the construction works. Nevertheless, the interior remains closed until spring 2021 (if no major event occurs). Kyushu and Kumamoto are a high place in tourist attractions which is why the opening of the Castle is so important. To promote tourism, the Nippon city plays with its image by its mascot “Kumamon”.



Photo 6: Kumamon hugs a Taiwanese tourist at a Kumamon Square in Kumamoto prefecture
Source: Shinya Sawai

The mascot was created by Kumamoto prefectural government in 2010 for an advertising campaign to attract tourists to the region after the opening of the Kyushu-Shinkansen line 1. To measure the impact of Kumamon, it generated 11.8 billion yen in merchandising revenue only for the first half of 2012. Today the mascot enjoys international popularity and it is still used to prompt tourists to visit.

Also the recovery is about the production facilities for the semiconductor and automobile industries. Due to its location, Kumamoto has good access to China, South Korea, (and other Asian countries), the United States, Taiwan and New Zealand. Kumamoto prefectural government promotes investment for manufacturing companies.

Regarding planning, Kumamoto city has constructed an Earthquake Disaster Revival Plan based on the National Spatial Policy. Unlike Christchurch, where the main damage occurred in the centre of the city, Kumamoto experienced prejudice over a very large area. Moreover, Japan has to deal with another variable.

The country has to face shrinking populations, declining birth rates, and an aging population. The challenge is then to (re)create a dynamic city with a reduced financial burden. The Kumamoto prefecture elaborates in 2015 a plan for the next 20 years: “Policies for the Improvement, Development and Conservation of the Kumamoto City Planning Area (Kumamoto City Planning Area Master Plan⁹)”. The guiding thread of this planning is “prosperity”. 4 points are identified:

- Vibrant city
- Eco-compatible
- Natural
- Historical background

Their desire is to create a link and a harmony between nature, history and culture, and landscape. The city tends to be polynuclear. Kumamoto deploys the required regional and urban functions in a way that is consistent with the development of the transportation network to make the city more convenient. To follow the region development, a high-speed network, a radiated and ring-networked transportation that links different areas of the region are built or will be.

The aging population incites the local authorities to allow people to get out and about in a safe and comfortable manner by adapting the public transportation system, increasing the safety and comfort of public spaces and public utility facilities and improving the functioning of life services in the community. As Christchurch, Kumamoto wants to increase the density of existing urban areas, such as the central city, through the use of existing buildings and the replacement of old ones.

⁹ Translated from the original:

熊本都市計画都市計画区域の整備、開発及び保全の方針（熊本都市計画区域マスタープラン: Available at: https://www.pref.kumamoto.jp/e.qp.hp.transer.com/common/UploadFileOutput.ashx?c_id=3&id=10699&sub_id=2&flid=31119 The development of this plan comes from the translation via DeepL of this original document written in Japanese. Translation of terms may be inaccurate.

To integrate nature in its plans, the city is rather in a desire to protect and enhance the existing. The territory is already surrounded by plateau and plains connected to the mountains of Aso and Kinpusan. It is made up of surface water from the White, Midori, Kasei, and Tsuboi rivers. The country is subject to torrential rain which is why it is important to maintain a permeable soil. Forests and farmland conservation are a key factor ensuring water sources, groundwater infiltration of rainwater in residential areas combined with the construction of public sewerage systems.

When the plan is written it is a year before the earthquake, this awareness of risk is already present. The following quote exposes the state of mind in which the plan was drafted: “a city that protects its residents' lives and assets, creates a city that is resilient to disasters, and provides a safe and secure living environment” (Policies for the Improvement, Development and Conservation of the Kumamoto City Planning Area, p6). This awareness of the risk of an earthquake took on a new dimension after the disaster of 2016.

The goal is to establish evacuation sites and routes, prepare public parks with disaster prevention features, and develop a plan for the development of urban areas. Non-combustibility and earthquake-proofing will be promoted.

The following map exposes that was just developed:

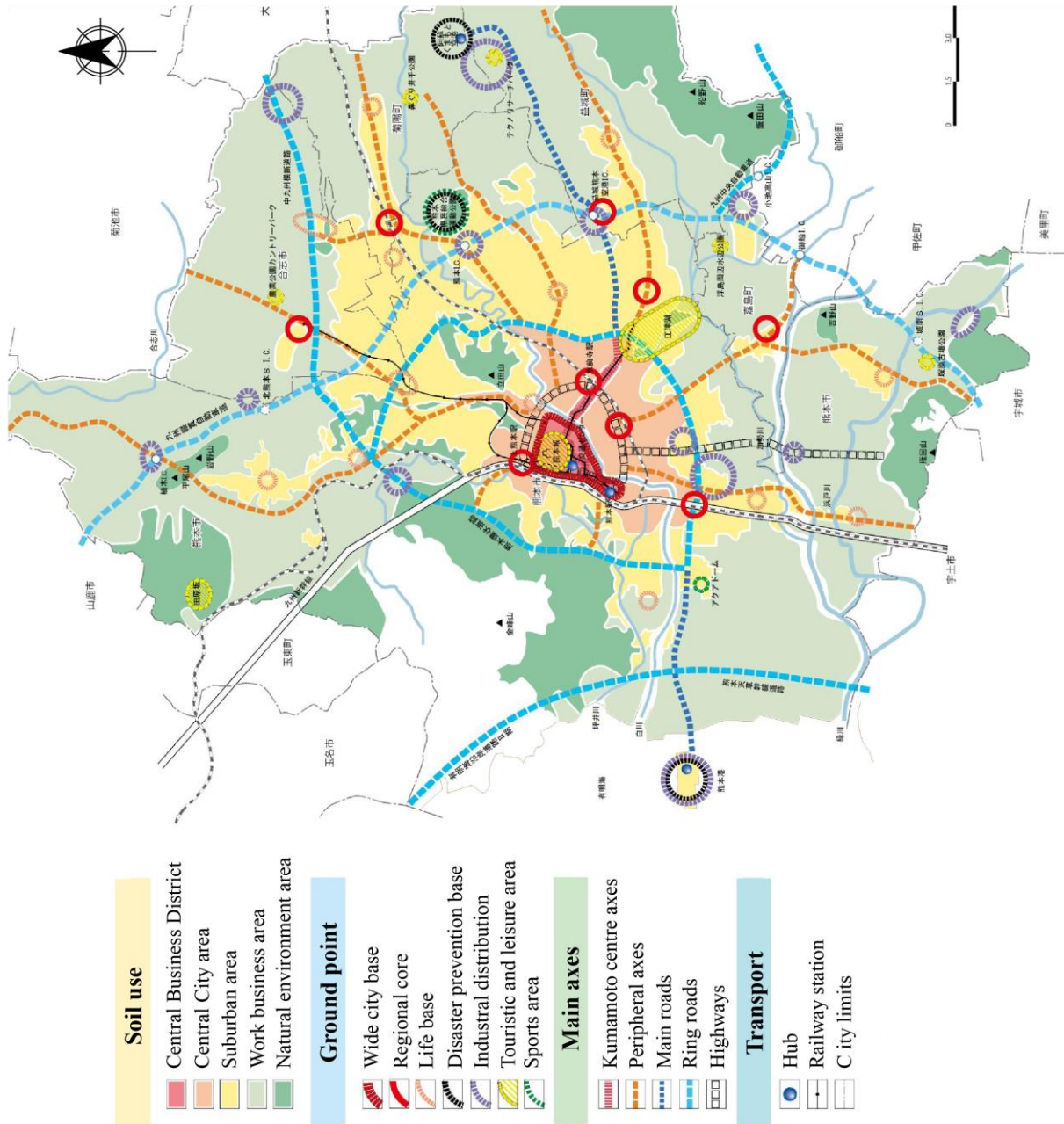


Figure 18: Kumamoto urban plan
 Author
 Source: Kumamoto city

This plan attaches great importance to the networks whether road, public transport or even water. The objective is to create new axes in order to decongest the city and to respond to its evolution but also to improve the existing one by the creation of cycle paths for example. This also involves improving infrastructure to respond to demographic change.

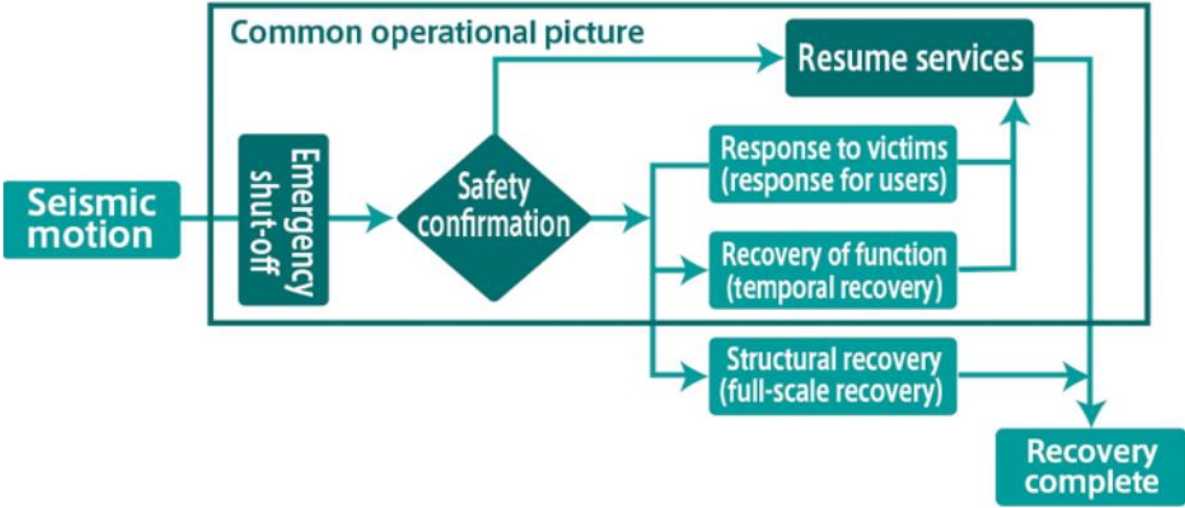


Figure 19: Summary of the different stages before reaching the complete recovery
 Source: National Research Institute for Earth Science and Disaster Resilience (NIED), 2020

Both cities face different challenges according to their specific characteristics. Christchurch has to deal with strong recurrent earthquakes that made the territory more fragile. The tragedy of 2011 pushed the complete reorganization of the CBD which is still in progress. But issues are also on a larger scale, and the lack of registration of earthquake-prone buildings in small towns in the Canterbury region and in New Zealand (like Kaikoura) is further evidence of the long way to go to protect residents from these disasters. Also one of the main policies of the earthquake management is to deal with buildings that are registered as vulnerable, unlike Japan, which considers all buildings built before 1981 are potentially earthquake-prone.

At first glance it is possible to think that Japan is the world reference on earthquake risk and disaster management. By continuing the analysis of the first 2 parts, this third and last part will then be an opportunity to question how the earthquake variable is managed in both countries and whether New Zealand should therefore follow the example of what is done in Japan.

3.

**Is Japan the world
reference?**

This third part extends to both countries. Kumamoto and Christchurch have known events that have profoundly changed both countries, but they were not isolated. The other natural disasters that occur regularly in these countries are not, or hardly, mentioned in this thesis because the focus is on earthquake resilience.

It is a personal choice to have studied these two cities according to certain criteria. But in this section, it is voluntary to talk about countries on their risk and disaster management as a whole rather than Christchurch and Kumamoto.

3.1. Japan: the world reference in disaster resilience

Japan has always faced major natural disasters. This culture of risk is very present and people have managed to adapt and recover from crises. The country has adjusted its measures and legislation in order to be prepared both on the hard and the human level. Prevention and research centres are being set up to prevent disasters in the best possible way to be able to anticipate them as far as possible. The National Research for Earth Science and Disaster Resilience (NIED) - science for resilience - is a Nippon institution in order to promote research with the objective of realizing resilient society to natural disasters by enhancing science and technology for disaster risk reduction. It was created in 1959 as a National Research Institute, in 2001 it became an Independent Administrative Agency for being a National Research and Development Agency in 2015. It is a network center for earthquakes, tsunamis and volcanoes. NIED is committed with different stakeholders (companies, organizations, universities).

The territory is covered with more than 4,000 seismometers which help to obtain alerts and information in real time on the activity of the ground. Unfortunately, today it is impossible to predict an earthquake before its completion. However, it is possible to establish probabilities on the date, magnitude and location of impact. Also, it enables us to assess the risk of a tsunami coming. During the earthquake that hit the Fukushima region in 2011, maximum warning was given but unfortunately this did not prevent human and material losses.

New Zealand can take example about how to involve businesses in reducing the impact of natural hazards. Economic loss by business interruption can have a real impact on resilience. In an effort to limit these impacts, Japan has set up a business continuity plan. “Pour éviter d’interrompre l’activité en cas de désastre naturel, les entreprises peuvent constituer un plan de prévention des catastrophes, qui prend en compte les étapes de prévention, de gestion de crise et de restauration, le but étant de prévoir puis d’assurer les conditions minimums pour poursuivre l’activité lors de l’apparition d’une catastrophe puis de faire en sorte de retrouver rapidement le niveau d’avant-crise” (Heimbürger, 2018 p.57). The plan is based on upstream preparation. In fact, it makes it possible to determine in advance the organization of personnel or substitute establishments in the event of a disaster. In 2015, 91.8% of large companies and 72.2% of medium-sized companies established a business continuity plan or were in the process of doing so.

Japan is also the only country in the world to have a plan in place to receive aid in the event of a disaster. It was first published in 2013 by Kobe, building on the disasters of 1995 and 2011. This plan was the result of communication problems between the different partners that can lead to a mismanagement of the resources sent in order to help the disaster-stricken populations. For example, the day after the Kumamoto earthquake, the government sent 1,85 millions meals in order to satisfy a theoretical demand over a period of 6 days. However, misunderstanding and lack of staff resulted in a poor distribution of products. In general, safe regions that send a lot of furniture and food in the short term without concentration can lead into stock management issues. By the end of 2016, half of Japanese Metropolises have adopted the same kind of plan. The major issue of this measure is for small regions that do not have the expertise nor funding to implement such a plan. It considers, among other things, that resources must be placed and managed directly in evacuation centres and not only in town halls or fire stations (Heimbürger, 2018).

Those two plans are a good example of preventive measures the country establishes in order to limit damage in case of a natural disaster.

Japan has also shown itself to be resilient in history. In 1945 Hiroshima suffered a nuclear attack. Today the same city has been reimagined as a Peace Memorial City. The Genboku dome is one of the rare buildings that was not destroyed by the bomb. It has become the Hiroshima Peace Memorial. It has been maintained in its present state, neither destroyed nor renovated and has become a witness to the ravages of war and a symbol of peace. There is a general belief that Japan does not bend under adversity but gets back up and emerges stronger (Gardiner, 2020). Even the devastating area of Tohoku due to the nuclear disaster in 2011 is now open to tourists. The Fukushima prefecture promotes the concept of “hope tourism” (as an antonym of “dark tourism”).

“Travellers can learn, not only from the earthquake and nuclear accident, but also from reconstruction and overcoming adversity.”

Takehiro Okamoto (organizer of the “hope tour”)

Source: Gardiner, 2020

This form of tourism raises questions in particular from an ethical point of view. But as New Orleans after hurricane Katrina, tourism became a new source of income and opportunities.

From a technical point of view, Japan also serves as a reference. Three techniques are used in order to improve the resistance of buildings:

- To integrate thick and solid posts into a building: it prevents the building from falling but people and objects inside might be more easily injured because the energy from the tremor is sent directly to the building.

The two other techniques are the most efficient known:

- To use parasitic shock absorbers: rubber insulators put between the ground and the building and on the walls absorb shocks and energy

- To build on ressorts: this technique is a world premiere. It is designed by the National Institute for Earth Science and Disaster Resilience (NIED), Hitachi company and Setsunan University. “Son principe consiste à construire un bâtiment sur un équipement qui le soulèverait légèrement en éjectant de l’air comprimé en cas de séisme, le mettant à l’abri des secousses horizontales - les secousses verticales étant quant à elles absorbées par les ressorts” (Heimberger, 2018 p.61).

This last technique reflects the image of a floating city where the shaking would no longer be suffered by the population.

Even if Japan has a strict regulation, a company confessed in 2015 that it falsified its reports. Construction norms have not been respected. 354 buildings (including 36 schools and 37 health-care institutions) had pillars that datas have been falsified.

Nevertheless, today, we can assume that Japan - despite its dysfunction - is the country that is the world reference in management of natural hazards. Of course, New Zealand has many assets. There is no perfection in the prevention of natural risks. The following part is about what other countries can learn and apply from these two experiences. Each territory has its specificities so the aim is rather to draw inspiration from them by adapting to its own situation.

3.2. What can we learn about disaster resilience from those two case studies

There are many things that we can learn from these two countries whether in success or failure.

Social connectedness has its importance after a disaster. But from the 60s, we are seeing a decrease in social connectedness in Japan. In 2010 appeared the term *muenshakai* (“socially disconnected society”). This can have negative effects on disaster management. For example, after the Kobe earthquake, 65% of the inhabitants trapped under the rubble were saved by their neighbors, 18,9% by their family and only 2,4% by the rescuers.

Also even if with all the precaution measures, 60.3% of respondents stated that they would not be able to take immediate action to ensure their safety if they received an emergency flash of warning in anticipation of a strong earthquake (Yahoo Japan, 2016). Despite evacuation school drills, evacuation plans, norms, the ignorance of seismic risk persists.

More important, some evacuation centers could not finally be used as a refuge because the buildings themselves were damaged.

Like New Zealand, relocating disaster victims has been difficult.

What may be lacking in these countries, and Japan in particular, which experiences many natural disasters, is a government agency solely responsible for managing these issues as a Ministry in charge of Disaster Prevention and Management. This would make it possible to unify the various schemes and plans so that small regions that do not have the necessary resources can also benefit from them. It could then concentrate the knowledge acquired on this subject, build on existing research poles, learn from the mistakes and success made in the past in the country but also learn from other countries. Even if Japan is known as the reference in this field, elements realized in New Zealand, can also serve as a basis for innovation (as the Earthquake Commission). The way it was set up shows its dysfunction but the creation of a governmental insurance on natural disaster is a great way to provide:

- Efficient management and settlement of claims
- Efficient pricing and financing of risk
- Improving the current state of knowledge about natural hazards

(EQC, 2018).

A Ministry like this could unify human, material and financial resources in order to manage natural disasters or to prevent them. So we could expect a faster and more effective response. The aim of this ministry would not be to deviate with what is already being done locally, but to provide better coordination and more equality between the large prosperous regions and the smaller ones. This thesis focused on earthquakes but prevention measures, disaster resistance, the rescue, evacuation and re-housing process and the whole post-disaster phase (reconstruction, assessment) can be applied to all natural disasters. The way to response and prevention actions adapt to each natural disaster but the steps remain the same. For Japan and New Zealand, it does not seem to be relevant at the moment.

At the local scale, under 7% of the Japan municipalities have had a “*plan local pour la solidification du territoire*”. Ce texte vise à maintenir les fonctions sociales et économiques en cas de catastrophe, en prenant des mesures de prévention et de réduction des dégâts, y compris en matière d’urbanisme participatif.” (Heimberger, 2020 p.1). The point is to think in advance with the inhabitants about what can be done in case of a reconstruction. But these initiatives are still very little followed up on the territory.

Another point that needs to be developed and known is all the aids accessible for the inhabitants. The issue is even more pertinent in Japan, where the population is increasingly ageing and risk awareness is still low. Prevention campaigns must be maintained and pursued on a regular basis in order to continue to raise public awareness.

“Family and community is more important than before.

We are more aware of the fragility of life and that life can change very quickly”

Paul P.

The first part of the thesis showed how it is important to gather information from previous events and history. In New Zealand during the 2011 earthquake, Statistic New Zealand experienced difficulties to collect and share data.

It is a testament to the necessary preparation that needs to be put in place before the arrival of a potential disaster.

Whether it is Christchurch or Kumamoto, these natural disaster-prone cities need to be prepared. And this means gathering information, taking stock of what the cities already have and what needs to be developed further in the event of a disaster. Databases on:

- “The location and availability of resources for temporary housing [...]
- [...] Areas that may be suitable for temporary housing [...]
- Assess the infrastructure requirements for buildings in these areas [...]
- [...] Identify potential suppliers for short-term sheltering solutions”

(Giovinazzi, 2012 p.9)

Anticipation is the key word. This is why both cities, especially, Kumamoto over the years and events, developed various plans and measures.

Humans are resilient, their own resilience benefits the city. But is simply surviving a disaster enough in itself to say that the city is resilient? It proves that the territory is resistant (one of the points of what resilience is). But it is not enough to qualify an object “resilient”, it needs a rebound. It does not have to be economic but a source of creative destruction (Schumpeter, 1942).

The previous part demonstrated how Japan is a reference. But current events have shown a New Zealand capable of handling an unprecedented crisis situation by becoming an example in the way it manages the coronavirus. Jacinda Ardern (New Zealand Prime Minister) is part of the world’s 100 most influential people according to the Time.

“Success is measured not only by the nation’s GDP but by better lives lived by its people”

Jacinda Ardern, 2019 (after the Christchurch mosques attack)

Source: McDonald, 2020

New Zealand is now known for its progressive politics. Also, Wellington is ranked the third happiest city of the world. Auckland and Christchurch are in the top 20, despite Christchurch's decade of tragedies (Begley Bloom, 2020).

Meanwhile, 4 July 2020, Kumamoto prefecture had to face a new natural disaster. A record-breaking heavy rain hit the area causing the death of 77 people. The heavy rain led to floods. Approximately 15,335 buildings have been destroyed, damaged or flooded. Kumamoto prefecture is now facing a new resilience process. We can not tell yet how the region will recover and if it will change plans and measures written after the 2016 earthquake. But it shows how the country has to anticipate as many natural hazards as possible and has to prepare its population.

The Insurance Council of New Zealand wrote in 2014 a document about protecting New Zealand from Natural Hazard. Here what we can remember and be interesting for Japan and also essential for every other countries that face natural hazards:

“Strategy and legislation:

- A strategy and coordination [...] a coordinated strategy to reduce the impact of natural disasters before they strike.
- Develop a national plan [...]
- Legislative alignment – review legislation to ensure risk management of natural hazards is aligned and focused on reducing or avoiding natural hazard risks consistent with the strategy.
- Take the long-view – require local authorities to deny consent applications where taking the long view shows risks from natural hazards will increase.
- Plan to address local hazards – legislation should require local authorities to assess those natural hazard risks relevant to their locality and have infrastructure plans in place to address them.
- Safer commercial buildings – make non-structural seismic restraints part of annual building inspections.

Information to make the right decisions:

- Science research – focus research spending to best inform risk reduction decisions.
- High quality data – establish a high quality, national natural hazard database to inform decision-making such as the cost benefit trade-offs around risk reduction.

- A hazard risk on every property – ensure there is publicly accessible information on the natural hazard risks every property in New Zealand faces.
- Be clear what are acceptable risks – provide local government decision-makers clear guidance about what can be considered acceptable risk from natural hazards.
- Consistent approach across New Zealand – provide local government with a natural hazards identification template so there is a consistent approach applied across the country.
- Educate people – a public education programme to inform people about the natural hazards they face and the actions they or their community can take to minimise them.

Funding:

- Fund resilience – a commitment to long-term annual funding of initiatives to build resilience where the risk and investment trade-off justifies it.
- Funding now saves bigger cost after an event – the cost of implementing adaptation measures is significant. There needs to be long-term, bipartisan commitment to fund measure that build pre-disaster resilience.

Insurance:

- Keep insurance affordable and available for all – introduce comprehensive measures to reduce the risk of natural disasters and remove levies from insurance premiums to help keep the transfer of risk to insurance affordable.”

(Grafton, 2014 p.4).

This list of recommendations can be a base and objectives towards which to strive in order to deal upstream with potentially destructive natural hazards.

New Zealand has not reached all these objectives but tries to get close to it.

Both countries are highly vulnerable to natural hazard risks. Global warming risks making things worse for these two territories but also for the whole world. Even if in France, we are not vulnerable to earthquakes as they can be. The question of resilience after a natural shock concerns all countries.

Resilience is not just about how people get up and rebuild, nor is it when the city heals its wounds by rebuilding. It is a process that results from many post and pre-disaster elements that allow for a more or less easy and quick "rebound". The construction of this thesis shows this. Resilience is something cyclical and non-linear. Before the Kumamoto earthquake in 2016 or the Christchurch earthquake in 2011, both countries had already experienced similar disasters in the past, which contributed to their construction. This is why the first part of the thesis is longer; it is all about the preparation. What happened before the shock is of great importance. The second part, on the whole disaster management is shorter because it is the result of everything that could have resulted before. Things could have been different if these countries had suffered a violent earthquake for the first time.



Conclusion

The purpose of the thesis was to understand whether Japan is really the world reference for earthquake resilience in particular from an urban planning point of view. To answer this question, two practical cases were studied. As the third part exposed, Japan is an example to follow. But it is far from being perfect and New Zealand has also interesting resources to cope with and respond to earthquake risks.

Three hypotheses were formulated:

- It is possible to assess the resilience of a city before the disaster occurs;
- The earthquake becomes the key to a major restructuring of the affected city;
- Japan is an exemplary country in risk and disaster management.

The first part of the thesis was about the preparation in case an earthquake occurs. It is the biggest part of the thesis and it shows how essential assessment and readiness are. It is hard to predict how the city will recover from an earthquake but history and previous disasters showed that countries adapted themselves. New Zealand and Japan are used to endure earthquakes, preparation belongs to the cycle of resilience.

Earthquakes (and disasters in general) drive changes in society and in human beings. It is the opportunity to redefine the city.

Resilience resides according to the 4 points developed in the thesis: assessment, readiness, response and recovery. It is the speed at which the territory resists and bounces back from the event.

This thesis is part of the paucity of information on earthquake resilience.

Due to the world context, it was written without a field investigation. Data are mostly from the authority method (scientific literature, news articles, testimony, government and organizations). I had the opportunity to realize an interview with a Christchurch inhabitant but unfortunately not with a Kumamoto inhabitant. It was harder to reach contact maybe for cultural reasons and also because of the floods that the city suffered early July.

An active cooperation began between Japan, New Zealand (and Taiwan). Each year since 2014, a workshop is organized by the National Research Institute for Earth Science and Disaster Resilience (NIED) and GNS Science in order to work on Seismic Hazard Assessment. “Under the lessons learnt from the destructive earthquakes and the awareness of the unexpected earthquake possibly occurring in the future, scientists on both sides have consensus of cooperative research to share data, knowledge and information”. (NIED, 2014 p.1).

Resilience encompasses four interdependent dimensions:

- Technical (physical systems, infrastructure)
- Organizational (governance, service delivery)
- Economic (fiscal, market)
- Social (community, individual).

(Bruneau et al. 2003).

This thesis is mainly interested in the urbanistic aspect while integrating the other elements. But this obviously raises other questions about the human, political, health or education aspects which are all elements to be taken into account in order to have a complete vision of resilience.

In order to verify the internal validity of my thesis it would have required a local verification. As I lived in New Zealand but not in Japan some aspects may have been influenced and biased by my local experience which is why I have diversified as much as possible the sources of information. Choosing two events that took place a few years ago allowed us to verify the validity of this thesis. The objective is to place this knowledge in the comparison of two countries with advanced economies in the already existing database. Earthquakes are often managed locally. There is therefore little comparison. It is only by looking at what other countries facing the same disasters can do that we can collectively find innovative solutions that are not necessarily transposable but at least adaptable. So even if Japan is considered a world reference, there are still dysfunctions and New Zealand also offers innovative solutions that deserve more attention.

As with individuals, given the obvious differences in challenges, assets and cultures, the question is also whether it is possible to compare places on the basis of their regional resilience despite all these disparities? Transposing the Japan or New Zealand response to an earthquake can only be done if it is adapted to the specificities of the territory. However, we can draw inspiration from the way risks are anticipated and the disaster is managed while learning from their failures and successes.

It is therefore possible to apply and learn from these two countries in certain aspects of earthquake risk and disaster management in other places.

But this process can also be interesting after another natural hazard that damages infrastructures and can harm human lives by trying for example by finding construction techniques that protect its hosts from destruction whether due to earthquakes or another natural hazard.

Annex

Annex 1: Registered earthquake-prone buildings in New Zealand on 27 June 2020

Regions	Registered earthquake-prone buildings			%	/10 000 inhabitants
	Non-priority	Priority	Total		
All	2837	424	3261	100	
Auckland	1311	0	1311	40.2%	8
Bay of Plenty	94	4	98	3%	3
Canterbury	650	151	791	24.3%	13
Gisborne	36	0	36	1%	7
Hawke's Bay	5	7	12	0.4%	1
Marlborough	11	0	11	0.3%	2
Manawatū-Whanganui	7	1	8	0.2%	0
Nelson	46	7	53	1.6%	10
Northland	0	0	0	0%	0
Otago	16	5	21	0.6%	1
Southland	14	33	47	1.4%	5
Taranaki	2	8	10	0.3%	1
Tasman	15	3	18	0.6%	3
Waikato	14	11	25	0.8%	1
Wellington	578	144	722	22%	14
West Coast	37	50	87	2.7%	27

Author

Source: Ministry of business, innovation and employment, 2020

Annex 2: Interview with a Christchurch inhabitant: Paul P.

- **How do you remember this event ?**

The first earthquake was very early in the morning. We woke to the whole room shaking violently. I got up and called to my daughters, to get under a door frame. It was very hard to walk and the whole house moved uncontrollably. My wife tried to run but kept hitting the wall as she was being thrown around. I woke my eldest daughter and held her under the door frame. When it stopped we ran outside. We were quite confused and didn't really know what was happening.

The second big quake was 1pm in the afternoon. The building in which I worked in was in the city. The CTV building was across the road from us and this building fell down, with many deaths. The whole of the CBD was cordoned off afterwards as the authorities searched for bodies. When we got home, we had damage to our house as well. Not uninhabitable but damage to the foundations.

- **Do you think the authorities reacted appropriately to the situation? And why ?**

Yes they acted appropriately but it was a huge issue. CHCH was put into a state of emergency so the army came in to help. We had specialist teams from other countries to help look for survivors from buildings that had collapsed.

- **Are you aware of prevention and awareness programs if an earthquake occurs?
Is there evacuation exercises at school or at your work ?**

Yes we have drill exercises and drill in schools. But no one thought there would be an earthquake in Christchurch, we all thought (and were taught at school) that Wellington would be the most likely place to have an earthquake. I knew to get under a door frame as this was the safest place in the house.

- **Are there evacuation centers in Christchurch ? If yes, do you know where to evacuate ?**

There was evacuation centres set up very quickly after the earthquakes in many different parts of CHCH. These were normally school halls or gymnasiums. Supplies were donated (food & clothing) but the civil defence had resources and ran these. There is an organisation called Civil Defence which is run from the government. They have plans for all emergencies and set these up.

- **Are you thinking about the potential threat of another earthquake? Or is it something you don't think about at all?**

Yes we always are aware of earthquakes and sometimes we still have aftershocks. Although less and less but they still give you a fright. We think about the earthquakes when buying houses as this affected both land and buildings.

- **Have you ever done any renovations to your home? Do you know of any assistance that can be put in place to help you carry out this work?**

We have had our home completely renovated since the earthquakes. There was a lot of damage to the foundations. This was repaired with concrete and the inside needed to be renovated. Most of this was paid for by EQC (Earthquake commission). We had to move out for 11 weeks whilst the repairs were done.

- **The Christchurch CBD has been greatly affected, what do you think of the progress of the work? Were you consulted about participation the renewal of the city ? If yes, did you participate ? Do you think the new plan of CHCH is the appropriate answer of what inhabitants were and are still looking for ?**

The progress has been very slow. Many building still have issues with insurance. This is the same for many houses as well. The insurance companies were very slow at settling their claims and tried to stall for a long time. Yes we did give feedback to the CHCH council on design ideas. All of CHCH was asked to submit and vote on ideas. Yes the new CBD will be great but it is taking a long time. It is completely new with better facilities, more precincts and better for biking/walking as the planning could do anything – (blank canvas).

- **Almost 10 years after the 2010 and 2011 earthquakes, do you feel that the city has recovered from the stigma of the disaster?**

No not yet. It is still very noticeable when you go into the CBD. Still a lot of old broken buildings. There are still a lot of people fighting their insurance companies to agree to fix or rebuild their houses. The insurance industry was not very moral in many cases. The EQC who were in charge of repairs to houses also tried to fix very cheaply and save money but this resulted in poor workmanship and bad repairs to people's houses.

- **In 2016 another earthquake hit the east coast and more specifically Kaikoura. Do you have the impression that New Zealand and Canterbury have learned from these tragic events in order to limit the material, human and economic damage as much as possible? And why?**

Yes we were better prepared. We had better resources available and knew how to react faster. The repairs were carried out faster in Kaikoura for homes etc but the road and access to Kaikoura were blocked both ways (north & south). The economic damage was an issue as Kaikoura is a tourist town but no one could go there as the roads were closed from repairs.

- **As an inhabitant, how did those earthquakes changed the way you live in your city ?**

We are less dependant on 'houses' as they can easily be knocked down with a big shake. Family and community is more important than before.

We are more aware of the fragility of life and that life can change very quickly.

Table of figures

Figure 1: The two states of resilience	14
Figure 2: Magnitude, energy release and shaking intensity	25
Figure 3: Structural components of Aboriginal knowledge, at different levels of incorporation in environmental assessment and management.....	28
Figure 4: Map showing events recorded orally by tribal groups in New Zealand.....	29
Figure 5: Probability of experiencing an earthquake of 6- intensity of above in the next 30 years.....	33
Figure 6: New Zealand Economic Growth.....	36
Figure 7: Region of Canterbury - New Zealand.....	38
Figure 8: Earthquake prone building framework.....	39
Figure 9: Seismic risk area of New Zealand regions	40
Figure 10: Distribution of earthquake-prone buildings in New Zealand on 27 June 2020	42
Figure 11: Spatial organisation in Japan	46
Figure 12: The large central of New Zealand.....	50
Figure 13: "Drop, cover, hold"	52
Figure 14: Christchurch damage and infrastructures	63
Figure 15: Christchurch earthquake-prone buildings.....	64
Figure 16: Christchurch central plan.....	70
Figure 17: Kumamoto damage, infrastructures and evacuation centres	77
Figure 18: Summary of the different stages before reaching the complete recovery.....	78

Table of photos:

Photo 1: Christchurch earthquakes of 2010.....	35
Photo 2: CTV building - Christchurch 2011	59
Photo 3: Kumamoto Castle damaged during the 2016 earthquake	62
Photo 4: Christchurch Cathedral damaged during the 2010 and 2011 earthquake	62
Photo 5: The Cardboard Cathedral	62
Photo 6: Kumamon hugs a Taiwanese tourist at a Kumamon Square in Kumamoto prefecture	74

Table of tables:

Table 1: Moment Magnitude Scale.....	24
Table 2: The Shindo Scale	26
Table 3: Kobe and Los Angeles earthquake facts.....	31
Table 4: Comparison between Christchurch and Kumamoto earthquakes	58

Bibliography:

Arakida.; Nakao. (2016). “2016 Kumamoto Earthquake Survey Report”. *Asian Disaster Reduction Center*. [Online]. Available at: https://www.adrc.asia/publications/201604_KumamotoEQ/ADRC_2016KumamotoEQ_Report_1.pdf (accessed 28 June 2020).

Atsumi, Tomohide. (2004). “Le séisme du Japon, huit ans après Kobé : Volontaires, risques et dangers”. *Les Annales de la recherche urbaine*, N°95. Apprivoiser les catastrophes. pp. 62-69.

Augendre, Marie. (2010). “Les facteurs culturels de la résilience - le cas du Japon”. *Séminaire Résilience urbaine* (27 May). Université Lyon II.

Begley Bloom, L. (2020). “Ranked: The 20 Happiest Countries In The World”. *Forbes*. [Online, 20 March]. Available at: <https://www.forbes.com/sites/laurabegleybloom/2020/03/20/ranked-20-happiest-countries-2020/#21b77f0b7850> (accessed 04 August 2020).

Bernardi-Morel, J. (2014). “Cataclysme et pouvoir politique dans l’imaginaire au Japon : l’exemple des namazu-e du séisme de l’ère Ansei (1855)”. *Ebisu* [Online]. Available at: <https://journals.openedition.org/ebisu/516> (accessed 18 April 2020).

Blundell, Sally (2018). “How the Christchurch earthquakes devastated mental-health services”. *Noted*. [Online, 2 May]. Available at: <https://www.noted.co.nz/currently/currently-social-issues/how-christchurch-earthquakes-devastated-mental-health> (accessed 15 June 2020).

Brebbia, C.A. Ivorra, S. (2018). “Seismic resistant structures”. Edition : Wit Press

Bruneau, Michel. Et al. (2003). “A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities”. *Earthquake Spectra* 19(4), p.733-751.

Brunelle, C. (2018). “Résilience économique urbaine et régionale”. *Institut national de la recherche scientifique (INRS) Urbanisation Culture et Société*. Montreal. Class.

Building performance. (2018) “How the system for managing earthquake-prone buildings works”. *Ministry of business, innovation and employment*. [Online, 24 August]. Available at: <https://www.building.govt.nz/managing-buildings/managing-earthquake-prone-buildings/how-the-system-works/#jumpto-map-of-seismic-risk-areas-2013-indicative-only> (accessed 09 June 2020).

Cabinet Office of Government of Japan. (2016). “Estimated Economic Impact Due to the 2016 Kumamoto Earthquakes”. [Online]. Available at: <http://www5.cao.go.jp/keizai3/kumamotoshisan/kumamotoshisan20160523.pdf> (accessed 02 July 2020).

Canterbury Earthquake Recovery Authority Christchurch, New Zealand. (2012). “Christchurch Central Recovery Plan”.

Canterbury Earthquake Recovery Authority Christchurch, New Zealand. (2012). “Land Use Recovery Plan”.

Canterbury Earthquake Royal Commission. (2012). “Final Report’s Summary and Recommendations”. [Online, 30 November]. Available at: <https://canterbury.royalcommission.govt.nz/Final-Report---Volumes-1-2-and-3> (accessed 21 June 2020).

Christchurch City Council. “Digital maps”. *Christchurch city librairie*. Available at: <https://christchurchcitylibraries.com/Heritage/Maps/Thumbnails/> (accessed 03 June 2020).

Christchurch City Council. “Christchurch City Plan” [Online]. Available at: <https://ccc.govt.nz/the-council/plans-strategies-policies-and-bylaws/plans/christchurch-district-plan/districtplans/operative-christchurch-city-plan> (accessed 21 June).

Cobbing, Andrew. (2009). “Kyushu : Gateway to Japan - a concise history”. *University of Nottingham*. Edition : global oriental.

Coates, Joe. (2018). “How New Zealand Prepares For Earthquakes”. *Culture trip*. [Online, 20 February]. Available at: <https://theculturetrip.com/pacific/new-zealand/articles/how-new-zealand-prepares-for-earthquakes/> (accessed 21 June 2020).

Cretney, Raven. (2016). “Christchurch five years on: have politicians helped or hindered the earthquake recovery?”. *The conversation*. [Online, 19 February]. Available at: <https://theconversation.com/christchurch-five-years-on-have-politicians-helped-or-hindered-the-earthquake-recovery-53727> (accessed 28 June 2020).

Dayman, Lucy. (2018). “8 Ways Japan Prepares for Earthquakes”. *Culture trip*. [Online, 10 January]. Available at: <https://theculturetrip.com/asia/japan/articles/8-ways-japan-prepares-for-earthquakes/> (accessed 21 June 2020).

Giovinazzi, Sonia (et al.). (2012). “Assessing temporary housing needs and issues following the Darfiel and Christchurch earthquake, New Zealand”. [Online]. Available at: https://www.iitk.ac.in/nicee/wcee/article/WCEE2012_5417.pdf (accessed 19 July 2020).

De Graaf, Peter. (2013). “Unitary authorities - a dummy’s guide”. *Nzherald* [Online 13 April]. Available at: https://www.nzherald.co.nz/northern-advocate/news/article.cfm?c_id=1503450&objectid=11096259 (accessed 06 June 2020).

Dolan, Brian (et al.). (2011). “Earthquake Disaster response in Christchurch, New Zealand”. *Journal of emergency nursing*. vol37.

Drewes, J.E.; Van Aswegen, M. & Richter, M. (2018). “Towards More Resilient Cities: Land Use and Urban Efficiency”. *The Academic Research Community Publication 2.1* . [Online] Available at:

https://www.academia.edu/38880817/Towards_More_Resilient_Cities_Land_Use_and_Urban_Efficiency (accessed 20 March 2020).

Ertl, Michael. (2016). “Christchurch earthquake: The battle to rebuild, five years on”. *BBC News*. [Online, 21 February]. Available at: <https://www.bbc.com/news/world-asia-35612298> (accessed 22 May 2020).

Edwards, Colin. (2012). Lloyd’s Global Underinsurance Report compiled by the Centre for Economics and Business Research.

Foster, K. A.(2007). “A case study approach to understanding regional resilience. Institute of Urban and Regional Development, Berkeley”. [Online]. Available at: <https://www.econstor.eu/obitstream/10419/59413/1/592535347.pdf> (accessed 04 April 2020)

Fonseca, Ryan. (17 January 2019). “The Northridge Earthquake Was 25 Years Ago, And It Looked Like This”. *LA ist*. Available at: https://laist.com/2019/01/17/northridge_earthquake_25th_anniversary_photos.php (accessed 06 June 2020).

Gardiner, K. (2020). “Why are the Japanese so resilient ?” *BBC*. [Online, 1 July]. Available at: <http://www.bbc.com/travel/story/20200630-why-are-the-japanese-so-resilient> (accessed 04 August 2020).

Gilbert, Claude. (1991). « Comment gérer les crises ? Les pouvoirs publics face à des risques polymorphes », *Regards sur l'actualité n°328 « L'Etat face aux risques »* , p.61 76, La documentation française, Paris.

Giovinazzi, S. (et all.). (2012). “Assessing temporary housing needs and issues following Christchurch Earthquakes, New Zealand Christchurch Earthquake, NZthe Darfie”. *15th World Conference on Earthquake Engineering*. [Online]. Available at: https://www.iitk.ac.in/nicee/wcee/article/WCEE2012_5417.pdf (accessed 25 July 2020).

Goff, James. King, Darren N. T. Skipper, Apanui. (2007). “ Māori environmental knowledge and natural hazards in Aotearoa-New Zealand ”. *Journal of the Royal Society of New Zealand*. 37:2, p59-73. Edition : Taylor & Francis.

Grafton, Tim. (2014). “Protecting New Zealand from Natural Hazards”. *Insurance Council of New Zealand*. [Online, October]. Available at: <https://www.waikatoregion.govt.nz/assets/PageFiles/26012/protecting-new-zealand-from-natural-hazards.pdf> (accessed 16 June 2020).

Goda, Katsuichiro. (et al). (2016). “The 2016 Kumamoto Earthquakes: Cascading Geological Hazards and Compounding risks”. *Frontiers in Built Environment - Earthquake Engineering*. [Online, 22 August]. Available at: <https://www.frontiersin.org/articles/10.3389/fbuil.2016.00019/full#B5> (accessed 02 July 2020).

Google map (2011). “Map of the destruction”. [Online]. Available at: <https://www.google.com/maps/d/u/0/viewer?ie=UTF8&hl=en&msa=0&ll=-43.51668899999998%2C172.629547&spn=0.348556%2C0.583649&z=10&source=embed&mid=1-3FDPDIDeUurAqhsCF5Hbz95cgU> (accessed 03 July 2020).

Hayes, Gavin. (2011). “How Often Do Earthquakes Occur ?”. *Incorporated Research Institutions for Seismology*. [Online, June]. Available at: https://www.iris.edu/hq/inclass/factsheet/how_often_do_earthquakes_occur (accessed 15 June 2020).

Hasegawa, Tomohiro. (2013). “Introduction to the building standard law - building regulation in Japan”. *Ministry of Land, Infrastructure, Transport and Tourism*. [Online, July]. Available at: https://www.bcj.or.jp/upload/international/baseline/BSLIntroduction201307_e.pdf (accessed 14 June 2020).

Heimbürger, J-F. (2016). “Séismes de Kumamoto, la conscience des risques secouée au Japon”. *Asialyst* [online, 15 June]. Available at: <https://asialyst.com/fr/2016/06/15/seismes-de-kumamoto-la-conscience-des-risques-secouee-au-japon/> (accessed 01 May 2020)

Heimbürger, J-F. (2018). “Le Japon face aux catastrophes naturelles - prévention et gestion des risques”. Edition ISTE.

Heimberger, J-F (2020). “25 ans après le séisme de Kobe, la résilience du Japon toujours en question”. *Asialyst* [Online, 17 January]. Available at: <https://asialyst.com/fr/2020/01/17/japon-25-ans-seisme-kobe-resilience-toujours-question/> (accessed 01 May 2020).

Hill, E. (et al.). (2008). “Exploring Regional Economic Resilience”. *Working Paper 2008–04, Institute of Urban and Regional Development*. Berkeley

Hiroiyuki, Fujiwara.; Shinichi, Kawai.; Shin, Aoi.; Nobuyuki, Morikawa.; Shigeki, Senna.; Kyoko, Kobayashi.; Toru, Ishii.; Toshihiko, Okumura.; Yuzuru, Hayakawa. (2006). “National Seismic Hazard Maps of Japan”. *National Research Institute for Earth Science and Disaster Prevention, Japan*. Vol.81. pp 221-232.

Holling, C.S. et Gunderson, Lance H. (2002). “Resilience and Adaptive Cycles.” In *Panarchy: Understanding Transformations in Human and Natural Systems*, edited by Lance H. Gunderson and C.S. Holling. Washington, D.C.: Island Press, pp. 27-33.

Japan Meteorological Agency. (2018). “Tables explaining the JMA Seismic Intensity Scale”. [Online, edited 30 January]. Available at: <https://www.jma.go.jp/jma/en/Activities/inttable.html> (accessed 13 June 2020).

Kallender, Paul. (2016). “Japan’s New Dual-Use Space Policy. The long road to the 21st Century”. *Asie.Visions*. [Online, November] No 88. Available at: <https://www.ifri.org/en/publications/notes-de-lifri/asie-visions/japans-new-dual-use-space-policy-long-road-21st-century> (accessed 09 June 2020).

(Dr) Katsu, Goda. (2016). “The Kumamoto Japan earthquake of 14 and 16 April 2016 - a field report by EEFIT (Earthquake Engineering Field Investigation Team)”. *University of Bristol*. [Online, 2 May]. Available at: <https://www.istructe.org/IStructE/media/Public/Resources/report-eeffit-mission-kumamoto-20170811.pdf> (accessed 02 July 2020).

Khan, S. (2020). “Jacinda Ardern”. *Time100*. [Online]. Available at: <https://time.com/collection/100-most-influential-people-2019/5567767/jacinda-ardern/> (accessed 045 August 2020).

Knight, John. (2000). “‘Indigenous’ regionalism in Japan” dans *Indigenous Environmental Knowledge and its Transformations - Critical Anthropological Perspectives*. pp151-167. Edition : Harwood academic publishers.

Kucharski, Jeffrey.; Unesaki, Hironobu. (2017). “Japan’s 2014 Strategic Energy Plan: A Planned Energy System Transition”. *Hindawi, journal of Energy*. [Online]. Available at: https://www.researchgate.net/publication/317556866_Japan%27s_2014_Strategic_Energy_Plan_A_Planned_Energy_System_Transition (accessed 18 June 2020).

Kumamoto city. “City planning system”. [Online]. Available at: https://www.city.kumamoto.jp.e.fm.hp.transer.com/hpkiji/pub/List.aspx?c_id=5&class_set_id=2&class_id=2609 (accessed 15 June 2020).

(Dr) Leathart, Chris. (2011). “In the aftermath of a catastrophe: The Christchurch earthquake”. *Bpac - better medicine*. [Online]. Available at: <https://bpac.org.nz/BPJ/2011/june/upfront.aspx> (accessed 30 June 2020).

Le vent se lève (dir. Hayao Miyazaki, 2014).

Martin, Ron. (2012). “Regional economic resilience, hysteresis and recessionary shocks”. *Journal of Economic Geography* pp1–32.

Masaman. (2019). “Ethnic Origin of the Japanese”. [Video upload 23 May]. Available at: <https://www.youtube.com/watch?v=NqCK46kk4VA>.

McAloon, Jim. (2008). “Land ownership - Early Pākehā land settlement”. *Te Ara - the Encyclopedia of New Zealand*. [Online, 24 Novembre] Available at: <http://www.TeAra.govt.nz/en/land-ownership/page-2> (accessed 8 June 2020).

McDonald, E. (2020). “Why is New Zealand so progressive” *BBC*. [Online, 19 May]. Available at: <http://www.bbc.com/travel/story/20200518-why-is-new-zealand-so-progressive> (accessed 04 August 2020).

McSaveney, Eileen. (2006). "Historic earthquakes". *Te Ara - the Encyclopedia of New Zealand*. [Online, 12 June]. Available at: <http://www.TeAra.govt.nz/en/historic-earthquakes> (accessed 01 June 2020).

Morita, Keiko.; Takayama, Mineo. (2017). "Lessons learned from 2016 Kumamoto earthquake: building damages and behavior of seismically isolated buildings". *American institute of physics*. [Online]. Available at: <http://dx.doi.org/10.1063/1.5005638> (accessed 15 June 2020).

Motoji, Ikeya. (2004). "Earthquakes and Animals: From Folk Legends to Science". Edition : World Scientific.

National Research Institute for Earth Science and Disaster Resilience. (2020). "Research Center for Enhancing Metropolitan Resilience". *Research Center for Enhancing Metropolitan Resilience*. [Online]. Available at: <https://www.bosai.go.jp/e/research/center/metro.html> (accessed 15 July 2020).

National research council - Committee on Disaster Research in the Social Sciences: Future Challenges and Opportunities. (2006). "Research on Disaster Response and Recovery". In *Facing hazards and disasters - understanding human dimensions*, 124-180. The National Academies Press, Washington.

New Zealand Planning Institute. (2011). "National Infrastructure plan 2011". *Te Tai Ohanga - The treasury*. [Online, issue date 4 July]. Available at: <https://treasury.govt.nz/publications/infrastructure-plan/national-infrastructure-plan-2011> (accessed 27 July 2020).

New Zealand Petroleum & Minerals. (2017). *Ministry of Business, Innovation and Employment (MBIE)*. [online, 16 January]. Available at: <https://www.nzpam.govt.nz/about/purpose-and-role/> (accessed 12 May 2020).

National Research Institute for Earth Science and Disaster Resilience (Nied). (2014). "Japan-New Zealand Seismic Hazard Assessment". *NIED, GNS Science*. [Online]. Available at: <http://www.j-shis.bosai.go.jp/intl/nz/index.html> (accessed 09 August 2020).

Ohsugi, Satoru. (2009). "The Organization of Local Government Administration in Japan". *Council of Local Authorities for International Relations*. [Online, July]. Available at: <http://219.109.36.105/j/forum/honyaku/hikaku/pdf/BunyabetsuNo11en.pdf> (accessed 13 June 2020).

Otani, Shunsuke. (2007). "Historical Development of Building Code in Japan". *Chiba University*. [Online, 17 January]. Available at: <https://www.uncrd.or.jp/hyogo/hesi/pdf/expmeeting/otani.pdf> (accessed 14 June 2020).

Palmite, David Et al (2020). "Building your resilience". *American Psychological Association APA*. [Online, 01 February]. Available at: <https://www.apa.org/topics/resilience> (accessed 24 April 2020).

Pernin, Jean-Mathieu. (2020). “Catastrophes naturelles, la France très exposées au changement climatique”. *RTL*. [Online 12 January]. Available at: <https://www.rtl.fr/actu/debats-societe/catastrophes-naturelles-la-france-tres-exposee-au-changement-climatique-7799934795> (accessed 21 March 2020).

Poole, Michele. (2012). “Public information Management in Christchurch following the February 2011 earthquake: lessons learned”. *Australian Journal of Emergency Management*. Vol. 27, No4. October.

Stratégie internationale de prévention des catastrophes des Nations Unies (UNISDR). (2009). “UNISDR, Terminologie pour la prévention des risques et de catastrophes”. *Nations Unies*.

Reeves, Janet. (2008). “Urban development strategy - Greater Christchurch”. *Ministry for the environment*. Available at: <https://www.mfe.govt.nz/publications/towns-and-cities/urban-design-case-studies-local-government/urban-development-strategy-#:~:text=Introduction,proactive%2C%20integrated%20and%20sustainable%20manner.> (accessed 09 June 2020).

Renard, Nicolas. (2018). “Les villes résilientes”. *La revue de l'Institut Veolia - FACTS Reports - 2018 - N° 18*.

Sasaki, Atsuro. (2014). “Local Self-Government in Japan”. *Ministry of Internal Affairs and Communications*. [Online, May]. Available at: https://www.soumu.go.jp/main_content/000295099.pdf (accessed 13 June 2020).

Schrader, Ben. (2015). “City planning”. *Te Ara - the Encyclopedia of New Zealand*. [Online, 26 March]. Available at: <http://www.TeAra.govt.nz/en/city-planning> (accessed 9 June 2020).

Schumpeter, J. (1942). “Capitalism, Socialism and Democracy”. Harper & Brothers.

Shinichi, Saoshiro. (2016). “Japan quake breaches the historic walls of 400-year old Kumamoto Castle”. *Reuters*. [Online, 16 April]. Available at: <https://www.reuters.com/article/us-japan-quake-castle/japan-quake-breaches-the-historic-walls-of-400-year-old-kumamoto-castle-idUSKCN0XD0AZ> (accessed 30 June 2020).

Staikos, Apostolos. (2019). “Au Japon, la force de la résilience”. *Euronews*. [Online, 27 February]. Available at: <https://fr.euronews.com/2019/02/27/au-japon-la-force-de-la-resilience> (accessed 01 May 2020).

Stapleton, Patricia. “Earthquake Preparedness in Christchurch, New Zealand” [Online]. Available at: https://serc.carleton.edu/integrate/workshops/risk_resilience/case/82120.html (accessed 21 June 2020).

Stevenson, Marc, G. (1996). “Indigenous Knowledge in Environmental Assessment”. Vol. 49, NO. 3. P278-291. Edition : arctic.

Sugiura, Shimon. (2018). "Kumamoto after the Earthquakes: Recovery and Resilience". *Air Worldwild*. [Online, 08 August]. Available at: <https://www.air-worldwide.com/blog/posts/2016/8/kumamoto-after-the-earthquakes-recovery-and-resilience/> (accessed 25 June 2020).

Sunley, Peter & Tyler, Peter. (2015). "Local growth evolutions: Recession, resilience and recovery". *Cambridge Journal of Regions, Economy and Society*. pp141-148. [Online, June]. Available at: https://www.researchgate.net/publication/279240405_Local_growth_evolution_Recession_resilience_and_recovery (accessed 02 April 2020).

Tissot, Pauline. (2011). "Comment le Japon se prépare aux séismes". *L'Express*. [Online, 11 March]. Available at: https://www.lexpress.fr/actualite/monde/comment-le-japon-se-prepare-aux-seismes_971252.html (accessed 05 May 2020).

The Headquarters for Earthquake Research Promotion (2018). "National Earthquake Motion Prediction Map 2018 Edition". [Online]. Available at: https://www.jishin.go.jp/evaluation/seismic_hazard_map/shm_report/shm_report_2018/ (accessed 20 June 2020).

The japantimes. (2018). "The need to sustain local autonomy". [Online, 13 January]. Available at: <https://www.japantimes.co.jp/opinion/2018/01/13/editorials/need-sustain-local-autonomy/> (accessed 13 June 2020).

The spatial planning plateforme (2014 to 2016). "National Spatial Policy Documents". *Ministry of Land, Infrastructure, transport and tourism*. Available at: <http://www.ued.or.jp/SPP/spatialplanning/japan.html> (accessed 13 June 2020).

Third United Nations Conference on Housing and Sustainable Urban Development (December 2015). "National Report of Japan". National Habitat Committee for Habitat III.

Tsunami Working Group Signage Subcommittee. (2007). "New Zealand national tsunami signage recommendations for CDEM Groups". *GNS Science Report* 39 p.

Unknown author. (2011). "Christchurch earthquake: CBD cordons relaxed". *NBR*. [Online, 06 March]. Available at: <https://www.nbr.co.nz/article/big-earthquake-hits-south-island-mn-86648> (accessed 03 July 2020)

Unknown author. (2016). "February 2011 Christchurch earthquake". *Ministry for Culture and Heritage*. [Online, 20 May]. Available at: <https://nzhistory.govt.nz/culture/february-2011-christchurch-earthquake> (accessed 25 June 2020).

Unknown author. (2020). “Japan’s nuclear power plants”. *Nippon.com*. [Online, 10 March]. Available at: <https://www.nippon.com/en/features/h00238/japan%E2%80%99s-nuclear-power-plants.html> (accessed 18 June 2020).

Unknown author. (2020). “Nuclear Power In Japan”. *World nuclear association*. [Online, March]. Available at: <https://www.world-nuclear.org/information-library/country-profiles/countries-g-n/japan-nuclear-power.aspx> (accessed 18 June 2020).

United Nations International Strategy for Disaster Reduction (UNISDR). (2009). “UNISDR Terminology on disaster risk reduction”. *United Nation*.

Vaselenko, Amy. (2015). “Earthquakes”. [Online, 10 June]. Available at: https://www.slideshare.net/amy_v91/earthquakes-powerpoint (accessed 12 June 2020).

Waka Kotahi - NZ Transport agency. Available at: <https://www.nzta.govt.nz/> (accessed 09 June 2020).

Williams, David. (2020). “EQC isn’t Canterbury’s problem, it’s everyone’s”. *Newsroom*. [Online, 9 April]. Available at: <https://www.newsroom.co.nz/eqc-isnt-canterburys-problem-its-everyones> (accessed 30 July 2020).

Wu Zun Min.(1995) “Moments of Fear - Eyewitness to the Great Hanshin earthquake”. *Kobe University*. Available at: <http://www.lib.kobe-u.ac.jp/directory/eqb/book/16-47/eng/55.html> (accessed 04 June 2020).

熊本都市計画都市計画区域の整備、開発及び保全の方針（熊本都市計画区域マスタープラン）. 平成27年5月29日.

Kumamoto’s prefecture (Kyushu). (2015). “Policies for the Improvement, Development and Conservation of the Kumamoto City Planning Area (Kumamoto City Planning Area Master Plan)”. Available at: https://www.pref.kumamoto.jp/common/UploadFileOutput.ashx?c_id=3&id=10699&sub_id=2&flid=31119 (accessed 08 July 2020).

Yahoo Japan. (2016). “Can you act quickly on an earthquake alert?”. [Online, 16 April]. Available at: <https://news.yahoo.co.jp/polls/domestic/22942/result> (accessed 31 July 2020).

Sitography:

100 resilient cities: <https://www.100resilientcities.org/>
Christchurch city council: <http://www.ccc.govt.nz/>
Environment Canterbury - regional council: <https://www.ecan.govt.nz/>
Geological hazard information for New Zealand: <https://www.geonet.org.nz/>
Géorisques. Ministère de la transition écologique et solidaire: <https://www.georisques.gouv.fr/>
GNS Science: <https://www.gns.cri.nz/Home/About-Us>
Greater Christchurch Group - The Department of Prime Minister and Cabinet: <https://dpmc.govt.nz/>
Greater Christchurch partnership: <http://www.greaterchristchurch.org.nz/>
Incorporated Research Institutions for Seismology: <https://www.iris.edu/hq/>
Japan meteorological agency - earthquake: <https://www.jma.go.jp/en/quake/>
Kumamoto city: <https://www.city.kumamoto.jp/>
Ministry of Land, Infrastructure, transport and Tourism, Japan : <https://www.mlit.go.jp/en/>
Ministry of Civil Defence & Emergency - Earthquake: <https://www.civildefence.govt.nz/about/about-nema/>
Land Information New Zealand (LINZ): <https://www.linz.govt.nz/about-linz>
National Research Institute for Earth Science and Disaster Resilience: <http://www.arcgis.com/home/item.html?id=aee230981e9c4f0f9690391b67e68262>
Nippon Communication Fondation: <https://www.nippon.com/fr/japan-data/h00549/>
Parliamentary counsel office - New Zealand Legislation. “Building Act 2004” : <http://www.legislation.govt.nz/act/public/2004/0072/latest/DLM306036.html>
The Headquarters for Earthquake Research Promotion: <https://www.jishin.go.jp/main/index-e.html>
U.S. Geological survey: <https://www.usgs.gov/about/organization>