Real Options Analysis of Strategies to Manage Risks to Westport from Climate Change

for HenleyHutchings

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Infometrics

Economics put simply

Authorship

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1. Introduction & Summary

Infometrics has been requested by HenleyHutchings Ltd on behalf of the West Coast Regional Council and the Buller District Council to undertake a Real Options Analysis of various adaptation options to protect Westport from the impacts of climate change, notably storm events and pluvial inundation.

A socioeconomic profile of Westport and the Buller district reveals an area which lags behind the rest of New Zealand on a number of indicators such as economic growth, household income and general wellbeing. Nevertheless Westport and the Buller district have an underlying economic viability. The Buller economy grew 15% in the year to March 2022, making it the second fastest growing territorial authority.

Looking to the future, tourism has both the existing economic mass and the potential to dominate economic growth in Westport and Buller, but a minimum level of social and economic infrastructure (roads, houses, social services etc) is essential to support any form of economic growth. Without protection from inundation risk Westport is not viable.

The analysis in this report, although based on rather patchy data, clearly shows that a stopbank option (Option A) recommended by the Technical Advisory Group, which protects the town from a 1-in-100 year inundation event is highly cost-effective, even if there was no escalation in risk with climate change. This is an unusual result. In most areas the risk arises from future climate change. In contrast Westport faces high risk today.

The results also show that adopting managed retreat, even if delayed for thirty years (until after 2052) is far more expensive than Option A. In the longer term manged retreat may need to be reconsidered, but until more is known about the nature of future risk the stop bank option is economically efficient. That is, constructing stopbanks to begin with does not preclude adopting managed retreat if new information over the next two or three decades indicates that climate change is worse than the modelled climate scenario.

We stress that data limitations mean that the adaptation pathways considered here are very simple. It is possible that one or more of the other options that were presented to the Technical Advisory Group are preferable to the one analysed here. Other adaptation options could also raise the possibility of transition between options, potentially adding many more pathways and changing the value of waiting for more information about how the risk of inundation is changing over time – in other words the value of the option to delay investing in expensive adaptation.

Our analysis excludes non-economic factors that may affect what sort of adaptation a community desires. For example a high river stopbank may impede views of the estuary from the dwellings being protected or there may be a loss of beach access. Multi-criteria analysis could be useful in this regard.

Finally, any analysis of adaptation options needs to be periodically updated in the light of new information about costs, the nature of climate change and associated hazard risks, and so on – and indeed after a seriously damaging event as that could enhance the economic case for manged retreat.

2. Socioeconomic Profile

Overview

There are many measures that could be included in a socioeconomic profile. We look primarily at demographics, GDP and income, concluding with a multi-dimensional wellbeing indicator. Most detailed measures are available only for the Buller district, and time series data only up to 2021, but as is clear from Figure 1, Westport dominates the district, accounting for 57% of its population, 58% of its employment and 49% of its GDP in 2021. The relatively lower GDP share is mirrored by the relatively high share of GDP in the Buller Coalfields and Inangahua areas, as GDP is measured where business activity occurs, not where employees reside.[1]

Historical picture

Most of the changes in GDP since 2011 have been negative. Westport Rural and Karamea went against the trend, but their small weight in total Buller GDP means that the net effect is still clearly negative – a decline of 4.2% pa over the decade.

The data suggests considerable economic inter-dependency between the SA2 regions such that economic growth in each location is affected by, and affects growth in other locations. Hence the measures presented below for the Buller district can be considered as generally representative of Westport.

The overall picture of Westport/Buller portrayed by the statistics below is of a region that has not kept pace – socioeconomically – with the rest of New Zealand. For relatively isolated communities (including in regions such as Tairawhiti and Northland) this is not unusual. Large urban areas provide better educational and employment opportunities, leading to migration out of isolated areas – it is a world-wide trend.

Recent data

Despite a long term trend of underperformance, Westport and the Buller district have an underlying economic viability. The Buller economy grew 15% in the year to March 2022, making it the second fastest growing territorial authority. Consumer spending was up 10% in the year to March 2022, running above the strong inflation rate of 6.9% in the same quarter.

Tourism expenditure has grown 9.8% over the past year, reflecting strong domestic tourism that has offset the loss of international tourists. High commodity prices for the primary sector have also helped Buller during the pandemic. The dairy payout is forecast to grow by $24m in the 2021/2022 season for the district, to a total of $150m.

Buller's housing market has been strongly affected by the floods in 2020 and 2021, with house values falling 8.3% in the March 2022 quarter. New dwelling consents are up 94% in the year to March 2022, reflecting both the flood rebuild and renewed interest in the district that predates the flood. Non-residential consents have also been strong, growing 148% to reach $35m over the 12 months to March 2022.

[1] All data in this section has been compiled by Infometrics is from sources such StatsNZ. See www.infometrics.co.nz

The future

Improved connectivity, both physically via road and rail, and virtually via telecommunications can enable people to remain in or indeed move to outlying locations such as Westport while still enjoying the pecuniary benefits of a city job. This does require, however, that those outlying locations have at least a minimum of degree of social and economic viability – essential retail, medical, recreational etc facilities.

Retaining these sorts of services in places such Westport not only alleviates pressure on corresponding services in cities (many of which struggle to meet the demands of more intensive residential development), it also means that these places are more attractive to investment in tourism and in other industries that need to be close to specific raw materials and have access to a local labour force. Westport is a fine example. It provides tourist access to Karamea and the Heaphy Track to the north, and to Punakaiki and the Paparoa National Park to the south. Although coal mining has been on the decline for many years, bituminous coal for steel production is found only on the West Coast, while further gold mining and rare earth mining (elements essential to electric vehicles) are also possibilities.

Forecasting economic growth with fine geographical resolution is risky. Top-down models combined with regional trends are useful as they capture changes in macroeconomic variables such as the terms of trade and government spending, but without knowledge of on-the-ground developments their projections can easily go awry. With that reservation in mind, our simple modelling indicates that tourism has both the existing economic mass and the potential to dominate economic growth in Westport and Buller over the next five years.

Infrastructure (roads, houses etc) that is robust with respect to climate change hazards is essential for future economic growth, not just for tourism, but also to keep other options open – options that are currently unknown, but that could emerge from technological advances or changes in consumer preferences. The future viability of Westport and its contribution to the wider West Coast and New Zealand economy depends on protection from natural hazards – hazards that were not foreseeable when towns such as Westport were developed.

Figure 1: Buller District Economic Profile by SA2

	Data from 2021				Annual % Change Since 2011			
Statistical Area 2	Population	Employment	GDP ($M)	Business Units	Population	Employment	GDP	Business Units
Westport South	2,420	544	$105.9	117	-1.0%	1.2%	-8.0%	-1.6%
Westport North	1,870	1,657	$173.4	273	-0.9%	-1.0%	-0.6%	0.3%
Westport Rural	1,260	279	$38.9	120	0.1%	1.2%	4.0%	0.0%
Reefton	920	376	$54.1	96	-1.1%	-2.6%	-3.7%	-0.6%
Buller Coalfields	890	364	$98.8	69	-1.2%	-8.0%	-9.4%	-1.6%
Inangahua	890	568	$108.4	204	-1.5%	-0.2%	0.3%	-0.8%
Karamea	860	231	$33.3	120	0.5%	1.7%	3.2%	-0.2%
Charleston (Buller District)	550	230	$31.3	102	-1.7%	-7.7%	-6.1%	-1.6%
Inlets Buller District					0.0%	0.0%	0.0%	0.0%
Total	**9,660**	**4,248**	**$644.1**	**1,101**	**-0.8%**	**-2.0%**	**-4.2%**	**-0.6%**

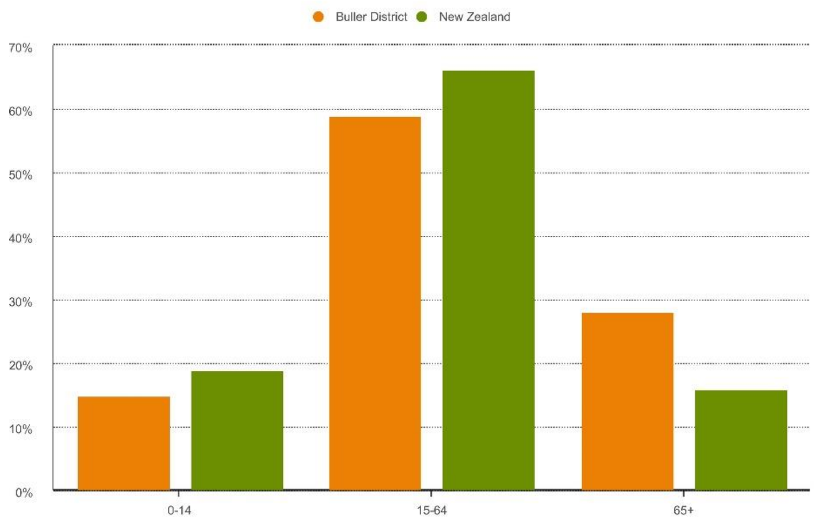
Population

In comparison to all New Zealand the population growth rate in Buller depicts a rather unusual profile. Although generally below the New Zealand rate it caught up over the period 2006 to 2013, only to slip back over the last eight years – and with considerable volatility (Figure 2).

The age composition of the Buller population is older than for New Zealand as whole, with mean ages of 47 and 39 respectively (Figure 3). Unsurprisingly the negative population growth since 2013 has been led by the 15-64 age group, with a natural flow-on effect to the younger age group.

Figure 2: Population Growth

Figure 3: Age Composition

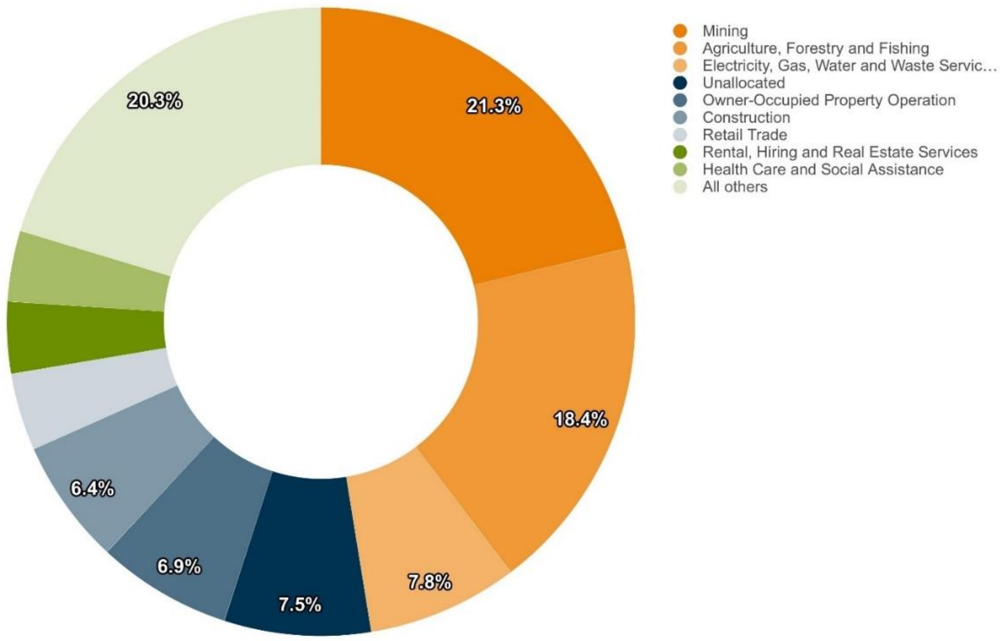


Gross Domestic Product

The growth profile for GDP in Buller is not dissimilar to the population growth profile, with positive growth between 2006 and 2013 (driven largely by coal mining), and again much more volatility than for all New Zealand (Figure 4). Two industries dominate economic activity; mining and agriculture (Figure 5), although the picture is likely to be somewhat distorted by the lack of tourists in 2020 and 2021. Also tourism is not an identified industry in the national accounts. It is a category of final demand that purchases goods and services from industries such as transport, retail trade and accommodation – which are in the 'Other' category in Figure 5.

Figure 4: Growth in GDP

Figure 5: Industry Composition of GDP, 2021

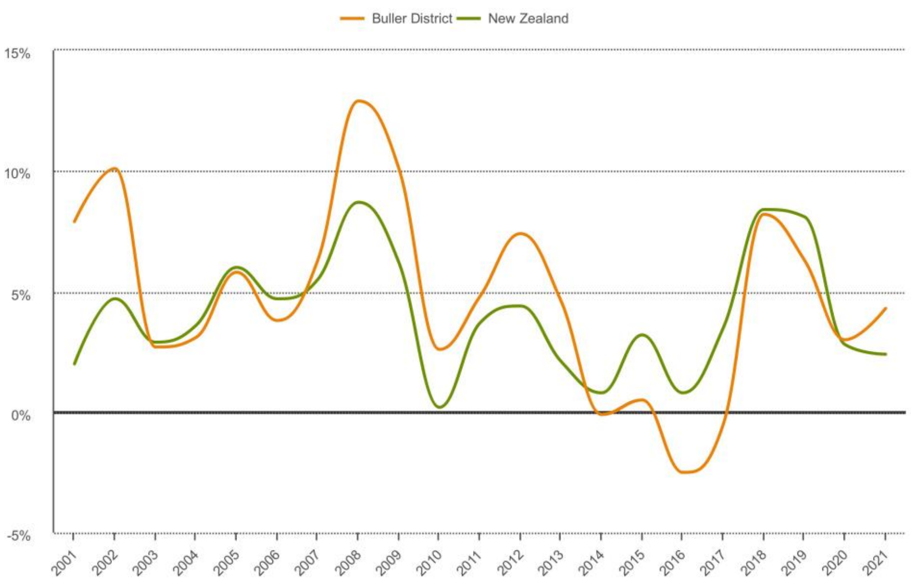


Household Income

Mean household income in Buller at $77,560 is 68% of the national mean (Figure 6), although proportionate changes over the last 20 years have closely followed the national profile. As with changes in population and GDP, the period 2006 to 2013 again stands out as relatively upbeat (Figure 7).

Figure 6: Mean household income 2021

Figure 7: Change in mean household income



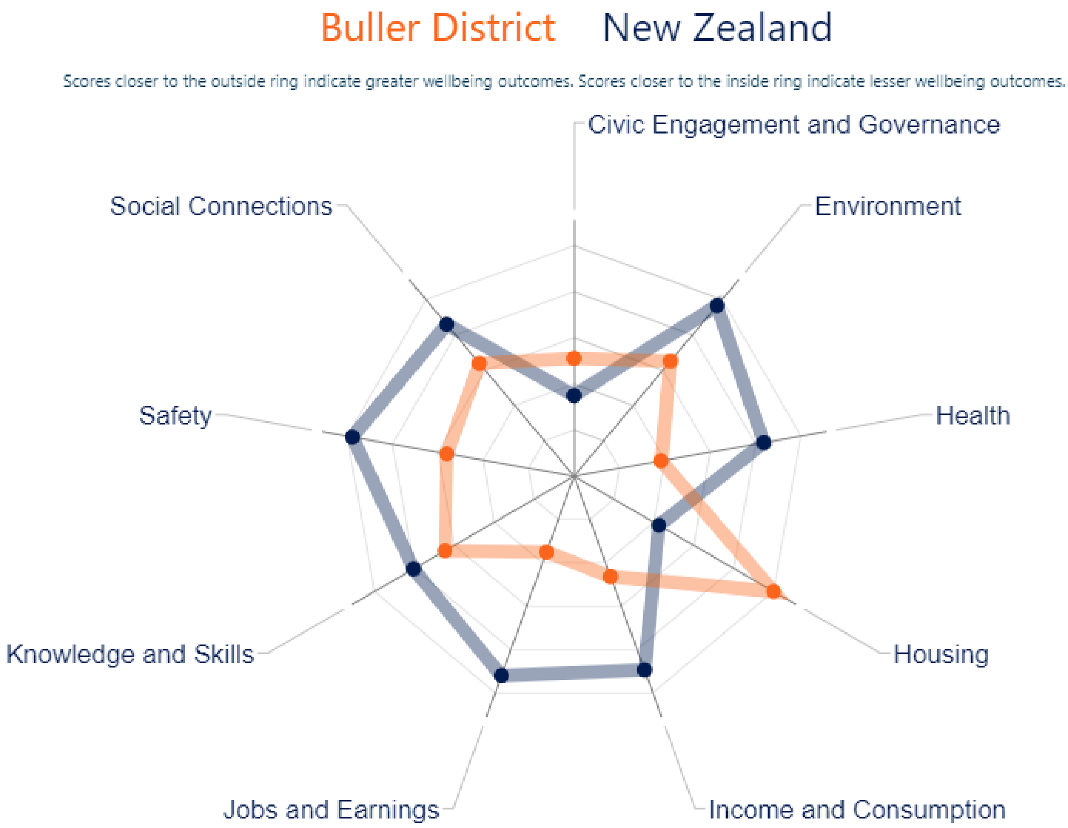
Wellbeing

Figure 8 presents the Infometrics wellbeing framework, showing how Buller performs on a range of measures relative to all New Zealand. In two areas; housing, and civic engagement and governance, Buller performs relatively well. The housing measure is a combination of measures of home ownership, household crowding, housing affordability, and rental affordability. Civic engagement and governance is based on the turnout rates for local and general elections.

The general picture, however, is of a region that has a lower level of wellbeing than the rest of New Zealand. Although 'wellbeing' here is not self-assessed one would expect indicators such as poorer health (including life expectancy and drinking water quality), lower earnings, and less safety (including crime rate and workplace injuries) to be strongly correlated with subjective measures of wellbeing.

More government investment in health and education would certainly assist with lifting the wellbeing of the people of Westport, but there needs to be a Westport to assist. In the next section we analyse the economics of various options to protect against climate change risk, including relocation of the town.

Figure 8: Wellbeing (latest available year – differs across measures)



3. Analysis of Adaptation Options

Assumptions

Adaptions Options

The Technical Advisory Group (TAG) has reduced a broad list of adaptation options to a favoured one, known as Option A, consisting of an extensive ring bank around Westport, including Carters Beach, but excluding the Snodgrass area. Further detail is available from G&E Williams Consultants Ltd.

We look at this option as well as managed retreat to higher ground south of Westport.

Ideally we would like to split the analysis into three management units; Carter's Beach, Westport and Snodgrass. However, time and data limitations prevented that approach.

Investment costs

Costs for a number of protection options have been estimated by G&E Williams Consultants Ltd and Land River Sea Consulting Ltd.[2] As recommended we adopt the latter's Option A for the analysis below. Comparing it with what appear some very similar options costed by Williams and which differ in cost by about ±10%, we assume a cost for Option A of $22m. In addition we assume an average $100,000 every five years for maintenance and repairs. Option A protects against an AEP=1% event under climate scenario RCP6.

At this stage we do not have the data to distinguish between different types of protection such as earth stopbanks compared to concrete walls.

Asset values and residual loss

Ideally we would have estimates of potential asset loss under various climate (RCP) scenarios, annual exceedance probabilities (AEPs) and time horizons – and then the same for various adaptation options. NIWA provided some data, as shown by the bold numbers in Tables 1 and 2, which relate to RCP6.[3] Both sea level rise and increasing fluvial/pluvial risk are taken into account.

Table 1: Residual Loss[4], No Protection

ARI	AEP	2022	2072	2122
		$m	$m	$m
20	0.0488	**50**	74	84
50	0.0198	**106**	231	286
100	0.0010	**264**	488	**596**
200	0.0005	462	615	682

[2] Figures provided via HenleyHutchings Ltd.

[3] NIWA (2022) Direct Damage Analysis for Scenario Flooding in Westport, report to HenleyHutchings Ltd.

[4] No realistic adaptation option, with the possible exception of retreat, can eliminate all risk. The TAG recommended option will protect against a 1-in-100 year flood, taking into account the increasing frequency of such events under RCP6. Rarer events (such as a 1-in-200 year flood) would still cause an economic loss. This is known as the Residual Loss.

The other numbers are estimates based on earlier work by NIWA[5] and statistically estimated relationships between river flows, flood heights and integration under fitted damage functions. Accordingly the estimates must be seen as preliminary. More accurate figures are welcome.

All values are in constant 2022 prices. There is no allowance for any economic growth., though this could be altered.

Table 2: Residual Loss, Option A

ARI	AEP	2022	2072	2122
		$m	$m	$m
20	0.0488	**35**	37	39
50	0.0198	**52**	80	94
100	0.0010	**66**	93	**100**
200	0.0005	100	250	334

In addition to considering Option A, we also look at managed retreat (Option MR). For this preliminary assessment we assume that managed retreat would occur only if the land is inundated so often that it becomes uninhabitable, in which case it is assigned a value of zero. However, to the extent that it might have value in other uses, such as wetlands, our analysis overstates the costs. Based on current capital values, plus an allowance for planning costs and remedial costs etc, we assume managed retreat would cost $1.7 billion spread over a 15 year period.[6]

With the exception of MR, the total cost of a protection strategy includes the cost of the protective measures themselves (capital and maintenance) and any expected residual loss. It is very unlikely that any protective strategy except managed retreat can reduce residual loss to zero.

We assume that regulations or other measures prevent additional development behind the protective structures as that would raise the expected residual loss.

Real Options Analysis

Introduction

Investment in flood protection can be expensive, but not investing in flood protection can also be expensive, as illustrated by the flooding in Westport in July 2021. Balancing the cost of investment in increased flood protection against the value of the reduction in economic loss from a flood is not an easy calculation, especially in the context of uncertain impacts of climate change that could substantially alter flood frequency and severity.

The aim of this analysis is to assess whether the risk of under-investment or over-investment can be reduced if a flexible investment strategy is maintained, rather than simply making a single (irreversible) investment at the start of a planning period.

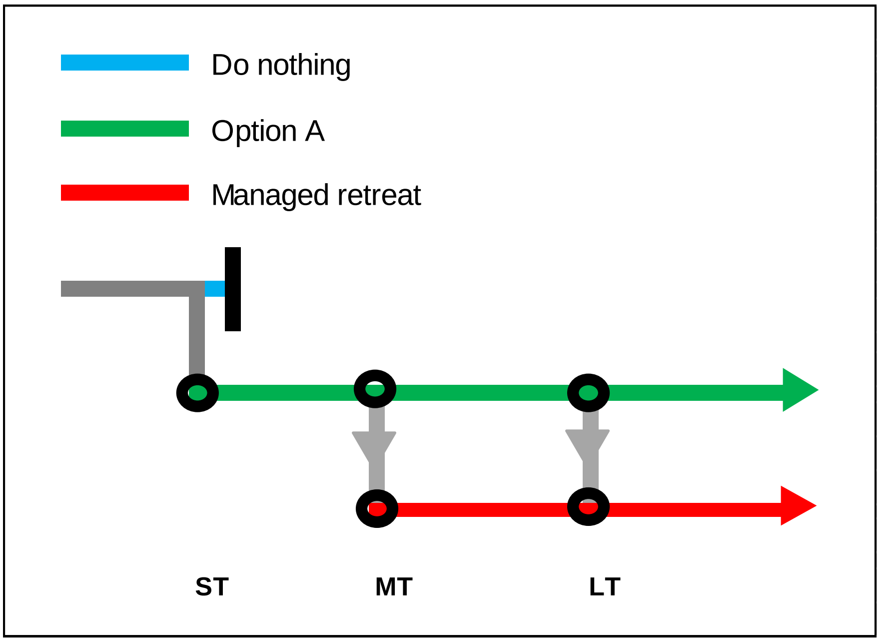
Maintaining a flexible strategy involves an on-going monitoring regime. Flood return periods could be recalculated after each storm or river 'event' and compared with other

[5] Options Keenan, N. J., & Oldfield, S. G. (2012). Impacts of Climate Change on Urban Infrastructure & the Built Environment - A Toolbox. Westport Case Study: Initial Assessment of Climate Change Flood Adaptation Options..
[6] Land purchase should be excluded as it is just a transfer of ownership. However, if land is lost to the sea or river there is a loss of a physical asset, which had a value.

new knowledge about the frequency of intense rainfall in the catchment, and with the characteristics of intense storms across New Zealand. The trigger to act might be a stipulated percentage change in the intensity and duration of rainfall; it could also reflect the coping capacity of those affected by repeat flood events at particular damage levels.

As noted above we consider Option A together with managed retreat that begins (in earnest) in the medium term – around 2052, or in the long term – around 2097. As illustrated in Figure1, the Do Nothing option has essentially reached its 'used-by' date, requiring transition to Option A in short order. Option A provides a long term solution to an AEP=1% event under RCP6 out to 2122. Managed retreat meets those criteria and more. Beyond 2122 it may be the only viable option.

Figure 1: Option Pathways (short, medium and long term)



Results

Table 3 presents a summary of total discounted costs (the cost of investment in adaptation plus the residual loss) with and without RCP6 climate change, and the associated cut-off probabilities compared to Do Nothing. The discount rate is 3%. Appendix A provides more detail on choosing discount rates.

Table 3: Discounted Investment Cost plus Residual Loss and Cut-Off Probabilities

Action	No Climate Change ($m)	RCP6 Climate Change ($m)	Cut-off Probability
Do nothing	169	213	
Option A	36	50	-451.4%
Option A to 2052, then MR	601	608	1171.7%
Option A to 2097, then MR	182	195	42.3%

The cut-off probability is not an estimate of the probability of damage from a particular climate change scenario, flood profile, etc. Rather it is the risk-neutral probability at which the statistically expected discounted cost from over-investing in flood risk management (spending more or sooner than is required for the desired degree of protection) is the same as the statistically expected discounted cost due to flood damage from under-investing or delaying investment in flood risk management (the level of protection being inadequate).

Table 3 shows that the case for pursuing Option A could not be clearer. It is cheaper than all other options and has a nonsensical (negative) value for the cut-off probability. Westport is unusual compared to most locations in New Zealand in that it has a very high inundation risk even without any exacerbation of the current hazard risk profile from climate change.

The results also show that adopting managed retreat after 2052 is far too costly and would require the probability of RCP6 inundation risk to be greater than 100% – again a nonsensical result. We may infer that immediate managed retreat would be even more costly. Even delaying managed retreat until 2097 is much dearer than Option A, although it is preferable to doing nothing if the expected probability of RCP6 exceeds 42%.

From a flexibility perspective, implementing Option A to begin with does not preclude adopting managed retreat if new information over the next two or three decades indicates that climate change is worse than the RCP6 scenario. This flexibility reinforces the substantial cost advantage that Option A has over managed retreat.

Caveats

Data limitations mean that the adaptation pathways looked at here are very simple. It is possible that one or more of the other options that were presented to the TAG are preferable to Option A. Additional adaptation options could also raise the possibility of transition between options, potentially adding many more pathways and changing the value of waiting for more information about how the risk of inundation is changing over time – in other words the value of the option to delay investing in expensive adaptation.

A second caveat is that the analysis has excluded non-economic factors that may affect what sort of adaptation a community desires. For example a high river stopbank may impede views of the estuary from the dwellings being protected or there may be a loss of beach access. Multi-criteria analysis could be useful in this regard.

Sensitivity Tests

In most ROA analyses a suite of sensitivity tests would be strongly recommended. Typically this would involve examining the effects of changes in variables such as:

- The discount rate
- Investment costs (such as to account for different types of stopbanks or walls)
- Residual loss
- Cost of managed retreat

However, Option A has such a marked advantage that even quite large variations in the above settings are unlikely to alter the conclusions, unless the amount of estimation that has been required to produce the above numbers is seriously askew. Exploring other adaptation options would probably generate more useful insights, as would analysing different climate scenarios, but that would be ambitious without better data.

Appendix A: Discount Rate Theory

Present Value

The present value (PV) of a flow of income (or analogously, payments) is the value that someone would pay today to receive those future income flows. For example if an investment paid $200 after two years, one should be willing to invest at a price up to about $181 if other uses of those funds deliver a return less than 5% per annum (200/1.05^2 = 181).

This example is easily generalised to a longer time period with more complicated investments.

Discount Rates

There are two fundamental properties of discount rates that are relevant to investment in protection from inundation and erosion:

1. If a project delivers returns that can be reinvested at the same rate and risk profile as the project itself, the cost of capital is an appropriate discount rate. This discount rate should incorporate a market based risk premium.

2. However, the capital cost of the project must truly represent the opportunity cost of that capital used for other investment. A social discount rate is likely to be more appropriate if this is not the case.

The first property is essentially a description of the Capital Asset Pricing Model (CAPM), a description of which can be found in Treasury (2008).[7] Treasury's current standard discount rate for infrastructure projects is 5.0%.[8]

The cost of capital is also known as the social opportunity cost of investment; the implicit assumption being that government investment displaces other investment that would have earned a similar rate of return. However, in the case of investment in flood or erosion protection by local government this is unlikely, especially if property rates are higher than they would otherwise be. Most of the opportunity cost of this funding is likely to be in the form of lower private consumption, not lower (private) investment.

In that case the cost of capital is not the appropriate discount rate to use for flood protection projects, or at least it should be substantially reduced towards something like the social rate of time preference (SRTP), which is the appropriate rate for discounting when the opportunity cost of the project is in the form of less consumption.

The SRTP is usually expressed as:

$$r = d + \varepsilon.g$$

r is the social rate of time preference

[7] Treasury (2008): Public Sector Discount Rates for Cost Benefit Analysis.

[8] See http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/currentdiscountrates

d is the rate at which future consumption is discounted over current consumption

g is the annual growth of consumption per capita

ε is the elasticity of the marginal utility of consumption

The variable d is frequently further disaggregated into two components:

$d = \rho + C$

ρ is the pure rate of time preference

C is the risk of a catastrophe which severely disrupts life on earth. See for example Stern et al (2006)[9] in connection with climate change.

There is much debate on the values of these variables, but the arguments are well beyond the ambit of this paper. The interested reader is referred to Parker (2009).[10] Parker suggests that a reasonable value of the SRTP for New Zealand is around 3.0% - 4.0%.

We adopt 3% as the default rate in our analysis as the climate change scenarios under investigation span over 100 years. Indeed following Stern a lower rate could be justified when dealing with climate change so we analyse the scenarios with a rate of 1.5% as well. A rate of 6% is also tested.

[9] Stern, N. et al (2006): *The Economic of Climate Change. HM Treasury.*

[10] Parker (2009): "The implications of discount rate reductions on transport investments and sustainable transport futures." *NZTA research report* 392.