Non-structural measures to mitigate coastal flooding

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Lessons from New Zealand

Master thesis

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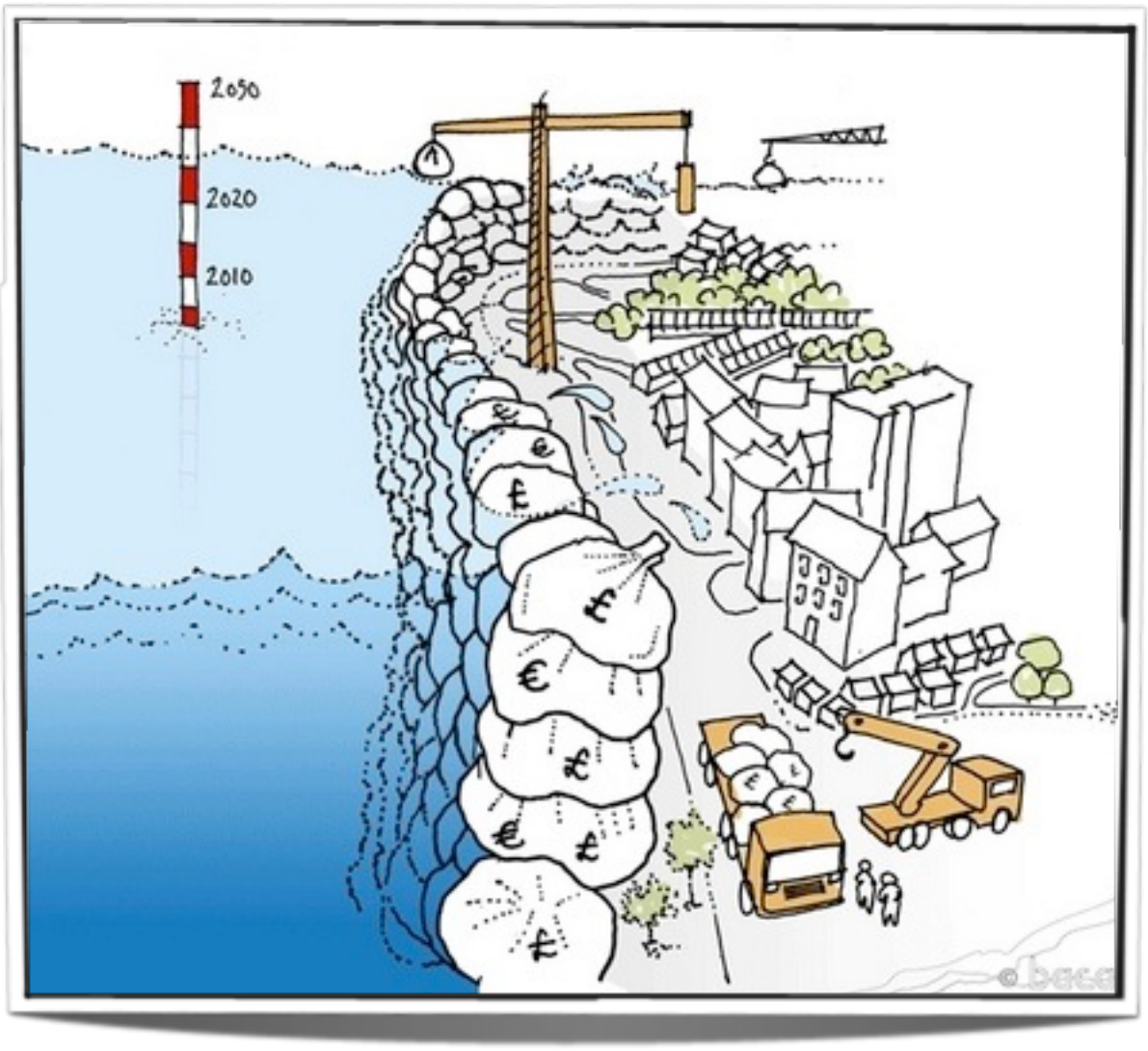
Is this the only solution?



Flood defence cartoon, altered (Building.co.uk 2008)

To Heike
@}-,-`-

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- ✳ Nigel Mark-Brown / Environmental Context Ltd. (Auckland)

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Abbreviations

ARC	Auckland Regional Council
CDEM	Ministry of Civil Defence & Emergency Management / Te Rākau Whakamarumaru
CDEMA	Civil Defence Emergency Management Act
CEM	Coastal Engineering Manual
CHZ	Coastal Hazard Zone
DoC	Department of Conservation / Te Papa Atawhai
EDS	Environmental Defence Society
EQC	Earthquake Commission
EW	Environment Waikato Regional Council
Excimap	European Exchange Circle on Flood Mapping
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Maps
GIS	Geographic Information System
GW	Greater Wellington Regional Council
IPCC	Intergovernmental Panel on Climate Change
MfE	Ministry for the Environment / Manatū Mō Te Taiao
MHWS	Mean High Water Springs
MSL	Mean Sea Level
NFIP	National Flood Insurance Program
NIWA	National Institute of Water & Atmospheric Research / Taihoro Nukurangi
NOAA	National Oceanic and Atmospheric Administration
NRC	Northland Regional Council
NZ	New Zealand
NZCPS	New Zealand Coastal Policy Statement
NZIER	NZ Institute of Economic Research
PWTC	Pacific Tsunami Warning Center
RMA	Resource Management Act 1991
UN	United Nations
UNEP	United Nations Environment Programme
USACE	United States Army Corps of Engineers

Chapter 1
Introduction

1. Introduction

„Floods are natural disasters that have been affecting human lives since time immemorial. Throughout history, nature has shown little respect for man's unwise occupancy of nature's right-of-way and has insured that the message has been clearly understood by sporadically flooding people's properties and taking their lives“ (Andjelkovic 2001).

World wide, coastal zones occupy less than 15% of the earths surface but contain more than 60% of the worlds population (European Commission 2004a, Green 2010). In Europe nearly half of population lives on or close to coastlines (European Commission 2007). In 1998 more than half of the worlds population, about 3.2 billion people lived and worked in areas that are less than 200 kilometres away from the coast. Coastal areas are the world‘s most important and intensely used areas by humans (Kay & Alder 1999). In almost every part of the world the sea coasts are seen as the preferred places to live, work, play and retire because of their boundless economic opportunities and better place of life (Hinrichsen 1999, Green 2010). Green (2010) explains that these places offer a more relaxed lifestyle in an attractive and natural environment with recreational opportunities. 60% of of the world‘s 39 metropolises with a population of over 5 million people are located within 100 km of the coast, including 12 of the world‘s 16 with populations greater than 10 million people (Nicholls et al. 2007). Today the highest population density exists below the 20 m elevation (Church et. al. 2001). The shift of population from the hinterland to the coasts increased after World War 2 because of the internationalization of trade (Hinrichsen 1999). The Unites States Census Bureau (2009) indicates that in 2010 the world has a population of about 6.8 billion people. They estimate a rise to 9.2 billion people in 2050. This means that the population density in coastal areas around the world will rise significantly. It is estimated that by 2020 approximately 75% of the world’s population is living on or near the coast (Green 2010). In Figure 1.01 the

United Nations Environmental Programme (UNEP) (2008) indicates the population density in coastal areas for the year 2008 and the status of the coastal shoreline degradation. Coastal population density and shoreline degradation can be seen in one context. Manmade impacts like drainage of coastal wetlands, deforestation or construction of engineering structures are negative for the natural dynamical shoreline system (Nicholls et al. 2007). Flood hazard is one of the most frequent phenomena in the world (Marfai & King 2008, Kron 2002). Sivakumar (2005) counted for the 10 years period between 1993 and 2002 2,654 natural hazardous[1] events, 70% of them where flood events or windstorms.

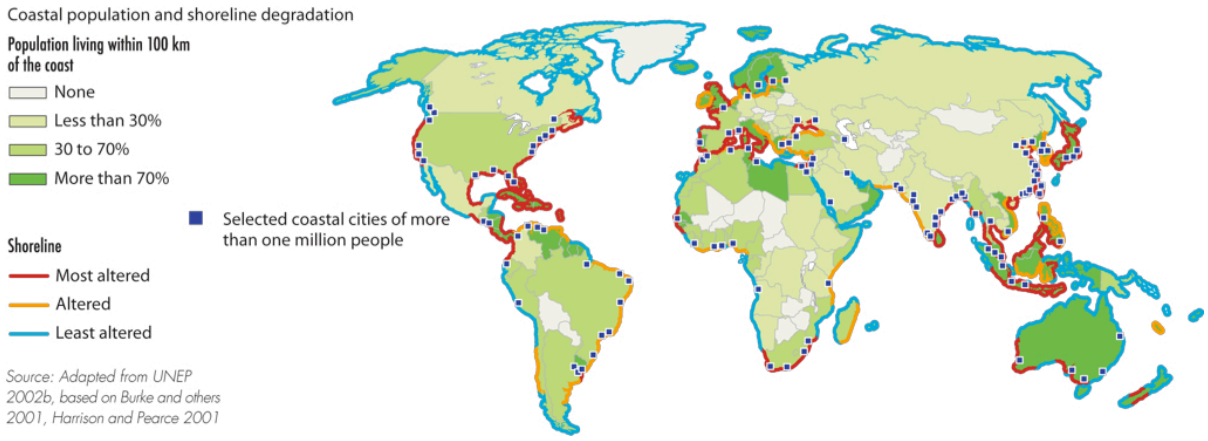


Fig. 1.01: Coastal population density and shoreline degradation (UNEP/GRID-Arendal 2009)

From above it is evident that a large number of the world population lives in areas that can be easily affected by natural hazards and therefore mitigation measures are necessary. In the past many countries used structural protection measures to cope with this hazards. But „local and international experience shows that protective works tend to stimulate development intensification and, paradoxically, increase the risk[2] of a disaster occurring when an event eventually exceeds the design parameters“ (Glavovic et al. 2010b) and „...people feel that the stop banks (embankments) make them feel secure from floods or new entrants to the area are left unaware of past flooding and the function of the stop banks.“ (Ericksen 2005a). This effect is called the safe development paradox (Burby 2006) or levee-effect (Merz et al. 2010).

Both statements make clear that it is not wise to trust only hard protection measures. Strategies to improve the resilience of the coastal floodplain seem to be more

1 Definition: „Natural hazard means any atmospheric or earth or water related occurrence the action of which adversely affects or may adversely affect human life, property, or other aspects of the environment” (Resource Management Act 1991)

2 Definition: „ ... risk is the product of a hazard and its consequences. Where there are no people or values that can be affected by a natural phenomenon, there is no risk“ (Kron 2002)

appropriate (Nehlsen et al. 2007). And even if no absolute flood protection is possible, this measures can reduce major parts of damages (Kreibich et al. 2005, Heidari 2009). According to Hagemeier-Klose & Wagner (2009) precautionary measures are the most effective protection against flooding damages. Kreibich et al. (2005) adds that precautionary measures can reduce the flood damage to buildings of up to 53%. Moreover, non-structural measures are able to minimise the impacts on environmental sensitive areas and can reduce the likelihood of further encroachment to this areas (Hayes 2004).

1.1. The difference between structural and non-structural measures

Structural measures involve the construction of solid structures designed to fix the position of the coastline, they are mostly advanced in engineering, technology and material. The main shortcoming of this measures is that a complete protection against all probable flood events cannot be provided by a designed structure because eventually a flood event will occur which will exceed the assessment threshold of the structure (Rasid & Paul 1987). Faisal et al. (1999) confirm that structural measures alone cannot guarantee flood protection. The use of structural measures is based on the paradigm that focuses on „holding the line“. Andjelkovic (2001) explains that a total flood protection is unrealistic and unwise because the ultimate goal of flood loss prevention is the improvement of the quality of life by reducing the impact of flooding.

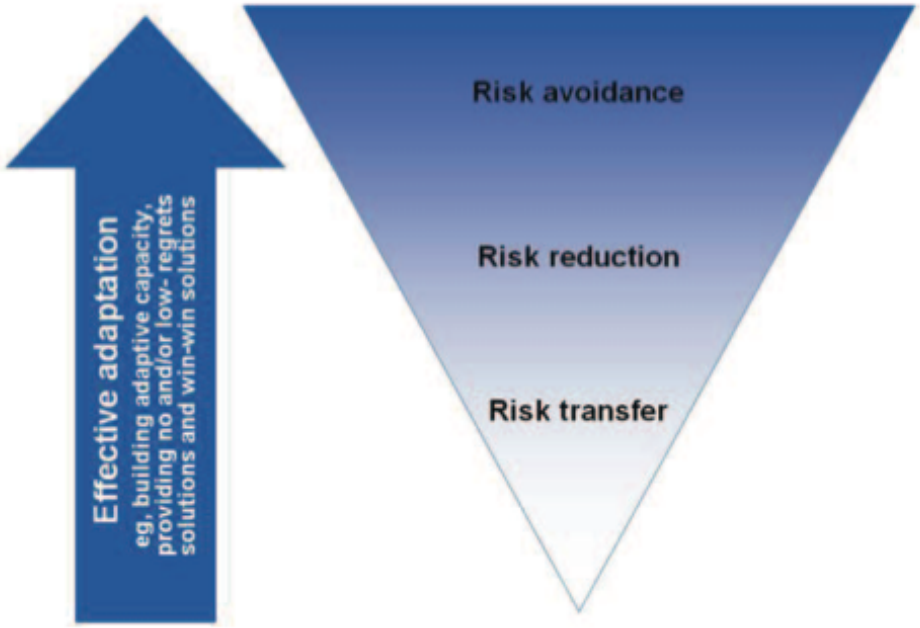


Fig. 1.02: Risk management and the move from structural to non-structural measures (Ministry for the Environment 2008a)

The movement to non-structural measures reflects a shift away from a „humans against nature“ view to a view of managing humans rather than nature (Blackett et al. 2010). Non-structural measures are designed to work with the natural processes (European Commission 2004b). Dhaka City in Bangladesh made the experience that non-structural measures contributed significantly to flood damage reduction (Faisal et al. 1999). But recent hazard events, like floods in New Zealand, showed that communities have the tendency to only focus on hazards when they experience an event or face a direct threat (Glavovic et al. 2010a). A goal of non-structural measures is to raise the public awareness about hazards and the change from a reaction based to a proactive and integrative approach (Associated Programme on Flood Management 2008).

1.2. The uncertainty of the future

The consequences of human induced climate change is hard to predict. Since 1975 the frequency of extreme high sea levels[3] has increased at various sites worldwide (IPCC 2007). Nicholls & Lowe (2004) expect a significant global-mean sea-level rise due to human-induced global warming in the 21st century. As a consequence of climate change and sea level rise the risk failure of structural coastal protection measures (e.g. dikes) will increase and areas behind them will not be safe anymore (Nehlsen et al. 2007). The arguments about the uncertainty about the future show the importance for the use of non-structural mitigation measures against coastal flooding.

The IPCC report (2007) highlights two impacts of future climate changes that are related to coasts. It is secured that the following impacts will happen:

1. Coasts will be exposed to increasing risks (e.g. coastal erosion) due to climate change and sea level rise. This effect will be enlarged by manmade pressure to coastal ares.
2. By the 2080s, many million people more than today are projected to experience floods every year due to sea level rise. The numbers of people affected will be the largest in the densely populated and low-lying megadeltas of Asia and Africa. But also some areas in Australia and New Zealand will see a rise in the frequency and power of coastal flooding.

Nicholls (2004) estimates that in future the number of people that are flooded in a typical year by storm surges will increase 6 times by 0.5 m and 14 times by 1.0 m of sea level rise.

3 excluding tsunamis, which are not induced by climate change

A short summary of climate change and sea level rise reads as follows. Between 1961 and 2003 the sea level rose with an average rate of 1.8 mm. This increase was related to global warming (IPCC 2007). Until the end of this century the models project a sea level rise between 18 cm and 59 cm (see Figure 1.03).

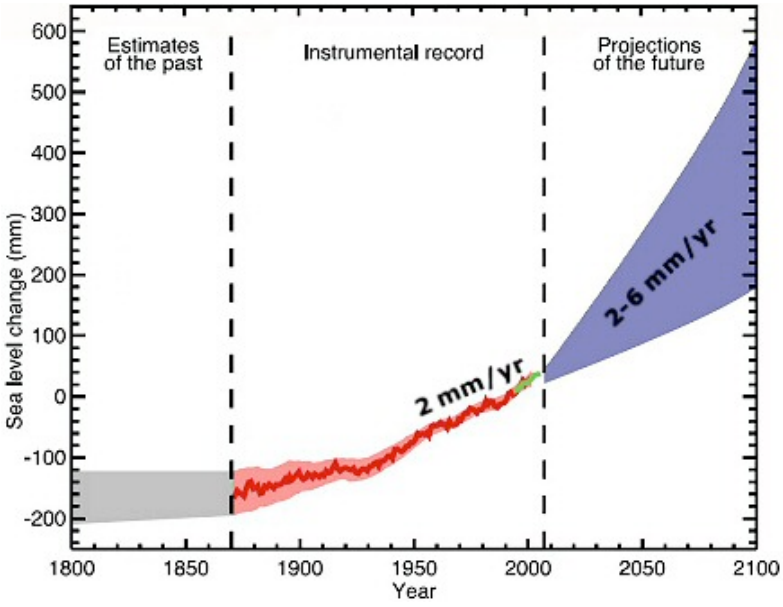


Fig. 1.03: Estimated sea level rise until 2100 (Rijkswaterstaat 2010)

The largest contribution is obtained from thermal expansion of water. The second largest contribution is from melting mountain glaciers and ice caps (Weisse & von Storch 2010). Beyond the 21st century, substantial additional rises of sea level appear to be likely and if climate change continues both Greenland and Antarctica could eventually become significant sources of sea level rise (Church et al. 2001).

1.3. Origins of floodings

„Coastal flooding is a different issue from river flooding, particularly for structures located on the seaward side of a barrier island, where waves riding on top of an elevated mean water level due to storm surge commonly exert damaging forces on the structure“ (Work et al. 1999).

World wide the origins of coastal floods are manifoldly. Coastal storm surges, winds, tides and earthquakes (that create tsunamis) are natural drivers (Petry 2002). Human activities like the disruption of natural protective coastal buffers (e.g. dunes or wetlands), land use change (e.g. the lowering of land through drainage) and human induced climate change are drivers (Environment Waikato 1999, Associated Programme on Flood Management 2008). But failure of manmade structural measures (e.g. dikes) are origins of floods, too (Andjelkovic 2001). Greiving et al. (2006) point out that natural extreme events are part of the natural process and do

not pose any threat to the natural system itself. Glavovic et al. (2010b) argues that the key factors of shaping community exposure[4] to hazards are social conditions and human choices. Environment Waikato (2006) support the argument that human activities and assets combined with natural coastal process create coastal hazards like flooding.

The most frequent hazard in New Zealand is flooding (Glavovic et al. 2010b) and the possibility of experience an extreme hazard event is high (Becker & Saunders 2007). Between 1920 and 1983, 935 damaging floods occurred in New Zealand (McSaveney 2009). Various origins like storms, cyclones and tsunamis create coastal flooding in New Zealand. Low pressure storm systems and ex-tropical cyclones can create waves and higher seas that are added to normal tides creating storm tides (Environment Waikato 1998, Bell & Borman 2007). Storm tide levels are dominated by high perigean-spring tides (Bell 2010a). New Zealand‘s location on the Pacific rim exposes it to a high risk of tsunamis. Tsunamis are generated by great earthquakes from several subduction zones like the Hikurangi-Kermadec zone at the east coast of the North Island and the Fjordland and Puysegur zone at the south-west coast of the South Island. Volcanoes or landslide on the continental shelf can also create tsunamis (Power et al. 2007). The east coast of New Zealand is the most vulnerable area for tsunamis (see Figure 1.04), specially for tsunamis from South America (Berryman 2005). The earthquake with a magnitude of 8.8 that occurred on the 27 February 2010 in Chile caused a tsunami that reached New Zealand. The two biggest recorded wave heights were in Kaingaroa (Chatham Island) with 1.55 m and in Timaru (South Island) with 1.30 m (Bell 2010b). Bell et al. (2000) state that „comparatively little is known in New Zealand about the recurrence intervals of extreme sea levels generated by storm surges, waves or tsunamis because of the paucity of good quality sea-level data of any length“. The Thames region saw in 1995 and 1997 storm surges of 0.6 m with coastal flooding, that caused a damage of 3-5 million NZ$ and acted as a wake-up call for the country. Other extensive coastal flooding and wave overtopping events occurred in the Hauraki Plains (1936), Haumoana / Te Awanga (1974, 2002), Invercargill (1999), Colac Bay (1999) and South Canterbury (2001) (Bell & Gorman 2003, Bell 2010, personal comment). Storm surges with coincidental high tides can vary up to 2-2.4 m MSL (mean sea level) (Bell et al. 2000). A technical publication by the Ministry for the Environment (2009) deals with the problem of climate change and sea level rise and its impacts to coastal hazards in New Zealand.

4 Definition: „ ... the values / humans that are present at the location involved“ (Kron 2002)

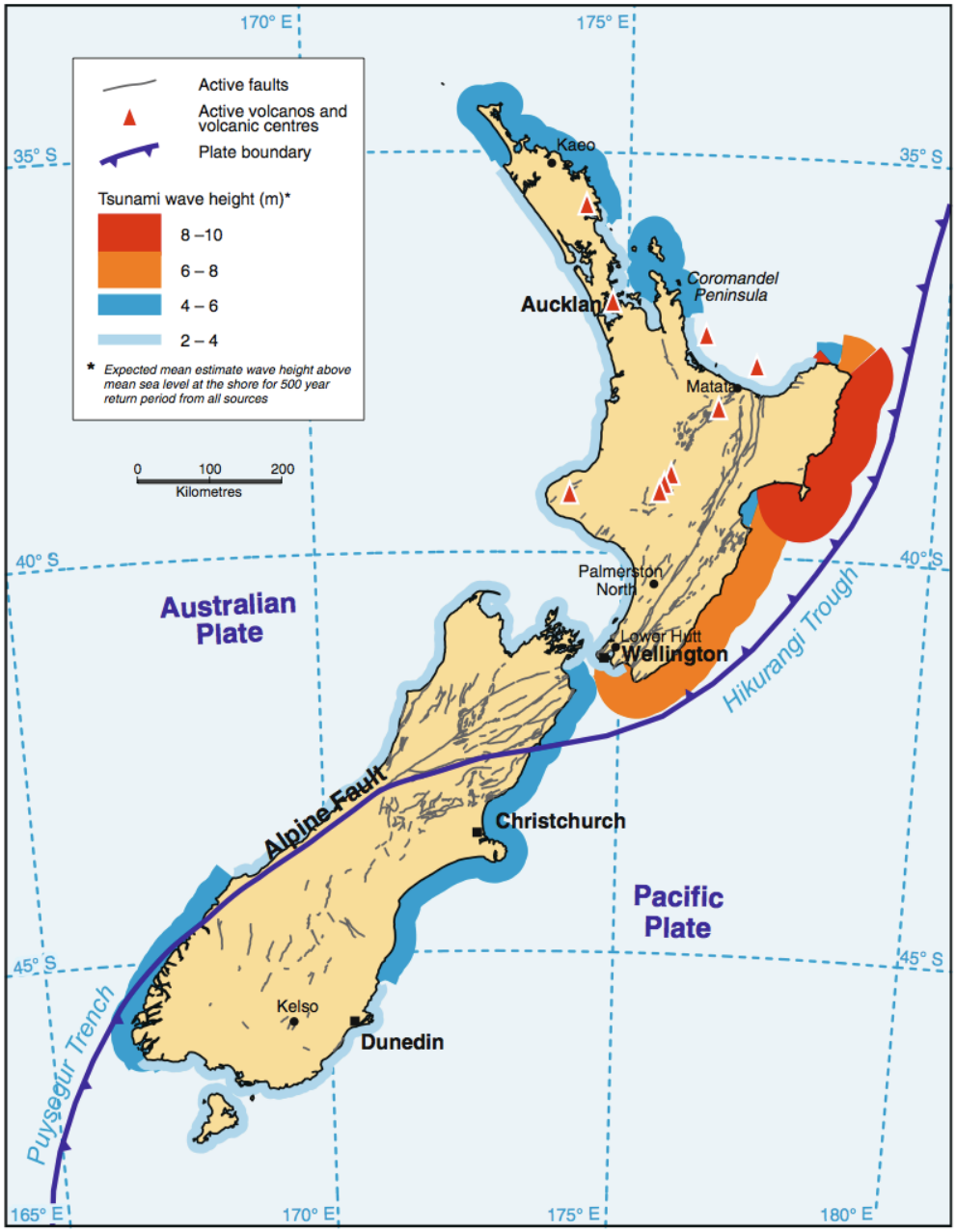


Fig: 1.04: The natural hazards of New Zealand (Glavovic et al. 2010b)

Studies indicate that the frequency and the magnitude of storms will change, that severe storms may become more intense and storm tides are more likely. This factors and the change in the wave climate will increase the probability of coastal floodings accompany with more extensive impacts.

Nevertheless one of the biggest driver for flooding is human activity in hazardous areas (Environment Waikato 2006, Glavovic et al. 2010b). Bell & Gorman (2007) point out that „the growing popularity of a coastal lifestyle and the increasing risk of natural hazards are on a collision course“. At the coasts in the Waikato Region for

example humans use and occupy natural flood-prone areas for agriculture, settlements and transportation (Environment Waikato 1999).

Fig. 1.05: The flooding Invercargill Airport in 1984 (The Southland Times 2009)

The airport of Invercargill / Southland (see Figure 1.05) is another bad example of using flood-prone areas. It is directly located at New River estuary with a tidal influence of the rough Foveaux Strait / Te Ara a Kiwa.

1.4. Research question & Methodology

In this master thesis the author will give an overview of international used non-structural measures that mitigate coastal flooding. New Zealand was selected for a case study because it is very unique compared to other countries in the world. The preservation of the natural character of the coastal environment is a matter of national importance under the Resource Management Act (section 6(a)) and this is why New Zealand has the NZ Coastal Policy Statement. The „coastal environment“ has been considered in many decisions of the Environment Court and it is well established that this area is more than the beach and sea below Mean High Water Springs (MHWS). It also includes those areas inland of MHWS that have vegetation suited for saline conditions, the nearest ridgeline and estuaries. This is relevant to integrated management of coastal hazards as it means that Regional Coastal Plans do not stick to regulating what happens below MHWS. They often direct district plans to provide for particular methods of managing development and thus cross that legal boundary (Crawford 2010, personal comment). The concept of sustainability is the central theme of the RMA that was introduced in 1991 (Resource Management Act 1991). The peoples personal responsibility is a very high commodity in the New

Zealand society and therefore awareness raising about natural hazards and the applying of self protection measures is distinct. The central question in the case study is, what kind of lessons can be drawn from the New Zealand case study for the international perspective and what kind of circumstances are necessary that this particular measure works?

The thesis is divided into two parts. Chapter 2 is the theoretical part about international used non-structural mitigation measures. It is based on literature research from peer reviewed journal articles, scientific books and official governmental publications. The research focus was based on keywords that are directly linked to coastal protection. Therefore everything else was sorted out. The factors that are necessary for a successful implementation will be identified and listed. In the end of this chapter a framework to classify all the non-structural mitigation measures will be developed.

Chapter 3 is a case study about New Zealand and hence the practical part. To gather all relevant informations it was necessary to do field work in place. The International Global Change Centre at The University of Waikato in Hamilton was my host in the months May and June 2010. First a literature research was done, again with the same focus as in Chapter 2, to find all relevant topics and informations. Then meetings with experts from NIWA (National Institute of Water & Atmospheric Research, a crown owned research and consultancy company that is specialised on water and atmospheric research), EDS (Environmental Defence Society, a non-profit environmental advocacy organisation) and independent planning consultancy companies (Planning Consultants Ltd. and Environmental Context Ltd) were setup to get deeper insights to the RMA (their strengthens and weaknesses), the used mitigation measures to coastal flooding and hazard planning.

The factors that are necessary for a successful implementation in New Zealand will be identified and presented. The developed classification framework from chapter 2 is used to compare the international prospect with the local New Zealand one. This will give an easy overview of the used measures.

At the end of this thesis a concluding chapter 4 will:

1. show what lessons can be learned from the New Zealand case study and
2. what kind of circumstances are necessary that a particular measure works
3. give an outlook about what kind of research should be done in future to round up the knowledge about non-structural measures to mitigate coastal flooding.

Chapter 2
Non-structural mitigation measures

2. Non-structural mitigation measures

This chapter will give an international overview of non-structural measures that are used to mitigate coastal flooding. The factors that are necessary for a successful implementation will be identified and at the end of this chapter a classification framework will be developed.

The advantages of non-structural measures are that they do not interrupt the natural processes in the coastal area (European Commission 2004b) and that they are able to raise the public awareness about hazards (Associated Programme on Flood Management 2008). This is because they are based on a proactive and integrative approach (Associated Programme on Flood Management 2008) and many measures can be applied by the people itself as self protection measures.

2.1. Restoration of nature

All measures that are used to enhance the natural resilience of the environment are part of this category. Niedkowski (2000) defines restoration as the re-establishment of previously existing natural resource character and functions at a site where they have ceased to exist, or exist only in a substantially degraded state. The restoration measures serve a double function. Beach nourishment, restoration of coastal dunes and coastal wetlands like mangroves and salt marshes are important natural buffers against floods and erosion. A major question for all restoration projects in the beginning is the question about a reference landscape (Provoost et al. 2009). The morphological response of dunes and wetlands to climate change induced sea level rise is not yet clear. A study by Pethick (2001) about the British coast shows that estuaries, open coasts and tidal deltas respond different to obtain their natural equilibrium. It is likely that dunes in estuaries will move stronger landwards and alongshore if enough sediment is available (Pethick 2001, Psuty & Silveira 2009). At open coasts a migration of salt marshes and dunes from one location to another is likely and therefore a replacement of existing land forms may happen. Tidal deltas seem to expand seawards and longs-shore and create a greater coastal protection buffer (Pethick 2001).

➡ Beach nourishment

Beach nourishment[5] is used since almost 100 years. In 1922 the beach in front of Coney Island[6] in New York was one of the first places where beach nourishment was used (Davison et al. 1992). Today it is widely considered that beach nourishment is a better alternative compared to the construction of hard measures to protect the coast against erosion (Adriaanse & Coosen 1991, Hanson et al. 2002). It is the most widely used method to cope with coastal erosion in the USA. Between 1923 and 1999 more than 573 nourishments were done at 154 locations on the east coast of the USA, a significant increase occurred in the 1970s. This is a result of adapting new legislations and the shift from hard coastal protection measures to soft measures. Approximately 267,594,200 m^3 sand were used for the nourishments (Valverde et al. 1999). Adriaanse & Coosen (1991) explain that beach nourishment is not „only more flexible but also offers potential benefits in terms of safeguarding the environment and the provision of improved recreational facilities“. Beach nourishments neutralise the effects of structural erosion problems. It is designed to treating the symptoms and not curing the disease (van de Graaff et al. 1991). Another two reasons of beach nourishments are protection against flooding and maintain a wide recreational beach (Verhagen 1992). Spybroeck et al. (2006) conclude that beach nourishment is the most ecologically coastal defence alternative available.

Fig. 2.01: Large scale beach nourishment in Ocean City, Maryland, USA (Rutgers University 2010)

5 or beach feeding

6 Coney Island is the place of New Yorks famous amusement park

To avoid negative impacts and to keep the coastline unchanged it should be repeated every 5-10 years (van de Graaff et al. 1991, Kelletat 1992) and this is often seen as a major disadvantage. To refuse this argument van de Graaff et al. (1991) argue that regular maintenance of houses or bridges (e.g. painting to conserve the value) is never seen as a waste of money. In their view some beaches need maintenance as well and compared to other coastal defence measures it is very effective and cheap. At the German North Sea coast for example 1,000,000 m^3 sand reach for more than 1 km coastline (Kelletat 1992). To achieve the optimum results the sand for the nourishment should have at least the same grain size as the native on. A slightly coarser grain size is moreover preferable (Davison et al. 1992, Hanson et al. 2002). Davison et al. (1992) made a literature review with annotations. The following aspects can be liberated from the article. A slightly coarser sand has the advantage that less material is necessary to fill up the beach. The performance is also improved because the beach is more stable and less erosion occurs. But coarser sand has also a disadvantage. Through wave action it can be accumulated in the swash zone, the most important biological zone, there it can have negative impacts on invertebrates (Peterson & Bishop 2005). If the borrow material is smaller then the native one, erosion will incline. Different sources for filling material are available. The USACE (2008) distinguish in their Coastal Engineering Manual (CEM) four different sources: terrestrial, backbarrier, offshore and navigation channels. Terrestrial sources are widely found on coastal zones. It is a cheap source but adverse impacts to coastal area occur very often. Material from navigation channels can be suitable if it is not too much contaminated. The source is very cheap because it has to be either dredged to maintain the functionality. Backbarrier or near shore sources are cheap because of their short transportation distances but the grain size is normally too small and dredging in this area has massive negative impacts to flora and fauna. Dredging offshore is the best solution even if the transportation costs are higher. Offshore sources contain usually large volumes of coarser material with uniform characteristics.

Beach nourishment is only effective if the following factors are considered in advance:

1. It can only be done in areas where beaches occur naturally.
2. It must be repeated every 5-10 years to avoid negative impacts to the coast.
3. Enough feeding material should be available, preferably slightly coarser sand from near distance sources.

➡ Restoration of coastal dunes

Coastal dunes are distributed worldwide with a variety of forms. They offer a broad range of ecological, geomorphological, geological, historical, archaeological and scenic values (Heslenfeld et al. 2008). Coastal dunes are also highly valuable multifunctional ecosystems that offer a wide variety of microhabitats (Martínez et al. 2008). But they are drastically altered through people‘s exploitation and coastal development (Provoost et al. 2009). Today the restoration of coastal dunes with vegetation is widely used to counteract coastal erosion and restore the natural coastal buffer because is a very efficient measure at a low cost (de Lillis et al. 2004).

Fig. 2.02: Dune restoration by planting sand-binding species, altered (DoC 2008)

Suitable vegetation for restorations are grasses, scrubs or woods. For example the Marram grass[7] is world wide the most common plant species to protect coastal dunes (Esler 1970, van der Putten & Peters 1995). Pre-grown seedlings are planted

7 *lat. Ammophila arenaria*, also known as European Marram Grass and European Beachgrass

to trap the wind-blown sand and stabilise the sand substrate (Esler 1970, van der Putten & Peters 1995, Nordstrom et al. 2009). The establishing of vegetational stands takes normally 5-10 years (Hewett 1970). In the beginning of the restoration process, semi permeable fences (see Figure 2.03) can be installed to increase the sand trapping efforts.

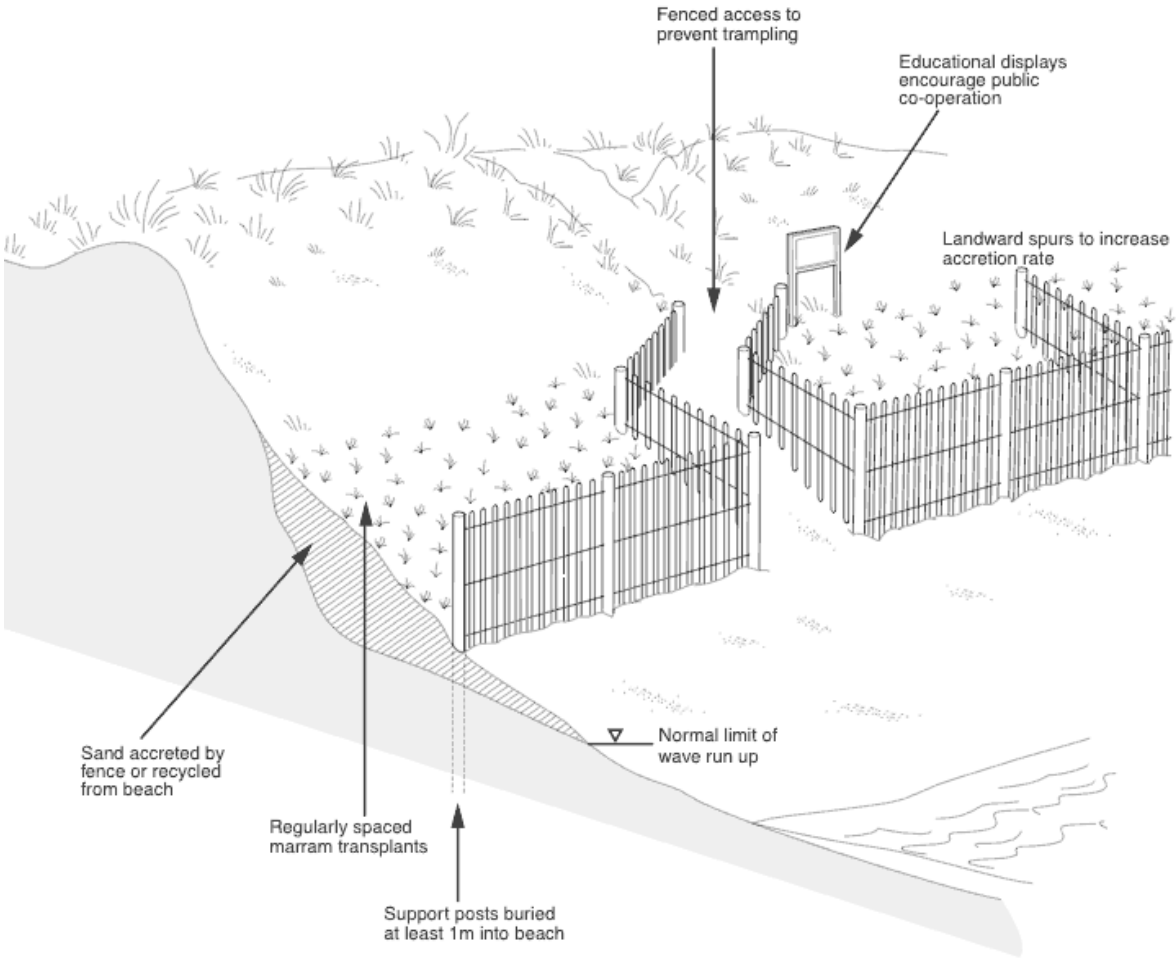


Fig. 2.03: Scottish method of fencing to stabilise dunes (Scottish Natural Heritage 2000)

Nevertheless future dune management will require creativity and multiple approaches to deal with the uncertainty of climate change, the human pressure and negative vegetation development trends. Many countries for example try to eliminate the widespread Maram grass because it is a introduced plant that creates monocultural problems. It is replaced by native species that have the same features (Martínez et al. 2008). Few authors (Martínez et al. 2008, van der Meulen et al. 2008) argue that the goal of modern dune management should be the natural restoration (less vegetation) and not stabilisation of sand dunes because stabilisation is extremely costly and has a lot of negative effects to natural processes (e.g. prevention of natural sand movement). Clarke & Randell (2010) counter their argument and explain that most of the todays stabilisation measures are long-term investments with a

historic seriousness of sand drift problems. From their point of view a shift to a more dynamic management approach with less vegetation and more naturalness is unwise and costly. Provoost et al. (2009) agree with them and explain that destabilisation is not recipe to cope with future challenges.

Coastal dune restoration is only effective if the following factors are considered in advance:

1. Semi permeable fences should be installed at the beginning to trap sand.
2. Pre-grown seedlings are more robust and will increase a successful restoration.
3. To avoid monocultural problems a mix of different plants is favourable especially native ones.

➡ Restoration of coastal wetlands

Coastal wetlands protect the populated areas from erosion, storm surges, tidal waves and floods. The wetland boundaries indicate the extent of normal flooding and therefore the zone where human development should not be permitted (Ewel et al. 1998). Mangrove forests and salt marshes are typical representatives of coastal wetlands.

Fig. 2.04: Salt marsh on the East Friesian Islands, Germany (Niedringhaus 2008)

Salt marshes are situated in temperated climate and occupy the intertidal zones of moderate to low energy shorelines along estuaries, bays and tidal rivers. They are

important areas for shoreline protection, seasonal wildlife, fishery nursery, primary production and nutrient cycle (Broome et al. 1988, King & Lester 1995, Williams & Faber 2001). The vegetation consists primarily of grasses, sedges and rushes (Broome et al. 1988). Even if salt marshes are recognised as valuable systems and therefore protected by various legislations they are under treat from agricultural, commercial, recreational use or diking (Broome et al. 1988, Teal & Weishar 2005). In the southern part of the North Sea for example over 90% of the salt marshes are diked or in anthropogenic use (Reise 2005). But the de-embanking of salt marshes for restoration purposes is know widely considered (Wolters et al. 2005). Barkowski et al. (2009) conclude in their study that salt marsh restoration is a long term process. Even if a few years after de-embankment the zonation of the salt marsh is re-established, it will take much longer to obtain the species richness and composition of a natural salt marsh. According to Weinstein et al. (2001) four conditions have to be met by possible areas for a successful restoration:

1. „Appropriate marsh plain elevations, groundwater and tidal relationships“
2. „the presence of plant propagules (seeds, rhizomes, larvae, etc.) in the restored marshes or neighbouring marshes“
3. „fauna that would populate the marshes from nearby populations“
4. „sediments of appropriate organic and nutrient content in tidal waters inundating the sites“.

For a better success of salt marsh restoration Broome et al. (1988) suggest to use pre-grown plants instead of sprigs or plugs because of the better moisture retention capacity.

Fig. 2.05: Mangroves at Baie D'Ambodi-Vahibe, Madagascar (Zumbrunn 2010)

Mangrove forests are situated in tropical climate and occur in about 90 countries around the world (Field 1998). Mangroves cover around 180,000 km² of tropical coastal areas (Grommbridge & Jenkins 2002). They provide different goods and services to the people and the nature like protection against flood, trapping of sediments and hence protection against erosion, act as an animal habitat or deliver plant products (Ewel et al. 1998). Data from India suggest also that man-made structures are less destructed by tsunamis if they are directly located behind extensive mangroves (Alongi 2008). An experiment by Harada et al (2002) showed for example that a mangrove forest has the same effectivity as a concrete seawall to protect houses against tsunamis. Even if the importance of mangroves for the vitality of coastal areas is widely accepted they are under threat (e.g. clearance of space for shrimp or fish farming). The average annually deforestation rate lies at 1-2% (Alongi 2008). The degenerated land is mostly not suitable for the proposed land use. This has started a world wide movement to restore mangrove forests. A study by Field (1998) has shown that only 20 of the 90 countries that contain mangroves have started to replant mangrove scrubs and trees. From the 20 countries only nine have planted more than 10 km² since 1970. But in this countries it is evident that the restoration of mangroves has high success to protect and stabilise the coastal zone again.

Restoration of coastal wetlands is only effective if the following factors are considered in advance:

1. The selected area must meet certain conditions (for salt marshes see Weinstein et al. 2001).
2. Pre-grown seedlings are more robust and will increase a successful restoration.

2.2. Spatial planning & Policy making

„How we use land is a powerful determinant of our vulnerability[8] to hazards. Building near bush, on floodplains or on foreshores creates vulnerability.“ (Keys 2010).

„Land use plans enable local governments to gather and analyze information about the suitability of land development, so that the limitations of hazard-prone areas are understood by policymakers, potential investors, and community residents.“ (Burby 1998)

Spatial planning can effectively reduce flood risks and losses from floods by the regulation of land use (Burby et al 1999, Pilon 2002, Böhm et al. 2004). Zoning and building codes are two main measures that are available in spatial planning to regulate the land use and the mitigate the impacts of floods (Ericksen 2004, Greiving et al. 2006). Significant damage can be eliminated by moving urban development into hazard free areas. If the avoidance of hazard prone areas is not possible, then modification of buildings and / or location design is able to reduce damage (Burby et al 1999). Planners can use two approaches to cope with natural hazards in planning:

1. stand alone hazard mitigation plans or
2. hazard mitigation as one component of a broader comprehensive plan.

Both approaches have advantages and disadvantages (Burby et al 1999, Godschalk et al. 2003). If hazard mitigation is undertaken in a stand alone plan, then the advantage is that the plan has greater technical details but this can lead to an increased development in hazard exposed areas because it makes this areas safer. On the other hand if hazard mitigation is part of a broader comprehensive plan then the plan has not too many technical details but the advantage is that more topics are united to shape a broader array of goals that can incorporate together. A second advantage is that public participation on broader plans is in general greater (Burby et al. 1999).

8 Definition: „ ... the lack of resistance to damaging / destructive forces“ (Kron 2002)

A general problem for planners is to generate high levels of public participation for hazard mitigation planning. But public participation is very important because otherwise citizen will not understand why hazard mitigation is important and the plan will fail. A study by Godschalk et al. (2003) compared the involvement and participation of the public into natural hazard mitigation policy making in Washington and Florida. The central question was why it is particularly difficult to generate high levels of public participation in making plans to reduce the dangers of natural hazards. The study showed that the right planning approach is essential for the participation of citizen. The top-down approach in Florida for example restricts the involvement much more then the bottom-up approach in Washington. They conclude that the interest of the public can be raised by hazard education programs, connecting hazard planning with other comprehensive plans, connecting hazard policies with quality of life concerns and preparing small area plans.

➡ Zoning / Development restrictions

The human occupation of hazard-prone areas has resulted in skyrocketing disaster costs in the last decade (Kunreuther 2006). This is a reason why zoning and development restrictions for flood-prone areas are effective measures prevent housing or minimise the density of development in this hazardous areas (Burby et al. 2001, Becker & Saunders 2007).

Areas that are exposed to flooding could be suitable for agriculture (Pilon 2002) or parklands for recreation instead of dens housing (Ericksen 2004). Böhm et al. (2004) suggest a similar two-zone concept:

1. priority zones, that are designated as flood plains, new housing or industrial development must be not allowed
2. reserve zones in that housing and industrial development could be allowed with certain restrictions or constructions requirements.

In the USA for example, flood zone categories are based on risk and inundation (Faisal et al. 1999). But zoning has also one essential side-effect. If zoning is applied to restrict development in hazardous areas, it is very likely that development and population density in non-hazardous areas will increase and therefore the vulnerability there (Burby et al. 2001).

Bin and Polasky (2004) compared different studies about house prising in flood-prone areas. They found out that if a property is located in a flood-prone area then its value is in average 4 to 12 % lower then in non flood-prone areas. Another study by Bin and Kruse (2006) could only verify this results for buildings on riverine floodplains

and not for coastal floodplains. It seems that the hazard risk to buildings in coastal areas is not reflected by the real estate market because coastal amenity values overwhelm them.

Zoning / development restrictions are only effective if the following factors are considered in advance:

1. It must be clear what the main activity in the selected zone will be without any exceptions otherwise the zoning concept will be watered down.
2. If development is allowed, does a building has to meet certain standards like some kind of flood proofing? If yes this requirements should be added as an obligation to the building permit.

➡ Development setback

Coastal setbacks are designated to prevent further housing and development (Alhorn 2009). They act as a buffer to protect the shoreline against development (Sanò et al. 2010) and to protect property against erosion and flooding (Environment Waikato 2002). In front of setback lines no important investments in infrastructure or buildings should be allowed (van de Graaff et al. 1991). Existing buildings can be relocated landwards to minimise the risks or can be bought by the government to abandon them.

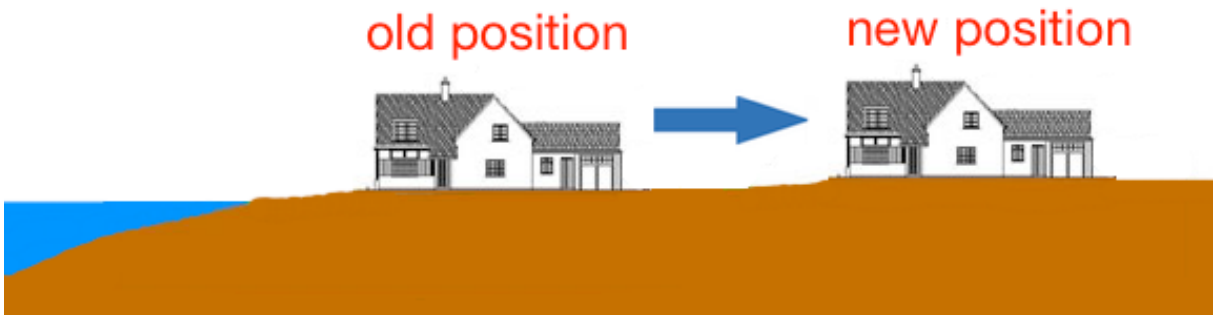


Fig. 2.06: Property setback for flood protection, altered (Environment Agency 2007)

Stutts et al. (1983) explain that the minimum setback is measured landwards from the seaward line of the stable dune vegetation and that the safety of a building increases if it is located further landwards. Setback distances must be based on the understanding of the local coastal processes to generate the minimum distance (Komar et al. 1999). Today coastal setbacks are used in many countries around the wide, e.g. Australia, France, The Netherlands, New Zealand, Spain or the USA (Sanò et al. 2010).

Development setbacks are only effective if the following factors are considered in advance:

1. It must be clear on what kind of event (e.g. a 100 years flood or a 500 years flood) the setback is based. This will determine the minimum setback distance.
2. The setback distances must be added to the building permits for new buildings.

➡ Flood proofing of houses

Gersonius et al. (2008) states that „private precautionary measures have a significant potential to safeguard buildings and contents from flooding“ even if „data on the costs and effects of such measures are rare, and consequently, the economic efficiency of different technologies is unclear.“. Flood proofing of houses can be done in four different ways: elevating of houses, dry proofing of houses, wet proofing of houses and floating houses (Gersonius et al. 2008, Hayes 2004, Nehlsen et al. 2007). Mostly, flood proofing is done as a retrofitting measure for existing houses. A study from the USA by Work et al. (1999) showed that flood proofed and / or supra-elevated houses are able to get a flood insurance discount but the real estate market did not show any clear signs to value the protection measures yet.

Dry proofing:

Dry proofing prevents water from entering the house.

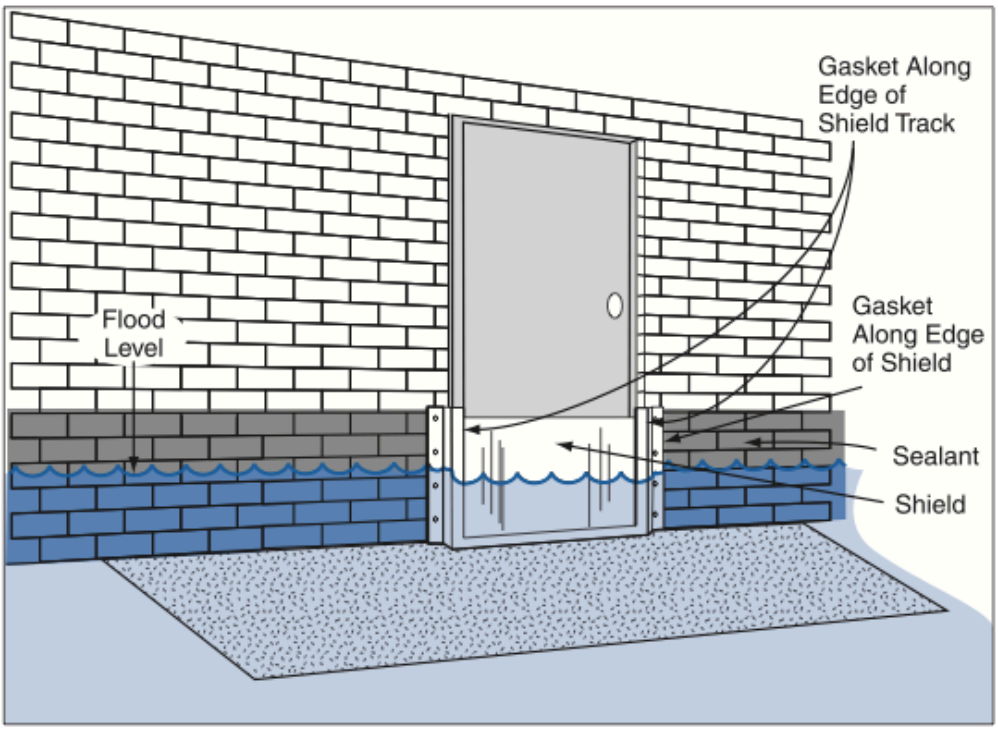
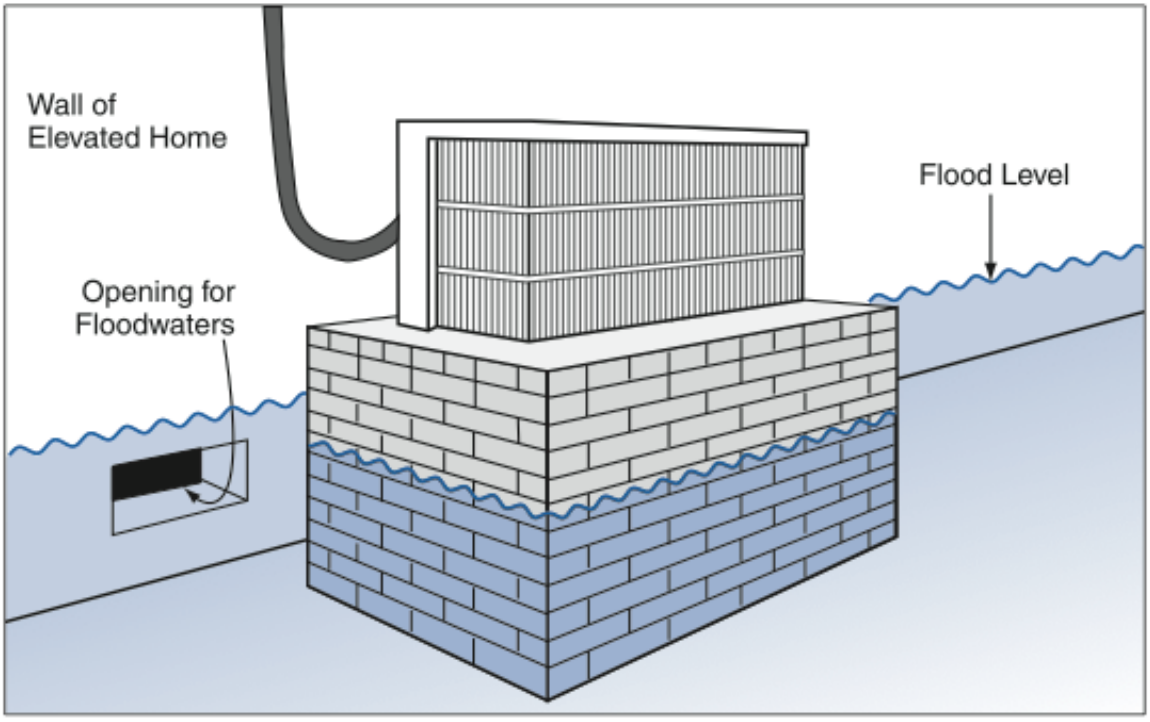


Fig. 2.07: Dry proofing of buildings, example of the wall and door (FEMA 2009)

This can be done by sealing of walls, enclosure of openings that are below the flood line or building small levees or flood walls around the house (Hayes 2004, FEMA 2009). A general problem of flood proofing is that buildings are exposed to hydrostatic pressure that will even increase the damage if the construction indulges (FEMA 2009).

Wet proofing:

Wet proofing allows water to enter the house. Two types of wet proofing can be done, the lowest floor of house is elevated above the flood line and the water only enters the enclosure of the building or the water can enter to the whole building (FEMA 2009). Then all important installations (like fuses, power outlets or the heating system) are elevated to higher grounds or enclosed by flood walls to protect them from water that may enter the house. Normally the 100 year flood[9] elevation is used as a indictor for the design of this measures (Hayes 2004). Special floor covering or wall material can be used to minimise the impacts of water.



*2.08: Wet proofing of buildings (*FEMA 2009*)*

Work et al. (1999) note explicitly that wet proofing is not suitable for coastal floods because of the potential of high loads to the structure and the saline water that

9 Definition: „ A so-called 100-year flood does not mean that there is exactly one flood of this size every 100 years. It means that there is a 1 in 100 chance in any given year that a flood of this size or bigger will happen“ (McKerchar & Smart 2007). This means for a 100 year period that there is a chance of 63.6 % of occurring (Bell 2010, personal comment).

increases the cleanup costs and the potential for corrosion. It is only suitable for fresh water floods like rivers and lakes.

Supra-elevating of buildings & residential areas:
Normally the 100 year flood elevation is used as a indictor for the design of elevating measures (Hayes 2004). In The Netherlands the use of artificial hills for buildings or complete residential areas is a common measure (Neuvel & van den Brink 2009). The elevation of buildings on stilts is a common measures in the USA. If a new house is build in a mapped floodplain, the Federal Insurance Administration requires that it is elevated above the 100 year flood (Holway & Burby 1993).

Supra-elevating of buildings can be done in two ways:

1. new buildings can be constructed on stilts or artificial hills or
2. existing buildings can be elevated to stilts.

Fig. 2.09 : Supra elevated house in Mississippi, USA (Harris 2007)

Floating homes / Amphibious homes:
Floating or amphibious houses are lightweight constructed houses. They are in general based on a hollow concrete or polystyrene concrete foundation to provide enough buoyancy (de Graaf 2009). Vertical piles, horizontal guide posts or ropes can be used to anchor them to land and hold the position. This types of homes could be a good solution, especially for densely populated countries like The Netherlands, to cope with flooding problems, urban expansion and sea level rise (ClimateWire 2009).

Fig. 2.10: Amphibious homes in Maasbommel, The Netherlands (Ecoboot 2007)

In his PhD thesis de Graaf (2009) reports also from floating infrastructure like roads and small scale floating gardens that were developed in The Netherlands.

Flood proofing measures are only effective if the following factors are considered in advance:

1. For new developments the measures must mentioned in the building permit as a requirement.
2. For existing buildings governmental incentives or insurance discounts after a successful retrofitting would help to minimise risks.

Especially for floating homes / amphibious homes the following circumstances must be considered:

1. appropriate building material and appropriate anchoring methods to prevent moving.
2. Special areas should be designated for this homes to prevent them from negative impacts from navigational channels (e.g. wash or eddy water).
3. Are they build according to standards for terrestrial houses or according to standards for vessels? This makes a hugh difference in the technical requirements.

➡ Insurance cover

The availability of flood insurances on the private insurance market is very limited. For example home owners insurance in Australia and the Netherlands exclude flood risks (Browne & Hoyt 2000). In Germany flood risks are partly excluded (e.g. coastal storm floods and tsunamis) from home owners insurances (Lührßen 2010, personal comment). In the USA a nation wide flood insurance cover is available from the national flood insurance program (NFIP). The actual flood insurance premiums are based on the real risk level. The risks for a certain area can be found in the flood insurance rate map (FIRM) (Work et al. 1999). But in general it can be said that if a special flood insurance cover is available then the insurance companies have the problem to determine the right insurance premium. Several uncertainties still exist about the estimation of the chance that a certain disaster occurs in a specific area (Kunreuther 1996). This means translated to flooding hazards that a determination of an accurate flooding zone and the flood damage risk is difficult (Faisal et al. 1999).

Insurance cover is a tool that has limited effectiveness to mitigate flood losses. Several US American studies show that affordable flood insurance does not prevent the building and living in flood-prone areas, on the contrary it stimulate the building in flood-prone areas and act as a incentive to do so (Burby et al. 1999, Burby 2001, Burby 2006). According to Burby (2001) a insurance is only effective tool „If property owners are required to purchase flood insurance at actuarial rates that reflect flood risk and if risk is reduced through regulations that require the elevation of new construction in floodplains and avoidance of development in floodways, the added costs of construction in the floodplain should dissuade uneconomic uses from locating there“.

Flood insurances are only effective if the following factors are considered in advance:

1. The responsibility between the public and the private must be clear.
2. In certain areas a flood insurance must be a requirement to reduce risks.
3. Flood insurance must cover the real costs to prevent building in highly hazardous areas.
4. An insurance discount could be given if a home owner applies flood proofing measures. This would work as an incentive.

2.3. Risk communication

Ericksen (2005b) points out that a liberal democracy needs a comprehensive information and education programme, if it should deal effectively with flood problems. So risk communication can be used as an education tool to strengthen people‘s risk awareness because only hazards and risks that are known can be

mitigated (Greiving et al. 2006). In the first step the public should be educated, but in the second step this education should be used to build a flood resilient community (Dufty 2008). This is the reason why one very important goal of risk communication and education is to bring the people to the point that they start to think themselves about personal safety measures and actions that can be done to protect their property and family. Risk communication informs about flood risks, flood protection and personal safety measures (Hagemeier-Klose & Wagner 2009).

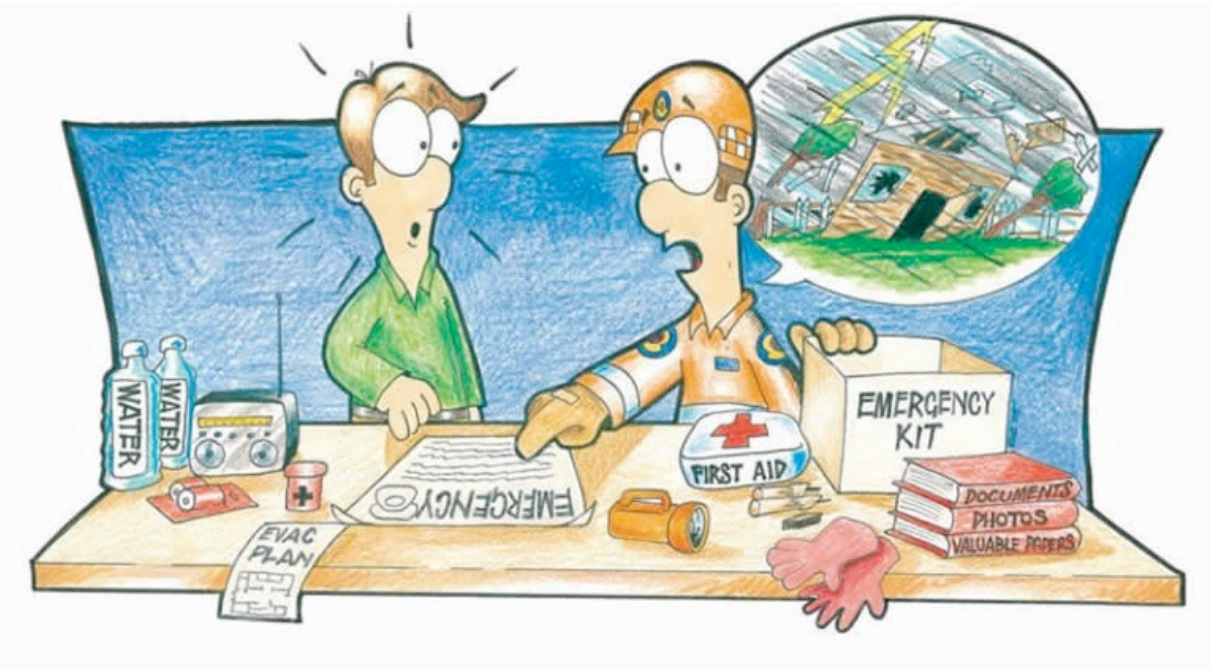


Fig. 2.11: Risk communication (State Emergency Service 2007)

As illustrated in Figure 2.11 personal safety measures include emergency household plans (e.g. where are the valves for water and fuel or what interior should be relocated to higher grounds), emergency survival kits (e.g. enough food to survive several days without contact to the outside) and getaway kits (e.g. know what kind of official documents are very important and where they are). Several countries and / or federal states or regions within a country published printed and online available booklets with informations about personal safety measures. A few examples of this booklets are:

Country / Region	Title
Australia / New South Wales	Home Emergency Kit
New Zealand	Get ready get through
New Zealand / Wellington Region	IT's EAsY Get prepared for an emergency

Country / Region	Title
United Kingdom	Preparing for emergencies
Germany / Schleswig-Holstein	Sturmflut – wat geiht mi dat an?

Tab. 2.01: Examples of personal safety measure booklets

In Appendix A.4. the complete „Get ready get through“ booklet is available. It contains not only floods but also storms, earthquakes, etc...

➡ Emergency management

Emergency management is designed to protect life, reduce the damage to property, the environment and decrease the loss of valuables. According to Rodrigues et al. (2002) emergency management or risk management is based on three cyclic phases: (1) Risk mitigation (green), (2) Response (red) and (3) Recovery (blue).

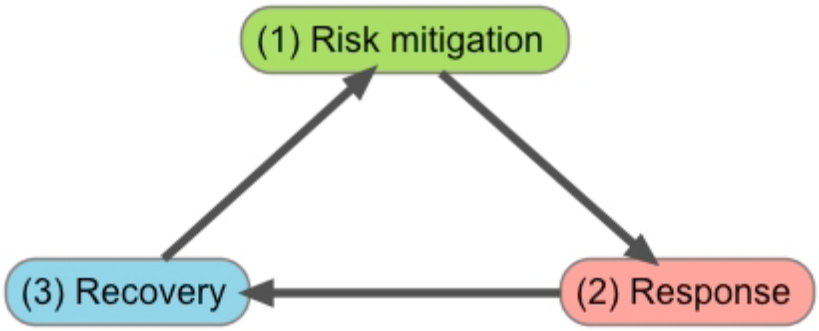


Fig. 2.12: Three cyclic emergency management circle

Step 1, risk mitigation, is the precautionary measure that is described in this chapter. Step 2, response, in the case of coastal flooding includes, the disseminate of warning messages, flood fighting and evacuation. Step 3, recovery, as name indicates includes the general clean up, the rebuilding of houses and infrastructure and the evaluation of the used measures to learn for the future.

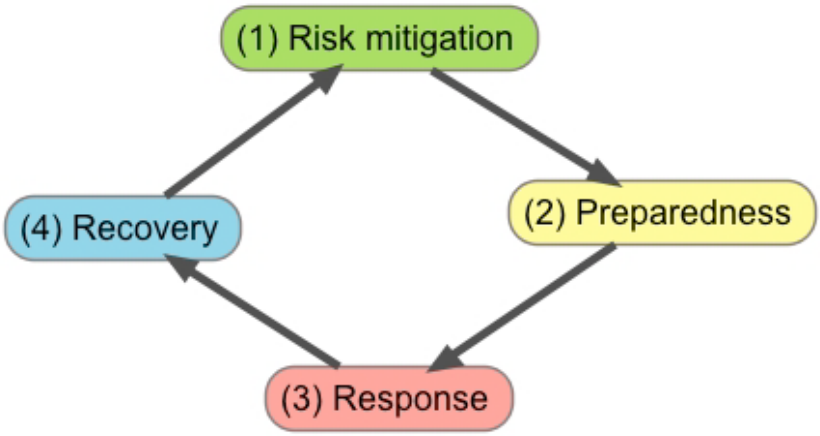


Fig. 2.13: Four cyclic emergency management circle

Rodrigues et al. (2002) mention also that some authors use a four cyclic emergency management circle. In this case number two the response is divided into preparedness and response.

Emergency management is only effective if the following factor is considered in advance:

1. Every step should be well designed with clear responsibilities.

➡ Mapping

Flood maps[10] are used to identify flood-prone areas (Pilon 2002). They contain informations about flood parameters like the probability, the magnitude, extend or depth (de Moel et al. 2009). Flood maps have a great value as a educational and communicational tool (Pilon 2002) and can be used to determine evacuation routes. They should be well designed and associative to create awareness and improve the knowledge level. If so, they can encourage people seek for further informations (Hagemeier-Klose & Wagner 2009).

Risk maps contain additional informations compared to hazard or flood maps. They are designed to show potential adverse consequences like the affected people or the economic damage (Hagemeier-Klose & Wagner 2009, de Moel et al. 2009). They can serve as a basis for spatial planning, emergency planning, hazard assessment and planning of protection measures (Eximap 2007).

10 also called Hazard Maps

Mapping is only effective if the following factors are considered in advance:

1. Accurate scientific data about hazards must be available.
2. Maps should be well designed with associative colours that the public is able to understand them very easily.

➡ Warning systems

Warning systems are complex systems and do not consist in a single set of action. They are rather a process or holistic system that start with the identification of a flood and end with an effective response. All groups and organisations that are involved, like collection of water related data, meteorological forecast, dissemination of informations and providing help, form together the warning system (Handmer 1988, Penning-Rowsell et al. 2000).

The prediction, detection and forecasting of floods has, thanks to modern near realtime weather- and tide-monitoring instruments, improved in the last 20 years (Sorensen 2000, Sene 2008). But it is still necessary to give more attention to the design of flood warning, forecasting and response systems, all matched to the needs of the public and the professionals (Penning-Rowsell et al. 2000). Warning messages that are spread over radio, television, newspapers or internet should be well designed and comprehensive to meet the needs of the public. Handmer (1988) explains that „People must be able to relate the warning to their situation“ he found out that 80% of its the surveyed flooded residents preferred the most detailed message instead of the vague one that was used.

To improve the technical natural-hazard warning system Leonard et al. (2005) suggest that „staff response and thus training must be designed within the wider context of effective warning systems: early warning and notification, response planning, discussion and communication, education, training and signs, simulation exercises, underpinned by hazard research and effectiveness evaluation“. This is why Keys (2008) suggest a total flood warning system that combines the following measures to enhance the quality and make it more comprehensive.

1. Prediction

   Prediction is a very theoretical aspect. It contains the flood forecasting as technical component. It is based on data-collections and modelling to predict the different (e.g. flood peak) stages.
2. Interpretation

   Interpretation contains the flood prediction and determines what area can be inundated in a horizontal and vertical dimension. This dimension of a flood warning system can be understood by the community. It also

contains the local flood information records from past floods that can give an overview of what can happen.

3. Message construction
   This is a very important aspect because often messages are jargonistic and bureaucratic and fail to transport the essential message. The used language should be simple but evocative. The message should describe the possible flood, what kind of effects could this mean and what kind of precautionary measures should be done.
4. Communication
   For common and lesser flood events a broad warning over radio or television as an information might be enough but for server floods with bigger impacts may require specifically target warning messages. This can be distributed via a range of channels like printed and electronic media or personal delivery. The appropriate channel is based on the time frame that is available. If a evacuation is necessary, door knocking should be considered to personalise the message and get the feedback if the message was proper understood.
5. Review
   Flood warning systems are an ongoing process with intensive and less intensive activities. All phases must to be reviewed to find weaknesses and deficits. Only then the phases and process can be improved.

Warning systems are only effective if the following factors are considered in advance:

1. Every step should be well designed with clear responsibilities.
2. Warning messages for the public must be designed in a way that they are easy to understand (no technical terms or bureaucratic language).
3. The messages should be personalised and comprehensive.

2.4. Classification framework

From the presented measures in this chapter a classification framework can be developed. The classification can be divided into three main categories (see Figure 2.14).

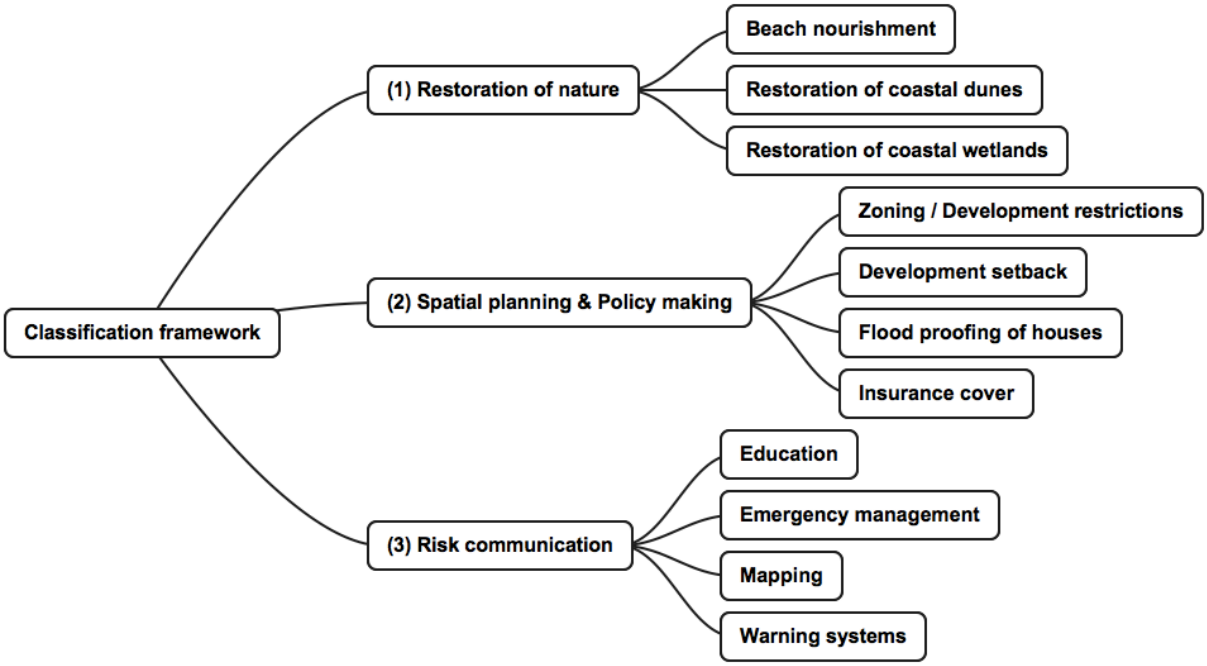


Fig. 2.14: Classification framework of non-structural measures to mitigate coastal flooding

The three main categories restoration of nature, spatial planning & policy making and risk communication were chosen because they all target a different but very important field.

In the category 2 (spatial planning & policy making) flood maps and risk maps were merged together. This was done because risk maps are based on flood maps. The difference is that they contain more detailed data.

Chapter 3
New Zealand

3. New Zealand

In this chapter a research about New Zealand‘s non-structural measures to mitigate coastal flooding will be done. The factors that are necessary for a successful implementation in New Zealand will be identified and presented. The developed classification framework from the previous chapter will be adapted to make a comparison with the international prospect easier.

The development pattern of New Zealand on one hand is like the rest of the world, i.e. most towns and cities are on the coast, usually by a river mouth. This was correct for Maori as well, they lived along the coast and thus therefore are many archaeological / culturally important sites at risk of coastal hazards. Rivers are short and fast so when high rainfall in the catchment causes the river to flood, many towns are particularly vulnerable at high tide. Cumulative effects make it quite hard to manage risk (Crawford 2010, personal comment). But on the other hand the country is also very unique compared to other countries in the world. Personal responsibility is a high commodity in the society. This is one reason why non-structural mitigation measures are mostly used in this country. The second reason is that the preservation of the natural character of the coast is a national priority (DoC 1994) and the concept of sustainability is the central theme of the Resource Management Act (RMA) that was introduced in 1991 (Resource Management Act 1991). In the end the developed classification framework from chapter 2 will be applied to identify any differences between the international and domestic use of the non-structural measures.

New Zealand has a coastline of 18,000 km that can be classified into nine different geomorphic sectors with their own dynamics and characteristics (Healy 2010). It consists of three main islands and about 700 smaller offshore islands.

Fig. 3.01: New Zealand's isolated position (Walrond 2009c)

It stretches 1,500 km across the latitudes 34° to 47° south (Walrond 2009a) and is surrounded by the south-western pacific ocean and parts of the country are located in the roaring forties and furious fifties between the latitudes of 40° and 60° south which are known for strong winds and water currents. The nearest country, Australia, is 2152 km away (Kerr 2005, Walrond 2009b).

3.1. The planning system of New Zealand

Since 1991 the environmental planning system of New Zealand is based on the Resource Management Act (RMA). The new law replaced the old Town and Country Act from 1977. 54 acts and 20 regulations were replaced by one new comprehensive resource management statute (Gleeson & Grundy 1997). But it caused several problem in the first decade after establishing the RMA according to Crawford (2010, personal comment):

- Regional and local councils received no funding and knowledge from the national government to prepare plans. This resulted in very poor plans because the councils did not have the money to employ experienced planners nor the 'know how' to prepare plans designed to achieve this innovative approach. Gleeson & Grundy (1997) reviewed the role of the national government in RMA procedures and conclude that it is a role minimal intervention.

- A lot of experience from the old system was washed away through the RMA and the institutional changes that accompanied reform e.g., loss of data about the natural environment (much of this was held by government departments and was fragmented during the institutional reforms of the 1980's).
- Regional and local councils did not work together during the 1990's.
- Regional and local governments were sub-financed and still are.

The RMA was adopted one year before the Environment and Development Conference[11] was held by the United Nations (UN) in Rio de Janeiro. Around this time, some countries, including New Zealand and the Netherlands, were already leading with innovative approaches to environmental planning (Ericksen et al. 2004). The RMA changed the emphasis from „activities" to „effects"[12] based. The RMA is all about risk assessment in terms of effects. When this emphasis on risk assessment is linked to the overlapping responsibility of regions and districts with respect to integrated management of natural hazards, there is a powerful mandate to work together and to develop suites of methods (Crawford 2010, personal comment). The previously anthropocentric development-oriented legislation was changed to a more ecocentric approach (Ballinger et al. 2000). Balancing human needs with the sustainable management of natural and physical resources (Resource Management Act 1991). To achieve this individuals or groups are required to internalize (e. i. absorb) the environmental costs of their use, development and protection of natural and physical resources (Ericksen et al. 2004). A second purpose of the act is the development of governance to the lowest level (subsidiarity principle) and to speed up the decision making process.

Plans that are made under the RMA are based on the rational-adaptive model. In this approach a iterative relationship consists between research and analysis on the one hand and public consultation and participation in the other hand (Ericksen et al. 2004).

The RMA imposes a hierarchy (see Figure 3.02) of planning instruments which are intended to manage the use, development, and protection of natural and physical resources in a way or at a rate, which enables people and communities to provide for

11 commonly known as the Rio Conference

12 Definition: „the term effect includes (a) any positive or adverse effect; and (b) any temporary or permanent effect; and (c) any past, present, or future effect; and (d) any cumulative effect which arises over time or in combination with other effects - regardless of the scale, intensity, duration, or frequency of the effect, and also includes (e) any potential effect of high probability; and (f) any potential effect of low probability which has a high potential impact." (RMA 1991)

their social, economic, and cultural well-being. This requires particular attention to avoiding, remedying, or mitigating the actual or potential adverse environmental effects of activities (Ministry for the Environment 2008a). The hierarchal planning structure involves central, regional and local governments in a descending order. Gleeson & Grundy (1997) explain that „this hierarchy is based on the assumption that decisions should be made as close as possible to the appropriate level of community of interest where the effects and benefits accrue“.

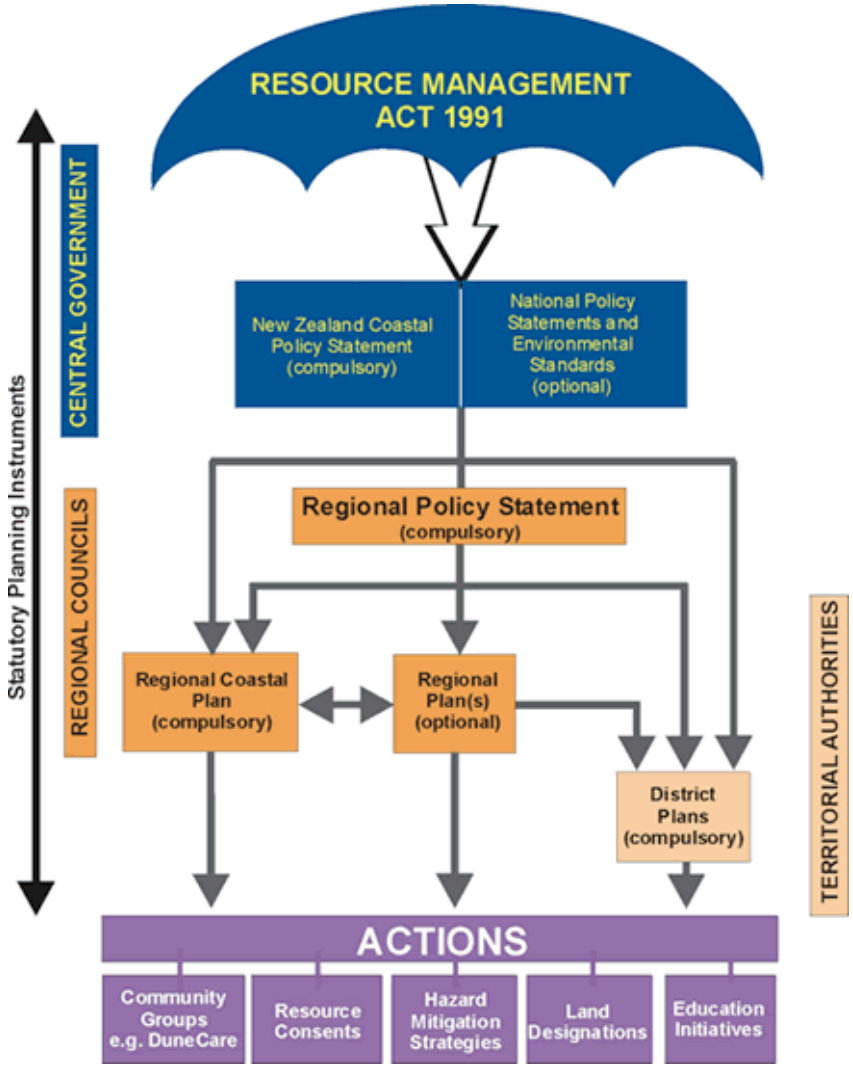


Fig. 3.02: The hierarchy of the RMA (Ministry for the Environment 2008b)

The central government monitors the RMA, maintains the level of standards, controls the crown[13] owned resources and is responsible for matters of national importance in terms of natural resources. With the regional councils it shares the responsibly for coastal management (Robertson 1993).

13 „crown“ refers to the New Zealand government system that is based on a constitutional monarchy. The head of the state is the Queen of England and is represented by the Governor-General. For practical reasons, the power of the monarch has largely been replaced by the Parliament (McDowell & Webb 1998).

The 12 regional councils and 4 unitary councils are responsible for soil conservation, water quality, issues associated with the disposal or transportation of hazardous substances and mitigation of natural hazards. They are required to produce mandatory regional policy statements (Robertson 1993). They share the responsibility for coastal management with the central government. Most coastal planes that are prepared by regional councils deal with the values of the tangata whenua[14] in relation to the natural environment, this is a mandatory obligation under the RMA (Keum & Crawford 2009).

The 74 district councils are responsible for local issues like noise control, local land use and also natural hazards. This issues can only be governed by lower-tier government bodies (Boyd 2007). They are responsible to create district plans and rules. The regular policy statement and regular coastal plan direct district councils as to the policy and methods to be used in their district plans (Crawford 2010, personal comment). In district plans land use activities are allowed unless otherwise specified because land is in private ownership. For water, air and coastal resources the reverse approach applies because the ownership belongs to the crown (Ericksen et al. 2004).

To reduce hazard risks, planners can use a wide range of regulatory planning tools that are included in the Resource Management Act 1991, the Local Government Act 2002, the Civil Defence Emergency Management Act 2002 and the Building Act 2004 (Ministry for the Environment 2008a, Glavovic et al. 2010b).

3.2. Coastal management in New Zealand

The RMA established in 1991 a new coastal management system that is based on the partnership between the Crown and the community through their regional and local authorities (Ballinger et al. 2000, DoC 2010). The central government monitors the Act and has a direct management possibility through the Department of Conservation (Ballinger et al. 2000). The minister of conservation prepares the New Zealand Coastal Policy Statement (NZCPS) which includes a vision for the national coastal zone, this document is required at all times to ensure the public interest for the whole country.

14 The people of the land, the Māori

Fig. 3.03: Planning framework under the RMA for the coastal environment (Ministry for the Environment 2008a)

Regional councils are required to prepare two statutory documents, regional policy statements and regional coastal plans (RCP) that are based on the national NZCPS (Ballinger et al. 2000). The regional coastal plan has the purpose to help the councils in achieving the sustainable management of their coastal environment. The RCPs include objectives, policies and rules that regulate what activities the councils can allow, control or prohibit. These are tools that are used to manage any actual or potential effects from the use, development or protection of the coastal area (DoC 2010). Potential effects can be for example natural hazards or the development of property (Ballinger et al. 2000). When preparing plans and policies, the RMA requires authorities on the same level to consult each other (Ministry for the Environment 2008a).

3.3. Non-structural mitigation measures

In New Zealand a whole range of measures are used to mitigate the risks of coastal flooding and to adjust the community to coastal hazards before an event happens. Most of the non-structural measures serve a dual function against coastal erosion and coastal flooding. Technical engineering measures, like smaller dikes or sea walls are also applied as protection measures. They are highly controversial discussed because of the negative impacts to the nature and the ongoing maintenance costs. Environment Waikato (2002) points out that „any of these structures affect the appearance of the beach, affect public safety and restrict public access to and along the beach“. From this and the sustainable management concept of the RMA it is clear that most of the used coastal hazard mitigation measures are non-structural nature to preserve the natural character of the coast.

Once again it can be said that New Zealand has a big knowledge about coastal hazards and about methods to mitigate them successfully but there are some implementation barriers that is why the whole potential of the wide range of measures is not used yet. These include a lack of money, a lack of commitment, the weight that is placed on property ownership and not interfering in a person‘s rights to use their land as they wish without very good reason.

The „Weather Bomb“ from the 21 June 2002 in Northland, Coromandel and Waikato is a very good example. The „Weather Bomb“ was a heavy rain and storm event that caused a lot of floodings with a high-impact area in Coromandel. A study by the NZ Institute of Economic Research (NZIER) showed that the overall preparedness for this event was low. The survey showed that „only 5 % of the respondents had raised the floor, 44 % had kept ditches and drains clean, 11 % had protected septic tanks, and 22 % avoided keeping valuables at ground floor levels“. Further more the survey showed that „only some 22 % of respondents had prior experience of floods“ and „some 55 % of respondents cited cost[15] as a significant constraint on carrying out hazard preparation activities“. The respondents were also asked if they would do any preparedness measures with the background of the „Weather bomb“. „Some 20 % reported taking out insurance, 3 % raising floor levels, 37 % ensuring ditches were kept clean, 9 % protecting septic tanks, and 27 % avoiding keeping valuables on the ground floor“ (NZIER 2004).

3.3.1. Restoration of nature

➡ Beach nourishment

Some beach nourishment is done in New Zealand, for example Balaena Bay in the Wellington Harbour (Carter & Mitchell 1985), Mangatawhiri Spit (Bridgewater 1986) or Omaha Beach (Noble Consultants 2010).

➡ Dune restoration

Dune restoration programmes are widely done by local community Coast Care Groups. In this groups, local people work voluntary together with distric councils, regional councils and the DOC. The planting of native dune plants or the repairing is done by the people. All the working material is provided by the distric councils, regional councils and the DOC (Peart 2009). The native Pingao[16], Spinifex[17] and

15 for example for raising floor levels

16 l*at. Desmoschoenus spiralis*

17 *lat. Spinifex sericeus*

Sand tussock[18] seedlings are raised in nurseries (Bergin & Kimberley 1999). Coast Care programmes are a hugh success around the country. In the Bay of Plenty region alone, 25 volunteer community groups are active (Whyte 2003).

Dune restoration in New Zealand is successful because of the following circumstance:

1. Regional Councils and volunteer groups work hand in hand together.

3.3.2. Spatial planning & Policy making

To manage and reduce coastal hazards risk „a precautionary approach is adopted when making land-use planning decisions relating to new, and changes to existing, development in coastal margins that takes account of the level of risk; and uses existing scientific knowledge and accounts for scientific uncertainties“ and „new development is not exposed to, or does not increase the levels of, coastal hazard risks over its intended serviceable lifetime. Progressively, the levels of risk to existing development are reduced over time“ (Ministry for the Environment 2008a).

A todays „compelling challenge in New Zealand is to translate policy and legal intentions into practical reality through better inter-governmental cooperation “ (Ericksen et al. 2004). Glavovic et al. (2010b) came to the same result and that „there is an opportunity to better align policies and laws (including insurance provisions) to promote more effective and integrated natural hazards planning, because important measures are spread out across various statutes with inevitable gaps, overlaps and inconsistencies“.

Due to this difficulties New Zealand lost at least 10 years of plan development under the new RMA. In 2009 / 2010 New Zealand parts of the responsibilities between the national and the regional / local government are changed. For example a new national Environmental Protection Authority will be introduced, it will be liable for matters of national importance (e.g. wind farms). The hope is that the changes will strengthen the RMA system (Crawford 2010, personal comment).

A second reason that levelled down the performance of the RMA is that, even if the main goal is the sustainable management of natural and physical resources, in the last years the Environment Court watered the RMA down. For example the protection of individual property with seawalls against coastal erosion had a higher priority instead of using soft measures. This was the case in the famous Environment Court

18 *lat. Austrofestuca littoralis*

decision „Mason and Keall vs. Western Bay of Plenty District“ (Peart 2010, personal comment).

➡ Zoning / Development restrictions

Zoning and development restrictions are done through development setbacks and the establishing of coastal hazard zones (CHZs) which both can imply certain building restrictions. Several district plans for example contain rules that specify that new buildings which are located in coastal hazard zones must be build in a way that they are easily relocatable (Ministry for the Environment 2008a, Mark-Brown 2010, personal comment). A study by Montz (1993) about property values in published hazardous areas in New Zealand showed that the disclosure of hazardous areas has no effect on property values. Only the building quality and property size have an impact.

➡ Development Setback

Setbacks zones act as a natural buffer zone. They are not only designed to protect development against coastal flooding and coastal erosion but also to preserve the natural character of the coast[19], public access[20] and amenity values. On the eastern Coromandel Peninsula for example setback lines are used since the early 1980s (Environment Waikato 2002).

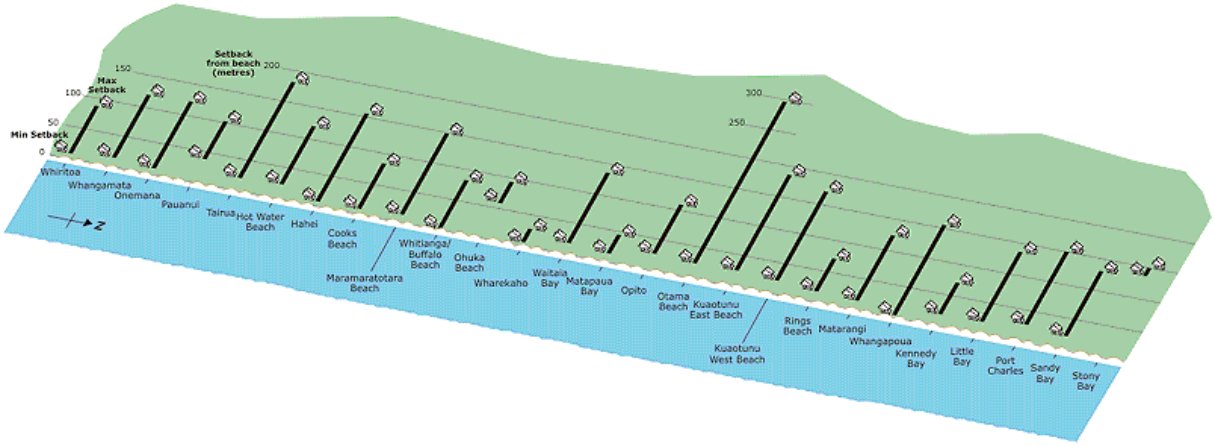


Fig. 3.04: Development setback recommendations for the Coromandel Peninsula (Environment Waikato 2010)

The NZCPS notes that local authorities shall generally set back subdivisions and its development from the coast line amongst others to protect them from coastal hazards (e.g. flooding). The Ministry for the Environment (2008a) explains that „the

19 protect the natural character of the coast is one of the main goals of the RMA

20 access to rivers, beaches, lakes, etc... Is a basic public right under RMA

use of planned or managed retreat will need to become a fundamental and commonly applied risk-reduction measure within the next few decades.“.

Development setbacks in New Zealand can be successful in the future because of the following circumstances:

1. The public interest has a higher priority as private interests.
2. Building requirements for new houses are added to the building regulations and permits (e.g. new houses must be build in a way that it is relocatable).

➡ Flood proofing of houses

Many district plans require the floor level of new houses to be set at or above a specified datum in mapped flood or hazard prone areas e.g. Papakura District Council (Crawford 2010, personal comment). The Building Regulations that are part of the Building Code (based on the Building Act 2004) state that „Surface water, resulting from an event having a 2% probability of occurring annually, shall not enter buildings“. Surface water is defined as in the Building Regulations as „all naturally occurring water, other than sub-surface water, which results from rainfall on the site or water flowing onto the site, including that flowing from a drain, stream, river, lake or sea“.

Flood proofing of houses in New Zealand would be more successful if the following circumstances were used:

1. Additional to todays required minimum flood level in the building regulations,
2. regulations about dry proofing methods (methods to prevent the water of entering the house) should be considered.

➡ Flood Insurance

Every New Zealander benefits from the EQC (Earthquake Commission) insurance, a government insurance scheme for natural disasters that is automatically included in every residential dwellings and content insurance. The EQC insurance includes protection against damages from earth quakes, natural landslips, volcanic eruptions, hydrothermal activities and tsunamis or storm, flood and fire that is caused by this perils. Dwellings are insured up to NZ$ 100,000 and personal effects up to NZ$ 20,000 plus taxes. Home owners can top up the insurance cover with private insurances (Glavovic et al. 2010b).

Glavovic et al. (2010b) mention that „insurance is a tool for managing residual risk, its full potential for risk reduction has yet to be realised. For example, if a house is affected by a flood and could be elevated to mitigate future flood impacts, the insurance payout will not cover this improvement. Insurance payouts can only be used to reinstate the damaged house to the condition that it was in before the event occurred, and not to make any improvements even if they reduce future risk. This is a 'lost' opportunity for risk reduction". A more general problem with flood insurances is that some 50% of households are not insured so when there is a flood, these households turn to the Government and councils, plus their local community for help. The central government is very sensitive to the politics of this, so usually it sends in aid. Thus, the uninsured get away with not paying their share and may well get as much help as those who do pay. A fairer system would require every owner to pay EQC insurance compulsorily e.g. at the same time as they pay property taxes (Crawford 2010, personal comment).

Flood insurances in New Zealand would be successful if the following circumstances were used:

1. The responsibility between the public and the private must be clear.
2. Flood insurance must cover the real costs to prevent building in highly hazardous areas.
3. An insurance discount could be given if a home owner applies flood proofing measures that are beyond the legislative requirement. This would work as an incentive.

3.3.3. Risk communication

➡ Education

In 2006 the New Zealand Government set up different campaigns with the goal to raise the hazard awareness of the public and strengthen the preparedness. The campaigns target different groups of the population. Businesses can find directly informations on the website of the Ministry of Civil Defence & Emergency Management / Te Rākau Whakamarumaru (CDEM) on how to prepare their property and business against natural and non-natural hazards. This includes a booklet of how much food, etc... should be stored for the employees.

Fig 3.05: Get ready get thru campaign logo (CDEM 2010b)

The „Get ready, get thru“ campaign target individuals and families to show that everyone can take simple steps to prepare themselves against natural and non-natural hazards. The campaign is promoted via radio and television advertisements and is back-upped with a comprehensive website (-> http://www.getthru.govt.nz) and printed booklets (see Appendix A.4. for the booklet). The website is published in eight different languages (english, chinese, hindi, māori, samoan, tongan and arabic) to reach as many people as possible. One special feature of this campaign is the „Get Ready Week“ in October. In this week the disaster awareness will be intensified. Another thing to push the campaign is that the CDEM works together with major supermarkets or department stores like New World or The Warehouse. Both companies use special ads and leaflets to inform the people what kind of food or equipment is necessary to survive a hazard event.

Fig 3.06: What‘s the plan Stan? campaign logo (CDEM 2010c)

A second campaign under the name „What‘s the plan Stan?“ was launched to promote the understanding of hazards and preparedness in primary and secondary schools. A website (-> http://www.whatstheplanstan.govt.nz) was launched that target directly students and teachers.

Education in New Zealand is successful because of the following circumstances:

1. People are aware that New Zealand faces not only one natural hazard but several different ones.
2. For every target group (businesses, the general public and pupils) a special education programme was designed.
3. The education programmes use every kind of media to broadcast their informations and work closely together supermarkets and department stores.

4. As part of the general hazard education the „Get Ready Week“ is repeated every year in October.

➡ Mapping

Mapping is used to establish coastal hazard zones and evacuation maps. CHZ‘s are used to identify coastal areas that may be effected by coastal hazards like coastal flooding or erosion (NRC 2008). CHZ are modelled with the help of geographic information systems (GIS) (Bell 2010, personal comment). Healy (2003) defines the CHZs as follows „A hazard zone is a zone in which, on the balance of probabilities within the next 100 years, there is going to be a hazardous situation."

To define the risk of coastal flooding, Environment Waikato (1999) requires informations on:

1. the magnitude and frequency of flooding
2. magnitude and frequency of potential tsunami events
3. the potential effects likely to predict global warming and
4. the land and building floor levels in low-lying flood-prone areas.

The tsunami evacuation zone maps for example are based on this data. Figure 3.07 shows a tsunami evacuation zone map of the Wellington including an explanation of the zones (see Appendix A.3. for a high resolution map).

RED: The red zone is the shore-exclusion zone. This represents the highest risk zone and is the first place people should evacuate from in any sort of tsunami warning (both formal and informal).

ORANGE: The orange zone is the area which is likely to be evacuated during official warnings and evacuations. The official warning will come from local Civil Defence Emergency Management agencies such as your local council.

YELLOW: The yellow zone identifies areas that need to evacuate for the largest possible tsunami. People should evacuate this zone in natural or informal warnings from local sources events such as a large local earthquake.

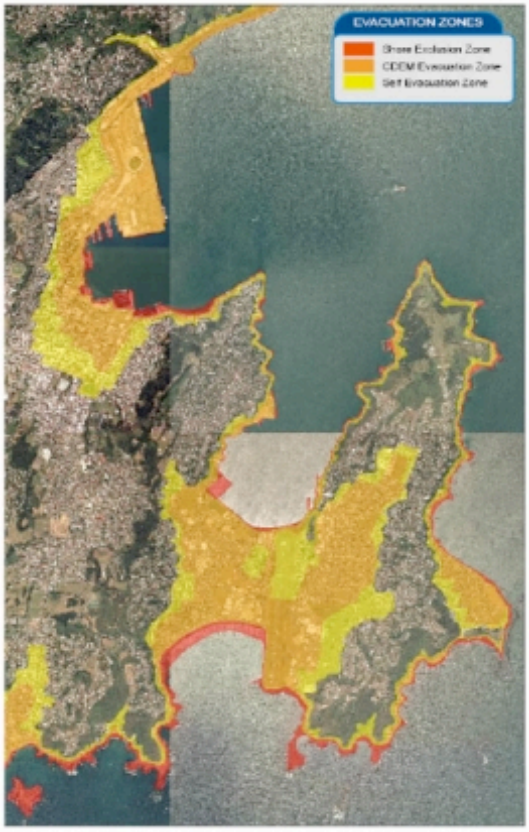


Fig. 3.07: Tsunami evacuation zone map of Wellington with explanation (GW 2010)

The Whangarei District Council (2010) uses the same colours for its tsunami evacuation maps and explains „ A red exclusion zone which takes in the foreshore and is a danger area in all tsunami events no matter what size. The orange zone is for the tsunamis that has been generated around the Pacific Rim and has some warning time before they hit our shores. The yellow zone is for any local tsunamis which is generated very close to shore and for which there is not enough time to provide an official warning (generally arrival times are less than one hour). These tsunamis tend to be larger than those generated around the Pacific Rim but impact only on a small area of the coast. They do not affect the whole of the New Zealand coastline. These local tsunamis are also much rarer than those generated around the Pacific Rim.“

Mapping in New Zealand is successful because of the following circumstances:

1. They are based on comprehensive scientific data.
2. The maps are well designed and easy to understand for the public.

➡ Warning Systems

The responsibility for the public weather forecast and the release of warning messages belongs to the MetService in Wellington. The extended weather forecast is modelled for 4 days in advance and for rainfall for 7 days. Tsunami related informations are received from the Pacific Tsunami Warning Center (PTWC) in Hawaii. The wave height is modelled for 2 days in advance by MetService and NIWA. NIWA publishes so called Red-Alert days for coastal flooding. On Red-Alert days, tides are higher then the normal average and can expose the coast with the coincidental occurrence of storm surges to a high flooding risk. Every coastal manager in New Zealand adds this Red-Alert days to his calendar and has to have a closer look to the weather forecast (Bell 2010, personal comment). For businesses and professional users NIWA launched a paid web service called EcoConnect. This is a realtime environmental forecasting and information service.

Coastal storms can be detected several hours or even several days before a flooding event happens. Distantly generated tsunamis have a lead time of several hours. Only for locally generated tsunamis the lead time with 15-30 minutes is very short (Environment Waikato 1999).

Fig. 3.08: Tsunami hazard zone warning sign at Castle Point / Wairarapa / New Zealand (CDEM 2010a)

Tsunami hazard zone warning and evacuation route signs and evacuation maps are in the implementation phase now, after positive results with local pilot communities in 2008. They were developed by Local District and Local Civil Defence Emergency Management Groups. The evacuation maps were modelled together with the Institute of Geological and Nuclear Sciences.

Warning systems in New Zealand are successful because of the following circumstances:

1. Comprehensive weather forecasting data is available.
2. Coastal managers are aware of Red-Alert days (high tide days) and know that they have to have a closer look to the weather forecast on these days.
3. Comprehensive and easy to understand tsunami hazard zone warning signs and evacuation route signs are in the installation phase after a successful pilot project.

➡ Emergency Management

Emergency Management in New Zealand is based on the Civil Defence Emergency Management Act (CDEMA) (2002). One purpose of the act states „improve and promote the sustainable management of hazards in a way that contributes to the social, economic, cultural, and environmental well-being and safety of the public and also to the protection of property“. Another one states „encourage and enable

communities to achieve acceptable levels of risk, including, without limitation“ (CDEMA 2002). The CDEMA and RMA are closely linked because they share the same sustainable management objective.

The emergency management cycle of New Zealand is called „the 4 Rs“. The 4 Rs are based on the international four cyclic approach only with a variation in the terms (see Table 3.01). Figure 3.09 shows the 4 Rs cycle with a short explanation for every step.

International term		New Zealand term
Risk mitigation	→	Reduction
Preparedness	→	Readiness
Response	→	Response
Recovery	→	Recovery

Tab. 3.01: International and New Zealand emergency management terms

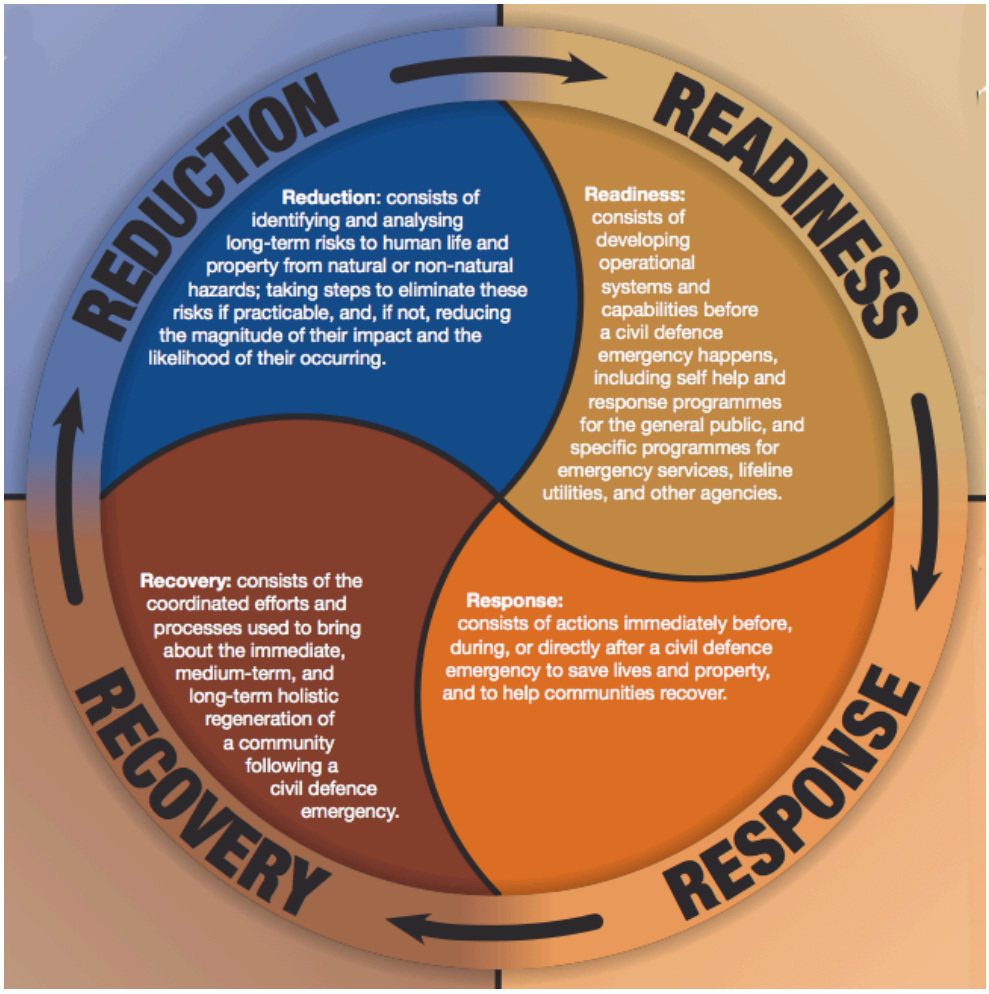


Fig. 3.09: The 4Rs of the NZ emergency management cycle, altered (CDEM 2006)

Emergency management in New Zealand is successful because of the following circumstances:

1. The Civil Defence Emergency Management Act and the Resource Management Act are closely linked with the same sustainable management objective.
2. Since New Zealand is prone to several different natural hazards the emergency management faces great challenges and this keeps them up to date.

3.4. Classification framework

The developed classification framework from chapter 2, is in Figure 3.10 adjusted to the New Zealand case study.

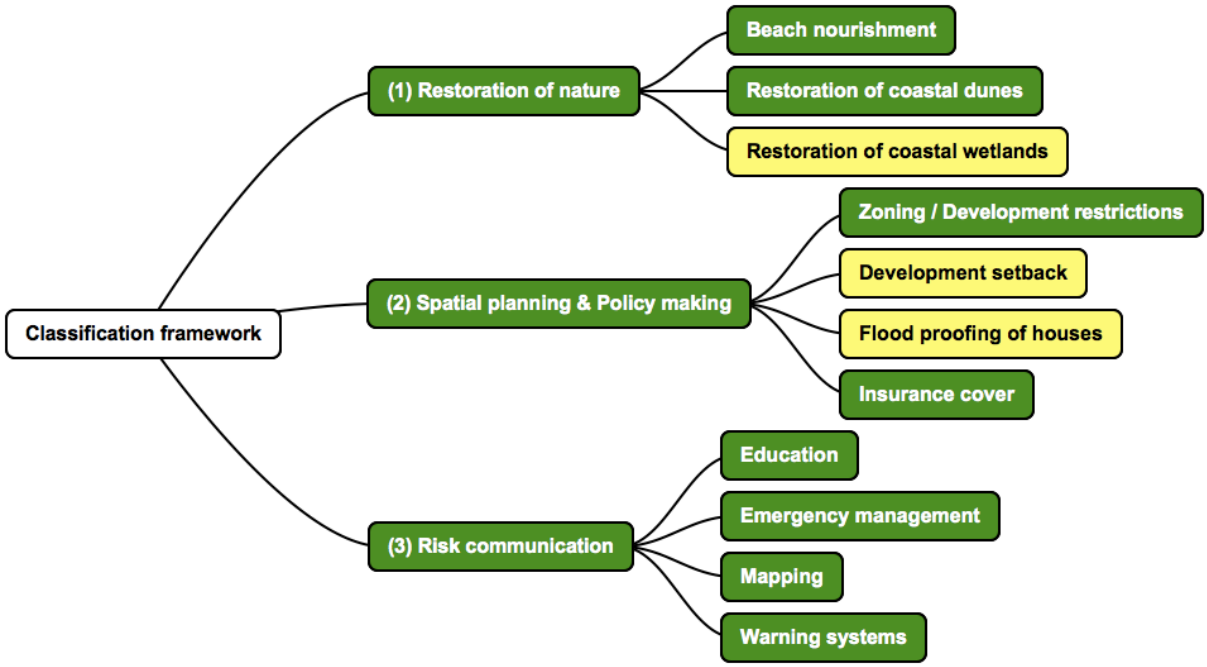


Fig. 3.10: Classification framework of non-structural measures to mitigate coastal flooding in the New Zealand case

All green (dark) coloured measures are applied in New Zealand. The three yellow (light) coloured ones, namely restoration of wetlands, development setback and flood proofing of houses are only partly applied in New Zealand.

First according to the Auckland Regional Council (ARC) (ARC 2009) wetlands will normally regenerate naturally and to assist this process the normal measures are fencing of the area to prevent trampling from stock and plant and animal past control. This are not classical international applied restoration measures for coastal wetlands. Second there are not so many wetlands left that could be restorated because of densely development pattern at the coast.

Development setback is a hot topic at the moment and it is applied in some Regional Councils but there are still a lot of things unclear like questions about coordination and the choice of the right methods. So a lot of research has to be done to find right answers.

The only measure that is applied for flood proofing of houses is a building regulation requirement of a minimum ground floor level for houses.

Chapter 4
Conclusion

4. Conclusion

„Disaster preparedness is a complicated business. There's much more to it than stashing away a few cans of baked beans." (Hon Rick Barker, Minister of Civil Defence & Emergency Management of New Zealand)

The objective of this thesis was to compare international used non-structural coastal flooding mitigation measures with measures that are applied in New Zealand and see what kind of lessons could be learned from this country. For every measure the needed circumstances to make the measure successful were listed and at the end a classification framework was developed to make the comparison easier and clearer.

Non-structural mitigation measures were selected because today coastal areas are the densely populated areas in the world and in future the population will further increase. With the uncertainties about the future climate and sea level it is wise to move from structural protection measures to non-structural mitigation measures.

Some general findings are that in advance applied non-structural measure have a positive impact on the protection against coastal flooding. This is specially true for the restoration of nature, spatial planning, applying of building codes and risk education of the public. Risk education is a very important tool to show the public that humankind is not able to control the nature and that we have eventually be more aware of the destructive forces from the nature. It will also show what kind of impacts the destructive forces have and how we can minimise them.

One negative finding was that the use of insurance cover to mitigate flood losses in flood-prone areas has failed because the contrary effect, stimulation of building, occurred. This is a problem of insurances that are bases on shared costs. If the real risks would be reflected from the insurance cover then it would prevent people to build in flood-prone areas.

Especially from the New Zealand case study some lessons can be learned:

1. Every applied measure in New Zealand has not released its full potential yet. This is a long term activity that will take several years or decades.
2. The raising of the peoples awareness about coastal hazards is a long term time-consuming and costly matter. It is absolutely necessary that awareness raising campaigns are recurring every year and that they involve of all types of media.
3. Open and true communication between the government and the public is necessary and will help to shape resilient communities.
4. The foundation of effective mitigation measures are comprehensive regulations and laws that incorporate the idea of sustainable management.
5. Communication between the national government and regional government or provinces is absolutely necessary to avoid any misunderstandings and to make it clear who is responsible for what.

Table 4.01 shows a comparison of factors that are necessary to make the presented mitigation measures successful in a general international context and in the specific New Zealand case.

Measure	International factors	New Zealand factors
Beach nourishment	It can only be done in areas where beaches occur naturally. It must be repeated every 5-10 years to avoid negative impacts to the coast. Enough feeding material should be available, preferably slightly coarser sand from near distance sources.	non-applicable because of a lack of data

Measure	International factors	New Zealand factors
Restoration of coastal dunes	Semi permeable fences should be installed at the beginning to trap sand. Pre-grown seedlings are more robust and will increase a successful restoration. To avoid monocultural problems a mix of different plants is favourable especially native ones.	Regional Councils and volunteer groups work hand in hand together.
Restoration of coastal wetlands	The selected area must meet certain conditions (for salt marshes see Weinstein et al. 2001). Pre-grown seedlings are more robust and will increase a successful restoration.	non-applicable because of a lack of remaining coastal wetlands

Measure	International factors	New Zealand factors
Zoning / Development restrictions	It must be clear what the main activity in the selected zone will be without any exceptions otherwise the zoning concept will be watered down. If development is allowed, does a building has to meet certain standards like some kind of flood proofing? If yes this requirements should be added as an obligation to the building permit.	-> see Development setback
Development setback	It must be clear on what kind of event (e.g. a 100 years flood or a 500 years flood) the setback is based. This will determine the minimum setback distance. The setback distances must be added to the building permits for new buildings.	The public interest has a higher priority as private interests. Building requirements for new houses are added to the building regulations and permits (e.g. new houses must be build in a way that it is relocatable).

Measure	International factors	New Zealand factors
Flood proofing of houses	For new developments the measures must mentioned in the building permit as a requirement. For existing buildings governmental incentives or insurance discounts after a successful retrofitting would help to minimise risks. Especially for floating homes / amphibious homes the following circumstances must be considered: appropriate building material and appropriate anchoring methods to prevent moving. Special areas should be designated for this homes to prevent them from negative impacts from navigational channels (e.g. wash or eddy water). Are they build according to standards for terrestrial houses or according to standards for vessels? This makes a hugh difference in the technical requirements.	Additional to todays required minimum flood level in the building regulations, regulations about dry proofing methods (methods to prevent the water of entering the house) should be considered.

Measure	International factors	New Zealand factors
Insurance cover	The responsibility between the public and the private must be clear. In certain areas a flood insurance must be a requirement to reduce risks. Flood insurance must cover the real costs to prevent building in highly hazardous areas. An insurance discount could be given if a home owner applies flood proofing measures. This would work as an incentive.	The responsibility between the public and the private must be clear. Flood insurance must cover the real costs to prevent building in highly hazardous areas. An insurance discount could be given if a home owner applies flood proofing measures that are beyond the legislative requirement. This would work as an incentive.

Measure	International factors	New Zealand factors
Education	non-applicable because of a lack of data	People are aware that New Zealand faces not only one natural hazard but several different ones. For every target group (businesses, the general public and pupils) a special education programme was designed. The education programmes use every kind of media to broadcast their informations and work closely together supermarkets and department stores. As part of the general hazard education the „Get Ready Week“ is repeated every year in October.

Measure	International factors	New Zealand factors
Emergency management	Every step should be well designed with clear responsibilities.	The Civil Defence Emergency Management Act and the Resource Management Act are closely linked with the same sustainable management objective. Since New Zealand is prone to several different natural hazards the emergency management faces great challenges and this keeps them up to date.
Mapping	Accurate scientific data about hazards must be available. Maps should be well designed with associative colours that the public is able to understand them very easily.	They are based on comprehensive scientific data. The maps are well designed and easy to understand for the public.

Measure	International factors	New Zealand factors
Warning systems	Every step should be well designed with clear responsibilities. Warning messages for the public must be designed in a way that they are easy to understand (no technical terms or bureaucratic language). The messages should be personalised and comprehensive.	Comprehensive weather forecasting data is available. Coastal managers are aware of Red-Alert days (high tide days) and know that they have to have a closer look to the weather forecast on these days. Comprehensive and easy to understand tsunami hazard zone warning signs and evacuation route signs are in the installation phase after a successful pilot project.

Tab. 4.01: Factors that make non-structural mitigation measures successful

This thesis has shown that future research should target the following aspects of mitigation measures:

- It is hardly impossible to find any evaluations of public educational and awareness raising campaigns or a comparison of campaigns from different countries and
- the performance of development setbacks is not clear yet, this applies especially for Europe and Australasia. The research should also cover the behavior of the real estate market and its pricing.

Appendix

A. Appendix

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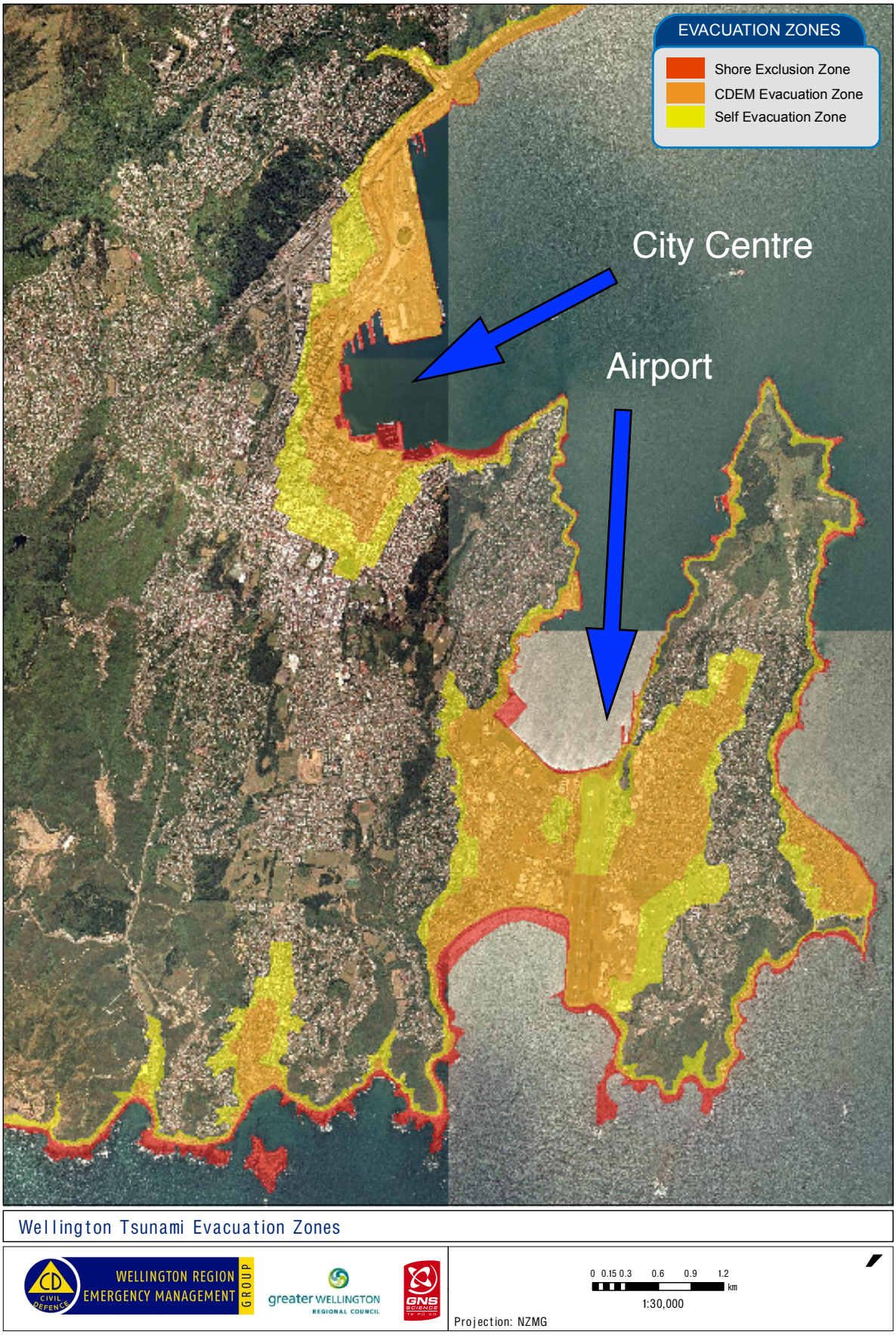
A.3. Wellington tsunami evacuation map

Map Copyright by Greater Wellington Regional Council 2010. The arrows for city centre and airport are added by the author for a better overview.



A.4. Get ready get through booklet

This booklet is published by the Ministry of Civil Defence & Emergency Management / Te Rākau Whakamarumaru of New Zealand.

GET READY GET THRU

CIVIL DEFENCE

Due to its location and environment, New Zealand faces many potential disasters. In some cases, such as a weather related or volcanic disaster, there may be time for a warning.

But an earthquake or a tsunami close to land could strike without warning. All disasters have the potential to cause disruption, damage property and take lives. So it's vital that you prepare now.

BE PREPARED TO COPE ON YOUR OWN FOR UP TO 3 DAYS, OR MORE.

This is when you will be most vulnerable.

The information in this brochure will show you how to look after yourself, your family, home, business and community. It will help you get ready, so you'll get through.

YOU SHOULD HAVE:

- **A Household Emergency Plan**
- **An Emergency Survival Kit**
- **A Getaway Kit if you need to be evacuated.**

HOUSEHOLD EMERGENCY PLAN

Many disasters will affect essential services and possibly disrupt your ability to travel or communicate with each other.

Get your family or household together and agree on a plan.

You should work out:

- Where to shelter in an earthquake, flood or storm
- How and where you will meet up during and after a disaster
- The best place to store Emergency Survival items and know who is responsible for checking essential items
- What you will need to have in your Getaway Kit and where you will keep it
- How to turn off the water, gas and electricity in your home or business
- How to contact your local civil defence organisation for assistance during an emergency

You can find a copy of the emergency plan at the back of this brochure or download it from the website **getthru.govt.nz**

Know what your local Civil Defence warning system is and find out the location of your local Civil Defence or Community Emergency Centre. It is also useful to learn First Aid, how to deal with small fires and how to evacuate your house in the event of a fire.

Plan to recover after a disaster

Make sure your insurance cover is adequate and up to date and that important documents can easily be gathered if you have to evacuate.

YOUR GETAWAY KIT

In some emergencies, such as a flood or volcanic eruption, you will need to evacuate and take your Getaway Kit with you. Everyone in the house should have a Getaway Kit. This kit should include:

Family documents

- Birth and marriage certificates
- Driver's licences and passports
- Financial information (insurance policies, mortgage information, etc)
- Family photos

Personal items

- Towels, soap, toothbrush, toothpaste, toilet paper and sanitary items
- Hearing aids, glasses, mobility aids for elderly or vulnerable members of your household

YOUR EMERGENCY KIT

In most emergencies you should be able to stay at home or at your workplace. In this situation, you may have to rely on your Emergency Survival Kit. This kit should include:

Emergency items

- Torch with spare batteries
- Radio with spare batteries (check all batteries every 3 months)
- A change of clothes for all family members (wind and waterproof clothing, sun hats, and strong outdoor shoes)
- First aid kit and essential medicines
- Blankets or sleeping bags
- Pet supplies
- Toilet paper and large rubbish bags for your emergency toilet
- Face and dust masks

Food and water for at least three days

- Non-perishable food (canned or dried food)
- Bottled water (at least 3 litres per person, per day for drinking)
- Plan how to get water for washing and cooking
- A primus or gas barbeque to cook on
- A can opener
- Check and replace food and water every twelve months

Supplies for babies and small children

- Food, formula and drink
- Change of clothing and nappies
- Toys or favourite activity

Place your Emergency Kit somewhere that is easy to get to in an emergency and make sure everyone in your house knows where it is kept. If you keep some of your Emergency Kit items in the house for everyday use, make sure you know where to find them quickly when an emergency occurs.

FIRST AID KIT

If someone you care for is injured in a disaster, your knowledge of First Aid may be the difference between life and death. Many organisations provide First Aid training courses. It is recommended that you take a First Aid course, followed by regular refresher sessions.

You can buy First Aid Kits ready made. If you are making your own, you can download a list of the minimum recommended items required from the website: **getthru.govt.nz**

CARING FOR SICK OR VULNERABLE PEOPLE

If you, or a member of your household or community has a disability, make arrangements now with a family member, friend or neighbour to help in an emergency.

Hearing impairment

People with hearing impairment may not hear warning systems or radio broadcasts. Make arrangements to be sure that someone will notify a hearing impaired person in the event of an emergency.

Sight impairment

People with sight impairment could experience difficulties if they have to evacuate or go to an unfamiliar Civil Defence Centre. Arrange a 'buddy system' so they will have someone to help them cope.

Asthma and respiratory problems

An asthma sufferer or someone with a respiratory disorder may be affected by volcanic ash, dust or the stress of an emergency. Make sure you have plenty of medicines and dust masks in your Emergency Survival and Getaway Kits.

Special food needs

If you are caring for someone with special food needs, make sure you include food for them in your Emergency Survival Kit.

Mobility impairment

You will need to include mobility aids in your Emergency Survival Kit if you or someone you are caring for has difficulty with mobility. This will help the person cope if they have to evacuate to a different area.

CARING FOR PETS AND LIVESTOCK

Remember, your pets will be affected by a disaster, too. Follow these steps to make sure they get through as well.

- Include your pets in your disaster planning
- Attach a permanent disc to your pet's collar that clearly states your phone number, name and address, if there is room
- If possible, take your pet's vaccination records with you if you have to evacuate. This will help your pet be rehoused if necessary
- Include a carry box, towel or blanket in your Emergency Survival Kit. Put your name and phone number on the box
- Keep an emergency supply of pet food
- Check with your local council about their arrangements for assisting with domestic animal issues
- If you are unable to take your animals with you, you should release penned animals, if possible

STORING WATER

Household water supplies, including drinking water, could be affected. Having a supply of water is absolutely essential and you need to store water for an emergency.

You need about 3 litres of drinking water for each person each day. You also need about one litre of water for each of the following:

- washing food and cooking for each meal
- washing dishes after a meal
- washing yourself (one litre per day for each person)

Your hot water cylinder and toilet cistern are valuable sources of water. Check that your hot water cylinder and header tank are well secured and try to avoid putting chemical cleaners in the cistern. Also, keep on hand a supply of household bleach for disinfecting.

DRINKING WATER

- To store enough drinking water for three days, prepare six large, plastic soft drink bottles of water for each person, including children. Add some extra for pets
- Wash bottles thoroughly in hot water
- Fill each bottle with tap water until it overflows. Add five drops of household bleach, per litre of water and put in storage. Do not drink for at least 30 minutes after disinfecting
- Label each bottle with dates showing when the bottles were filled and when they need to be refilled
- Check the bottles every 12 months. If the water is not clear, throw it out and refill clean bottles with clean water and bleach
- Store bottles in two separate places, somewhere dark away from direct sunlight where there is not likely to be flooding
- Alternatively, fill plastic ice cream containers with water, cover, label and keep in the freezer. These can help keep food cool if the power is off and can also be used for drinking
- Keep a supply of ice cubes and fruit juices

HANDY HINTS

Collect rain water but make sure that you disinfect it with household bleach (1/2 teaspoon to 10 litres). If you're at all uncertain as to the quality of water, e.g. from a well that has been flooded, or if it might have been contaminated by smoke or ash DO NOT drink it.

GET YOUR CAR READY

If you are in your car or driving when a disaster strikes, you will need to know what to do. Follow these simple steps:

- If you drive to work, understand that you may be stranded in your vehicle for some time. A flood, snow storm or major traffic accident could make it impossible to proceed
- Store a pair of walking shoes, waterproof jacket, essential medicines, snack food, water and a torch in your car
- In an earthquake, pull over to the side of the road and stop
- Do not drive in floodwaters
- You can get up to date roading information at **www.aaroadwatch.co.nz**

GET YOUR BUSINESS READY

You should have a Workplace Emergency Plan.

- Businesses have an OSH and Fire Regulations obligation to be prepared for an emergency. This will help you identify potential hazards and plan for your staff during and after an emergency
- Get your staff ready. Ensure every member of staff has these items: walking shoes, waterproof jacket, torch, snack food and water by their desks
- Get involved in business continuity and emergency plans at industry level.

Find out more about **Workplace Emergency Planning at www.getthru.govt.nz**

EARTHQUAKES

There are hundreds of earthquakes in New Zealand every year, but most of them are not felt because they are either small or very deep within the earth.

However, a large, damaging earthquake could occur at any time. The biggest danger you face in an earthquake comes from falling debris and collapsing structures such as buildings and bridges.

Before an earthquake

Getting ready before an earthquake strikes will help reduce damage to your home and business and help you survive.

- Develop a Household Emergency Plan and prepare an Emergency Survival Kit so that you can cope with being on your own for up to three days or more
- Identify safe places within your home, school or workplace. A safe place is:
  - under a strong table; remember to hold onto the legs
  - next to an interior wall
  - somewhere close to you, no more than a few steps, or two metres away, to avoid injury from flying debris.
- Secure heavy items of furniture to the floor or wall. Visit **www.eq-iq.org.nz/** to find out how to quake-safe your home
- Seek qualified advice to make sure your house is secured to its foundations. Also check that any renovations comply with the New Zealand Building Code

During an earthquake

- If you are inside a building, move to a safe place
- If you are outside, move no more than a few steps, then drop, cover and hold
- If you are driving, pull over and stop
- If you are at the beach or near the coast, drop, cover and hold then move to higher ground immediately in case a tsunami follows the quake

After an earthquake

- You should expect to feel aftershocks
- Help those around you if you can
- If you are in a damaged building, try to get outside and find a safe, open place
- If you smell gas, try and turn off the gas main outside the building if it is safe to do so
- If you see sparks, broken wires or evidence of electrical system damage, turn off the electricity at the main fuse box if it is safe to do so
- Listen to the radio for information and advice
- If your property is damaged take notes and photographs for insurance purposes

STORMS

Damaging wind is caused by cyclones, tornados or areas of very low pressure air called deep depressions. The MetService issues a strong wind warning when winds of over 87km/h are expected over land.

Follow these steps to get through the dangers of strong winds:

Before a storm

Getting ready before a cyclone strikes will help reduce damage to your home and business and help you survive.

- Develop a Household Emergency Plan and prepare an Emergency Survival Kit so that you can cope on your own for three days or more
- Check that your roof and guttering is secure every two years
- Keep materials at hand for repairing windows, such as tarpaulins, boards and duct tape
- If you are renovating or building, make sure all work complies with the New Zealand building code which has specific standards to minimise storm damage

When a warning is issued

- Pick up any debris around your house that could become airborne
- Bring rubbish bins indoors
- Bring pets inside. Move stock to shelter
- Listen to your local radio station for information

During a storm

- Open a window on the side of the building away from the wind. This will relieve pressure on the roof and help prevent it lifting
- Close all curtains to slow down flying glass and airborne objects
- Stay away from doors and windows. If the wind becomes destructive, shelter further inside the house
- Don't walk around outside. Don't drive unless absolutely necessary

After a storm

- Contact your local council and insurance company if your house or building has been severely damaged
- Ask your council for advice on how to clean up debris safely

FLOODS

Floods are a common hazard in New Zealand.
A flood becomes dangerous in the following conditions:

- If the water is travelling very fast
- If the water is very deep
- If the floods have risen very quickly
- If the floodwater contains debris, such as trees and sheets of corrugated iron

Getting ready before a flood strikes will help reduce damage to your home and business and help you survive.

Before a flood

- Develop a Household Emergency Plan and prepare an Emergency Survival Kit so that you can cope with being on your own for three days or more
- Find out if your home or business is at risk from flooding. If there is a risk, your local council can give you information to help you reduce the effects. This information could cover:
  - Evacuation plans
  - How to protect items in your home or business by raising them above floor level
  - How you can reduce the risk of future flooding to your home or business
- Know where the closest high ground is and how to get there
- Keep your insurance up to date

When a flood threatens

- Listen to your local radio station for information and follow the advice and instructions from Civil Defence Emergency Management
- You will receive a warning from your local council or Civil Defence Emergency Management Group. Talk to them to find out how they will warn you

During a flood

- Move out of the flooded area or go to the nearest high ground
- Lift household items as high above the floor as possible
- Do not attempt to drive or walk through floodwaters unless it is absolutely essential
- Stay in a safe place. Do not go sightseeing

After a flood

- If you have been affected, have your house inspected and the damage assessed

TSUNAMI

A tsunami is a series of sea waves caused by an earthquake, landslide or volcanic eruption beneath or near the ocean.

How much warning will you have?

There are three distinct types of tsunami – distant, regional and local. In the case of a distant tsunami, we will have more than three hours warning. A regional tsunami will be between one and three hours away, while a local tsunami – the most dangerous – may only give us a few minutes warning.

Tsunami warning

Here are the ways you will know that a tsunami is approaching:

- The Ministry of Civil Defence & Emergency Management will issue a national warning on the television and radio
- You will receive a warning from your local council or Civil Defence Emergency Management Group
- If you are at the coast and you feel a strong earthquake, see the sea receding (the waterline moving away from the shore), the sea bubbling or making a roaring sound, move to higher ground immediately
- Be aware that there may be more than one wave, sometimes as many as seven, and it may not be safe for up to 24 hours. The waves that follow the first one may also be bigger

Before a Tsunami

- If you live in a coastal area, check with your council about the level of risk a tsunami may pose
- Check with your local Civil Defence Emergency Management Group to find out what warning procedures you should expect
- Develop a Household Emergency Plan and ensure you have a Getaway Kit ready should you need to leave in a hurry
- Know where the nearest high ground is and how you will reach it. Higher ground should be at least 35 metres above sea level or at least 1km inland. Plan your escape route now with your household
- If you are buying land, investing or building in a coastal area, talk to your council about the risks of a tsunami, coastal storm surge and erosion

During a tsunami

- If you haven't done so already, move immediately to the nearest higher ground

After a tsunami

- Listen to the radio for civil defence advice
- Do not go down to the sea until you have been told it is safe to do so

VOLCANIC ERUPTION

There are seven active volcanic regions in New Zealand. Those living in these regions are at risk from volcanic ash, debris, lahars and lava flows. A major eruption can deposit huge quantities of ash across vast areas creating serious problems.

Before a volcanic eruption

- Find out if you live in a volcanic area and the hazards that could affect you
- If you live in an area that could experience a lahar or lava flow, make sure you know a quick route to safe ground
- Talk to your local Civil Defence Emergency Management Group about how they will warn you of a volcanic eruption
- Develop a Household Emergency Plan and prepare an Emergency Survival Kit so that you will cope with being on your own for three days or more
- You should also plan what you need in your Getaway Kit in case you need to evacuate

When a volcanic eruption threatens

- If a life-threatening eruption is likely to occur, a Civil Defence Emergency will be declared and the danger area will be evacuated
- Listen to your radio for information and follow Civil Defence Emergency Management advice

During a volcanic eruption

- Save water in your bath, basins, containers or cylinders at an early stage. Your normal water supply may become polluted
- Bring your pets indoors and stay indoors as much as possible
- If you have to go outside, wear a dust mask and goggles. This will keep ash out of your eyes and lungs
- Keep your gutters and roof clear of ash. Heavy deposits of ash can collapse your roof
- Turn your electricity and gas off at the mains
- Do not leave your home unless advised by Civil Defence Emergency Management officials

After a volcanic eruption

- Do not return to your home until Civil Defence Emergency Management officials have told you that it is safe to do so
- If you are affected by the eruption, have your house inspected and the damage assessed

LANDSLIDE

A landslide is the movement of rock and soil down a slope. Landslides can range in size from a single boulder in a rock fall to a very large avalanche of debris with huge quantities of rock and soil that can be spread across many kilometres.

Heavy rain, floods or earthquake shaking can cause a landslide. Human activity, such as removal of trees and vegetation, steep roadside cuttings or leaking water pipes can also cause landslides.

Before a landslide

Getting ready before a landslide will help reduce damage to your home and business and help you survive.

- Find out from your council if there have been landslides in your area before and where they might occur again
- Check for signs that the ground may be moving. These signs include:
  - Sticking doors and window frames
  - Gaps where frames are not fitting properly
  - Decks and verandahs moving or tilting away from the rest of the house
  - New cracks or bulges on the ground, road or footpath
  - Leaning trees, retaining walls or fences
  - Water springs, seeps or waterlogged ground in areas that are not usually wet

If you think a landslide is about to happen

You will need to know how to respond immediately.

- Evacuate and take your Getaway Kit with you
- Contact your local Civil Defence Emergency Management Office
- Warn neighbours who might be affected

After a landslide

- Do not return to a site that has been affected by a landslide until it has been properly inspected
- Take photographs and notes for insurance purposes when it is safe to do so

RADIO STATIONS

The following radio networks will carry civil defence information and advice in an emergency:

- **National Radio**
- **Newstalk ZB**
- **Classic Hits**
- **More FM**
- **Radio Live**

Know how to tune in to your local radio station and record the station's AM/FM frequency in your Emergency Plan.

OTHER EMERGENCIES

What to do in a pandemic
For up to date information, visit **www.moh.govt.nz**

What to do in a fire
For fire readiness and response, visit **www.fire.org.nz**

Bomb Threat /Terrorism
For information on criminal acts and terrorism, visit **www.police.govt.nz**

MORE INFORMATION

For more information on being prepared, or to link to your nearest council visit **www.getthru.govt.nz**

To make sure your home is quake-safe, visit **www.eqc.govt.nz**

For weather updates visit **www.metservice.co.nz**

For updates on earthquake, volcano, landslide and tsunami hazards visit **www.geonet.org.nz**

HOUSEHOLD EMERGENCY PLAN FOR OUR HOME

Work through the checklist with all members of your household. Keep the plan handy.

NAME: _____

_____

ADDRESS: _____

_____

1. Put all items, especially blankets and clothing, into leak proof plastic bags.
2. The person responsible for collecting the children from school in an emergency is: (name/contact numbers)

   _____

   _____

   Contingency _____

   _____
3. The person responsible for checking the emergency survival items is:

   _____

   _____
4. In a civil defence emergency we will remain in our home unless advised otherwise. We will need to be prepared to look after ourselves for up to 3 days or more. In an emergency we will:
   - Stop, think and respond
   - Get our emergency survival items – torch, radio, batteries, etc.
   - Listen to the radio for advice and information
5. If we have to evacuate our home in an emergency we will:
   - Take our Getaway Kit, with the necessary emergency survival items
   - Turn off our water, electricity and gas (always seek professional advice before reconnecting the gas supply)
6. **IMPORTANT CONTACT NUMBERS**

   Police, Fire or Ambulance _____ 111

   Civil Defence _____

   Others (e.g. family members) _____

   _____

   _____

HOUSEHOLD EMERGENCY PLAN FOR OUR HOME CONT'D

7. Check your neighbours – they may need your help

   Name / Address / Phone _____

   _____

   _____

   _____

8. The radio station (incl AM/FM frequency) we will tune in to:

   _____

9. A plan of our house showing places to shelter e.g. in an earthquake, exits, assembly areas and where to turn off water, electricity and gas:

For more information visit www.getthru.govt.nz

Produced by Ministry of Civil Defence & Emergency Management

A.5. Get ready get through store information flyer

This Flyer was distributed by the New World management to the stores to inform them about the Get ready get trough campaign.

Store Informer
– Civil Defence

NEW WORLD

Dates of promotion: 12 – 18 Oct 2009

Promotion details: to support national Civil Defence Awareness Week to "GET READY GET THRU" New World is promoting this through our weekly circular with a double page spread with relevant products; Civil Defence survival kit information and branding.

POS: posters (A0 and A3) will be provided for all stores (modified for NW from this standard one shown) together with advertising in the circular.

In addition your local Civil Defence Emergency Management group is likely to contact you to see how else they can work with you at a local level to promote this week-long event.

We will also include a link from our website to promote http://www.getthru.govt.nz/

Promoted Products: The Circular will feature a range of relevant products such as: bottled water, canned food, First Aid kits, buckets, storage containers 52L etc, Latex gloves, Microfibre towels, can opener, batteries, light bulbs, Torches, Radio.

Any enquiries please contact Roy Scoon (04) 568 0827 or email roy.scoon@foodstuffs-wgtn.co.nz

Non-plagiarism statement Groningen

By this letter I declare that I have written this thesis completely by myself, and that I have used no other sources or resources than the ones mentioned.

The sources used have been stated in accordance with the rules and regulations that are applied at the Faculty of Spatial Sciences of the University of Groningen. I have indicated all quotes and citations that were literally taken from publications, or that were in close accordance with the meaning of those publications, as such.

Moreover I have not handed in an essay, paper or thesis with similar contents elsewhere. All sources and other resources used are stated in the bibliography.

In case of proof that the essay, paper or thesis has not been constructed in accordance with this declaration, the Faculty of Spatial Sciences considers the essay, paper or thesis as negligence or as a deliberate act that has been aimed at making correct judgment of the candidate's expertise, insights and skills impossible.

In case of plagiarism the examiner has the right to exclude the student from any further participation in the particular assignment, and also to exclude the student from further participation in the MSc program at the Faculty of Spatial Sciences of the University of Groningen. The study results obtained in the course will be declared null and void in case of plagiarism (also see Article 12 of Rules and Regulations Exams).

Name:

Place:

Date:

Non-plagiarism statement Oldenburg

Hiermit versichere ich, dass ich diese Arbeit selbstständig verfasst und keine anderen als die angebenden Quellen und Hilfsmittel benutzt habe. Außerdem versichere ich, dass ich die allgemeinen Prinzipien wissenschaftlicher Arbeit und Veröffentlichungen, wie sie in den Leitlinien guter wissenschaftlicher Praxis der Carl von Ossietzky Universität Oldenburg festgelegt sind, befolgt habe.

Name: