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Beyond Gross Domestic Product: The New Zealand Genuine Progress Indicator to Measure the Economic, Social and Environmental Dimensions of Well-being from 1970 to 2016

Murray Patterson
Garry McDonald
Vicky Forgie
John Kim
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Professor Murray Patterson[1]
Dr Garry McDonald[2]
Dr Vicky Forgie[3]
Joon-Hwan (John) Kim[2]
Derrylea Hardy[1]
Dr Nicola Smith[2]
Yanjiao (Jenna) Zhang[2]

[1] School of People, Environment and Planning, Massey University, Palmerston North
[2] Market Economics Ltd, Auckland
[3] Ecological Economics Research New Zealand, Massey University, Palmerston North

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Synopsis

This is a short non-technical synopsis of the NZ Genuine Progress Indicator research.

Unless otherwise stated, all numerical values apply for the year 2016. All dollar values are inflation adjusted so they are expressed in 2014 dollars.

Gross Domestic Product or GDP is widely used to measure the performance of national economies, including New Zealand's. Many consider it to be the pre-eminent indicator of economic performance. Although the GDP measures the amount of goods and services produced in the economy each year, it is a woeful measure of a country's well-being. In the GDP, many activities like, for example, a near-shore oil spill might perversely contribute to GDP, when they are clearly not beneficial to society – refer to Box 1 for further explanation. The Genuine Progress Indicator seeks to overcome these limitations in the GDP.

Through our meticulous process of data collection and analysis and by following international best practice, a Massey University and Market Economics Ltd team tracked New Zealand's economic performance since 1970, by using the Genuine Progress Indicator framework. The Genuine Progress Indicator measures 21 benefits and costs associated with economic activity in New Zealand, most of which are not tracked by the GDP. These 21 benefits and costs are first of all converted to monetary terms ($NZ) using standard economic valuation methods; and then 'added up' to obtain an overall Genuine Progress indicator for New Zealand for every year over the time period 1970 to 2016.

Overall Results: The results of this analysis are that the Genuine Progress Indicator shows our societal progress is not as rosy as GDP indicates (refer to Chart A). Overall, on a per capita basis, since 1970 the GDP increased by 91%, whereas the Genuine Progress Indicator, which gives a more accurate measure of the nation's well-being only increased by 53%.

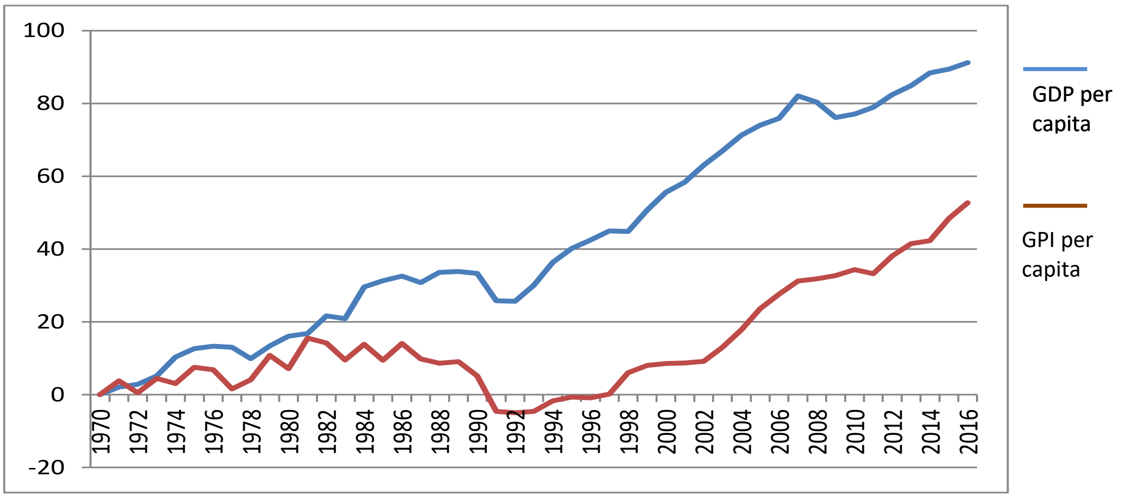

Chart A National Progress: GDP versus Genuine Progress Indicator
(Both Indicators are measured in per capita terms, and then converted to their 'percentage change since 1970'. By definition, 1970 = 0% change for both indicators).

The Genuine Progress Indicator can be broken down to its component parts to provide a more detailed and nuanced picture of the nation's progress – across economic, social and environmental indicators and data:

Personal Consumption of Goods and Services: The largest component in both the Genuine Progress Indicator, and the GDP, is the consumption of everyday goods and services that we purchase, including everything from food items, entertainment, clothing, through to the purchase of electronics and white-ware. Compared with 1970 we are materially a lot better off, with the 'average' New Zealander in 2016, spending 80% more on consumer goods and services than we did in 1970. That is, the average person spent in inflation-adjusted terms $18,846 on consumer goods and services in 1970, increasing to $31,820 in 2016.

Inequality: These 'average' figures in consumption growth are deceiving. Even before the economic reforms first instigated by the Labour government in the 1980s, there was a growing gap between rich and poor in New Zealand, and this very much blunted improvements in our material standard of living, as the benefits of an improved economy were not shared equally.

The level of the Genuine Progress Indicator dropped by 23% purely due to growing income inequality over the 1970 to 2016 period. Income inequality does not only mean that poorer people consume less goods and services, but income inequality has well documented impacts on the decline in social cohesion, negative medical and mental health outcomes associated with poverty, through to aspects such as more limited access to education and other barriers to well-being.

Use of Time: Another downside of the economic growth of the last five decades, has been that more of us have become 'time poor'. First of all, more and more time is wasted in **commuting to work**, as transport infrastructure has not kept pace with economic growth – our economic analysis shows that in 2016 that the time lost during commuting and other commuting costs amounted to a cost of $7.1 billion, which is the second highest 'cost externality' in the GPI next to income inequality. Secondly, changes to the employment conditions in New Zealand, particularly since the enactment of the Employment Contract Act 1991 and subsequent legislation, have contributed to our 'time poverty'. We are working on average more hours per week, with lower income people working more than one job and more than the standard work week of 37.5 hours. Higher income people often on a salary are also working more than the standard working week. The cost of 'overworking' was calculated to be $5.6 billion in 2016.

Time use surveys, combined with economic analysis, reveal that **unpaid household work**, such as cleaning or caring for children, as well as **unpaid community work**, were worth $27 billion in 2016. The value of such work is completely ignored by the GDP indicator, which gives a very distorted view of how household and community work contributes to the nation's well-being. The value of unpaid 'Household and Community Work' is the second highest beneficial component of the New Zealand GPI next to personal consumption of goods and services.

Unemployment and Under-employment: Labour market conditions in New Zealand have changed dramatically since 1970 with the decline of the 'guaranteed' full-time job, and, in general, much higher levels of unemployment and under-employment. The cost of 'involuntary leisure time' was used to measure the economic cost of unemployment at $1.1 billion in 2016, and the economic cost of under-employment at $2.7 billion for the same year.

Public Services and Infrastructure: The Genuine Progress Indicator not only considers the benefits derived from goods and services that we purchase on an everyday basis, but it also takes account of the benefit of 'public services' such as health, education, welfare, local government services such as sewage treatment and waste disposal; as well as the services derived from public infrastructure (capital), such as roading. Although there was a serious decline in the provision of services from public infrastructure, with the economic reforms of the late 1980s through to the mid-1990s, this has rebounded with government reinvestment in such services, but this has not returned to the levels prior to 1984. In 2016, these public services and public infrastructure (capital) had in total a value of $14,417 per person – which compares with $31,820 per person for 'private' consumption of goods and services.

Crime: Year-on-year decreases in crime rates have meant that the economic cost of crime has declined consistently since 1992. In 1992, the economic cost of crime (not including crime already included in the other components of the GPI[1]) was $5.5 billion and by 2016 it had decreased to $3.2 billion.

Environmental Costs: The Genuine Progress Indicator shows that the 'boom' in the growth personal consumption of goods and services over the last five decades, has come at the expense of the deterioration of the natural environment. Overall, this deterioration of the natural environment was conservatively costed at $18.3 billion, in the GPI analysis, for the year 2016. The most significant environmental cost was **air pollution** with an economic cost of $5.1 billion for 2016, based on air pollution causing premature deaths and restricted activity days, as well as negative health effects such as respiratory and cardiac illnesses.

The **loss of soil ecosystem services** was the second highest environmental cost, with the loss of elite soils through urban expansion, and more importantly, with the loss of soils in the rural environment through human-induced soil erosion. Such soil erosion has not only resulted in the loss of productive land, but also has had other effects such as increasing flood severity and damage to property all of which have an economic cost. Overall, the loss of soil ecosystem services was costed at $3.5 billion for the year 2016.

The third largest environmental cost in the Genuine Progress Indicator is **greenhouse gas emissions** and the negative impact this has had on climate change. Greenhouse gas emissions attributable energy use in the economy dramatically rose more than two and half times over the 1970 to 2016 period. Fortunately, forestry plantings and other land-use changes nullified this effect, to some extent. However, overall there was still a net increase of greenhouse gases of 24%, having an economic cost of $3.0 billion pa in 2016.

The fourth largest environmental cost is **water pollution**, which has very significantly increased since 1992, mainly due to the intensification of agriculture through greater numbers of dairy cattle. The economic cost of water pollution increased from $1.5 billion in 1992 to $2.4 billion in 2016.

Other environmental costs included in the Genuine Progress Indicator are: the loss of wetland ecosystem services, noise pollution, cost of biological pests, cost of solid wastes disposal and contaminated sites, ozone depletion and loss of indigenous forests, which collectively all had an economic cost of $4.3 billion in 2016.

The Genuine Progress Indicator represents a challenge to governments to more comprehensively take account of benefits and costs when they make policy decisions. And, to not rely solely on the GDP when making policy decisions, as it provides a narrower and sometimes distorted picture of how the economy is performing. Increasingly economists worldwide and politicians, including those in New Zealand, are recognising that we need better indicators of economic performance than the GDP. A recent article in the prestigious academic journal *Nature*, by leading ecological economist Robert Costanza, makes the point quite bluntly stating it "is time to leave GDP behind us".

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[1] Crime is also covered in other components of the Genuine Progress Indicator. That is, public sector costs of crime (e.g. policing, Justice system, prisons and so on) have already been taken account of in the in the 'Public Services' component of the Genuine Progress Indicator. In addition, medical and other expenses resulting from violent crime and sexual offences have already been taken account of in the 'defensive expenditure' aspect of the 'Consumption of Public Services', as well as being included in the GPI compoment 'Private Defensive Expenditure on Health'.

Like all indicators, the GPI is not perfect or complete. It commensurates a wide range of benefits and costs that result from economic activity, in terms of a monetary metric, in a way that is consistent with orthodox economic theory. For some, this monetising may seem objectionable, for a variety of philosophical reasons. Whilst we acknowledge this, our approach is pragmatic – that is, it's better to include these 'externalities' in an aggregate measure of national progress, for all the flaws that this approach may entail, rather than ignore them completely.

This project was originally funded by the government's Foundation for Research Science and Technology (2003-2009), and recently (2017-2018) the data have been updated to 2016 with some significant methodological and technical improvements being made to the estimates.

Box 1 – Oil Spills and GDP: An oil spill in near-shore environment, could increase GDP, even though clearly this oil spill is not beneficial to society. The most famous example of this is the spill by the Exxon Valdez oil tanker in 1989. In spite of the very considerable ecological damage to the near-shore ecology and fisheries, this oil spill event had a significant positive impact on GDP. This was because the payment of many businesses and federal/state employees (and payment of other costs) needed in this cleanup were all captured as positive contributions to GDP – and the ecological damage due to this event was not captured by the GDP at all. Essentially, GDP is an 'activity meter' in that it measures increases or decreases in economic activity, making no assessment on whether the activity be measured as 'good' or 'bad', which leads to the anomalous situations with the GDP that occurs in circumstances like a near-shore oil spill. The same argument can be made in respect to the grounding to the *Rena* container ship on the Astrolabe Reef near Tauranga in 2011.

Extended Summary

Limitations of the Gross Domestic Product

Gross Domestic Product is considered to be the pre-eminent indicator of national economic performance. It not only guides and informs public policy in New Zealand as it does in other countries, but it also has a high recognition level amongst the general public. All that said, the limitations of the GDP indicator, and the way it is mistakenly used as a proxy for measuring the nation's welfare, are increasingly being recognised by economists, academics and policy makers. The main limitations of the Gross Domestic Product (GDP) indicator as a measure of the nation's welfare were identified to be:

- Not taking account of **cost externalities** such as for example the negative impacts on human health of air pollution, or the psychological stress caused by noise pollution.
- Not taking account of **benefit externalities** such as for example the value of unpaid household work and voluntary community work.
- Not taking account of the **undesirable ways in which we use our time**, such as for example 'overworking', 'wasting time' in unnecessary long commuter trips, and 'work-life balance' issues (all of these factors are manifestations of 'the opportunity cost of time').
- Not taking account of the **inequality of income distribution**, by not allowing for the fact that an extra dollar's worth of income to a poor person is worth more than an extra dollar's worth of income to a rich person.
- Failure to consider **intergenerational equity** (or more broadly speaking long term sustainability issues), as GDP only measures income within a one year time frame with no account of any long term impacts on future generations.

Recognising these limitations in the Gross Domestic Product, in our study, we used the Genuine Progress Indicator approach, to measure welfare across three main wellbeing dimensions (economic, social and environmental).

What is the Genuine Progress Indicator? And How is it Measured?

Internationally, the Genuine Progress Indicator has emerged, as a more accurate and comprehensive measure than GDP of economic performance, taking account of both welfare[2] enhancing (benefits) and welfare reducing (costs) factors. This GPI approach was applied to the New Zealand economy, tracking its performance from 1970 to 2016. Drawing on best practice from overseas studies with some adjustments to allow for New Zealand's unique situation and making some methodological improvements[3], twenty one[4] components were identified to that make up the New Zealand GPI, some of which are 'benefits' and some 'costs': personal consumption of goods and services, consumption of public services, income distribution (equity), unemployment, under-employment, over-employment, services of public capital, household and community work, commuting, crime, deforestation of indigenous forests, biological pests, loss of wetland ecosystem services, loss of soil ecosystem services, loss of air quality, solid wastes and contaminants, greenhouse gas emissions, loss of water quality, ozone depletion and noise pollution.

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[2] In our analysis, we use the terms 'welfare' and 'well-being' interchangeably.

[3] It is commonplace in constructing a Genuine Progress Indicator, to attempt to measure 'sustainability' as well as 'welfare'. We consider this simultaneous measurement of 'welfare' and 'sustainability' to be an inappropriate conflation of two fundamentally different ideas; as well as an inappropriate aggregation of 'flow' measurements (used for welfare) and 'stock' measurements (often used to measure sustainability). We therefore argue that 'sustainability' should be measured by other indicators (eg, the Genuine Savings Index and the Ecological Footprint), and to be used in a complementary fashion alongside the GPI that has a focus on 'welfare'.

[4] This includes 4 benefits, 15 costs, 1 item that is solely a defensive expenditure (on private health) and 1 item where personal consumption is weighted to take account of income equality/inequality.

The **first step** is to measure these 21 components in 'natural' or physical units. The **second step** is then to monetise all those components in the GPI using various valuation (monetisation) methods – though some of the components (7) were already 'naturally' measured in monetary terms. The **third step** involved aggregating these 21 components to produce one aggregate index (one number) for each of the 47 years starting with 1970. The overall approach is to start with the 'Personal Consumption' of everyday goods and services which is the largest and most beneficial component of the GPI, and then to: (1) **Add** other 'benefit' components; (2) **Subtract** 'cost' components; and (3) **Subtract** 'defensive expenditures'[5]. The following table outlines how this has been undertaken for the year 2016:

Genuine Progress Indicator Component		Costs	Benefits	Defensive Expenditures
		$2014 million	$2014 million	$2014 million
1	Personal Consumption		156,655	
2	Changes in Income Distribution	35,934		
3	Consumption of Public Services[a]		44,659	
4	Unemployment	2,659		
5	Under-employment	1,151		
6	Over-employment (Overwork)	5,560		
7	Services of Public Capital		23,052	
8	Household and Community Work		45,579	
9	Private Defensive Expenditure on Health			537
10	Commuting	7,118		
11	Crime	3,669		
12	Deforestation of Indigenous Forests	177		
13	Biological Pests	974		
14	Loss of Wetland Ecosystem Services	1,542		
15	Loss of Soil Ecosystem Services	3,522		
16	Loss of Air Quality	5,100		
17	Solid Wastes and Contaminants	477		
18	Greenhouse Gas Emissions	2,967		
19	Loss of Water Quality	2,399		
20	Ozone Depletion	325		
21	Noise Pollution	839		
	Total Costs (TC)	74,413		
	Total Benefits (TB)		269,945	
	Defensive Expenditures (DE)			537
	GPI = Net Benefit (TB-TC-DE)		**194,995**	

GDP versus Genuine Progress Indicator, 1970 to 2016

The New Zealand Genuine Progress Indicator was calculated for each year over the 1970 to 2016 period, based on an exhaustive exercise of compiling and processing data to measure the 21 components of the GPI. Accordingly, Chart 1 reveals Gross Domestic Product per capita almost doubled over the 1970 to 2016 period, increasing by 91% once adjustments for inflation had been made – leading some to conclude that we were nearly two times 'better off 'in 2016, than we were in 1970. Chart 1 however shows that in terms of the per capita 'Genuine Progress Indicator' over the same 1970 to 2016 period that well-being only increased by 53%, which suggests a significantly worse result than the GDP indicates. From **1970 to 1982**, there was not much divergence between the rate of increase of the per capita GDP compared with the rate of increase in the per capita Genuine Progress Indicator.

[5] Ideally, these defensive expenditures should be explicitly separated out as a separate element of each of the 20 GPI components – however, this was not possible in our analysis because of the way the data was compiled.

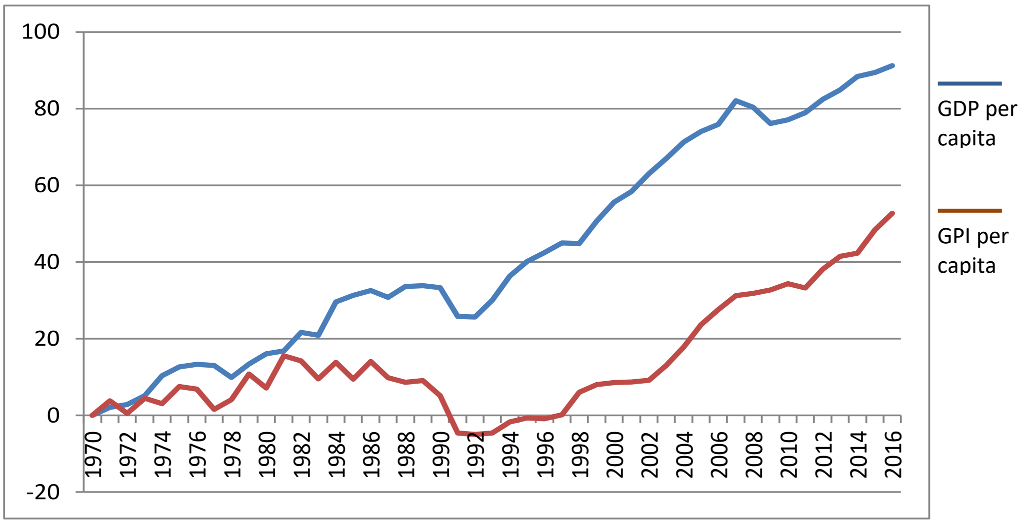


Chart 1 Real GDP versus Real GPI, on a per capita basis, percentage change, from 1970 to 2016.

But from **1982 to 1992** that situation dramatically changed, with an increasingly wider gap between the two indicators, as per capita GDP continued to increase, whilst the per capita Genuine Progress Indicator declined over this period. The sharpest decline in the per capita Genuine Progress Indicator was from **1986 to 1992**, largely due to the negative impacts on wellbeing of the reforms initially undertaken by the 4th Labour Government and then continued by the 4th National Government. As Chart 1 shows by 1992 there was a significant 'gap' between the two indicators, with a 31 percentage points gap opening up. From **1992 to 2016**, although both indicators increased steadily (around 2% per annum), the 'gap' between the two indicators that first became apparent during the 1980s-1990s reforms, not only persisted but slightly increased from 31 percentage points in 1992 to 38 percentage points in 2016.

'Per Capita' versus 'Total'?

The Genuine Progress Indicator, and for that matter the GDP, is often measured in terms of 'total' amounts. The problem with this approach is that much of the increase in GPI can be attributed to solely population growth, rather than increases in the well-being of individuals. To eliminate the effect of population growth, we have tended to report the results in per capita terms.

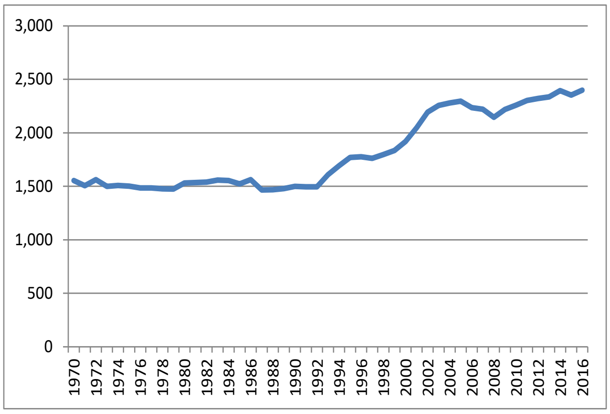


Chart 2 'Total Cost' of Water Pollution, ($$_{2014}$ million)

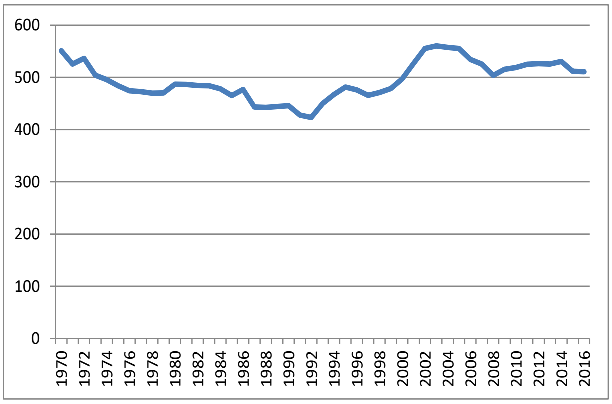


Chart 3 'Per Capita Cost' of Water Pollution, ($$_{2014}$ per person)

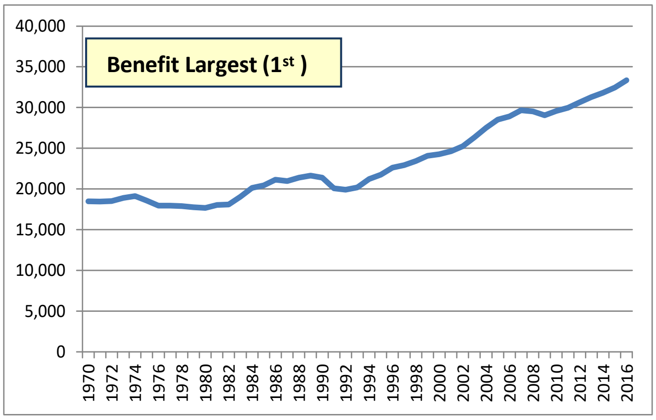
However, there are some limitations to this 'per capita' approach – for example in water pollution, the 'total' amount of pollutants relative to the absorptive capacity of a water body is all-important, and therefore in these cases the 'total' amounts are just as significant, or arguably even more significant than the 'per capita' amounts. The contrast between measuring the cost of water pollution, in terms of 'total cost' and 'per capita cost' is illustrated by Charts 2 and 3 respectively. That is, if 'total cost' is used as the metric, it is clearly shown in Chart 2 that the level of water pollution remained more-or-less constant from 1970 to 1992, and then appreciably increased from 1992 to 2016 as both dairy herd numbers and the application of nitrogenous fertilisers increased. In contrast, if the 'per capita cost' is used as the metric, as shown by Chart 3, quite a different picture emerges – for example, there was a decrease from 1970 to 1992, as the cost of pollution remained more-or-less constant, but population growth increased. Neither of these approaches is right or wrong, rather it depends on the nature of the research or policy question being asked and the general nature of the enquiry.

Box 2 – Unpaid Household and Community Work: New Zealander Marilyn Waring pioneered research that highlighted the importance of unpaid household work and how this was not accounted for in the GDP indicator. Unpaid household work (caring for children, food preparation, household cleaning and so forth), which is primarily undertaken by a woman makes a large contribution to human welfare and well-being, but is systematically ignored by national economic accounts. In 2016, unpaid household and community work, was conservatively estimated to be $46 billion which is equivalent to 21% of GDP, and this far exceeds the contribution to GDP made by our largest economic sectors such as tourism or dairying. Time use surveys, of which two have been undertaken in New Zealand (1998/1999 and 2009/2010), provide useful insights into how much time is spent on unpaid work activities, and these data can be used to estimate the contribution of unpaid household and community work to the GPI. Interestingly, the 2009/2010 time use survey showed that males and females spent about the same amount of time on work activities, but most male work was paid (63%) and most female work was unpaid (65%).

Component-by-Component Changes in the GPI from 1970 to 2016 ($\$_{2014}$ per capita)

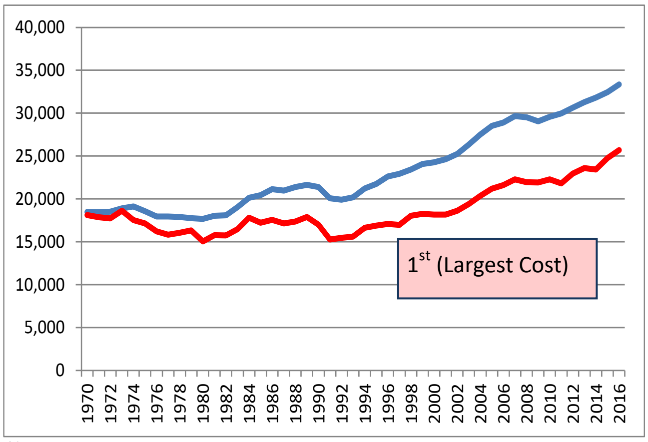
Each of the 21 GPI components are graphed below, from 1970 to 2016, in terms of $ per capita in $2014. Benefits are indicated by yellow shading, in terms of the largest benefit (1st) to the lowest benefit (4th) for their 2016 value. Costs are indicated in terms of pink shading in terms of the largest cost (1st) to the lowest cost (16th) for their 2016 value. The 'Private Defensive Expenditure on Health' component is not included, as it is neither a benefit nor cost.

Personal Consumption of Goods and Services
($\$_{2014}$ per person)



- Personal consumption of goods and services is the highest contributor to the NZ GPI, and it consists of everyday goods and services are purchased by consumers. It amounted to $31,820 per person in 2016.
- Personal consumption per capita of every-day goods and services has grown 80% since 1970.
- 35 years out of 46 saw an increase in personal consumption – with many of the annual decreases, attributable to 'external shocks' such as the oil crisis in the 1970s, 1987 stock market crash and 2008 global financial crisis.

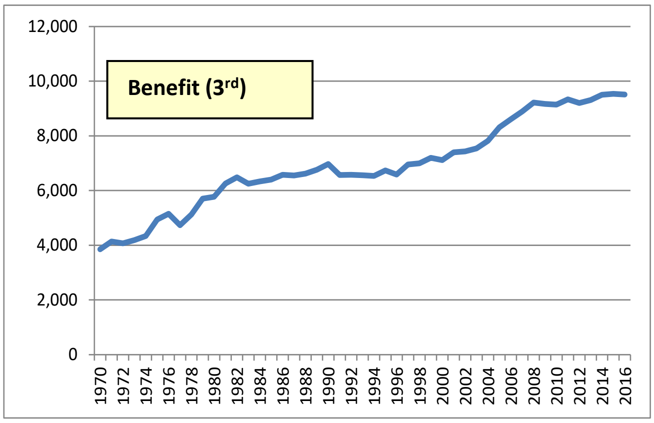
Personal Consumption Weighted for Inequality Effects ($\$_{2014}$ per person)



Note:
Income equality is measured by the difference between 'unweighted consumption' (blue line) and 'weighted consumption' (red line)

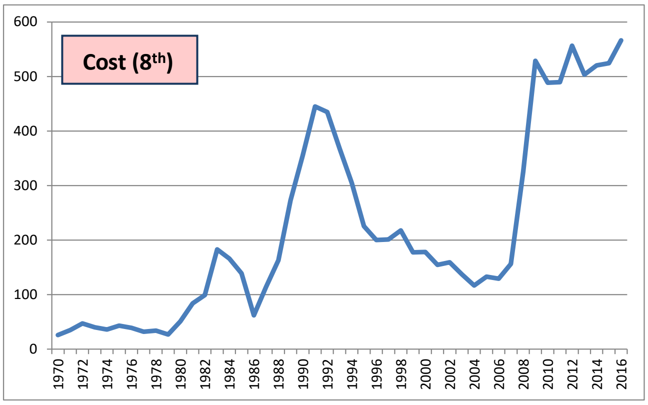
- Income inequality has the largest negative effect on welfare of any of the of the components on this analysis. This effect is costed at $23,441 per capita in 2016.
- When 'weighted' (red line) for income inequality 'Personal Consumption per capita' from 1973 onwards trended downwards – taking 29 years until 2002 to recover back to the same level as 1973.
- New Zealand's income inequality in 2014 was ranked 13th worse out of 35 countries in the OECD.

Consumption of Public Services[6] ($2014 per person)



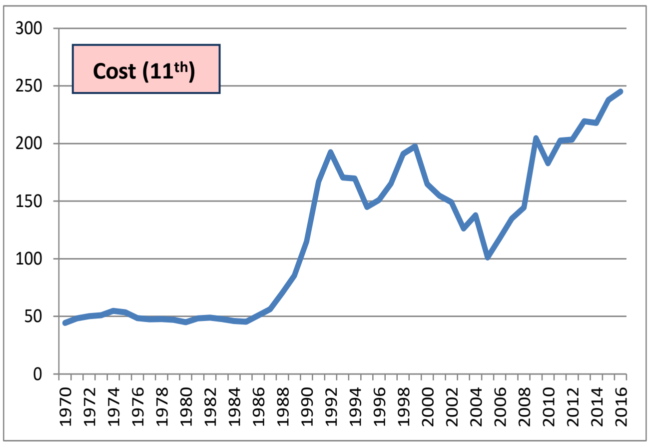
- Public Services such as health and education are provided for by government, and make a strong contribution to welfare, amounting to $9,509 per person in 2016.
- With the withdrawal and decline of some public services during the economic reforms, there was very little growth in public services from 1984 to 1992, on a per capita basis.
- In 2016, the 'Consumption of Public Services' was 28.5% of privately purchased goods and services (Personal Consumption).

Unemployment ($\$_{2014}$ per person)



- The cost of unemployment as measured by 'involuntary leisure time' dramatically increased from only $26 per person in 1970 to $566 per person in 2016.
- Over the 46 year period, there were two distinct peaks in unemployment: (i) in 1991 as the result of economic amd labour market reforms; (ii) from 2008 to 2016 intially in the wake of the global financial crisis.

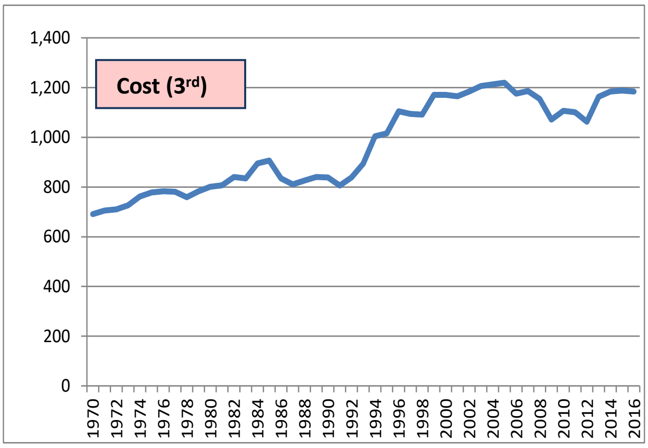
Under-employment ($\$_{2014}$ per person)



- The Employment Contracts Act 1991 and subsequent legislation has had a long-lasting impact on the level of under-employment, with the decline of the guaranteed full-time job.
- Although on our per capita basis cost of under-employment has been at a relatively high level since 1991, it did decline markedly from 1999 to 2005 – only to rebound since then to a historically high rate in 2016.

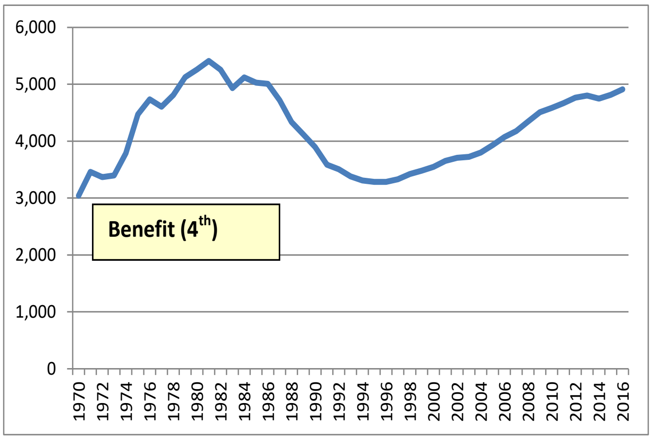
[6] This excludes 'defensive' public services, as they don't contribute welfare.

Overwork ($\$_{2014}$ per person)



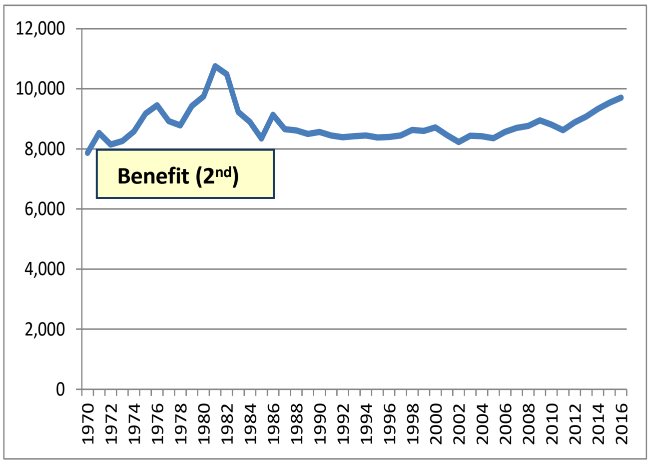
- Overwork has a greater social cost (\$) than unemployment and underemployment.
- The amount of overwork did not increase much from 1970 to 1991, and then increased nearly every year from 1992 to 2005.
- With a tightening of the labour market, levels of overwork declined from 2008 to 2012, only to rebound after that.

Services of Public Capital ($\$_{2014}$ per person)



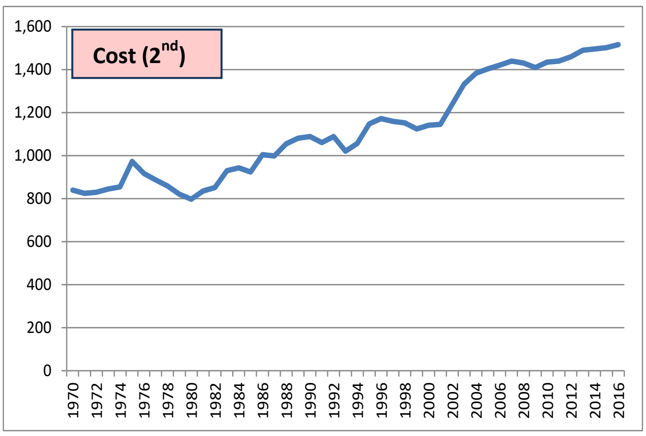
- From 1970 to 1981 there was a significant increase in services derived from public capital, peaking at \$2014 5,408 per person in 1981.
- There was a steep decline in services from public capital, over the period 1984 to 1996.
- 1996 onwards saw a rebound in the government's investment in public services, but it did not return to the peak of 1981.

Household and Community Work ($\$_{2014}$ per person)



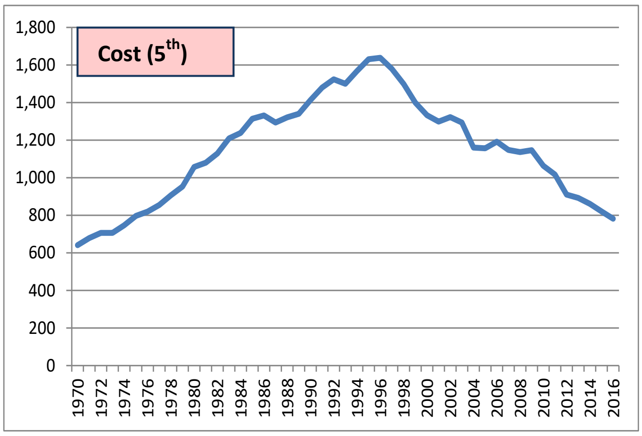
- The value of unpaid 'Household and Community Work' is the second highest beneficial component of the NZ Genuine Progress Indicator after 'Personal Consumption'. Refer to Box2.
- Lack of time-use data, which have only been surveyed for two years by Statistics New Zealand, restricts the accuracy of these data.
- An aging population is an emerging key factor in pushing the value of unpaid 'Household and Community Work' higher, with older people spending significantly more time on unpaid work.

Commuting ($\$_{2014}$ per person)



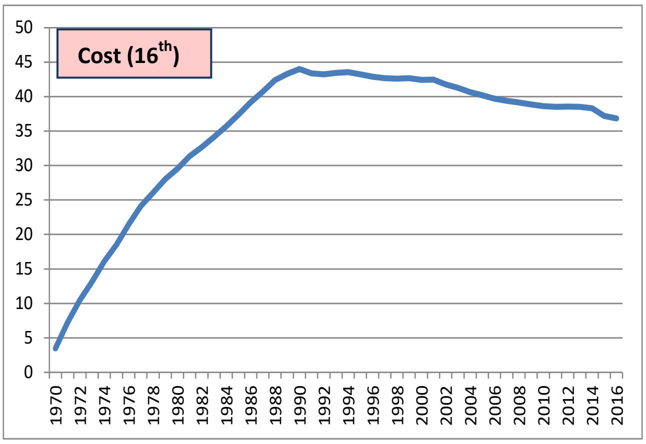
- Commuting to work was the second highest cost externality, next only to deteriorating income inequality.
- Commuting to work, on a per capita basis, increased from \$840 in 1970 to 1,496 in 2014 (78% increase), as kilometres travelled by vehicles increased nearly five fold.
- These per capita costs were greatest in the Auckland region, where the level of congestion is greater than similar size cities overseas.

Crime ($$_{2014}$ per person)



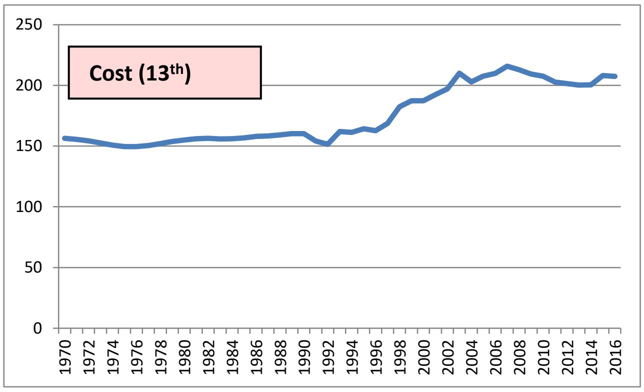
- The cost of crime in New Zealand society is significant, being estimated as $3,669 million in 2016.
- Cost of crime in New Zealand follows a similar pattern to other developed countries – increasing from 1970 to a peak in 1996, and then decreasing nearly every year from this peak.
- The causes behind this pattern of decline in crime since 1996 are poorly understood and are contested.

Loss of Indigenous Forests ($$_{2014}$ per person)



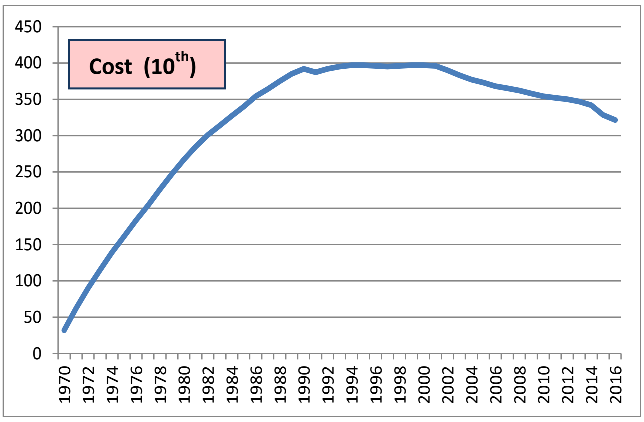
- This cost of losing indigenous forests is the lowest of all of the components included in the NZ Genuine Progress Indicator. This is part due to the very dramatic decline of milling of indigenous forests brought about by various Forest Accords in the 1980s and early 1990s.
- On a per capita basis, in 2016, the loss of indigenous forest ecosystem services due to milling was estimated to be only $37 per capita or $173 million in total.

Biological Pests ($$_{2014}$ per person)



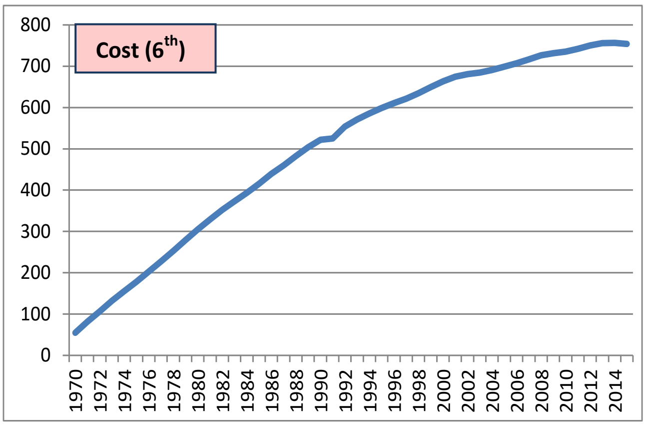
- Unlike overseas GPIs, pest control is included in the NZ Genuine Progress Indicator due to the importance of protecting both our unique biodiversity and productive sector from potential foreign pests.
- No actual data of pest control before 1991 are available, so they were estimated.
- The cost of pest control increased from 1993 to a peak in 2007 of $216 per capita, which by 2016 had slighly declined to $207 per capita. This makes pest control one of the lowest (13th) components in the GPI.

Loss of Wetland Ecosystem Services ($$_{2014}$ per person)



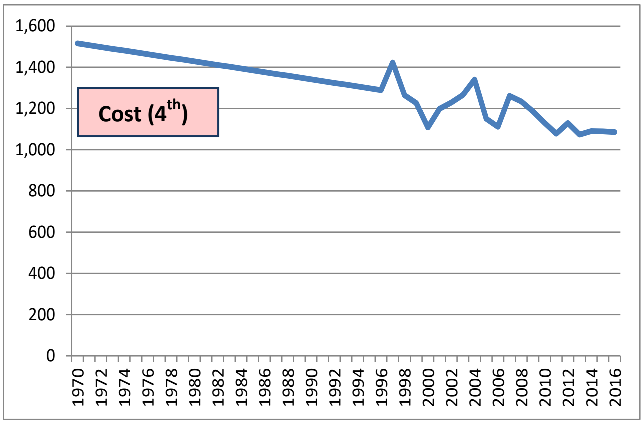
- Wetlands are amongst our most productive and valuable ecosystems, with an average 'ecosystem services value per hectare' of $13,469.
- In 2016, the 'loss of wetland ecosystem services' was costed at $1,542 million or $322 per person.
- Wetland destruction continued up until the late 1990s but has significantly declined since then.

Loss of Soil Ecosystem Services ($\$_{2014}$ per person)



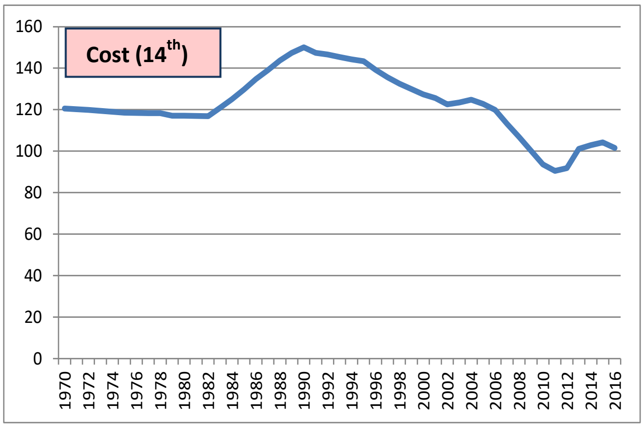
- There has been a negative impact on well-being due to both the expansion of urban areas onto elite soils, and the loss of agricultural land by human-accelerated erosion.
- For 2016, it was estimated that the cost of loosing these soils was \$757 per capita and \$3,552 million in total. However, in recent years this cost per capita has tapered off, with factors such as greater urban densities coming into play.

Air Pollution ($\$_{2014}$ per person)



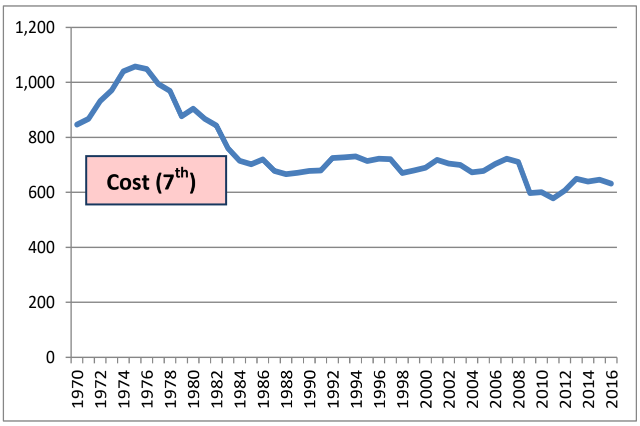
- The PM_{10} metric is considered to be the best proxy indicator of air pollution, as it is widely monitored and is closely linked to negative health effects
- PM_{10} measured in terms of $\mu g/m^3$, decreased from from an estimated 22.1 in 1970 to 15.8 in 2016.
- Although this translated into a lower per capita cost of air pollution, at \$1,086 in 2016, the total cost increased due to more people being affected by air pollution due to a growing population.

Solid Wastes and Contaminated Sites ($\$_{2014}$ per person)



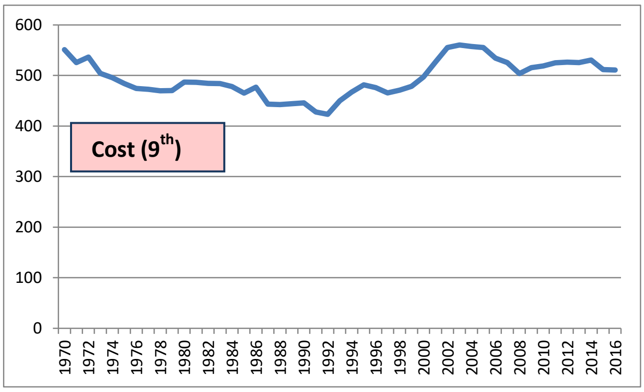
- The cost of the disposal of 'solid wastes' is put at \$465 million in 2016, using a full cost accounting methodology.
- The 'cost per capita' of solid waste disposal low of \$88 per capita in 2011.
- In this category the social cost of contaminated sites has decreased consistently since 1970, as remedial and preventative actions have been implemented.

Net Greenhouse Gas Emissions ($\$_{2014}$ per person)



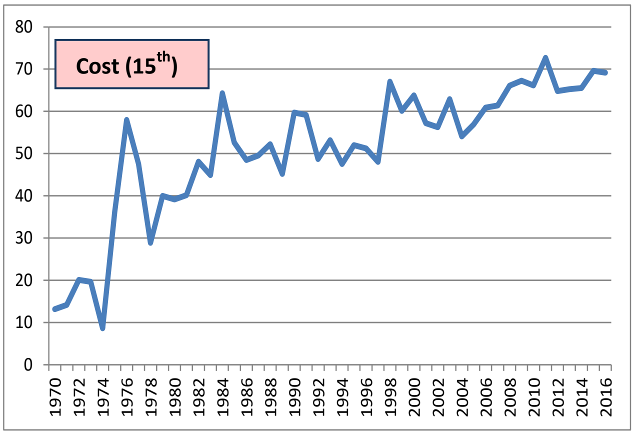
- Energy-derived greenhouse gas emissions rose 164% in total and by 59% on a per capita basis, from 1970 to 2016.
- This trend was counteracted, to some extent, both by a drop in agricultural emissions and in land use changes reducing emissions.
- Therefore, taking account of all these factors, from 1970 to 2016, there was a net incease in annual greenhouse gas emissions of 24%.
- For the year 2016, the cost of net greenhouse gas emissions was \$2,967 million or \$632 per person.

Water Pollution ($$_{2014}$ per person)



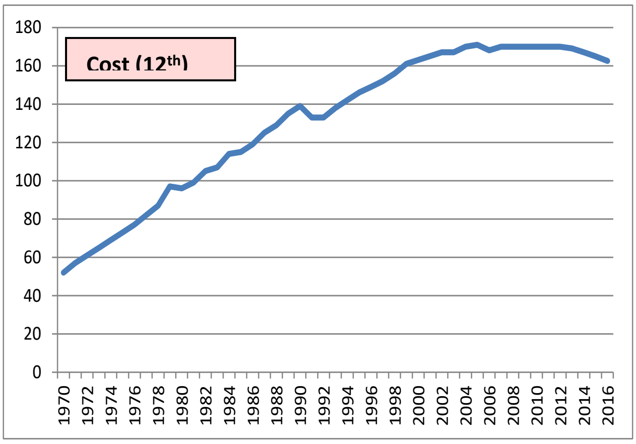
- The social cost of polluted water in NZ remained largely unchanged through the 1970s and 1980s, although the per capita cost declined.
- After then, the cost of water pollution dramatically increased from $1,495million in 1992 to $2,399 million in 2016, with the increase on a per capita basis being less marked.
- The main reasons for this increase in water pollution costs from 1992 onwards were the: (1) increase in dairy cattle numbers, (2) increase in the use of nitrogenous fertilisers.

Ozone Depletion ($$_{2014}$ per person)



- Ozone depletion has a very small estimated social cost compared with the other components in the New Zealand GPI, but is included for consistency with overseas studies.
- The cost of ozone depletion is estimated using premature melanoma deaths as the proxy. On this basis, the social cost of ozone depletion was calculated to be $325 million in 2016.
- There has been a consistent increase in these costs over the 1970 to 2016 period, as melanoma deaths have trended upwards.

Noise Pollution ($$_{2014}$ per person)



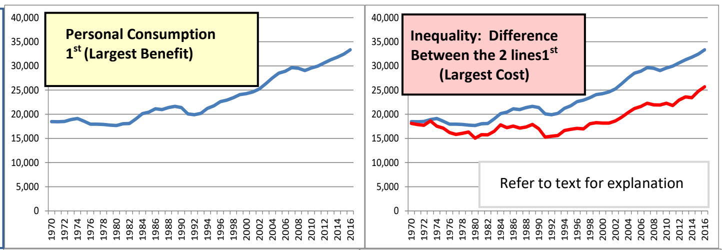
- Traffic is the major source of noise and can be measured; so therefore it is used as a proxy for noise pollution. Other sources of noise cannot so easily be measured at an aggregative level.
- The social cost of traffic noise was calculated to be $762 million in total and $163 per capita in 2016.
- The per capita cost increased almost every year from 1970 to 2005, but then it plateaued from 2006 to 2014, and then slightly declined in 2015 and 2016.

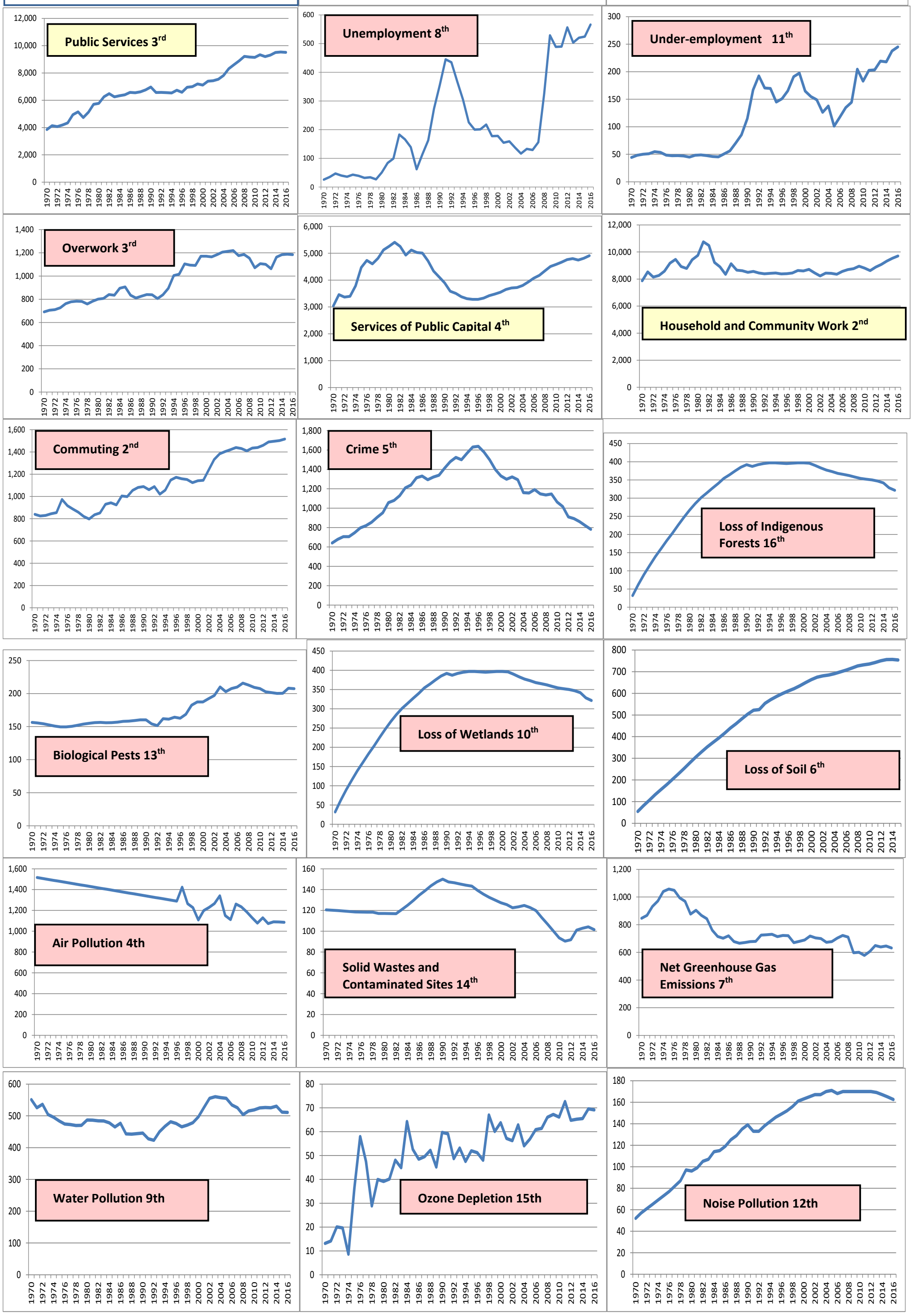
Dashboard of GPI for the New Zealand GPI Components

It is often argued that the GPI's shortcoming is that it conflates too much information into one single number, and therefore a 'dashboard' approach (whereby a range of well-being indicators are displayed) is a superior way of tracking the nation's well-being. We disagree with this argument, as the information can be presented both as a 'dashboard' as well as a 'single number'. It's not a matter of 'one or the other' – both approaches can be used to answer different types of research and policy questions. The following chart presents a 'dashboard' of changes in the 20 components (not including the defensive expenditure on private health) of the New Zealand GPI, over the 1970 to 2016 period:

Dashboard:
NZ Genuine Progress Indicator, 1970 to 2016

$2014 per capita.
Yellow = Benefits, Pink = Costs (Benefits & Costs Ranked Largest to Smallest for 2016 Value)





Preface

The New Zealand Genuine Progress Indicator attempts to measure societal progress in a broader fashion than does the GDP. One of the primary methodologies used in development of the New Zealand Genuine Progress Indicator, was to place a monetary value on costs and benefits that are not explicitly taken account of in the GDP. For example, the value of unpaid household and community work is determined in the Genuine Progress Indicator as a benefit externality, and the cost of greenhouse gas emissions is as accounted for as a cost externality. Even though a great deal of care has been exercised in constructing the New Zealand Genuine Progress Indicator, like all indicators is not perfect, complete or free from value judgements. That said, we believe that all the main externalities are included in the New Zealand Genuine Progress Indicator, and if we were to include other externalities they would generally be of a lower magnitude, and in many cases their inclusion would involve significant double counting when aggregating its component parts. It also needs to be recognised that the Genuine Progress Indicator deliberately measures effects (both positive and negative) on welfare associated with *economic activity*[1] rather than every conceivable aspect of welfare.

The New Zealand Genuine Progress Indicator has had a long period of gestation as we have grappled with several methodological issues, and cast a very wide net to collect and process data from diverse sources. One important methodological issue was a decision not to include some indicators (related to capital stock) which we considered to be more appropriately included as a measure of intergenerational sustainability – for example, we have not included the depletion of non-renewable resources in the Genuine Progress Indicator. In some cases, the data needed to populate the 21 components of the New Zealand Genuine Progress indicator did not exist which required the development of alternative methodologies to produce such data. Although a great deal of care was taken to derive methodologies that were robust and defensible, assumptions had to be made.[2] When making such as assumptions, and developing all aspects of the methodologies, we have made a very deliberate attempt to be transparent about such matters, so that readers are cognisant of its limitations and use it appropriately.

There are several methodologies that can be utilised to measure societal progress at the level of the nation state – for example, the New Zealand Treasury's dashboard approach currently being developed. All of these methodologies have their own strengths and weaknesses, and are designed to answer different policy and research questions. We selected the Genuine Progress Indicator approach essentially for two reasons. First, this methodology has been very widely used, tested and evaluated over a period of several decades and hence there is now a rich literature on how to operationalise this indicator. Second, the Genuine Progress Indicator methodology covers a comprehensive range of factors, including economic, social and environmental 'well-being'; whereas other indicators of societal progress are more restricted – for example, the ecological footprint indicator arguably only measures progress in relation to the required amount it takes to support a human activity.

All that said, we are not arguing that the Genuine Progress Indicator is superior to other societal progress indicators. On the contrary, we have consistently argued over several decades that a richer picture of societal progress will be obtained if a number of indicators and methodologies are used. And, above all, we consider it important that there is a debate on the appropriate role of such indicators, how they should used, and what is the role of government in supporting such indicators of national progress. For far too long, it has been assumed that GDP is the pre-eminent measure of national progress, and we are hoping at least, in a small way, that this publication of the New Zealand Genuine Progress Indicator can catalyse a debate on such issues.

Professor Murray Patterson
April, 2019

1. As Kubiszewski *et al*. (2013) argued in response to the proposition that political freedom should be included in the GPI, responds by arguing "political freedom is not a welfare benefit generated by economic activity. It should not, therefore be incorporated into the GPI. If it so happens that greater political freedom has a positive impact on economic well-being generated by economic activity it is reflected in many items that make up the GPI. Thus it is incorrect to say that the GPI overlooks positive effects of greater political freedom. To include a separate welfare item for political freedom would involve double counting."

2. There has been a great deal of thought put into how to develop the New Zealand Genuine Progress indicator to the extent that we consider significant improvements since we first started this work over a decade ago. Reflecting on these methodological developments and how other GPIs have been developed worldwide Neumayer (2013, p162) commented in his book *Weak versus Strong Sustainability,* "Fortunately, some of the more recent studies have avoided these methodological errors. A role model in this regard is the New Zealand GPI (Genuine Progress Indicator) …"

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Authors' Contributions

Research Leader: Murray Patterson.
Conceptualisation of the Research Idea: Murray Patterson.
Funding Acquisition: Murray Patterson, Garry McDonald.
Writing the Research Proposal: Murray Patterson
Research Design and Methodology: Murray Patterson[=], Vicky Forgie[=], Garry McDonald[=], Nicola Smith[=]
Data Collection: Joon-Hwan Kim, Garry McDonald, Vicky Forgie, Murray Patterson, Yanjiao Zhang.
Data Analysis: Garry McDonald, Murray Patterson, Vicky Forgie, Joon-Hwan Kim, Yanjiao Zhang.
Writing and Interpretation of the Results: Garry McDonald[=], Murray Patterson[=], Vicky Forgie[=], Derrylea Hardy, Nicola Smith, Yanjiao Zhang.
Editing and Review: Murray Patterson, Garry McDonald
(Under each area of contribution, the Authors' names in descending order of contribution)
(Under each area of contribution, the equals sign denotes equal contribution)

Glossary

The approach taken in this publication is to use language that is accessible to a number of audiences. This is not always easy when concepts and terms have different meanings across different disciplines and in different contexts. Therefore, to avoid any possible ambiguities, and to assist the reader, key terms used in this report are defined in this Glossary. Blue boldings denote cross-references to other entries in this Glossary.

Capital (In Economics). Capital has a number of similar, but not necessarily the same meanings, in Accountancy, Commerce, Economics and Finance. Conventionally in Economics, 'Capital' is considered to be one of the main factors of production along with Labour, Land and Information. Capital's distinguishing feature, is that although its contributes to production, it is *not used up immediately in the process of production,* unlike raw materials or intermediate goods. That is, other than a small amount of depreciation, it endures across time and generations. In traditional economic models only **physical and financial capital** were usually considered, but in more recent years other forms of capital have been developed, including for example **human capital**, **natural capital** and **social capital**. Capital is a **stock**, as opposed to a **flow**. Capital is a central concept in economic analysis of **sustainability** issues, which is explained in a further entry in this glossary. The concept of 'four capitals' is also fundamental to the **NZ Treasury's 'Living Standards Framework'**.

Carbon Dioxide Equivalents. 'Carbon dioxide equivalents' measure greenhouse gas emissions that are standardised in terms of their 'global warming potential'. In these terms, one tonne of carbon dioxide equals 25 tonnes of methane and 298 tonnes of nitrous oxide based on a 100 year time horizon. Carbon dioxide equivalents are abbreviated to: CO_2e.

Commensuration. Commensuration is at the heart of the construction of the Genuine Progress indicator (GPI). The very different factors that make up the GPI (which are measured in diverse units) need to be commensurated in terms of one **numeraire** before they can be added up to obtain the overall GPI. The numeraire used in the GPI is a specific monetary unit (e.g., $\$NZ_{2014}$). This commensuration uses criteria such as **'opportunity cost'** (for costs), or **'willingness to pay'** (for benefits), to arrive at the monetary value for the factors that make up the GPI. It needs to be noted, that **stocks and flows** have different units and are thus not commensurable – that is, they cannot be meaningfully compared, equated, added, or subtracted.

Chain Linking Method. Joining together two indices that overlap in one period by rescaling one of them to make its value equal to that of the other in the same period, thus combining them into a single time series. More complex methods may be used to link together indices that overlap by more than one period. The chain linking method is used, for example, to construct a time series of **real** Gross Domestic Product, as is used in this **GPI** analysis.

Constant Dollars. In this GPI analysis, **nominal dollars** are converted to constant dollars to allow for the effects of inflation. For example, $10 in 1975 nominal dollars is converted to about $93 in 2014 constant dollars, based on New Zealand inflation rates. This conversion to constant dollars, enables valid comparisons to be made across different years, as the confounding effect of inflation has been removed. Constant dollars are also called **real dollars**.

Consumer Surplus. This is the difference between the price a consumer is willing to pay and the actual price they do pay. Many of the non-market valuation methods used in the GPI attempt to measure consumer surplus. Either at an individual level, or societal level, consumers are prepared to pay more for the first few units of consumption (e.g., drinking water for human survival), but diminishing marginal payments for further units of consumption. The other component of the economic surplus is producer surplus, which is the difference between how much a producer is willing to sell its product for, in comparison with what the producer is actually paid in a market transaction.

Dashboard of Indicators. An approach to displaying indicators of societal progress, whereby indicators are collectively and simultaneously displayed – analogous to how different meters are displayed on a dashboard of a vehicle to monitor different aspects of performance. Proponents of this dashboard approach are often philosophically opposed to aggregation of indicators (**commensuration**) into one numerical indicator.

Defensive Expenditure. A defensive expenditure is made to eliminate, mitigate, neutralise, or anticipate and avoid damages and deterioration that industrial society's process of growth has caused to living, working and environmental conditions. An example of a defensive expenditure, is residents near an airport double or triple glazing their windows, purely to eliminate the noise pollution caused by aircraft. Defensive expenditures are removed from the GPI (particularly from the personal consumption component), as they do not contribute to well-being; rather they 'neutralise' the impact of a **cost externality** associated with economic growth.

Double Counting. When aggregating data or indicators, they can be counted twice or even more than twice. This occurs because individual indicators, to some extent overlap with each other and/or are not totally independent of each other. When double counting is not eliminated (or adjustments not made for it) during the aggregation process, this can lead to an overestimation of an aggregate indicator such as the Genuine Progress Indicator.

Ecosystem Service. An ecosystem process, function or quantity that is beneficial to humans and has a positive impact on human well-being. It is measured as a **flow**. Typically, ecosystem services are derived from **natural capital** which is a stock. Examples of ecosystem services include: climate regulation, water purification, processing of industrial wastes, provisioning of food and fibre, habitat of valued species, buffering from storm events and pollination.

Externality. A consequence of economic activity that has no market price, but impacts negatively or positively on well-being. An example of a negative externality (cost externality) is industrial greenhouse gas emissions that contribute to climate change, which has a number of well documented negative impacts on human well-being. An example of a positive externality (benefit externality) could be a farmer planting riparian margins to improve water quality of a stream in the farmer's property – but downstream users also benefit from the improved water quality without incurring any financial cost. In the GPI analysis, attempts are made to 'price' these externalities, and include them in the GPI.

Financial and Physical Capital. The Treasury (New Zealand) in their **Living Standards Framework** combines financial and **physical capital** into one category. The Treasury defines "financial and physical assets" as: (1) individual assets (e.g., homes, cars, factories and machinery); (2) community assets (e.g., roads and hospitals); and (3) financial assets that can buy these individual and community assets.

Flows. A flow variable is measured over an interval of time. Therefore, a flow is measured as a 'quantity' per 'unit of time' – for example, 20 tonnes of aluminium produced per day. Stocks on the other hand, are the measurement of a quantity, at a certain point in time – for example, the volume of water in Lake Taupo at 12 noon 1 December 2018. Economists and system modellers often refer to 'stocks and flows'. Both the GDP and GPI measure flows. A common mistake in well-being accounting is to confuse stocks and flows. Refer to **commensuration.**

Four Well-beings. The 'Four Well-beings' in the New Zealand Local Government Act 2002 are: social, economic, environmental and cultural. After being removed from the Local Government Act 2002 by the National Party government, the current government intends to reinstate these 'four well-beings' in the Act.

GDP. **GDP** stands for '**Gross Domestic Product'** which is defined as a separate entry in this glossary.

Genuine Progress Indicator or GPI. The GPI is a measurement of the 'progress' typically of a nation state or economy, measured from year to year. It covers a broader range of factors than the GDP. Typically, there are around 20 factors in the GPI, which can be considered benefits or costs depending on how they impact on well-being. All costs and benefits are monetised, and then aggregated to arrive at an overall measurement of the GPI. **Defensive expenditures** are also removed from the final aggregated GPI.

Genuine Progress Indicators (plural). The use of the term Genuine Progress Indicators (plural) should not be confused with the term **GPI**. **'**Genuine Progress Indicators' (plural) is another paradigm that contends progress indicators should not be aggregated or **commensurated**. Proponents of **'**Genuine Progress Indicators' argue that a richer picture of progress can be obtained by viewing the indicators in a non-aggregated fashion, using graphical devices such as **dashboards.**

Gini Coefficient or Gini Index. An indicator used to measure **income inequality** in a given economy. Numerically, it ranges from a value of 0 to 1. A Gini coefficient of zero represents perfect income equality, with everyone receiving the same income. A Gini coefficient of one means that there is perfect income inequality, with one person receiving all of the income – though, in strict terms, the Gini Coefficient is not measured at the level of the 'individual', rather it is based on a frequency distribution of incomes, by dividing the population into groups of equal number of people in each group (e.g., quintile or decile).

GPI. GPI stands for '**Genuine Progress Indicator**', which is defined as a separate entry in this glossary.

Gross Domestic Product or GDP. The total market value of final goods and services produced by a national economy in a given year. The most widely used measure of national economic performance.

Human Capital. The **OECD** defines human capital as the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being. The Treasury's **Living Standards Framework** uses a similar definition.

Income Distribution. This is how a nation's income is distributed amongst different members of society. A narrow and more traditional definition of income distribution, is how income is distributed across the main factors of production (land, labour, capital). Income distribution is an important factor in determining a nation's well-being, and accordingly it is incorporated into the New Zealand GPI calculations by using the Gini coefficient as a measure of **income inequality**.

Income Inequality. This refers to the extent to which income is distributed in an uneven fashion amongst members of society. Accounting for income inequality is an important component in the Genuine Progress indicator, as uneven distribution of the nation's income has a major impact on societal **well-being** and **welfare.**

Living Standards Framework. This is a framework developed by The Treasury, to assist them in their advisory functions to the New Zealand government. The framework is based on the idea that 'Four Capitals' provide the basis for "intergenerational well-being": **Human Capital**, **Financial-Physical Capital**; **Social Capital** and **Natural Capital**. The Treasury defines living standards as giving people "greater opportunities, capabilities and incentives to live a life that they value, and that they face fewer obstacles to achieving their goals".

Manufactured Capital. Refer to **Physical Capital.**

Methods of Non-Market Valuation. These methods determine the economic value of a cost externality or a benefit **externality**. These methods include contingent valuation (**willingness to pay**, willingness to accept compensation), travel cost, replacement cost, avoided cost, hedonic pricing opportunity cost, benefit transfer, and conjoint analysis. Specific methods of non-market valuation and market valuation used in this **GPI** analysis are outlined by Tables 2.3 and Table 2.4 Refer to **Nonmarket Valuation**.

Monetising (or Monetisation). This has several meanings, depending on the context. In this publication, monetising refers to determining and placing a monetary value on 'something'. It does not refer to converting that 'something' to a source of income or an item for market exchange – for example, it does not refer to monetising websites by selling advertising space or charging website users.

Natural Capital. Natural capital is the world's (or country's) stocks of natural assets which includes its geology, soil, air, water and all living things. Natural Capital is difficult to aggregate, as it is very heterogeneous, multi-scaled and often has diffuse boundaries. Natural capital provides people with **ecosystem services** that are often unpriced by the market. Natural capital, because it is a **stock** (or series of stocks), is not directly included in the GPI calculations, as the GPI is based on **flow** measurements. For example, soils, which can be considered to be an item of natural capital, is not included in the GPI because it is a stock, but soil ecosystem services are included because they are flow measurements.

Nominal dollars. Sometimes called 'current dollars'. This refers to the market value of a commodity or group of commodities, at the time they were produced or sold. The difference between nominal dollars in **real dollars**, is that the latter is adjusted for inflationary effects.

Non-Market Valuation. This refers to the economic valuation of the **benefits** (positive impacts on wellbeing) and **costs** (negative impacts on wellbeing) of the items, activities and attributes that have no market price. Nonmarket valuation methods were used in the GPI analysis, to place an economic value on items that usually are not captured by GDP or national economic accounts. An example of the nonmarket valuation of a cost **externality** is the calculation of the costs associated with premature deaths caused by air pollution. Refer to **Methods of Nonmarket valuation.**

Numeraire. A quantity, used as the standard, in the measurement of value (e.g., a commodity used to standardise relative prices in Economics).

Opportunity Cost. This is what has been foregone by undertaking one activity or using a resource, as opposed to the next highest value alternative. For instance, in the GPI analysis, the time that is consumed when commuting to work as an example of an opportunity cost – as this time could be more beneficially used to undertake some leisure activity or to earn extra income. When dealing with an entire population, as in the case of time used on commuting, the 'next highest value alternative' is not known for everyone in the population and it will vary from person to person, so in this case the 'average salary and wage rate' is used as a proxy for opportunity cost. "Time is money" is a colloquial way of expressing that using time (like any other resource) has an opportunity cost that can be expressed in monetary terms.

Physical Capital. Comprises material goods or fixed assets which contribute to the production process rather than being the output itself – e.g. machines, buildings and roads. Sometimes, more traditionally, this is referred to as manufactured capital.

OECD. OECD stands for the Organisation for Economic Co-operation and Development. It was founded in 1961 to stimulate economic progress and world trade. It currently has 36 member countries, including New Zealand, and accounts for about 62% of the Gross World Product (combined GDPs of all nation states in the world).

PM_{10}. This is particulate matter of 10 micro metres or less in diameter. It is suspended in the air, but invisible to the human eye. It is considered to be one of the best markers or indicators of air pollution, because of its high correlation with harmful health outcomes. PM_{10} was used as a proxy for air pollution in the New Zealand GPI analysis.

Real. The value of a commodity or some other variable (e.g., GDP) that has been adjusted to eliminate the effects of inflation.

Real Dollars. Refer to constant dollars.

SNZ. Statistics New Zealand. Government department in New Zealand that undertakes and leads the collection of official data on population, the labour market, the economy, business, society and the environment.

Social Benefit. Refer to Social Welfare.

Social Cost. Refer to Social Welfare.

Social Capital. There are several contested definitions of social capital. The **OECD** defines social capital. as networks together with shared norms, values and understandings that facilitate co-operation within or among groups. The Treasury's **Living Standards Framework** uses a similar definition.

Social Welfare. This term is generally avoided in this publication, as its use can be confusing, as it has different meanings in different contexts. In economics, 'social welfare' refers to welfare at the 'societal' level rather than the individual or firm level. In more common language 'social welfare' refers to government assistance to individual citizens by way of, for example, health care, housing, or financial assistance like an unemployment benefit. For similar reasons, the terminologies of **social cost** and **social benefit**, which are frequently use in Welfare Economics, are generally avoided in this publication.

Statistical Life. Refer to Value of Statistical Life.

Stocks. Refer to Flows.

Sustainability. There is no one unequivocal measure of 'sustainability'. Its meaning can vary according to its academic and policy context – refer to: **Sustainability (Economics), Sustainability (Ecological), and Sustainability (Policy and Planning)**.

Sustainability (Ecology). Ecological systems are always in a state of change, which presents challenges in defining what sustainability may mean from an ecological perspective. That said, sustainability in ecology means maintaining an ecological system so it can persist and be resilient over time. If the systems 'ecological limits' are exceeded, then the system is irreversibly changed, ceases to exist, or there is a regime shift to another relatively stable system.

Sustainability (Economics). In economics, it can be defined as 'strong' or 'weak' sustainability. 'Strong' sustainability refers to at least maintaining the same aggregate level of natural capital stock across generations. 'Weak' sustainability, refers to at least maintaining the same aggregate level of capital stock across generations, adding up all the capitals (manufactured, natural and so forth). That is, under 'weak sustainability' **natural capital** can decline from generation to generation, as long as it is at least matched by an increase in the aggregate stock of the other capitals (particularly **manufactured capital**). In this publication, unless otherwise stated, when using the term 'sustainability' we are referring to 'weak sustainability'. 'Weak sustainability' assumes that there is substitutability between the different forms of capital.

Sustainability (Policy and Planning). The attempt often used in policy analysis and planning to 'balance' the different dimensions of sustainability (economic, social, environmental) in order to develop and implement policies to achieve the 'best' overall outcomes for a community or for a country. There is no *a priori* assumption that any one of these dimensions of sustainability is more or less important than any other dimension – as opposed to the Russian-doll model of sustainability, which has an implicit hierarchy of importance of the (environmental > social > economic).

System of National Accounts. The System of National Accounts (SNA) is an international standard system of national economic accounts. The aim of SNA is to provide an integrated, complete system of accounts enabling international comparisons of all significant economic activity. Almost all countries in the world use the SNA to measure activity in their national economies, although there can be significant adaptations and variations. The first international standard was published in 1953. Handbooks have been released for the 1968 revision, the 1993 revision, and the 2008 revision.

Threshold Hypothesis. The idea that for all societies, there is a period of economic growth (as defined by GDP) where there is an improvement in quality of life and well-being, up to a threshold point, where thereafter there is a deterioration in quality of life and well-being. Some analysts use time series GPI data to test this hypothesis.

The Treasury's Living Standards Framework. Refer to Living Standards Framework.

Value of Statistical Life. In conceptual terms, this is how much people are **Willing to Pay** to reduce their risk of death. This concept is often used in evaluating (using cost benefit analysis) transport and roading proposals regarding preventing fatalities.

Well-being and Welfare. Used interchangeably in this study. Operationally, in this study, at the national level, net welfare (net well-being) is the sum total of monetised benefits, minus the sum total of monetised costs. Conceptually, welfare/well-being is a state of healthiness, resilience and individual happiness.

Willingness to Pay. The maximum price a consumer will pay for a good or service. It is also a **non-market valuation** method often used to determine the value of a benefit **externality** (which by definition has not got a market price).

Contents

1. Context and Introduction

This chapter provides an overview of the context and foundations of this report, setting out the rationale for developing and operationalising a Genuine Progress Indicator, in particular from a New Zealand perspective.

Developing a Measure of National Well-being

Well-being is regarded as a necessary condition for human happiness and what a good life achieves (Walsh, 2005). Improvement in well-being[7] for a nation can therefore be interpreted as genuine progress. Traditionally, Gross Domestic Product (GDP) has been used to measure progress but there is increasing demand for indicators that take into account a broader range of factors than just aggregated national income (The European Commission *et al*., 2007). While it was never intended to be used as a measure of well-being for a nation, GDP has assumed this role by default. Simon Kuznets, arguably the originator of the GDP, has said "The welfare of a nation can scarcely be inferred from a measurement of national income as defined (by the GDP) …. Goals for 'more' growth should specify of what, and for what" (Kuznets, 1962). The need for a meaningful measure of national well-being has led many countries to construct indicators such as the Genuine Progress Indicator (GPI) or the Index of Social and Economic Welfare (ISEW).

Based on a modification of the GPI framework[8], the 'New Zealand Genuine Progress Indicator' (NZGPI) has been developed to provide such a measure of well-being, using the most rigorous methods available. The construction of the NZGPI has been limited by the quality and coverage of available data and at times data have had to be modelled, interpolated/extrapolated, and sometimes based on the assumptions – this particularly applies to some of the environmental categories that make up the NZGFPI. While this is less than ideal, for all situations assumptions have been deliberately made on the conservative side so the 'New Zealand Genuine Progress Indicator' cannot be undermined by claims that the cost of environmental damage and undesirable social impacts have been exaggerated.

The development of the 'New Zealand Genuine Progress indicator' stemmed from previous Ecological Economics research at Massey University, on developing and trialling alternative measures of societal progress (McDonald and Patterson, 2004; Patterson, 2006; Jollands *et al*., 2006). As part of this stream of research the Ministry for the Environment commissioned Patterson (2002) to investigate and evaluate possible national headline indicators of progress towards sustainability. That report made four recommendations:

- *Recommendation 1:* The ecological footprint should be implemented as a standalone headline indicator of ecological sustainability. It is easily implemented, at low cost, and would be readily understood by the general public.
- *Recommendation 2*: A more comprehensive indicator of ecological sustainability should be developed. This would be a composite index that systematically covers source and sink functions of the biophysical environment, pressure and state indicators, and representatively encapsulates all aspects of the biophysical environment and ecological functioning.

[7] Well-being and welfare are regarded as interchangeable terms when used in this publication, where welfare is described by the Oxford Dictionary of Economics (2002) as "enjoyment of the necessary resources for a worth-while life". In the terminology of welfare economics, GPI is a measure of social welfare.

[8] The New Zealand GPI deleted 3 constituent variables that are usually included in most international GPI's, which meant that 21 variables were left for inclusion in the New Zealand GPI. These variables were deleted because they did not directly measure 'welfare', rather they were measurements of 'change of stock levels' – for further discussion of this matter, refer to fourth sub-section in this Chapter, and Dietz and Neumayer (2006).

- *Recommendation 3*: The Genuine Progress Indicator should be constructed for New Zealand, to cover in one index the economic, social and environmental dimensions of Sustainable Development. It would be sensible to use the Australian GPI as an initial template and draw on Australian expertise gained in its construction.
- *Recommendation 4*: Investigations be undertaken into constructing a composite index of Sustainable Development for New Zealand, which explicitly measures the economic, social and environmental aspects of progress.

The first recommendation (to construct the ecological footprint) was implemented both at the national and regional council levels, in research funded by the Ministry for Environment. Initially this was undertaken by McDonald and Patterson (2003) for financial year 1997/1998 using an input-output analysis approach, and then updated by Smith and McDonald (2007) for 2003/2004. In conjunction with this research, a web-based ecological footprint calculator was developed for the Ministry for Environment[9], and a similar calculator was also developed for a New Zealand TV reality series WA$TED where households attempted to reduce their ecological footprints by changing their behaviour and adopting resource conservation measures.

The second and fourth recommendations were never implemented, although the Waikato Regional (2014a) developed a composite index for their region, covering economic, social and environmental aspects of progress. This Composite Index measured 32 indicators from 2001 to 2013 and was aggregated into one overall indicator using Principal Components Analysis (Huser, Patterson and Kimberly, 2016). Furthermore, also at the regional level, the Wellington Regional Council (2014) has also developed a composite index of progress indicators, with the overall index being derived by 'adding up' 85 equally weighted indicators covering economic, environmental, social and cultural "well-beings". Additionally, for New Zealand as a whole, Statistics New Zealand (2010) has compiled a series of 16 "key indicators" measuring "progress towards sustainable development" covering "New Zealand's environmental, economic, and social progress" – no attempt however has been made to construct an overall indicator from these "key indicators".

The third recommendation, which was to construct a Genuine Progress Indicator for New Zealand, was implemented under Foundation for Research Science and Technology funding of the 6 year 'Sustainable Pathways Programme', as well as a significant staff time contribution from the Office of the Parliamentary Commissioner for the Environment. Additionally, Genuine Progress Indicators have been developed both for the Auckland and Waikato regions, although this work could be characterised as being only 'indicative', as for the most part the data was derived from regionalising national data which itself at this stage was only in prototype stage (McDonald *et al*., 2010a,b).

The Inadequacy of GDP as a Measure of Societal Well-being

GDP is defined as a monetary measure of the goods and services annually produced by domestically located factors of production in an economy. Governments have successfully used this indicator to manage national economies and foster economic growth. However, while GDP has an important role to play in economic monitoring it is not a benchmark for the overall progress of society. Many factors that contribute to long-term well-being are not adequately reflected in GDP calculations. These include but are not limited to: stay-at-home mothers who care for their children; voluntary community work that provides social cohesion; the environment and ecosystems services provided by nature (on which all life depends); the stability of government; and work/life balance – all important aspects of a

[9] The Ministry for the Environment eventually withdrew this ecological footprint calculator due to a number of concerns including those from agricultural interests.

nations' well-being. In fact, in the words of Robert Kennedy (1968), "GDP measures everything… except that which makes life worthwhile". [10]

The problem is that GDP as the foremost measure of economic activity, universally recognised and widely accepted, is incorrectly used by many – explicitly or implicitly – as a gauge of national welfare. As a result, growth in GDP (the provision of more goods and services) is the aspiration of most governments and hence when GDP statistics are reported, they are always interpreted on the basis of 'the bigger the better', with little if any diagnosis of how this growth has been achieved or the wider welfare implications.[11] It is not acknowledged that many of the important activities that contribute to well-being are excluded and other activities that have a detrimental effect on a nation's well-being contribute to the GDP growth statistic. According to Daly (2005), growth must produce more 'goods' than 'bads' [12] to improve the welfare of a nation. Many examples can be cited of situations that increase GDP without a similar directional change in the welfare of a nation. For instance, output from heavy industry that increases GDP but reduces air quality and impacts on the health and well-being of citizens; a road accident results in increased GDP due to the greater activity of emergency services and the vehicle repairs required; marriage breakdown results in increasing demand as two households need to be supported instead of one; while buying bottled water because the public water supply is not of sufficiently high quality to drink increases GDP but not welfare.

Marketplace transactions as measured by GDP cannot be used as a proxy for actual change in quality of life. The individual willingness-to-pay decisions that aggregate to make GDP do not prevent the exploitation of environmental goods and services as much of the goods and services essential for human survival are not exchanged in the marketplace (for example, clean air, clean water, and climate stability). Neither does GDP reflect distributional change. Growth in GDP does not report on whether or not the benefits accrue to a small or large number of individuals. As such, GDP privileges the world of the market without taking into account the social and environmental cost of producing the goods and services that are bought and sold in the market place.

A country's natural and human resource base constitutes its critical endowment and as such needs to be managed like any other asset. A nation's accounting framework, therefore, needs to reflect natural and human capital losses and liabilities. When GDP is used as a welfare yardstick this is not done, as national output measures do not focus on whether such output is sustainable in the long-run. As examples of this, if natural resources are extracted and some of the proceeds not re-invested to maintain a nation's income-generating capital, the nation is rendered poorer. Likewise, when environmental damage takes place, a country incurs a liability that has to be rectified at some future date. Unfortunately, GDP indicates the reverse by treating such losses as benefits. The more assets a nation consumes, the higher the GDP is for a given time period. The more money spent on defensive expenditure to compensate for environmental damage (such dredging to remove sludge caused by erosion), the more GDP increases. It is important to maintain the asset base of any country, which is underpins real wealth, and not use income growth as a policy measure when producing it depletes the resource base that future generations need to support themselves.

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[10] In New Zealand, as early as 1974, Massey University academics Fordham and Ogden (1974) recognised the disconnect between welfare and GDP arguing "Gross National Product is a deficient indicator of economic progress, let alone welfare. ... "Included in it are indicators of 'ill-fare' rather than welfare, such as the costs of preventing or cleaning up pollution and crime and medical expenses of a car crash victim."

[11] Governments also have other policy objectives, such as stable prices, a healthy trade balance, low unemployment, and for some but not all, a fair distribution of income, but growth in GDP is generally the foremost goal.

[12] 'Goods' are products that contribute to well-being and utility. 'Bads' are the unwanted side effects of growth, such as pollution, that have disutility and require sacrifices bigger than the worth of the good produced (Daly, 2005).

Dalziel and Saunders (2014) highlight how well-being is created through the choices we make in relation to our use of time. They argue that by studying these choices we can gain insight into personal and household activities that add value to our lives. Such choices do not involve the exchange of money and happen outside the market mechanism, so therefore they are not included in GDP. In this way, the value of time spent on household work and child rearing is not taken account of by GDP. Nor is voluntary work, although both obviously contribute to the well-being of families and the nation as a whole.

In summary, GDP has the following limitations as a measure of the nation's welfare:

- Not taking account of **cost externalities** such as for example the negative impacts on human health of air pollution, or the psychological stress caused by noise pollution.
- Not taking account of **benefit externalities** (value of beneficial non-market activities that are not priced), such as for example the value of unpaid household work and voluntary community work.
- Not taking account of the **undesirable ways in which we use our time**, such as for example 'overworking', 'wasting time' in unnecessary long commuter trips, and 'work-life balance' issues (all of these factors are manifestations of 'the opportunity cost of time').
- Not taking account of the **inequality of income distribution**, by not allowing for the fact that an extra dollar's worth of income to a poor person is worth more than an extra dollar's worth of income to a rich person.
- Failure to consider **intergenerational equity** (or more broadly speaking long term sustainability issues), as GDP only measures income within a one year time frame with no account of any long term impacts on future generations.
- It incorrectly counts defensive expenditures, such as double glazing (to reduce the negative effects of traffic noise), as a positive contribution to welfare.

There is a need for a new measure that will complement GDP and guide decision-making to meet the challenges of the 21st century. Such a measure needs to place importance on societal aspects and reflect the pressure increased affluence and population numbers place on the natural environment. Any new indicator needs to build our understanding of the shifts in our societies as well as develop effective capacity to respond to such shifts. Research is increasingly focusing on the decoupling material wealth from happiness, showing that economic growth and well-being are not the same thing (Easterlin, 2003; Hatfield-Dodds, 2005). Having the best possible indicator available makes sense for a number of reasons, including economic reasons, as if the true contribution of the environment and social systems to the current economy is ignored there is a real risk that economic development will not be on the right long-term course.[13]

Alternative Indicators of National Well-being

A number of alternatives have been proposed to provide more encompassing indicators of the well-being of nation states such as New Zealand. Accounting methods are important as they affect policy by determining where the attention of policy-makers should be directed. To measure progress, wealth and well-being effectively, it is necessary to establish indices that are as clear and appealing as GDP, but are more inclusive than GDP — i.e. they also incorporate social and environmental factors. A number of such alternative indicators been developed, which this section briefly reviews.

[13] The GDP indicator, besides its limitations as a measurement of welfare, has been more broadly criticised. For example, Coyle (2014) catalogues a number of deficiencies in the GDP, including the way in which imputes the value of homes and residents, in terms of an equivalent rental return; the way in which it imputes value of 'non-marketed' government activities by the wages paid to government employees; the inadequacy of GDP in not taking account of the value of Internet services which are often free but clearly have a consumer surplus, as well as technical issues to do with chain-weighted price indices and rebasing.

Genuine Progress Indicator

The GPI aims to adjust for the limitations of GDP reporting by incorporating important aspects of the non-monetised or non-market economy. The GPI starts with the personal consumption element of GDP, rather than GDP itself, on the premise that while consumption contributes to well-being not all other components of GDP meet this requirement. Adjustments (plus and minus) are made to personal consumption to reflect this. Calculations make deductions for negative or defensive spending undertaken to correct, for example, the effects of pollution or crime.

The GPI builds on a number of earlier attempts to provide a more robust and comprehensive indicator of welfare and to incorporate environmental and/or sustainability aspects into such an indicator – see, for example, Nordhaus and Tobin's (1972) *Measure of Economic Welfare* (MEW), Zolotas' (1981) *Index of the Economic Aspects of Welfare* (IEAW), Eisner's (1990) *The Total Incomes System of Accounts* (TISA), and Daly and Cobb's (1989) *Index of Sustainable Economic Welfare* (ISEW).

ISEWs and GPI studies have been calculated for a number of countries including: Australia (Hamilton and Denniss, 2000; Lawn and Clarke, 2006), the UK (Jackson et al., 1997; Jackson *et al.*, 2008), the USA (Daly and Cobb, 1989; Anielski, 2001; Venetoulis and Cobb, 2004b; Talberth *et al*., 2007), Austria (Stockhammer *et al*., 1997); Sweden (Jackson and Stymne, 1996); Italy (Guenno and Tiezzi, 1998); and Japan, China, Thailand, Vietnam (Lawn and Clarke, 2008), Chile (Castaneda, 1999); Poland (Gil and Sleszynski, 2003); and The Netherlands (Bleys, 2007). Using such data, Kubiszewski *et al*. (2013) synthesised, GPIs of 17 countries, concluding that GPI per capita had begun this likely decrease from 1978 to 2003 whilst GDP per capita continued to steadily increase.

While a number of GPIs and ISEWs have been produced, valuation methodology modified and theoretical issues debated (Neumayer, 2000; Lawn, 2003; Neumayer, 2003), no handbook or set of standards has yet been established along the lines of the United Nations' System of National Accounts (SNA) that is used to calculate GDP. That said, in recent years there has been a concerted effort to standardise the construction of the Genuine Progress Indicator internationally, and to release the so-called GPI 2.0 – refer to Bagstad *et al*. (2014). Although this development appears to have the support of the Department of Natural Resources in Maryland and others, it falls well short of official sanction by agencies such as United Nations, which would be required if the GPI 2.0 standards were to be universally recognised and applied.

Cobb *et al*. (1995) argue that while the ISEW (and, similarly, the GPI) may lack the precision of GDP in that extensive statistical systems and conventions have not been established for data collection, it is a more reliable measure of well-being, as it does not arbitrarily place a zero value on factors essential for welfare and long-term sustainability: "To use the GDP as a measure of progress is to assume that families and communities and the natural habitat add nothing to economic well-being, so that the nation can safely ignore their contributions, and, in fact their destruction can be regarded as economic gain" (Cobb *et al.*, 1995: 8).

System of Economic and Environmental Accounting (SEEA)

The System of Economic and Environmental Accounting (SEEA), first released in 1993 and revised in 2003 and 2014, is an add-on to System of National Accounts (SNA)[14] which includes environmental accounts (or green accounts) as satellite accounts. These accounts, the development of which has

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[14] The System of National Accounts (SNA) is an international standard system of national economic accounts. The aim of SNA is to provide an integrated, complete system of accounts enabling international comparisons of all significant economic activity. Almost all countries in the world use the SNA to measure activity in their national economies, although there can be significant adaptations and in some cases there can be considerable delays. The first international standard was published in 1953. Handbooks have been released for the 1968 revision, the 1993 revision, and the 2008 revision.

been led by the United Nations, are comprehensive in coverage, with all environmental flows included and balanced, i.e. inputs equal outputs. The additional environmental accounts track the interaction between the environment and the economy in detail, but not all results are in monetary terms and SEEA does not include measures of national well-being (Hecht, 2005). Data availability is a problem and SEEA has not been sufficiently developed to be extensively used. The United Nations Statistical Commission adopted the *System of Economic and Environmental Accounting* as an international statistical standard its forty-third session in 2012 (United Nations, 2014). SEAA implementation in New Zealand since the 1990s has been very limited and sporadic, and arguably has had very little impact on policy-making and other communities of interest.

Green Net National Product/Sustainable Net Domestic Product

Green Net National Product (Green NNP) or Sustainable Net Domestic Product (SNDP) starts with GDP as a base and makes adjustments for depreciation of capital, the depletion of natural resources, the degradation of the environment and profits that go to overseas owners of domestic capital. A number of Green GDP studies have been completed, the most well-known being the Repetto et al. (1989) study for Indonesia and the Cobb and Cobb (1994) study for the USA. A criticism of Green GDP/SNDP is the assumption that the quantity of goods and services produced by domestically located factors of production is an appropriate measure of well-being (Daly, 1996). Another criticism, is that Green NNP does not indicate a level of output that can be sustained indefinitely (Lawn, 2007b).

Human Development Index

The Human Development Index (HDI), developed in 1993 by the United Nations Development Programme to measure progress in monetary and other terms, has been used to compare the development of nations world-wide, using the following variables: length of life, adult literacy rates, school enrolment, and GDP (UNDP, 2007). The reports, which are produced at regular intervals, also cover issues such as gender equity (UNDP, 2007). The HDI is generally regarded as an index more applicable to developing rather than developed countries, and it completely ignores the environmental dimensions of well-being and development. In this latter regard, there have been a number of proposals to extend the HDI to take account of the environment and sustainability, which for example include: Desai (1995), Sagar and Najan (1996), Ramanathan (1999), De la Vega and Urrutia (2001) and Neumayer (2001).

Quality of Life Measures and Subjective Well-being[15]

Numerous indices designed to measure 'quality of life' have been developed by gathering information directly from individuals. The aim is to monitor the state and development of quality of life in different countries and/or for different social groups within a country. Perhaps the best well-known such indicator is the 'Gross National Happiness Index' for Bhutan, when in 2010 and repeated in 2015, Bhutan surveyed 8,510 and 8,881 Bhutanese aged 15 and over across nine domains to measure how content their citizens were – these nine domains included: psychological well-being; health; education; time use; cultural diversity and resilience; good governance; community vitality; ecological diversity and resilience; and living standards (Centre for Bhutan Studies and GNH Research, 2016).

In Australia, there is a national 'Australian Unity Well-being Index' which began on an annual basis in 2002 (Australian Unity Ltd, 2015). This index measures 'quality of life' by using a 7 item 'personal well-being index' (mood/affect, self-esteem, optimism, perceived control, depression, anxiety, stress and personality), as well as by using a 6 item national well-being index (economic situation, natural

[15] Dier *at al.* (2002) define subjective well-being as "a person's cognitive and affective evaluation of his or her life." Many may argue that 'subjective well-being' and 'quality of life' a different types of well-being measures, but we have included them here as one category for brevity's sake, and because the specific indicators that we discuss do have considerable overlap between these two categories.

environment, social conditions, government and national security). In New Zealand, there is no national 'quality of life' index. However, carried out regularly is a quality of life survey of New Zealand's larger cities (AC Nielson, 2012; Colmar Brunton, 2016). The quality of life indicators cover areas such as health, crime, safety, public transport, and sense of community, and are based primarily on non-economic or non-monetised factors.

Genuine Savings Index

The Genuine Savings Index is one of the simplest measures of societal progress, based on the concept that sustainability depends on maintaining the value of assets over time. It measures the stock of income-generating capital by comparing national investment in all forms of capital with depreciation of capital. The World Bank calculates and reports Genuine Savings or Net Adjusted Savings measures as part of their World Development Indicator. Genuine savings is so called because it endeavours to include natural, environmental and human capital as sources of wealth in contrast to the standard System of National Accounts, which only shows changes in physical capital (i.e. man-made assets like machinery and infrastructure). The Genuine Savings Index has shown that by failing to compensate for the depletion of natural resources by either reconstituting their natural capital, or by investing in human capital some countries have actually become poorer while at the same time increasing their GDP (The European Commission *et al*., 2007). It is also possible for natural capital to decline and for Genuine Savings to be positive when investment in human-made capital exceeds the decline in stock of natural capital (Lawn, 2007b).

The Treasury's Living Standards Framework

The New Zealand Treasury over recent years developed their 'Living Standards Framework' based on the idea that 'Four Capitals' provide the basis for "intergenerational well-being": Human capital, Financial and Physical Capital; Social Capital and Natural Capital. The theoretical underpinnings of this framework appear to be diverse, drawing on concepts of sustainability as well as Sen's (1985) capabilities framework. A challenging aspect of this framework is the well-known difficulty in measuring capital stock, particularly natural, social and human capital which are very heterogeneous, and therefore difficult to measure in terms of one aggregate. Hence, Treasury have advocated the use of a "dashboard" approach where a multiplicity of indicators are measured and displayed; and most recently The Treasury have evaluated a number of indicators that could be part of that dashboard. From a methodological point of view there are some gaps and challenges in operationalising this framework, many of which Treasury acknowledge (Smith, 2018). Particularly evident, is a lack of a clear definition of the term "intergenerational well-being" and how, in explicit terms, this concept relates to the four capitals.

Discussion of Alternatives

Each of these indicators has strengths and weaknesses, the GPI included. The SEEA is extremely data intensive, complex and difficult to implement. Green NNP counts the cost of resource depletion and environmental degradation but does not include social factors or indicate whether the economic welfare being enjoyed is sustainable in the long-term. Quality of life indicators provide useful longitudinal data trends but focus on socio-economic rather than environmental change. The HDI is a more meaningful measure for developing rather than developed countries and is specifically a socio-economic indicator. With the Genuine Savings Index, it has been shown that even if the value is non-negative this in itself is an insufficient condition to determine whether or not the economic welfare being enjoyed is sustainable in the long term. Likewise, while the GPI is a better measure of well-being than GDP, it not an indicator of sustainability. The ecological footprint is a good indicator of biocapacity but not an indicator of sustainable well-being. The 'quality of life' or 'life satisfaction' surveys, which often rely on self-reported 'subjective well-being' measures, are difficult to compare across 'nations' because of their subjective underpinnings.

Economic analysis increasingly embraces a broader set of policy objectives than standard welfare-economic analysis (Stern, 2006), and attempts to develop new indicators reflect this. The scope, ability and freedom for individuals to live a life they have reason to value is recognised as just as important as the bundle of goods and services they consume (Sen, 1999). Over the last decade there has been increasing momentum to seek alternative measures to GDP – ones which more comprehensively and more accurately measure the nation's well-being. Governments across the world have increasingly recognised this, with high profile initiatives, for example, in countries like France where President Nicolas Sarkozy set up a commission to identify the limits of the GDP and outline new metrics that take account of things like education, gender equality and environmental sustainability Stiglitz, Sen and Fitoussi, 2009). The United Kingdom Prime Minister David Cameron directed the Office of National Statistics to conduct a nationwide survey asking citizens what they believe should be used to measure happiness. In Germany, the Bundestag has established a commission on "Growth, Prosperity, Quality of Life" to develop a more holistic measure of progress. Recently, capturing this mood for change, ecological economists Robert Costanza and his colleagues made a plea in the leading science journal *Nature* for better metrics of societal progress (Costanza *et al*., 2013).

What does the New Zealand Genuine Progress Indicator Measure?

The goal of the GPI is to obtain a more accurate and comprehensive measure of well-being for New Zealanders than the currently used GDP measure. While putting dollar values on social and environmental contributions to well-being is sometimes difficult, and deciding what should be included or excluded in the GPI usually involves at least some subjectivities, such an exercise does bring us a lot closer to providing a realistic picture of how we are progressing as a nation.

A careful methodological review of the draft version of NZ Genuine Progress Indicator measurement was undertaken, with the assistance of Professor Martin O'Connor (University of Versailles St Quentin, France)[16] and with a commissioned peer review from Professor Eric Neumayer (London School of Economics). The conclusions of this review were:

- Current GPIs inappropriately conflate the measurement of 'welfare' and the measurement of 'sustainability'. It was therefore recommended that the GPI should be restricted to the measurement of 'welfare' only.
- Related to the first point, since welfare (well-being) is a flow measurement, the GPI should not include measurements of stocks, or change in stock levels unless a change of stock level is directly connected or correlated with a change in welfare (wellbeing).

Therefore, taking these factors into consideration we made the decision to exclude the following variables from the NZ Genuine Progress Indicator, essentially because they measured a 'change in stock level' or 'stock levels':

- 'Net Capital Growth' was excluded because it is a measurement of the 'change of stock level in manufactured capital' rather than a 'flow'.
- Net Foreign Borrowing was excluded because it is a 'change in the stock of money' owed by New Zealanders to foreign sources, rather than a 'flow'.
- Loss of Non-Renewable Resources' was excluded because it only measures the decrease in 'stock levels' of non-renewable resources such as oil, gas and minerals.

[16] O'Connor's (2009) report was commissioned by the New Zealand Centre for Ecological Economics to systematically review the draft version of the NZ Genuine Progress Indicator, and on that basis give methodological advice on the how to construct a New Zealand Genuine Progress Indicator.

These three variables are most often included in the Genuine Progress Indicator of a nation – e.g., refer to Hamilton and Saddler's (1997) analysis which included these three variables in an Australian Genuine Progress indicator.

Included in the New Zealand Genuine Progress Indicator from 1970 to 2016 were measurements of the following 21 variables or components: Personal Consumption of Goods and Services Income Inequality, Consumption of Public Services, Unemployment, Under-employment, Over-employment (Overwork), Services of Public Capital, Household and Community Work, Private Defensive Expenditure on Health, Commuting, Crime, Deforestation of Indigenous Forests, Biological Pests, Loss of Wetland Ecosystem Services , Loss of Soil Ecosystem Services, Loss of Air Quality, Solid Wastes and Contaminants, Greenhouse Gas Emissions, Loss of Water Quality, Ozone Depletion and Noise Pollution.

Confusing Terminology

The terminology in this field is confusing and not always used consistently. First of all, the actual term Genuine Progress Indicator/s. Most of the time the term Genuine Progress Indicator refers to one overall monetised measurement of progress in a nation state (or a sub-national jurisdiction) that takes account of economic social and environmental measures of progress – indicators developed and in this tradition stem from the early framework developed by Daly and Cobb (1989) for the United States economy. Originally the Daly and Cobb (1989) indicator was termed the 'Index of Sustainable Economic Welfare' – however, around about the year 2000 the term 'Genuine Progress Indicator' (GPI) started to be widely used instead of the Index of Sustainable Economic Welfare (ISEW). The GPI/ISEW measures progress in terms of monetary valuation measurements of welfare, broadly drawing on the theory from Applied Welfare Economics.

In this publication, we use the term Genuine Progress Indicator/s when we are referring to the measurement of progress using monetised welfare measurements, across 21 components that can be 'added up' to produce one overall indicator of progress. This reflects the way in which Genuine Progress indicators are usually referred to internationally. However, another school of thought which is well represented by Colman (2004) is antagonistic to developing one overall monetary measurement of progress, because they argue amongst other things that there is a loss of richness and information in aggregating indicators of progress. Instead, this school of thought, who also uses the term "Genuine Progress Indicators", prefers the measurement of progress in terms of mixed units of measurement mostly being of a non-monetary nature – for example, the number of criminal offences per hundred thousand people per year. This school of thought also prefers the use of community engagement in developing these indicators, rather than the top-down prescribed approach of the monetary GPI.

Another area of confusion is the interchangeable use of the terms 'welfare' and 'well-being'. In this publication, as is often the case elsewhere, we also use these terms interchangeably although we acknowledge that in strict academic terms they are different yet related concepts. Well-being is generally speaking more generic and a term that is used across a number of disciplines ranging from 'health', 'psychology', 'development studies', as well as increasingly being used in 'economics'. In this way McGillivay (2007) defines well-being for the individual "… to be aligned with satisfaction with life, pleasure and enjoyment, health, leisure, personal development opportunities to fulfil one's potential, and having a purpose so that life has meaning.".

On the other hand, the term 'welfare' or 'social welfare' which strictly speaking is most closely aligned to what is measured by the New Zealand GPI, has a narrower focus. From the viewpoint of welfare economics, 'social welfare' is defined as whether a society is 'better off', 'worse off' or 'indifferent' in comparison with every possible social state. Historically, economists have struggled to identify the best way of measuring 'welfare' as so defined, as there needs to be a robust criterion to decide whether society is 'better off'/'worse off'/'indifferent'. One approach to this problem has been to use Pareto optimality – the so-called first theorem of welfare economics – as well as other approaches such as Kaldor and Hicks' 'compensation principle' or using a social welfare function as first promulgated by economists such as Samuelson. All that said, in the New Zealand GPI, social welfare is empirically measured in terms of monetised 'net benefit' or 'net cost'. This cost benefit analysis calculus used in our calculation of the New Zealand Genuine Progress Indicator is closely aligned to the idea of social welfare at least in-so-far as it is used in applied welfare economics field.

To muddy the situation further, economists are increasingly using the term 'well-being', as for example New Zealand economists Dalziel and Saunders (2014). As such, Dalziel and Saunders (2014) make the plea for New Zealand to be transformed from a "traditional welfare state to a progressive well-being state". Even orthodox welfare economists such as Ng (2004) define welfare as "an individual's *well-being* or more explicitly, his or her *happiness …*" (emphases added). Indeed, this emphasis on 'happiness' leads to another strand of potential confusion, with for example, Anieski (2007) arguing the case for "The Economics of Happiness", and the Bhutan government using an 'National Happiness Index' to replace GDP as Bhutan's national primary measure of progress.

Furthermore, the terminology 'Genuine Progress Indicator' (or Genuine Progress Indicators) is also problematic in a number of respects. Firstly, the adjective 'genuine' is perhaps misplaced, as ultimately 'genuine' is a subjective concept and its meaning varies across individuals and cultures. For this kind of reason the Waikato Regional Council (2014 a,2014b) has dropped the use of the adjective 'genuine' and just uses the terminology "Waikato Progress Indicators". Secondly, the word 'progress' implies that there is some agreed upon goal or target [17] for measuring progress against. Unfortunately, setting a goal or target is very rarely the case in the Genuine Progress Indicators analysis. Thirdly, the word 'indicator' is perhaps misleading, as more correctly the Genuine Progress Indicator is a 'composite index' which is a collection of quantitative indicators aggregated in a standardised way to produce one numerical measurement (OECD, 2008).

In spite of these difficulties with the terminology we have retained the most commonly used terms, and not been too pedantic in our use of the words 'welfare',' well-being',' happiness',' quality of life',' progress',' indicator' or 'index'. This means we have retained the use of the word Genuine Progress Indicator, and we use the words 'well-being' and 'welfare' interchangeably, although we recognise that the GPI is more closely aligned to the concept of 'welfare' as used in Economics.

[17] For example, for climate change or greenhouse gas variable, appropriate goal or target could be for New Zealand: "to reduce (its) greenhouse gas emissions by 30% below 2005 levels, by 2030", which was New Zealand's commitment to the Paris agreement. 'Progress' could then be measured in terms of 'how close' (in terms of tonnes CO2 equivalents) New Zealand is to the target in any given year.

2. Methodology

This section outlines and justifies the overall methodological approach taken in the construction of the New Zealand Genuine Progress Indicator. Readers should refer to individual sections in this publication for the detailed information on how each components of the New Zealand GPI was calculated.

Key Principles and Conventions

The following section provides a brief discussion and justification of the principles and conventions that we used in the construction of the New Zealand GPI. Our approach is generally consistent with the common practice in most other GPI, with a few modifications for New Zealand's unique situation and the adoption of some methodological improvements particularly those recommended by our international reviewers.

Measurement of Costs and Benefits

The overall aim of this analysis was to calculate an aggregate indicator that more adequately measures the changes in welfare of New Zealand than the GDP aggregate. The underlying research question, was accordingly: *Is New Zealand 'better off' or 'worse off' in terms of welfare of each of the years over 1970 to 2016?* This approach requires a broader quantification of the 'costs' and 'benefits' of economic activity than occurs in the GDP measurement. As pointed out previously, not all of the activities that make up the GDP measurement are necessarily 'benefits' (e.g., cost of cleaning up water pollution), and there are many costs and benefits which are non-market activities. This approach of measuring these external 'costs' and 'benefits' is in principle no different to the social cost benefit analysis which is advocated by The Treasury for evaluating government expenditure on specific projects . Nor is this cost benefit approach any different from the cost benefit approach used by the New Zealand Transport Agency for evaluating roading and transportation options. The only difference between our GDP approach, and the approaches of the Treasury and New Zealand Transport Agency, is one of scale – The Treasury and the New Zealand Transport Agency apply their procedures to individual projects or policies, where we are applying this cost-benefit approach to the whole of the New Zealand economy.

Aggregate GPI and Dashboard

Often in the literature there is debate on whether to use 'one aggregate' or a series of indicators in the form of a 'dashboard' or other pictorial presentations. It is often asserted, or implied, in this literature debate that one of these approaches is 'better' or 'more useful' than the other (Colman, 2004). We disagree with this assertion, as we consider there is a lot is to be gained by using both methods alongside each other in a complementary fashion. The 'one aggregate' indicator answers the question: 'Overall, are we doing better or worse in terms of well-being (net benefit) compared with the reference year?' On the other hand, the 'dashboard' approach helps explain the movements of the different components that make up the changes and the aggregate GPI.

It is therefore not a matter of the 'aggregate GPI' or the 'dashboard GPI' being superior, but instead it depends, on the questions being asked, and on the audience. The aggregate GPI may be more suitable for reporting in the media when there are 'five second sound-bites' – and indeed one of the reasons why the GDP is so popular is that it is a single number that can easily be presented in public media and immediately understood by the public. On the other hand, using the dashboard indicators may be more useful to policy analysts, who don't only want to know about the overall aggregate number, but may also want to understand details of movements in individual indicators that make up the aggregate number.

Stocks and Flows[18]

New Zealand GPI measures 'flows' both in physical and monetary terms. That is, measuring the amount of a cost or a benefit *per unit of time* (in this case, per year). Incidentally, the Gross Domestic Product also measures 'flows' in terms of the amount of marketed goods and services produced per unit of time (per year). On the other hand, the four capitals model advocated by The Treasury, if it was operationalised, would measure 'stocks'– for example, the amount of fish (tonnes) in the specific New Zealand fishery could be one aspect of measuring 'natural capital' stock. One of the errors sometimes made in GPI accountancy and measurement, is that 'stocks' and 'flows' are inappropriately added together, or more subtly it is assumed that a 'change in stock level' equals or implies a 'change in the level of welfare'. The approach in the New Zealand Genuine Progress Indicator, has been to give strict attention to measuring 'flows' only, whether such flows be in physical units or monetised.

Conflation of Measurements of Welfare and Sustainability

Very often in the GPI literature, and in the broader indicators literature, it is claimed that a particular metric can simultaneously measure both 'welfare' and 'sustainability'. Indeed, originally the GPI was termed an 'Index of Sustainable Economic Welfare'. One way of approaching the measurement of 'sustainability' is to measure capital stock levels (natural, social, manufactured and so forth) from one generation to the next, and put forward the argument if intergenerational equity is to be maintained then the aggregate level of stock must be at least maintained from one generation to the next. Though this is a simple proposition, in practice it is more difficult to justify as there may not be substitutability between the different types of capital stock, so it is not a simple matter of just maintaining the aggregate level of stock. Furthermore, a 'critical' level of capital stock is required to sustain human activity, and this needs to be provided irrespective of the movement of the aggregate capital stock across generations.

The position that we take in the New Zealand GPI, is not to try to conflate 'welfare' and 'sustainability' into one indicator, as our argument is that they are fundamentally different phenomena. 'Sustainability' using economic frameworks such as the Genuine Savings Index, or non- economic frameworks such as the Ecological Footprint, fundamentally requires quite different types of measurement, and almost invariably at least in the economic context requires the measurement of capital stocks, over different generations. Therefore, in the New Zealand GPI we have excluded a number of factors that some other GPI practitioners have used. However, we have included in Appendix IV physical and monetary data on the depletion of non-renewable resources, so that analysts can include this particularly if they wish to compare the New Zealand GPI with international GPIs which have included the depletion of non-renewable resources.

Aggregation, Commensuration, Monetising [19]

One of the contested issues with a single indicator GPI, is the aggregation of the individual components, where those components are measured in terms of different physical or natural units. It is simply not valid to 'add up' say a microgram PM_{10} of air quality, plus number of crimes committed per year. For example, The Treasury (2017) asserts, "it cannot be measured as a single number without making significant implicit or explicit value judgements." We disagree with this assertion, as there are a number of ways of combining well-being indicators into one aggregate, where value judgements have either no impact or very little impact on the procedure. Indeed, Treasury themselves in their cost benefit analysis manual and advocacy of it, encourage the monetisation of costs and benefits so that

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[18] Cryptically: flow = amount per unit of time; and stock= amount.

[19] Monetising (or Monetisation) has several meanings, depending on the context. In this publication, monetising refers to determining and placing a monetary value on 'something'. It does not refer to converting that 'something' to a source of income or an item for market exchange – for example, it does not refer to monetising websites by selling advertising space or charging website users.

they can be aggregated into one metric such as a benefit:cost ratio. As long as the valuation of the costs and benefits in this process are objectively surveyed and assessed, it's hard to argue that there are any 'value judgements' on the behalf of the analysts. Second, there are statistical methods such as factor analysis or principal components analysis that enable the 'objective' aggregation of variables according to the implicit characteristics and variances in the data that do not depend on analysts imposed 'value judgements' (refer to Huser *at al*., 2017; Jollands, *et al*., 2003).

Monetising is the most common way to commensurate, and then aggregate, benefits and costs that are naturally measured in different types of units. It is important, however, when monetising costs and benefits, that as far as possible this should be consistent with economic theory. For example, when measuring a benefit externality, willingness to pay to obtain a service is commonly accepted as a good measure of how much an individual or society may prefer that benefit in comparison to some other benefit which has been valued in the same terms. Opportunity cost, which measures the opportunity forgone in money terms, may be used for example in monetising the time lost in urban commuting. This way monetisation, not only allows for costs and benefits to be added up because they are in the same monetary units, but it also enables the extent of the cost or benefit to be measured or imputed by some notion of 'transactional exchange' – like how much money are you willing to give up, to receive some benefit or avoid some costs. Another advantage of monetisation is that it expresses the information in terms that decision-makers understand and in terms of a valuation metric (i.e. the dollar) that they use in their everyday personal and professional lives. This is particularly valuable in public policy analysis, where for example the magnitude of these costs in monetary terms, can be compared with the expenditure in money terms to mitigate or reduce these costs.

Boundary Problem and Double Counting

Which factors to include in the New Zealand Genuine Progress Indicator needed to be carefully considered. Generally speaking, we followed the lead of the Australian Genuine Progress Indicator constructed by Hamilton and Saddler (1997), with the exceptions of removing variables which measured sustainability rather than welfare, and/or measured a stock rather than a flow, and/or measured a change in stock rather than a flow. The purpose of this was to be consistent in measuring 'welfare' effects only, and to measure them in terms of 'flows'. Consistent with the approach of Hamilton and Saddler (1997) and most other GPI practitioners, we only measured factors that were related to or caused by economic activity. The rationale for this is that the Genuine Progress Indicator, like the GDP, has been designed to provide an indicator of performance of economic activity to inform economic policy decisions made by governments, usually made at the national level.

It is sometimes tempting to add extra factors to the GPI index, but in doing so there is often a risk of double counting some of the welfare effects which have been measured by other variables already in the GPI. For example, Kubiszewski *et al*. (2013) in response to the proposition that 'political freedom' should be included in the GPI, responds by arguing "political freedom is not a welfare benefit generated by economic activity. It should not, therefore be incorporated into the GPI. If it so happens that greater political freedom has a positive impact on economic well-being generated by economic activity it is reflected in many items that make up the GPI. Thus it is incorrect to say that the GPI overlooks positive effects of greater political freedom. To include a separate welfare item for political freedom would involve double counting.". In the latest proposed protocol for the GPI (GPI 2.0) Bagstad (2014) provide a number of other cautionary examples where double counting should be at least reduced if not eliminated.

Methodological Process

The methodological process for measuring and constructing the New Zealand GPI, as well as its components, is outlined by Figure 2.1.

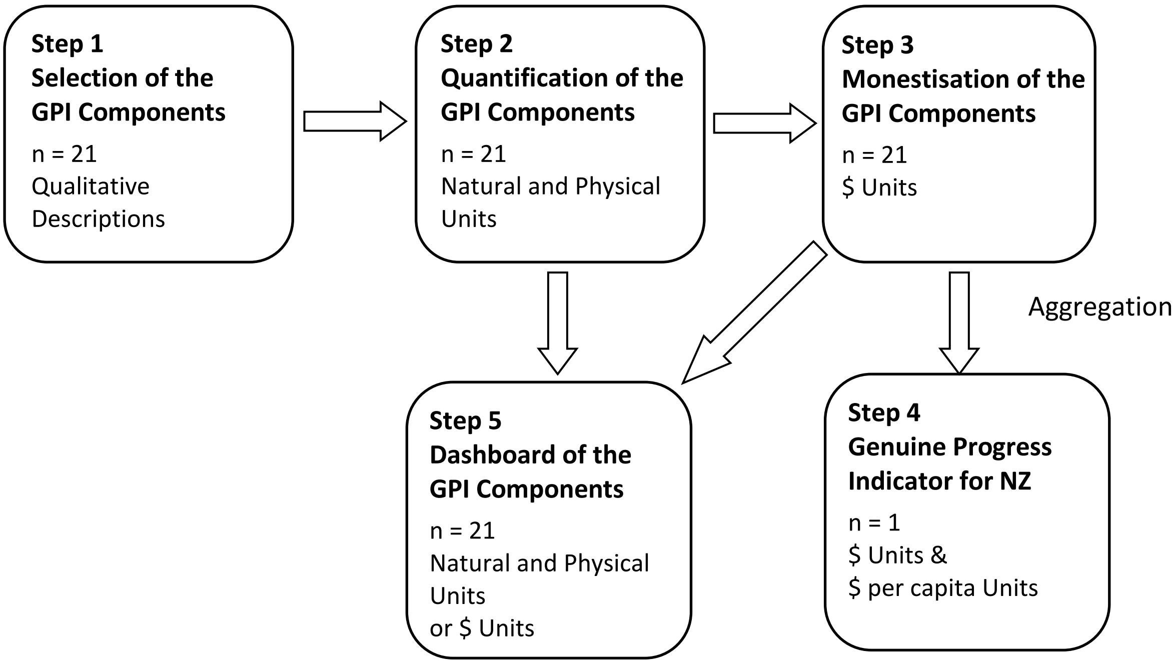

Figure 2.1 Methodology – Construction of Genuine Progress Indicator for New Zealand, 1970 to 2016 (n = number of components)

Briefly, the steps in the methodological process are:

Step 1: Selection of the Components of the New Zealand GPI. Although there have been some efforts to standardise the range of components included in GPI studies, there is no internationally accepted list of such components. The approach used in the New Zealand GPI was to: (1) start with the components used in the Australian GPI study by Hamilton and Saddler (1997), as at the time the New Zealand GPI analysis was first commenced the Australian GPI study was one of the most complete national GPI studies, and furthermore Australia and New Zealand have similar cultures, social institutions and lifestyles; (2) then exclude variables that were inconsistent with the 'principles' outlined above – for example "costs of depletion of non-renewable energy resources" was excluded because it is a 'stock' rather than a 'flow' – and as such the indicator of 'depletion of non-renewable energy resources' arguably focuses more on the issue of 'sustainability' rather than 'well-being' which is our focus; (3) then, there were some modifications, additions and re-naming of the Hamilton and Saddler (1997) components, particularly to the environmental components to allow for New Zealand's unique and different biophysical environment – for example, "biological pests" were added, as they have a significant impact on New Zealand's well-being, both directly and indirectly. In this re-naming, there were some reframing definitions so that there was a focus on 'ecosystem services flows', rather than on their underpinning 'natural capital stocks'. As previously discussed, it is important in identifying and selecting that only the **costs and benefits related to economic activity** be included, and that double counting (overlap between components) is avoided, or at the very least minimised. By following this process, 21 indicators were ultimately identified to be included in the New Zealand GPI – these are defined in detail in the next section below titled "Components Covered".

Step 2: Quantification of Components of the New Zealand GPI. First of all, **precise definitions** of the 21 component from Step 1 were developed, to facilitate quantitative measurement of these 21 components in **natural and physical units**. For example, the quantification of the value of household and community work was defined and then measured in terms of 'unpaid time spent per year on various household and community tasks'. This quantification was a reasonably straightforward task for most of the socio-economic components of the New Zealand GPI, but became somewhat more difficult for some of the environmental components – for example, in the 'loss of air quality' there are several air pollutants that have a known negative impact on health and well-being, but it is difficult to derive one overall quantitative measure that encapsulates all of these negative impacts of air quality loss – so, therefore, in our GPI analysis, a 'proxy' of PM_{10} was adopted as the best available indicator of these negative impacts on health and well-being [20]. In the case of the loss of ecosystem services from the decline of indigenous forests, wetlands and soils, intermediary proxies (such as hectares lost[21]) were used, and these intermediary proxies were converted to $ ecosystem services lost per hectare. Tables 2.3 and 2.4. outlined the 'physical and natural units' we use to initially quantify the 21 components of the New Zealand GPI.

Step 3: Valuation (Monetisation) of the Components of the New Zealand GPI. Eight[22] of the 21 components of the GPI were already quantified in terms of monetary units in Step 2, so therefore they required no further processing. The remaining 13 components of the GPI, were converted to monetary units using the nonmarket valuation methods that are outlined in Tables 2.3 and 2.4. In several cases, this valuation data was drawn from other studies that often combined the use of several valuation methods in deriving such data – for example, the cost of commuting involved and measurement of the opportunity cost time, as well as direct measurements of the cost of maintaining vehicles based on market prices.

Step 4: Calculation of the New Zealand GPI for 1970 to 2016. The New Zealand GPI was calculated for each year by summing the benefits (total benefits), then subtracting the sum of the costs (total costs), and then finally subtracting the total defensive expenditures – that is, for any specified year:

GPI = net benefits = total benefits - total costs - in total defensive expenditures.

For example, for 2016:

GPI = $195 billion = $270 billion - $74.5 billion - $0.5 billion

For this calculation, as for most other calculations in this GPI computation, the dollars were expressed in terms of 2014 constant dollars ($2014), which enabled the comparison of the GPI data across different years of the New Zealand GPI analysis. The GPI data, for any given year, could be **normalised** by dividing the GPI by the population for that given year – this GPI per capita then enabled a fairer comparison of GPI between years (that had different levels of population) and between countries[23] (that had different levels of population).

Step 5: Dashboard of the Components for the New Zealand GPI 1970 to 2016. The data collected in Steps 2 and 3, which are expressed in physical, natural or monetary units, can be used to display the

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[20] The use of PM10 as the key proxy indicator is consistent with the approach used by Kuschel *et al*. (2012) in the study, prepared for the National Health Council of New Zealand, Ministry of Transport, Ministry for the Environment and the New Zealand Transport Agency.

[21] In itself 'hectares' cannot be a measurement of 'well-being' – because, hectares are 'stock 'measurements, rather than a 'flow' measurement which is required in the quantification of well-being. That said, 'flow' measurements such as '$ per hectare per year', can be readily determined from hectares of land coverage for ecosystems such as wetlands and forests or soil systems [refer to Patterson and Cole (2013) for the application of such a methodology].

[22] The eight components already quantified in monetary terms in Step 2 were: Personal Consumption; Consumption of Public Services; Services of Public Capital; Private Defensive Expenditure on Health; Costs of Biological Pests; and the Loss of Ecosystem Services from the Deforestation of Indigenous Forests/Soil Loss/Wetland Loss).

[23] This 'between country comparison' also requires the exchange rates, between the two countries in question, to be factored into the calculation of the comparative data.

GPI data in terms of the dashboard of 21 indicators. Some practitioners prefer displaying the data as a 'dashboard' (analogous to a dashboard of a car), as they argue that the performance of an economy cannot be judged in terms of just one indicator, no more than you would expect to drive a car by using just one performance metric (say, kilometres per hour, or revolutions per minute). As we argue elsewhere, we do not consider this to be an 'either/or' argument, as both the 'dashboard' and the single indicator' approach can be used simultaneously in GPI analysis. The dashboard approach allows for the GPI components (which are measured in different or mixed units), to be visually displayed, although there is no reason why the monetary data from Step 3 could also be displayed on a 'dashboard'.

Components Covered

In total 21, components make up the New Zealand GPI. The overall approach is to start with personal consumption of everyday goods and services, which is the largest component of the GPI, and then to subtract costs, add benefits and then remove defensive expenditures. The following components thereby included in the GPI are:

1. **Personal Consumption of Goods and Services (PC) (Benefit).** This is the total amount of private goods and services consumed by New Zealanders each year. It is the largest component in the New Zealand GPI, as it is also the largest component of the GDP. Personal consumption refers to goods and services that are directly 'purchased' by consumers, as opposed for example to 'public services' that are provided by government. In the System of National Accounts, it is a 'final demand' category as opposed to an 'intermediate demand' category, indicating that it is the final consumption of goods and services once they have been manufactured, processed, added to and/or transformed in the intermediate demand sectors.

2. **Weighted Personal Consumption (WPC) (Benefit).** This is the personal consumption for any given year 'weighted' by the 'income distribution index' for the year, to reflect changes in **income equality** as measured by the Gini Index. If the income distribution index numerically increases then the weighted personal consumption decreases and it becomes a widening gap between 'personal income consumption' and 'weighted personal income consumption'. Full calculation details of the Gini coefficient can be found in Chapter 4, and calculation details of the 'weighted personal consumption' can be found in Chapter 5. If WPC is less than PC, then there is a loss of income equality, and this is equal to: $WPC - PC = \alpha$. The variable α monetises the **loss of income equality,** so therefore it needs to be entered into the GPI as a negative number as it is essentially a cost to society.

3. **Consumption of Public Services (CPS) (Benefit).** This is the consumption of Public Services by citizens, as opposed to consumption of privately purchased goods and services, which were covered under the above components 'PC' and WPC'. These Public Services are provided by both central and local government, essentially 'free of charge' or subsidised, but funded through the taxation system, rates and other revenues sources available to government. The three largest areas of Public Services are: social welfare, education and health. GPI accountancy requires 'defensive expenditures'[24] to be

[24] Defensive expenditure is formally defined by Leipert (1989, p.28) as "expenditure … made to eliminate, mitigate, neutralise, or anticipate and avoid damages and deterioration that industrial society's process of growth has caused to living, working and environmental conditions." The use of 'Defensive Expenditures' in GPIs has been the subject of some debate in the literature, with for example scholars questioning where you draw the line in defining "a defence against unwanted side effects of other production"– Neumayer (2013) for example points out that expenditure on a holiday could be "a defensive expenditure for dealing with a stressful, exhausting or boring modes of production".

subtracted from the consumption of public services, on the basis it would be preferable to avoid these 'side-effects of economic growth' (e.g., ill-health caused by air pollution).

4. Unemployment (UnE) (Cost). This refers to those who do not have paid employment, yet desire and are seeking such employment. In the New Zealand GPI, unemployment is measured by involuntary leisure time. The costing (monetisation) of this involuntary leisure time is calculated by measuring the difference between the minimum real wage rate and unemployment benefits received

5. Under-employment (UnderEM) (Cost). This refers to workers, though employed, who would like to increase their working hours. As in unemployment (UnE), the cost of underemployment is monetised by using the difference between the real wage rates and unemployment benefits received.

6. Overwork (OW) (Cost). This refers to workers, working longer hours than they consider desirable, which may have a number of negative mental health impacts, disruption to family and personal life and so forth. Based on literature sources it is assumed, that on average any work over 50 hours per week constitutes overwork. The average hourly pay rates for all occupations were used to cost the hours of overwork in the New Zealand GPI.

7. Services of Public Capital (Benefit). This includes items of physical capital owned by the government that provide benefits and well-being to New Zealanders, covering: publicly owned roads, transport infrastructure, telecommunication infrastructure, sewerage and sanitary infrastructure, and water supply engineering works. More recently items such as 'software' have been included in this category. Over the time period of this analysis, there have been some significant shifts in the ownership of previously owned public assets, to the private sector, particularly during the time of the economic reforms in the 1980s and 1990s.

8. Household and Community Work (HCW) (Benefit). This is unpaid household and community work, ranging from caring for children, cooking and food preparation, housecleaning, gardening, household maintenance, through to volunteer work for non-profit institutions like the Red Cross or voluntary work to support a school. As with most countries, this component of unpaid household and community work is very significant, and represents a group of beneficial activities that are routinely not accounted for in the National System of Accounts, or in the GDP metric.

9. Private Defensive Expenditure on Health (PDEH) (Non-Benefit). This is an accounting component which needs to be carefully considered in GPI accounting. Since some private expenditure on health is a defensive expenditure, it needs to be subtracted from the GPI accounts or more precisely subtracted from the personal consumption component where it has already been included as a positive item. This is on the basis that some portion of private expenditure on health is defensive expenditures to do with dealing with the ill-effects of economic activity.

10. Cost of Commuting (Com) (Cost). This refers to the undesirable effects of travelling to and from the individual's place of work. This involves a number of costs including for example, the cost of maintaining a vehicle, costs of public transport particularly for long commutes, the loss or waste of time commuting where the commuter would rather be doing something else, the stress associated with being 'stuck in the traffic', and so forth. It's important in the GPI analysis not to double count some of these ill-effects, if they are accounted for elsewhere in the GPI.

11. Cost of Crime (Crime) (Cost). This refers to illegal activity that has negative impacts on members of society including for example short-term and even long-term mental health outcomes for victims, loss of property, physical damage or injury, loss of a sense of security and so forth. It is important with this category not to double count items already taken account of in the New Zealand.

12. Deforestation of Indigenous Forests (Deforest) (Cost). This refers to the loss of ecosystem services and other welfare flows associated with deforestation of indigenous forests. It's important to note this is a measurement of welfare 'flows', and not of the capital stock of indigenous forests.

13. Biological Pests (BP) (Cost). This refers to animal, plants and microbes that are threats to New Zealand's indigenous flora and fauna, as well as productive areas such as farming. Because of New Zealand's geographic isolation over long periods of geological time, much of New Zealand's biodiversity is unique and therefore highly valued, which provides a rationale for protection from biological pests.

14. Loss of Wetland Ecosystem Services (WetES) (Cost). This refers to the loss of wetland ecosystem services and the negative impact this has on the welfare of New Zealanders. Wetland ecosystem services include: the regulation and purification of water, regulation of gas, a habitat for birds and fish, flood protection, and so on. On a per hectare basis, wetlands are amongst the most beneficial type of ecosystems in New Zealand, in terms of ecosystem services delivery.

15. Loss of Soil Ecosystem Services (SoilES). (Cost). This is the loss of soil ecosystem services and the negative impact this has on the welfare of New Zealanders. Soil ecosystem services include flood mitigation, filtering of nutrients, detoxification, carbon storage and regulation and other services that don't have a market value, and therefore are not included in the GDP. The loss of soil ecosystem services in New Zealand is primarily due to 2 factors: (i) urban expansion onto high-quality soils; (2) loss of soil, and hence associated services, due to accelerated (anthropogenic) erosion.

16. Loss of Air Quality (Air). **(Cost).** This refers to the loss of air quality (due to anthropogenic causes) and the negative impact this has on the health and quality-of-life of New Zealanders. Air pollution, for example, can seriously impact on human health particularly affecting the lungs as a known source of cancer, can damage property, have negative impacts on visual quality, and more recent studies have highlighted the role air pollution has on the cognitive functioning. Greenhouse gases and the depletion of ozone gas in the atmosphere are not included in this category, but in categories 20 and 21 below.

17. Solid wastes and contaminants (Wastes). (Cost). This is the full life-cycle costs of disposing of solid wastes and contaminants, and dealing with their negative impacts on welfare. Where possible a full cost methodology was used. Solid wastes and contaminants include paper, cardboard packaging waste, glass, building debris, food wastes, plastics, chemicals, pesticides and so forth, all of which are by-products of economic activity.

18. Greenhouse Gas Emissions (GHG) (Cost). Climate Change resulting from increased greenhouse gas emissions from human activity, will impact on the future well-being of New Zealand in a number of ways including, for example, increased flooding and storm events, inundation of low-lying areas, droughts in certain parts of the country and increased pests and diseases. This component is costed according to New Zealand's contribution to the increased global level of greenhouse gas emissions, including mainly carbon dioxide and methane. There are also some economic benefits associated with climate change (e.g., increasing the geographical spread of higher value sub-tropical crops) – these are not calculated in the New Zealand GPI, due to lack of reliable data and due to the economic benefits of climate change considered to be relatively low compared with the costs of climate change.

19. Water Quality (Water) (Cost). This is the loss of water quality in our rivers, streams and lakes and the external negative impact this has on the use of water for recreation and cultural purposes, our health and on valuable aquatic species. Poor water quality also has an impact on commercial and economic activities, but care needs to be taken not to 'double count' such impacts. In general terms 'point source' water pollution has decreased over the last few decades, but 'nonpoint source' water pollution through the intensification of agriculture has markedly increased.

20. Ozone Depletion (Ozone) (Cost). This is the depletion of stratospheric ozone that provides humans and other species with a protective layer against incoming solar ultraviolet radiation. Although the rate of ozone depletion has been reduced as a result of the Montréal protocol, New Zealand continues to experience the negative impacts of ozone depletion, through some of the world's highest rates of melanoma and skin cancer.

21. Noise Pollution (Noise) (Cost). This refers to unwanted or offensive sounds coming from a variety of sources including industry, activities such as lawn mowing, recreational events, traffic noise and so forth. In this study, we were only able to measure the cost of traffic noise, which is recognised in most countries as the largest component of overall levels of noise.

Valuation and Monetisation of the GPI Components

Valuation is important for a number of reasons: (1) it enables the importance of each component to be compared in terms of a common yardstick, mostly some specified monetary units (e.g. $NZ) but other valuation methods are available that don't necessarily require monetisation; (2) knowing the relative importance in terms of some real or simulated market change process (e.g., willingness to pay for some beneficial activity) is important to decision-makers so that they can make more informed funding choices, about alternative expenditures or policy choices; (3) the use of monetary units in the valuation process, means that costs and benefits can be understood in terms that are readily known to the general public, as they use money as a means of exchange in their everyday life. All that said, the GPI data can be presented in physical or natural terms, if the user of the GPI data so desires, or these data can be framed in terms of other criteria such as percentage of some policy target achieved. However, by using physical and natural data only, it is difficult if not impossible to aggregate the GPI into one indicator, and therefore on a year by year basis it is impossible to tell whether overall the economy and society are improving in terms of the components in the GPI indicator. Aggregation, therefore, via valuation and monetisation, is not just a theoretical exercise, but it enables a very important question to be answered – as a society or as an economy over periods of years if not decades, has our overall well-being got better or worse?

The valuation of non-market 'goods' and 'bads' generally speaking is not an easy process, as monetary values need to be imputed from statistical data (as in hedonic pricing), or uplifted from one economic and social context to another (as in benefit transfer), or perhaps elected by using difficult to frame consumer surveys (as in contingent valuation) or by using any of the other non-market valuation methods, all of which encounter operational difficulties. The situation becomes even more challenging as the valuation data in our GPI analysis often needs to be scaled up, from individual surveys and localised analyses, to the nation as a whole, which inevitably introduces further difficulties and assumptions. All that said, non-market valuation methods were successfully used to measure the monetary value of 18 of the components of the New Zealand GPI, with 3 components either being measured directly in terms of market prices or provided to us already in monetary terms. These market and nonmarket methods are outlined in Table 2.1 for the socio-economic components, and in Table 2.2 for the environmental components. Detailed information on the valuation methods, and how they were used to monetise the 21 GPI components, is outlined in each chapter sub-heading "How to include?"

Table 2.1 Valuation Methods of the Socio-Economic Components of the New Zealand GPI

	GPI Costs and Benefits	Physical or Natural Units	Valuation Methods	Explanation of the Valuation Methods
1	Personal Consumption	$	Market Prices	Annualised time-series of private final consumption expenditure obtained from Statistics New Zealand.
2	Changes in Income Inequality	Gini Coefficient	Imputed values from income data	Quintile income data from Statistics New Zealand, is used to calculate Gini coefficients and income distribution index, to monetise changes (-/+) in income equality from a base year of 1969.
3	Consumption of Public Services	$	Imputed Market Prices	The value of government services is imputed taking account of costs such as labour. Defensive expenditures are subtracted.
4	Unemployment	time	Cost of Involuntary Leisure time	Total unemployed hours multiplied by average hourly wage rate.
5	Under-employment	time	Cost of Involuntary Leisure time	Total under-employed hours multiplied by average hourly wage rate.
6	Over-employment (Overwork)	time	Cost of Involuntary Leisure time	Total hours of work multiplied by the average wage rate. 50 hours and over constitutes overwork.
7	Services of Public Capital	$	Opportunity cost	Opportunity cost of the government investing its funds elsewhere in the money market in order to gain interest, in order to cover the depreciation of capital stocks.
8	Household and Community Work	time	Imputed Market Price	Time spent on household and community work by age-sex cohort multiplied by median wage rates by housekeepers adjusted through time for known changes in age-sex cohort demographics.
9	Private Defensive Expenditure on Health	$	Defensive Expenditures	Total private expenditure on health multiplied by assumed defensive expenditure proportion.
10	Commuting	time, $ cost	Cost of Involuntary Leisure time & other costs	Time costs are estimated as total hours spent on committing by employed people multiplied by a cost per hour. Direct costing of other items such as vehicle purchase & maintenance, bus and train fare.
11	Crime	number of offences	Replacement cost of property lost, repair cost of property damage and preventative expenditure	Total offences multiplied by a cost per offence. Requires scaling of recorded offences to derive actual offences using a multiplier by Roper and Thompson (2004).

Table 2.2 Valuation Methods of the Environmental Components of the New Zealand GPI

GPI Costs and Benefits		Physical or Natural Units	Valuation Methods	Explanation of the Valuation Methods
12	Deforestation of Indigenous Forests	$	Costing of lost ecosystem services	Costing of the lost ecosystem services from the deforestation of indigenous forests; then adding the ecosystems value of the scrub (that replaces the lost indigenous forests).
13	Biological Pests	$	Cost of pest control	Costs of pest control including border control, rabbit and land management, pest control on the conservation estate and other pest control by central/local government.
14	Loss of Wetland Ecosystem Services	$	Costing of lost ecosystem services	Costing of the lost ecosystem services from wetlands, and then adding the ecosystem services of pastoral farming which is the assumed replacement landcover.
15	Loss of Soil Ecosystem Services	$	Costing of lost ecosystem services	Costing of the loss of soil ecosystem services from agricultural and horticultural land occupied by urban sprawl. Costing of soil loss through accelerated erosion, including lost agricultural production and associated cost of environmental impacts.
16	Loss of Air Quality	PM_{10} (µg/m³)	Social Cost of Health Impacts of Air Pollution	Costing of the health impacts of air pollution including for example premature deaths, extra hospital admissions, and restricted activity days due to air pollution. PM_{10} used as the metric for allocating costs to particular years
17	Solid Wastes and Contaminants	tonnes	Full Life-cycle costs of wastes	Full cost accounting methodology to cover the full costs of disposing of wastes rather than for example charging the actual amount charged at a landfill facility.
18	Greenhouse Gas Emissions	tonnes (CO_2 equivalents)	Price of carbon recommended by the Stern (2006) report	Cost calculated by multiplying the Stern Price of Carbon ($US30 per tonne), by the total net greenhouse gas emissions (CO_2 eq tonnes).
19	Loss of Water Quality	Nitrogen, BOD and other pollutants	Mainly Avoidance Cost	Cost of planting a 15 metre riparian margin to intercept and process non-point source pollutants. For point source pollutants (which are far less), known clean-up costs were accounted for and extrapolated to other cases.
20	Ozone Depletion	Deaths	Costing premature deaths from melanoma	Ministry of Transport's (2009) 'Statistical Life' cost was used to estimate the economic cost of lost years of life due to melanoma onset.
21	Noise Pollution	Traffic volume as a proxy	Social cost of Traffic Noise	Social cost of traffic noise from estimated by the Ministry of Transport (1996), then proportionally allocated to each other year by scaling according to vehicle kilometres travelled.

Calculation the Genuine Progress Indicator

In total, 21 components make up the New Zealand GPI. These 21 components were 'added up' to produce one aggregate index (one number) for each of the 47 years starting with 1970 – the overall approach is to start with Personal Consumption of everyday goods and services which is the largest and most beneficial component of the GPI, and then to: (1) **Add** other 'benefit' components; (2) **Subtract** 'cost' components; (3) **Subtract** 'defensive expenditures'. Table 2.3 outlines how this has been undertaken for the year 2016. The same GPI accounts need to be constructed for each of the other years in the study period (1972 to 2015). Ideally, those defensive expenditures should be explicitly separated out as a separate element of each of the 21 GPI components – however, this was not possible in our analysis because of the way the data was compiled.

Table 2.3 Calculation of the Genuine Progress Indicator, New Zealand, 2016

Genuine Progress Indicator Component		Costs	Benefits	Defensive Expenditures
		$\$_{2014}$ million	$\$_{2014}$ million	$\$_{2014}$ million
1	Personal Consumption		156,655	
2	Changes in Income Distribution	35,934		
3	Consumption of Public Services[a]		44,659	
4	Unemployment	2,659		
5	Under-employment	1,151		
6	Over-employment (Overwork)	5,560		
7	Services of Public Capital		23,052	
8	Household and Community Work		45,579	
9	Private Defensive Expenditure on Health			537
10	Commuting	7,118		
11	Crime	3,669		
12	Deforestation of Indigenous Forests	177		
13	Biological Pests	974		
14	Loss of Wetland Ecosystem Services	1,542		
15	Loss of Soil Ecosystem Services	3,522		
16	Loss of Air Quality	5,100		
17	Solid Wastes and Contaminants	477		
18	Greenhouse Gas Emissions	2,967		
19	Loss of Water Quality	2,399		
20	Ozone Depletion	325		
21	Noise Pollution	839		
	Total Costs (TC)	74,413		
	Total Benefits (TB)		269,945	
	Defensive Expenditures (DE)			537
	GPI = Net Benefit (TB-TC-DE)		**194,995**	

Note:

a. Defensive Expenditures subtracted from this benefit prior to table entry

Table 2.3, which expresses costs, benefits, defensive expenditures and the overall Genuine Progress Indicator in total $\$_{2014}$ million (rather than $\$_{2014}$ per capita) is useful for comparing the results with the GDP and top-level System of National Accounts aggregates. This should be of interest to economists with a macroeconomic interest and policymakers at the national level. However, for communicating this GPI data on a more personal level, and on a level that may communicate better with the general public, it may be helpful to express these GPI accounts on a per capita basis. This should enable individuals to gain an appreciation of the relative magnitude of external costs and benefits, in comparison with the average level of personal consumption per year, and relative to other items that they may purchase – refer to Table 2.4. Perhaps to make the data even more relevant to individuals, expressing the data in terms of dollars per person per week, may even have greater relevance.

Table 2.4 Calculation of the 'Per Capita' Genuine Progress Indicator, New Zealand, 2016

	Genuine Progress Indicator Component	Costs	Benefits	Defensive Expenditures
		$\$_{2014}$ per person	$\$_{2014}$ per person	$\$_{2014}$ per person
1	Personal Consumption		33,356	
2	Changes in Income Distribution	7,652		
3	Consumption of Public Services[a]		9,509	
4	Unemployment	566		
5	Under-employment	245		
6	Over-employment (Overwork)	1,184		
7	Services of Public Capital		4,908	
8	Household and Community Work		9,705	
9	Private Defensive Expenditure on Health			114
10	Commuting	1,516		
11	Crime	781		
12	Deforestation of Indigenous Forests	37		
13	Biological Pests	207		
14	Loss of Wetland Ecosystem Services	322		
15	Loss of Soil Ecosystem Services	750		
16	Loss of Air Quality	1,086		
17	Solid Wastes and Contaminants	102		
18	Greenhouse Gas Emissions	632		
19	Loss of Water Quality	511		
20	Ozone Depletion	69		
21	Noise Pollution	179		
	Total Costs (TC)	15,838		
	Total Benefits (TB)		57,478	
	Defensive Expenditure (DE)			114
	GPI per Capita= Net Benefit (TB-TC-DE)		**41,526**	

Notes:
a. Defensive Expenditures subtracted from this benefit prior to table entry

3. Personal Consumption of Goods and Services

Why Include

Fundamental to concepts such as well-being, economic prosperity and the standard of living, is the ability of individuals in a society to access those goods and services that improve their quality of life.[25] For example, a society where the majority of people have the ability to access the internet and the wealth of information it contains is likely to be better-off than a society where the majority cannot afford such a service. Personal consumption expenditure is therefore used as the starting point for calculating the New Zealand Genuine Progress Indicator based on the premise that, other aspects of life notwithstanding, a higher level of expenditure indicates a higher level of well-being.

A key feature of the GPI is that it also balances personal consumption against several negative aspects associated with such consumption that are not captured in standard national accounts, particularly costs needed to offset unwanted damage (often termed externalities) to social structures and the environment. In the New Zealand GPI subtractions are made, for example, to account for loss of time spent commuting, noise, air and water pollution and the loss of wetlands and native forests.

Data Used

The source of the personal expenditure data used in the calculation of the 'Personal Consumption' component is the annualised time-series of Private Final Consumption Expenditure obtained from Statistics New Zealand (SNZ) via the INFOS database. Four data series (SNA, SNB, SNC and SNE)[26] covering three discrete time periods were extracted from the database[27]. These series include all household outlays on consumer goods and services along with expenditure on non-capital items by private non-profit organizations serving households – e.g. private schools, religious bodies and cultural and recreational groups.

How to Include

The four raw data series (SNA, SNB, SNC and SNE) were aggregated into one final series using a rebasing method[28] and then the Consumer Price Index (CPI) was applied to deflate this series to constant New Zealand 2014 dollars.

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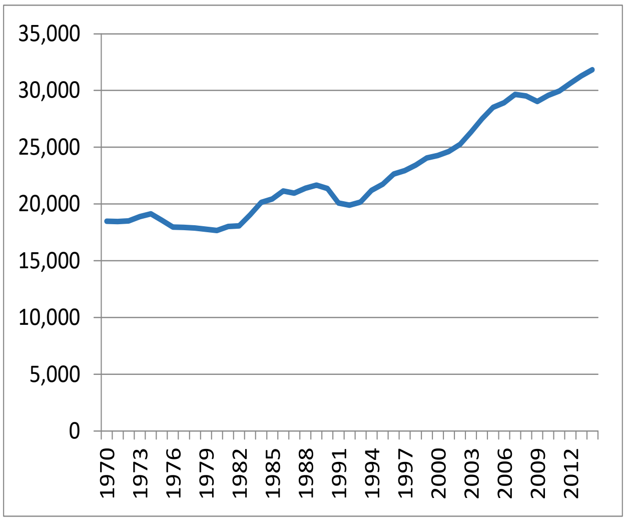
[25] However, as noted by Anielski and Rowe (1999) and many others, there may be a level (or threshold) of 'enough' beyond which individuals derive no or very little further satisfaction from increased material consumption. Refer to the 'Threshold Hypothesis' in the Glossary.

[26] These time series are based on different valuation techniques applied by SNZ in creating New Zealand's National Accounts. The SNA and SNB series are compiled in accordance with the United Nations System of National Accounts 1968 (UNSNA68). The SNB series differs from the SNA series in that it contains adjustments that remove the effect of changing stock valuations. The SNC series is compiled in accordance with the United Nations System of National Accounts 1993 (UNSNA93) and uses a narrower definition of final household consumption expenditure (Statistics New Zealand, 2000a). Similarly, the SNE series is compiled in accordance with the United Nations System of National Accounts 2008 (UNSNA08) and addresses issues brought about by changes in the economic environment, advances in methodological research and needs of users.

[27] Quarterly data from the SNB, SNC and SNE were summed so as to provide annual December-year data for the period 1983-2014. For the period 1970 to 1982, annual March-year data from the SNA series was inflated to December-year values based on the CPI. All three series were then combined using the rebasing method.

[28] At the time of writing the authors are aware that it is SNZ's intention to provide an updated SNE series that may well eliminate the need for application of the rebasing method. This updated series may also alleviate methodological differences between the SNA, SNB, SNC and SNE series

Findings



Highlights

- Personal consumption is the highest contributor to the NZ Genuine Progress Indciator.
- Personal consumption per capita of everyday goods and services has grown 72% since 1970.
- 33 years out of 44 saw an increase in personal consumption per person.
- 'Temporary' decreases in personal consumption per person occurred in the mid to late 1970s, and as result of the 1987 stock market crash and 2008 global financial crisis.

Figure 3.1 Per Capita Personal Consumption 1970-2014, $\$_{2014}$ per person

New Zealanders consumption of goods and services over the 45 year period of this analysis increased by 72.14% on a per capita basis (refer to Table 3.1). This means the average New Zealander purchased everyday consumer goods such as food, whiteware and clothing at a much higher level, and if this trend continues it won't be long until it will be double the 1970 level. The average[29] annual rate of increase in consumption of consumer goods and services however was relatively slow at 1.21% per annum financial crisis.

Most of this growth in personal consumption has occurred from 1993 onwards as can be seen from Figure 3.1. – that is, 60 % of the 72% of the per capita personal consumption was from 1993 to 2014, with only 12.27% occurring from 1970 to 1992. The 1970s were a difficult time for the New Zealand economy with high inflation, low GDP growth and worsening unemployment, in the face of new export challenges such as United Kingdom entering the EEC and to 'oil crises' in 1973 and 1979. This economic situation was reflected in the decrease personal consumption from $\$_{2014}$ 18,486 per capita in 1970 to a low of $\$_{2014}$ 17,681 in 1980. This was followed by a period of strong increase in personal consumption per capita from 1981 to 1989, as deregulation and liberalisaton of the economy took place resulting in many consumer goods becoming more accessible more easily affordable.

From 1992 through to 2007 the economy was buoyant period and this was reflected in consumption per capita increasing every year for 15 years. This was a period of stable management of the economy, low inflation and steady economic growth following the tumultuous years of 1970s and 1980s. However, with the 2008 global financial crisis there was a relatively sharp dip in personal consumption per capita for the two-year period 2008 and 2009. No doubt consumers were affected directly as 67 Finance companies collapsed in New Zealand, and there was a general downturn in the economy. This recession was relatively shallow compared with most other OECD countries, and by 2010 personal consumption per capita resumed its strong upward trend, during a prosperous period with strong commodity prices and growing export markets.

[29] In this publication, the 'average' growth rate, across multiple years, is calculated on a compounding annual basis.

Table 3.1 Personal Consumption: Total and Per Capita, 1970 to 2014

Year	Personal Consumption $_{2014}$ million	Personal Consumption $_{2014}$ per person	Year	Personal Consumption $_{2014}$ million	Personal Consumption $_{2014}$ per person
1970	52,122	18,486	1993	72,130	20,184
1971	52,837	18,447	1994	76,808	21,208
1972	53,956	18,506	1995	79,968	21,755
1973	56,281	18,905	1996	84,504	22,632
1974	58,174	19,125	1997	86,753	22,935
1975	57,555	18,566	1998	89,433	23,438
1976	56,267	17,966	1999	92,372	24,072
1977	56,392	17,944	2000	93,719	24,278
1978	56,228	17,887	2001	95,691	24,620
1979	55,758	17,770	2002	99,746	25,245
1980	55,589	17,681	2003	106,069	26,335
1981	56,930	18,035	2004	112,493	27,513
1982	57,522	18,084	2005	117,959	28,520
1983	61,372	19,049	2006	121,021	28,916
1984	65,508	20,139	2007	125,393	29,670
1985	66,906	20,451	2008	125,845	29,527
1986	69,296	21,146	2009	125,002	29,037
1987	69,249	20,962	2010	128,779	29,584
1988	70,966	21,395	2011	131,459	29,970
1989	72,113	21,654	2012	135,168	30,645
1990	71,885	21,378	2013	139,103	31,282
1991	70,230	20,090	2014	143,607	31,820
1992	70,322	19,904			

Update to 2016

Year	Personal Consumption $_{2014}$ million	Personal Consumption $_{2014}$ per person
2014	143,607	31,820
2015	149,237	32,448
2016	156,655	33,356

- Both in 2015 and 2016 there was continued strong growth in personal consumption of goods and services.
- On a per capita basis, personal consumption increased from $_{2014}$ 31,820 per person in 2014 to $_{2014}$ 33,356 in 2016. This represented 3.92% increase in the year 2015, and 4.97% increase in the year 2016.
- This growth in personal consumption in 2015 and 2016 is the continuation of trend since 1992 that has seen consistent increases in every year except those affected by the 2008 global financial crisis.

4. Income Distribution and Inequality

Why Include

Whilst the well-being of a society can in part be expressed by measuring the personal consumption expenditure of all the individuals in that society, the resulting measure does not take into account the diminishing marginal utility of that consumption, i.e. the benefit received from an extra dollar of consumption is likely to be more for a poor family than for an affluent family. It is therefore necessary to consider how income, and thus spending power, is distributed throughout the society.

It is inevitable that the income of individuals will differ depending on the value placed on their work and the common consensus of the importance of this in society. If, however, most of the income and spending power of the nation is in the hands of only a small percentage of the total population, the well-being of the majority is likely to be lower than the distribution had been more broadly based and equitable. This reflects that as income distributions widen, there is a tendency for the poor to become poorer as they are less able to maintain their living standards in the face of rising costs (Kerr et al., 2004). There is also an additional 'dis-utility' as the poorer people in society become not only relatively worse off financially, but they feel disadvantaged in terms of their social standing (Brekke and Howarth, 2002; Kerr et al., 2004).

In this study it is implicitly assumed that the more equally incomes are distributed the better.[30] The purpose of this Component of the GPI is therefore to weight the Personal Consumption component in order to account for differences in income distribution over time.

What to Include

There are a number of methods identified for adjusting personal consumption expenditure to account for income inequality. The two methods commonly used are Gini Coefficients[31] and the Atkinson Index[32]. In this study, Gini Coefficients have been applied in line with other studies that have been undertaken for the New Zealand context (Easton, 1996; Statistics New Zealand, 1999b).

Gini coefficients are typically determined by taking the difference between a straight line equal to complete income equality and a Lorenz Curve (Figure 4.1), which describes the distribution of income among deciles of the population (Kerr *et al*., 2004). The Gini coefficient represents the ratio between the yellow area highlighted in Figure 4.1 to the entire area under the perfect distribution line. The coefficient ranges between 0 and 1, where a coefficient of 0 means all income is equally spread and a coefficient of 1 means all income is held by a single decile.

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[30] This assumption is not without contention. Refer to O'Dea (2000), Dodds and Colman (2001), Neumayer (2003), Lawn (2004), McConnell and Brue (2004) and Talberth *et al.* (2006) for further information on income inequality and its measurement.

[31] The Gini coefficient was, for example, applied by Anielski and Rowe (1991) in the calculation of the United States GPI. Gini coefficients, G, are calculated using the formula shown below, where n is the number of income groups (ten deciles), i is the rank value in ascending order (1 to 10), and X_i is the average annual income in each income interval (Buchan, 2002),

$$G = \frac{\sum_{i=1}^{n}(2i-n-1)X_i}{n\sum_{i=1}^{n}X_i}$$

[32] The Atkinson Index was applied by Hamilton and Denniss (2000) in the calculation of the GPI for Australia. Whilst the Atkinson Index is similar to the Gini coefficient in that it seeks to capture differences in income distribution between different income groups, in the Atkinson Index the importance placed on inequality may vary – for example, in two societies with the same degree of inequality, one society may regard this as a significant impediment to well-being, while the other may not (Hamilton and Denniss, 2000; Neumayer, 2003). A severe paucity of data prohibited the use of the Atkinson Index in this study.

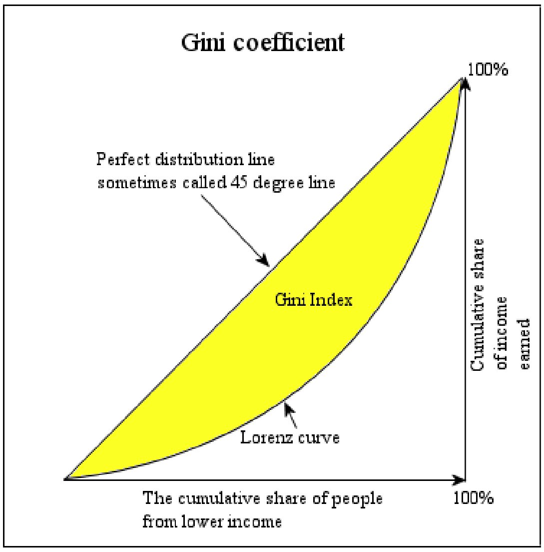


Figure 4.1 Lorenz Curve and the Gini Coefficient

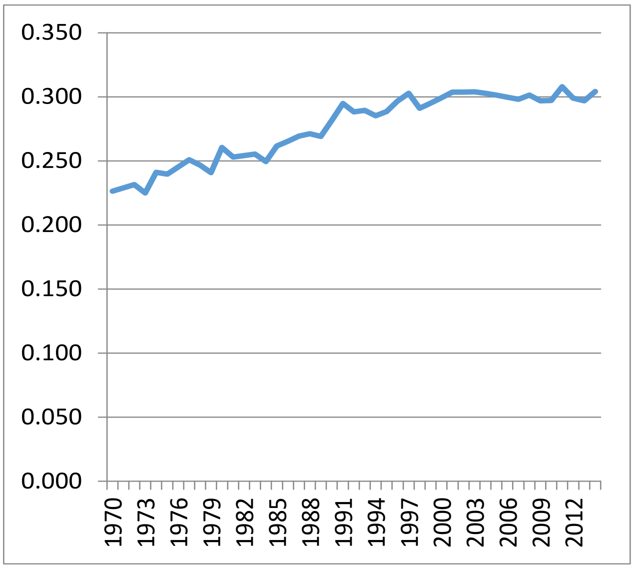
Mazin (2006), in a paper on the correlation between the Gini index and observed prosperity (as measured using purchasing power parity), found that a healthy and dynamic economy typically exhibits a Gini coefficient of between 0.22 and 0.36.

How to Include

Gini coefficients were calculated for most years in the study period based on income distributions sourced from SNZ (Statistics New Zealand, 1999b, and various downloads from Statistics NZ website). For the years 1970 to 1972 and 2005 to 2006, Gini coefficients were estimated using a linear regression trend. For the remaining years (between 1973 and 2014) where there were gaps in the income distribution data from Statistics New Zealand, geometric growth rates were used to estimate the Gini coefficients.

The Gini Coefficient, by itself, is not directly included in the Genuine Progress Indicator. However, it is used to 'weight' the Personal Consumption (from Chapter 3), to take account of the negative impacts on wellbeing of income inequality.

Findings



Highlights

- The Gini Coefficent is used to measure income inequality.
- Labour market reform, tax changes, welfare cuts and a less regulated economy have all contributed to this increasing inequality, from 1984 to 1991 – though there is evidence of such a trend beginning in the early 1970s.
- Income inequality has remained about the same for the 14 years since 2001. This is on the back of a consistent upward trend in income inequality from 1970 to 2000.
- New Zealand's income inequality in 2014, is ranked 13th worse in the OECD out of 35 countries.

Figure 4.2 Gini Coefficient for New Zealand, 1970-2014

Figure 4.2 shows that income inequality increased over the 1970s from a Gini coefficient of 0.226 in 1970 to 0.260 in 1980, which represented an increase of 15.02%. Even though income inequality was on the rise during the 1970s, New Zealand's level of income inequality as indicated by the Gini coefficient was one of the lowest in the OECD.

From 1980 to 1984, income inequality improved slightly, with the Gini coefficient decreasing. However, with the economic reforms of the Labour Party government from 1984 onwards, income inequality increased markedly. This trend was continued under the National Party government in the early 1990s. Over this period the income tax scale was flattened and GST introduced which arguably disproportionately negatively affected those on lower incomes. Labour market reforms led to a labour market with fewer restraints, resulting in a wider gap between high income earners and lower income earners. Furthermore, the introduction of 'user pays' disproportionately affected those on lower incomes, as did cuts to state welfare payments in the early 1990s. All of these factors combined meant that inequality in New Zealand increased over this 1984 to 1991 period, with specifically, the Gini coefficient (which measures income inequality) dramatically increasing by 18.17% from 1984 to 1991.

With the slowing down of the pace of economic reform through the 1990s, the rate of income inequality started to flatten off, with an increase of only 1.53% from 1991 to 2000, as measured by the Gini coefficient. Then, from 2001 to 2014, income inequality under both the Labour Party led government (1999 to 2008) and National Party led government (2008 to 2014), virtually remained unchanged, with only a minuscule increase (0.14%) in the Gini coefficient over that period.

By 2014, New Zealand had slightly above the OECD average income inequality as measured by the Gini coefficient (Statistics New Zealand, 2018). However, despite New Zealand's significant increase since 1970 (particularly during the mid to late 1980s), there is significantly more income inequality in the United States and the United Kingdom (Hilleband, 2009; OECD 2012). Furthermore, unlike some other countries that have relatively high income inequality (United Kingdom, India, China, United States), New Zealand's income inequality has remained virtually the same for the last 15 years, whereas for these other countries, income inequality is still increasing (OECD, 2012).

5. Weighted Personal Consumption

Why Include

'Weighted personal consumption' is important in GPI calculations as it combines: (1) the effect of improved welfare from increased consumption of goods and services; with (2) the negative impact on welfare of increasing income inequality. Both these effects on welfare are very significant factors in the GPI calculation, outweighing most other components in terms of their magnitude. Personal consumption is of fundamental importance because it provides for many of the basic needs of humans from food, clothing, shelter, to increasingly non-material services such as entertainment and education. These positive effects on welfare and well-being can, however, be thwarted by the uneven nature of this increasing personal consumption which in this study is measured by the 'Income Distribution Index' – although the opposite effect is also possible, when more income equality has a positive effect on welfare.

What and How Included

An 'Income Distribution Index' was then derived from the calculated Gini coefficients time series data (1970 to 2014) outlined in chapter 4. The ratio of each year's Gini coefficient to the base year Gini coefficient was calculated and the base year Gini coefficient indexed to 100. To determine the index of distribution in 2004, for example, we multiplied the Gini coefficient in 2004 (0.4043) by 100 and then divided by the 1969 base year Gini coefficient, 0.2979. The resulting number, 136, represents the Income Distribution Index value for 2004.

Total Personal Consumption (Chapter 3) for each year was adjusted by its corresponding 'Income Distribution Index' to give a Weighted Personal Consumption. This was performed by dividing Personal Consumption by the Income Distribution Index, and then multiplying by 100 as follows,

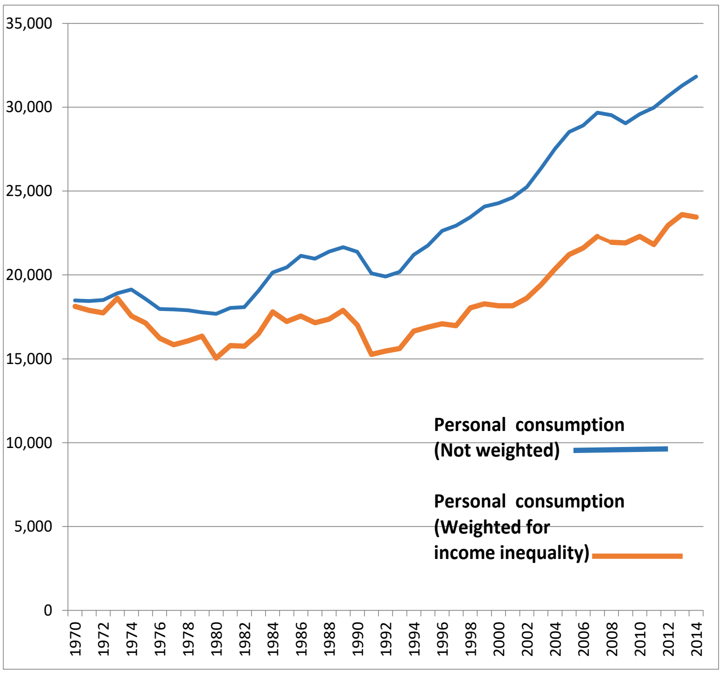
$$WPC = \frac{PC}{DI} \times 100$$

Where: *WPC* is the weighted personal consumption, *PC* is the Personal Consumption and *DI* is the Distribution Index.

Findings

Figure 5.1 contrasts, on a per capita basis: (1) Personal Consumption with no adjustments; (2) Personal Consumption adjusted downwards for adverse income inequality effects. The widening gap between these two measures shows the increasing effect from 1970 to 2014 of income equality impacting on the real value of personal consumption. It should be noted that if income inequality had remained the unchanged, then there would be no divergences between the two lines on Figure 5.1.

Although it is often assumed that income inequality had a dramatic effect on welfare during the economic reforms of the Labour government from 1984 to 1989, this was not the case in terms 'per capita weighted personal consumption'. In fact, the most significant and sustained drop in per capita weighted consumption was from 1973 to 1980 when 'per capita weighted consumption' dropped by 19.19% – mainly due to increasing income inequality rather than to a decline in per capita consumption which was relatively minor over this period. From 1980 to 1984, (which was mostly under National Party government) 'per capita weighted consumption' however rebounded strongly to increase by 18.39%.



Highlights

- The effect of welfare increasing with higher levels of Personal Consumption of goods and services, was blunted by deteriorating income inequality.
- This was shown by 'per capita personal consumption' increasing by 72.1% from 1970 to 2014 – but when this 'weighted' for income inequality this was only a 29.4% increase.
- New Zealand went backwards in terms of 'weighted per capita personal consumption' from 1973 onwards – and it took 29 years, until 2002 to climb back to the same level as 1973.

Figure 5.1 Per Capita Personal Consumption: Weighted versus Unweighted, 1970-2014, $\$_{2014}$ per person

From 1985 to late 1989 when the economic reforms of the Fourth Labour government were in full swing, 'per capita personal consumption' grew relatively well at 5.88%, but the welfare effect of this was blunted by increased income inequality which resulted in 'per capita weighted personal consumption' only increasing by 3.86% over this period.

The most dramatic fall in 'per capita weighted consumption' was in fact during 1990 and 1991 when it dropped 14.70% in the space of two years. Negative GDP growth was an underlying factor behind this decline in 'per capita personal consumption'. Notably also, the Employment Contracts Act was enacted in 1991 which would have a long-lasting impact on driving down 'per capita weighted personal consumption' by the dual effect of: (1) decreasing the overall level of 'per capita personal consumption' due to a decline in real wage and salary levels – that is, wages and salary earners had less income to spend on Personal Consumption; and (2) increasing income inequality as less constraints in the labour market, bought about by the Act, meant freer upwards and downwards movement in levels of remuneration.

Over the 22 years from 1992 to 2014, there was a steady upward trend in 'per capita weighted personal consumption' increasing by 53.59%, which is a compounded average rate of 1.88% per annum. This improving trend could arguably be at least partly attributed to both National Party led and Labour Party led governments moving away from the more extreme policies of the 1970s and 1980s, adopting more moderate approaches to economic policy, and in some cases 'un-doing' or 'reversing' some of those policies that had an adverse effect on income equality. Only a few years over this 1992 to 2014 period recorded declines in 'per capita weighted personal consumption' – most notably, 2008 and 2009 principally due to the impact the global financial crisis.

A final point of interest is that in 1973 'per capita weighted consumption', was $18,610, which is a level that would not be reached be again until 29 years later in 2002. This single fact arguably serves to highlight how poor the performance was of the New Zealand economy 1970s and 1980s in terms of 'per capita weighted personal consumption', and how long it took to make up lost ground.

Table 5.1 Weighted Personal Consumption: Total and Per Capita, 1970 to 2014

Year	Weighted Personal Consumption		Year	Weighted Personal Consumption	
	$\$_{2014}$ million	$\$_{2014}$ per person		$\$_{2014}$ million	$\$_{2014}$ per person
1970	51,096	18,122	1993	55,811	15,618
1971	51,213	17,880	1994	60,300	16,650
1972	51,703	17,733	1995	62,086	16,891
1973	55,403	18,610	1996	63,783	17,082
1974	53,375	17,547	1997	64,185	16,969
1975	53,137	17,141	1998	68,836	18,040
1976	50,802	16,221	1999	70,100	18,268
1977	49,781	15,841	2000	70,124	18,166
1978	50,503	16,066	2001	70,593	18,163
1979	51,287	16,345	2002	73,559	18,617
1980	47,283	15,039	2003	78,194	19,414
1981	49,829	15,785	2004	83,199	20,349
1982	50,118	15,756	2005	87,702	21,205
1983	53,110	16,485	2006	90,455	21,612
1984	57,918	17,805	2007	94,218	22,294
1985	56,357	17,227	2008	93,532	21,945
1986	57,507	17,549	2009	94,320	21,910
1987	56,643	17,146	2010	97,050	22,295
1988	57,605	17,367	2011	95,643	21,805
1989	59,586	17,892	2012	101,234	22,952
1990	57,197	17,010	2013	104,931	23,598
1991	53,353	15,262	2014	105,791	23,441
1992	54,650	15,468			

Table 5.1 shows that 'weighted personal consumption' as an aggregate increased from $\$_{2014}$ 51.1 billion in 1970 to $\$_{2014}$ 105.8 billion in 2014. This represented slightly more than a doubling of New Zealand's 'weighted personal consumption' from 1970 to 2014. More detailed analysis however shows that 77.3% of this doubling is purely due to population increase, with per capita increase in personal consumption only increasing by 22.7% over this 45 year period.

Update to 2016

Year	Weighted Personal Consumption	
	$\$_{2014}$ million	$\$_{2014}$ per person
2014	105,791	23,441
2015	113,970	24,780
2016	120,721	25,704

- The Gini coefficient improved during 2015 and 2016, indicating more equitable income distribution. This meant that the 'weighted' (for income inequality) personal consumption increased even more than would otherwise be the case.
- This has resulted in very strong growth in 'weighted' personal consumption in 2015 and 2016 of 5.71% and 3.73% respectively on a per capita basis.

6. Consumption of Public Services

Why Include

New Zealanders are provided public services by central and local government – 'public' in the sense that they are provided by government to citizens predominantly 'free of charge' funded through the taxation and other revenue sources available to government. The three largest areas of such 'public' services' provided by central government are: Social Security and Welfare ($29 billion in 2015/16), Health ($15 billion) and Education ($14 billion) as reported by The Treasury (2016). Other areas of 'consumption of public services' include: policing and criminal justice, environmental protection and conservation, defence, social housing, cultural and heritage services and core government services over a wide variety of activities. These services provided by government (even with the corporatisation and privatisation of many government services that started in the mid-1980s), play fundamental roles in supporting the material well-being of many New Zealanders, ensuring social cohesion and necessary levels of education and health of New Zealanders as well as promoting cultural and other values that are all required in maintaining a functioning civilised and progressive society.

What to Include

Care needs to be taken in the 'accountancy principles' that underpin the quantification of 'consumption of public services'. In this regard, the main issue at hand, that a significant proportion of the services provided by government, are considered to be 'defensive expenditures'– that is, expenditures that should not be counted in the GPI because they involve dealing with the 'unwanted' or 'undesirable side' effects of economic activity. As can be seen from Table 6.1, a significant proportion government expenditure, across a range of categories, involves 'defensive expenditures'.

A defensive expenditure is formally defined by Leipert (1989, p.28) as "expenditure … made to eliminate, mitigate, neutralise, or anticipate and avoid damages and deterioration that industrial society's process of growth has caused to living, working and environmental conditions." The argument has been made that it would be preferable to avoid the side-effects of economic growth, such as ill-health caused by environmental pollution, by avoiding producing them in the first place, and therefore all 'defensive expenditures' in the fundamental sense are undesirable government expenditure categories, and therefore should not be counted in the Genuine Progress Indicator.

All that said, there is some controversy over the treatment of defensive expenditures in the GPI calculation. A number of commentators (Maler, 1991; Hamilton, 1994, 1996; Neumayer, 2000) have critiqued this practice, with one of the difficulties identified being that it is impossible to draw the line between what does and does not properly constitute defensive expenditure. Neumayer (2000, pp. 7-8), for example, states "if health expenditures are defensive expenditures against illness, why should food and drinking expenditure not count as defensive expenditures against hunger and thirst?". While it might be, for example, that health expenditures for pollution-related illnesses are clearly defensive expenditures, and the majority of food and drink related expenditures are not, there are certainly situations where the distinction between defensive and non-defensive is difficult to define. Ultimately however the construction of the GPI accounts calls for some assessment on 'what does' and 'what does not ' count as defensive expenditure – an assessment that has proved to be a difficult research challenge internationally in the construction of national GPIs (Lawn and Clarke, 2008).[33]

[33] In the New Zealand GPI calculations, in Chapter 11, the 'defensive expenditures' associated with 'private' health expenditure are also subtracted from the GPI index; in the same way that 'defensive expenditures' associated with 'public' health expenditure are subtracted in this Chapter.

Care also needs to be taken in ensuring that 'services from public capital' are not included in the 'consumption of public services' category covered in this chapter – that is, for example, 'services' provided by public transport infrastructure such as roads, or 'services' provided by recreational infrastructure such as public parks. It is not always straightforward to distinguish services derived from 'public capital stock' and the services provided by other 'flow' inputs such as labour, but they need to be kept as separate entries in the accounting framework as 'flows', 'stocks' and 'flows from stock' are fundamentally different and therefore they require fundamentally different accountancy approaches.

Data Used

Consumption of public services is measured by Statistics New Zealand as general government expenditure, including health and education[34]. Similar to the Personal Consumption (Chapter 3) time series, three data series (SNA, SNB, SNC and SNE) were extracted from INFOS and aggregated into one single series by applying the Rebasing Method. In turn, the rebased series was deflated to 2014 dollars by application of the General Government Consumption Implicit Price Deflator (IPD).

In order to differentiate between the defensive and non-defensive proportions of public consumption expenditure, total public expenditure was categorised into seven categories according to spending purpose: services to land transport, public administration, sanitary and similar services, education services, health services, social and community services, and recreation and cultural services.

How to Include

For the years *1970 to 2000,* data pertaining to the 7 categories were extracted from the Inter-Industry Study of the New Zealand Economy for the following years: 1971-72, 1976-77, 1981-82, 1986-87 and 1995-96 (Statistics NZ 1980, 1983, 1989, 1991b, 2001b). The ratios of expenditure in each category to total expenditure during each of the **five** given years were then used to estimate the expenditure during other years. For this purpose, **five** time periods were identified: 1970-1976, 1977-1981, 1982-1985, 1986-1995 and 1996-2000. It was then assumed that general government consumption patterns remained the same within each time period. The ratios calculated for 1971-72 were therefore applied to the period 1970-1976, while the ratios calculated for 1976-77 were applied to the period 1977-1981, and so on. Once public consumption expenditure by the 7 categories had been determined, the next step was to estimate the 'defensive proportion' of each category's expenditure. These estimations were based on the underlying spending purposes for each category, and the extent to which they represent an addition to the national wellbeing. It is also assumed that the non-defensive percentage remains the same over the entire study period (refer to Table 6.1).

For years *2001 to 2014*, similar calculations were undertaken using data extracted from input output tables of the New Zealand economy for 2006-07 and 2012-13 (Statistics New Zealand, 2016).

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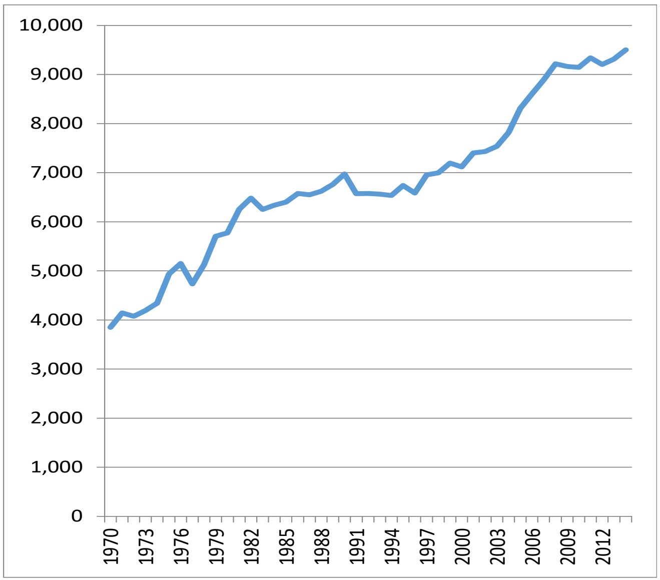
[34] The measurement of consumption of public services, or the contribution of the public service to the economy is a problematic area of national accounting. The approach to this issue in national accounting, as pointed out by Coyle (2014), is to measure the inputs (mainly labour) into the public service, and to assume that this is a good proxy for the value of the output of the public service. Such an approach is required, as there is no way of measuring the value of the output as consumers don't directly purchase the consumption of public service outputs, as is the case in private/personal consumption where the price of the purchased goods is a measurement of their economic value.

Table 6.1 Proportion of Non-Defensive Public Expenditure

Expenditure Category	Description	Non-Defensive Proportion
Services to Land Transport	This expenditure is assumed to be 100 percent non-defensive, since it is undertaken to provide baseline living standards. For example, expenditure by local authorities on maintenance of roads preserves existing levels of service provided to residents.	100%
Public Adminis-tration	Expenditure on public administration comprises the administration, civil order and defence functions of central government, and the administrative functions of local government including civil defence, fire-fighting, traffic control and health inspection. This category is the major component of government consumption expenditure, averaging 35 percent over the study period. Overall, it has been assumed that 95 percent of expenditure on public administration is for non-defensive purposes.	95%
Sanitary & Similar Services	Sanitary and similar services comprise refuse collection, sewage disposal, and drainage by local authorities. In addition, there are a number of privately-owned enterprises sub-contracted to undertake such services for the public benefit. This expenditure is regarded as 100 percent defensive as it is undertaken to provide a sanitary living environment in the face of refuse and other residuals produced by economic processes.	0%
Education Services	Education services include all establishments engaged in teaching or providing education, whether operated by central government, private-non-profit organisations serving households, or commercial undertakings. It is assumed that 100 percent of public expenditure on education is non-defensive.	100%
Health Services	Expenditure on health services included the provision of medical, dental and nursing services, and a variety of para-medical and ancillary services. It is assumed that 90 percent of public expenditure on health is non-defensive.	90%
Social & Community Services NEC	Expenditure on social and related community services comprises payments made to scientific research institutes and businesses, professional and labour associations, and other establishments engaged primarily in providing community services. Non-market organisations (such as Work and Income New Zealand) providing a variety of welfare services to the community are also included here. It is assumed that 90 percent of public expenditure on social and community services is non-defensive.	90%
Recreation & Cultural Services	Expenditure on recreation and cultural services is the spending on establishments engaged primarily in preparing and presenting entertainment services, cultural services and amusement and recreational services. It is regarded as entirely consumptive and non-defensive, and is therefore fully included in the GPI. This approach was used in the calculation of the Australian GPI.	100%

Findings



Highlights

- Public Services such as health and education provided by government, make a strong contribution to welfare, amounting to $9,500 per person in 2014.
- With the withdrawal and decline of some public services during the economic reforms there was very little growth in public services from 1984 to 1992, on a per capita basis.
- In 2014, the 'Consumption of Public Services' was 29.8% of privately purchased goods and services (Personal Consumption).

Figure 6.1 Per Capita, Consumption of Public Services, 1970-2014, $\$_{2014}$ per person

From 1970 to 1983, there was a strong growth in the 'consumption of public services' [35], as State provision of services played a key, and arguably increasing, role in enhancing welfare and well-being. Over this period, these government services increased from $\$_{2014}$ 3,848 to $\$_{2014}$ 6,482 per person, which represents an increase of 68.5%.

With the Labour Party elected to power in 1984, it heralded a change in direction in the role of the state in provisioning basic services in health, education, welfare and social housing amongst other services – over the period from 1984 through to 1988, the strong growth in government services which had previously been evident in the 1970s and early 1980s, very much slowed down and only increased by 10.4% over this 15 year period (refer to Table 6.2). It is, however, important to note that, perhaps contrary to some other evidence[36], in general terms, there was *no decrease* in the per capita (or total) expenditure in government services over these years, despite both Labour and National Party Governments adopting policies, such as privatisation of state assets and services, and 'user pays' for some government services.

This long period of slow growth in aggregate levels of public services, which lagged behind the growth in 'private consumption', came to an end with the coming to power of the Helen Clark led Labour government in 1999 which saw a reversal of this trend with the strong growth of the Public Service and services provided by the State. From 1999 to 2008, consumption of public services rose on a per capita basis by 23.6% – with particularly strong growth from 2004 to 2008 which saw the 'consumption of public services' per capita rising at the fastest rate of the 45 year period covered by this GPI analysis. This represented a growth from 2004 to 2008 in the economic value per capita on public services at a compounded rate of 3.23% per year.

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[35] For brevity sake, in this Chapter, we refer to "consumption of public services", rather than "consumption of public services (non-defensive)". Readers should therefore take "consumption of public services" to mean "consumption public services (non-defensive)" in this Chapter.

[36] For example, Kelsey (1993) provides a strong impression that from 1984 through to 1991, there was a "privatisation of power" leading to the significantly diminished role of the State in providing services such as in health, education, housing, superannuation and welfare – dramatically describing this whole process as a "blitzkrieg".

Table 6.2 Consumption of Public Services: Total and Per Capita, 1970 to 2014

Year	Consumption of Public Services $_{2014}$ million	$_{2014}$ per person	Year	Consumption of Public Services $_{2014}$ million	$_{2014}$ per person
1970	10,849	3,848	1993	23,454	6,563
1971	11,860	4,141	1994	23,665	6,535
1972	11,878	4,074	1995	24,762	6,737
1973	12,475	4,190	1996	24,594	6,587
1974	13,203	4,341	1997	26,301	6,953
1975	15,312	4,939	1998	26,697	6,996
1976	16,126	5,149	1999	27,601	7,193
1977	14,874	4,733	2000	27,472	7,117
1978	16,112	5,126	2001	28,762	7,400
1979	17,905	5,706	2002	29,350	7,428
1980	18,143	5,771	2003	30,358	7,537
1981	19,749	6,256	2004	31,958	7,816
1982	20,618	6,482	2005	34,362	8,308
1983	20,145	6,253	2006	36,006	8,603
1984	20,612	6,337	2007	37,562	8,888
1985	20,935	6,399	2008	39,276	9,215
1986	21,553	6,577	2009	39,445	9,163
1987	21,640	6,550	2010	39,808	9,145
1988	21,959	6,620	2011	40,953	9,337
1989	22,508	6,759	2012	40,586	9,202
1990	23,444	6,972	2013	41,397	9,310
1991	22,968	6,570	2014	42,876	9,500
1992	23,231	6,576			

Note: Non-defensive expenditures have been excluded.

This growth in government provided services and the Public Service abruptly came to an end with the election of the National government on the back of the 2008-2009 global financial crisis, with decreases (on a per capita basis) in expenditure in these services in 2009 and 2010. Over the period from 2008 to 2014 when the National government remained in power, there was close examination of government expenditure in public services such as welfare support and general budgetary restraints across the entire public service.

Over the whole 45 years of this GPI calculation (1970 to2014) the consumption of public services increased from $3,848 per capita to $9,500 per capita (146.9% increase), This contrasts with the growth in private consumption over the same period, increasing from $15,125 per capita to $26,036 per capita (72.1%). So, in absolute terms ‘private consumption’ increased more; but on a percentage basis, ‘consumption of public services’ actually increased at a higher rate, which may contradict the commonly held impression that the provision of public services in New Zealand has declined over the last three or four decades.

Overall, Table 6.2 shows that ‘public consumption’of government services increased from $10.8 million in 1970, to $42.9 million in 2014 , which is over a threefold increase (295.2%) Only about one-fifth of this increase can be expained by population growth.

Update 2016

Year	Public Consumption	
	$\$_{2014}$ million	$\$_{2014}$ per person
2014	42,811	9,486
2015	43,862	9,537
2016	44,659	9,509

- There was only a very slight increase overall in the expenditure on public services over the 2014 to 2016 period – and this lagged considerably behind the very strong growth of goods and services provided by the private sector as measured by 'Personal Consumption'. That is, consumption of public services increased by only 0.53% in 2015, and declined by 0.29% in 2016.

7. Cost of Unemployment

Why Include

There are many negative effects on the well-being of individuals and their families, as well as on society as a whole that arise from being unable to find paid employment. A society where there are people who want to work but are unable to do so is one that is not fulfilling its potential well-being and prosperity. Unemployed people have lower than average incomes; the impacts of a drop in income are significantly exacerbated when one moves unexpectedly from paid employment to unemployment. This can for example make it difficult for unemployed people to meet financial obligations such as mortgage payments. High unemployment rates can also lead to increases in crime, due to both financial pressures and the breakdown of social cohesion. Furthermore, there is some evidence that unemployment has lifelong effects on levels of life satisfaction, with on average individuals not completely returning to the former levels of life satisfaction, even after they become re-employed (Lucas *et al*., 2004).[37]

Unemployment and associated poverty-related issues also increase susceptibility to illness, mental stress and loss of self-esteem; increased suicides rates and incidence of depression; all of which lead to poorer mental health and lower levels of psychological well-being (Kee-Ryan *et al*., 2005; O'Brien, 2008). These negative psychological and mental health to a reduction in the well-being of society as a whole, not just those directly affected (Junankar and Kapuscinski 1992; Davidmann 1996). It is these costs that are measured in this component of the GPI. It is difficult to value the psychological effects of unemployment as the causality between unemployment and, say, stress and trauma are not well understood and the data upon which to base such an analysis are not readily available. Consequently, an indirect valuation method has been adopted in this study, based on valuing the involuntary leisure time that unemployment brings.

What to Include

To obtain an accurate measure of the number of people unemployed, and thus potentially suffering a loss of well-being, the unemployed were separated into five categories, as shown in Table 7.1 and discussed further below.

The 'official unemployed' category includes those persons actively seeking and available for work (Statistics New Zealand, 2005). Within this 'official unemployed' category is a sub-group classified as 'frictionally unemployed'. These people tend to be unemployed for a short time, usually as a result of job transition (Mankiw, 1999; Hamilton and Denniss, 2000). For these people, unemployment is unlikely to be the cause of any significant reduction in psychological well-being. The estimated figures of frictional unemployment have therefore been excluded from the calculation of unemployment in this component of the New Zealand GPI. In New Zealand, the 1950s–1970s are regarded as years of full employment[38], although the average unemployment rate during this period was around 1.3 percent. This figure has therefore been taken as the historical norm for the level of frictional unemployment, and applied to most of the years of this GPI study. For the period 1970–1978, however, unemployment

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[37] The far-reaching impacts of unemployment on an economy mean that its measurement straddles a number of factors covered elsewhere in the New Zealand Genuine Progress Indicator: lower levels of personal consumption (covered in Chapter 5) due to the unemployed having less income; expenditures on health (Chapters 5 and 12), costs of crime (Chapter 14) and direct/indirect impacts on government services (Chapter 6). Care was taken not to 'double count' these factors in the calculation of the New Zealand Genuine Progress Indicator.

[38] Full employment occurs when everyone in the labour force is willing to work at the market rate in their chosen occupation, with the exception of those who are switching from one job to another (Bannock, Baxter and Davis, 1992).

dropped even further to around 0.25 percent. For this discrete period, 0.25 percent is applied as the frictional unemployment rate.

The 'hidden unemployed' are those people who are unemployed or underemployed but are not recorded in official unemployment statistics. Hidden unemployment typically consists of three sub-categories: those who have given up looking for a job (i.e. the discouraged), those who are working less than they would like (i.e. the underemployed), and those who work in jobs in which their skills are underutilised (i.e. the underutilised) (Hirsch, Kett and Trefil, 2002). In this study, only the psychological costs of unemployment associated with discouraged workers are assessed. The cost of underemployment are covered in Chapter 8 of this publication, and data restraints prohibit any assessment of the costs resulting from workers being underutilised[39]. `

Table 7.1 Typology of Unemployment Types

Type of Unemployment	Actively Seeking Work	Available for Work	Cannot Find a Job
Official Unemployment	Yes	Yes	Yes
Frictional Unemployment	Yes	Yes	No (waiting to start)
Hidden Unemployment (Discouraged and other)	No	Yes	Yes
Hidden Unemployment (Underemployment)	No/Yes	Yes	Yes
Hidden Unemployment (Underutilised)	No/Yes	Yes	Yes

How to Include

Calculation of the cost of unemployment is undertaken in three steps:

Step 1: Determine the Number of Unemployed. The following data sources and assumptions were used in determining the number of unemployed:

- A times series for the official unemployment count was formulated from two sources: the consolidated Household Labour Force Survey (HLFS) of Official Unemployed numbers was found in Statistics New Zealand's Long Term Data Series (LTDS) Labour Market Table B2.2 and INFOS (HLFA.SAB3AZD). The LTDS provided unemployment counts according to the March year for the period 1970 to 1985, while INFOS provided unemployment counts for the period 1986 to 2014 to the December year. To achieve consistency between the datasets, the LTDS was rebased to the same reporting period as INFOS.
- The official unemployment rate was obtained from the Consolidated HLFS Unemployment Rate (LTDS, Table B2.3) and INFOS (HLFA.SAF3AZD). Both data sources reported unemployment rates according to the December year.
- The total labour force was computed by dividing the official unemployment count by the unemployment rate.
- As discussed above, frictional unemployment was estimated to be 0.25 percent of total X unemployment for the period 1970–1978, and 1.3 percent for the rest of the study period.
- Data pertaining to the hidden unemployment count were obtained from Statistics New Zealand and refer to those people who are available to work, but not actively seeking work; including those

[39] Data presented by the OECD (2017) shows that New Zealand between 2012 and 2015 had the highest percentage (34%) of workers 'overqualified' for their jobs, of any OECD country. That is, 34% of New Zealand's workforce have skills and knowledge which are 'underutilised'.

seeking work through "newspapers only" (INFOS series; HLFA.SXR3TBD)[40], "discouraged workers" (HLFA.SXR3TCD) and "other" (HLFA.SXR3TDD)[41]. These data series are only available for the period 1986 to 2006.. To estimate the missing years, the average hidden unemployment count for each category over the 1986–2006 period was indexed to the total 'unemployment count'[42] and backcast from 1985–1970. It was also assumed that hidden unemployment only imposes a cost if the official unemployment rate exceeds the frictional unemployment rate (i.e. when so-called 'costly unemployment' occurs).

***Step 2: Determine hours of Involuntary Leisure Time*.** For those people seeking full-time work, their hours of involuntary leisure were calculated by taking the unemployment figures generated in Step 1, multiplying by the percentage of unemployed seeking fulltime work, and, in turn, multiplying by 37.5 (the average hours in a full working week). In order to estimate the percentage of unemployed seeking full-time work (as opposed to part time work), the participation rates for full-time work as sourced from the Household Labour Force Surveys (HLFS) from 1986 to 2014 were used as a proxy. For those seeking part-time work, their hours of involuntary leisure were calculated by taking the unemployment figures generated in Step 1, multiplying by the percentage of unemployed seeking part-time work, and, in turn multiplying by 20 (the hours in an average part-time week). Once again in order to estimate the percentage of unemployed seeking part-time work, reference was made to employment participation rates.

***Step 3: Cost of Involuntary Leisure Time*.** The minimum wage rate and unemployment benefits for the period 1986–2014 were taken from SNZ's Official Year Book and SNZ's INFOS system, respectively, and deflated to a constant (inflation-adjusted) value based on the Consumer Price Index (CPI). The cost of an hour of involuntary leisure time is expressed as the difference between the minimum real wage rate and the unemployment benefits received. The average cost per hour of involuntary leisure for that period was then applied as a proxy for the remainder of the study period. The full formula for estimating the total costs of unemployment per annum is as follows:

$$TC = UH \times 52.14 \times C,$$

where: *TC* is the total cost of unemployment, *UH* represents total unemployed hours per week and *C* is the cost ($) per hour. The *52.14* constant approximates the number of weeks per year and is used to convert hours per week to annual estimates. The total unemployed hours per week, *UH* is calculated as:

$$UH = UHF + UHP,$$

where: *UHF is* the unemployed hours per week for people seeking full-time work, and *UHP* is the unemployed hours per week for people seeking part-time work. The *UHF* term is, in turn, derived as:

$$UHF = U \times UF \times 37.5,$$

where: *U* is total unemployment, *UF* is the proportion of unemployed people seeking full-time work and 37.5 represents involuntary leisure hours per week per unemployed person seeking full-time work. Similarly, the *UHP* term is derived as:

$$UHP = U \times UP \times 20,$$

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[40] The category 'looking through newspapers only' is excluded on the grounds that the International Labour Organisation (ILO) does not consider this as actively seeking employment.

[41] This is predominantly people who place themselves on a mail-out list, but take no other actions.

[42] 'Unemployment count' is calculated as official unemployment, less frictional unemployment plus hidden unemployment.

where: U is total unemployment, UP is the proportion of unemployed people seeking part-time work and *20* represents involuntary leisure hours per week per unemployed person seeking part-time work. Total unemployment, U, is defined as:

$$U = CU + HU,$$

where: CU is costly unemployment and HU represents hidden unemployment. In turn, CU is calculated as:

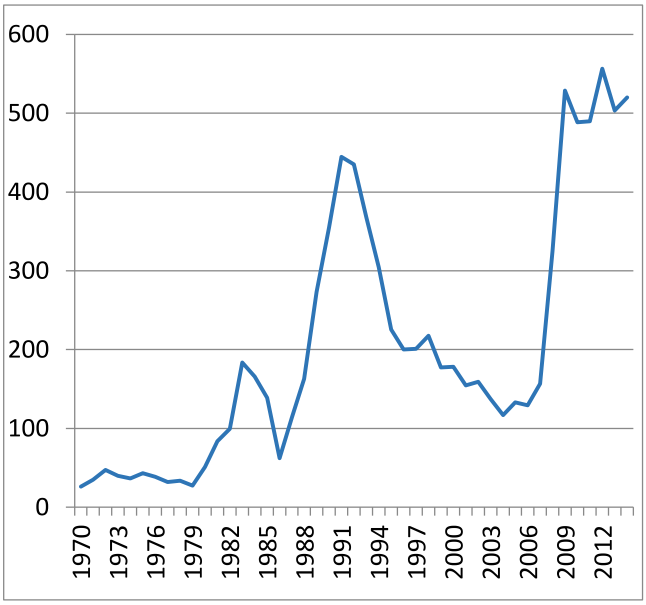
$$CU = (OUR - FUR) \times LF,$$

where: OUR and FUR represent the official unemployment and frictional unemployment rates respectively, and LF is the total labour force. Finally, C, the cost ($) per hour is determined as:

$$C = M - \frac{B}{37.5},$$

where: M is the minimum wage rate per hour[43] and B is unemployment benefits per week[44]. The 37.5 constant approximates the number of hours worked per week and is used to convert dollars per week into hourly estimates.

Findings



Highlights

- 'Involuntary Leisure time' is a large cost of unemployment, as generally workers would prefer to have higher income than what they receive when they are unemployed
- The cost of unemployment as measured by 'involuntary leisure time' dramatically increased from only $26 per person in 1970 to $566 per person in 2016.
- Over the 46 year period, there were two distinct peaks in unemployment: (i) in 1991 as the result of economic and labour market reforms;

  (ii) from 2008 to 2016 initially in the wake of the global financial crisis.

Figure 7.1 Per Capita Cost of Unemployment, 1970 -2014, $\$_{2014}$ per person,

Throughout the 1950s and 1960s New Zealand had close to full employment and unemployment was persistently at very low levels – for example, it was reported that there was a 0.6% unemployment rate in March 1960 quarter and 0.8% in March 1970 (MBIE, 2017). Even with the economy being in turmoil in the 1970s due to the impacts of two oil crises and the United Kingdom entering the EEC,

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43 The minimum wage rate was extracted for different years from the New Zealand Official Year Book. The data series has also been verified by comparing it to Chapple's (1997) report.

44 Data on annual unemployment benefits distributed (SOWA.SM2C and SOWA.SJ2C), as well as on the number of people receiving the benefit (SOWA.SM1C and SOWA.SJ1C), were used to estimate unemployment benefits per week. Refer to Vroman (2002) for further definitional information on unemployment benefits in New Zealand.

unemployment rate only rose slightly to peaks of 1.3% in 1972 and 1.2% in 1975, and indeed by 1977 the unemployment rate had returned to 0.8% (MBIE, 2017). As a consequence of this, as can be seen from Figure 7.1, the 'involuntary leisure time'[45] cost of unemployment per capita remained very low from 1972 to 1979 at about the $30-$50 per capita.

However, from 1979 to 1984, the 'involuntary leisure time' cost per capita of unemployment rose significantly from $27 per capita 1979 to $166 per capita in 1984, under an increasingly interventionist National government where at one stage prices and wages for 12 months during 1982 and 1983 were frozen by government regulation. With the coming to power of the Labour government in 1984, the unemployment rate dropped for three consecutive years until the stock market crash in 1987, which hastened rising unemployment for the next five years (along with structural change in the economy brought about by economic reforms instigated by the Labour Party government and then continued

Table 7.2 Cost of Unemployment: Total and Per Capita, 1970-2014

Year	Cost of Unemployment $_{2014}$ million	Cost of Unemployment $_{2014}$ per person	Year	Cost of Unemployment $_{2014}$ million	Cost of Unemployment $_{2014}$ per person
1970	74	26	1993	1,315	368
1971	99	35	1994	1,103	305
1972	138	47	1995	828	225
1973	118	40	1996	747	200
1974	111	36	1997	760	201
1975	134	43	1998	830	218
1976	121	39	1999	681	177
1977	100	32	2000	688	178
1978	105	34	2001	600	154
1979	86	27	2002	629	159
1980	160	51	2003	552	137
1981	265	84	2004	478	117
1982	316	99	2005	550	133
1983	591	183	2006	541	129
1984	539	166	2007	661	156
1985	454	139	2008	1,386	325
1986	204	62	2009	2,276	529
1987	378	114	2010	2,126	488
1988	541	163	2011	2,148	490
1989	909	273	2012	2,454	556
1990	1,193	355	2013	2,239	503
1991	1,554	445	2014	2,348	520
1992	1,537	435			

Note: As measured by involuntary leisure time.

[45] 'Involuntary leisure time cost' is a narrow definition of the social costs of unemployment, with unemployment having a wide array of negative effects both directly and indirectly on physical health, mental health, alcohol and drug addiction, crime rates suicide rates and family life amongst the many identified in the literature (Lucas *et al*., 2004; McKee-Ryan 2005; Delvin *et al*., 1997; Yang and Lester, 1995). That said, some of these effects are captured by other components of the New Zealand Genuine Progress Indicator, and are not included in this chapter to avoid 'double counting' – these include the negative effects of unemployment on: Inequality (Chapters 4 and 5), Health (Chapter 12) and Crime (Chapter 14).

with the National Party government). The unemployment rate increased from 4.0% in March 1987 to a peak of 11.2% in September 1991 (MBIE, 2017). As a consequence of this rising unemployment, the 'involuntary leisure time' cost of unemployment per capita dramatically increased to $435 per capita in 1992.

From 1992 to 2007 there was a prolonged period of decreasing levels of unemployment as the economy and the labour market recovered in the wake of the painful restructuring of the economy during the late 1980s and early 1990s. The unemployment rate steadily decreased from 10.4% in June 1992 to 3.7% in June 2007 (MBIE, 2017). Therefore, as depicted by Figure 7.1, the 'involuntary leisure time' cost per capita of unemployment decreased from $435 per capita in 1992 to $129 per capita in 2007.

Table 7.2 shows that the 'Involuntary Leisure Time' Cost of Unemployment increased from $74 million in 1970, to $2,348 million in 2014 , which is a nearly a 19 fold increase (1,894%), mostly explained by the dramatically increased number of unemployed and in recent years the growing gap between the 'minimum wage'and the unemployment benefit.

Update to 2016

Year	Cost of Unemployment $_{2014}$ million	$_{2014}$ per person
2015	2,412	524
2016	2,659	566

- Unemployment in 2015 and 2016 remained at relatively high levels, consistent with the trend that has persisted since the Global Financial Crisis in 2008.
- The total cost of unemployment as measured by the 'involuntary leisure time' indicator, increased from $_{2014}$2,348 million to $_{2014}$2,659 million in 2016.
- The cost per capita in 2016 of unemployment was calculated to be $_{2014}$ 520 per person, which compares with the $_{2014}$ 156 per person in 2007, just prior to the Global Financial Crisis.

8. Cost of Under-Employment

Why Include

Underemployment in this study refers to workers who, though employed, would like to increase their working hours. As with the calculation of unemployment costs, we have used the value of involuntary leisure hours resulting from underemployment as a measurement of the 'cost of underemployment'.

Very little attention is given to the impacts on well-being of underemployment. Nevertheless, it would be reasonable to assume that these impacts are similar (but perhaps not so accentuated) to those that occur for unemployment. For example, the lack of financial resources, meaningful social interaction from being engaged in a workplace, and psychological anxiety of not being employed can push unemployed people to take jobs that do not fit their skills or allow them to use their talents, leading to underemployment. Such underemployment not only has an impact on an individual level, but also for society as a whole, with loss from un-used 'human capital' though underemployment being a negative drain on the economy.

Although, not the same as, under-employment there is also a significant rate of under-utilisation of employees in New Zealand, where employees have higher qualifications or skills than is needed in their jobs. The OECD (2017) reports that New Zealand has the highest percentage of underutilised employees in the OECD, based on data from 2012 to 2015. This underutilisation of all employees impacts on our productivity, which continues to be lower than many OECD countries. As such employees who are underutilised, receive income from lower wages and salaries than they would if they were fully utilised, they will have less income available for purchasing goods and services, and in this way in the GPI, their personal consumption of goods and services will be lower than it otherwise would be.

How to Include

The total cost of underemployment, *TC*, is calculated as:

$$TC = U \times H \times C \times 52.14,$$

where *U* is total part-time employees looking for further work, *H* is hours sought per week per part-time employee, and *C* is the cost ($) per hour. The *52.14* constant approximates the number of weeks per year and is used to convert hours per week into annual estimates.

Underemployment population statistics for the period 1986–2014 were taken from SNZ: first, part-time employees who prefer to work more hours (INFOS Series HLFA.SNH3JAD), and second, part-time employees looking for full-time work (INFOS Series HLFA.SNH3JBD). In calculating the cost of underemployment, only the statistics for part-time employees looking for full-time work were assessed.[46]

To estimate the number of part-time employees looking for full-time work during the period 1970 to 1985 (where no SNZ data are available), the 1986 proportion[47] of this group relative to total part–time employment between 1986 and 2014 was applied to the total part-time employment for each year between 1970 and 1985.

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[46] This approach has been used in both the calculation of the United States GPI (Anielski and Rowe, 1999) and the Australian GPI (Hamilton and Denniss, 2000). Unfortunately, no reliable data exist regarding the number of hours desired by part-time workers who wish to work additional hours, but not necessarily full-time.

[47] This assumption is questionable as the labour market conditions of the late 1970s and early 1980s were certainly different from those which prevailed around 1986 at the peak of the economic reforms. Nevertheless, a severe lack of data restricts this analysis to the use of this assumption.

For the years 1987–2005 the number of part-time workers,[48] as defined by number of hours worked per week, was extracted from SNZ's Household Labour Force Survey database and converted to a percentage profile (see Table 8.1). Using the annual profiles and the associated hours required to reach full-time status (i.e. 37.5 hours minus the hours currently worked), a weighted average of working hours required across all part-time workers was calculated. Between 1986 and 2014 part-time workers looking for work full-time, on average, sought an additional 21.25 hours per week. This value was applied to the count of part-time workers looking for full-time work for the years 1970–1985, for whom no data regarding the numbers of hours currently worked are available.

Table 8.1 Additional Hours of Work Required by Part-time Workers, 1987-2005

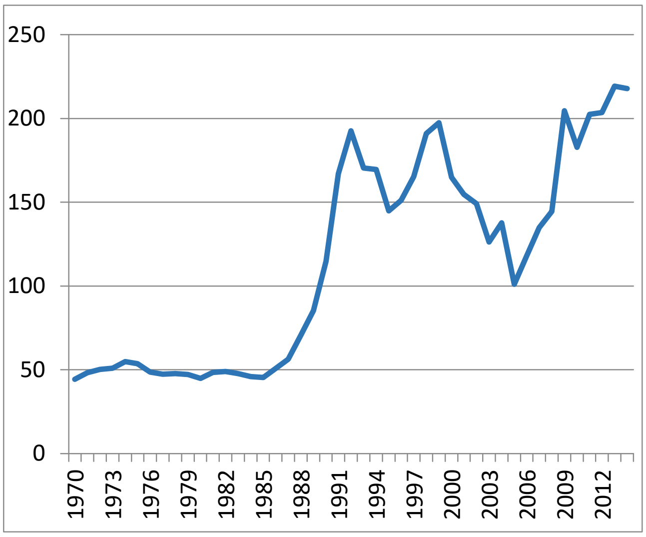
	Current hours worked: 1-9 (5)	Current hours worked: 10-19 (15)	Current hours worked: 20-29 (25)
% of Workers in Each Category	27	34	49
Additional hour required to reach full-time status	32.5	22.5	12.5

Notes:

1. Source: Household Labour Force Survey Database, Statistics New Zealand
2. Values in parenthesis are the mid-points use in the calculation of "additional hour required to reach full-time status"

To value the total additional hours of work sought for each year, the number of underemployed was multiplied by the average hours sought (21.25 hours) and the average hourly wage rate in that year. The product represents the opportunity cost of those working part-time but wishing to work full-time. Lastly, the CPI was used to convert the resulting costs into 2014 constant dollars. To value the total additional hours of work sought for each year, the number of underemployed was multiplied by the average hours sought (21.25 hours) and the average hourly wage rate in that year. The product represents the opportunity cost of those working part-time but wishing to work full-time. Lastly, the CPI was used to convert the resulting costs into 2014 constant dollars.

Findings



Highlights

- The Employment Contracts Act 1991 and subsequent leglisation has had a long-lasting impact on the level of under-employment, with the decline of the guaranteed full-time job.
- The cost of under-employment, measured in terms of the opportunity cost of an involuntary leisure time, was $983 million in 2014.
- Although on the cost per capita basis cost of under-employment has been at a relatively high level since 1991, it did decline markedly from 1999 to 2005 – only to rebound since then to a historic peak in 2013.

Figure 8.1 Per Capita Cost Underemployment, 1970 -2014, $$_{2014}$ per person

[48] In Statistics New Zealand's (2005) Household Labour Force Survey, part-time workers are defined as those people working less than 30 hours each week.

The cost of underemployment (measured by opportunity cost of 'involuntary leisure time'), remained at the low levels in the 1970s well into the late 1980s, in spite of the tumultuous events of those times and the impact they had on the economy. That is, the estimated cost of under-employment was very low at $\$_{2014}$ 44 per capita in 1970, increasing to $\$_{2014}$ 85 per capita in 1989 (refer to Table 8.2). Arguably, during these two decades, strong labour laws and a dominant role for trade unions enshrined in the nearly century-old Industrial Conciliation and Arbitration Act, meant that under-employment was not as problematic than it is today.

These years of relatively low underemployment abruptly changed with the enactment of the Employment Contracts Act 1991 – that is, the Act had a major impact on not only underemployment levels but on many other aspects of employment. Labour unions' status and power were very much diminished by the 1991 Act, with for example, bargaining over contracts and disputes becoming entirely voluntary, and employees could have either individual or collective employment contracts. According to Morrison (1996), by 1996 union membership had about halved, compared with prior to the enactment of the Employment Contracts Act 1991. All of this led to greater casualisation of the workforce, less job security, and the decline in 'standardised work' whereby a worker had previously almost been guaranteed to have 40 hours work per week. Not surprisingly, therefore, the cost of under-employment (as measured by the opportunity cost of involuntary leisure time) rapidly increased over the 1990 to 1993 period – refer to Figure 8.1. By 1993, the cost of under-employment was $\$_{2014}$ 680 million, which translated into $\$_{2014}$ 193 per capita of the New Zealand population.

From 1993 to 1998 when the Fourth National Government was in power, the cost of under-employment did increase to $\$_{2014}$ 729 million or $\$_{2014}$ 191 per capita of the New Zealand population, although there was a significant that dip to $\$_{2014}$ 145 per capita in 1995. With the coming to power of the Fifth Labour Government, the situation did improve somewhat with a steady decline in both the level and cost of under-employment from 1999 to 2005. By 2005, the estimted cost of under-employment had dropped to $\$_{2014}$ 418 million per annum or $\$_{2014}$ 101 per capita.

From 2005 to 2014 the cost of under-employment, once normalised to be on a per capita basis, increased steadily, although there were a couple of dips recorded for the years 2010 and 2013. Most commentators agree that under-employment and more broadly what Spoonley (2010) terms "non-standard" work (part-time, contract, temporary, casual, portfolio) became more entrenched over this period from 2005. As is shown by Table 8.2, by 2014 the cost of under-employment (as measured by the opportunity cost of non-voluntary leisure time) was $983 million. It can be noted that although this is a significant cost to New Zealand society, it is less than half the estimated cost of unemployment of $2,348 million in 2014 at which was calculated in Chapter 7.

Incidentally, although the combined cost of both unemployment and underemployment is very significant at nearly $2.5 billion in 2014, due to the lack of empirical research, it is very difficult to know exactly what the 'net benefit' or 'net cost' of the 1991 instigated labour market reforms might be. Proponents of these labour market reforms will, of course, argue that the economy has become significantly more efficient and flexible as a result of these labour market reforms and these benefits greatly outweigh the social costs – but, unfortunately the empirical evidence for either supporting or not supporting this assertion is weak and for the most part, largely non-existent (Morrison, 1996).

Table 8.2 Cost of Under-employment: Total and Per Capita, 1970-2014

Year	Cost of Under-employment $_{2014}$ million	$_{2014}$ per person	Year	Cost of Under-employment $_{2014}$ million	$_{2014}$ per person
1970	125	44	1993	609	170
1971	138	48	1994	614	170
1972	146	50	1995	532	145
1973	152	51	1996	564	151
1974	167	55	1997	625	165
1975	166	54	1998	729	191
1976	152	49	1999	758	198
1977	149	47	2000	637	165
1978	150	48	2001	602	155
1979	148	47	2002	589	149
1980	141	45	2003	509	126
1981	153	48	2004	563	138
1982	156	49	2005	418	101
1983	154	48	2006	493	118
1984	150	46	2007	570	135
1985	149	45	2008	616	144
1986	166	51	2009	881	205
1987	186	56	2010	796	183
1988	234	71	2011	888	203
1989	284	85	2012	897	203
1990	386	115	2013	975	219
1991	584	167	2014	983	218
1992	680	193			

Note: As measured by involuntary leisure time

Update to 2016

Year	Cost of Under-employment $_{2014}$ million	$_{2014}$ per person
2015	1,094	238
2016	1,151	245

- For 2015 and 2016, data from the Household Labour Force Survey indicated that there was an increase of part-time employees seeking extra hours of employment.
- This led to a significant increase in the total cost of 'under-employment' from $_{2014}$ 983 million in 2014 to $_{2014}$ 1,151 million in 2016.
- On a per capita basis, the cost of 'underemployment' increased 12.5% from $_{2014}$ 238 in 2014 to $_{2014}$ 245 in 2016 2016. This per capita cost of under-employment in 2016, was the highest recorded value over the entire time series from 1970 to 2016.

9. Cost of Overwork

Why Include

There are many potential personal and national benefits associated with the provision of work. There is, however, also a point at which too much work may have detrimental effects on individuals and on the economy at large. The negative consequences that may result from overwork are similar in nature to those caused through no work or not enough work, such as poor physical and mental health and increased stress on family life. According to one perspective, "having people work long hours is neither good for the health and safety of the workforce, nor does it help increase GDP per capita in a suitable way. The key to sustainable growth is, instead, raising productivity" (Career Services, 2006).

Conceptually, it can be argued that the point at which overwork is reached is when people work more than they would ideally like to in order to maintain the security of their current employment (Hamilton and Denniss, 2000). Although many of the costs arising from overwork are captured in other components, the loss of leisure time associated with overwork is not included elsewhere. Valuing this loss is the focus of the current chapter (Chapter 9 – Cost of Overwork).

How to Include

There are 2 steps used to calculate the cost of overwork, as set out below.

Step 1: Value of Overwork for the Years 1986-2014. The valuation of the annual loss of leisure hours due to overwork is based on the following calculation:

$$CO = OH \times 52.14 \times C,$$

where *CO* is the cost of overwork, *OH* is the number of overtime hours worked per week per worker, and *C* is the cost ($) per hour. The 52.14 constant approximates the number of weeks per year, and is used to convert the hours per week overworked into annual estimates.

Step 1.1 Estimation of the Number of Overwork Hours Worked Per Week for the Years 1986-2014. Annual December year raw data on persons employed by hours worked per week for their primary job were extracted from INFOS. Persons employed are categorised into nine groups according to the number of hours worked: 1-9 hours (HLFA.SMA3IABD), 10-19 hours (HLFA.SMA3IACD), 20-29 hours (HLFA.SMA3IADD), 30-34 hours (HLFA.SMA3IAED), 35-39 hours (HLFA.SMA3IAFD), 40 hours (HLFA.SMA3IAGD), 41-44 hours (HLFA.SMA3IAHD), 45-49 hours (HLFA.SMA3IAID),and 50 hours and over (HLFA.SMA3IAJD). For each of the first eight groups, the average number of hours worked per week is estimated as the mid-point in the time band. For the category of 50 hours and over, the average number of hours worked per person is estimated by dividing total hours worked for that group by number of people in the group.[49] On average, persons within the 50 hours and over category, worked 60 hours per week, for the period between 1986 and 2014. Table 9.1 shows the average hours worked per week per person for each time band over the period 1986-2014.

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[49] The total number of hours worked by people within the 50 and over category is calculated as the difference between the total hours worked per week by all people, and the sum of the total hours worked per week by persons within the other eight time groups. The total hours worked by all people is taken from SNZ's quarterly data on actual hours worked per week (HLFQ.SHB). A moving average is applied to the quarterly data (March June, September and December) for each year in order to calculate an annual December data series. The total number of hours worked per week in each of the first eight groups is calculated by multiplying the number of people in each group by the group's estimated average number of hours worked per week.

Table 9.1 **Average Hours Worked, Per Week, per Person, 1986-2014**

1-9 Hours	10-19 Hours	20-29 Hours	30-34 Hours	35-39 Hours	40 Hours	41-44 Hours	45-49 Hours	50 Hours and Over
5	14.5	24.5	32	34.5	40	42.5	47	60

Source: INFOS, Statistics New Zealand

A judgment was required as to the number of hours worked per week, above which constitutes 'overwork'. To help inform this decision it has been noted that in New Zealand, the number of working hours is generally negotiated on an employee-by-employee basis, an employer may not unilaterally impose more than 40 hours of work per week exclusive of overtime.[50] Alternatively, social policy analyst, Paul Callister, has suggested that the cut-off point for overwork is above 50 hours per week (Career Services, 2006). Notably this cut-off point has also been used by the Ministry of Social Development (2004) and the Department of Labour (2008) to define long working hours. In this study, the number of hours which constitute overwork has been set at 50 hours and above per week. As a result, persons grouped in the 50 hours and over category have been counted as undertaking overwork.

The average overwork hours per week per person in the 50 hours and over category is estimated by subtracting the average hours worked per week per person by 50 hours. The overwork hours per week per person are then multiplied by the number of persons employed in the 50 hours and over category so as to calculate the total overwork hours.

***Step 1.2 Value of Overwork per Hour*.** The average hourly wage rate for all occupations, full and part-time, for each year is used to value an hour of overwork. It is noted that overtime, when paid by an employer, has typically been at a higher rate than the normal wage rate as a way of recompensing for loss of leisure, the impacts on family life and so on. Nowadays, it is increasingly common for people, especially salaried workers in service occupations, to do unpaid overtime (e.g. doing paperwork at home) as a normal requirement of a job. In placing a value on an hour of overtime it therefore seems most appropriate to use the average wage rate. Finally, given the values of overwork calculated for the period 1986–2014, these values are deflated by the CPI to constant 2014 dollars.

***Step 2: Cost of Overwork for the Years 1970-1985*.** There are no data available on working hours for the years 1970-1985. Unfortunately, trends in working hours established for the years in which data are available also do not constitute a satisfactory basis for estimating the missing data. This is because working conditions have changed significantly over the last 35 years, with improved technologies (e.g. widely used computers) and changes in the labour force structure (e.g. including more woman entering the labour force). Therefore, in order to crudely estimate the cost of overwork for the period 1970 to 1985, the following method was used: (1) the ratio of the real cost of overwork to real GDP is calculated for the years 1986 to 2006 and this was found to constitute on average 2.6% of GDP; (2) the cost of overwork is then calculated for the years 1979 to 1985, by multiplying the real GDP for each year by this ratio (0.026).

Findings

The reasons for overwork are varied, complex and affect a number of different segments of the labour market in different ways. On one hand 'overwork' may occur among low-waged workers, who need to work longer hours and often several jobs in order to 'make ends meet'. On the other hand, more

[50] Most European countries have a standard 40-hour week; the United States has a 40-hour week for wage earners, while in Australia the standard working week is 38 hours without payment of overtime (New Zealand Parliament, 2007).

highly skilled and highly paid employees may work longer hours, due to employer or colleague expectation 'to get the job done'. All of this makes the interpretation of the cost of overwork data less than straightforward.

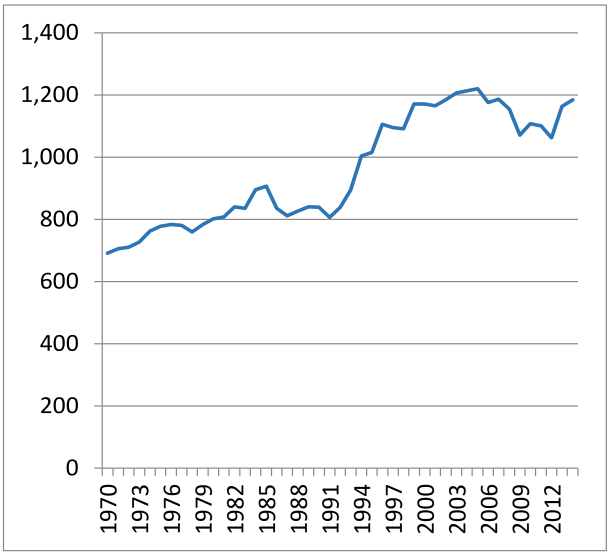

Figure 9.1 Per Capita Cost of Overwork 1970-2014, $_{2014}$ per person

Highlights

- With increasing levels of 'non-standardised work', the potential for overworking has increased, particularly over the last 30 years.
- Overwork in 2014 was estimated to have cost \$5.3 billion, as employees worked more than 50 hours a week, which is deemed to be undesirable from a well-being perspective.
- The amount of overwork did not increase much from 1970 to 1991, and then increased nearly every year from 1992 to 2005.
- With the global financial crisis in 2008 and the consequent tightening of the labour market, there was declining levels of overwork from 2008 to 2012.

From 1970 to 1985, the data show a slow increase in overwork was relatively low, increasing slowly from $\$_{2014}$ 691 per person and 1970 to $\$_{2014}$ 907 in 1985. However, caution needs to be displayed when interpreting these data, because of the crude method which was used to estimate overwork over this 1970 to 1985.

This trend of increasing overwork abruptly stopped in 1985, when there was a decrease in the per capita cost of overwork from of $\$_{2014}$907 in 1985, down to \$806 in 1991. This decline in overwork over the six-year period, corresponded to a period of high unemployment in New Zealand, and therefore it could be reasonably concluded at this time there was a declining 'demand for labour' and hence there was less potential for overworking.

From 1992 to 2005 the 'costs of overwork' increased almost every year, peaking at an historical high of $\$_{2014}$1,219 per capita in 2005. This rise in the amount of overworking directly corresponds to decreasing unemployment rates and increasing employment prospects – which seen through the lens of 'labour supply and demand', provides a reason for this increasing overwork. No doubt, however, a fluid and less regulated labour market, brought about by the Employment Contracts Act 1991, also played a role in increasing the level of 'overworking', particularly at the lower income end of the market. Spoonley (2010) also concludes that between 2000 and 2008 New Zealand experienced … significant shortages of labour both in terms of the quantum available but also the quality of human capital …", which also provides a further explanation of increasing 'overwork' during that period, as perhaps those with the required skills worked longer hours to meet the skill shortages."

With the Global Financial Crisis in 2008 and increasing unemployment from 2007 to 2012, the 'cost of overwork' declined presumably because it became more difficult to procure extra hours of paid work. Only in 2013 and 2014, when the unemployment situation eased, did the amount of overwork increase again. By 2014, the estimated cost of overwork in New Zealand increased to $\$_{2014}$5.3 billion (refer to

Table 9.2), which interestingly is more than the combined estimated cost of unemployment and underemployment at $\$2.5_{2014}$ billion in the same year.[51]

Table 9.2 Cost of Overwork, Total and Per Capita, 1970 to 2014

Year	Cost of Overwork $\$_{2014}$ million	$\$_{2014}$ per person	Year	Cost of Overwork $\$_{2014}$ million	$\$_{2014}$ per person
1970	1,947	691	1993	3,194	894
1971	2,020	705	1994	3,635	1,004
1972	2,071	710	1995	3,732	1,015
1973	2,163	726	1996	4,126	1,105
1974	2,318	762	1997	4,140	1,094
1975	2,412	778	1998	4,163	1,091
1976	2,452	783	1999	4,494	1,171
1977	2,454	781	2000	4,520	1,171
1978	2,386	759	2001	4,527	1,165
1979	2,457	783	2002	4,680	1,184
1980	2,520	802	2003	4,857	1,206
1981	2,547	807	2004	4,959	1,213
1982	2,672	840	2005	5,043	1,219
1983	2,690	835	2006	4,922	1,176
1984	2,912	895	2007	5,013	1,186
1985	2,967	907	2008	4,920	1,154
1986	2,737	835	2009	4,610	1,071
1987	2,680	811	2010	4,818	1,107
1988	2,741	826	2011	4,828	1,101
1989	2,799	840	2012	4,685	1,062
1990	2,821	839	2013	5,172	1,163
1991	2,819	806	2014	5,344	1,184
1992	2,961	838			

Update to 2016

Year	Cost of Overwork $\$_{2014}$ million	$\$_{2014}$ per person
2015	5,463	1,188
2016	5,560	1,184

- The total cost of overwork increased to a record high of $\$_{2014}$ 5,460 million in 2016. However, once normalised for population growth, the cost per capita of overwork was $\$_{2014}$ 1,184 in 2016, which is exactly the same value that was reported for 2014.
- This level of overwork is, however, close to the highest levels of overwork per capita previously recorded over the 2003 to 2005 period.

[51] Even though this study finds the cost of overwork has been significantly greater than the social cost of unemployment or underemployment, overwork seems to be a poorly researched area in comparison. Many New Zealand studies (Spoonley, Dupuis and de Bruin, 2004; O'Brien, 2008; Loughrey-Webb, 2015; Ministry of Social\Development, 2016) focus on unemployment and to a lesser extent underemployment and its relationship to poverty, mental health and other negative outcomes, particularly in relationship to the changing role of the state. However, very few New Zealand studies focus on overwork and the negative effect that it obviously has on individual and societal well-being.

10. Services of Public Capital

Why Include

'Capital' as defined here is 'tangible' and 'non-tangible' property used to produce other goods and services within a certain time period. Capital is durable, but depreciates over time. Capital can include buildings, machines, equipment, transport infrastructure such as roads, and in more recent times items such as software have been included in the national economic accounts (Statistics New Zealand, 2014). The economy benefits from services gained from the use of public capital stocks. These services are valued as a positive component of the GPI. There are two types of public capital stocks providing goods and services. First, are the stocks owned by trading enterprises (e.g. electricity and gas supply infrastructure) whose services are charged to consumers directly; second, there are the stocks owned by the government, which offer both market (e.g. road-user charges) and non-market (e.g. use of national parks) goods and services. The New Zealand System of National Accounts (SNA) records the goods and services supplied by the first type of these capital stocks as consumption spending, either directly in final consumption or indirectly in intermediate consumption. It is therefore unnecessary to account for this spending again. Market goods and services produced by capital stocks owned by the government, such as services paid for through road user charges, are also captured in national accounts through consumption spending. Importantly, it is only the non-defensive services of public capital stocks that are of interest in this category.

How to Include

The value of non-defensive, non-market services rendered by government owned stocks is calculated as the depreciation of capital stocks and the opportunity cost of the government investing its funds elsewhere in the money market in order to gain interest. The formula used to estimate the value of the services, *S*, is therefore as follows:

$$S = CS \times ND \times NM \times DR + CS \times ND \times NM \times RI,$$

where *CS* is capital stocks owned by the government, *ND* represents the non-defensive proportion, *NM* is the proportion of these stocks used to produce non-market goods and services, *DR* is the depreciation rate associated with these stocks and *RI* is the real interest rate.

The consumption of fixed capital (i.e. depreciation), *CFC*, is calculated as:

$$CFC = CS \times DR,$$

And the capital stock, *CS,* as*:*

$$CS = NCS + CFC,$$

where *NCS* represents the net capital stock.

The 1970–2014 data series for net capital stocks (INFOS Series: SNCA.S5NK90T2 and SNCA. S5NK90T3) and consumption of fixed capital (INFOS Series: SNCA.S3NK10T2 and SNCAS3NK10T3) for central and local government were obtained from SNZ's National Accounts. These data were then aggregated into a single value for general government.

The figures for 1970/71 for each time series were backcast using an exponential equation derived from the data given for 1972–1979. The resulting data is defined according to the March year, and was thus converted to a December year by adding up one quarter of a particular March year value with three-quarters of the following March year value. The final December year time series for NCS and CFC were then converted to constant 2014 dollars. It is estimated that 80 percent of the capital stocks owned by the government are used to produce non-market services (pers. comm., Officer, Statistics New Zealand), and furthermore that 100 percent of these services are non-defensive.

Depreciation is, by definition, the multiplication of capital stocks by the deprecation rate. The depreciation rate was measured directly as the ratio of consumption of fixed capital (as obtained from SNZ time series data)[52] and the total capital stocks. Capital stocks were calculated as the sum of net capital stocks and consumption of fixed capital. A real interest rate of 10 percent per annum was assumed.

Findings

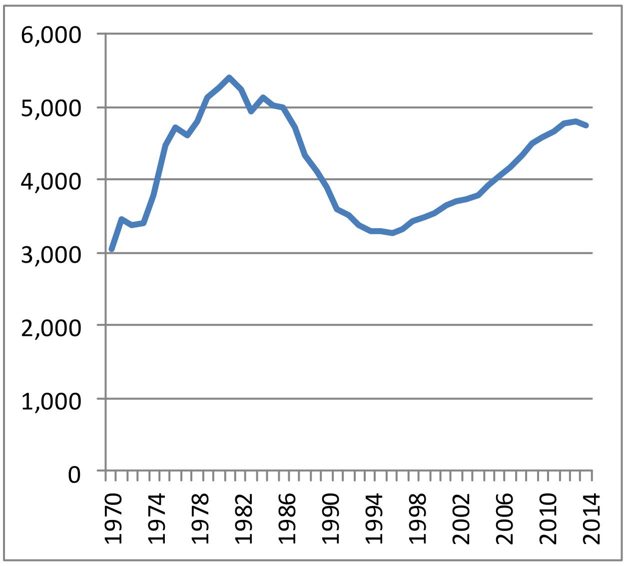

Figure 10.1 Per Capita Services of Public Capital, 1970–2014, $$_{2014}$ per person

Highlights

- From 1970 to 1981 there was a significant increase in services derived from public capital, peaking at $$_{2014}$ 5,408 per person in 1981.
- There a steep decline in services from public capital, over the period 1984 to 1996, as many services were 'transferred' to the private sector.
- From 1996 to 2013, there were year-on-year increases in the services from public capital, increasing to a peak of $$_{2014}$ 4,802 per person in 2013.

Figure 10.1 outlines the 'services derived from public capital' (excluding defensive expenditures) from 1970 to 2014. The interpretation of these results were made difficult due to the lack of disaggregated data available from Statistics New Zealand. That is, although the aggregate trends can be described, it is difficult to precisely understand the determinants of these trends, when it is for example not known what components of capital make up these aggregate trends. That said, there is reasonable evidence to indicate that the changes and shifts in the level of services of public capital, are due to changes in central government investment, rather than changes in local government investment which has remained relatively unchanged (Gemmell *et al*., 2016).

As can be seen from Figure 10.1, services derived from public capital increased on a per capita basis from $$_{2014}$ 3,042 in 1970 to a peak of $$_{2014}$ 5,408 in 1981. Although it can't be ascertained from the available data precisely what types of capital service increased over this 1970 and 1981 period, it can be broadly commented upon that this was a period of increased government involvement in the economy, as can be seen by analysing the various metrics of the "size of the State in New Zealand" as put forward by Gemmell *et al*. (2016).

During the period of the National government from 1981 to 1984, there was a slight decline in the per capita services derived from public capital, dropping from $$_{2014}$ 5,408 in 1981 to $$_{2014}$ 5,120 in 1984.

[52] The consumption of fixed capital is defined as the decline in value of fixed assets used in production as a result of physical deterioration and normal obsolescence (Statistics New Zealand, 2006a).

Table 10.1 Services of Public Capital: Total and Per Capita, 1970 to 2014

Year	Services of Public Capital $_{2014}$ million	Services of Public Capital $_{2014}$ per person	Year	Services of Public Capital $_{2014}$ million	Services of Public Capital $_{2014}$ per person
1970	8,577	3,042	1993	12,080	3,380
1971	9,912	3,461	1994	11,983	3,309
1972	9,816	3,367	1995	12,069	3,283
1973	10,116	3,398	1996	12,256	3,282
1974	11,523	3,788	1997	12,593	3,329
1975	13,860	4,471	1998	13,051	3,420
1976	14,827	4,734	1999	13,365	3,483
1977	14,465	4,603	2000	13,703	3,550
1978	15,120	4,810	2001	14,196	3,653
1979	16,074	5,123	2002	14,646	3,707
1980	16,537	5,260	2003	15,006	3,726
1981	17,071	5,408	2004	15,543	3,801
1982	16,713	5,254	2005	16,251	3,929
1983	15,885	4,931	2006	17,042	4,072
1984	16,654	5,120	2007	17,648	4,176
1985	16,455	5,030	2008	18,517	4,345
1986	16,408	5,007	2009	19,405	4,508
1987	15,584	4,717	2010	19,949	4,583
1988	14,387	4,337	2011	20,466	4,666
1989	13,711	4,117	2012	21,013	4,764
1990	13,102	3,896	2013	21,355	4,802
1991	12,541	3,588	2014	21,422	4,747
1992	12,383	3,505			

The steepest and most dramatic decline in the per capita provision of public capital services, occurred during the period of the fourth Labour government from 1984 to 1990. As has been extensively documented this was a period where there was transfer of enterprises from the public to private sector, across for example an array of infrastructure services such as railways, energy networks to telecommunications. This transfer of 'capital' to the private sector and the disinvestments in public sector capital, lead to this sharp decline from $\$_{2014}$ 5,120 per capita in 1984 to $\$_{2014}$ 3,588 per capita in 1990 in services derived from public capital. This downward trend in the provision of public capital services continued until 1996, falling to a low of $\$_{2014}$ 3,282 per capita.

From 1996 to 2013 there was a reversal of this decline, with a steady increase in the level of services from public capital, from $\$_{2014}$ 3,282 per capita in 1996 to $\$_{2014}$ 4,802 per capita in 2013 – this peak in 2013, still did not reach the previous peak of $\$_{2014}$ 5,408 achieved in 1981. Although these data shows a clear and consistent increase in the services from public capital from 1996 to 2013, it cannot be ascertained from this Statistics New Zealand data exactly what these increased services from public capital were. It is possible for example, that over this 1996 to 2013 period, that the provision of roading 'services' may have increased, but to what extent is not known, as is the case for other components of public capital services.

Update to 2016

Year	Services of Public Capital	
	$\$_{2014}$ million	$\$_{2014}$ per person
2014	21,422	4,747
2015	22,132	4,812
2016	23,052	4,908

- On a per capita basis, 2014 was the first year to record a decrease to services provided from public capital since 1996.
- However, both 2015 and 2016 reported increases in per capita services provided by public capital – 2015 recorded a per capita value of $\$_{2014}$ 4,812 and 2016 recorded a value of $\$_{2014}$ 4,908.

11. Value of Household and Community Work

Why Include

Some of the most essential work undertaken in a society to facilitate national well-being is performed without monetary payment in compensation. Importantly, unpaid household work (caring for children, home decoration, food preparation and so on) makes a large contribution to human welfare, providing a source of utility to members of each household. Additionally, there is a significant amount of work undertaken for under-serviced communities, schools, churches, and neighbourhoods. This volunteer community work may be formal, such as volunteering for private non-profit institutions like New Zealand Red Cross, or informal, such as childcare for other households. Anielski and Rowe (1999, p8) refer to this work as the "nation's informal safety net" or the "invisible social matrix" upon which a healthy market economy depends.

Despite the importance of unpaid household and community work to national well-being, such activities, which do not involve monetary transfers, are not accounted for in GDP (Hyman, 1994). This has led to claims that the accounts are conceptually inconsistent as a measure of economic activity, and the call for the development of supplementary accounts in order to provide a more comprehensive picture of economic production (Statistics New Zealand, 2001a). One of the aims of calculating the GPI is to address this issue, and to provide a more accurate measure of the value of society's work. In this study, this is undertaken by assigning a monetary value to the unpaid household and community work undertaken in New Zealand. This value is determined according to an estimate of the total number of hours spend in unpaid household and community work, and the application of an hourly wage rate to this total.

How to Include

The following 4 steps are conducted to calculate the value ($) of household and community work in New Zealand from 1970 to 2014:

Step 1: Determine Residential Population by Age and Sex. For the years 1991-2014 raw data on mean estimated residential population by age (single-year and five-year cohort) and sex for each year ended 31 December was obtained from SNZ[53]. These data were then grouped into 12 age-sex cohorts: males and females in the following age groupings – 12-24 years, 25-34 years, 35-44 years, 45-54 years, 55-64 years and 65 years and over.

***Step 2: Determine Time Spent on Household and Community Work In 1998/1999 & 2009/2010*.** Between 1 July 1998 and 30 June 1999, SNZ conducted New Zealand's first major time use survey (Statistics New Zealand, 2001c). The survey involved a sample of over 8,500 residents aged 12 years and over and required each participant to fill in a 48 hour time diary. The work was commissioned by the Ministry of Woman's Affairs, primarily to identify the annual volume of unpaid work undertaken by New Zealanders (Statistics New Zealand, 2001a). Furthermore, it applied detailed activity classifications to identify unpaid household and community work. This time use survey was repeated again over the period from September 2009 to August 2010**,** this time for 9,159 residents. (Statistics New Zealand, 2011). The time use categories (4) and subcategories (20) covered by these time-use surveys were: Household Work (9 subcategories including: food preparation, indoor cleaning, grounds/gardening, home maintenance, household administration, production of goods, gathering of food, travel, and other); Caregiving of Household Members (7 subcategories including: physical care, being available, playing, teaching, educational, health, travel, and other); Purchasing Goods and Services (2 subcategories including: purchasing and travel); Unpaid Work Outside the Home (2 subcategories including: formal and informal).

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[53] INFOS series: DAEA.SPA012 to DAEA.SPA014, DAEA.SPAG04 to DAEA.SPAG18, DAEA.SPAG90 and DPE.058.AA.

Data from these two time use surveys were used as a basis for estimating the time spent on household and community work for years 1998/1999 [54] and 2009/2010 [55], by each age-sex cohort. Essentially, the resident population by age-sex cohorts was used to 'scale up' the time use data from Step 1, from minutes per person per day to obtain *national totals* in hours per year for all of the time use categories (4) and subcategories (20) specified above.

***Step 3: Determine Time Spent on Household and Community Work for Non-Survey Years*.** Unfortunately, no time-use data are available for most years in the GPI calculations. So, therefore for these years hours per year for each 'age-sex cohort by time use category' had to be either assumed or estimated as follows:

- *1970 to 1997:* It was assumed that the 'age-sex cohort by time-use category' per resident *stayed the same* as for the 1998/1999 time-use survey – though, the 'scaling up' from individual resident data to the national population, varied in magnitude due to the changing national population.
- *1999 to 2008:* For each of these years, there was *linear interpolation* between the 1998 and 2009 'age-sex cohort by time-use category' data which was directly drawn from the National time use surveys during those two years– though, the 'scaling up' from individual resident data to the national population, varied in magnitude due to the changing national population.
- *2010 to 2014:* It was assumed that the 'age-sex cohort by time use category' per resident *stayed the same* as for the 2009 /2010 time-use survey – though, the 'scaling up' from individual resident data to the national population, varied in magnitude to the changing national population.

Step 4: Monetary Estimates of the Value of Household and Community Work. Several approaches have been identified for assigning monetary value to a unit of unpaid household work, which include for example opportunity cost and market replacement cost methods (Statistics New Zealand, 2001a). In this study, the housekeeper replacement method is adopted on the basis of data availability and ease of calculation.[56]

Before the monetary estimates of the value of household and community work could be calculated, the amount of time spent on 'leisure' activities needed to be subtracted from the Step 2 and 3 data:

- Around 90 percent of the time spent undertaking indoor cleaning and home administration is deemed to be non-leisure and is thus included within the GPI.
- Gardening activities and playing with other members of the household are viewed entirely as leisure and are therefore not valued in the GPI. This is consistent with the approach adopted in the calculation of the Australian GPI (Hamilton and Denniss, 2000).
- For each sex and age cohort, typically around 50 percent of the time spent on other household work is valued in the GPI. There are some minor variations across the age-sex cohorts reflecting differing life-styles and time use patterns.
- All formal unpaid community work, and 50 percent of informal community work is deemed to be non-leisure.

Once leisure time had been excluded, the hours per person per year data from Steps 2 and 3 needed to be multiplied by wage rates, in order to calculate the total monetary value of household and community work in New Zealand, for each year from 1970 to – 2014. To do this, a single general housekeeper wage rate was used to value all the activities, and hours for all persons in each year independent of age or sex. The hourly wage rate, $9.60, used to represent a general housekeeper was

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[54] It was assumed in subsequent analysis that the 1998/1999 time use survey was representative of the calendar year 1998.

[55] It was assumed in subsequent analysis that the 2009/2010 time use survey was representative of the calendar year 2009.

[56] The housekeeper replacement method was also adopted in the calculation of the Australian GPI (Hamilton and Denniss, 2000), and in the Statistics New Zealand (2001a) report 'Measuring Unpaid Work in New Zealand 1999'.

extracted from the 1999 median wage of occupation 512 "Housekeeping and Restaurant Services Workers" in the New Zealand Income Survey (Statistics New Zealand, 2006b). It was assumed that in real terms (inflation adjusted) that this wage rate remained constant throughout the 45 years covered by the New Zealand GPI calculations.

Findings

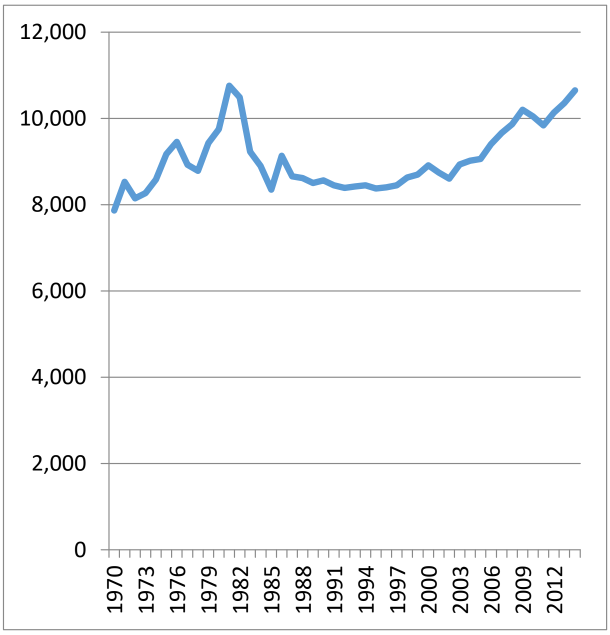

Figure 11.1 Per Capita Value of Household and Community Work 1970-2014, $\$_{2014}$ per person

Highlights

- The value of unpaid 'Household and Community Work' is the second highest beneficial component of the NZ Genuine Progress Indicator after 'Personal Consumption'.
- Lack of time-use data, which have only been surveyed for two years by Statistics New Zealand, restricts the accuracy of these data.
- An aging population is an emerging key factor in pushing the value of unpaid 'Household and Community Work' higher, with older people spending significantly more time on unpaid work.

The value of unpaid Household and Community Work is one of the largest and most important components of the New Zealand Genuine Progress Indicator valued at $\$_{2014}$ 42.11 billion in 2014 (refer to Table 11.1) The time use surveys undertaken by the Statistics New Zealand in 1998/1999 and 2009/2010, provides very good data for estimating the value of household and community work for the years 1998/1999, and 2009/2010. However, even then assumptions based on the overseas literature, had to be made to apportion leisure and non-leisure (work) for the purposes of calculating the New Zealand Genuine Progress Indicator, with only non-leisure (work) time being counted. Furthermore, and more importantly, interpolations, extrapolations and assumptions which are specified above, had to be made for the remaining 43 years of the time series. Although some of these assumptions and interpolations, are reasonable (for example, the linear interpolation between 1998/1999 and 2009/2010), most of these time series are indicative rather than precise measurements.

Notwithstanding these reservations and caveats, some broad conclusions about the trends and magnitude of the value of household and community work can be made (refer to Figure 11.1) First, the monetary value per capita of unpaid housework and community work has not immeasurably changed from the value of $\$_{2014}$ 7,867 per capita in 1970 to $\$_{2014}$ 9,330 per capita in 2014, in spite of the many social changes that have taken place over this 45 year period – such as, the wider diversity in the way that children are reared apart from the nuclear family model, number of children per couple decreasing, changing roles of women in the workforce with higher labour market participation rates most markedly for part-time work, labour-saving technologies, and indeed lifestyle changes such as a move away from labour-intensive food preparation in the home and the greater occurrence of 'eating out' (Rankin 1993; Davies and Jackson, 1993; Else, 1996).

Table 11.1 Household and Community Work: Total and Per Capita, 1970 to 2014

Year	Household and Community Work $_{2014}$ million	Household and Community Work $_{2014}$ per person	Year	Household and Community Work $_{2014}$ million	Household and Community Work $_{2014}$ per person
1970	22,181	7,867	1993	30,089	8,420
1971	24,425	8,528	1994	30,594	8,448
1972	23,750	8,146	1995	30,783	8,375
1973	24,606	8,265	1996	31,360	8,399
1974	26,096	8,579	1997	31,950	8,446
1975	28,438	9,173	1998	32,922	8,628
1976	29,601	9,452	1999	32,989	8,597
1977	28,049	8,925	2000	33,629	8,712
1978	27,610	8,783	2001	32,866	8,456
1979	29,583	9,428	2002	32,493	8,224
1980	30,641	9,746	2003	33,981	8,437
1981	33,947	10,754	2004	34,424	8,419
1982	33,357	10,487	2005	34,551	8,354
1983	29,718	9,224	2006	35,848	8,565
1984	28,935	8,895	2007	36,752	8,696
1985	27,304	8,346	2008	37,350	8,764
1986	29,923	9,131	2009	38,505	8,945
1987	28,597	8,656	2010	38,348	8,809
1988	28,576	8,615	2011	37,828	8,624
1989	28,306	8,500	2012	39,170	8,881
1990	28,793	8,563	2013	40,356	9,076
1991	29,538	8,449	2014	42,109	9,330
1992	29,620	8,384			

Second, related to the first point, although most of these factors are difficult to quantify and be directly linked to changes in the unpaid value of household and community work, some can be quantified in such a way. For example, by comparing the changes and time use between the 1998/1999 and 2009/2010 surveys, it can be seen that over this decade there has been a slight decrease in the amount of 'minutes per person', of unpaid household and community work, with the female amount of household work from 287 minutes to 260 minutes and the male amount of work decreasing from 164 minutes to 150 minutes – the largest decreases for both females and males has been the decrease in the amount of time spent on food preparation, household cleaning and unpaid community work. Another factor that can be quantified with some certainty is the impact of changing age-sex structures in the population – with ageing of the population having a significant effect increasing the monetary value per capita (and overall monetary value) of unpaid household work, because those in the in 45-54 year, 55-64 year and particularly 65+ years cohorts spend more time on unpaid household and community work, than the younger age cohorts. Indeed, the increasing value of household work per capita from 2002 to 2014 can be mainly explained by the ageing of the population.

Update to 2016

Year	Household and Community Work $_{2014}$ million	Household and Community Work $_{2014}$ per person
2015	43,874	9,539
2016	45,579	9,705

- The unpaid value of household and community work continued to rise – a 2.2 % increase for 2015 on a per capita basis, and 1.7% for 2016 on a per capita basis.
- These percentage increases only measure the impact of an ageing population, on the amount (and hence value) of unpaid household and community work – there may well be other factors at play, but there is no available data to measure their impact.

12. Private Defensive Expenditure on Health

Why Exclude

One of the principles of GPI accounting is to remove defensive expenditures from the accounts, as they do not contribute to an improvement in well-being. In the case of public health expenditure this exclusion of health expenditure has already been undertaken in Chapter 6 of this publication. The purpose of this Chapter is to calculate private health expenditure, so that it can be removed from the GPI in the final calculations undertaken in Chapter 25.

How to Exclude

SNZ's National Accounts (SNC Series) were used to derive resident households' private expenditure on health (INFOS series: SNCA.S2NP30EAE) for the years 1988–1996[57]. These data provided estimates of private expenditure by households, excluding private non-profit organizations (PNPOs). Inclusion of PNPO expenditure was achieved as follows. First, in the period 1988–1996, the ratio of total household expenditure to total household plus PNPO was determined[58]. Second, the average ratio across the 1988–1996 period was used to estimate the PNPO contribution in the remaining years (i.e. 1970–1987 and 1997–2014). Next it was assumed that the defensive proportion of private expenditure on health constituted 10 percent through the entire study period[59]. The final nominal data series was converted to 2014 constant dollars by using the Consumer Price Index.

Findings

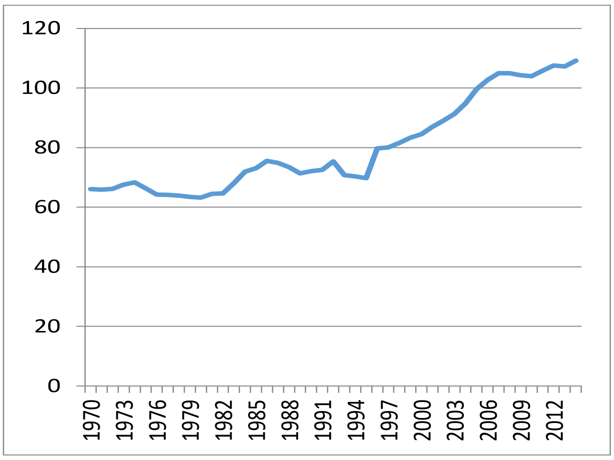

Figure 12.1 Per Capita Private Defensive Expenditure on Health, 1970-2014, $$_{2014}$ per person

Highlights

- 'Defensive expenditure on private health care' has thus far been included in the Personal Consumption data in Chapters 3 and 5 – this defensive expenditure now needs to be subtracted from the GPI accounts as it does not contribute to well-being.
- This amount is very small, but nevertheless its increase from 1996 to 2014, does reflect the growth of private expenditure on health-care over this period.

It needs to be recognised that 'Private Defensive Expenditure on Health' is a very small, constituting only on average only about 0.2% of the New Zealand GPI. However, we have included this factor in

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[57] Consistent data were not available for all years due to definition changes in the System of National Accounts (SNA68 and SNA93).

[58] On average, total household expenditure accounted for 98% of the total combined expenditure.

[59] The definition of defensive expenditure produced in the study is "expenditure on defensive measures undertaken to limit the unwanted side effects of production (economic activity)". Therefore, in the calculation of 'Private Defensive Expenditure on Health' expenditure on facemasks used to mitigate against the adverse impacts of the anthropogenic air pollution is counted. However, expenditure on facemasks would not be counted if was being used solely to mitigate against the adverse impacts of inhaling spores and pollens that would occur naturally. That is, only anthropogenic air pollution is included in the calculation of 'Private Defensive Expenditure on Health'.

the calculation of the New Zealand GPI, primarily so that it is consistent with studies overseas. Nevertheless, Figure 12.1 and Table 12.1 show some interesting trends in respect to the level of private defensive expenditure on health, which reflects the overall trends in private expenditure on health. For example, it can be seen that 'per capita Private Defensive Expenditure on Health' by New Zealand householders slightly trended downwards in the 1970s, from 1981 to 1986 it grew quite strongly, from 1987 to 1995 it trended downwards, and then from 1996 onwards there has been a steady increase in private expenditure on health every year with a few small exceptions. These trends in our data are broadly corroborated by The Treasury's (2014) data that show that over this period (1996 to 2014) health expenditure overall grew as a percentage of GDP and that this could be one of the factors behind this upward trend since 1996. In addition, over this 1996 to 2014 period, New Zealand has increasingly been reliant on private health insurance, rather than out-of-pocket payments for health care.

Table 12.1 Private Defensive Expenditure on Health, 1970 to 2014, $\$_{2014}$ per person

Year	Private Expenditure on Health		Year	Private Expenditure on Health		Year	Private Expenditure on Health	
	$\$_{2014}$ million	$\$_{2014}$ per person		$\$_{2014}$ million	$\$_{2014}$ per person		$\$_{2014}$ million	$\$_{2014}$ per person
1970	186	66	1985	239	73	2000	326	85
1971	189	66	1986	248	76	2001	338	87
1972	193	66	1987	247	75	2002	352	89
1973	201	68	1988	244	73	2003	368	91
1974	208	68	1989	238	71	2004	388	95
1975	206	66	1990	242	72	2005	412	100
1976	201	64	1991	253	72	2006	430	103
1977	201	64	1992	266	75	2007	443	105
1978	201	64	1993	253	71	2008	447	105
1979	199	63	1994	255	70	2009	449	104
1980	199	63	1995	256	70	2010	452	104
1981	203	64	1996	298	80	2011	464	106
1982	206	65	1997	303	80	2012	474	108
1983	219	68	1998	311	82	2013	477	107
1984	234	72	1999	320	83	2014	492	109

Update to 2016

Year	Private Expenditure on Health	
	$\$_{2014}$	$\$_{2014}$ per person
2015	512	111
2016	537	114

- The cost of private expenditure on health continues to increase, as it has every year since 1996. The per capita cost was $\$_{2014}$ 111 in 2015, rising to $\$_{2014}$ 114 in 2016.

13. Cost of Commuting

Why Include

As countries become increasingly urbanised and cities become larger, it is inevitable that people will spend more time and money getting to and from work; a result of greater distances travelled and increased traffic congestion (Hamilton and Denniss, 2000). Commuting and traffic congestion problems are most acute in Auckland[60] where around one third of work journeys take place according to Statistics New Zealand (2014). Not surprisingly therefore the 2014/2015 New Zealand Attitudes and Values Study found that Auckland recorded the longest commute time with an average (medium) of just under 5 hours a week, with Wellington and the Canterbury regions having average (medium) commute times of 4.4 and 4.2 hours respectively (University of Auckland and Victoria University, 2015). Most (81.7%) commuters according to the 2013 Census of Population and Dwellings use cars/trucks/van though there are again some significant regional differences, with for example higher levels of public transport use and active transport in Wellington.

What to Include

In the calculation of GDP, the direct costs of commuting are counted as a positive contribution. Such expenditure, as well as the time spent commuting, is however a drain on well-being because it limits funds available for consumption and time available for productive work and leisure. The costs associated with commuting are hence a negative parameter in the GPI. When calculating the costs of commuting, two negative contributions to well-being associated with commuting are taken into account. First, direct costs made by commuters in the pursuit of getting to work (e.g. vehicle purchases, petrol, maintenance, bus and train fares); and second, the value of time spent commuting in terms of lost productive hours in work or lost leisure time (i.e. time costs). There are other less tangible costs associated with commuting such as the stress and frustration caused by sitting in traffic which are not reflected in GPI due to difficulties in measurement.

Peryvoux *et al*. (2015) point out that there are also negative impacts from air pollution associated with commuting, particularly related to longer car commutes. The external cost of this air pollution is factored into the New Zealand Genuine Progress Indicator calculations in the air pollution component and is not therefore included in the ‘cost of commuting’ category so as to avoid double counting.

How to Include

The **direct costs** of commuting, *CC,* are calculated as follows:

$$CC = 0.23 \times (Pr - 0.10Pr) + 0.10 \times Pu,$$

where: *Pr* represents expenditure on private transportation, the first *0.10* constant incorporates a depreciation rate across the entire private transportation sector[61], *Pu* represents expenditure on public transportation, and *0.23* and the second *0.10* constant represent the share of expenditure on

[60] Leung *et al*. (2017) highlight a problem with traffic congestion in Auckland, citing data from the GPS navigation company Tom indicating that Auckland's congestion is greater than comparable cities of about the same population such as Brisbane, and now is more comparable with larger cities such as Sydney.

[61] This figure represents the depreciation rate of private vehicles (capital goods) deflated to take into account the fact that purchases of capital goods account for only a proportion of direct expenditures on commuting.

private and public transportation for commuting respectively. These shares are derived from the average distance travelled by a person for work purposes relative to total distance travelled [62].

Expenditures on private and public transportation (*Pr* and *Pu*) were calculated by multiplying total household expenditure by the percentage of household expenditure for private and public transportation (Statistics New Zealand, 2004a). Total household expenditure is estimated as 98 percent of private final expenditure.[63] The percentages of household expenditure on private and public transportation were extracted from the study of Dravitzki and Lester (2006).[64]

The **time costs** of commuting, *TC*, were calculated as follows:

$$TC = E \times CH \times C,$$

Where: *E* is total employment, *CH* is hours spent on commuting annually per employee and *C* is the cost per commuting hour.

Total employment (E) counts by commuting mode were extracted from Statistics New Zealand's *New Zealand Official Year Book* for each census year in the study period. It is interesting to note that the commuting structure in New Zealand has not varied significantly, with the proportions of employed people in each commuting mode relatively consistent over time. As a result, a linear growth rate between the dates of two census years is used to interpolate the remainder of the time series.

The Time Use Surveys (1999, 2010)[65] published by Statistics New Zealand were used to calculate the 'hours spent on commuting annually per employee' variable *(CH)*. These Time Use Surveys provided the average minutes spent per day on commuting by mode, for the years 1999 and 2010. The average annual growth rate of average minutes spent per day on commuting between the two surveyed years (1999 to 2010) was 0.41% per annum. For the years when there was no time use survey this 0.41% per annum was applied by backcasting (1970 to 1998), interpolation (2000 to 2009) and forecasting (2011 to 2014).

The cost of commuting *C* was obtained from the Project Evaluation Manual published by Transfund (1997). This cost of commuting *C* of $NZ 7.00 per hour for 1997 was adjusted for inflation by using Consumer Price Index (transportation component), to be converted to $2014.

Figure 13.1 indicates that the 'per capita' cost of commuting slightly decreased over the decade, starting in 1970 and ending in the 1980. Thereafter, the per capita cost of commuting increased strongly, and nearly doubled, from $\$_{2014}$797 per person in 1980 to $\$_{2014}$1,496 in 2014. The underpinning data indicates that there has been an increase in commuting times for cars and other commuter vehicles, which explains most of this increase. Recent evidence for Auckland from the New Zealand Institute for Economic Research (2017) indicates that congestion in the road network, results in longer travel times and is expected to deteriorate even more in the near future.

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[62] Data from the New Zealand Travel Survey (New Zealand Road Safety Trust, 1999) and the Travel Survey (Ministry of Transport 2003-2006) was used to calculate the "average distance travelled by a person for work purposes relative to total distance travelled".

[63] The proportion of final expenditure attributable to households has been discussed in Chapter 12 in relation to "Private Defensive Expenditure on Health".

[64] The percentage given in Dravitzki and Lester (2006) are categorised by high income and low income for some years only. The average "percentage of household expenditure on private and public transport" was calculated and then applied in this New Zealand GPI study.

[65] Statistics New Zealand's 1998/1999 time use survey (1 July 1998 and 30 June 1999) was assumed to be representative of the calendar year 1999. Statistics New Zealand's 2009/2010 time use survey (September 2009 to August 2010) was assumed to be representative of the calendar year 2010.

Findings

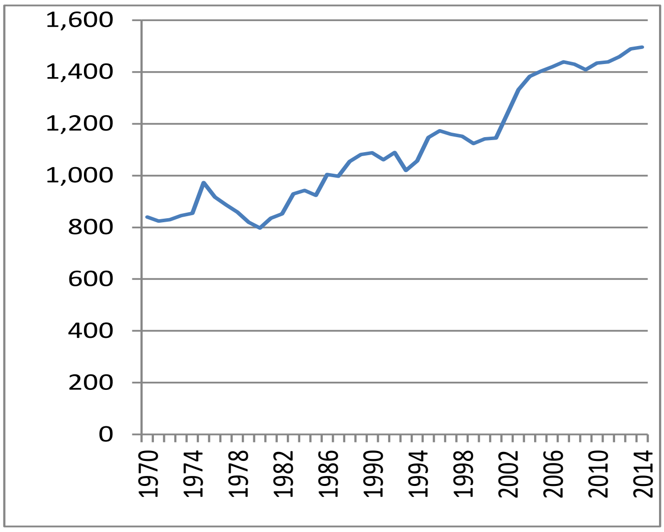

Figure 13.1 Per Capita Cost of Commuting, 1970-2014, $\$_{2014}$ per person

Highlights

- Commuting to work was the second highest cost externality, next only to deteriorating income inequality.
- Commuting to work, on a per capita basis, increased from $840 in 1970 to $1,496 in 2014 (78% increase), as kilometres travelled by vehicles increased nearly five fold.
- These per capita costs were greatest in the Auckland region, where the level of congestion is greater than similar size cities overseas.

The increase in the 'total cost' (185%) of commuting, over the 1970 to 2014 period, was even more dramatic than the increase in the 'per capita cost' (78%) – refer to Table 13.1. This is because strong population growth is driving the demand for commuting, which is reflected in the 'total cost' data, but not in the per capita cost data. The 'total cost' of commuting (direct costs like vehicle purchases, petrol, maintenance; plus time costs) rose from $\$_{2014}$ 2,369 million to $\$_{2014}$ 6,751 million in 2014, representing the second highest external costs in this GPI study ahead of all other categories other than cost of the deterioration of income equality in New Zealand.

Table 13.1 Cost of Commuting: Total and Per Capita, 1970 to 2014

Year	Cost of Commuting	
	$\$_{2014}$ million	$\$_{2014}$ per person
1970	2,369	840
1971	2,361	824
1972	2,419	830
1973	2,515	845
1974	2,599	854
1975	3,017	973
1976	2,873	917
1977	2,787	887
1978	2,698	858
1979	2,573	820
1980	2,507	797
1981	2,637	836
1982	2,710	852
1983	2,995	930
1984	3,067	943
1985	3,022	924
1986	3,290	1,004
1987	3,296	998
1988	3,498	1,054
1989	3,599	1,081
1990	3,659	1,088
1991	3,709	1,061
1992	3,846	1,089
1993	3,645	1,020
1994	3,827	1,057
1995	4,215	1,147
1996	4,378	1,172
1997	4,385	1,159
1998	4,395	1,152
1999	4,311	1,123
2000	4,405	1,141
2001	4,449	1,145
2002	4,892	1,238
2003	5,363	1,331
2004	5,655	1,383
2005	5,802	1,403
2006	5,942	1,420
2007	6,083	1,439
2008	6,097	1,430
2009	6,064	1,409
2010	6,243	1,434
2011	6,312	1,439
2012	6,438	1,460
2013	6,624	1,490
2014	6,751	1,496

Update to 2016

Year	Cost of Commuting	
	$\$_{2014}$ million	$\$_{2014}$ per person
2015	6,908	1,502
2016	7,118	1,516

- The cost of commuting rose from $\$_{2014}$ 6,908 million in 2015 to $\$_{2014}$7,118 million in 2016, primarily driven by a trend of increasing minutes per person per day spent on commuting.
- On a per capita basis, this amounts to $\$_{2014}$1,502 in 2015 to $\$_{2014}$ 1516 in 2016.
- These increases are a continuation of a trend that began in the early 1980s which has seen the cost of commuting steadily increase most years since then.

14. Cost of Crime

Why Include

Despite the suffering caused by crime and the negative impacts it creates on quality of life, higher rates of crime can actually be counted as a positive contribution to GDP due to the increased expenditures on policing, security, replacing property and the like. By contrast, in the calculation of the GPI, a peaceful and secure society is viewed as a valuable social asset, and higher crime rates are regarded as signifying a deterioration or depreciation of social capital (Dodds and Colman, 1999). The purpose of this component is therefore to determine the costs associated with crime. These are regarded as a negative contribution to the GPI on the basis that such costs are expenses that could have been invested in more productive and welfare enhancing activities.

As all of the ***public sector costs*** of crime (e.g. policing, justice systems, prisons and so on) have already been considered in the defensive public expenditure component of the GPI (Chapter 6 on Public Services), only the following ***private costs*** associated with property and serious traffic crimes are considered in this chapter:

- Property loss. It could be argued, in strict economic terms, that theft does not result in any loss of well-being as it represents a property transfer (from the owner to the thief), and not a loss. Given however that a thief acquires goods by dishonest means to the detriment of the social fabric, it is argued that this is a loss that needs to be accounted for. We therefore value property loss resulting from robbery, burglary and theft.
- Property damage.
- Serious traffic offences.
- Preventative expenditure*.* The cost of insurance premiums, alarms and the like.

Medical and other expenses incurred as a result of violent crime and sexual offences are deemed to be a defensive aspect of personal and public consumption, and are therefore already considered in Chapters 6 and 12. The trauma experienced by the victims of crime in terms of psychological distress, heightened anxiety and feelings of insecurity can seriously curtail an individual's ability to conduct a normal lifestyle. For example, an elderly person may not go out at night to socialise with friends due to feelings of insecurity. These hidden aspects of the effects of crime are difficult to quantify and have not been included in the NZ GPI. Similarly, the personal time lost as a result of crime (filing police reports, obtaining insurance quotes and so on) is also difficult to quantify, and has not been included.

How to Include

The cost of crime, CC, is measured by multiplying the total actual offences occurring each year by the estimated cost per crime according to the equation,

$$CC = O \times C$$

where O is the total number of property and serious traffic offences and C is cost per offence in the private sector:

***Step 1: Estimation of the Total Number of Property and Serious Traffic Offences*.** As the methods used to record crimes have changed over time, it is very difficult to compile a single data set of recorded crimes consistent for the entire study period[66]. To accommodate definitional changes in

[66] To complicate matters further, the definition of an offence has changed many times during the years of the study. The consumption of alcohol by 18 and 19-year-olds, for example, ceased to be an offence when the drinking age was lowered to 18 in December 1999 (Statistics New Zealand, 2001d).

the NZ Police crime recording methods during the study period, the number of property and serious traffic offences committed for a particular year was taken to be a set percentage of 70 percent, of the total recorded offences for that year. This percentage is based on Roper and Thompson (2004) who estimated that 70% of the total recorded offences in 2003/04 were property and serious traffic offences.

The 'total recorded offences' data provided by the New Zealand Police for the years 1970-2000 are based on a December year, while the given offences for years after 2000 are based on a June year (New Zealand Police, 2006). The latter statistics were converted to a December year using a Rebasing Method, with figures then being rescaled using a multiplier of 4.3[67] in order to better reflect the actual number of offences (both recorded and unrecorded) in each year.

Step 2: Total Cost of the Total Number of Property and Serious Traffic Offences. Roper and Thompson (2004) estimated the total costs of crime in 2004 are $9.14 billion. Subtracted from this figure were the values of all public sectors (23%) which have already been covered in Chapter 6; and all private sector costs by violent offences (23%) and sexual offences (11%) which have already been covered in Chapter 12.

Step 3: Cost per Property and Serious Traffic Crime in the Private Sector. The average cost per property/serious traffic crime for the year 2004 was derived by dividing the estimated total cost for that year (from Step 2) by the estimated number of property and serious offences as reported by Roper and Thompson (2004)[68]. Finally, the estimated 2004 value of $2,896[69] was inflated to 2014 constant dollars by using the New Zealand Quarterly Property Index. This average cost per offence is assumed to be the same through the remainder of the study period.

Findings

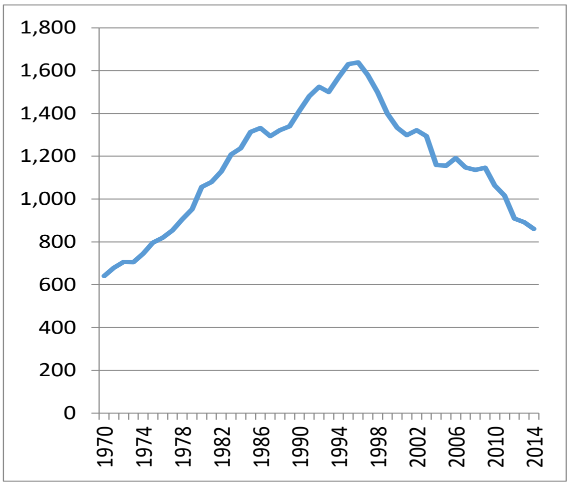

Figure 14.1 Per Capita Cost of Crime, 1970-2014, $$_{2014}$ per person

Highlights

- The cost of crime in is significant being estimated to be $3,669 million in 2016, with some additional costs also included in the other GPI components.
- Cost of crime in New Zealand follows a similar pattern to other developed countries – increasing from 1970 to a peak in 1996, and then decreasing nearly every year from this peak.
- The causes behind this pattern of decline in crime since 1996 are sometimes contested and generally not well understood.

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67 The multiplier is extracted from the work of Roper and Thompson (2004) who, based on work undertaken in the UK, derived an average multiplier of 3.92 for all crimes taking account of differing reporting rates for different crime types. This average multiplier increases to 4.3 when only property and serious traffic offences are considered.

68 This cost also includes the private expenditure on insurance premiums, alarms and the like.

69 The cost per property/serious traffic crime is initially estimated at $20042,847 for the March year. This translates to $20042,896 for the December year when adjusted by the New Zealand Quarterly Property Index.

It important to note that the results presented in this section, do not include the cost of all crime taking place in New Zealand, as to do so would constitute double counting, when adding up the component parts of the New Zealand GPI. That is, public sector costs of crime (e.g. policing, Justice system, prisons and so on) have already been considered in Chapter 6; and medical and other expenses resulting from violent crime and sexual offences are covered in the defensive expenditure aspect of consumption of public services (Chapter 6) and in the component 'Private Defensive Expenditure on Health' (Chapter 11). With these provisos in mind, the cost of the crime that was counted in this chapter, over the 1970 to 2014 time period, shows a similar trend to that observed in several other developed countries, most notably the United States and United Kingdom (Friedmann *et al*., 2017). That is, as is shown by Figure 14.1, the cost of crime increased steadily almost year-on-year from 1970 to a peak in 1996, and then this trend was reversed with the cost of crime decreasing from 1996 to 2014.

Table 14.1 shows the *total cost of crime*, increasing from $\$_{2014}$ 1,807 million in 1970 to a peak of $\$_{2014}$ 6,115 million in 1996. This was followed by a decline in the total costs of crime to $\$\$_{2014}$ 3,882 million in 2014. This pattern of decline in the total cost of crime since a peak in 1996, is not well understood, and furthermore contradicts public opinion that wrongly perceives that crime rates have increased over this time. For example, a random sample survey of 1,500 New Zealand adults by Paulin, Searle and Knaggs (2003) found that 83% of the sample believed that crime had increased over the two years prior to the survey, when it had actually done the opposite.

Figure 14.1 shows that the crime cost per capita, over the 45 year period, was at its lowest in 1970 at $\$_{2014}$641 per capita. However from this low point in 1970, over the next 26 years the per capita cost rose to a peak of $\$_{2014}$1,638 in 1996, with every year recording an increase with the exception of 1973 and 1986. Over this 1970 to 1996 period, the per capita cost of crime increased by 2.55 times.

Table 14.1 Cost of Crime: Total and Per Capita, 1970 to 2014

Year	Cost of Crime $\$_{2014}$ million	$\$_{2014}$ per person	Year	Cost of Crime $\$_{2014}$ million	$\$_{2014}$ per person
1970	1,807	641	1993	5,360	1,500
1971	1,944	679	1994	5,678	1,568
1972	2,058	706	1995	5,992	1,630
1973	2,100	705	1996	6,115	1,638
1974	2,269	746	1997	5,973	1,579
1975	2,469	796	1998	5,719	1,499
1976	2,566	819	1999	5,368	1,399
1977	2,684	854	2000	5,145	1,333
1978	2,846	906	2001	5,048	1,299
1979	2,989	953	2002	5,222	1,322
1980	3,323	1,057	2003	5,209	1,293
1981	3,407	1,079	2004	4,741	1,160
1982	3,590	1,129	2005	4,780	1,156
1983	3,895	1,209	2006	4,988	1,192
1984	4,026	1,238	2007	4,851	1,148
1985	4,297	1,314	2008	4,839	1,135
1986	4,364	1,332	2009	4,936	1,147
1987	4,273	1,293	2010	4,627	1,063
1988	4,382	1,321	2011	4,459	1,017
1989	4,461	1,339	2012	4,010	909
1990	4,748	1,412	2013	3,967	892
1991	5,173	1,480	2014	3,882	860
1992	5,384	1,524			

After this peak in crime costs per capita (and in total costs) in 1996, there was a steady decline from 1996 to 2014 every year except for 2000 and 2009. As pointed out by Maxwell (2009) there has been a decline in all categories of reported crime except technology-related crimes, although the reported composition of crime remained relatively constant with theft and property crimes dominating.

There has been much speculation about the root causes and proximal causes of the declining crime rates (and hence cost) since 1996 in New Zealand – as there has been for other developed countries that have experienced similar trends. Maxwell (2009), for example, suggests that this decline in crime rates could be due to "economic patterns, better security, and changes in culture and lifestyle" as well as improved "police effectiveness" deterring criminal activity.

Update to 2016

Year	Cost of Crime $\$_{2014}$ million	$\$_{2014}$ per person
2015	3,774	821
2016	3,669	781

- The number of recorded offences continued to drop in 2015 and even further in 2016. In 2014, there were 224,113 recorded offences, decreasing to 217,891 recorded offences in 2015 and decreasing even further to 211,832 recorded offences in 2016.
- These translated into a per capita cost of crime of $\$_{2014}$ 821 in 2015 and $\$_{2014}$781 in 2016, which is a continuation of a trend since 1992 of decreasing per capita cost of crime.

15. Deforestation of Indigenous Forests

Why Include

Most Genuine Progress Indicators at a national and subnational level take account of the costs of the depletion of forests resources, particularly so-called "old growth" forests: China (Wen *et al*., 2007); Alberta (Anieslski, 2001); United States (Cobb *et al*., 2001), Hawaii (Ostergaard-Klem and Olesen, 2014); South Korea (Feeny *et al.,* 2013); and Brazil (Andrada and Garcia, 2015). Although deforestation of indigenous forests in New Zealand , has been debated since the 1970s, it is important to include this in the calculation of the New Zealand GPI, not only for comparative purposes with other countries, but also because of the legacy losses of ecosystem services and other values due to significant deforestation of indigenous forests in the 46 years covered by this GPI analysis.

Public opposition to clear felling of indigenous forests such as South Island beech forests in the 1970s and later on individual forests (Okarito, Pureora, Waihaha and Whirinaki) resulted in a decline in the volume of logging on a year-by-year basis. A number of Accords in the 1980s and early 1990s (1986 West Coast Forest Accord, 1989 Tasman Accord, 1991 NZ Forest Accord) played a significant role in decreasing logging of indigenous forests. Eventually, by 1993, the Government passed the Forests Amendment Act which required that indigenous wood products may only be produced from forests with an approved sustainable management plan or permit.

When forests are cut, the value of the products produced from the tree and the services and labour used in the process contribute to GDP. These dollar amounts reflect the exchange value of timber in the market place and are determined by supply and demand for timber products. This is the 'use' value of the timber only and does not take into account the other non-use services that forests provide. There are no markets for forest ecosystem services or regulations that require these to be maintained at optimal levels so ecosystem services provided by forests are not valued. Such services include: open access to non-priced recreation, landscape amenity, prevention of soil erosion, sediment control, maintenance of biodiversity, providing a habitat for wildlife, carbon sequestration, pollution absorption, protecting watersheds, and tourism promotion.

Data Available

Reliable time series data from the Ministry of Primary Industries (2016) is available on the volumes (m^3) of indigenous forests harvested each year, from 1951 to 2015. Most of the current harvesting does not clear the forest but targets key species of trees that, depending on the species, range between 250 and 500+ years in age. While the removal of these trees does impact on the forest ecosystem, natural processes allow rapid regeneration.

Surveys estimates indicate the total indigenous forest area is currently 6.256 million ha (23.3% of New Zealand's land area). This figure is based on a 1974 revision of the 1955 and 1963 National Forest Surveys. Adjustments were made to private merchantable forest to allow for loss of forest through roundwood removals since 1974 and for some re-allocation in forest use. During the late 1970s and early 1980s government subsidies resulted in the clearance of indigenous forest for other land uses. It is estimated approximately 25,000 ha of cutover forest were converted to exotic forest, and additional forest was lost to farming on private land. However, this loss was frequently offset by other heavily cutover or partially cleared areas reverting to indigenous forest.

It is more difficult to obtain reliable data on the valuation of losses (in ecosystem services and other values), which is applicable to the New Zealand situation. Nevertheless, Patterson and Cole's (1999, 2013)[70] study calculates the direct, indirect and passive values of New Zealand forest ecosystems in 1994.

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[70] Patterson and Cole's (1999) analysis of the value of ecosystem services in New Zealand, was updated and refined by Patterson and Cole (2013). For consistency sake with other published studies, the $/ha data from Patterson and Cole (1999) for passive values were retained in this GPI analysis.

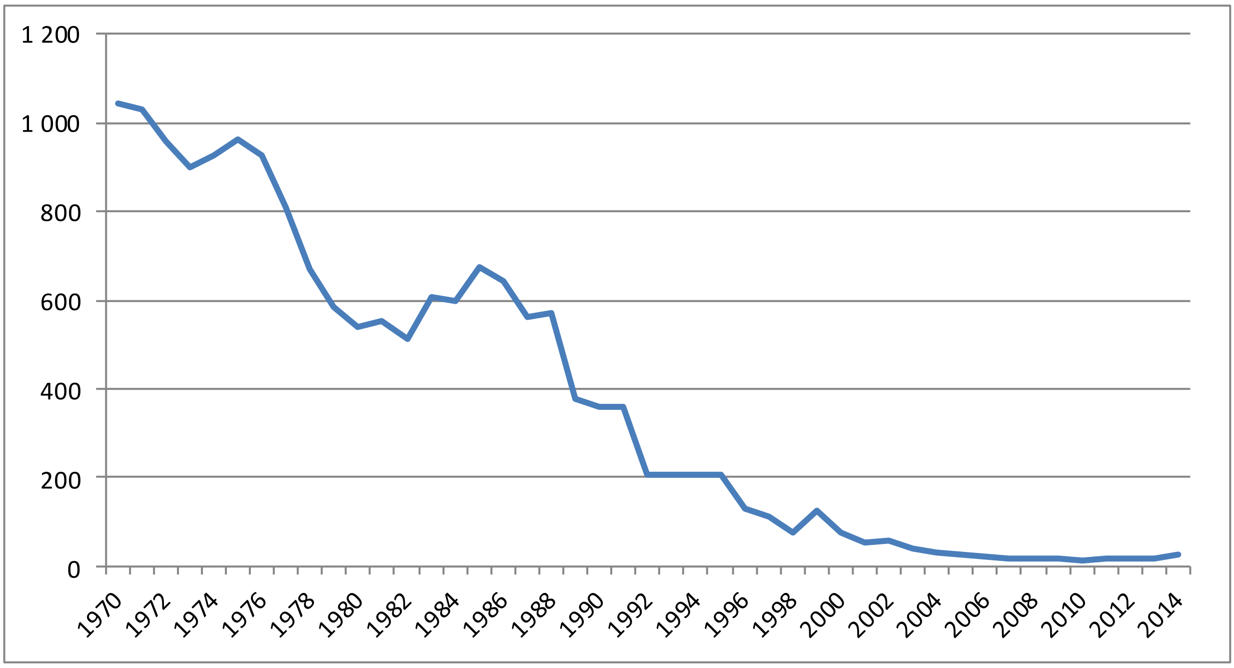

Figure 15.1 Estimated Removals from Indigenous New Zealand Forests, 1970–2014, 000m^3
Source: Ministry of Primary Industries (2015)

In this GPI study, when indigenous forest is milled, it is assumed to revert to forest scrub. Forest scrub provides similar levels of direct and indirect ecosystem services as forest ecosystems; so the net difference (between forest ecosystems and scrub) is the loss of passive value. This passive value[71] (or non-use value), is where there is no direct 'use' of forest ecosystems, but nevertheless it has significant value. Passive value itself consists of, and is the sum total of: option value[72], bequeath value[73] and existence value[74].

The Patterson and Cole (1999, 2013) study was based on 6,330,000 ha of forest ecosystems, which equates to a net value of forest at NZ_{1994}$ 871 per ha or NZ_{2014}$ 1,344 per ha. In our GPI study, this value used to estimate the loss from each hectare of indigenous forest milled. The NZ_{20014}$ 1,344 per ha value applied is however considerably lower than the value for preservation of virgin boreal forest in Norway, a country similar to New Zealand, with a relatively low population density, and abundance of forests. In this regard, Turner *et al.* (2003) cite a study that showed Norwegians were willing to pay at least US_{2000}$4,500 per ha and a maximum of about US_{2000}$6,500 per ha for preserving existing virgin boreal forest stocks.

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[71] Some scholars claim 'passive value' to be the same as 'intrinsic value'. We disagree with this assertion as 'intrinsic value' by definition, is value: "in itself," or "for its own sake," or "as such," or "in its own right." On the other hand, 'passive value' is the value ascribed by humans, in contrast to the above definitions of intrinsic value all of which necessarily exclude human ascribed values.

[72] Option value is the willingness to pay for the preservation of an ecosystem/resource against some probability that an individual will make use of the ecosystem/resource at a later date.

[73] Bequeath value is the willingness to pay to preserve an ecosystem/resource so that future generations can gain the benefit from that ecosystem/resource.

[74] Existence value is how much an individual is willing to pay to preserve an ecosystem/resource, even though that individual may never intend to use that ecosystem/resource. For example, an individual may wish to preserve tuatara on an offshore island of New Zealand, but have no intention or inclination of ever visiting such an island because of its isolation.

How to Include

First, the number of hectares affected by harvesting indigenous forests in New Zealand, for each year from 1970 to 2014 was calculated by:

$$\Delta\ In_{ha} = In_{m3} \times In_{ha/m3}$$

where:

$\Delta\ In_{ha}$ = loss of indigenous forests (hectares), be solved for
In_{m3} = harvest of indigenous forests in (cubic meters)
$In_{ha/m3}$ = conversion factor (hectares per cubic metres)

The annual harvesting or removal of indigenous forests (In_{m3}) was obtained from data compiled by the Ministry of Primary Industries (2015), which is graphically depicted for each year by Figure 15.1. The conversion factor ($In_{ha/m3}$) for converting cubic metres of harvest (In_{m3}) to hectares of indigenous forest lost (Δ In_{ha}) was calculated using data from the Ministry of Forestry (1988) for beech trees – that is, sawlog volumes in unmanaged beech forests range from 70 to 200 cubic metres per hectare (Ministry of Forestry, 1998) so the mid-point of 135 cubic metres per hectare was used for the conversion rate in this GPI study. The choice of beech trees for calculating the conversion factor ($In_{ha/m3}$) is justified on the basis that beech forest represents two-thirds of New Zealand's 6.4 million hectares of indigenous forest (Ministry of Forestry, 1998).

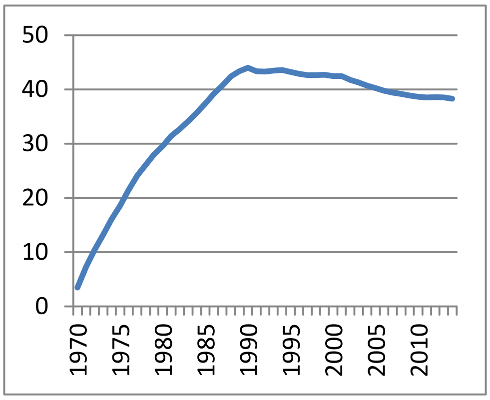
Second, the estimated annual cost of losing indigenous forests by harvesting is then calculated by multiplying the number of lost hectares of indigenous forests (Δ In_{ha} from equation 15.1), by the passive value of each hectare of indigenous forests which is estimated by Patterson and Cole (1999) to be $\$NZ_{2014}$ 1,344 per ha. As pointed out above, although there was a loss of ecosystem services from removing indigenous trees, it is argued that in this GPI study, that when indigenous forest is removed it is assumed to revert back to forest scrub – and this forest scrub provides similar levels of indigenous forests ecosystem services, so the *net difference is loss of passive values* with indigenous forests be having higher passive values than forest scrub as quantified by Patterson and Cole (1999, 2013).

Within the timeframe of this study, given that it takes in a range of about 250 to 500 years for indigenous forest to re-establish itself, it is assumed that any losses of value in removing indigenous forests will be essentially 'permanent' within the timeframe of this GPI study, and therefore it is appropriate to accumulate losses. Applying this simplifying assumption is standard practice in overseas Genuine Progress Indicator analyses.

Findings

Figure 15.2 shows that the cost per capita of harvesting indigenous forests increased strongly until the late 1980s and early 1990s when the effects of public opposition to harvesting indigenous forests and the Accords (1986 West Coast Forest Accord, 1989 Tasman Accord, 1991 NZ Forest Accord) played a significant role in restricting the amount of harvesting of indigenous forests. Over the period from 1970 to 1990, as reported by Ministry of Primary Industries (2015) annual harvesting of indigenous forest decreased from 1,042,000 m^3 in 1970 to 357,000 m^3 in 2014.

After a peak in 1990, of the per capita cost of \$44 (for the deforestation of indigenous forests), this per capita amount decreased very slowly but consistently to eventually become \$38 per person in 2014. The reason for this decline in per capita cost from the 1990 peak, is that the total cost slowed down to the extent that it was outstripped by population growth – refer to Table 15.1.



Highlights

- This 'deforestation of indigenous forests', is the lowest of all of the components included in the NZ Genuine Progress Indicator. This is largely attributable to the very dramatic decline of milling of indigenous forests brought about by various Forest Accords in the 1980s and early 1990s.
- On a per capita basis, the loss of indigenous forest ecosystem services due to milling, in 2014, was estimated to be only $38 per capita or $173 million in total.

Figure 15.2 **Per Capita, Cost of Deforestation of Indigenous Forests, 1970-2014, $$_{2014}$ per person**

Table 15.1 **Cost of Deforestation of Indigenous Forests: Total and Per Capita, 1970 to 2014**

Year	Cost of Deforestration		Year	Cost of Deforestration	
	$$_{2014}$ million	$$_{2014}$ per person		$$_{2014}$ million	$$_{2014}$ per person
1970	10	3	1993	155	43
1971	21	7	1994	158	44
1972	31	10	1995	159	43
1973	39	13	1996	160	43
1974	49	16	1997	161	43
1975	57	19	1998	163	43
1976	67	21	1999	164	43
1977	76	24	2000	164	42
1978	82	26	2001	165	42
1979	88	28	2002	165	42
1980	93	30	2003	166	41
1981	99	31	2004	166	41
1982	104	33	2005	166	40
1983	110	34	2006	166	40
1984	116	36	2007	166	39
1985	122	37	2008	167	39
1986	128	39	2009	167	39
1987	134	41	2010	168	39
1988	141	42	2011	169	39
1989	144	43	2012	170	39
1990	148	44	2013	171	39
1991	152	43	2014	173	38
1992	153	43			

Update to 2016

Year	Cost of Deforestration	
	$\$_{2014}$ million	**$\$_{2014}$ per person**
2015	175	37
2016	177	37

- The Ministry for Primary Industries (2017) data for annual forestry production reports 22,730 m³ of indigenous roundwood was extracted in 2015, followed by 17,630 m³ in 2016.
- This translates into a very small loss of indigenous forests – a total cost of $\$_{2014}$ 177 million and per capita cost of $\$_{2014}$ 37 per person 2016, which is very similar to the valuation data we have recorded over the last decade.

16. Cost of Biological Pests

Other GPIs do not include the environmental cost of pests and weeds. This component has been included for New Zealand GPI as introduced invasive animal pests have been identified as the single greatest threat to New Zealand's indigenous land-based biodiversity, surpassing even habitat loss (Department of Conservation and Ministry for the Environment, 1998). New Zealand's geographical isolation and absence of native mammalian predators (except for two species of small bat) mean flora and bird species have evolved lacking defensive mechanisms to deter predation, and are therefore particularly vulnerable to introduced pests (Markey, 2006). In addition, the temperate climate makes growing conditions ideal for many introduced plant species. The valuation for pests and weeds covers only the damage from human interference, not naturally occurring ecological change.

The annual cost of pest control in New Zealand will continue to rise, even if no new organisms are introduced, because some pests already established have not yet become invasive (Hackwell and Bertram, 1999). In the report "Pests and Weeds – A Blueprint for Action", Hackwell and Bertram (1999) estimated that defensive and production loss in New Zealand from plant and animal pests cost NZ$840 million per year, or approximately 1% of GDP. A 2006 estimate of the true cost of just weeds in New Zealand was around $3 billion a year. Of this amount, $1.2 billion per year is the cost to the pastoral sector of weed control and lost arable pasture. The remaining $1.8 billion is the cost to other production industries (e.g., forestry) and weeds in the conservation estate (S. Fowler and G. Bourdot, pers. comm., 29.11.06).

Why Include

Pest damage impacts on the well-being of New Zealanders as invasive plants and animals alter ecosystems, kill bird species and affect the social enjoyment of natural areas. Most pest species established in New Zealand were introduced to promote economic growth. Prime examples of this are possums introduced for the fur trade and gorse brought in to provide fences to keep animals confined. The negative adjustment associated with pests and weeds in the GPI is the cost of the environmental deterioration such economic activity has caused.

Since human arrival, at least 31 species of introduced mammals have established wild or feral populations (King, 1990, 2001). Possums are considered the primary threat to New Zealand's forests, with impacts ranging from negligible, to compositional change, to complete canopy collapse over wide areas (Rose *et al.*, 1992; Payton *et al.*, 1997; Payton, 2000).

Over 2,000 introduced plant species have become established in the wild, with around 240 of these species having been noted as weeds that significantly impact on natural communities (Department of Conservation, 2006). Weeds have invaded nearly all types of native habitats, but some habitats, such as lowlands, wetlands and coastal areas, are at greater risk than others, as they are already under stress from human development and habitat fragmentation (Department of Conservation, 2006). The number of known invasive species has grown steadily at an average of eight species per year since the 1960s (Department of Conservation, 2005). It has been predicted that if weed invasions are not controlled, they will threaten natural areas covering more than 575,600 hectares in the next 10 to 15 years. This is a conservative figure, as it does not include some existing control programmes and new high priority sites identified in conservancy inventory work (Department of Conservation, 2006).

Data Available

Hackwell and Bertram (1999) provide data on the cost of pest control by central and regional governments between 1991 and 1999. From 2000 onwards, expenditure by the Department of Conservation on species and habitat protection (Annual Reports, Vote Conservation and Vote Biosecurity) and MAF on border control and quarantine statistics was used (Annual Reports, Vote Biosecurity). Regional Council spending has been estimated based on the Waikato Regional Pest

Management Strategy – Operative 2002–2007, as well as Waikato Regional Council's pest management plan 2013-2014.

How to Include

Table 16.1 outlines pest-related expenditure estimates for the period 1991–2014, including the categories: Central Government Funded, Agriculture and Horticulture Sector, Household Expenditure, Regional Council Funded and Pest Related Research.

Central Government funded expenditure on pest control is calculated from 1991 to 2014 from The Treasury budgets for 'Vote Biosecurity', 'Vote Conservation', and 'Supplementary Estimates', as well as from Annual Reports from the Ministry of Agriculture and Forestry, Ministry for Primary Industries and Department of Conservation. These data for the March year needed to be converted to calendar year by using the simple ratio method.

Regional Council expenditure is estimated as $20–25 million per year between 1991 and 1999 (Hackwell and Bertram, 1999). From 2000 onwards all Regional Council expenditure has been increased in line with budget costs in the Waikato Regional Pest Management Strategy – Operative 2002–2007, and the Waikato Regional Council's pest management plan 2013-2014.

The Agricultural Sector and Other Sectors undertake substantial expenditure just to control animal and plant pests. Data on this were obtained from the New Zealand System of National Accounts. This figure is an underestimate as it excludes labour and capital employed in agricultural pest control.

Households in New Zealand also incur costs to control insect, animal and plant pests in both their houses and gardens (Hackwell and Bertram, 1999). This study used Hackwell and Bertram's (1999) estimate of $20 per household per year for pest related spending, which was multiplied by the number of households.

Research into pest-related topics is funded by the New Zealand government New Zealand government funds. Limited data availability has, however precluded exact quantification of this research spending (Hackwell and Bertram, 1999). Hackwell and Bertram have estimated that $40 million was spent on research in 1996/97, and have justified this estimate on the basis of biosecurity-related research contracts under the Public Good Science Fund and the Marsden Fund (Hackwell and Bertram, 1999). This study took this figure of $40 million for research in 1997 and divided it by the sum total of the other defensive expenditures for 1997 to estimate the proportion of spending that is allocated to research each year. This proportion was then used to estimate research expenditure for the other years between 1991 and 2014.

All expenditures were then summed to give an estimate for total defensive expenditure from 1991 to 2014 (see Table 16.1). No reliable data are available for the period 1970-1990[75] – therefore for the purposes of the GPI calculation we indicatively back-casted from 1990 at a 1% pa level of decline in expenditure.

[75] The only data we could uncover for this period was the total receipts of Nassella Tussock Districts and Pest Destruction Districts (Local Authority Statistics, 1969/70–1987/88). These data were not sufficient to generate 1970-1990 time series compatible with the categories in Table 16.1.

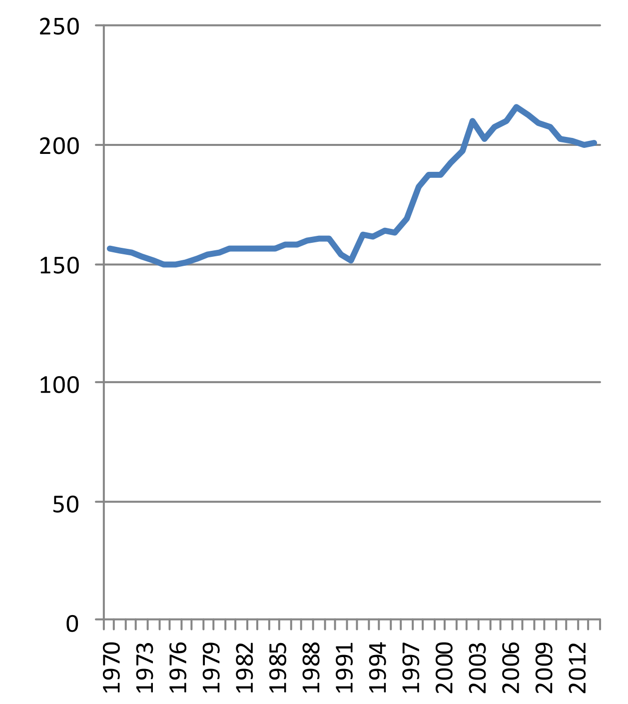
Table16.1 Identified Pest-Related Expenditure by Activity $$_{2014}$ million, 1991-2014

Year	Central Government												Agriculture and Other Sectors		Household Expenditure	Regional Councils	Research	Total
	Policy Advice	Border Control and Quarantine	Pest Surveillance and Response	TB Vector Control	Rabbit and Land Manage-ment	Pest Control on Conser-vation Estate	Protected Species and Island Habitats	Agricultural Security	Noxious Plants Control	Pest Manage-ment	Other	Sub-Total	Weed and Pest Control by the Agriculture Sector	Weed and Pest Control by Other Sectors				
1991	22.24	25.30	35.93	0.24	6.48	38.74	16.38	3.91	1.47	1.83	5.50	158.03	207.03	52.31	36.54	26.77	57.93	538.61
1992	7.21	26.40	43.26	0.00	4.03	28.11	21.02	4.03	0.73	0.00	1.83	136.64	224.39	49.74	36.91	29.45	57.93	535.06
1993	7.21	27.13	34.34	0.00	2.32	21.88	22.12	6.11	0.00	1.10	0.00	122.22	278.04	52.19	37.40	31.53	57.93	579.30
1994	7.21	28.23	37.03	12.10	0.00	35.44	21.88	4.52	0.00	0.86	0.00	147.27	253.35	54.75	37.89	32.88	57.93	584.07
1995	7.21	29.82	35.32	18.58	4.52	36.05	23.47	4.77	0.00	0.98	0.00	160.71	251.89	57.32	38.50	37.15	57.93	603.50
1996	7.21	33.12	33.12	25.18	0.00	38.62	29.58	5.62	0.00	1.10	0.00	173.55	243.21	59.03	39.11	34.34	57.93	607.17
1997	7.21	46.32	34.46	18.82	0.00	41.31	36.66	0.00	0.00	0.00	0.00	184.79	260.56	63.06	39.72	31.41	57.93	637.48
1998	11.61	40.70	37.40	23.59	0.00	46.93	43.88	0.00	0.00	2.57	14.79	221.46	275.11	71.74	40.33	33.98	53.53	696.14
1999	7.82	42.29	28.97	27.99	0.00	52.31	46.44	0.00	0.00	2.93	10.76	219.50	298.21	73.70	40.82	33.24	53.53	719.00
2000	7.58	42.53	29.58	0.00	0.00	4.40	119.53	0.00	0.00	0.00	0.00	203.61	322.04	72.96	40.45	31.78	52.31	723.15
2001	7.58	44.00	32.63	0.00	0.00	3.54	129.18	0.00	0.00	0.00	0.00	216.93	333.41	76.75	39.23	31.41	50.11	747.84
2002	6.84	51.21	40.94	16.13	0.00	36.42	43.02	0.00	0.00	0.00	0.00	194.57	385.84	77.49	39.35	32.02	49.62	778.88
2003	7.33	54.26	74.92	18.33	0.00	38.25	44.61	0.00	0.00	0.00	0.00	237.71	396.59	87.14	39.48	35.93	48.89	845.74
2004	11.73	63.31	74.55	15.89	0.00	43.75	42.90	0.00	0.00	0.00	0.00	252.25	369.70	87.38	38.86	33.98	47.18	829.24
2005	12.12	67.24	67.88	20.51	0.00	41.20	50.16	0.00	0.00	0.00	0.00	259.13	384.64	90.29	37.80	40.55	46.38	858.78
2006	12.39	70.62	61.26	26.20	0.00	38.42	58.03	0.00	0.00	0.00	0.00	266.93	402.70	93.66	38.30	31.68	45.12	878.38
2007	12.85	75.27	56.09	33.97	0.00	36.36	68.12	0.00	0.00	0.00	0.00	282.65	415.50	98.08	38.76	32.31	44.54	911.84
2008	12.65	78.64	56.46	34.65	0.00	35.27	68.47	0.00	0.00	0.00	0.00	286.13	419.64	99.19	39.12	21.75	41.37	907.21
2009	12.45	82.97	59.62	33.48	0.00	35.08	66.69	0.00	0.00	0.00	0.00	290.30	414.18	99.48	39.40	19.28	38.26	900.89
2010	12.41	88.62	63.74	32.74	0.00	35.33	65.75	0.00	0.00	0.00	0.00	298.57	410.64	100.78	39.68	17.92	35.63	903.22
2011	11.06	91.86	63.07	31.96	0.00	33.42	48.35	0.00	0.00	0.00	0.00	279.72	422.27	98.17	39.93	16.20	32.33	888.61
2012	9.74	96.95	62.58	32.04	0.00	31.82	32.48	0.00	0.00	0.00	0.00	265.62	438.44	96.97	40.22	18.02	29.64	888.91
2013	8.60	102.47	62.19	32.17	0.00	30.34	21.86	0.00	0.00	0.00	0.00	257.63	451.13	96.64	40.58	17.29	26.96	890.23
2014	6.35	102.92	75.36	32.23	0.00	29.85	14.67	0.00	0.00	0.00	0.00	261.38	462.58	98.53	41.01	16.71	24.61	904.82

Data Sources and Calculations:

1. 1991-1999. Adapted from Hackwell and Bertram (1999).
2. 2000-2014. Central Government Expenditure from The Treasury budgets and the Departmental Annual Reports. Other sources of data and calculations, refer the text details.

Findings



Highlights

- Unlike overseas GPIs, pest control is included in the NZ Genuine Progress Indicator due to the importance of protecting both our unique biodiversity and productive sector from potential foreign pests.
- No actual data of pest control before 1991 are available, so they were estimated.
- The cost of pest control increased from from 1993 to a peak in 2007 of \$216 per capita, which by 2014 had slighly declined to \$200 per capita. This makes pest control as one of the lowest (13th) costs in the GPI.

Figure 16.1 Per Capita Cost of Biological Pests, 1970-2014, $\$_{2014}$ per person

The cost of pest control defensive expenditures increased from an estimated $\$_{2014}$ 441 million in 1970 to $\$_{2014}$ 905 million in 2014, although it should be noted that the estimates from 1970 to 1990 are crude (refer to Table 16.1). Once the data is normalised in terms of per capita expenditure (refer to Figure 16.1), there is also an increase in expenditure on pest control, from, $\$_{2014}$156 per capita in 1970 to $\$_{2014}$200 per capita in 2014. The magnitude of these data on the cost of pest control in New Zealand, justifies its inclusion in the New Zealand GPI as this is a significant cost, which is larger than some of the other costs recorded in the GPI.

From 1991 to 2014, there is a more robust picture of the changes in pest control expenditures in New Zealand based on the work of Hackwell and Bertram (1999), as well as our detailed analysis of government budgets, regional council expenditure, research expenditure and other data. This analysis shows that expenditure on pest control steadily increased from $\$_{2014}$ 538 million in 1991 to a peak of $\$_{2014}$ 912 million in 2007. Since this peak in 2007, over the 2008 to 2014 period, pest control expenditure flattened off and on a per capita basis, slightly declined. The strong upward trend in pest control expenditure from 1991 to 2007 was due to weed and pest control expenditure in the agricultural sector which doubled (100.7% increase), border control and quarantine services which nearly tripled (an extra 197.5% increase), and a significant growth in expenditure on pest surveillance (56.1% increase).

Finally, of note, over the 1991 to 2014 period, there was growth (69.1%) in the overall expenditure of pest control, but there was however a slight decline in pest control expenditure in the conservation estate (-6.2%), as well as declines of expenditure of pest related research (-23.%) and policy advice related to pest control (-42.3%).

Table 16.2 Cost of Pest Control: Total and Per Capita, 1970 to 2014

Year	Cost of Pest Control $\$_{2014}$ million	Cost of Pest Control $\$_{2014}$ per person	Year	Cost of Pest Control $\$_{2014}$ million	Cost of Pest Control $\$_{2014}$ per person
1970	441	156	1993	579	162
1971	445	155	1994	584	161
1972	450	154	1995	604	164
1973	454	153	1996	607	163
1974	459	151	1997	637	169
1975	464	150	1998	696	182
1976	468	150	1999	719	187
1977	473	150	2000	723	187
1978	478	152	2001	748	192
1979	483	154	2002	779	197
1980	487	155	2003	846	210
1981	492	156	2004	829	203
1982	497	156	2005	859	208
1983	502	156	2006	878	210
1984	507	156	2007	912	216
1985	513	157	2008	907	213
1986	518	158	2009	901	209
1987	523	158	2010	903	207
1988	528	159	2011	889	203
1989	534	160	2012	889	202
1990	539	160	2013	890	200
1991	539	154	2014	905	200
1992	535	151			

Update to 2016

Year	Cost of Pest Control $\$_{2014}$ million	Cost of Pest Control $\$_{2014}$ per person
2015	957	208
2016	974	207

- Both 2015 and 2016, saw a significant increase in expenditure in pest control with all-time highs of $\$_{2014}$957 million for 2015, and $\$_{2014}$974 million for 2016.
- This represents a 4.8% increase and a 6.6% increase respectively for the years 2015 and 2016. The largest increase was in the category 'Border Control and Quarantine'.

17. Loss of Wetlands Ecosystem Services

Wetlands in this GPI study are defined as: "A collective term for permanently or intermittently wet land, shallow water and land-water margins. Wetlands may be fresh, brackish or saline, and are characterised in their natural state by plants and animals that are adapted to living in wet conditions" (Commission for the Environment, 1986). Wetlands are described by three general types: coastal; bogs; and ponds, swamps or river margins. It should be noted that our analysis did not cover estuarine wetlands or mangroves due to lack of data.

Why Include

Wetlands provide a variety of ecosystem services, including regulation and purification of water, regulation of atmospheric gas, a habitat for birds and fish, flood protection, and so on. When a wetland is drained and converted to an alternative use (such as agriculture) these ecosystem services that the wetland provided are lost. In addition, society may need to counteract the loss of wetlands through investment in expensive waste treatment and water purification plants, and through the development of man-made constructions to control erosion and flooding. This expenditure contributes to GDP growth but the welfare of New Zealanders is not necessarily improved as wetland ecosystem.

The vast majority of New Zealand wetlands have been drained or modified for coastal land reclamation, farmland, flood control, road construction and the creation of hydro-electricity reservoirs. Most of the loss of wetlands occurred between 1920 and 1980, but loss was still occurring up to 1997 (Ministry for the Environment, 1997) Wetland conversion was encouraged by the government with the Rural Banking and Finance Corporation funding Improvement Loans, Livestock Incentive Schemes and Land Encouragement Loans (National Water and Soil Conservation Organisation, 1983). The end of government subsidies for flood control and drainage schemes in the mid-1980s stopped wholesale drainage and infilling. However, even during the 1990s, conversions were taking place that were associated with dairying and urbanisation. For example, parts of the lower Taupo Swamp near Plimmerton, the turned into sports fields and industrial land (Wellington Regional Council, 2005). The only significant wetlands that have not undergone change are those located at high altitude in the South Island (Ministry for the Environment, 1997).

While several thousand wetlands still remain, (including more than 708 deemed of international importance), many have been degraded by drainage, pollution, animal grazing and introduced plants. Added to this, the majority of the remaining wetlands are small (half of them are less than 2 ha), and have no surrounding buffer area, which compromises the way they function. Small wetlands are more susceptible to the detrimental effects of pest plants and animals, as well as human induced changes to the catchment, local hydrology and pollution (Wellington Regional Council, 2005).

What to Include

Measuring the change in wetlands in New Zealand is difficult, as time series data on the loss of wetlands have not been collected. Comparisons between studies are also difficult, as definitions of what constitutes a 'wetland' vary over time. Using soil characteristics as the determinant, Landcare Research scientists have estimated that the original area of freshwater wetlands in New Zealand was approximately 2,267,611 ha. This is much greater than the State of the Environment estimate, which states that wetland areas have been reduced by about 85% over the last 150 years from 700,000 ha to about 100,000 ha (Ministry for the Environment, 1997).

In their GPI calculation for the United States, Anielski and Rowe (1999) included all wetlands lost from the colonial period onward. This amounted to $\$_{US}$349.9 billion, and is justified on the basis that the loss of ecosystem services when wetlands are converted to other uses is permanent, and therefore the value needs to be accounted for in perpetuity. Initial wetlands conversion was valued at a lower marginal rate than later conversion, as the value of the ecosystems loss increases with scarcity. In

1983, more than 40% of the wetlands in most American states were in an unmodified condition. By comparison, at this time less than 15% of New Zealand's wetlands were unmodified (National Water and Soil Conservation Organisation, 1983). The present wetland resource in New Zealand is not a representative remnant of the former one, with many wetland types completely lost by 1983 (National Water and Soil Conservation Organisation, 1983).

Table 17.1 Loss Per Hectare of Converting Wetlands to Pastoral Farming ($\$NZ_{2014}$ per hectare per year)

Ecosystem Services	Type of Ecosystem Service	Wetlands	Pastotral Farming	Gains and Losses of Converting from Wetlands to Pastoral Farming
Food	Provisioning		479	479
Water Provisioning	Provisioning	63	5	-58
Raw Materials	Provisioning	3	29	26
Genetic/Medicinal Resources	Provisioning	152		-152
Climate Regulation	Regulating	749		-749
Disturbance Regulation	Regulating	1,605		-1,605
Water Storage and Retention	Supporting	5,022		-5,022
Waste Treatment	Regulating	4,629	138	-4,491
Erosion Control	Supporting	389	390	1
Nutrient Cycling	Supporting	2,558		-2,558
Biological Control	Regulating	1,456	37	-1,419
Gas Regulation	Regulating	733	11	-722
Refugia	Supporting	3,665		-3,665
Cultural - Other	Cultural	3,059	3	-3,055
Recreation	Cultural	1,018	3	-1,015
Soil Formation	Supporting		2	2
Pollination	Supporting		40	40
Primary Production	Supporting	1,835	274	-1,561
				0
Gross Total (P+C+R+S)[1]		26,936	1,411	-25,525
Net Total (S) = (P+C+R)		13,468	705	-12,763
				0
Provisioning (P)[2]		218	513	295
Cultural (C)[2]		4,077	7	-4,070
Regulating (R)[2]		9,172	186	-8,986
Supporting (S)[2]		13,469	705	-12,764

Notes:

1. Refer to Patterson and Cole (2013) for details of the Accounting Framework.
2. P = Provisioning Services, R = Regualting Services, C = Cultural Services, S = Supporting Services.
3. From TEEB Valuation Database Adapted to New Zealand Using the Referencing Method Outlined by Patterson et al. (2017).
4. From Patterson and Cole (2013), Updated Using Production Values for Food and Raw Materials from Ministry of Primary Industries (2017)
5. Value of Wetlands ($/ha) - Value of Pastoral Farming ($/ha) = Gains/Losses of converting ($/ha) Wetlands and Farmlands

Only the hectares of wetlands lost since 1970 has been valued for the New Zealand GPI, in order to be consistent with the valuation approach use for some of the other environmental components in the New Zealand GPI – e.g., for the valuation of the loss of indigenous forests in Chapter 15. By 1970, New Zealand had converted approximately 1.9 million hectares of wetlands to agricultural and urban use. Wetland loss from 1970 onwards is cumulative as the ecosystem services lost from a hectare of wetlands is an ongoing.

Data Available

The following sources have provided data on the area of wetlands in New Zealand: (1) Landcare Research estimates of wetlands based on vegetation type, during the early 1970s; (2) a 1983 estimate of the wetland resource from the New Zealand Land Resource Inventory (based on vegetation type); (3) Ausseil *et al.*, (2008) provided data for 2002.

Previous prototypes of the New Zealand GPI used the data from Patterson and Cole's (1999) broad estimates of ecosystem services by biomes (ecosystem types). Since then, although there remains a paucity of New Zealand studies, a number of international studies have provided more rigorous and comprehensive analyses of the value of wetlands worldwide and the factors that determine such values. In particular, the "TEEB Valuation Database", which was compiled by van der Ploeg, de Groot and Wang (2010) and is further summarised by de Groot *et al.* (2012) provides some very valuable data on the value of ecosystem services produced by wetlands worldwide (n=244). This provides a real advance on the previous data produced by Costanza *et al.* (1997) which underpin much of the New Zealand valuation estimates derived by Patterson and Cole not only for wetlands but also for other types of ecosystem services. [76]

How to Include

An estimate of the number of hectares of wetlands remaining in 1970 (350,055 ha), 1983 (311,300 ha) and 2002 (249,565 ha) was obtained from the above data sources. For the intermediate years, the rate of decline is estimated at 211 ha per year. This is the average annual rate of decline between 1972 and 2002 calculated from known data points. In 1972 the average per annum loss was 7,000 ha. This declined to 4,300 ha in 1983, which is a much lower rate than the Stephenson *et al.* (1983) estimate of approximately 12,000 ha per year between 1954 and 1976. From 1983 onwards, the loss is assumed to level off in 2002 through to 2014.

Other ecosystem services including the buffering effects of wetlands against storm surges is not so significant in New Zealand on $/hectare basis, as it is in other countries where wetlands are situated in close proximity to large populations and hence providing protection for a greater number of people. Furthermore, a regression analysis of the TEEB valuation database of 244 wetlands by de Groot *et al.* (2012), indicated that some of the cultural values, such as aesthetics were greater in overseas studies in terms of $/ha, purely because of greater population densities. That is, although the $/person may be similar in New Zealand as overseas, the greater number of people increases the value $/hectare of cultural ecosystem services in wetlands in overseas studies.

Using this regression analysis of the TEEB valuation database, it was accordingly calculated that the

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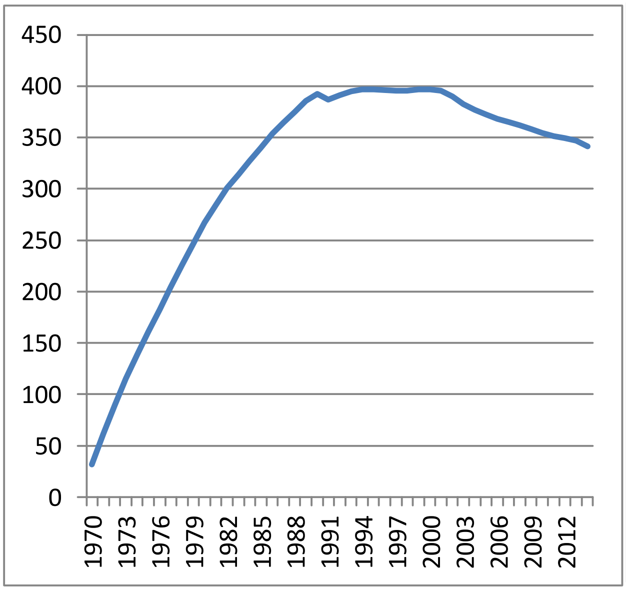
[76] There have been only a few valuation studies of New Zealand wetlands – for example, the most studied wetland in New Zealand from an economic valuation perspective is the Whangamarino wetland in the Waikato (Waugh, 2007) with, for example, Kirkland (1988?) estimating $US2003 9.9 million benefit per year, with most of this ($US2003 7.2 million) being passive or non-use value. Ndebele (2009) estimates, by using the contingent valuation method, that the Pekapeka Swamp is worth between NZ$1.64 million to NZ$ 3.78 million per year (see also Ndebele and Forgie, 2017). Unfortunately, these studies have tended to examine only one of the value of wetlands, rather than taking a comprehensive ecosystem services valuation approach, such as undertaken by Costanza *et al.* (1997) which was more recently updated by Costanza *et al.* (2014).

value of wetlands ecosystem services for New Zealand was $\$_{2014}$ 13,469/ha. Next it was assumed in the GPI calculation that lost wetlands were replaced by agricultural land which was calculated (in Table 17.1) to be worth $705/ha. Therefore, in overall terms, the loss of value of converting wetlands to agricultural land was: $\$_{2014}$ 13,469 *minus* $\$_{2014}$ 705/ha = $\$_{2014}$ 12,763 (refer to Table 17.1). Then, the total economic value of lost wetlands was calculated by multiplying the estimated loss of hectares per annum by this value of $\$_{2014}$ 12,763 – for example, the year 2002:

120,742 ha lost since 1970 x $ 12,763 per hectare = $1,541 million

Many previous ecosystem services valuation and accounts, have 'double counted' the supporting ecosystem services. According to the Millennium Ecosystem Services (2005) framework, supporting ecosystem services, by definition, support or underpin the other ecosystem services (regulating, provisioning, cultural) all of which directly contribute to human well-being. Because these 'supporting services' do not directly contribute to human well-being, rather they support other services, they therefore should not be counted as a contribution to well-being. The methodology developed by Patterson and Cole (2013) overcomes this problem by delineating 'gross value' from 'net value', and hence the value of $\$_{2015/16}$ 12,763 for New Zealand is significantly lower than values used in Massey University's previous prototype GPI accounts (for example, Forgie *et al*., 2007).

Findings



Highlights

- Wetlands are amongst our most productive and valuable ecosystems – in spite of this 90% of NZ have been destroyed by humans.
- Wetland destruction continued up until the late 1990s. Though the rate of destruction decreased each year – and by the early 2000's such destruction had almost been completely halted.
- Average 'ecosystem service value per hectare' of wetlands was estimated to be $13,469.
- Estimated, in 2014, that the cost of loss of wetlands and their services is $1,152 million or $342 per person

Figure 17.1 Per Capita Cost of Lost Wetlands' 1970-2014, $\$_{2014}$ per person

Table 17.2 shows that between 1970 and 2014, there has been a loss of 120,817 hectares of wetlands in New Zealand with most of this loss being between 1970 up until the mid-1990s when there were government incentives to convert wetlands to pastoral farming, and there was a general lack of awareness of the value of wetlands. Although it is accepted that there has been a loss of wetlands over this period, there is a paucity of data on the coverage area of wetlands, with very little recent information other than the Ministry for Environment report which states that approximately 250,000 ha of wetlands remained, in 2008. All of this means that it is difficult to make precise annual estimates of the loss of wetlands, though there is very little debate about the overall trend in the loss of wetlands and their services.

It is widely also accepted that New Zealand wetlands now cover 10% of the pre-human level of hundreds of wetlands (Clarkson *et al*., 2008). Our first-order estimates do however disguise and not take account of a number of factors including the wide variety of wetlands (ranging from swamps, bogs, marshes to ephemeral and pakihi systems) and the qualitative degradation (caused by nutrient run-off, sedimentation, invasive species, change in hydrological regimes etc.) occurring in many wetland ecosystems throughout New Zealand. Although future studies will need to take account of these factors, we don't expect any revised valuations will materially affect the general trend described by Figure 17.1.

In 2014, Table 17.2 indicates that the 'total cost' of wetlands that have been converted to other land uses is high, at an estimated $1,542 million, which is nearly 9 times the 'total cost' of deforestation of indigenous forests in 2014. The reason for this nine fold difference in 'total cost', is essentially he value per hectare of wetlands is $\$_{2014}$ 12,763, is about nine times the value per hectare of indigenous forests logged at $\$_{2014}$ 1,334 per hectare[77]. From 1970 to 2003, Table 17.2 indicates that the accumulated 'total cost' of lost wetlands continued to increase each year from 1970 to 2003, but the rate of increase slowed down as less and less wetlands were converted to (mainly) pastoral farming. Indeed, the evidence shows that from 2002 to 2014 there were no virtually no further loss of wetlands, and hence no further addition to the 'total cost' enumerated in Table 17.2. There may also be some evidence that restoration of wetlands over from this 2003 to 2014 period, bought about by greater awareness and available funding – this increase the wetland stock in New Zealand, albeit probably very small, in terms of GPI accounting to be counted as a 'benefit'.

The 'per capita' cost (refer to Figure 17.1) of losing wetland ecosystem services increased each year from 1970, but by smaller and smaller increments each year until 1990 when it reached $392 per person. From 1990 to 2000, the per capita cost of losing wetland ecosystem services essentially 'plateaued'. Thereafter, from 2001 and 2014, the 'per capita' cost of lost wetlands actually decreased – simply because population increased whilst the 'total cost' of losing wetlands remained constant. In 2014, the per capita cost of lost wetlands is estimated to be $342 per person.

Update to 2016

Year	Estimated Area of Wetlands	Cumulative Lost Area of Wetlands	Cost of Wetland Loss	
	hectares	hectares	$\$_{2014}$ million	$\$_{2014}$ per person
2015	249,776	120,817	1,542	328
2016	249,776	120,817	1,542	322

There is no update available on the estimated area of wetlands in New Zealand for the years 2015 and 2016. However, it is assumed that it is unlikely that the estimated area of wetlands in New Zealand has significantly changed since 2014, and hence the 2014 area estimates are assumed for 2015 and 2016. This translates into loss of wetland ecosystem services of $\$_{2014}$ 1,542 million for 2015 and 2016.

[77] The argument put forward in chapter 15, is that regenerating indigenous forests have similar $/ha values to mature indigenous forests, and the only *net difference* is that mature indigenous forests have higher non-use (passive) values of an addtional $\$_{2014}$ 1,334 per hectare. Whereas, for 'wetlands' it is a complete regime shift to 'pastoral farming' which has significantly lower ecosystem services value from the wetlands – refer to Table 17.1.

Table 17.2 Loss of Wetland Ecosystem Services: Total and Per Capita, 1970 to 2014

Year	Actual Area of Wetlands[1]	Estimated Area of Wetlands[2]	Cumulative Lost Area of Wetlands	Cost of Wetland Loss	Cost of Wetland Loss
	hectares	hectares	hectares	$\$_{2014}$ million[3]	$\$_{2014}$ per person
1970		363,486	7,032	90	32
1971		356,665	13,853	177	62
1972	350,055	350,055	20,463	261	90
1973		343,656	26,862	343	115
1974		337,467	33,050	422	139
1975		331,490	39,028	498	161
1976		325,723	44,795	572	183
1977		320,167	50,351	643	204
1978		314,821	55,696	711	226
1979		309,687	60,831	776	247
1980		304,763	65,754	839	267
1981		300,050	70,467	899	285
1982		295,548	74,969	957	301
1983	311,300	291,257	79,260	1,012	314
1984		287,177	83,341	1,064	327
1985		283,307	87,211	1,113	340
1986		279,648	90,869	1,160	354
1987		276,200	94,317	1,204	364
1988		272,963	97,555	1,245	375
1989		269,937	100,581	1,284	385
1990		267,121	103,397	1,320	392
1991		264,516	106,001	1,353	387
1992		262,122	108,396	1,383	392
1993		259,939	110,579	1,411	395
1994		257,966	112,551	1,436	397
1995		256,205	114,313	1,459	397
1996		254,654	115,864	1,479	396
1997		253,314	117,204	1,496	395
1998		252,185	118,333	1,510	396
1999		251,266	119,251	1,522	397
2000		250,559	119,959	1,531	397
2001		250,062	120,456	1,537	396
2002	249,776	249,776	120,742	1,541	390
2003		249,776	120,817	1,542	383
2004		249,776	120,817	1,542	377
2005		249,776	120,817	1,542	373
2006		249,776	120,817	1,542	368
2007		249,776	120,817	1,542	365
2008		249,776	120,817	1,542	362
2009		249,776	120,817	1,542	358
2010		249,776	120,817	1,542	354
2011		249,776	120,817	1,542	352
2012		249,776	120,817	1,542	350
2013		249,776	120,817	1,542	347
2014		249,776	120,817	1,542	342

Footnotes to Table 17.2 on the next page.

Footnotes to Table 17.2:

1. Measurements obtained from the Landcare Research (Ausseil *et al.*, 2008).
2. A smooth curve was fitted to the few data points available to estimate the loss of wetlands between 1970 and 2002. This curve did not pass exactly through the 1983 data point.
3. 'Cost of Wetland Loss($\$_{2014}$ million)' = '$\$_{2014}$ 12,764 per hectare' multiplied by 'Cumulative Loss of Wetlands (hectares)'. '$\$_{2014}$ 12,764 per hectare' is calculated in Table 17.1.

18. Loss of Soil Ecosystem Services

Why Include

The GPI recognises that the urban environment contributes to the well-being of New Zealanders and this is accounted for by the increase in personal consumption as a result of building construction and property transactions. However, soils are depleted by erosion or urban expansion onto agricultural, horticultural and market gardening land which current national accounting systems do not reflect this loss. The expansion of the urban environment in New Zealand has resulted in the permanent loss of some of the most fertile soils in the country. "As cities have expanded, they have taken a disproportionately large area of horticultural land, or 'elite' soils as assessed on a technical basis. Elite soils make up only a small percentage of total farmland …" (Ward *et al*., 1996) Reducing the productive capacity of soils by building on elite soils reduces the natural capital stock available in New Zealand for future generations. Where conversion is irreversible (e.g., when farmland is used for housing, industry or transport networks), such land-use change is a form of resource depletion.

Apart from the loss of soils due to urban expansion, the GPI also takes account of the loss of soils due to erosion. It is estimated that the total loss of soils by erosion to the New Zealand coast is approximately 209 million tonnes per year (Hicks and Shankar, 2003). Of this total, only the portion attributed to economic activity (such as farming) is included in the GPI – in other words, only 'accelerated erosion' is included with its two main impacts on well-being comprising of: (i) the permanent loss of the asset 'soil' for agricultural production and the loss of ecosystem services that are associated with this, and (ii) the damage that requires defensive expenditure by other sectors of the economy to correct, such as additional water treatment for silt removal (Krausse *et al*., 2001). Off-farm damage from erosion is generally greater than on-farm damage (Phillips and Marden, 2006). As a result, most on-farm efforts to prevent erosion are to maintain farm productivity and downstream externalities imposed on other societal members of less importance.

What to Include

The New Zealand GPI calculation, in regards to the loss of soils, is limited to the following negative impacts on well-being: (i) **urban expansion**, meaning that there is a loss of high quality soils that have not only have productive uses which are captured by the national economic accounts, but also provide other valuable ecosystem services which aren't part of these accounts – such as biological control of pests, soil formation, mineralisation of plant nutrients, pollination, services provided by shelter belts and hedges, hydrological flows, aesthetics, carbon accumulation, nitrogen fixation, pollination and soil fertility amongst others. There are, of course, some existing services that are maintained in the urban environment, such as for example carbon storage in trees, pollination by ornamental plants, and habitat provided by household gardens – but however, the evidence is that these services are small and most cases negligible. (ii) **accelerated erosion** resulting from agriculture and other economic activities mainly in the rural environment. The negative impacts of accelerated erosion include damage to private property, farm infrastructure damage, damage to railroads and other public infrastructure, amongst others. Other negative impacts on well-being from accelerated erosion include defensive expenditures to cope with increased flood severity, treatment of reticulated water, loss of water storage capacity, and loss of habitat from sedimentation.

Data Available

Data for soil loss to urban development were obtained from Official Year Book estimates of the size of urban areas, and Land Cover Databases from the Ministry for the Environment, covering various years, starting from the 1996/97 and then to 2002/02, 2008/09 and 2012/13. In addition, a 1970 estimate for urban area in New Zealand of 162,492 ha was obtained from Bockemuehl (1970). Erosion estimates come from the Landcare soil erosion model based on the number of hectares of agricultural land in 'grassland, lucerne and tussock' (Statistics New Zealand, 2002c). Valuation was calculated using

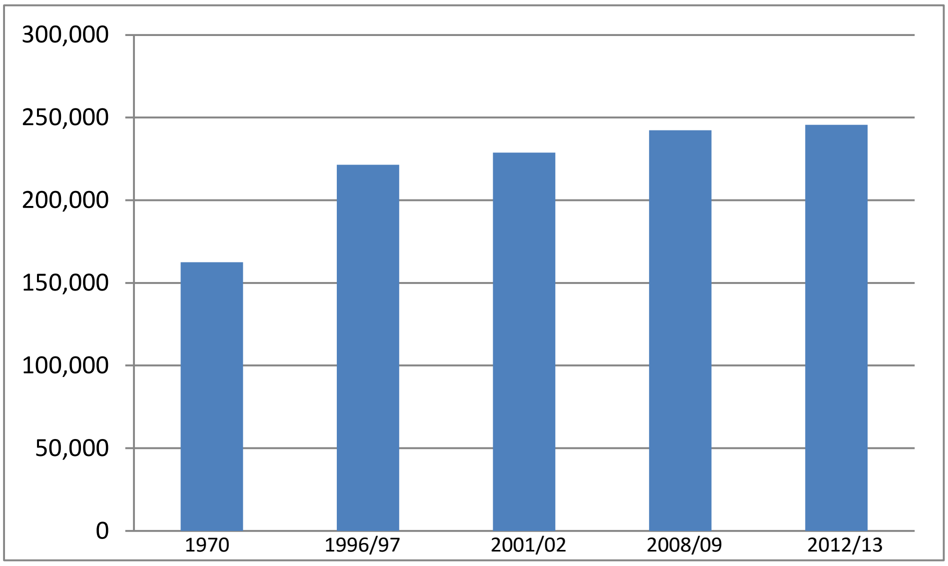
Patterson and Cole's (1999) study of New Zealand's biodiversity, and the Sandhu *et al*. (2007) study of ecosystem services provided by arable land in Canterbury.

How to Include (Loss of land to urban expansion)

Calculating the loss of fertile soil to the built environment is difficult due to significant discrepancies in estimates of land occupied by the built environment in New Zealand. The Official New Zealand Year books show urban areas of 270,000 ha in 1969 (1970 Year Book), 390,000 ha in 1978 (1979 Year Book), 470,000 ha in 1984 (1985 Year Book), and 730,000 ha (3% of New Zealand) in 1993 (Statistics New Zealand, various dates). According to the 1994 Year Book a further 160,000 ha are taken up by transportation networks. Using the definition 'Urban Area Description' in 2001 there was a total of 714,083 hectares of urban land in New Zealand (Statistics New Zealand, 2001).

The statistical definition of 'Urban Area Description' is not appropriate for the GPI as many cities have large areas of farmland within their territorial authority boundaries. Comparisons in two specific areas show major discrepancies between the hectares classified as urban in the 'Urban Area Description' and actual local authority estimates. The Urban Area Description gives the hectares of urban land in Auckland as 108,630 hectares, whereas the Auckland Regional Transport Authority uses a figure of 55,000 hectares. Likewise, for Christchurch – the Urban Area Description is 60,836 hectares and according to the Christchurch City Council 12% or 19,032 hectares is zoned for residential, commercial or industrial urban land uses.

The situation is further complicated by the number of lifestyle blocks and smallholdings. Land in such blocks is usually productive farmland in close proximity to major urban centres. While productivity is reduced by lifestyle blocks subdivision, this land is not necessarily unavailable for agriculture. In addition, ecosystem services provided by lifestyle blocks and smallholdings would not vary markedly from farmland. Many smallholders currently engage in agricultural production, but the income generated does not generally support the household (Sanson *et al*., 2004). The amount of land being subdivided into small blocks increased significantly over the 1970–2006 period. Between 1998 and 2003 alone approximately 6,800 new lifestyle blocks were registered annually on the Valuation roll, which with an average size of 5.53 ha amounted to 37,600 ha per year (Sanson *et al.*, 2004).



Data sources: Bockemuehl (1970), Land Cover Database 4.1

Figure 18.1 Land Covered by Urban Areas in New Zealand 1970 – 2013 (hectares)

After evaluating a number of methods[78] it was decided to use Land Cover Database information to calculate the loss to urban expansion. The *Land Cover Databases* (LRI v1, 1975-79; LCDB2, 2004; LCDB4.1) estimates for urban areas for the land-use categories "built up area (settlement), urban parkland/open space, surface mines and dumps, transport infrastructure". The Land Cover Databases are collected over a summer period spanning two years. For example, the LCDB 2001/2002 means it was compiled using data for the summer period between 2001 and 2002 (December 2001, January 2002, February 2002), which meant that we needed to assume that it measures the calendar year ending December 2002 – and so on for other years.

This overall method for calculating the cost $\$_{2014}$ of losing productive land to urban expansion was as follows:

Step 1: Estimation of annual urban land areas. As discussed above, over the 1970 to 2016 period, there are only five known measurements of urban land area that are considered to be accurate for the purposes of this analysis: 162,492 ha for 1970; 221,419 ha for 1996; 228,709 ha for 2001; 242,304 ha for 2008 and 245,640 ha for 2012 – refer to Figure 18.1. Data for other unknown years between 1970 to 2016, were determined by linear interpolation of the two closest known years. Data for other unknown years from 2013 to 2016 were determined by linear extrapolation using the data from 2008 to 2012. The results of these calculations for the period 1970 to 2016, appear In Column A of Table 18.2.

Step 2: Estimation of lost agricultural/horticultural/viticulture/market gardening land. It was assumed that the land covered by urban expansion represented land lost from agriculture, horticulture, viticulture and market gardening. Since this land is 'permanently' lost, the increasing amounts of lost land need to be added up cumulatively – that is, in 1970 3,072 ha were lost, and in 1971 an additional 2,267 ha, giving a cumulative total in 1971 of 5,339 ha. The results of these calculations for the period 1970 to 2016, appear in Column B of Table 17.2.

Step 3: Cost of lost agricultural/horticultural/viticulture/market gardening land. A study to quantify the economic value of ecosystem services associated with highly modified arable landscapes in Canterbury, New Zealand by Sandhu *et al.* (2007) estimated the total economic value to be between $\$_{2005}$1,792/ha/yr and $\$_{2005}$20,254/ha/yr for conventional farmland, at an average of $\$_{2005}$11,023/ha/yr or $\$_{2014}$ 13,118/ha/yr which was used in this GPI analysis. The ecosystem services values that were measured in this $13,118/ha/yr included: biological control of pests, soil formation, mineralisation of plant nutrients, pollination, services provided by shelter belts and hedges, hydrological flows, aesthetics, carbon accumulation, nitrogen fixation, soil fertility, food and raw materials (Sandhu *et al*., 2007). This is a conservative estimate, given the quality of the land lost to urbanisation is likely to be closer to that at the top end of the range of Sandhu *et al.* (2007) at $\$_{2005}$20,254/ha/yr. The results of these calculations for the period 1970 to 2016, appear In Columns C and D of Table 18.2.

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[78] Two methods were evaluated: (1) Method 1: This involved analysing changes in the density of residents and workers reported in the Statistics New Zealand Census of Population & Dwellings. We examined the 1996, 2001 and 2006 population census results, calculating for each year the density of residents and workers per hectare for every meshblock unit in New Zealand. These statistics were translated into a set of GIS layers and overlaid on satellite imagery to determine whether a critical population density threshold signifying the divide between urban and rural could be detected. Unfortunately, Statistics New Zealand meshblock boundaries do not align precisely with the extent of many urban areas, leading to an over-estimate in the size of many urban areas.; Method 2: An attempt was also made to estimate the change in urban land area using dwelling data from Statistics New Zealand. The change in section size per dwelling was calculated between 1996 and 2001, and was assumed to be the average rate of change for the 1970–2014 period. The total size of urban areas (in hectares) was then calculated by multiplying the number of dwellings by the average size of a section. The number of hectares of agricultural land lost to development as calculated by this method was significantly less than the estimate given in the State of New Zealand's Environment report (1987), of 15,000 hectares per year throughout the 1970s (1,498 hectares per year), and 30,000 hectares per year by the early 1990s (1,119 hectares per year). Ward *et al*. (1996) cites an urban expansion rate of 4% to 5% per year.

Table18.1 Estimate of the Cost of Accelerated Erosion in New Zealand

	Total cost of erosion (natural and accelerated) $\$_{1998}$m	Percentage of total erosion costs assigned to accelerated erosion $\$_{1998}$m	Total cost of erosion assigned accelerated erosion $\$_{1998}$m
Damage costs (lost production, repair costs)			
Agricultural production loss[3]	37	100%	37
Farm infrastructure damage[4]	5.6	100%	5.6
Private property damage[5]	5.7	36%	2.1
Road/rail infrastructure damage[6]	26.3	36%	9.5
Utility network damage[7]	0.8	36%	0.3
Recreational facility damage[8]	0.4	36%	0.1
Defensive expenditure from sediment effects[9]			
Increased flood severity	16.3	36%	5.9
Treatment of reticulated water	2.8	36%	1.0
Water storage loss	0.2	36%	0.1
Navigation	7.5	36%	2.7
Water conveyance (irrigation)	0.6	36%	0.2
Avoidance / Prevention costs[10]			
Regional authority expenditure	18.5	100%	18.5
East Coast Forestry (from 1991 onwards)	2.7	100%	2.7
Road preventative maintenance	2.3	36%	0.8
Total	126.7		86.4
Per tonne of erosion based on 75 megatonnes in 1998			1.15

Source : Adapted from Krausse *et al*. (2001)

Notes:

1. Accelerated Erosion refers erosion resulting from agriculture and other economic activities in addition to the background natural rate of erosion.
2. Data in Table 18.1 are adapted from Krausse *et al*. (2001). ‘Agricultural Production Loss’ is considered ‘permanent’ Column G, in Table 18.2). All other costs in Table 18.2 are considered one-off annual costs. Refer to the text for explanations.
3. Agricultural production loss: occurs on-farm only and includes losses to vegetative production and animal performance. As erosion scars take 100 years to reach 80% of their former productivity (Parfitt, 2005), mass movement erosion ($12.5m) has been included as 100%. Surface erosion accounts for the remaining ($24.5m) cost, and as it is assumed this soil is either washed or blown away, and the loss is permanent – therefore 100% of the estimated cost is used.
4. Farm infrastructure damage: occurs where slips impact on farming operation such as fencing, non-residential buildings, roading and water reticulation. This was assumed to be 100% related to accelerated erosion.
5. Private property damage: includes direct damage to buildings and dwellings from erosion. This was assumed to be 36% related to accelerated erosion.
6. Road and rail infrastructure damage: covers damage to the transport network from erosion. This was assumed to be 36% related to accelerated erosion.
7. Utility network damage: major erosion-related damage covers slips dislocating poles or lines for telephone and electricity generation. Utilities located in settled areas are likely to be damaged from accelerated erosion, so 36% of this cost was assigned.
8. Recreation facility damage: this is most likely to be impacted on by natural erosion events, so 36% of the damage cost was assigned accelerated erosion.
9. For the defensive expenditure from sediment effects it was assumed that natural erosion accounted for 64% and accelerated erosion effects were responsible for 36%.
10. Soil conservation costs covering both Regional Council and the Central Government funded East Coast Forestry (ECF) project were assigned 100% to agricultural land use as these expenses are required to stabilise erosion predominantly on uneconomic marginal land that was brought into farming when Supplementary Minimum Prices were introduced by the Government in 1985. For road preventative maintenance 36% of the cost was assigned to accelerated erosion

How to Include (Erosion from agricultural land)

Erosion causes permanent long-term loss of productive capacity as well as external effects not captured by market values, such as impacts on landscape quality, siltation of dams and rivers, reduced biodiversity, and reduced water quality.

Step 4: Sediment Loss (mt/year). Sediment loss from soils is calculated based on the number of tonnes of sediment lost from land in agricultural use as estimated by the soil erosion model developed by Landcare Research (Dymond *et al*., 2010). This model required, as an input, the area of land lost for each year from 1970 to 2006 and covers sedimentation of waterways and soil transfer to the marine environment. Soil loss from forestry and horticultural land use is not included. The model also does not take into account wind erosion, but this is small by volume, compared to water erosion (Dymond, Landcare Research, pers. comm., 2007). The model calculated *annual* sediment loss from soils for each year from 1970 to 2006 (Column E, Table 18.2), as a *cumulative* sediment loss (Column F, Table 18.2). The Landcare Research model was not available to calculate the sediment loss from soils from 2007 to 2016 – instead for those years in Column F, Table 18.2 it was assumed to be the same as 2006.

Step 5: Attribution of erosion and sedimentation caused by agriculture. In this analysis we are only ultimately concerned with the cost of 'accelerated erosion' caused by agriculture, and not erosion caused by 'background' pedological and geological processes. An estimated 209 million tonnes of soil was lost in 1998 (Krausse *et al.*, 2001). It was assumed 1998 was a typical year. From the modelled data (Dymond and Betts, 2007), in 1998 agricultural land-use-related erosion accounted for 75 million tonnes, which is 36% of the 209 million tonnes total. Therefore, where appropriate, 36% has been used to proportion total costs in steps 6 and 7 (refer to Table 18.2)

Step 6: Cost of permanent loss of agricultural production. The permanent loss of soil from erosion has been valued in the same way as the loss of wetlands in the GPI, as erosion loss can be regarded as permanent, given the length of time required to rebuild soil structure. For each year, the total loss is the cumulative sum of the current year's loss, plus previous years' losses from 1970. Using data from (Krausse *et al*., 2001) for 1998, the erosion impacts from agricultural land use in 1998 were estimated as $\$_{1998}$ 37 million (see Table 18.1). When this dollar amount is divided by the estimated 75 million tonnes of soil lost in 1998 this is equivalent to \$0.49 $_{1998}$ per tonne. Before the East Coast Forestry Project was in initiated in 1992, the per-tonne cost estimate was $\$_{1998}$ 0.48. These dollar values were converted to 2014 dollars and then multiplied by the *cumulative sediment loss* (Column F, Table 18.2) to determine the *permanent loss of agricultural production due to accelerated erosion* (Column G, Table 18.2).

Step 7: Cost of other effects of soil erosion from agriculture land. These 'other costs' include downstream costs imposed on other sectors, and the cost of defensive expenditure undertaken to prevent further erosion. These costs are of a more temporary nature (than those covered in Step 6), and therefore for the purposes of this analysis are assumed to be a 'one-off' cost for a particular year. Data from Krausse *et al*. (2001) estimated these costs at $\$_{1998}$ 49.4 million for 1998 (see Table 18.1). When this dollar amount is divided by the estimated 75 million tonnes of soil lost in 1998 this is equivalent to \$0.66 $_{1998}$ per tonne. Before the East Coast Forestry Project was initiated in 1992, the per-tonne cost estimate was $\$_{1998}$ 0.63. These dollar values were converted to 2014 dollars and then multiplied by the *annual sediment loss* (Column E, Table 18.2) to the 'cost of other effects of soil erosion' for each year.

The dollar values used for erosion are conservative, given that the Krausse *et al*. (2001) value excludes a number of other costs that could be included if there were sufficient data. Soil, especially soil with high organic matter content, provides ecosystem services that include improved water storage and release, biodiversity protection, as well as the ability to filter and degrade wastes which are not included in our analysis due to this lack of data (Dominati *et al*., 2010).

In addition, erosion as a result of agricultural production also causes a loss of visual amenity due to the scarred landscape, the damage to aquatic life, the loss of traditional food sources and recreational use, the need for research into erosion prevention, and flood prevention. Soil losses as a result of construction, deforestation and wind are also not accounted for due to lack of data. Neither the direct nor indirect costs of these activities have been included.

Findings

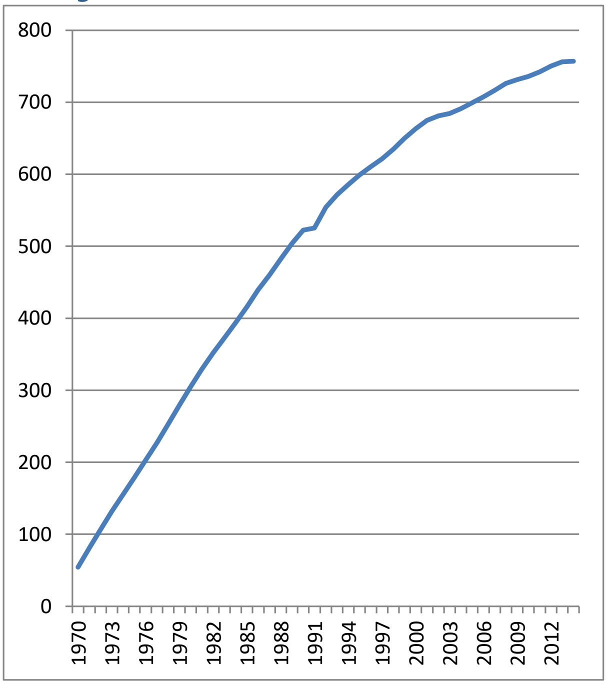

Figure 18.2 Per Capita Loss of Soil Ecosystem Services, 1970-2014, $$_{2014}$ per person

Highlights

- There has been a negative impacts on well-being due to expansion of urban areas onto often elite soils, and the loss of agricultural land by accelerated (human-induced) erosion.
- *Urban expansion* onto elite soils was costed at $1,153 million in 2014, based on calculation of the value of ecosystem services lost.

  Accelerated ersoison was costed at $2,263 million in 2014, based on the loss of agricultural land, impacts of sediment loadings resulting from this erosion, as well as other factors.

  Total cost of the loss of soils (across urban expansion, soil erosion) was $757 per capita in 2014, making it 2nd highest environmental cost next to air pollution.

The New Zealand GPI shows that the loss of soil and land due to economic activity is very significant, being costed at $3,416 million for 2014 (refer to Table 18.2) This is due to following dominant factors: (1) the loss of sediment from relatively fertile soils causing loss of agricultural production, damage to infrastructure, defensive expenditures such as the need to treat reticulated water, and avoidance costs – in total, this was costed at $2,296 for 2014, although not all of the cost could be accounted for due to the lack of reliable data. Our data are based on modelling by Landcare Research which shows that the amount of sediment loss from the land, eventually flushing out to the coastal environment, was 73 million tonnes per year from agricultural landin 1970 , reducing to 62 million tonnes in 2006[79]; (2) due to urban expansion, the loss of agricultural, horticultural, viticultural and market gardening land were all often on 'elite'soils. This was costed at $1,105 in 2014, mainly through the loss of ecosystem services provided by this land, such as soil fertility, nitrogen fixation, filtration of contaminants, pollination, and so forth. Although the are enough data points to indicate the overall trend in the increasing of urban expansion, future research could be developed to refine the data to provide more reliable estimates, than the linear interpolation and extrapolation methods used in our analysis. There are no reliable data for 2006 to 2014, due to the lack of access to the Landcare Research model. So it was assumed in our analysis that the rate of sediment lost remained the same in 2006 to 2014, as it was in 2005.

Over the 1970 to 2014 period, the total overall cost of the loss of land caused by 'accelerated erosion' (human induced) and urban expansion, increased from $$_{2014}$ 153 million in 1970 to $$_{2014}$ 3,416

[79] There is no reliable data for 2007 and 2014, due to the lack of access to the Landcare research model. So it was assumed in our analysis that the rate of sediment lost remained in 2007 to 2014, the same as it was in 2006.

million in 2014. When looking at this year-to-year change, the data shows there has been a close to linear increase, meaning that the rates of change are more or less constant, in terms of the loss of soil ecosystem services caused by both sediment loss due accelerated erosion and soils lost to urban expansion.

Further analysis could focus on the spatial resolution and depiction of these data. In this vein, Rutledge *et al*. (2010) showed that urbanisation differentially impacted on the most versatile and high-quality soils (land use classes one and two). The geographic distribution of higher absolute amounts of urbanisation in some areas such as Auckland and Queenstown may also have differential negative impacts on well-being. In terms of accelerated erosion, the negative impacts of this are highly spatially differentiated, displaying greater sediment loss for example in the East coast region of the North Island where there is a lower population density, and thereby it could be argued that the loss of well-being in our analysis is overestimated as fewer people are negatively affected by this soil loss in these less populated regions.

On a per capita basis, the overall cost of the loss of agricultural land through accelerated erosion and high-quality land due to urban expansion, also reveals an increase in costs on a year-by-year basis, but tapering off in recent years due to population increasing at a faster rate than these land use loss trends (refer to Figure 18.2). That is, in 1970 to 1994 there was a median annual per capita increase of 7.00%, then gradually tapering off to 2.05% in 2000 and only 0.09% in 2014. By 2014, the per capita cost of the loss of land/soil was calculated to be $\$_{2014}$ 757 per capita.

One of the key underlying determinants of this decrease in per capita costs, is our land cover data, which show a decreasing area per person in urban areas. The land use data shows that in 1970 there were 711 m² of land area per urban resident, decreasing to 676 m², a resident in 2012. Although we could not obtain any definitive data, this decrease in land area per capita in urban areas, is no doubt due to higher urban densities through smaller average section sizes and the greater use of multi-storeyed residential buildings. Another reason for this decrease in the per capita costs is that the sediment modelling shows decreasing amounts of sediment and soil loss per year over the 1970 to 2014 time period – although this effect is less than the effect of greater urban densities in New Zealand.

Update to 2016

Year	**Loss Due to Urban Expansion**				**Loss Due to Accelerated Erosion**				**Total Loss**
	Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H	Column I
	Area in Urban Land	Cumulative Lost Agricultural Land (to Urban Land)	Cost per Hectare of Lost Agriucultural Land	Cumulative Cost of Lost Agriucultural Land	Sediment Loss	Cumulative Sediment Loss	Permanent Loss of Agricultural Production due to Accelerated Erosion	Other Costs due to Accelerated Erosion from Agricultural Land	Total Cost of Loss Land due Urban Expansion to Accelerated Erosion
	ha	ha	$\$_{2014}$/ha	$\$_{2014}$ million	Mt/yr	Mt	$\$_{2014}$ million	$\$_{2014}$ million	$\$_{2014}$ million
2015	248,142	88,722	13,118	1,164	62	3,287	2,249	57	3,469
2016	248,976	89,556	13,118	1,175	62	3,349	2,291	57	3,522

The urban population in New Zealand increased significantly from 2014, with annual increases of 2.05% in 2015, and 2.17% in 2016. Although some of this increase is absorbed by urban intensification, a significant amount of this population increase was on greenfield developments leading to the loss of ecosystem services on land previously used for agriculture, horticulture and other rural land uses. This loss of these ecosystem services due to urban expansion is estimated to be $\$_{2014}$ 1,164 million in 2015, and $\$_{2014}$ 1,175 million in 2016.

For 2015 and 2016, there are no data available of the amount of sediment loss due to accelerated erosion. Therefore in this update, the 2014 amount of 63 megatonnes was assumed for 2015 and 2016. This translated into estimated losses of $\$_{2014}$ 2,305 million for 2015, and $\$_{2014}$ 2,348 million in 2016.

Table 18.2 Cost of Loss of Soil Ecosystem Services in New Zealand, 1970-2014

Year	**Loss Due to Urban Expansion**				**Loss Due to Accelerated Erosion**				**Total Loss**
	Column A Area in Urban Land	Column B Cumulative Lost *Agricultural Land (to Urban Land)	Column C Cost per Hectare of Lost *Agricultural Land	Column D Cumulative Cost of Lost *Agricultural Land	Column E Sediment Loss	Column F Cumulative Sediment Loss	Column G Permanent Loss of *Agricultural Production due to Accelerated Erosion	Column H Other Costs due to Accelerated Erosion from *Agricultural Land	Column I Total Cost of Loss Land due to Urban Expansion and Accelerated Erosion
	ha	ha	$\$_{2014}$/ha	$\$_{2014}$ million	Mt/yr	Mt	$\$_{2014}$ million	$\$_{2014}$ million	$\$_{2014}$ million
1970	162,492	3,072	13,118	40	73	73	48	64	153
1971	164,758	5,339	13,118	70	74	147	97	65	232
1972	167,025	7,605	13,118	100	74	221	146	65	311
1973	169,291	9,872	13,118	130	76	297	196	67	393
1974	171,558	12,138	13,118	159	76	373	246	67	473
1975	173,824	14,404	13,118	189	77	450	297	68	554
1976	176,091	16,671	13,118	219	77	527	348	68	635
1977	178,357	18,937	13,118	248	76	603	398	67	714
1978	180,623	21,204	13,118	278	77	680	449	68	795
1979	182,890	23,470	13,118	308	77	757	500	68	876
1980	185,156	25,737	13,118	338	78	835	551	69	958
1981	187,423	28,003	13,118	367	78	913	603	69	1,039
1982	189,689	30,269	13,118	397	78	991	654	69	1,120
1983	191,956	32,536	13,118	427	78	1,069	706	69	1,201
1984	194,222	34,802	13,118	457	77	1,146	757	68	1,281
1985	196,488	37,069	13,118	486	76	1,222	807	67	1,360
1986	198,755	39,335	13,118	516	76	1,298	857	67	1,440
1987	201,021	41,602	13,118	546	76	1,374	907	67	1,520
1988	203,288	43,868	13,118	575	76	1,450	957	67	1,600
1989	205,554	46,134	13,118	605	75	1,525	1,007	66	1,678
1990	207,820	48,401	13,118	635	74	1,599	1,056	65	1,756
1991	210,087	50,667	13,118	665	75	1,674	1,105	66	1,836
1992	212,353	52,934	13,118	694	74	1,748	1,196	68	1,958
1993	214,620	55,200	13,118	724	77	1,825	1,248	70	2,043
1994	216,886	57,467	13,118	754	74	1,899	1,299	68	2,121
1995	219,153	59,733	13,118	784	74	1,973	1,350	68	2,201
1996	221,419	61,999	13,118	813	73	2,046	1,400	67	2,280
1997	222,877	63,457	13,118	832	74	2,120	1,450	68	2,350
1998	224,335	64,915	13,118	852	75	2,195	1,502	69	2,422
1999	225,793	66,373	13,118	871	76	2,271	1,554	69	2,494
2000	227,251	67,831	13,118	890	73	2,344	1,603	67	2,560
2001	228,709	69,289	13,118	909	69	2,413	1,651	63	2,623
2002	230,651	71,232	13,118	934	66	2,479	1,696	60	2,691
2003	232,593	73,174	13,118	960	63	2,542	1,739	58	2,756
2004	234,535	75,116	13,118	985	63	2,605	1,782	58	2,825
2005	236,478	77,058	13,118	1,011	62	2,667	1,824	57	2,892
2006	238,420	79,000	13,118	1,036	62	2,729	1,867	57	2,960
2007	240,362	80,942	13,118	1,062	62	2,791	1,909	57	3,028
2008	242,304	82,884	13,118	1,087	62	2,853	1,952	57	3,096
2009	243,138	83,718	13,118	1,098	62	2,915	1,994	57	3,149
2010	243,972	84,552	13,118	1,109	62	2,977	2,037	57	3,202
2011	244,806	85,386	13,118	1,120	62	3,039	2,079	57	3,256
2012	245,640	86,220	13,118	1,131	62	3,101	2,121	57	3,309
2013	246,474	87,054	13,118	1,142	62	3,163	2,164	57	3,362
2014	247,308	87,888	13,118	1,153	62	3,225	2,206	57	3,416

Footnotes on next page:

Footnotes for Table 18.2:

* Agricultural Land in this Table refers to Agricultural Land, Horticultural Land, Viticulture Land and Similar Uses

Column A: Data available for 1970, 1996, 2001, 2008, 2012 (Bockemuehl 1970; Landcover Database 4.1).
Data for other unknown years between 1970 & 2012 (1971 - 1995; 1997 - 2000; 2002 - 2007; 2009 - 2011) determined by linear interpolation of the 2 closest known years.
Data for other unknown years (2013 and 2014) determined by linear extrapolation using data from 2008 to 2012.

Column B: Directly determined from Column A data, assuming extra urban land *equals* lost farmland .

Column C: The value of ecosystem services per hectare of arable land. Average Value from Sandhu *et al.* (2007).

Column D: Column B multiplied by the value in Column C.

Column E: Data for 1970 to 2006, determined by using the farm area data in conjunction with a soil erosion model developed by Landcare Research (Dymond et al., 2010).
Data 2007 to 2014, assumed to have the same value as 2006 (in the absence of modelled data).

Column F: Year-by-year cumulative total of data in column E.

Column G: Column F data (mt) multiplied by $/Mt - refer to text for details on $/ha values used derived from Krausse et al. (2001).

Column H: Column G data (mt) multiplied by $/Mt - refer to text for further on $/ha values used derived from Krausse et al. (2001).

Column I: Column D (cost of land lost to urbanisation), plus Columns G & H (cost of soil erosion and sedimentation from agricultural land).

19. Air Pollution

Calculating the change in New Zealand's air quality from 1970 to 2014 is difficult, as the measures used to determine air quality standards have changed over time, and air quality monitoring has not been extensive or consistent. It should be noted that this Chapter (Chapter 19) focuses on air pollution the effects of which are by and large restricted to *impacts on well-being of New Zealanders*. Whereas, both Greenhouse Gas emissions (covered in Chapter 21) and the Ozone Depletion (covered in Chapter 23) impact not only on the well-being of New Zealanders but also have a *global-wide impact on well-being.*

Why Include

Oxygen from fresh air is vital for health, well-being, and indeed life. Air pollution from activities such as industrial manufacturing, transportation emissions and home heating decrease air quality, and have a detrimental impact on human health. On average, a person inhales around 14,000 litres of air every day. Airborne particles known as particulate matter (PM10 and PM2.5) can cause adverse health impacts ranging from irritation of the nasal tracts to respiratory and cardiac disease and even premature death. Furthermore, over the last decade there has also been mounting empirical evidence of the negative impact of air pollution on neuropsychological development (Suades-González *et al.,* 2015), cognition (Weuve *et al*., 2012), brain development (Calderón-Garcidueñas *et al*., 2014) as well as other mental health and psychological outcomes.

Kuschel *et al.*'s (2012) comprehensive analysis concluded that the economic cost of anthropogenic air pollution in New Zealand was $4.28 billion per year attributable to various sources: 56% due to domestic fires, 22% due to motor vehicles, 12% due to open burning and 10% due to industry. They found that domestic fires dominated the health impacts from anthropogenic air pollution across New Zealand, except in Auckland where motor vehicle emissions dominated. The Kuschel *et al*. (2012) study also found that the health impacts of anthropogenic air pollution in New Zealand each year included: "

- 1,175 premature deaths in adults and babies
- 607 extra hospital admissions for respiratory and cardiac illnesses
- 1.49 million restricted activity days (days on which people cannot do the things they might otherwise have done if the pollution was not present). "

Weather plays a key role in the level of air pollution throughout New Zealand. Cold weather leads to increased use of wood and coal fires for heating and also results in the thermal inversions that trap air pollution, and hence cities such as Christchurch have relatively high levels of air pollution which exceed of World Health Organisation guidelines – refer to Figure 19.1. Indeed, the effect of weather determines almost all exceedances of national standards appearing during the colder months of May, June, July and August (Ministry for the Environment, 2015). Oppositely, New Zealand being in the path of the 'roaring forties' and having generally windy weather, helps disperse air pollutants and thereby improves health and well-being.

What to Include

In the 1970s, attention was paid to Total Suspended Particulates (TSP), which measures large particles in the air (e.g., TSP data are available for Auckland 1965-2015 – refer to Figure 19.2). While TSP is visible in the atmosphere, it is generally filtered out by the nasal passage, and inflicts less damage to the health than microscopic Fine Particulate Matter (PM_{10} or $PM_{2.5}$), which is now monitored. There are conclusive studies that show a correlation between levels of fine particles in the air and the number of people who die each year even though they are not readily detectable by the senses (Hales *et al.*, 1999). Therefore we used PM_{10} in our analysis. Specifically, we used PM_{10} data for Auckland,

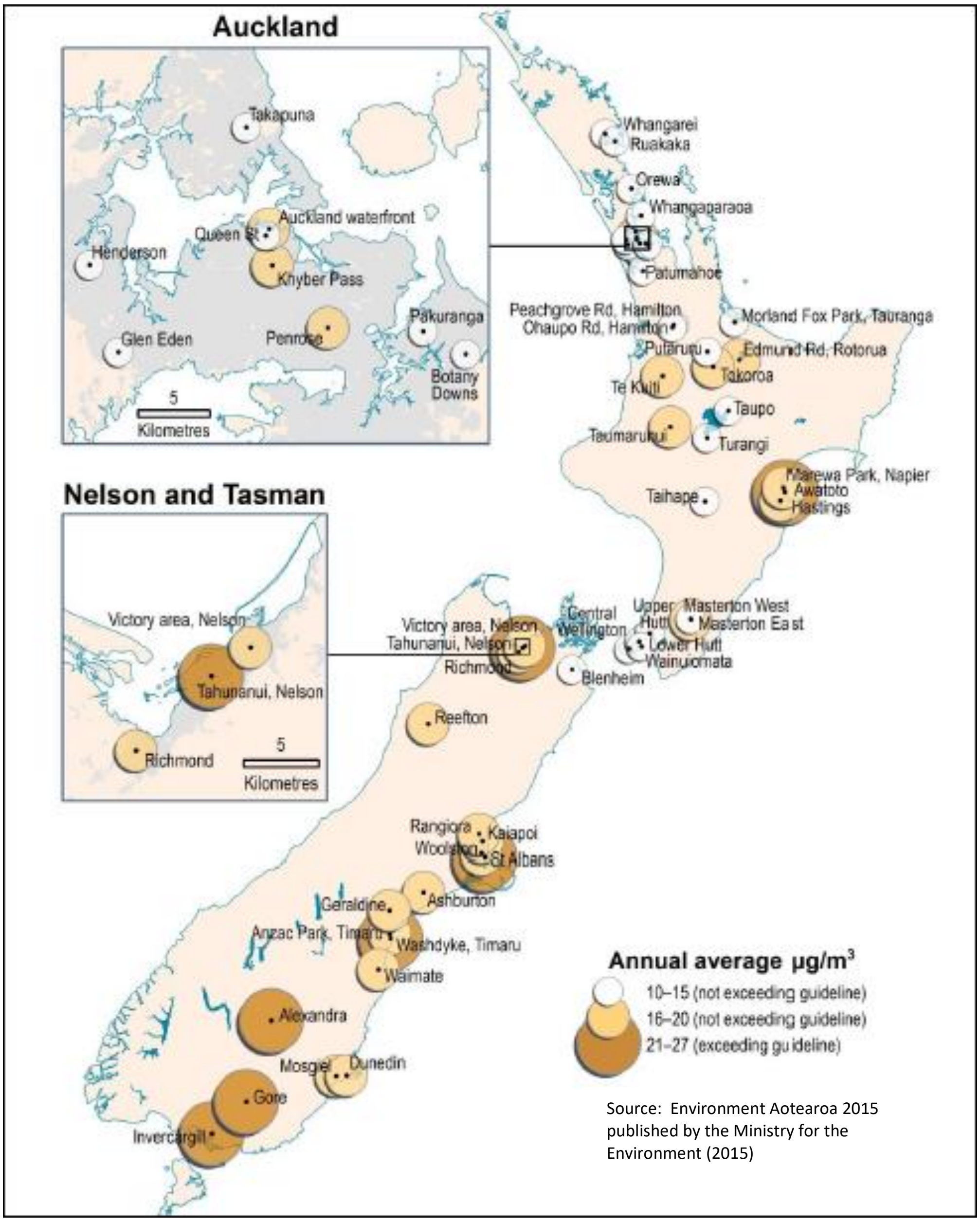

Figure 19.1 Days of PM_{10} Exceedances of National Standards New Zealand in 2013

Hamliton, Wellington, Christchurch and Dunedin, covering the period 1997-2007 (Statistics New Zealand, 2008; Canterbury Regional Council, 2009; Auckland Regional Council, 2006 and 2009)[80]. These 5 cities covered in 2006 64% of New Zealand's urban population and 53% of New Zealand's total population (Statistics New Zealand, 2008).

Caution needs to be displayed in converting the PM_{10} in data into monetary terms. Costs do not include the loss of work output, as this is allowed for in the other items that make up the GPI (e.g., lower personal consumption). Adjustment for defensive expenditure on health, which includes the direct health costs of all sources of air pollution, is also made elsewhere in the GPI calculations. The cost of

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[80] The Ministry for the Environment (2007) also has data on the PM10 values of 29 cities and towns in New Zealand for 2005. Analysis of this 2005 data shows that the 5 cities selected in our GPI analysis are very representative of these 29 cities and towns, therefore providing some validity to using these 5 cities as proxies for all New Zealand.

air pollution is therefore estimated in terms of 'intangible' losses in well-being, such as life years lost and reduced quality of life. Air pollution levels in New Zealand are not regarded as intense enough for measurable impacts on building maintenance, and the effects on animals and ecosystems are not included as they are considered insignificant (Fisher, G., 2006, pers. comm.)

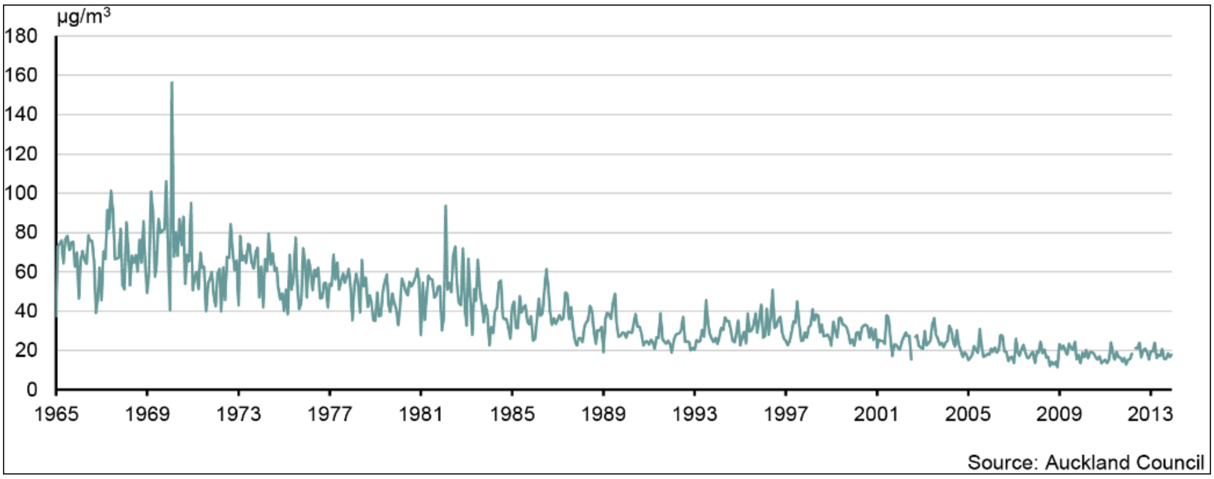

Figure 19.2 Monthly Total Suspended Particulates (TSP), in Auckalnd, 1965-2015

How to Include

Air pollution can be measured using a number of different criteria, including: fine particles (PM_{10}), oxides of nitrogen (NO_x), carbon monoxide (CO), volatile organic compounds (VOCs), sulphur dioxide (SO_2) and various toxic compounds. All these air pollutants are known to have health effects when they exceed a given level, particularly (but not only) exacerbating cardiopulmonary diseases and symptoms. ***Our study uses PM_{10} levels as the key indicator of air pollution[81].*** PM_{10} are particles less than 10 microns diameter that are invisible to the human eye but are suspended in the air. They affect human health, especially in children, the elderly (over 65), and people subject to any respiratory related illness such as asthma and heart and lung disease. Particles can also carry carcinogenic material into the lungs (Auckland Regional Council, 2006b). Experts agree that particulate matter, especially PM_{10}, is a good surrogate for the health impacts from air pollution (Fisher *et al*., 2002; Auckland Regional Council, 2006b). To avoid double counting, it is assumed the impacts of NO_x, SO_2 and CO are subsumed in the effects of PM_{10}, although there is growing evidence that separate and independent effects are associated with NO_2 exposure, especially affecting children (Fisher *et al*., 2007).

Hales *et al.* (1999) have shown a correlation between levels of fine particles in the air and the number of people who die in New Zealand each year. The most sensitive people are: (a) older people, particularly those over 65, (b) infants, particularly those under 1, (c) asthmatics and people with bronchitis, (d) people with respiratory problems, and (e) people whose health is compromised in other ways (Fisher *et al.*, 2005). Schwartz (2004) has identified high health risks for all children exposed to air pollution. In addition to increasing the mortality rate, fine particles also increase hospital admissions and emergency department visits, school absences, and lost work days, and can also restrict normal activity (Auckland Regional Council, 2006b).

Physical Time Series (PM_{10}): Reliable data are available for 1997-2016 for the PM_{10} values for Auckland, Hamilton, Wellington, Christchurch and Dunedin (Statistics New Zealand, 2008; Canterbury Regional Council, 2009; Auckland Regional Council, 2006 and 2009). These data were weighted

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[81] in our study, using PM10 as the key proxy indicator is consistent with the approach used by Kuschel *et al*. (2012) in the study prepared for the National Health Council of New Zealand, Ministry of Transport, Ministry for the Environment and the New Zealand Transport Agency.

according to the population of each city to obtain as estimate of 'average' PM_{10} for New Zealand over the 1996-2016 period. Although air quality monitoring in New Zealand is now undertaken in most urban locations (largely in response to national standards for PM_{10} introduced in September 2005), we constructed a New Zealand weighted mean (or average) based on data from the four main centres and Hamilton for the period 1996-2016, due to no other centres having availability of PM_{10} that far back.

The lack of air quality data before 1997 presented a significant problem in our analysis. Evidence based on ad-hoc studies from 1970-1996, does suggest that the average level of PM_{10} pollution is probably higher than it is now, but how much higher we don't know. For example, a study by the Institute of Environmental Science and Research shows in Penrose (Auckland) that the total suspended particulate matter was 55 μg/m^3 in 1970 decreasing to 31 μg/ m^3 in 1995 (Ministry for Environment, 1997).

A number of other methods were also trialled to estimate the PM_{10} levels for New Zealand from 1970-1996:

- ***Method 1: Fossil fuel consumption as a proxy***
  Fossil fuel consumption for New Zealand has been used to approximate air quality changes over time. Fossil fuel consumption data were obtained from the *Energy Data File* (Ministry of Economic Development, 2007) back to 1974 and then extrapolated to 1970 using a figure for oil consumption for the year 1964 from the 1980 Official Year Book. This method using Fossil Fuel Consumption as a proxy for air pollution was used by Hamilton and Saddler (1997) for the Australian GPI, on the basis that fossil fuels are the largest source of air pollutants. We didn't use this fossil fuel proxy method because, it resulted in quite low levels of air pollution in the 1970s and 1980s which didn't seem to correlate well with what few field studies we did have access to. More importantly the fossil fuel proxy method predicts an increase in PM_{10} concentration over the 1997-2007 period, when the factual evidence clearly shows the opposite trend.
- ***Method 2: Divisia decomposition method***
  One of the limitations of our application of the 'fossil fuel proxy method', is that it assumes a constant emission factor (PM_{10}/PJ) and makes no adjustment for technology improvements or fuel substitution which may reduce the emission factor. One advantage of the divisia method is that it allows for both technological improvements as well as fuel level effects (Ang and Zhang, 2000; Jollands *et al*., 2004). Backcasting using the divisia method (i.e., assuming some rate of technological improvement, prior to 1997 as measured for 1997-2007), however produced a PM_{10} value for 1970 which seemed too high. For this reason, we did not use the results from the divisia decomposition method.
- ***Method 3: Time series regression***
  This involved using time series regression to fit a linear trend to the known New Zealand PM10 data by time series regression. The regression equation was then used to backcast the PM_{10} time series from 1970 to 1996. This method assumes that the same trend (of a decrease 0.1269 PM_{10} μg/m^3/year) that existed for 1997-2007, also applies to the years 1970-2006. The time series regression gives a PM_{10} value of 21 μg/m^3 for 1970. In our judgment this is a more plausible value than the 33 μg/m^3 produced by the divisia decomposition. Therefore the 'time series regression' backcasted data were used in our analysis, although these backcasted data (1970-1996) need to be treated with a great deal of caution.

Valuation: Kuschel *et al.*'s (2012) updated a previous study by Fisher *et al.* (2007) on the economic cost to society of anthropogenic air pollution in New Zealand. Kuschel *et al*.'s (2012) analysis included: data collected in the 2006 population census; updated monitoring and inventory data for PM_{10} throughout New Zealand; more recent epidemiological results for the main health impacts of air pollution exposure differentiated for key population sub-groups (for example, Māori and children) as well as the whole population; and updated data on the economic value of our 'statistical life'. In total, the Kuschel *et al*.'s (2012) analysis covered 16 regions, 74 territorial local authorities, 139 'urban areas' and 71 airsheds throughout New Zealand.

The Kuschel *et al.*'s (2012) economic valuation of anthropogenic air pollution in New Zealand, covered the following key categories of 'health outcomes': premature mortality, cardiac hospital admissions, respiratory hospital admissions and restricted activity days (the justification for the use of these categories, is outlined in Chapter 4 of Kuschel *et al*.'s (2012) publication). Data across these categories were drawn from a number of sources: (1) the 'value of statistical life' (VOSL) used in the transport sector and regularly updated by the Ministry of Transport, which was $3.56 million per life at June 2010; (2) for hospitalisation, data were drawn from a NZIER (2009) study, that estimated the average medical cost per hospitalisation was $\$_{2008}$ 7,700 based on average length of hospitalisation of 12.6 days for traffic accidents and 6.8 days for PM_{10} related air pollution; (3) for the loss of output, the average loss per day in hospital was estimated as an average weekly income divided by seven, which worked out to be $310 per cardiovascular hospital admission, and $205 per respiratory hospital admission.[82]

Putting a value on life, as promulgated in the Kuschel *et al*. (2012) study, by using the 'value of statistical life' metric can be seen as problematic and philosophically questionable. The use of such 'value of life metrics' are for example highly susceptible to framing effects and what contextual information is presented in the survey process required to quantify this metric. Not surprisingly, therefore, there are different literature values for the value of a life. For example, a study by the National Occupational Health and Safety Advisory Committee put the value of a life in New Zealand at $\$_{2004\text{-}2005}$ 3.9 million (Access Economics *et al.*, 2006) – whereas, the Fisher *et al*. (2007) study used the Land Transport New Zealand value of statistical life (VOSL) of $NZ_{2004}\$2.725$ million. This value was derived from a willingness-to-pay study carried out by Miller and Guria (1991) in 1990. The estimate is largely based on sample surveys of what New Zealanders were willing to pay to buy road safety for their families. Furthermore, this value reflects personal loss and does not include lost income.

For estimating the total cost of anthropogenic air pollution in New Zealand in the GPI analysis, we used as a benchmark Kuschel *et al.*'s (2012) data: $\$_{2014}$ 1,112 per person, which is equivalent to $\$_{2014}$ 4.65 billion for the base year of 2006 (refer Table 19.1). From this benchmark year, the total economic cost of anthropogenic air pollution in New Zealand was scaled (upwards or downwards), relative to population level compared with 2006, and also (upwards or downwards) relative to the level of New Zealand's estimated PM_{10} µg /m^3 in 2006.

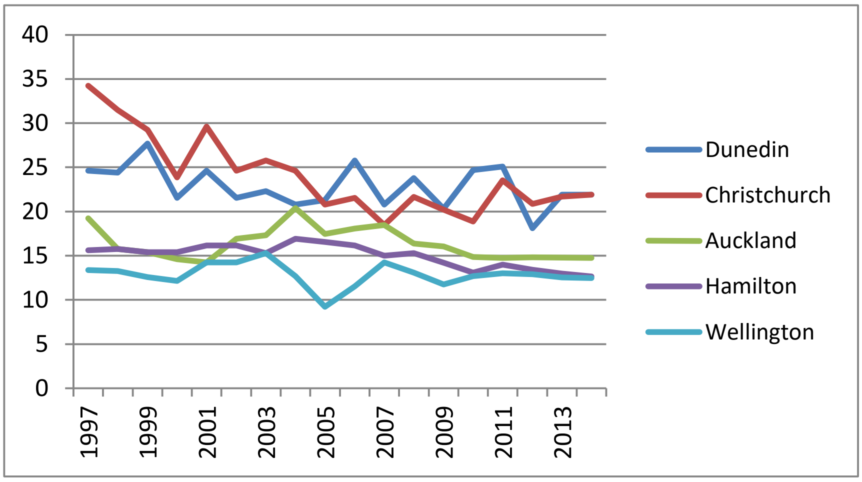

Figure 19.3 Particualate Matter, PM_{10} (µg/m^3) in New Zealand Cities, 1997-2014

[82] Combining the total costs for 'hospitalisation' and 'loss of output' Kuschel *et al*. (2012) estimated $6,354 for each incident of cardiovascular disease and $4,535 for respiratory disease, in June 2010 prices.

Findings

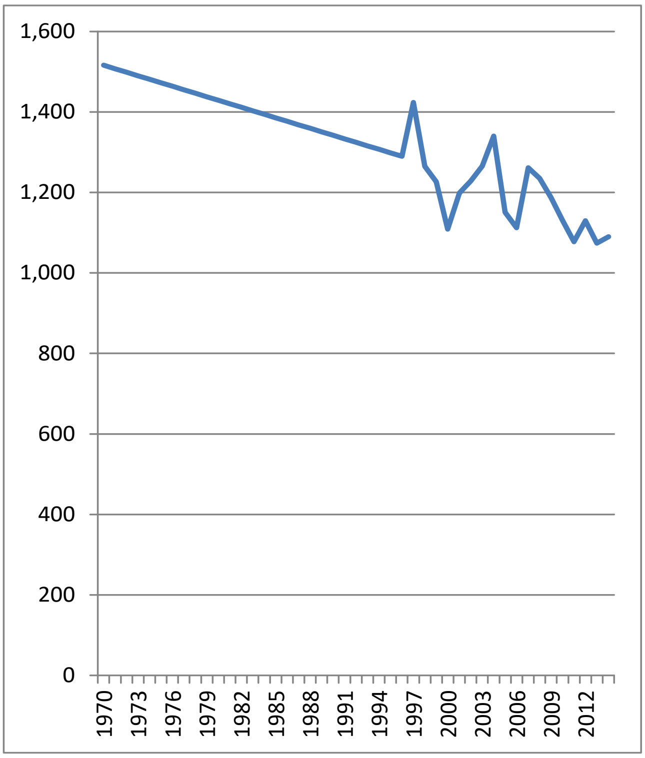

Figure 19.4 Per Capita Cost of Air Pollution, 1970-2014, $2014 per person

Highlights

- The PM_{10} metric is considered to be the best proxy indicator of air pollution, as it is widely monitored and is closely linked to negative health effects.
- It is estimated that PM_{10} be decreased from 22.1 μg/m^3 in 1970 to 15.9 in 2014, particularly due to improved standards in air pollution from domestic heating and motor vehicles
- Although this translated into a lower per capita cost of air pollution, at $1,090 in 2014, the total cost increased due to more people being affected by air pollution due to a growing population.
- The total cost, and negative impact on well-being of air pollution in New Zealand, was therefore calculated to be $4,920 in 2014.

Air quality monitoring in New Zealand over the 1970 to 2014 period has been too patchy and inconsistent to enable us to accurately estimate the cost ($) of air pollution before 1997. Fortunately however robust PM_{10} data are available for 5 cities (Auckland, Hamilton, Wellington, Christchurch and Dunedin) from 1997-2014, which enables us to put a reasonably reliable monetary cost on the health effect of air pollution over this period. The cost of anthropogenic air pollution was calculated to be $\$_{2014}$ 5,384 million in 1997 declining $\$_{2014}$ 4,920 million in 2014. Figure 19.3 as well as tracking the 1997-2007 data, shows an indicative trend based on time series regression for 1970-1996. Over the entire period from 1970 to 2014 the cost of air pollution was found to decrease on a per capita basis by 19%.

The total cost of air pollution in New Zealand increased only slightly from $\$NZ_{2014}$ 4,360 million in 1970 to $\$NZ_{2014}$ 4,920 million 2014. That is, in spite of better monitoring and standards, the level of air pollution increased slightly due to the net effect of two countervailing trends: (1) the decreasing the cost of air pollution which was due to improved standards, and better monitoring and enforcement which led to lower levels of air pollution as measured by the PM_{10} metric – that is, air pollution improved as the PM_{10} dropped from an estimated 22.1 μg/ m^3 in 1970 to 15.9 μg/ m^3. In the regard, Figure 19.4 shows this decline in the overall level of air pollution for the 5 largest cities over the 1997 to 2014 period. The largest decline in PM_{10} levels was in Christchurch over the period due to the imposition of stricter home heating standards. Dunedin over this 1997 to 2014 period also recorded a decline in PM_{10} but not dramatically as Christchurch; (2) and countering this first trend, even though air quality is improved, population increased over the 1970 to 2014 period, which means that more people were negatively affected by air pollution, resulting in an overall cost of air pollution that increased slightly by an annual average rate of 0.2% per annum.

Table 19.1 Cost of Air Pollution: Total and Per Capita, 1970 to 2014

	Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H	Column I
Year	PM_{10} Auckland	PM_{10} Hamilton	PM_{10} Wellington	PM_{10} Christchurch	PM_{10} Dunedin	PM_{10} New Zealand Weighted Mean	Estimated Cost of Air Pollution in New Zealand	Estimated Cost of Air Pollution in New Zealand	Per Capita Cost of Air Pollution in New Zealand
	µg /m3	µg /m3	µg /m3	µg /m3	µg /m3	µg /m3	$\$NZ_{2014}$ mil	$\$NZ_{2014}$ mil	$\$NZ_{2014}$ per person
1970						*22.1*		4,360	1,516
1971						*22.0*		4,403	1,507
1972						*21.9*		4,456	1,498
1973						*21.7*		4,524	1,490
1974						*21.6*		4,595	1,481
1975						*21.5*		4,656	1,472
1976						*21.3*		4,676	1,464
1977						*21.2*		4,664	1,455
1978						*21.1*		4,637	1,446
1979						*21.0*		4,601	1,438
1980						*20.8*		4,582	1,429
1981						*20.7*		4,573	1,420
1982						*20.6*		4,579	1,411
1983						*20.5*		4,610	1,403
1984						*20.3*		4,625	1,394
1985						*20.2*		4,623	1,385
1986						*20.1*		4,602	1,377
1987						*19.9*		4,610	1,368
1988						*19.8*		4,599	1,359
1989						*19.7*		4,588	1,351
1990						*19.6*		4,602	1,342
1991						*19.4*		4,660	1,333
1992						*19.3*		4,679	1,324
1993						*19.2*		4,702	1,316
1994						*19.1*		4,734	1,307
1995						*18.9*		4,773	1,298
1996						*18.8*		4,815	1,290
1997	19.2	15.6	13.4	34.2	24.6	20.8		5,384	1,423
1998	15.7	15.7	13.3	31.5	24.4	18.4		4,827	1,265
1999	15.4	15.4	12.6	29.2	27.7	17.9		4,707	1,227
2000	14.6	15.4	12.2	23.8	21.5	16.2		4,279	1,109
2001	14.2	16.2	14.2	29.6	24.6	17.5		4,659	1,199
2002	16.9	16.2	14.2	24.6	21.5	17.9		4,855	1,229
2003	17.3	15.3	15.3	25.8	22.3	18.5		5,097	1,266
2004	20.4	16.9	12.7	24.6	20.8	19.5		5,480	1,340
2005	17.5	16.5	9.2	20.8	21.3	16.8		4,757	1,150
2006	18.1	16.2	11.5	21.5	25.8	17.5	4,654	4,654	1,112
2007	18.5	15.0	14.2	18.5	20.8	18.4		5,331	1,261
2008	16.4	15.3	13.1	21.7	23.8	18.0		5,263	1,235
2009	16.1	14.2	11.8	20.2	20.3	17.3		5,109	1,187
2010	14.8	13.1	12.7	18.9	24.7	16.5		4,922	1,131
2011	14.8	14.0	13.0	23.6	25.1	15.7		4,727	1,078
2012	14.8	13.4	12.9	20.9	18.1	16.5		4,981	1,129
2013	14.8	13.0	12.6	21.7	21.9	15.7		4,775	1,074
2014	14.8	12.6	12.5	21.9	21.9	15.9		4,920	1,090

Footnotes on the next page:

Notes:

Columns A to F: Ministry for the Environment (2015) for 2008 to 2012; 2013 and 2014 trend extrapolation.

Column A: Statistics New Zealand (2008). Auckland Regional Council (2006 a,b;2009). For 1997-2007.

Column B: Statistics New Zealand (2008). For 1998-2007. The 1997 value was estimated by linear extrapolation of 1998-2007 trend.

Column C: Statistics New Zealand (2008) all values except 2000-2007 The 1997-1999 values were estimated by linear extrapolation of 2000-2007 trend.

Column D: Statistics New Zealand (2008); Environment Canterbury (2009). For 1997-2007.

Column E: Statistics New Zealand (2008). For 1997-2007.

Column F (1997-2007): Weighted mean of PM_{10} data columns B to F. Weighted according to the population in each of the 5 cities.

Column F (1970-1996): Time series linear regression equation (for 1997-2007 values) used to backcast PM_{10} values. (1970-1996). and should only be used with considerable caution. Indicated by italics.

Column G: Based on data from Kuschel et al. (2012) = $\$_{2010}$ 4.28 billion = $\$_{2014}$ 4,654.28 billion for the base year 2006.

Column H: For years, apart from the 2006 base year. Base Year (2006) value x PM_{10} scalar (from column F) x population scalar.

Although the overall decline from 1970 to 1996 in anthropogenic air pollution, as measured by the PM_{10} metric, can only be estimated (by a regression method), this decline is corroborated by the downwards trend in 'total suspended particulates' data for Auckland. That is, the Auckland 'total suspended particulates' data show a similar downward trend from 1997 to 2014, to our regression estimates for New Zealand's weighted mean PM_{10} levels for the same period.

Kuschel *et al.* (2012) report that PM_{10}, is now monitored for "more than 40 urban areas ". In our analysis we only covered five urban areas (Auckland, Hamilton, Wellington, Christchurch, Dunedin), to determine a population weighted annual PM_{10} for New Zealand. Now that there is improved geographical coverage, it should be possible in future updates of the New Zealand GPI to use these more complete data, to obtain more accurate estimates of annual PM_{10} levels for New Zealand. There is also potential to have a more nuanced measurement to take account of factors such as the differential health effects of air pollution across ethnicity groupings or income levels; some of which are reported by Kuschel *et al.* (2012). Our study has focused on the health effects of air pollution and how that affects well-being – future versions of the New Zealand GPI could factor into the calculations 'other effects' such as aesthetics and damage to property of air pollution, although these effects are considered to be relatively minor in New Zealand.

Update to 2016

	Column A	Column B	Column C	Column D	Column E	Column F	Column H	Column I
Year	PM_{10} Auckland	PM_{10} Hamilton	PM_{10} Wellington	PM_{10} Christchurch	PM_{10} Dunedin	PM_{10} New Zealand Weighted Mean	Estimated Cost of Air Pollution in New Zealand	Per Capita Cost of Air Pollution in New Zealand
	µg /m3	µg /m3	µg /m3	µg /m3	µg /m3	µg /m3	$\$NZ_{2014}$ mil	$\$NZ_{2014}$ per person
2015	14.5	14.0	13.7	22.4	18.9	15.9	5,009	1,089
2016	14.4	14.1	13.9	22.7	18.4	15.8	5,100	1,086

Overall, there was a slight decline in the estimated PM_{10} from 15.9 to 15.8; based on slight decreases in Auckland and Dunedin outweighing slight increases Hamilton, Wellington and Christchurch. This led to a slight decline in the cost per capita of air pollution, from $\$_{2014}$ 1,090 in 2014 to $\$_{2014}$ 1,086 in 2016.

20. Solid Wastes and Contaminated Sites

Why Include

'Wastes' such as paper, cardboard, packaging wastes, glass, building debris, food wastes chemicals and pesticide residues are inevitable by-products[83] of economic activity. Even with careful waste management and the use of the best available technology, the negative impacts of 'wastes' on the environment and human health, and hence well-being, cannot be entirely avoided. The New Zealand GPI calculations focus on a number of gaseous, liquid and solid wastes, being disposed of across a wide range of environments, ecosystems and landscapes.

The focus of this particular chapter is on solid wastes as well as agricultural and industrial contaminants – specifically on assessing the costs and negative impacts on well-being of:

- the cost of disposing of solid wastes[84], primarily through landfill systems
- the costs of remediation of contaminated sites, many of which were a legacy of a time when less care was taken in disposing of chemical by-products of industrial activity.

Until the 1980s, most New Zealand landfills were no more than tip/dump sites for commercial and household rubbish – and were often poorly sited, designed and managed. Furthermore, according to a Ministry for the Environment study (2001), closed landfills are considered to be potentially contaminated sites for the following reasons:

- "The nature of what was disposed of at the site is often not well characterised and has the potential to include hazardous substances.
- Contaminants in leachate or landfill gas can be discharged off the site.
- Many closed landfills are located inappropriately, particularly near waterways or sites with unsuitable underlying geology/hydrogeology.
- There is the potential for a wide range of contaminants to be released, including toxic, persistent and/or bio-accumulative compounds".

Besides closed landfill sites, there is a wide array of 'contaminated sites' which are a legacy of a time in our history when less care was taken in regard to the contamination of land, soil and surrounding water systems affected by leachate and run-off. Such sites include retired petrol stations, sawmills, timber treatment plants, railway yards, engine works, metal industries, and chemical manufacturers. Statistics New Zealand (2010) reports a total of 1,895 contaminated sites existing in New Zealand in 2010. Of these sites, Statistics New Zealand (2010) reported that 1,423 have been "cleaned up or were being managed to make sure they did not significantly affect the environment".

Some specific examples of contaminated sites include: (1) Land formally occupied by the Fruitgrowers' Chemical Company at Mapua, which closed in 1988. Opened in 1931, the site produced more than 120 chemicals, including DDT, 245T, other organochlorines and organophosphates. It is now being cleaned up by central government and the Tasman District Council at a cost of $8 million (Murdoch, 2006); (2) The Waiwhetu Stream in Lower Hutt, containing 20,000 cubic metres of sediment contaminated with heavy metals and chemicals, which has been estimated will cost $6 million to clean up (Nichols, 2007);

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[83] Ecological Economists such as Baumgärtner *et al*. (2001) and Bisson and Proops (2002) point out that 'wastes', 'by-products' or more broadly joint production is inevitable and pervasive consequence of economic activity, due to the implications of the second law of thermodynamics. Wastes can be 'minimised' by using strategies such as 'recycling' or the 3 R's, and their harmful effects can be mitigated against, but waste itself is an unavoidable when economic activity takes place.

[84] Such solid wastes are often referred to as Municipal Solid Wastes (MSW), even though strictly speaking, not all of these wastes are 'municipal' in origin.

(3) Horticultural land around Hastings which has a build-up of pesticides in the soil; (4) Housing built on land contaminated by asbestos in Auckland.

Since the introduction of the Resource Management Act in 1991 large-scale industrial contamination has been controlled. While contamination still takes place in landfills, and on a smaller scale at farm-drenching yards and industrial sites, the standards for the disposal of hazardous substances have been raised, and better systems are now in place to prevent widespread land degradation.

What to Include

This chapter has a specific focus on assessing the full economic cost (or negative impact on welfare) of dealing with 'solid wastes' and 'other contaminants' which are by-products of economic activity. Other chapters in this publication cover other significant wastes which are by-products of economic activity and which have a negative impact on well-being:

- greenhouse gases impacting on climate change (Chapter 21)
- other air pollutants (in addition to greenhouse gases) and their negative impact on health and well-being (Chapter 19)
- water pollutants negatively impacting on the quality of rivers and lakes and hence well-being (Chapter 22)
- ozone-depleting chemicals impacting negatively on human health and well-being through decreasing the protection from ultraviolet rays (Chapter 23)

Data Available

Municipal solid waste data (tonnes) for 1990–2014 come from the New Zealand Greenhouse Gas Inventory 1990–2015 (Ministry for the Environment, 2016). The waste data figures in the inventory are based on the national waste data report (1995), the landfill review and audit (2002), and the solid waste analysis protocol baseline survey (2003). Some useful data on sectoral production of solid waste are available in the New Zealand physical input output model constructed by McDonald and Patterson (2006).

The publication by the Centre for Advanced Engineering (2005) provides data on the 'full cost' of landfill facilities over their lifetime including: management, administration and organisational overheads, pollution control, planning and resource consents, land costs, development costs, operational costs, as well as closure and aftercare costs (Ministry for the Environment, 2004)

A study carried out by Worley Consultants (1992) estimated the cost of cleaning up high- and moderate-risk contaminated sites in New Zealand at $\$_{1992}$1,644 million (Worley Consultants Limited, 1992). Estimates for cleaning up several of the major contaminated sites have also been made by central or local government. Furthermore, costs of cleaning up major sites have been widely reported in the print media, as well as in government publications, as for example a report by the Ministry for Environment (2000), which indicated that specific contaminants (PCDDs and PCDFs) of the Waipa Mill (Rotorua) cost $38 million to remediate.

How to Include

The GPI methodology that is utilised in this study focused on costing in monetary terms: (a) the full cost ($) in New Zealand of disposing solid waste by using a 'full cost accounting framework'; (b) the cost of remediating contaminated sites in New Zealand through the 45 year period of the study.

The methodology involved the following steps:

Step 1: Determination of Landfill Solid Wastes (kilo-tonnes) from 1970 to 2014. Data from 1992, 2014 were obtained from the Ministry for Environment's 'New Zealand's Greenhouse Gas Inventory 1990-2014'. For the 1970-1981 period, an estimate for total solid waste in 1982 was used to derive a statistic for the kilograms of waste per head of population. This was multiplied by the population statistics to generate estimates for 1970–1981. The increase in waste between 1982 and 1990 was calculated and averaged to obtain an estimate of yearly increases from 1982 to 1990. The trend was consistent with Auckland Regional Council statistics on waste to landfills for the same timeframe (Envision New Zealand, 2003).

Step 2: Economic valuation of the cost of disposing landfill solid wastes. Economic valuation of solid waste disposal should reflect, as far as possible, the total cost of waste disposal, rather than for example the actual amount charged to use a landfill facility. To achieve this end, a system of Full Cost Accounting (FCA) was used to capture the capital and operating costs incurred over the life of a landfill. FCA includes costs to cover: management, administration and organisational overheads, pollution control, planning and resource consents, land costs, development costs, operational costs, as well as closure and aftercare costs (Ministry for the Environment, 2004). This GPI study used the cost of disposing of a tonne of waste at the Kate Valley regional landfill ($125 per tonne) because the FCA guide was used extensively to check costs when the landfill was proposed (Centre for Advanced Engineering, 2005). The Kate Valley landfill disposal cost is at the upper end of the major city costs as can be seen from Table 20.1. To determine the total cost ($million/year) of disposing of landfill solid waste in New Zealand, the number of tonnes (from Step 1) is multiplied by this statistic of $125 per tonne ($\$_{2014}$ 152.60).

Table 20.1 Disposal Cost per Tonne, at Major City Landfills

	$ per tonne
Auckland (Redvale)	90.00
Hamilton	95.50
Wellington (Southern)	101.00
Christchurch (Kate Valley)	125.00
Dunedin (Environwaste)	75.00

Source: Parliamentary Commissioner for the Environment (2006)

Step 3: Estimation of the total cost of remediating all contaminated sites in New Zealand. Worley Consultants (1992) estimated the cost of remediating 7,800 sites in New Zealand. The overall cost of this remediation was estimated by categorising the sites according to their risk and other factors: high risk (n=1,580), high risk – timber treatment (n= 3,950), moderate risk, (n=3,950) and slight risk (n =1,670). Then, by knowing the cost of remediating these different categories, the Total Cost over the 1951 to 1988 period ($TC_{1951\text{-}1988}$) of remediating all of the sites was estimated to be $\$_{1992}$ 1,644 million. (refer to Table 20.2).

Table 20.2 Number and Estimated Cost of Remediating Contaminated Sites ($\$_{1992m}$)

Category	Number	Cost $\$_{1992}$ million
High risk	1,580	$515
High risk – timber treatment	600	$105
Moderate risk	3,950	$1000
Slight risk	1,670	
Site assessment costs		$24
Total	7,800	$1,644

Source: Worley Consultants (1992) covering the period 1951 to 1988

Step 4: Apportioning to each year (1970 to 1988), the total cost remediating contaminated sites. The total cost of remediating all contaminated sites ($TC_{1951\text{-}1988}$), then needed to be allocated to each of the years from 1951 to 1988 to get the Annual Costs (AC) of remediation. For example, the Annual Cost of remediation for 1970, was calculated using the following formula:

$AC_{1970} = TC_{1951\text{-}1988} \times (VA_{1970} / VA_{1951\text{-}1988})$

Where: AC_{1970} = Annual Cost (AC) of remediating contaminated sites for 1970; $TC_{1951\text{-}1988}$ = Total Cost ($) of removing contaminated sites over the entire period from 1951 to 1988 calculated from step three; VA_{1970} = Value-Added ($) by contaminants-producing industries in 1970; $VA_{1951\text{-}1988}$ = Value-Added ($) by contaminant-producing industries over the entire period; *From 1951 to 1988*

VA_{1970} and $VA_{1951\text{-}1988}$ were obtained from a detailed spreadsheet analysis of data acquired from literature searches, historical economic data obtained from Market Economics Ltd, and data available from media sources – although these data were incomplete, it was considered robust enough to make reliable estimates of the Annual Costs (AC) of remediation of contaminated sites. The underlying assumption, in the above formula, is that the cost of remediating contaminants is directly proportional to the economic production (value-added) of these contaminating-industries.

Step 5: Apportioning to each year (1989 to 2014), the total cost remediating contaminated sites. In recent times, from 2000 to 2014, the levels of industrial contamination has been extremely low – primarily a result of tighter requirements of the Resource Management Act 1991. This has been estimated at $10 million per year since 2000 and accounts mainly of accidental spills and low-level effects from industry. Between 1989 (when the step 4 data ends) and 1999, the annual amounts were determined by linear interpolation. These data contained in Step 5 are indicative but don't warrant further attention, given the now extremely low levels of contaminants being produced by industries over the last two decades.

Findings

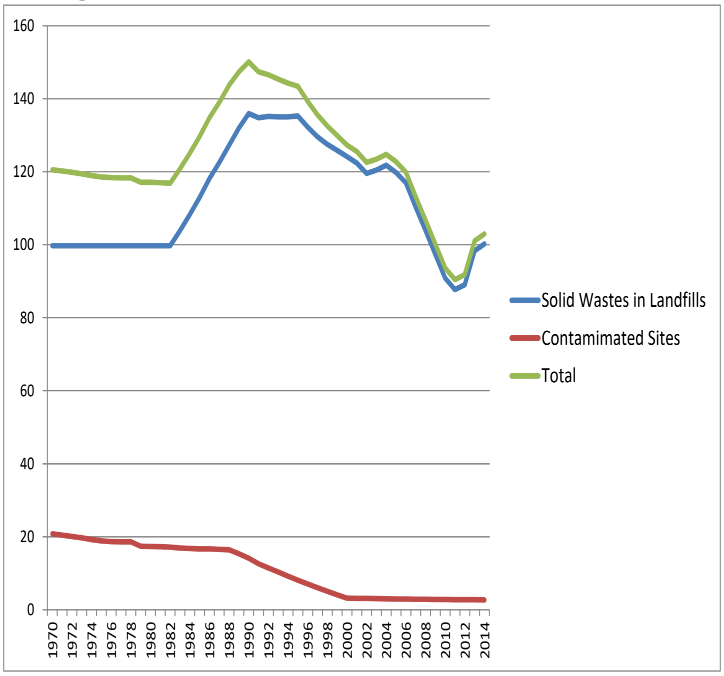

Figure 20.1 Per Capita Cost: Solid Wastes Disposal in Landfills & Remediation of Contaminated Sites, 1970-2014, $2014 per person

Highlights

Solid Waste in Landfills:

- The cost of the disposal of 'solid wastes' is significant put at $452 million in 2014, using a full cost accounting methodology.
- The 'cost per capita' of solid waste disposal decreased from a peak $$_{2014}$ 136 per capita in 1990 to a low of $$_{2014}$ 88 per capita in 2011.

Contaminated Sites:

- The negative effects of contaminated sites *have decreased consistently since 1970, as* remedial and preventative actions have been implemented.
- The 'cost per capita' required to 'clean up' contaminated sites is comparatively low, averaging about $$_{2014}$ 36 per person over the 1970 to 2014 period.

The cost of remediation of contaminated sites is relatively low. Even at its highest point (in 1970) in our analysis it only amounted to an estimated $\$_{2014}$ 21 per capita for that year. However, it could be argued that the full 'health costs' of contaminated sites and the inappropriate disposal of hazardous waste, which could not be measured in this GPI analysis due to the lack of data, may be considerably higher than costs of remediation of contaminated sites. Measuring such 'health effects' of materials from contaminated sites, is intrinsically difficult – not only because of the pure lack of data, but also because of the complexity of the linkages between the 'contaminants' and the 'health effects'. Often for example, the health effects of contaminants may be 'indirect' and mediated through complex biochemical and ecological processes. Furthermore, for example, contaminants may have cumulative effects such as bioaccumulation in food chains, which may mean there is a significant 'time lag' in the health effects manifesting themselves.

All that said, it is well-known that the spatial extent and number of contaminated sites in New Zealand, has decreased over the 45 year period of this GPI analysis, particularly from the 1990s onwards with the enactment of the Resource Management Act 1991 and the Hazardous Substances and New Organisms Act 1996. Both these pieces of legislation, combined with the greater awareness of the problem of contaminated sites, has resulted in central and local government taking action to prevent the 'past mistakes' that led to contaminated sites, and to mitigate against the effects of historical contaminated sites. Accordingly, the data in Table 20.3 indicate that the 'cost per capita' of remedial action to mitigate the effects of contaminated sites, is now a very low level, nominally put at about $\$3_{2014}$ per capita in 2014.

The full cost (across the life-cycle) of solid waste is very significantly higher than the cost of remediation of contaminated sites – as can be calculated in data presented in Table 20.3, the full costs of solid waste disposal, outweighs the cost of remediation of contaminated sites in the order of 5 to 10 times prior to the early 1990s, and in the order of 10 to 30 times from the early 1990s onwards.

Figure 20.1 shows that from a peak of $\$_{2014}$ 136 per capita in 1990, there has been a reasonably consistent downward trend in the 'per capita cost' of solid waste disposal, to a low of $\$_{2014}$ 88 per capita in 2011[85]. This downward trend, which persisted for two decades, was due to improved waste management practices, most particularly greater levels of recycling. By 2007, the Ministry for Environment (2008) reports that 73% of New Zealand households had access to kerbside recycling, which was virtually non-existent at the beginning of this period. In more general terms, it can be argued that this downwards trend in the per capita costs (and per capita kilograms) of solid waste, was brought about by a 'paradigm shift' – moving away from the almost total dependence on often poorly designed and managed landfill systems, to a more sophisticated approach of urban waste transfer systems and mandatory household recycling systems.

Somewhat alarmingly, it should however be noted that this two decade trend of decreasing 'cost per capita' of disposing of municipal solid waste, reversed every year from 2011 to 2014 – that is, the 'cost per capita' increased from $385 in 2011 to $452 in 2014 which represented a 17.64% increase. The reason/s for this 'concerning' increase in the 'cost per capita' of disposing of municipal solid waste, is not known and requires investigation.

[85] Caution needs to be displayed in interpreting these solid waste data. That is, though the 'per capita cost' of solid waste disposal has decreased since the 1990s, the picture is not so rosy when examining the 'total cost' of solid waste disposal. For example, as an illustration of this point, the 'total cost' of solid wastes going to landfill actually increased from $471 million in 1991 to $490 million in 2006, which is contrary to that trend suggested by the 'per capita cost' metric..

Table 20.3 Cost of Landfills and Remedial Action of Contaminated Sites: Total and Per Capita, 1970-2014

Year	Landfill Solid Waste[1]	Cost of Landfills[2]	Cost of Remedial Actions to Contaminated Sites	Total Cost	Total Cost per Capita
	kilo-tonne	$\$_{2014}$ million	$\$_{2014}$ million	$\$_{2014}$ million	$\$_{2014}$ per person
1970	1,799	281	59	340	121
1971	1,828	286	59	344	120
1972	1,861	291	59	349	120
1973	1,900	297	59	355	119
1974	1,941	303	58	362	119
1975	1,978	309	58	368	119
1976	1,999	312	58	371	118
1977	2,006	313	58	372	118
1978	2,006	313	58	372	118
1979	2,003	313	55	367	117
1980	2,007	314	55	368	117
1981	2,015	315	55	369	117
1982	2,030	317	55	372	117
1983	2,142	335	55	389	121
1984	2,254	352	55	407	125
1985	2,366	370	55	424	130
1986	2,478	387	55	442	135
1987	2,590	405	55	459	139
1988	2,701	422	55	477	144
1989	2,813	440	51	491	147
1990	2,925	457	48	505	150
1991	3,016	471	44	515	147
1992	3,055	477	40	518	147
1993	3,088	483	37	519	145
1994	3,129	489	33	522	144
1995	3,182	497	30	527	143
1996	3,159	494	26	520	139
1997	3,136	490	23	513	136
1998	3,113	486	19	506	133
1999	3,091	483	16	499	130
2000	3,068	479	12	492	127
2001	3,045	476	12	488	126
2002	3,022	472	12	484	123
2003	3,104	485	12	497	123
2004	3,186	498	12	510	125
2005	3,171	495	12	508	123
2006	3,133	490	12	502	120
2007	2,983	466	12	478	113
2008	2,834	443	12	455	107
2009	2,683	419	12	431	100
2010	2,531	395	12	408	94
2011	2,461	385	12	397	90
2012	2,514	393	12	405	92
2013	2,798	437	12	449	101
2014	2,895	452	12	465	103

Notes:

1. Obtained from the Ministry for the Environment (2015) for 1990-2014.
2. Cost of Landfill = Solid Wastes x 'Full cost' of landfill disposal ($\$_{2014}$152.60 per tonne). Full costs data of $152.60 obtained from the Centre for Advanced Engineering (2005).
3. Cost of Remedial Action obtained and estimated from various sources. Refer to the text.
4 Total Cost = Cost of Landfill + Cost of Remedial Actions to Contaminated Sites.

Update to 2016

Year	Landfill Solid Waste kilo-tonne	Cost of Landfills $\$_{2014}$ million	Cost of Remedial Actions to Contaminated Sites $\$_{2014}$ million	Total Cost $\$_{2014}$ million	Total Cost per Capita $\$_{2014}$ per person
2015	2,991	467	12	480	104
2016	2,974	465	12	477	102

- The total cost of solid wastes and contaminated sites, increased by an estimated 2.7% from 2014 to 2016, reaching a cost of $\$_{2014}$ 477 million by 2016. On a per capita basis, this represented a very slight decrease to $\$_{2014}$ 102 per person.
- It should be noted that estimates of the total landfill solid wastes (which underpin these cost estimates), were based on a decomposition analysis of the trends and cycles of landfill solid wastes over the 2000 to 2016 period. This is because actual measurements of landfill solid wastes for 2015 and 2016 could not be sourced.

21. Greenhouse Gas Emissions

Why Include

Increased fossil fuel use, cement manufacturing, deforestation and farming have led to a global rise in carbon dioxide, methane and other greenhouse gases in the atmosphere. As a result of the greater concentration of greenhouse gases in the atmosphere, the Earth has begun to warm up and its climate is changing. New Zealand's greenhouse gas emissions profile is somewhat unique, with for example in 2014, 48% of New Zealand's total greenhouse gas emissions being methane and nitrous oxide from the agricultural sector. This compares with around 10-12 % of global emissions from agricultural sources. The energy sector was responsible for 39% of New Zealand emissions in 2014 which is comparatively low by international standards, with remaining 13% coming from industrial processes and wastes (refer to Table 21.1). Carbon dioxide sequestered by forestry planting plays a very important role reducing New Zealand net greenhouse gas emissions, with forestry and land-use changes offsetting 33% of New Zealand's gross emissions profile in 2014.

Climate change will impact on the well-being of New Zealanders in the future in a number of ways. The anticipated effects include increased flooding and storm events, inundation of low lying land due to sea-level rises, drought in eastern parts of the country, increases in pests and disease due to warmer temperatures, and social disruption as refugees from other parts of the world affected by climate change seek new homes. Climate change is interconnected to many other environmental, economic and social issues facing New Zealand, in particular our freshwater. For example, the Ministry for the Environment (2017) in its Briefing Paper to Incoming Ministers pointed out that "Rising sea levels could reduce the availability of fresh water in some parts of the country, as salt water moves into coastal aquifers… Actions to improve freshwater quality, such as planting riparian margins and afforesting erosion prone land, could support the offset of carbon emissions".

In November 2016, the Paris Agreement on Climate Change came into force, which set out a new benchmark for multilateralism that commits all countries to reduce greenhouse gas emissions, to adapt to the impact of climate change, and to make all finance flows low-carbon and climate resilient (New Zealand Foreign Affairs and Trade. 2016). New Zealand ratified the Paris Agreement in 2016 and adopted a target of reducing emissions to 30% below 2005 levels by 2030, corresponding to approximately an 11% per cent reduction on 1990 levels (Ministry for the Environment, 2017). The goal of the Paris Agreement is to hold the increase in the global average temperature to well below 2^{o}C above pre-industrial levels, and to pursue efforts to limit the increase to no more than 1.5^{o}C. Five-yearly global stock-takes will be undertaken to review countries' collective progress against the goals of the Paris Agreement with the first (the Talanoa Dialogue) to be held in 2018.

The New Zealand Productivity Commission (2018) investigated how New Zealand could transition to a low emissions economy while continue to grow incomes and well-being. The Commission concluded that three main changes were required to achieve this low emissions goal: (1) a transition from fossil fuels to electricity and other low emission fuels across the economy, meaning a switch of the light vehicle fleet to electric vehicles and other very low-emission vehicles, and a switch away from fossil fuels in providing process heat for industry, particularly for low- and medium-temperature heat; (2) a continuation of substantial levels of afforestation to offset emissions; (3) changes to agricultural production, including the diversification of land use towards for horticultural and cropping, as well as greater adoption of "low emissions factors on farms".

What to Include

The GPI calculations included all of the greenhouse gases covered in the New Zealand Greenhouse Gas Inventory (1990–2015) published by the Ministry for the Environment (2017):

- *Energy* – this refers to greenhouse gases produced as a by-product of energy use across all sectors of the economy, as well as including private transport and household energy use. The main greenhouse gas produced by energy use is carbon dioxide (CO_2).
- *Agriculture* – this refers to greenhouse gases directly produced by farm activity and/or livestock. It does not include the agricultural use of energy, which has already been included in the 'energy category'. Within this agricultural category, methane (CH_4) produced from livestock is the predominant source of greenhouse gases emissions. Other greenhouse gas emissions from the agricultural sector are nitrous oxide (N_2O) from animal excreta, nitrogenous fertilisers, as well as direct emissions of nitrous oxide (N_2O) from soils.
- *Industrial Processes* – this refers to greenhouse gases being produced from chemical transformation or reaction, as an unwanted or undesirable by-product. It does not include combustion processes that produce energy, as this is already been covered in the energy category. Some of the more important 'industrial processes' include: steel production (from my iron-sand), aluminium production, calcination of limestone for use in cement production, production of ammonia, production of urea and production of hydrogen.
- *Solvents* – this refers to solvents and including those for example used in dry-cleaning, printing, and painting applications. Greenhouse gas emissions resulting from solvent use in New Zealand is very small, if not negligible.
- *Wastes* – this mainly refers to greenhouse gases resulting from disposal of municipal solid wastes (79% in 2005), and methane being produced by waste water treatment plants (21% in 2005) (Ministry for the Environment, 2015).
- *Land Use Change and Forestry* – this refers to net emissions of greenhouse gases to the atmosphere, resulting from forestry activities and land use changes. For example, increased plantings of forests will lead to carbon being removed from the atmosphere, and being converted to biomass – these removals of carbon/greenhouse gases from the atmosphere are recorded as negative values[86] in this analysis (refer to Column D of Table 21.1). Oppositely, carbon can be added to the atmosphere by harvesting production forests, deforestation and the decomposition of organic material resulting from these activities – these additions of carbon/greenhouse gases from the atmosphere are recorded as positive values[87] (refer to Column D of Table 21.1) in this analysis. For most years since 1970, there have been significantly more removals from the atmosphere (mainly from forestry), and they have outweighed greenhouse gas emissions to the atmosphere.

Data Available

Greenhouse gas emissions, for the 1990–2014 period can be obtained from the New Zealand Greenhouse Gas Inventory 1990–2014 (Ministry for the Environment, 2017). Before 1990, the following data were used to calculate greenhouse gas emissions back to 1970: (1) Livestock numbers from the Ministry of Agriculture and Forestry (MAF, 2005), (2) Fertiliser use in New Zealand from O'Hara *et al*. (2003), (3) Sequestration rates from Scion (Wakelin, 2008, pers. comm.).

A number of different values per tonne of carbon are quoted in the literature, based on different criteria and contexts. The Stern Review (2006) used a value of $\$US_{2005}30$ per tonne of CO_2 to reflect the social cost of reaching a goal of 450ppm of atmospheric $C0_2$. The International Energy Agency (2008) using scenario modelling 'Energy Technology Perspectives: Scenarios and Strategies to 2050' to conclude that technologies already in existence, or at an advanced state of development, could bring global CO_2 emissions back to current levels by 2050 at marginal costs up to $\$US_{2005}50$ per tonne ($\$NZ_{2005}71$) of CO_2. Similarly, In New Zealand, Patterson's (2012) optimisation scenario modelling of the

[86] This can be confusing, as in the GPI analysis (Column D of Table 21.1) a negative number represents a net benefit to New Zealand society – that is: negative number = negative cost = benefit.

[87] This can be confusing, as in the GPI analysis a positive number (Column D of Table 21.1) represents a net cost to New Zealand society – that is: positive number = positive cost = cost.

New Zealand energy system estimated costs of producing greenhouse gases from the base year of 2007 to 2026 have a similar cost magnitude, although it is difficult to directly compare this with the overseas studies due to different criteria being used. The New Zealand Transport Agency (2013) 'Economic Evaluation Manual' recommends a value of $\$NZ_{2004}$ 40 per tonne, which is closer to the Stern (2006) value $\$US_{2005}$30 per tonne of CO_2 once the exchange rate of 0.70 is applied.

How to Include

Greenhouse gas emissions **for the 1990 to 2014 period** were collated, primarily drawing on the Ministry for Environment's (2017) New Zealand's Greenhouse Gas Inventory (1990–2016). Unfortunately, this inventory does not cover the years 1970 to 1989 and other sources of information needed to be used in order to calculate these emissions to prior to 1989. As can be ascertained from Table 21.1, the data cover sources of greenhouse gases across four categories, which are based on those in the New Zealand's Greenhouse Gas Inventory: (1) energy, (2) agriculture, (3) industrial, wastes and solvents, (4) Land use and forestry.

The greenhouse gas emissions **from 1970 to 1989** were estimated as follows, using a wide variety of data sources:

Step 1: Energy-Related Greenhouse Gas Emissions. Energy data use statistics were mainly obtained from the Ministry of Economic Development's Energy Data File (MED, 2007b). These data were tabulated and expressed in terms of petajoules per year. The energy-related greenhouse gas emissions were calculated by:

$$C_i = E_i \times EF_i$$

Where:

C_i = GHG emissions from a given energy type *i* (tonnes/yr), for a given year
E_i = GHG use of energy type *i* (petajoules/yr), for a given year
EF_i = GHG emissions factor of energy type *i* (tonnes CO_2-e /petajoule)[88] [89]

There is no one source of emission factors (EF_i) for the 1970 to 1989 energy data, so the number of sources needed to be utilised. For the coal emission factor (before 1990), was assumed to be the average for the period of 1990 to 1994. The natural gas emissions factor used for 1970–1989 was the average for the 10-year period 1990–1999 of 43.8 $GgCO_2$-e/PJ. Fugitive energy-related emissions were calculated as follows:

- *Geothermal*: the geothermal fugitive emissions factor (0.189 CO_2-e/GWh) applies to the electricity produced between 1990 and 1996. Electricity generation statistics between 1970 and 1974 from geothermal sources are from White (2007). The assumption being that all geothermal emissions prior to 1990 follow the pattern or trend of electricity emissions.
- *Gas processing and flaring*: Emissions factors from the various fields were calculated using the Energy Greenhouse Gas Emissions 1990–2006 report (MED, 2007a). Emissions from Kapuni were reduced to approximately 1/6 of current emissions for the 1986–2003 period during which the Motanui Methanex plant was operating.
- *Gas transmission losses*: assumed a constant proportion of reticulated gas lost based on figure for 2006 (MED, 2007a).

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[88] "tonnes CO2-e" refers to tonnes of 'carbon dioxide equivalents'. 'Carbon dioxide equivalents' measure greenhouse gas emissions that are standardised in terms of the 'global warming potential'. In these terms one tonne of carbon dioxide equals 25 tonnes of methane and 298 tonnes of nitrous oxide based on a 100 years' time horizon.

[89] "petajoule" or the abbreviated "PJ" equals 1,000,000,000,000,000,000 joules of energy (x1015 J)

- *Coal*: Fugitive emissions factor of 80.4kg/t which was the average for the 1990–2004 period.
- Oil: Fugitive emissions factor is very small and was assumed to have the average of the values for the 1990–2006 period.

***Step 2: Industrial Greenhouse Gas Emissions, Solvents and Wastes*.** These emissions were pegged to energy use over the 1970-1989 period, backcasting by: (1) using the ratio: 'Industrial Greenhouse Gas Emissions and solvents' to 'energy use' average for the period 1990–1994; (2) using the ratio: 'wastes' to 'energy use' average for the period 1990–1994. That is, it was assumed that as energy use increased or decreased percentage-wise, so did 'Industrial Greenhouse Gas Emissions, solvents' or 'wastes' change by exactly the same percentage, and furthermore it was assumed that the above ratios that connected 'Industrial Greenhouse Gas Emissions' and 'wastes' to 'energy use' remained unchanged. At best, therefore these estimates and step two, are only indicative approximations. It is noted that for example, there may have been fluctuations when the Glenbrook Steel Mill and Tiwai Point aluminium smelter came on line. The Montreal protocol signed in 1987 would also have impacted on CFC use for refrigeration. Industrial processes, solvents and other product use only account for a small proportion of New Zealand's total GHG emissions.

***Step 3: Agricultural Greenhouse Gas Emissions*.** Three-yearly stock number averages for sheep, beef cattle, dairy, deer, pigs, goats and horses were multiplied by the 1990 CO_2-e emissions factors. Emissions from 'Other' animals were increased by 1% per year between 1970 and 1990. While it is known that emissions rates from animals have changed between 1990 and 2005, it has been assumed this was the result of stock breeding and farm management changes that occurred predominantly after 1990 (Calder and Tyson, 1999). Nitrogen fertiliser emissions have been calculated from tonnes applied multiplied by the standard emission factor used in New Zealand's Greenhouse Gas Inventory 1990–2005.

***Step 4: Land-use Greenhouse Gas Emissions*.** Estimates of sequestration by forestry during the 1970–1989 period are based on data from Maclaren and Wakelin (1992). These data are for plantation forestry only. Other land-use changes were assumed to be the same as in 1990 for each year from 1970 to 1989.

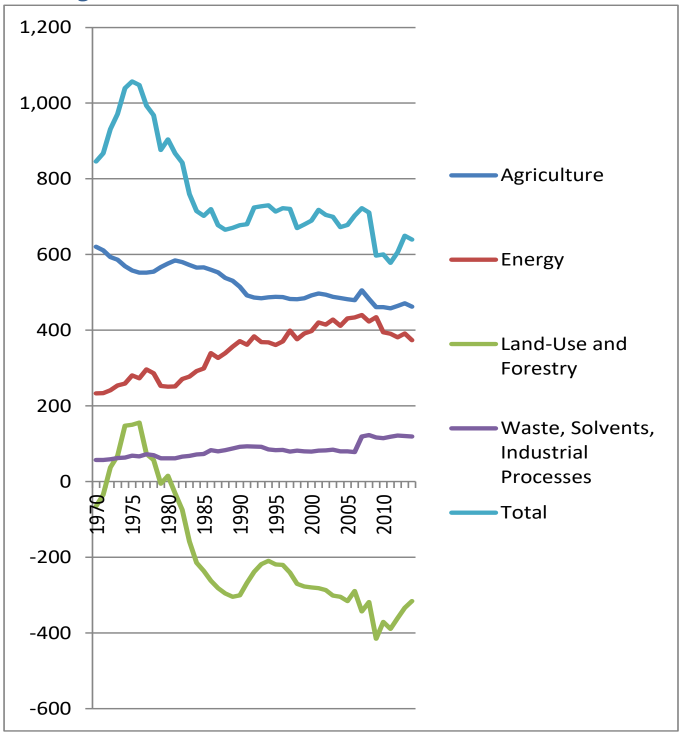
Aggregation of Greenhouse Gases. After the calculation of the GHG emissions (ktonnes/year) from 1970 to 1989, they were added to the data from 1990-2014 (which was uplifted from *New Zealand's Greenhouse Gas Inventory*) to obtain a time series for the entire period. For each year, the different types of greenhouse gas emissions (ktonnes/year), such as methane (CH_4) and nitrous oxide (N_2O) needed to be converted to CO_2 equivalents, to reflect their 'global warming potential' relative to one tonne of carbon dioxide (CO_2). CO_2 equivalents are, as per convention, abbreviated to CO_2-e.

Economic Valuation. The next step was to monetise these aggregated greenhouse gas emissions (CO_2-e tonnes). We based our economic valuation on the Stern (2006) Review's marginal social cost of carbon at \$US30 per tonne CO_2-e – this reflects the economic cost required to achieve the goal of 450ppm CO_2-e atmospheric carbon. At a 2005 exchange rate of NZ\$0.70 to \$US1.00, this equates to \$NZ$_{2005}$42.6 for 450ppm CO_2-e[90]. It could however be argued that the marginal social cost of greenhouse gas emissions increases over time, as the effect of an additional tonne of carbon is a positive function of the stock of carbon still resident in the atmosphere; therefore the higher the

[90] This Stern (2006) Review' \$NZ2005 42.6 per tonne of carbon dioxide is very similar to the value recommended by the New Zealand Transport Agency (2013) of \$NZ2004 40 per tonne. The New Zealand Productivity Commission (2018) suggests based on modelling results that "a rise of at least \$75 a tonne of carbon dioxide equivalent, and possibly over \$200 a tonne, over the next three decades." – this is a considerably higher price of carbon emissions compared with previous studies both in New Zealand and overseas.

historically accumulated carbon concentration in the atmosphere, the higher the social damage caused by each additional unit of emitted carbon (Neumayer, 2000).

Findings



Highlights

- Energy-derived greenhouse gas emissions rose by an extra 156% between 1970 to 2014.
- This trend of soaring emissions from energy use, was counteracted by increased forestry plantings and other land use changes .
- Taking account of all these factors, from 1970 to 2014, there was a net increase in annual greenhouse gas emissions of 21%.
- For the year 2014, these net greenhouse gas emissions were costed at $2,886 million or $640 per person.

Figure 21.1 Per Capita Cost of Greenhouse Gas Emissions

Figure 21.1 shows that the **per capita cost** of greenhouse gas emissions in New Zealand has in overall terms declined by 24.4% from 1970 to 2014. However, when considered in terms of the total cost greenhouse gas emissions in New Zealand, it has actually increased by 21.0% from 1970 to 2014 (refer to Table 21.1)[91]. The macro-level reasons for this decline in the per capita cost of greenhouse gas emissions, are evident by examining Figure 21.1 – the overall per capita cost of GHG emissions peaked in 1975 at $\$_{2014}$ 1,058 per capita, and then thereafter declined through the rest of the 1970s and through the 1980s to a low of $\$_{2014}$666 per capita in 1988. From 1989 through the 2008, the per capita cost of GHG emissions stayed relatively unchanged hovering around about $\$_{2014}$700 per capita. The main drivers of this overall pattern of change with the per capita cost of GHG emissions peaked are:

(1) Land Use and Forestry is a dominant driver particularly with forestry plantings absorbing atmospheric carbon dioxide. It can be seen from the Figure 20.1, over the period from 1980 to 2014, there has been a trend of increased carbon absorption through the forestry and land-use changes, with fluctuations being due to factors such as log prices and harvesting schedules influencing deforestation rates. Overall, from 1970- 2014 the removal of carbon from the atmosphere changed from 1.22 tonnes CO_2-e per capita ($\$_{2014}$65 per capita) in 1970, to a very significant 5.93 tonnes CO_2-e

[91] It is a common observation in environmental and ecological economics: (1) there is an apparent ‘decoupling’ of environmental pollution from economic growth when the data is expressed in ‘normalised’ terms such as kilograms of pollutant per person; (2) that when the same data is presented in ‘absolute’ terms such as kilograms of pollutant, there is not necessarily any decoupling. The former is termed ‘relative de/coupling’ and the latter termed ‘absolute de/coupling’. Both phenomena can be measured by the so-called environmental Kuznet curves that plot ‘environmental damage’ (e.g., kgs of pollutant or kg of pollutants per capita) against income per capita (e.g., GDP per capita).

per capita ($\$_{2014}$316 per capita) in 2014. Hence, by 2014, this carbon dioxide absorbed by forests, was getting closer to outweighing the emissions of greenhouse gases from the energy sector.

(2) Energy related GHG emissions on a per capita basis were costed at $\$_{2014}$ 233 per capita in 1970, steadily increasing to a peak of $\$_{2014}$ 440 per capita in 2007. Then, from 2008 to 2014, there was a general downwards trend to eventually $\$_{2014}$ 374 per capita cost of greenhouse gas emissions in New Zealand in 2014. Typically, almost all other OECD countries experienced their 'peak', in their per capita greenhouse gas emissions, a lot earlier than in New Zealand – that is, most countries experienced 'peak' GHG from energy use (when measured on a per capita, or on a per unit of GDP basis) in the 1970s and 1980s, typically when they moved from heavily industrialised economies to more service based economies. New Zealand's poor performance in lagging behind other countries in reaching 'peak' GHG from energy use, is in part due to structural factors in the New Zealand economy such as the continued predominance of some energy intensive sectors, but also factors such as energy efficiency improvements being comparatively weak in New Zealand (Patterson, 1989; Patterson, 1993).

(3) Agriculture related greenhouse gas emissions, play a far more important role in the greenhouse gas emissions profile of New Zealand, compared with other developed countries where energy-related Emissions usually dwarf agricultural greenhouse gas emissions. In this regard, the Ministry for Environment (2017) reports that in 2015 47.9% of the gross greenhouse gas emissions of New Zealand were from the agricultural sector. That said, both on a 'per capita' and 'total' basis, agricultural sector greenhouse gas emissions trended downwards from 1970 to 2014. This downwards trend (dominant in the 1980s through to the mid-1990s) was due to decreased animal stock numbers[92] – total sheep numbers decreased from 60.3 million in 1970 to 47.4 million in 1996, and beef cattle numbers decreased from 5.5 million in 1970 to 4.9 million in 1996. In more recent years, there has however been a significant increase in dairy herd numbers pushing agricultural sector greenhouse gases upwards, both on a 'per capita' and 'total' basis.

(4) **Wastes, Solvents and Industrial Processes** related GHG emissions have a smaller effect on the level of greenhouse gas emissions in New Zealand, than the other categories. That said, this category has doubled from 1.1 tonnes CO_2-e per capita ($\$_{2014}$57 per capita) in 1970 to a significant 2.2 CO_2-e per capita ($\$_{2014}$119 per capita) in 2014. In fact, in percentage terms, this category has been increasing at a far more rapid pace than the energy sector GHG emissions over the 1970 to 2014 period. The Ministry for the Environment (2017) attributes this relatively rapid escalation in GHG from the 'Wastes, Solvents and Industrial Processes' category, due to the increased use of substitutes for ozone depleting products in refrigeration and air-conditioning, as well as increased levels of carbon dioxide emissions from production of cement, metals and ammonia.

Table 21.1 and Fig 21.2 summarises the **total cost** of greenhouse gas emissions in New Zealand from 1970 to 2014. Overall, the total amount of greenhouse gas emissions increased from 4,786 kilotonnes CO_2-e in 1970, to 54,201 kilotonnes CO_2-e in 2014. As can be ascertained by comparing Fig 21.1 (per capita basis) and Fig 21.2 (total cost basis), the same for underlying factors contribute to the overall level of GHG, irrespective of which of these metrics is used – the only difference being is that the 'total' graph is flatter than 'per capita' graph. The 'total cost' of greenhouse gas emissions for 2014 is $\$_{2014}$ 2.886 billion, which ranks the second highest environmental cost behind the loss of soil ecosystem services.

[92] Agricultural sector greenhouse gas emissions are predominantly due to enteric fermentation by domesticated animals – the Ministry for Environment (2017) reported that in 2015 73.1% of the agricultural sector GHG emissions were methane emissions from enteric fermentation from domesticated animals. That said, other sources such as emissions from soil and the use of synthetic fertilisers also significantly contribute to greenhouse gas emissions by the agricultural sector – the Ministry for Environment, (2017) reported that in 2015 20.6% of the agricultural sectors GHG emissions are N2O emissions from the 'agricultural soils' category.

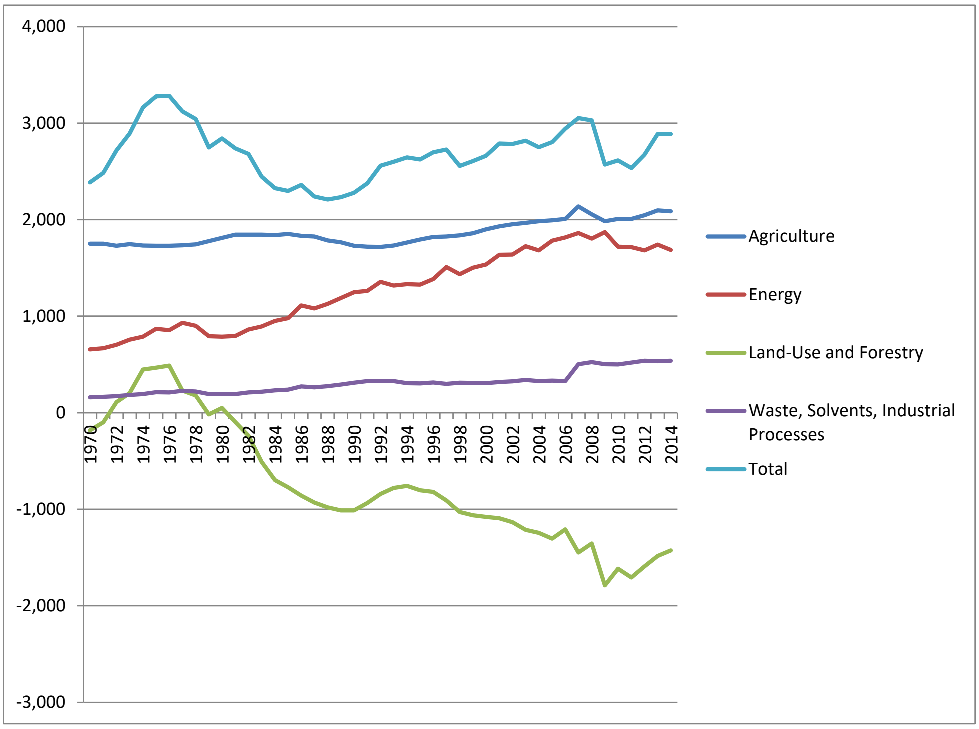


Figure 21.2 Total Cost of Greenhouse Gas Emissions, 1970-2014, $\$_{2014}$

Update to 2016

Year	Sources of Greenhouse Gas Emissions					Total Cost of Greenhouse Gas Emissions	Per Capita Cost of Greenhouse Gas Emissions
	Agriculture	Energy	Land-Use, Land-Use Change and Forestry	Waste, Solvents, Industrial Processes	Total Net Greenhouse Gas Emissions		
	kt CO_2e	kt CO_2e	kt CO_2e	kt CO_2e	kt CO_2e	$\$_{2014}$million	$\$_{2014}$ per person
2015	39,226	32,444	-26,169	10,318	55,818	2,973	646
2016	38,794	32,631	-26,155	10,446	55,716	2,967	632

- The total cost of greenhouse gas emissions increased to $\$_{2014}$ 2.967 billion for 2016, which represents a 2.8% increase over the period 2014 to 2016. However, the per capita total cost of greenhouse emissions dropped by 1.2% over this period – due to population growth outstripping the increased cost of greenhouse gas emissions.
- Over the 2014 to 2016 period, energy greenhouse gas emissions increased (by 3.1%), as did emissions from wastes, solvents and industrial processes (by 3.2%). Whereas, agricultural greenhouse gas emissions decreased (by 1.0%), as did emissions from land use and forestry changes (by 2.3%).

Table 21.1 Cost of Greenhouse Gas Emissions: Total and Per Capita, 1970-2014

Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Year	Sources of Greenhouse Gas Emissions					Total Cost of Greenhouse Gas Emissions	Per Capita Cost of Greenhouse Gas Emissions
	Agriculture	Energy	Land-Use Change and Forestry (Refer to Note 1)	Waste, Solvents, Industrial Processes	Total Net Greenhouse Gas Emissions		
	kt CO_2e	kt CO_2e	kt CO_2e	kt CO_2e	kt CO_2e	$\$_{2014}$million	$\$_{2014}$ per person
1970	32,864	12,338	-3,434	3,018	44,786	2,385	846
1971	32,872	12,566	-1,861	3,074	46,650	2,484	867
1972	32,473	13,231	2,064	3,236	51,004	2,716	932
1973	32,795	14,196	3,815	3,472	54,279	2,891	971
1974	32,522	14,814	8,423	3,624	59,382	3,162	1040
1975	32,489	16,326	8,756	3,994	61,565	3,279	1058
1976	32,468	16,074	9,160	3,932	61,634	3,282	1048
1977	32,569	17,484	4,299	4,277	58,629	3,122	994
1978	32,756	16,900	3,363	4,134	57,154	3,044	968
1979	33,387	14,891	-304	3,643	51,618	2,749	876
1980	34,026	14,804	913	3,621	53,365	2,842	904
1981	34,645	14,915	-1,807	3,648	51,401	2,737	867
1982	34,632	16,186	-4,452	3,959	50,326	2,680	843
1983	34,637	16,769	-9,557	4,102	45,951	2,447	760
1984	34,553	17,849	-13,106	4,366	43,662	2,325	715
1985	34,769	18,382	-14,502	4,496	43,145	2,298	702
1986	34,432	20,872	-16,118	5,106	44,292	2,359	720
1987	34,289	20,266	-17,466	4,957	42,046	2,239	678
1988	33,529	21,163	-18,404	5,177	41,464	2,208	666
1989	33,174	22,319	-19,004	5,459	41,948	2,234	671
1990	32,497	23,449	-18,981	5,826	42,791	2,279	678
1991	32,314	23,722	-17,556	6,140	44,620	2,376	680
1992	32,245	25,451	-15,803	6,166	48,060	2,559	724
1993	32,517	24,754	-14,630	6,177	48,818	2,600	727
1994	33,130	25,006	-14,241	5,763	49,659	2,645	730
1995	33,706	24,940	-15,100	5,723	49,268	2,624	714
1996	34,170	25,987	-15,416	5,897	50,638	2,697	722
1997	34,296	28,344	-17,081	5,624	51,184	2,726	721
1998	34,521	26,955	-19,333	5,849	47,993	2,556	670
1999	34,923	28,184	-19,951	5,783	48,939	2,606	679
2000	35,678	28,835	-20,245	5,735	50,002	2,663	690
2001	36,266	30,707	-20,545	5,961	52,388	2,790	718
2002	36,658	30,785	-21,279	6,114	52,279	2,784	705
2003	36,920	32,388	-22,786	6,380	52,902	2,817	699
2004	37,259	31,599	-23,381	6,155	51,632	2,750	672
2005	37,445	33,473	-24,501	6,232	52,649	2,804	678
2006	37,700	34,100	-22,700	6,140	55,240	2,942	703
2007	40,114	34,951	-27,189	9,437	57,313	3,052	722
2008	38,598	33,854	-25,437	9,866	56,882	3,029	711
2009	37,254	35,113	-33,563	9,452	48,255	2,570	597
2010	37,703	32,276	-30,321	9,409	49,067	2,613	600
2011	37,713	32,189	-32,057	9,765	47,611	2,536	578
2012	38,426	31,556	-29,883	10,098	50,197	2,673	606
2013	39,347	32,695	-27,849	10,035	54,229	2,888	649
2014	39,177	31,659	-26,761	10,125	54,201	2,886	640

Footnotes on the next page:

Footnotes for Table 21.1

Column B: 1990-2014 from Ministry for the Environment (2017); 1970-1989 based on animal stock numbers

Column C: 1990-2014 from Ministry for the Environment (2017); 1970-1989 Ministry of Economic Development (2007b)

Column D: 1990-2014 from Ministry for the Environment (2017); 1970-1989 mainly from Maclaren and Wakelin (1992)

Column E: 1990-2014 from Ministry for the Environment (2017); 1970-1989 pegged to the same rate of change of energy CO_2e

Column F: Column B + Column C + Column D + Column E = Column F

Column G: Total Cost of Greenhouse Gas Emissions = Price of CO_2e x Column F (Quantity of Greenhouse Gas Emissions, CO_2e)

Where: 'Price of CO2e' = $\$US_{2005}$30,000 per kilotonne CO2e [Stern's (2005) price], converted to $\$NZ_{2014}$

Note 1: In strict terms, this is not 'greenhouse gas emissions'. Rather: (a) a negative number equals net sequestration of atmospheric carbon (CO_2e) by land-use and forestry activities; (b) a positive number equals net release to the atmosphere of CO_2e by land-use and forestry activities

22. Water Pollution

Why Include

Fresh water fundamentally supports almost every aspect of not only human life, but also that of animals and plants. It is pivotal to New Zealanders' health and cultural well-being, ecosystem health and resilience, and our economy. The consumption of pure water is required to sustain life. For Maori, freshwater is a taonga and fundamental to cultural identify of iwi and hapū. The quality of water in our groundwater, streams, rivers, lakes and estuaries must also be of a sufficient purity to enable the life and abundance of creatures that live in such ecosystems, as well as for recreational and cultural pursuits, which contribute to our wellbeing. In the production of goods and services, New Zealand's economy is heavily reliant on the provision of fresh water with the agriculture, horticulture and other primary sector industries being prime examples. Furthermore, our environmental reputation also increasingly influences the international value of our traded goods and services. New Zealand's "100% pure" environmental image underlies much of our marketing strategy to sell our goods and services to the world. A "clean and green" environmental reputation is a significant factor in attracting tourists, in what is a fast-growing and important economic contributor for New Zealand.

Land use is the main driver of water quality in New Zealand's 4,200 catchments, which vary in size and complexity throughout the country, with complex interactions between land use, surface water and ground water. "It can take decades in some catchments for water (and some contaminants) to cycle from the Earth's surface through the ground to aquifers, and back to surface water systems. For example, in the Waikato time lags for nitrogen cycle to cycle through the system may be 80 years, while in Southland it may be only one to two years. This means some effects seen today are legacies of past activities, and the impact of human activities today may not be seen in waterways for a long time" (Ministry for the Environment, 2017).

Over 100 years of intensification of land use in both urban and rural areas is taking a toll on the quality of New Zealand's fresh water bodies and ecosystems, with increased pressures from activities such as clearing of native vegetation, draining of wetlands, farming, forestry, and urbanisation. For example, New Zealand's population grew 17 per cent from 1996 to 2012, driving a 10 per cent increase in urban land area. At the same time, there has been a shift in pastoral farming – from 1994 to 2015, sheep numbers decreased 41 percent but dairy cattle increased 69 per cent. These changes have increased pressure on the quality of fresh water in both rural and urban areas (Ministry for the Environment, 2017).

The Ministry for Environment's (2017) briefing paper to the new Labour-led coalition government summarise the trends and state of New Zealand's freshwater as follows: (1) between 1994 and 2013, nitrate concentrations deteriorated by 55% of monitored sites and improved by 28% of monitored sites; (2) between 1994 and 2013, dissolved phosphorus concentrations deteriorated by 42% of monitored sites and improved by 25% of monitored sites; (3) between 1989 and 2013, water clarity improved at two-thirds of monitored sites; (4) of the aquatic native species reported on, three-quarters of fish, one third of invertebrates, and one-third of plants are threatened with, or at risk of extinction.

What to Include

Water quality degradation in New Zealand occurs in a number of aquatic environments and ecosystems, resulting from intensification of land use, urbanisation expansion, increased fertiliser use, industrial effluent, urban run-off stormwater, sewage effluent disposal, and more recently has been linked to climate change. These aquatic environments include rivers and streams, lakes, groundwater, wetlands, harbours and coastal environment.

River and stream water quality is assessed in NIWA's 77 site network by the following indicators: dissolved oxygen, temperature, pH (acidity and alkalinity), conductivity, Biological Oxygen Demand (BOD), various nitrogen and phosphorus variables, turbidity, coloured dissolved organic matter (CDOM), visual clarity, *escherichia coli* concentration, periphyton and macro-invertebrate fauna.[93] Not all regional councils however monitor river, stream (and lake) water quality using the same consistent set of indicators, as shown by Figure 22.1 for chemical and physical indicators of water quality.

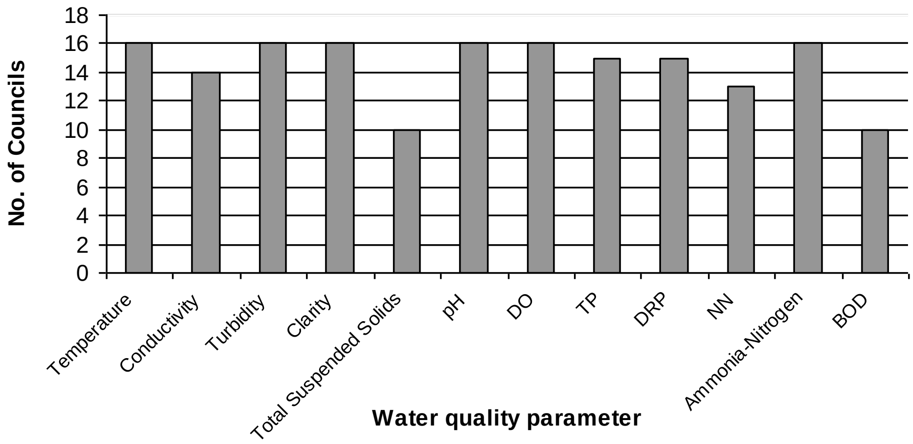


Figure 22.1 Water Chemical and Physical Parameters Measured by Regional Councils
Source: Ministry for the Environment (2001b)

Increases in Nitrate (NO_3) and Dissolved Reactive Phosphorus (DRP) are considered to be of greatest concern for water quality in New Zealand, as elevated concentrations of these nutrients are responsible for excessive growth of aquatic plants and algal blooms with consequential negative impacts on individual species and overall 'ecosystem health' (Environment Waikato, 2006). The main source of these elements in waterways is attributed to agricultural production, and most particularly dairy farming, and sheep and beef farming.

Nitrogen losses occur principally from the leaching of nitrate from the surface soils, rather than from run-off. Annual nitrate leaching losses are generally lower on sheep-grazed pastures than on cattle-grazed pastures. On a per unit area basis, vegetable cropping systems produce by far the largest nitrate leaching to groundwater compared to any other land use type. Leaching losses range from 80 to 292 kg N/ha/yr depending on the amount of rainfall and the type of crop grown (Ledgard, 2001). However, the total impact on waterways from vegetable cropping is negligible as this land use is a small portion of the total New Zealand land area.

Phosphorus losses from agricultural systems are generally much lower than nitrogen losses, but still have a critical impact on the eutrophication of surface waters. Phosphorus (P) losses vary dramatically with differences in the animal stocking rate, soil type, topography, cultivation, fallow periods, cover crop and P fertilizer management. The majority of P (up to 80%) in run-off is in the form of particle-bound P, while less than 20% is present as dissolved P. Storm events have an important influence on the amount of P loss from pastures, especially in hill country farms. McColl *et al.* (cited in Menneer *et al.*, 2004) found about 70% of particulate P losses from hill country pasture occurred during large storms, and these comprised about 55% of total P losses for the year. In general, forestry contributes the least amount of P to waterways, followed by hill country sheep farming. Comparisons of pine forest versus grazing systems show that, in all situations, the total P losses from pine plantations are in the order of 24–57% of the P losses from pasture catchments (Menneer *et al.*, 2004).

[93] These are the "core variables" used in the NIWA's National River Water Quality Network as reported by Davies-Colley *et al.* (2011).

Data Available from 1970 to 1989. During this perod, the Ministry of Agriculture published regional summaries of the main pollution sources and general water quality trends in a series of reports entitled “Regional Modifications to Waterways” in the now obsolete journal *Freshwater Catch* (Ministry of Agriculture, various dates). These qualitative summaries generally indicated that up to 1988, water quality was at its lowest in the 1970s and early 1980s due to high numbers of direct point discharges from sewage and trade wastes combined with farm leaching.

It is known that in the 1970s large volumes of organic matter entered waterways from dairy factories, meat-works, wool scours, tanneries, pulp and paper mills as well as other activities that process New Zealand’s primary produce. Urban expansion added to this with sewage outflows (Ferrier and Marks, 1982). Overall, water pollution from point sources decreased throughout New Zealand between 1970 and 2006, but actual data to measure this change is not available. Effluent flows from factories were not systematically recorded in the 1970s and 1980s, and while The Ministry of Works collected sewage treatment and disposal statistics from local authorities, the majority of these authorities did not analyse waste characteristics (Ministry of Works, 1971, 1976, 1981).

There are no comprehensive data for non-point pollution from 1970 onwards. Some information is available, such as the fact that while point organic waste pollution was high in the 1970s, the actual volume was still less than non-point sources. Surveys in the 1970s showed that agricultural run-off accounted for 58% of the biological oxygen demand (BOD) in freshwater, 45% of total phosphorus, and 88% of total nitrogen (McColl and Hughes, 1981; McColl, 1982). A decade later, agricultural sources were still the main causes of water pollution, accounting for 75% of the total nitrogen loading in surface waters (Ministry for the Environment, 1997). Diffuse (≈non-point) pollution from agricultural development, particularly dairy-farming, was recognised as a major contributing factor to poor water quality in the 1980s.

As early studies of overall water quality focused on different criteria than those currently used, direct comparison over time is not possible. Attempts at nationwide comparisons of river water quality were conducted by Mosley (1982) based on river temperature; and by Biggs and Price (1987) based on river temperature and conductivity (obtained during a survey of algal proliferations). In addition, in late summer to autumn 1987, Close and Davies-Colley provided a snap-shot investigation by analysing (up to three times) 96 rivers throughout New Zealand in base-flow conditions, for a number of water quality indicators (Close and Davies-Colley, 1990a, b).

Data Available from 1990-2014 Cooper (1992, cited in Ministry for the Environment, 1997), show a 1992 pattern of non-point sources of water pollution far exceeding point sources in their contribution to nitrogen loadings, with agriculture being the major contributor – refer to Table 22.1. The

Table 22.1 Estimated Yearly Nitrogen Loadings to New Zealand Surface Waters

Non-point source		Point source	
Category	tonnes of nitrogen/yr	Category	tonnes of nitrogen/yr
Agriculture	100,000	Agriculture	7,000
Native Forest	15,000	Urban and Sewage	2,400
Exotic Forest	7,000	Pulp and Paper	800
Total	122,000	Total	10,200

Source: Ministry for the Environment (1997)

A comprehensive national water quality dataset was collated by NIWA (2006) for the 1989–2004 period. Changes in nitrogen and phosphorus levels over this period demonstrate that while overall levels fluctuate, possibly due to climate variation, a nationwide trend of increasing total nitrate (TN) and total phosphorus (TP) is not discernible. However, the national sample covers waterways in both pristine areas and agricultural areas so average statistics have the potential to conceal concentrated degradation in some sites.

Scarsbrook (2006) provides a summary of water quality trends in New Zealand, by analysing data obtained from NIWA's 'National River Water Quality Network' sites from January 1989 to December 2005. From this analysis Scarsbrook (2006), attributed: (1) decreasing trends in Biological Oxygen Demand (BOD) and ammoniacal-N to reducing loads of point source pollution; (2) increasing visual quality to improved farming and forestry practices; (3) increasing nitrogen and phosphorus loadings resulting from increased levels of 'nonpoint source pollution' brought about by the intensification of agriculture.

Data Available for Lakes

Lakes act as sinks for sediment and nutrients and, as water is resident in lake basins for long periods of time, it is more vulnerable to the effects of human activities and developments in the lakes' catchments than rivers, which are constantly renewed by flows upstream (Spigel and Viner, 1992). Of New Zealand's 700 or so shallow lakes, between 10 and 40% are eutrophic (Ministry for the Environment, 1997). In these lakes the nutrient levels are so high that dissolved oxygen levels are significantly reduced, and many fish and aquatic organisms cannot survive. Most of these eutrophic lakes are located in the pasture-dominated catchments of the North Island (Ministry for the Environment, 1997), and a number are subject to fish kills, or are no longer capable of supporting fish life (Ministry for the Environment, 1997). Trends in the ecological condition of 46 lakes tested recently showed a decline in the condition of most lakes, with only 22% showing improvement (Hamill, 2006).

The publication 'Inventory of New Zealand Lakes' (Livingston *et al.*, 1986), classified lakes in New Zealand according to their trophic state. Although the study was not exhaustive, it captured most major lakes and many smaller lakes. In total, 81 lakes in the North Island and 84 lakes in the South Island for which chemical or biological information was available were classified (Livingston *et al.*, 1986). Comparisons of data from the Livingston *et al*. (1986) study with data collated by Hamill (2006) indicate that lake water quality overall is in decline, especially in those lakes in lowland areas. Lakes where water quality had improved were mostly the near pristine Canterbury high-country lakes (Hamill, 2006).

Table 22.2 Classification of New Zealand Lakes According Trophic State

Livingston et al. (1986)		Hamill (2006)	
Trophic State	Number of Lakes	Trophic State	Number of Lakes
Highly eutrophic	11	Hypertrophic	18
Moderately eutrophic	5	Supertrophic	13
Eutrophic	25	Eutrophic	44
Total	165	Total	134
% of all Lakes	25	% of all Lakes	59

How to Include

The cost ($) of water pollution in New Zealand, was calculated across 3 categories, listed here in order of diminishing impact: (1) non-point source pollution of rivers and streams; (2) point source pollution of rivers and streams; (3) pollution of lakes. Full technical details of the calculation of the cost ($) of water pollution across these categories are contained in Appendix I, Appendix II and Appendix III – a summary of these costings follow:

Non-point source pollution of rivers and streams ($). The first step of the costing was to calculate the level of nonpoint source pollution and rivers and streams, from 1970 to 2014. Nitrogen was used as the proxy for nonpoint source pollution of rivers and streams – the amount of nitrogen from livestock was calculated from multiplying livestock numbers for each year, by the nitrogen per head of different types of stock. Then, these yearly data on the amount of nitrogen from livestock, were combined with the amount of nitrogen from fertilisers, to get the total amount of nitrogen loadings, across both these sources.

The second step was to estimate the total cost ($) over the entire 1970 to 2014 period. This was calculated by estimating over a 44 year period, the cost of planting riparian margins to intercept pollutants such as nitrogen, phosphorus and sediments. By taking account of data from Zhang (2010) and other sources, it was concluded that an optimal width of riparian margin is about 15 m (refer to Figure 22.2). It was calculated that the total cost of riparian margins, over 284 million kilometres of river and stream banks, over this 44 year period would be= $\$_{2014}$ 65.0 billion, of which $\$_{2014}$ 50.0 billion was the 'cost of lost agricultural production' by land covered by the riparian margins, and $\$_{2014}$ 14.9 billion was the 'cost of planting, fencing and maintenance'.

The final step was to combine the data from the first two steps. This involved apportioning this total cost of $65.0 billion over the entire time period, to each specific year. Hence, those years which had high levels of non-point source pollution (as indicated by the nitrogen proxy) would have higher costs ($), and vice versa for those years that had lower levels of non-point source pollution (as indicated by the nitrogen proxy) would have lower costs ($)

For full details of this costing ($) of non-point source pollution of rivers and streams, refer to Appendix I

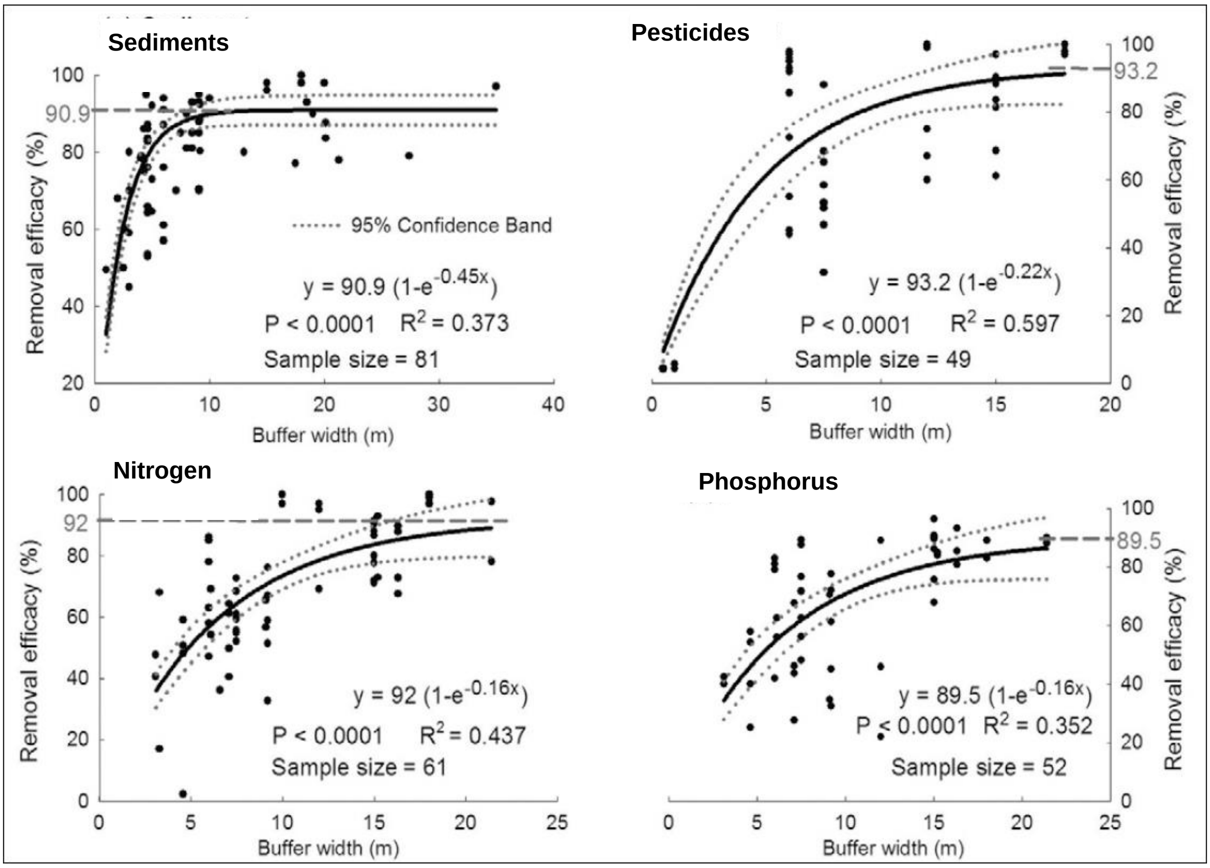


Figure 22.2 Riparian Width versus Efficacy of Pollutants Removal
Source: Zhang *et al.* (2010)

Point source pollution of rivers and streams ($) The first step of the costing was to calculate the level of point source pollution in rivers and streams, from 1970 to 2014. Biological Oxygen Demand (BOD_5 ppm) was used as a proxy of point source pollution in rivers and streams over this period (refer to Figure 22.3) – the levels of BOD_5 were known for the 15 years from 1988 to 2002, and by using a regression equation of the downward trend over this period, the levels of BOD_5 could be 'back-casted' for the years 1970 to 2001 and 'forecasted' for the years 2002 to 2014.

The second step was to estimate the total cost ($) over the entire 1970 to 2014 period. Since the total nitrogen-loading of 'point source pollution' to 'non-point source pollution' was 10.2%, according to the Ministry for the Environment (1997), it was assumed that the total cost ($) was the same percentage. That is, the total cost of point source water pollution was 10.2 % of $\$_{2014}$ 64.9 billion, which equals $6.6 billion.

The final step was to combine the data from the first two steps. This involved apportioning this total cost of $6.6 billion over the entire time period, to each specific year. Hence, those years which had high levels of point source pollution (as indicated by the Biological Oxygen Demand proxy) would have higher costs ($), and vice versa for those years that had lower levels of point source pollution (as indicated by the Biological Oxygen Demand proxy) would have lower costs ($).

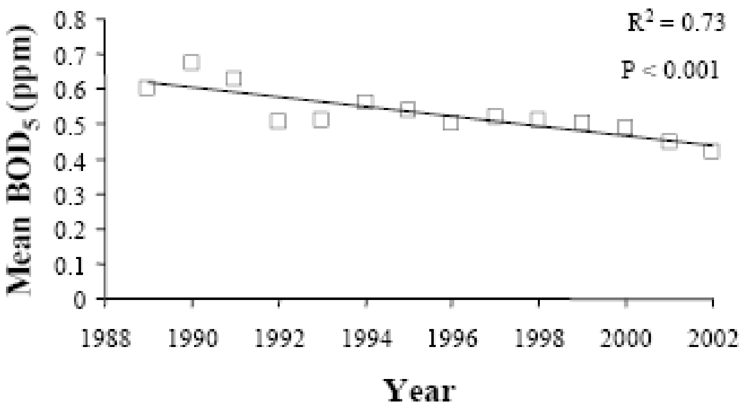


Figure 22.3 Mean BOD_5 in New Zealand Rivers 1988–2002
Source: (Scarsbrook and McBride, 2003)

For full details of this costing ($) of point source pollution of rivers and streams, refer to Appendix II.

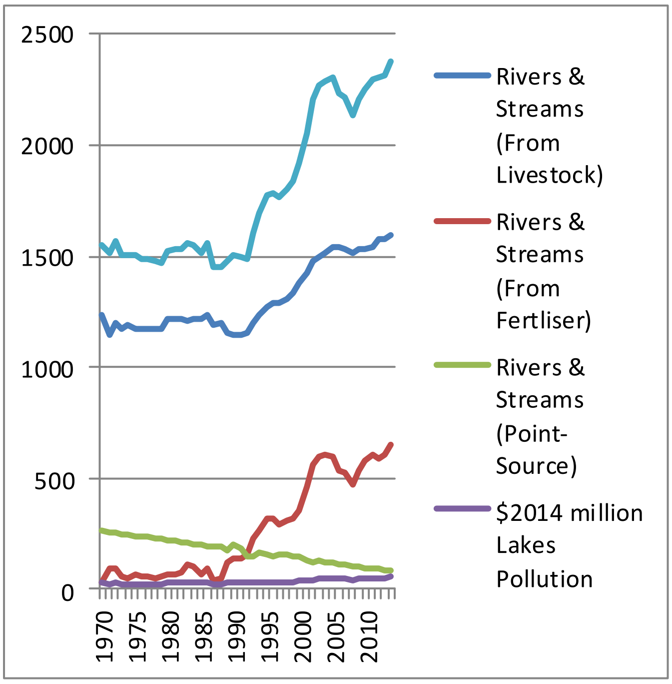
Pollution of Lakes ($) This includes the cost of both point source and non-point source pollution of lakes. The first step of the costing was to calculate the level of nonpoint source pollution and rivers and streams, from 1970 to 2014. Nitrogen was used as the proxy for pollution of lakes and streams, as calculated from multiplying livestock numbers for each year, by the nitrogen per head of different types of stock. Then this yearly data on the amount of nitrogen from livestock were combined with the amount of nitrogen from fertilisers, to get the total amount of nitrogen loadings, across both these sources.

The second step was to estimate the total cost ($) of pollution of lakes in New Zealand. This was calculated by summing the component costs: (1) cost of restoring the water quality of eutrophic lakes in New Zealand to an acceptable level, based on restoration costs for the Rotorua lakes; (2) the cost of maintaining Lake Taupo at the 2003 water quality level over a 10 to 15 year period. This total cost [(1) + (2)] was calculated to be $\$_{2014}$ 791 million.

The final step was to combine the data from the first two steps. This involved apportioning this total cost of $\$_{2014}$ 791 million over the entire time period, to each specific year. Hence, those years which had high levels of pollution of lakes (as indicated by the BOD proxy) would have higher costs ($), and vice versa for those years that had lower levels of pollution of lakes and streams (as indicated by the nitrogen proxy) would have lower costs ($).

For full details of this costing ($) of pollution of lakes, refer to Appendix III.

Findings



Highlights

- The cost of polluted water in NZ remained largely unchanged through the 1970s and 1980s, although the per capita cost declined.
- After then, the cost of water pollution dramatically increased from $1,495 million in 1992 to $2,394 million in 2016, with the increase on a per capita basis being less marked.
- The main reasons for this increase in water pollution costs from 1992 onwards were the: (1) increase in dairy cattle numbers; (2) increase in the use of nitrogenous fertilisers.

Figure 22.4 Per Capita of Loss of Water Quality, 1970-2014, $$_{2014}$ per person

The deterioration of water quality in New Zealand, particularly over the last two decades has been well documented. As Davies-Colley (2013) concludes "Unfortunately, the water quality of rivers in New Zealand has been declining for the last 25 years … Gains from point pollution control have been negated by steadily increasing diffuse (non-point source) pollution, particularly nitrogen and phosphorus enrichment from the intensification of pastoral agriculture." Therefore, it is not surprising that the 'total cost' associated with water quality degradation have increased from $$_{2014}$ 1,553 million in 1970 to $$_{2014}$ 2,394 million in 2014.

As can be seen from Fig 22.4 (above), the most striking trend was that the total cost of water quality degradation in New Zealand rivers and lakes, remained relatively unchanged, and indeed very slightly declined from 1970 to 1991, before it sharply increased from 1992 onwards with an increased loadings of pollutants and nutrients, particularly of nitrogen, primarily from increased numbers of dairy cattle as well as leakage of nitrogen into water bodies from accelerated use nitrogenous fertilisers.

Over this **period (1970-1991)**, as reflected, in Figure 22.4, this slight downward trend in the cost of water pollution was in part due to the improvement of the disposal of effluent from point source such as pipelines, drains and other waterways – across a number of industries such as freezing works and dairy factories, as well as particularly in the urban situation where sewage works improved their treatment of effluent. That said, throughout this 1970-1991 period, even at the beginning when point-source pollution was at its highest, loads of the 'less visible' nonpoint water pollution in rivers greatly outweighed point-source water pollution in rivers. This imbalance between nonpoint and point source pollution is due to the comparatively large size of New Zealand's export-orientated pastoral farming sector (which is responsible for most nonpoint pollution), compared with the relatively small size of our urban population and industry (which is responsible for most point source pollution)[94].

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[94] The analysis shows that in 1970 the costs associated with point source pollution were 20.7% of the costs associated with nonpoint source pollution – and, by 1991 it decreased to only 14.5%.

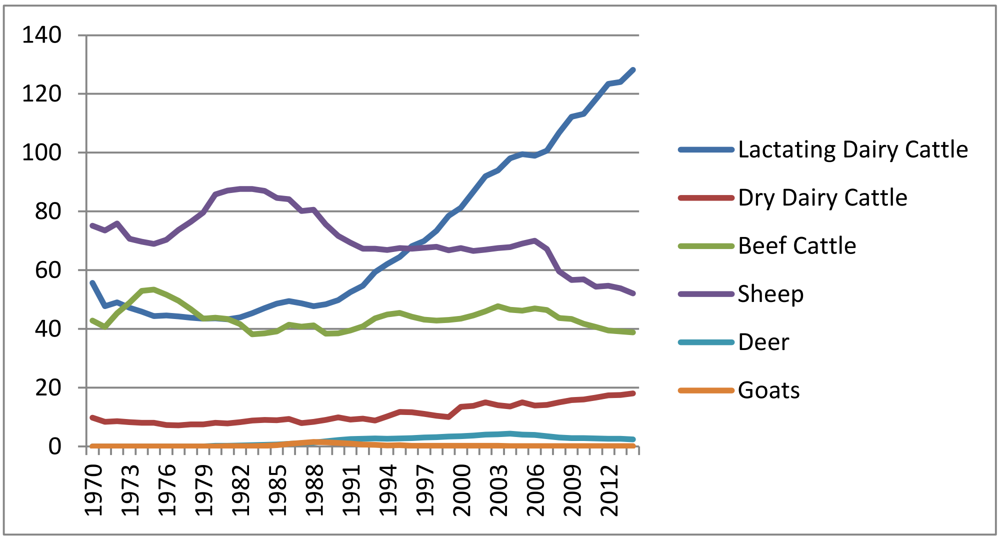

Figure 22.5 Nitrogen Leaching and Run-off from Livestock in New Zealand (GgN per year)

Most of this non-point or diffuse pollution of rivers over the 1970 to 1991 period, was caused by excreta from livestock – for example, Fig 22.5 data (which were used for our costings), show that for 1970-1991 the largest amount of nitrogen leaching and run-off was from sheep excreta (average of 78 Gg-N/year[95]); followed by significant loading from lactating dairy cattle (average of 47 Gg-N/year) and beef cattle (average of 44 Gg-N/year), then a sizable drop to dry dairy cattle (average of 8 Gg-N/year), and then by finally very small amounts from other livestock such as goats and deer.

By 1991, the cost ($$_{2014}$) of water pollution, by using nitrogen and BOD as the proxies, it was estimated, in our analysis, to consist of the following components:

- non-point source river pollution caused by livestock run-off and leaching: $1,145 million/yr
- non-point source river pollution caused by fertiliser run-off and leaching: $138 million/yr
- point source river pollution: $186 million/yr
- lake pollution: $26 million /yr

The next period (**1992 to 2014**) saw a dramatic and unprecedented increase in the level pollution of New Zealand's rivers, streams, lakes and other water bodies. Hence, over this period the cost associated with the degradation of water quality in New Zealand increased from an estimate of $$_{2014}$ 1,495million in 1992 to 2,394 million in 2014 (refer to Table 22.3). This dramatic increase in the level of water pollution was essentially due to rapid expansion of the size of the dairy farming industry driven by strong export growth into markets such as China, as well just as importantly the year-on-year consistently high increases in the use of nitrogenous fertilisers to boost pasture production. As can be seen from Figure 22.5, over this period, although increased dairy cow numbers and the accelerated use of nitrogenous fertilisers had a negative effect on water quality, the sharp decline in sheep numbers[96] had the opposite effect of improving water quality.

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[95] 1 Gg-N = 1 gigagram of nitrogen =1,000,000,000 grams of nitrogen = 1,000 tonnes of nitrogen= 1 kilotonne of nitrogen

[96] Sheep numbers declined from 52.6 million in 1992 to only 29.8 million in 2014. This is a continuation of the trend that started in the early 1980s, when sheep numbers where at a peak in 1982 (70.3 million), but have been on the decline ever since (refer to Appendix IV for further statistical details)

Table 22.3 Cost of Loss of Water Quality: Total and Per Capita, 1970 to 2014

Year	Rivers & Streams (Non-Point Source From Livestock)	Rivers & Streams (Non-Point Source From Fertlisers)	Rivers & Streams (Point Source)	Lakes	Total Cost	Total Cost per capita
	$\$_{2014}$ million	$\$_{2014}$ million	$\$_{2014}$ million	$\$_{2014}$ million	$\$_{2014}$ million	$\$_{2014}$ million per person
1970	1,293	28	206	26	1,553	551
1971	1,200	77	203	25	1,505	525
1972	1,262	76	200	26	1,563	536
1973	1,234	45	196	25	1,500	504
1974	1,245	44	193	25	1,507	496
1975	1,232	54	190	25	1,501	484
1976	1,226	48	187	25	1,486	474
1977	1,231	45	183	25	1,485	473
1978	1,230	42	180	25	1,477	470
1979	1,227	46	177	25	1,475	470
1980	1,278	53	174	26	1,530	487
1981	1,280	59	171	26	1,535	486
1982	1,280	67	167	26	1,540	484
1983	1,269	99	164	27	1,558	484
1984	1,280	86	161	27	1,554	478
1985	1,279	60	158	26	1,522	465
1986	1,300	80	154	27	1,562	477
1987	1,251	37	151	25	1,465	443
1988	1,254	41	148	25	1,468	443
1989	1,208	104	140	26	1,478	444
1990	1,198	117	157	27	1,498	446
1991	1,202	120	147	27	1,495	428
1992	1,215	134	118	28	1,495	423
1993	1,262	196	119	31	1,608	450
1994	1,298	230	131	33	1,692	467
1995	1,334	276	125	35	1,770	482
1996	1,349	275	117	35	1,777	476
1997	1,352	252	121	35	1,761	466
1998	1,372	269	120	36	1,797	471
1999	1,398	283	117	37	1,835	478
2000	1,450	315	114	40	1,919	497
2001	1,492	406	104	44	2,046	527
2002	1,550	497	98	49	2,194	555
2003	1,574	532	99	51	2,256	560
2004	1,594	538	96	52	2,279	557
2005	1,620	530	93	53	2,296	555
2006	1,621	475	89	51	2,236	534
2007	1,611	472	86	51	2,221	525
2008	1,587	427	83	49	2,146	503
2009	1,607	480	80	52	2,219	515
2010	1,606	521	77	55	2,258	519
2011	1,621	552	73	57	2,303	525
2012	1,656	537	70	57	2,320	526
2013	1,653	557	67	59	2,336	525
2014	1,672	597	64	62	2,394	530

Caveats

A few caveats about assessing the nature and costs (and benefits) associated with water quality changes in New Zealand, are required in interpreting the above data. Firstly, our analysis used nitrogen pollutants, and to a much lesser extent BOD, as proxies to track the degradation of water quality in New Zealand. Whilst we argue that this approach provides a good indicative quantitative picture of times series trends, and relative numerical magnitudes between different sources and types of pollution, it does not reflect the full picture of water quality changes – future research and implementation of the GPI could work towards a more comprehensive approach, perhaps by developing a water quality index, although this would be difficult not only due to the recognised complexity of the concept of water quality, but also due to a lack of reliable time series data to populate such an index. In particular, microbiological and bacteriological data, will be difficult to include as the impacts of these vectors on water quality, are often very site specific, and often occur sporadically, and therefore are difficult to track over time. Finally, although arguably the impacts of nutrients (by the use of the nitrogen proxy) are adequately covered, factors such as the negative impacts of sediment loads on biodiversity are not explicitly covered in our analysis – that said, arguably however, at least some extent, the environmental impacts of sediment loss are covered elsewhere in the GPI (refer to Chapter 18). [97]

Groundwater pollution was also not included in this analysis due to the lack of consistent nationwide data over the study period. However, we acknowledge that groundwater pollution has increased particularly in areas where there has been an intensification of pastoral farming and/or permeable soils and substrate, as for example in Canterbury. Besides groundwater pollution, other areas where water quality degradation is not taken account of in this GPI analysis, includes wetlands and the coastal zone including harbours. This exclusion is primarily due to the lack of robust time series data, but in general terms the magnitude of water quality in these areas and its impact on well-being, although important, is considered often to be site and time specific (e.g., beaches in Auckland in summer after a storm event), and is relatively low in comparison to the other types of water pollution covered in this chapter.

Update to 2016

Year	Rivers & Streams (Non-Point Source From Livestock)	Rivers & Streams (Non-Point Source From Fertlizers)	Rivers & Streams (Point Source)	Lakes	Total Cost	Total Cost per capita
	$2014 million	$2014 million	$2014 million	$2014 million	$2014 million	$2014 per person
2014	1,672	597	64	62	2,394	530
2015	1,621	610	61	61	2,352	511
2016	1,621	659	58	62	2,399	511

- Over the 2014 to 2016 period, the decreases in dairy cattle numbers, and to a lesser extent decreases in beef cattle and sheep numbers meant that there were lower pollutant loadings attributable to livestock numbers. However, working against this trend of decreasing livestock

[97] In the case sediments, the loss of sediments is explicitly covered in Chapter 18 of this GPI analysis is, albeit perhaps without a full costing of the loss of biodiversity which is evident in New Zealand rivers (Joy and Death, 2013).

numbers, were higher pollutant loadings attributable to the increased use of nitrogenous fertilisers.

- Overall, the net effect was slightly increased pollutant loadings over the 2014 to 2016 period, as the effect of increased loadings from fertiliser use, slightly outweighed the effect of decreased loadings from a fewer number of livestock. This meant that the total cost associated with water pollution in our rivers, streams and lakes increased slightly from $\$_{2014}$ 2,394 million in 2014 to $\$_{2014}$ 2,399 million as there was a slight overall increase in pollutant loadings.

23. Ozone Depletion

Why include

Stratospheric ozone provides humans and other species of life with a protective layer against incoming solar ultraviolet radiation. Damage to the ozone layer from chlorofluorocarbons (CFCs) and other ozone depleting substances has reduced the effectiveness of this protective area. Because of its location at the south of the southern hemisphere, New Zealand is vulnerable to solar ultraviolet radiation, as the Earth's orbit takes New Zealand closer to the sun during the summer months. Health risks from ultraviolet radiation in New Zealand are accentuated by the proportion of the population with pale skin, relatively low air pollution levels, plentiful sunlight and an outdoors-oriented lifestyle.

The main contributor to ozone depletion is CFCs, which have been used since the 1930s as refrigerants, propellants and industrial solvents. CFCs released into the atmosphere disperse globally and have a cumulative impact remaining airborne for many decades (Hamilton and Denniss, 2000). The importation of CFCs has been prohibited in New Zealand since 1996; with the only exemptions being recycled CFCs and a provision for use relating to human health and safety.

In 1993, CFC use in New Zealand per person was half that of the OECD, though this was still twice the global average (Ministry for the Environment, 1997). Long-term measurements of total ozone over New Zealand, carried out at the NIWA site at Lauder, Central Otago, reveal that negative ozone trends are greater in summer than in other seasons. On average, in mid-latitudes, the so-called 'ozone hole' has resulted in 5–6% less ozone in spring and summer, which resulted in a 6–7% more erythemal UV, which is the UV irradiation that causes sunburn (Ajtić and Connor, 2004).

Ultraviolet-B (UV-B) radiation also impacts on terrestrial and aquatic ecosystems, as well as damaging property, causing paint to fade, plastics to perish, window glazing to yellow and car roofs to become chalky. While these impacts are reported (UNEP, 2006) our research did not find any attempts at quantification. The effects most easily measured are those on health. As can be seen in Table 23.1 in the year2000 New Zealand (and Australia) had very high rates of melanoma cancer compared with other countries. New Zealand also has the highest melanoma mortality rate in the OECD (New Zealand Health Information Services, 2005). Australian research indicates that many other organisms including plants and insects are also at risk (Department of Environment Sport and Tourism, 1996).

Table 23.1 Comparison of Melanoma Rates between Countries, 2001

Country	Cases per 100,000 population
Australia	46.1
New Zealand	44.0
United States	14.6
Netherlands	14.5
Germany	10.3
United Kingdom	9.8

Source: (Ferlay *et al*., 2001)

What to Include

While New Zealand emits small quantities of CFCs and is responsible for very little of the damage to the ozone layer, as a nation, New Zealand's well-being is reduced markedly by this environmental 'bad' because the country is located relatively close to the thin ozone layer meaning higher levels of ultraviolet radiation. The GPIs constructed for the United States and the United Kingdom multiply the quantity of CFCs produced by a monetary price per kg. The Australian and Swedish indexes also relate ozone depletion to CFC release, using consumption rather than production as their measure (Hamilton and Denniss, 2000). As the effects felt by the New Zealand population are a result of the global rather than just New Zealand's use of CFCs, the New Zealand index calculates the impact on well-being for the nation in terms of health damage, rather than CFC emissions levels.

In 1970, official statistics recorded 74 deaths annually from melanoma. By 2014, this had increased to 333 deaths per annum (Ministry of Health, 2014). Like other cancers, melanoma occurs most often in older people, but can also affect younger people, and is the most common form of cancer in men aged 20–39. Melanoma is also the most common cancer experienced by women aged 20–30, and the second most common cancer after breast cancer in women aged 30–39 years (New Zealand Health Information Services, 2005). There is some uncertainty whether high death rates can be attributed to ozone depletion alone because of the relatively long incubation time of serious skin cancer forms such as melanoma; but they do signal a high degree of vulnerability to prolonged high levels of UV radiation (McKenzie and Elwood, 1990, cited in Woodward *et al*., 2001).

The Cancer Society estimates the annual cost associated with the treatment of skin cancer in New Zealand at $33 million (Woodward *et al*., 2001). In addition to skin cancer, excessive sun exposure can lead to blindness from cataracts, and suppressed cell-mediated immunity – which enhances the risk of infectious diseases, and limits the efficacy of vaccinations (World Health Organisation, 2004). In the GPI, the other health costs associated with increased UV radiation are accounted for in the defensive expenditure portion of government consumption.

Data Available

Erythemal Ultraviolet radiation readings, both for clear and cloudy days, taken by NIWA at the Lauder site in Otago for the months of December, January and February between 1970 and 2006 are available.

The New Zealand skin cancer registry records data for deaths from melanoma of the skin (ICD 10 code C43) (New Zealand Health Information Services, 2003). While melanoma is the most serious skin cancer, UV exposure causes other common skin cancers such as squamous cell carcinoma and basal cell carcinoma. Providing an exact figure for the number of non-melanoma skin cancers is difficult, as they are not required to be notified under the Cancer Registry Act 1993; however, estimates range from 45,000 to 70,000 per annum, in New Zealand (Cancer Society of New Zealand, n.d.).

Data covering the period from 1979 to 2016 show the thickness of the ozone layer as measured in terms of Dobson units [98] at the Central Otago site, to be slightly decreasing over time (refer to Figure, 23.1). However, these are average annual levels and there are significant diurnal and seasonal differences in the thickness of the ozone layer. For example, the ozone layer is at its thickest from July to October, and at its thinnest from December through to late April a time when many New Zealanders spend more time outdoors (Statistics New Zealand, 2018). It should also be noted that although New Zealand is not directly under the Antarctic 'ozone hole' when it breaks up in spring, it can send plumes of ozone depleted air over New Zealand (Ajtić *et al*., 2004)

How to Include

The cost of ozone damage to New Zealand has been conservatively estimated using death from melanoma statistics. In the GPI, other health costs associated with increased UV radiation are accounted for in the defensive expenditure portion of government consumption. The economic cost attributable to melanoma deaths was estimated in the following two steps:

[98] Ozone layer thickness is expressed in terms of Dobson units, which measure what its physical thickness would be if compressed in the Earth's atmosphere. One Dobson Unit (DU) is defined to be 0.01 mm thickness at STP (standard temperature and pressure).

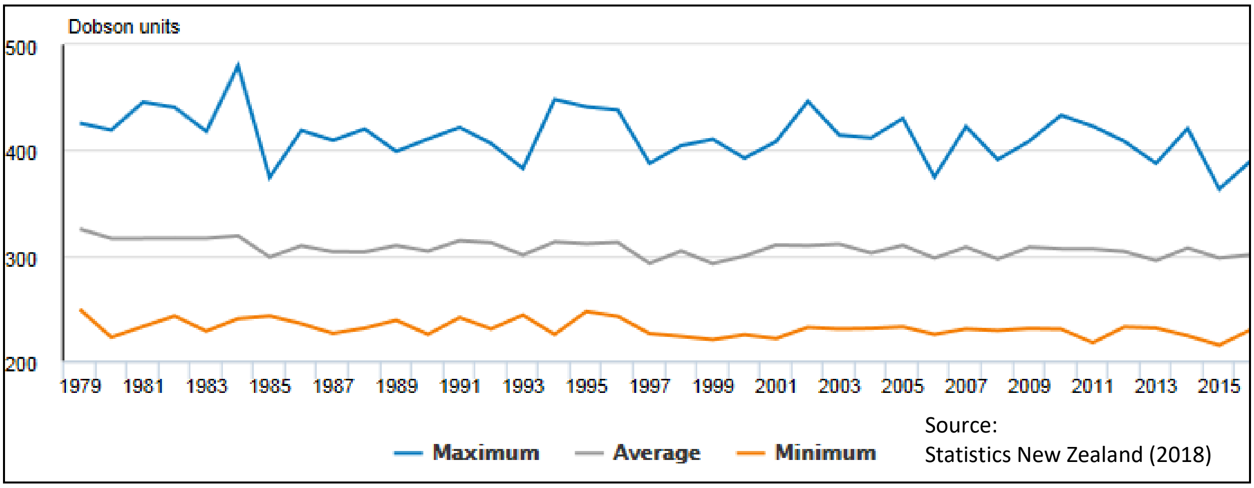


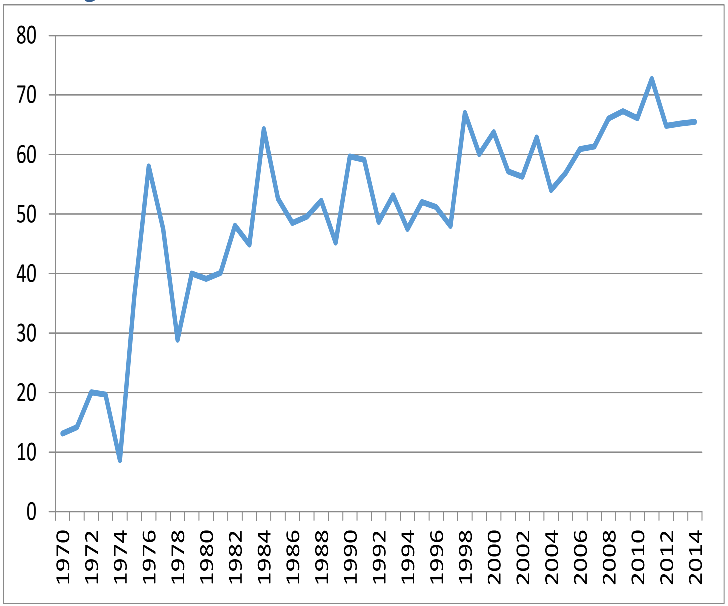
Figure 23.1 Ozone layer thickness (in Dobson Units) at Lauder, Otago, New Zealand, 1979-2016

Step 1: Estimation of Lost Years of Life due to Melanoma. Between 1970 and 2014, the rate of death from melanoma increased significantly. To calculate the cost of ozone depletion the average number of deaths for each 5-year age cohort was calculated for the 1954–1969 period, and this was treated as the base number of expected deaths. The number of years of life lost from melanoma death over and above this figure was attributed to ozone depletion. The average life expectancy figures from Statistics New Zealand were used to calculate the difference between expected and actual life years.

Step 2: Economic Cost of Years of Life due to Melanoma Deaths. The Ministry of Transport's (2009) 'value of statistical life' measurement, at $\$_{2004}$ 2.725 million, was used to estimate the economic costs of lost years of life due to melanoma onset (Ministry of Transport, 2009). For example, if this value is for a citizen of an average age of 35 with a life expectancy of a further 44 years, this gives an annual value of life of $\$_{2004}$ 61,032 pa ($\$_{2004}$ 2.725 million divided by 44 years). This calculation assumes the utility gained from one year of life is the same regardless of age. As mentioned elsewhere in this publication, placing a monetary value on human life is difficult and potentially controversial. That said, the Land Transport New Zealand's 'value of statistical life' was derived from a 'willingness-to-pay' study carried out Miller and Guria (1991) in 1990. The estimate is largely based on sample surveys of what New Zealanders were 'willing-to-pay' to buy road safety for their families. People were asked what they were prepared to pay in dollars or time saved, for small reductions in fatality risks.

This is a conservative estimation of the economic cost of ozone depletion, particularly for New Zealand, which is a country exposed to relatively high levels of ultraviolet radiation. In our GPI calculations, we have taken account of the economic costs of melanoma, but we have not taken account of skin cancers which usually are nonfatal, as well as other effects on the eye and vision impairment, such as cataracts, which are linked to greater levels of ultraviolet radiation (Abarca and Casiccia, 2002). In addition, along with the effects of enhanced ultraviolet radiation being linked to skin cancer and other aspects of health; other impacts include the effect of ultraviolet radiation on commercial crops, property, buildings and natural ecosystems – these other impacts are not included in our GPI cost estimates due to the difficulty in obtaining reliable data, and sometimes the causality is complex and not solely relatable to ultraviolet radiation (Han, Sinha and Hader, 2003).

Findings



Highlights

- Ozone depletion has a very small estimated social cost compared with the other components in the New Zealand GPI, but is included for consistency with overseas studies.
- The cost of ozone depletion is estimated using premature melanoma deaths as the proxy. On this basis the social cost of ozone depletion was calculated to be $296 million in 2014.
- There been consistent increase in these costs over the 1970 to 2014 period, as melanoma deaths have trended upwards.

Figure 23.2 Per Capita Cost of Ozone Depletion, 1970-2014, $_{2014}$ per person

It is difficult to comprehensively measure the impact of ozone depletion on well-being in New Zealand for a number of reasons. First, there is the issue of attribution – that is, it is difficult to directly attribute emissions of ozone-depleting substances *from New Zealand sources*, to directly causing adverse health effects on New Zealanders. This is because, emissions from other countries and not just New Zealand, affect the thickness of the ozone layer and hence are also reponsible for adverse health effects suffered by New Zealanders. Second, even though emissions of ozone-depleting substances (such as refrigerants in aerosols) have decreased dramatically since the instigation of the Montréal protocol in 1987, some of these ozone-depleting substances have accumualted over centuries. Thirdly, there is a lack of hard data on the impact of ozone depletion (and hence anincrease of ultraviolet light concentrations) on buildings, property, commercial crops and biodiversity.

All that said, it is possible to accurately measure the economic cost, and the impact on well-being of melanoma deaths in New Zealand. Table 23.2 shows that there were 333 deaths from melanoma in 2014, which was costed at $_{2014}$ 296 million using Transport New Zealand's statistical life metric. This was a very significant (11.2 times) increase from the 1970 level at 74 deaths costed at $_{2014}$ 37 million, outstripping population growth which increased at a much slower rate (1.6 times). This very significant increase in the incidence of melanoma also cannot be explained by changes in thickness of the stratospheric ozone layer, which Figure 23.1 shows only very slightly decreased from 1979 to 2014, although any causal link between thickness of the ozone layer and the incidence of melanoma would be a lagged effect.

Table 23.2 Cost Ozone Depletion in New Zealand: Total and Per Capita, 1970-2014

Year	Number of Deaths from Melanoma	Total Cost of Melanoma Deaths	Per Capita Cost of Melanoma Deaths
		$\$_{2014}$ million	$\$_{2014}$ per person
1970	74	37	13
1971	75	41	14
1972	73	59	20
1973	73	59	20
1974	57	26	9
1975	103	112	36
1976	132	182	58
1977	127	149	48
1978	99	91	29
1979	119	125	40
1980	124	123	39
1981	121	127	40
1982	141	153	48
1983	134	145	45
1984	161	209	64
1985	160	172	53
1986	159	159	48
1987	150	164	50
1988	170	173	52
1989	166	151	45
1990	188	201	60
1991	180	207	59
1992	182	172	49
1993	194	190	53
1994	193	172	48
1995	197	191	52
1996	194	191	51
1997	201	182	48
1998	248	256	67
1999	231	231	60
2000	253	246	64
2001	244	222	57
2002	235	222	56
2003	285	253	63
2004	249	221	54
2005	265	235	57
2006	287	255	61
2007	292	259	61
2008	317	282	66
2009	326	290	67
2010	324	288	66
2011	359	319	73
2012	322	286	65
2013	327	290	65
2014	333	296	66

Note:
1. Only the economic cost of deaths from melanoma is measured in this table, as this is considered to be the main impact on well-being of ozone depletion.There are other economic costs associated with ozone depletion, but these are smaller and generally more difficult to measure.

Compared with other factors in the New Zealand Genuine Progress Indicator, this costing of melanoma is relatively low, being only $\$_{2014}$ 13 per resident in 1970, and even though it increased rapidly, was still only at$\$_{2014}$ 63 per resident in 2014 – refer to Figure 23.2.

Update to 2016

Year	Number of Deaths from Melanoma	Total Cost of Melanoma Deaths	Per Capita Cost of Melanoma Deaths
		$\$_{2014}$ million	$\$_{2014}$ per person
2015	360	320	70
2016	366	325	69

- Both 2015 and 2016, saw a continuation of the trend since 1970, whereby there has been an underlying trend of increases in melanoma deaths. In fact, both 2015 and 2016, recorded the highest on record levels of melanoma deaths of 360 and 366 respectively.
- Hence, the total costs of melanoma also increased to levels greater than any previous years, being $\$_{2014}$ 320 million in 2015 and $\$_{2014}$ 325 million in 2016.

24. Noise Pollution

Why Include

Noise pollution refers to unwanted or offensive sounds coming from a variety of sources including: cars and vehicles, industry, as well as activities such as lawn mowing, recreational events, people communicating, animals, air traffic and so forth. It is both a health and an environmental issue. While the extent of sustained loud noise is controlled in New Zealand with District or City planning controls, due to increased urban living there has been an increase in the length of time people are exposed to noise on a daily basis. One of the main sources of noise that unreasonably intrudes into our daily activities is traffic noise, especially from heavy vehicles (Hamilton and Denniss, 2000). Traffic noise, according to an OECD (1995) report has the following negative impacts:

- Productivity losses due to poor concentration, communication difficulties or fatigue due to insufficient rest.
- Health care costs to rectify loss of sleep, hearing problems or stress.
- Lowered property values.
- Reduction in psychological well-being.

A 2005 survey on the quality of life in New Zealand's 12 largest cities found just over a quarter of residents (26%) stated that noise was an issue. Residents in these cities were significantly more likely to perceive a problem with noise pollution in their local area (31%), than those living elsewhere in New Zealand (21%) (Gravitas Research and Strategy Limited, 2005).

What to Include

Although noise is a significant environmental problem, it is difficult to quantify its associated costs. In addition, measuring the extent of the increase in noise pollution in New Zealand between 1970 and 2014 is not possible as no data exist. While property values can be affected if noise levels are extreme, for most people noise is an uncompensated cost. In New Zealand, noise is present even in small urban settlements, where ribbon development with road and rail networks in close proximity to houses is common.

As no data are available to calculate absolute noise levels or change in intensity, vehicle kilometres travelled (VKM) in New Zealand has been used as a proxy. Given that most people in New Zealand live in urban areas and that car ownership levels are high, a significant proportion of the population experience noise associated with traffic. In large urban areas, high density development as well as urban spread (which increases car dependency) mean people live close to traffic noise (Statistics New Zealand, 1999). According to Statistics New Zealand, the largest contributor to increased kilometres travelled by vehicles is the car – however, kilometres travelled by light and heavy commercial vehicles have also increased (Statistics New Zealand, 2002b). While engine and road noise from motor vehicles would have decreased with improved technology between 1970 and 2008, as can be seen the number of cars on the road has risen significantly (refer to Figure 24.1). Vehicles may have become quieter but more densely populated urban areas expose more people to noise over longer time periods.

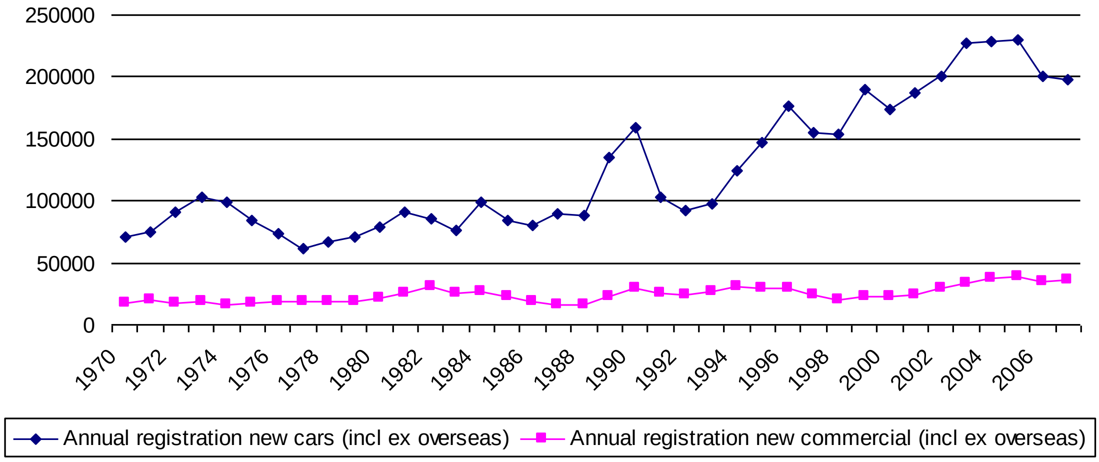


Figure 24.1 Annual Car and Commercial Vehicle Registrations 1970–2006
Source: Source: Land Transport New Zealand (2006)

Statistics from the Accident Compensation Corporation for noise-induced hearing loss incidences in the New Zealand workforce, indicates that noise is an increasing problem. That is, these statistics shows the total cost of hearing loss claims has risen from \$8 million in 1994/1995 to \$71 million in 2013/2014 – refer to Table 24.1. Such hearing loss is often a gradual process but brings with it both financial and social repercussions.

How to Include

Our method involved calculating the cost of *traffic noise only* on the basis that it is the most important source of noise and because there are reliable data available for this calculation. We acknowledge that there are other sources of noise but reliable data are not available, meaning that our estimation of the cost of noise is an under-estimate. Our approach is the same as that carried out for Australian GPI by Hamilton and Saddler (1997).

Specifically, our method involved the following steps:

Step 1: Total Vehicle-kilometres Travelled (1970-2014). From 2000 onwards, VKT (Vehicle-kilometres travelled) are based on odometer readings recorded at Warrant of Fitness and Certificate of Fitness checks. Data for 1990–2000 are based on large-scale traffic count projects and line up well with results from the odometer approach (S. Badger, pers. comm.). Before 1990 modelled data for vehicle kilometres travelled (VKT) for 1979 to 2000 were used (Ministry of Transport, 2008) with VKT before 1979 based on trends in those data.

Step 2: Cost (\$) of Traffic Noise for 1995. A Ministry of Transport study (1996) researched environmental externalities associated with motor vehicle use, estimating the total annual cost of noise pollution from vehicles at between $\$_{1995}$230 million and $\$_{1995}$2,650 million with the best estimate being $\$_{1995}$290 million per year. The total cost is defined as private costs plus externalities. According to the research, the $\$_{1995}$290 million was derived from a pilot study of road traffic exposure in an Auckland suburb with a range of road networks. The $\$_{1995}$290 million was converted to $\$_{2014}$ 537 million for the reference year 1995.

Table 24.1 Noise Induced Hearing Loss Claims, New Zealand 1994/95 to 2013/2014

Year (June Year)	Number of claims	Cost ($ million)[2]	Cost per claim ($)[3]
1994/1995	3,939	8	2,031
1995/1996	4,220	8	1,896
1996/1997	5,195	11	2,117
1997/1998	5,783	16	2,767
1998/1999	6,261	17	2,715
1999/2000	6,417	18	2,805
2000/2001	7,508	21	2,797
2001/2002	9,152	22	2,404
2002/2003	11,949	31	2,594
2003/2004	16,327	38	2,327
2004/2005	19,991	43	2,151
2005/2006	23,301	53	2,275
2006/2007	26,067	59	2,263
2007/2008	28,455	62	2,178
2008/2009	31,061	68	2,178
2009/2010	33,906	74	2,178
2010/2011	37,012	81	2,178
2011/2012	32,850	72	2,178
2012/2013	32,791	71	2,178
2013/2014	32,766	71	2,178

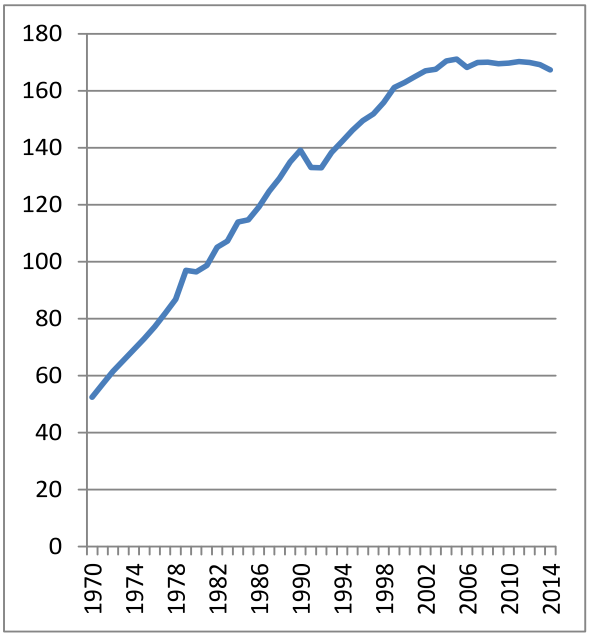
Notes:

1. Datasource: Accident Compensation Authority (2014)
2. For 2007/08 to 2013/2014:
   $million = number claims x $2,178
3. For 2007/08 to 2013/2014: Assumed
   same cost per claim as mean for 1994/95 to 2006/07
   which is $2,178

Step 3: Cost ($/km) of Traffic Noise. The 1995 estimate figure of $\$_{2014}$ 537million for traffic noise (from Step 2) was divided by 29,913 million traffic kms for 1995, which resulted in a cost of noise pollution as measured by 'vehicles per kilometre travelled' of 1.8 cents_{2014}/km.

Step 4: Cost ($) of Traffic Noise Pollution. Variation in the cost of noise pollution each year has been allowed for by multiplying the cost of noise per kilometre travelled (from Step 3) by the estimated number of kilometres travelled annually (from Step 1). This assumes that the ratio of the 'cost ($\$_{2014}$) of traffic noise' to 'vehicle kilometres travelled' remains constant at 1.8 cents_{2014}/km for every year in the time series.

Findings



Highlights

- Traffic is the major source of noise and furthermore it can be measured. So, therefore it is used as a proxy for noise pollution. Other sources of noise cannot so easily be measured at an aggregative level.
- The cost of traffic noise was calculated to be $755 million in total and $167 per capita in 2014.
- The per capita cost increased almost every year from 1970 to 2005, but then it plateaued from 2006 to 2012, with a slight dip in 2013 and 2014.
- The cost of non-traffic sources of noise is uncertain, but could represent several $100s of million.

Figure 24.2 Per Capita Cost of Traffic Noise Pollution, 1970 to 2014, $$_{2014}$ per person

Some countries estimate the cost of traffic noise pollution from expenditure on noise mitigation. These international estimates range from 0.02% to 0.05% of GDP (Ministry of Transport, 1996). Such studies however are unique to particular countries and may not necessarily be directly applicable to New Zealand. Nevertheless, by extrapolating these data to New Zealand, for the year 2014, the lower percentage (0.02% of GDP) produces an estimate of $$_{2014}$ 562 million and the higher percentage (0.05% GDP) $$_{2014}$ 1,406 million (refer to Table 24.2).

Only the cost of traffic noise can be measured accurately (refer to Table 24.2). This cost of traffic noise pollution increased from $$_{2014}$ 148 million in 1970 to $$_{2014}$ 755 million in 2014 This represents a 411% increase in the cost of traffic noise due to much higher traffic volumes, significantly ahead of both GDP (218%) and population (60%) growth, as New Zealand has become more-and-more reliant on road transport.

Figure 24.2 shows that, on a per capita basis, the traffic noise had an estimated cost of $$_{2014}$52 per person in 1970, increasing in a close to linear fashion to $$_{2014}$171 per person in 2005. Thereafter from 2006 to 2014 the per capita costing of traffic noise plateaued, decreasing slightly to $$_{2014}$171 per person in 2014. This ‘plateau’ was due to a slowdown in the rate of increase of vehicle kilometres travelled, to the point where this increase was slightly less than the rate of population increase during this period – the reason why there a slowdown in the rate of increase of the kilometres travelled over the 2006-2014 period is unclear.

In our Genuine Progress Indicator calculations, we somewhat conservatively, have only included the cost of traffic noise as there is significant uncertainty about the cost of other sources of noise, such as for example from industrial or domestic sources such as lawn mowing. Local bodies do keep statistics on noise complaints, which may provide some basis for an economic costing of these sources of noise and the impact they have on well-being in future research. Data from the Accident Compensation Authority (refer to Table 24.1) also provides an opportunity to incorporate further data for noise pollution in future GPI calculations – for example, in 2013/14, there were 32,766 claims costing an estimated $71 million.

Table 24.2 Cost of Noise Pollution New Zealand: Total and Per Capita, 1970-2014

Year	Column A Vehicle km travelled	Column B Cost of Traffic Noise (1995)	Column C Cost of Traffic Noise (1995)	Column E Estimated Cost of Traffic Noise	Column F Estimated Cost of Traffic Noise per capita	Column G Cost of All Noise: 0.02% of GDP	Column H Cost of All Noise: 0.05% of GDP
	km million	$\$_{1995}$ million	$\$_{2014}$ million	$\$_{2014}$ million	$\$_{2014}$ per person	$\$_{2014}$ million	$\$_{2014}$ million
1970	8,234			148	52	186	466
1971	9,105			163	57	193	484
1972	9,975			179	61	198	496
1973	10,845			195	65	207	518
1974	11,716			210	69	222	555
1975	12,586			226	73	231	577
1976	13,456			242	77	235	587
1977	14,326			257	82	235	587
1978	15,197			273	87	229	571
1979	16,950			304	97	235	588
1980	16,884			303	96	241	603
1981	17,349			311	99	244	610
1982	18,602			334	105	256	640
1983	19,232			345	107	258	644
1984	20,641			371	114	279	697
1985	20,898			375	115	284	710
1986	21,751			390	119	287	718
1987	22,950			412	125	286	715
1988	23,883			429	129	293	733
1989	25,045			450	135	295	737
1990	26,055			468	139	296	741
1991	25,900			465	133	291	727
1992	26,163			470	133	294	734
1993	27,526			494	138	307	768
1994	28,700			515	142	327	816
1995	29,913	290	537	537	146	341	852
1996	31,085			558	149	352	880
1997	31,986			574	152	363	907
1998	33,126			595	156	365	914
1999	34,448			618	161	382	956
2000	35,013			629	163	397	993
2001	35,705			641	165	407	1,017
2002	36,759			660	167	426	1,065
2003	37,572			675	167	445	1,112
2004	38,804			697	170	463	1,158
2005	39,411			708	171	476	1,190
2006	39,192			704	168	487	1,217
2007	39,992			718	170	509	1,272
2008	40,354			724	170	508	1,271
2009	40,645			730	170	501	1,254
2010	41,149			739	170	510	1,275
2011	41,596			747	170	519	1,298
2012	41,728			749	170	532	1,331
2013	41,896			752	169	544	1,359
2014	42,063			755	167	562	1,406

Notes:
Column A: Vehicle-km for 1970-2014 (refer to the text for calculation details)
Column B: Ministry of Transport (1996)
Column C: Converted form $\$_{2006}$ to $\$_{2014}$
Column D: Column C divided by Column A for the reference year 1995
Column E: Column A (km million) x Column D ($\$_{2014}$ per km) = $\$_{2014}$ million
Column F: Column E ($\$_{2014}$) divided by New Zealand population
Column G: NZ's GDP multiplied by 0.002 (0.2%) from Ministry of Transport's (1996) – lower estimate
Column H: NZ's GDP multiplied by 0.005 (0.5%) from Ministry of Transport's (1996) – higher estimate

Update to 2016

Year	Vehicle km travelled	Estimated Cost of Traffic Noise	Estimated Cost of Traffic Noise per person
	km million	$\$_{2014}$ million	$\$_{2014}$ per person
2015	42,246	758	165
2016	42,429	762	162

- There was an estimated vehicle kilometres travelled of 42,063 million km in 2014 and 42,429 million km in 2016.
- This led to an increase in the cost of traffic noise from $\$_{2014}$755 million in 2014 to $\$_{2014}$762 million in 2016.

25. Data Summary

Table 25.1 summarises the main indicators used in the New Zealand GPI analysis, for each year from 1970 to 2016. Most importantly, the Genuine Progress Indicator appears in column 3 of Table 25.1. In columns 4 and 6, both the Gross Domestic Product and the Genuine Progress Indicator are normalised so that they are expressed in terms of per person (per capita) terms, which enables the data to be more meaningfully compared across different years.

Table 25.2 (over 3 pages) outlines all of the 21 components of the New Zealand Genuine Progress Indicator over the period 1970 to 2016. When aggregating these components to obtain the overall New Zealand Genuine Progress Indicator for each year, it must be remembered that some of these components are positive (as they contribute to well-being) and some negative (as they do not contribute to well-being) – refer to Table 2.1, and its related text, for further details on how to aggregate these GPI components.

In order to obtain the GPI components per capita, this can be undertaken by dividing the values in Table 25.2, by the population from the first column in Table 25.1.

Table 25.1 New Zealand Population, GDP, GPI and Gini Coefficient, 1970-2016

Year	Population	Gross Domestic Product $\$_{2014}$ million	Gross Domestic Product $\$_{2014}$ per person	Genuine Progress Indicator $\$_{2014}$ million	Genuine Progress Indicator $\$_{2014}$ per person	Gini Coefficient
1970	2,819,600	69,181	24,536	76,679	27,195	0.226
1971	2,864,200	71,751	25,051	80,844	28,226	0.229
1972	2,915,600	73,577	25,236	79,746	27,351	0.231
1973	2,977,100	76,826	25,806	84,598	28,416	0.225
1974	3,041,800	82,338	27,069	85,261	28,030	0.241
1975	3,100,100	85,668	27,634	90,629	29,234	0.240
1976	3,131,800	87,106	27,814	91,012	29,061	0.245
1977	3,142,600	87,171	27,739	86,841	27,633	0.251
1978	3,143,500	84,779	26,970	88,999	28,312	0.247
1979	3,137,800	87,300	27,822	94,551	30,133	0.241
1980	3,144,000	89,528	28,476	91,628	29,144	0.260
1981	3,156,700	90,491	28,666	99,201	31,426	0.253
1982	3,180,800	94,938	29,847	98,820	31,068	0.254
1983	3,221,700	95,546	29,657	95,997	29,797	0.255
1984	3,252,800	103,439	31,800	100,731	30,967	0.249
1985	3,271,500	105,386	32,213	97,401	29,772	0.262
1986	3,277,000	106,579	32,523	101,623	31,011	0.265
1987	3,303,600	106,031	32,096	98,674	29,868	0.269
1988	3,317,000	108,767	32,791	98,021	29,551	0.271
1989	3,330,200	109,324	32,828	98,791	29,665	0.269
1990	3,362,500	109,987	32,710	96,171	28,601	0.281
1991	3,495,800	107,919	30,871	90,710	25,948	0.295
1992	3,533,000	108,959	30,840	91,288	25,839	0.288
1993	3,573,600	114,039	31,911	92,756	25,956	0.289
1994	3,621,600	121,161	33,455	96,852	26,743	0.285
1995	3,675,800	126,422	34,393	99,300	27,015	0.288
1996	3,733,900	130,525	34,957	100,681	26,964	0.297
1997	3,782,600	134,541	35,568	103,060	27,246	0.303
1998	3,815,800	135,567	35,528	110,031	28,836	0.291
1999	3,837,300	141,899	36,979	112,728	29,377	0.295
2000	3,860,200	147,378	38,179	114,002	29,533	0.299
2001	3,886,700	150,988	38,847	114,935	29,571	0.304
2002	3,951,200	158,079	40,008	117,309	29,689	0.304
2003	4,027,700	164,992	40,964	123,775	30,731	0.304
2004	4,088,700	171,820	42,023	131,042	32,050	0.303
2005	4,136,000	176,626	42,705	139,093	33,630	0.301
2006	4,185,300	180,625	43,157	145,196	34,692	0.300
2007	4,226,200	188,779	44,669	150,852	35,694	0.298
2008	4,262,000	188,628	44,258	152,758	35,842	0.301
2009	4,304,900	186,048	43,218	155,350	36,087	0.297
2010	4,353,000	189,136	43,450	159,050	36,538	0.297
2011	4,386,300	192,590	43,907	158,908	36,228	0.308
2012	4,410,700	197,456	44,767	165,720	37,572	0.299
2013	4,446,700	201,729	45,366	171,130	38,485	0.297
2014	4,513,100	208,582	46,217	174,647	38,698	0.304
2015	4,599,300	213,746	46,474	185,598	40,354	0.293
2016	4,696,500	220,289	46,905	194,995	41,519	0.291

Table 25.2 New Zealand Genuine Progress Indicator Components ($$_{2014}$ million)

Year	Personal Consumption of Goods and Services	Weighted Personal Consumption of Goods and Services	Consumption of Public Services	Cost of Un-employment	Cost of Under-employment	Cost of Overwork	Services of Public Capital
1970	52,122	51,096	10,849	74	125	1,947	8,577
1971	52,837	51,213	11,860	99	138	2,020	9,912
1972	53,956	51,703	11,878	138	146	2,071	9,816
1973	56,281	55,403	12,475	118	152	2,163	10,116
1974	58,174	53,375	13,203	111	167	2,318	11,523
1975	57,555	53,137	15,312	134	166	2,412	13,860
1976	56,267	50,802	16,126	121	152	2,452	14,827
1977	56,392	49,781	14,874	100	149	2,454	14,465
1978	56,228	50,503	16,112	105	150	2,386	15,120
1979	55,758	51,287	17,905	86	148	2,457	16,074
1980	55,589	47,283	18,143	160	141	2,520	16,537
1981	56,930	49,829	19,749	265	153	2,547	17,071
1982	57,522	50,118	20,618	316	156	2,672	16,713
1983	61,372	53,110	20,145	591	154	2,690	15,885
1984	65,508	57,918	20,612	539	150	2,912	16,654
1985	66,906	56,357	20,935	454	149	2,967	16,455
1986	69,296	57,507	21,553	204	166	2,737	16,408
1987	69,249	56,643	21,640	378	186	2,680	15,584
1988	70,966	57,605	21,959	541	234	2,741	14,387
1989	72,113	59,586	22,508	909	284	2,799	13,711
1990	71,885	57,197	23,444	1,193	386	2,821	13,102
1991	70,230	53,353	22,968	1,554	584	2,819	12,541
1992	70,322	54,650	23,231	1,537	680	2,961	12,383
1993	72,130	55,811	23,454	1,315	609	3,194	12,080
1994	76,808	60,300	23,665	1,103	614	3,635	11,983
1995	79,968	62,086	24,762	828	532	3,732	12,069
1996	84,504	63,783	24,594	747	564	4,126	12,256
1997	86,753	64,185	26,301	760	625	4,140	12,593
1998	89,433	68,836	26,697	830	729	4,163	13,051
1999	92,372	70,100	27,601	681	758	4,494	13,365
2000	93,719	70,124	27,472	688	637	4,520	13,703
2001	95,691	70,593	28,762	600	602	4,527	14,196
2002	99,746	73,559	29,350	629	589	4,680	14,646
2003	106,069	78,194	30,358	552	509	4,857	15,006
2004	112,493	83,199	31,958	478	563	4,959	15,543
2005	117,959	87,702	34,362	550	418	5,043	16,251
2006	121,021	90,455	36,006	541	493	4,922	17,042
2007	125,393	94,218	37,562	661	570	5,013	17,648
2008	125,845	93,532	39,276	1,386	616	4,920	18,517
2009	125,002	94,320	39,445	2,276	881	4,610	19,405
2010	128,779	97,050	39,808	2,126	796	4,818	19,949
2011	131,459	95,643	40,953	2,148	888	4,828	20,466
2012	135,168	101,234	40,586	2,454	897	4,685	21,013
2013	139,103	104,931	41,397	2,239	975	5,172	21,355
2014	143,607	105,791	42,876	2,348	983	5,344	21,422
2015	149,237	113,970	43,862	2,412	1,094	5,463	22,132
2016	156,655	120,721	44,659	2,659	1,151	5,560	23,052

Table 25.2 (Continued) New Zealand Genuine Progress Indicator Components ($$_{2014}$ million)

Year	Value of Household and Community Work	Privative Defensive Expenditrue on Health	Cost of Commuting	Cost of Crime	Cost of Deforest-ration	Costs Biological Pests	Loss of Wetlands Ecosystem Services
1970	22,181	186	2,369	1,807	10	441	90
1971	24,425	189	2,361	1,944	21	445	177
1972	23,750	193	2,419	2,058	31	450	261
1973	24,606	201	2,515	2,100	39	454	343
1974	26,096	208	2,599	2,269	49	459	422
1975	28,438	206	3,017	2,469	57	464	498
1976	29,601	201	2,873	2,566	67	468	572
1977	28,049	201	2,787	2,684	76	473	643
1978	27,610	201	2,698	2,846	82	478	711
1979	29,583	199	2,573	2,989	88	483	776
1980	30,641	199	2,507	3,323	93	487	839
1981	33,947	203	2,637	3,407	99	492	899
1982	33,357	206	2,710	3,590	104	497	957
1983	29,718	219	2,995	3,895	110	502	1,012
1984	28,935	234	3,067	4,026	116	507	1,064
1985	27,304	239	3,022	4,297	122	513	1,113
1986	29,923	248	3,290	4,364	128	518	1,160
1987	28,597	247	3,296	4,273	134	523	1,204
1988	28,576	244	3,498	4,382	141	528	1,245
1989	28,306	238	3,599	4,461	144	534	1,284
1990	28,793	242	3,659	4,748	148	539	1,320
1991	29,538	253	3,709	5,173	152	539	1,353
1992	29,620	266	3,846	5,384	153	535	1,383
1993	30,089	253	3,645	5,360	155	579	1,411
1994	30,594	255	3,827	5,678	158	584	1,436
1995	30,783	256	4,215	5,992	159	604	1,459
1996	31,360	298	4,378	6,115	160	607	1,479
1997	31,950	303	4,385	5,973	161	637	1,496
1998	32,922	311	4,395	5,719	163	696	1,510
1999	32,989	320	4,311	5,368	164	719	1,522
2000	33,629	326	4,405	5,145	164	723	1,531
2001	32,866	338	4,449	5,048	165	748	1,537
2002	32,493	352	4,892	5,222	165	779	1,541
2003	33,981	368	5,363	5,209	166	846	1,542
2004	34,424	388	5,655	4,741	166	829	1,542
2005	34,551	412	5,802	4,780	166	859	1,542
2006	35,848	430	5,942	4,988	166	878	1,542
2007	36,752	443	6,083	4,851	166	912	1,542
2008	37,350	447	6,097	4,839	167	907	1,542
2009	38,505	449	6,064	4,936	167	901	1,542
2010	38,348	452	6,243	4,627	168	903	1,542
2011	37,828	464	6,312	4,459	169	889	1,542
2012	39,170	474	6,438	4,010	170	889	1,542
2013	40,356	477	6,624	3,967	171	890	1,542
2014	42,109	492	6,751	3,882	173	905	1,542
2015	43,874	512	6,908	3,774	175	957	1,542
2016	45,579	537	7,118	3,669	177	974	1,542

Table 25.2 (Continued) New Zealand Genuine Progress Indicator Components ($$_{2014}$ million)

Year	Loss of Soils Ecosystem Services	Air Pollution	Solid Wastes and Contaminated Sites	Greenhouse Gas Emissions	Water Pollution	Ozone Depletion	Noise Pollution
1970	153	4,360	340	2,385	1,553	37	148
1971	232	4,403	344	2,484	1,505	41	163
1972	311	4,456	349	2,716	1,563	59	179
1973	393	4,524	355	2,891	1,500	59	195
1974	473	4,595	362	3,162	1,507	26	210
1975	554	4,656	368	3,279	1,501	112	226
1976	635	4,676	371	3,282	1,486	182	242
1977	714	4,664	372	3,122	1,485	149	257
1978	795	4,637	372	3,044	1,477	91	273
1979	876	4,601	367	2,749	1,475	125	304
1980	958	4,582	368	2,842	1,530	123	303
1981	1,039	4,573	369	2,737	1,535	127	311
1982	1,120	4,579	372	2,680	1,540	153	334
1983	1,201	4,610	389	2,447	1,558	145	345
1984	1,281	4,625	407	2,325	1,554	209	371
1985	1,360	4,623	424	2,298	1,522	172	375
1986	1,440	4,602	442	2,359	1,562	159	390
1987	1,520	4,610	459	2,239	1,465	164	412
1988	1,600	4,599	477	2,208	1,468	173	429
1989	1,678	4,588	491	2,234	1,478	151	450
1990	1,756	4,602	505	2,279	1,498	201	468
1991	1,836	4,660	515	2,376	1,495	207	465
1992	1,958	4,679	518	2,559	1,495	172	470
1993	2,043	4,702	519	2,600	1,608	190	494
1994	2,121	4,734	522	2,645	1,692	172	515
1995	2,201	4,773	527	2,624	1,770	191	537
1996	2,280	4,815	520	2,697	1,777	191	558
1997	2,350	5,384	513	2,726	1,761	182	574
1998	2,422	4,827	506	2,556	1,797	256	595
1999	2,494	4,707	499	2,606	1,835	231	618
2000	2,560	4,279	492	2,663	1,919	246	629
2001	2,623	4,659	488	2,790	2,046	222	641
2002	2,691	4,855	484	2,784	2,194	222	660
2003	2,756	5,097	497	2,817	2,256	253	675
2004	2,825	5,480	510	2,750	2,279	221	697
2005	2,892	4,757	508	2,804	2,296	235	708
2006	2,960	4,654	502	2,942	2,236	255	704
2007	3,028	5,331	478	3,052	2,221	259	718
2008	3,096	5,263	455	3,029	2,146	282	724
2009	3,149	5,109	431	2,570	2,219	290	730
2010	3,202	4,922	408	2,613	2,258	288	739
2011	3,256	4,727	397	2,536	2,303	319	747
2012	3,309	4,981	405	2,673	2,320	286	749
2013	3,362	4,775	449	2,888	2,336	290	752
2014	3,416	4,920	465	2,886	2,394	296	755
2015	3,469	5,009	480	2,973	2,352	320	758
2016	3,522	5,100	477	2,967	2,399	325	762

26. References and Data Sources

Access Economics, Pezzullo, L., and Crook, A., 2006. The Economic and Social Costs of Occupational Disease and Injury in New Zealand. National Occupational Health and Safety Advisory Committee.

Abarca, J.E., Casiccia,C.C., 2002. Skin Cancer and Ultraviolet-B Radiation Under the Antarctic Ozone Hole: Southern Chile, 1987-2000. *Photodermatology, Photoimmunology and Photomedicine* 18, 294-302

AC Nielson., 2013. Quality of Life Survey 2012 Six Councils Report. Retrieved from www.qualityoflife.govt.nz

Ajtić, J. and Connor, B., 2004. The Antarctic Ozone Hole and Southern Mid-Latitudes: The Dilution Effect. Water and Atmosphere on line NIWA Science, Vol. 12 (No 2).

Ajtić, J., Connor, B.J., Lawrence, B.N., Bodeker, G.E., Hoppel, K.W., Rosenfield, J.E., Heuff, D.N. 2004. Dilution of the Antarctic Ozone Hole into Southern Midlatitudes, 1998–2000. *Journal of Geophysical Research: Atmospheres, 109*(D17).

Anand, S. and Sen, A., 2000. Human development and Economic Sustainability. World Development, 28 (12):2029–2049.

Ang, B.W. and Zang, F.Q., 2000. A Survey of Index Decomposition Analysis in Energy and Environment Studies. *Energy* 25: 1149-1176.

Angner, E., 2010. Subjective Well-being. *The Journal of Socio-Economics, 39*(3), 361-368. doi:http://dx.doi.org/10.1016/j.socec.2009.12.001

Anielski, M., 2001. The Alberta GPI Blueprint. The Genuine Progress Indicator (GPI). Sustainable Well-being Accounting System. The Pembina Institute, Edmonton, 126 p.

Anielski, M., Rowe, J., 1999. The Genuine Progress Indicator – 1998 Update. Redefining Progress, San Francisco, 61 p. www.rprogress.org.

Anielski, M., 2007. The Economics of Happiness: Building Genuine Wealth. New Society Publishers, Gabriola Island, Canada.

Anielski, M., Griffiths, M., Pollock, D., Taylor, A., Wilson, J., Wilson, S., 2001. Alberta Sustainability Trends 2000: The Genuine Progress Indicators Report 1961–1999. Retrieved from http://www.anielski.com/wp-content/uploads/2011/11/Alberta-Sustainability-2000.pdf

Auckland Regional Council, 1997. Ambient Air Quality: Monitoring Results for the Auckland Region 1964-1995.

Auckland Regional Council, 2001. Riparian Zone Management. Auckland Regional Council, Auckland. ISSN 1175 205X.

Auckland Regional Council, 2006a. Air Pollution in Auckland. http://www.arc.govt.nz/arc/index.cfm?7AB56726-21F1-4D53-A079-BFC1CE8CDF25[9 November 2006].

Auckland Regional Council, 2006b. Auckland Air Emissions Inventory: 2004. Auckland Regional Council, Auckland.

Auckland Regional Council, 2009. Auckland air emissions data supplied by Janet Petersen

Ausseil, A.-G., Gerbeaux, P., Chadderton, W. L., Stephens, T., Brown, D. J., Leathwick, J., 2008. Wetland Ecosystems of National Importance for Biodiversity: Criteria, Methods and Candidate List of Nationally Important Inland Wetlands. Landcare Research Contract Report for the Department of Conservation, Palmerston North, New Zealand, 162 p.

Australian Unity Ltd., 2015. What Makes Us Happy? Fifteen Years of the Australian Unity Well-Being Index. Australian Unity Ltd, Melbourne.

Azar, C. and Sterner, T., 1996. Discounting and Distributional Considerations in the Context of Global Warming. *Ecological Economics*, 19 (2):169–184.

Bagstad, K.J., Berik, G., Gaddis, E.J.B., 2014. Methodological Developments in US State Level Genuine Progress Indicators: Toward GPI 2.0. *Ecological Indicators*, 45: 474-485

Bannock, G., Baxter, R., Davis, E., 1992. Dictionary of Economics. Penguin Books Ltd, London, England.

Barbier, E.B., Acreman, M., Knowler, D., 1997. Economic Valuation of Wetlands: A Guide for Policy Makers and Planners. Ramsar Convention Bureau, Gland, Switzerland

Baumgärtner,S., Dyckhoff, H., Faber, M., Proops, J., Schiller, J. 2001. The Concept of Joint Production and Ecological Economics. *Ecological Economics* 36:3 365-372

Bell, B. and Elliott, R., 1993. Aspects of New Zealand's Experience in Agricultural Reform Since 1984. Ministry of Agriculture and Forestry, Wellington.

Beston, A., 2006. Underwater Lake Wall Okayed. The New Zealand Herald, 15.09.06. http://subs.nzherald.co.nz/topic/print.cfm?c_id=281&objectid=10401374 [9.11.06].

Biggs, B., J.F. and Price, G.,M., 1987. A Survey of Filamentous Algal Proliferations in New Zealand Rivers. *New Zealand Journal of Marine and Freshwater Research*, 21:175–191.

Black, J., 2002. A Dictionary of Economics. Oxford University Press, Oxford, UK.

Bisson,K., Proops, J. 2002. Waste of Ecological Economics, Edward Elgar, Cheltenham

Bleys, B., 2008. Proposed Changes to the Index of Sustainable Economic Welfare: An Application to Belgium. *Ecological Economics*, 64 (4): 741–751.

Bockemuehl, H. W. (Editor), 1970. New Zealand's Wealth. Studies in Resource Development and Utilisation. Manawatu Branch, New Zealand Geographical Society (Inc), Palmerston North.

Brekke, K. and Howarth, R., 2002. Status, Growth, and the Environment: Goods as Symbols in Applied Welfare Economics. Edward Elgar, Cheltenham, UK.

Britton, S., Le Heron, R., Pawson, E. (eds), 1992. Changing Places in New Zealand: A Geography of Restructuring. New Zealand Geographical Society, Christchurch, New Zealand.

Broome, J., 1992. Counting the Cost of Global Warming. Cambridge University Press, Cambridge.

Buchan, I., 2002. Calculating the Gini Coefficient of Inequality. Eastern Region Public Health Observatory (ERPHO), Institute of Public Health, University of Cambridge, UK.

BTE, 2001. Economic Costs of Natural Disasters in Australia. Bureau of Transport Economics, Canberra. http://www.mfe.govt.nz/publications/climate/economic-impacts-extreme-events-jul04/index.html.

Calder, M. and Tyson, J., 1999. Meat Acts: The New Zealand Meat Industry 1972–1997. Meat New Zealand, Wellington, NZ.

Calderón-Garcidueñas, L., Torres-Jardón, R., Kulesza, R .J., Park, S-U., D'Angiulli, A., 2014. Air Pollution and Detrimental Effects on Children's Brain. The Need for A Multidisciplinary Approach to the Issue Complexity and Challenges. *Frontiers in Human Neuroscience* 8: 1-7.

Cancer Society of New Zealand, n.d. Sun Exposure and Skin Cancer http://www.cancernz.org.nz/HealthPromotion/SkinCancerControl/Cancer/ [22 May 2007].

Career Services, 2006. Overworked New Zealand – a Matter of Choice? Career Edge, the Magazine for the Careers Industry, 15 (February), 6-8.

Castaneda, B.E., 1999. An Index of Sustainable Economic Welfare (ISEW) for Chile. *Ecological Economics* 28 (2): 231-244

Centre for Advanced Engineering, 2005. Landfill Full Cost Accounting Guide for New Zealand. Information Bulletin, 34: 8.

Centre for Bhutan Studies and GNH Research, 2016. A Compass Towards a Just and Harmonious Society. Centre for Bhutan Studies and GNH Research, Thimphu, Bhutan

Chapple, S., 1996. Full Employment: Whence It Came & Where It Went. Research Monograph 66. New Zealand Institute of Economics Research, Wellington.

Chapple, S., 1997. Do Minimum Wages Have an Adverse Impact on Employment? Evidence from New Zealand. Labour Market Bulletin, 2, 25-50.

Christie, A., Brathwaite, R., 1999. The Mineral Potential of New Zealand. Institute of Geological & Nuclear Sciences Limited, Lower Hutt.

Clarke, M., Lawn, P., 2005. Measuring Victoria's Genuine Progress: A Genuine Progress Indictor (GPI) for Victoria. *Economic Papers, 24* (4):368–389.

Clarkson, B.R., Ausseil, A-G, Gerveaux, P., 2013. Wetland Ecosystem Services. In, Dymond J.R, (ed). Ecosystem Services in New Zealand – Conditions and Trends, pp192-202. Manaaki Whenua Press, Lincoln, New Zealand.

Close, M.E., Davies-Colley, R., J., 1990a. Baseflow Water Chemistry in New Zealand Rivers - 1. Characterisation. *New Zealand Journal of Marine and Freshwater Research*, 24:319–341.

Close, M., E., Davies-Colley, R., J., 1990b. Baseflow Water Chemistry in New Zealand Rivers - 2. Influence of Environmental Factors. *New Zealand Journal of Marine and Freshwater Research*, 24:343–356.

Cobb, C., Halstead, T., Rowe, J., 1995. The Genuine Progress Indicator: Summary of Data and Methodology. Redefining Progress, San Francisco.

Cobb, C.W., Cobb, J.B., 1994. The Green National Product: A Proposed Index of Sustainable Economic Welfare. University Press of America, Lanham, M.D.

Cohen, A.J., Harcourt, G.C., 2003. Whatever Happened to the Cambridge Capital Theory Controversies? *Journal of Economic Perspectives*, 17(1), 199-214

Cole A. O., Patterson, M.G., 2013. A Dynamic GPI Accounting Model for the Nelson Tasman Regions and the Motueka Catchment of New Zealand. School of People, Environment and Planning, Massey University. ISBN 978-0-9876621-1-18

Colman, R., 1998. Measuring Sustainable Development: Application of the Genuine ProgressIndex to Nova Scotia. Retrieved from http://www.gpiatlantic.org/pdf/general/framework.pdf

Colman, R., 2004. The Nova Scotia Genuine Progress Index: Insights for New Zealand. Ministry for Social Development, Wellington

Colmar Brunton., 2016. Quality of Life Survey 2016 – Topline Report. A Report Prepared on Behalf of Auckland Council, Wellington City Council, Christchurch City Council, and Dunedin City Council. ISBN 978-0-9941405-6-2

Commission for the Environment, 1986. New Zealand Wetlands Management Policy. Wellington, NZ. http://www.doc.govt.nz/publications/conservation/land-and-freshwater/wetlands/ new-zealand-wetlands-management-policy/ [21 May 2009].

Costanza, R., d'Arge, R., deGroot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., 1997. The Value of the World's Ecosystem Services and Natural Capital. *Nature,* 387 (6630): 253–260.

Costanza, R., Kubiszewski, I., Giovannini, E., Lovins, H., McGlade, J., Pickett, K. E., Ragnarsdottir, K.V, Roberts, D., De Vogli, R.. Wilkinson, R., 2014. Development: Time to Leave GDP Behind. *Nature*, *505*(7483), 283-285. DOI: 10.1038/505283a

Costanza, R., Sutton P., van der Ploeg, S., Anderson, S., Kubiszewski, I., Faber, S., Turner, R. K., 2014. Changes in the Global Value of Ecosystem Services. *Global Environmental Change*. 25: 152-158

Coyle, D. 2014. *GDP: A Brief but Affectionate History*. Princeton: Princeton University Press.

Daly, H.E., 1996. Beyond Growth. Beacon Press, Boston.

Daly, H., 2005. Economics in a Full World. *Scientific American*, 293 (3):100–107.

Daly, H. 2013. A Further Critique of Growth Economics. *Ecological Economics, 88*, 20-24.

Daly, H.E., Cobb, J., 1989. For the Common Good: Redirecting The Economy Toward Community, The Environment and a Sustainable Future. Beacon Press, Boston.

Davidmann, M., 1996. Exporting and Importing of Employment and Unemployment. Community Economics, Oakland, CA.

Davies, L, Jackson, N. 1993. 100 years Old Women's Labour Force Participation: Some Comments. Department of Social Welfare, Wellington

Dalziel, P., Saunders, C. 2014. Well-Being Economics: Future Directions for New Zealand. Brigid Williams Books, Wellington de Groot, R., Brander, L., Van Der Ploeg, S., Costanza, R., Bernard, F., Braat, L., Hussain, S. Christie, M., Crossman,N.,Ghermandi,A., Hein,L., Hussain,S., Kumar,P., McVittie,A. Portela,R. Rodriguez,L.C., ten Brink,P., van Beukering,P., 2012. Global Estimates of the Value of Ecosystems and their Services in Monetary Units. *Ecosystem Services* 1(1): 50-61

Delang, C.O., Yu, Y H., 2015. Measuring Welfare Beyond Economics – The Genuine Progress of Hong Kong and Singapore. Routledge, New York

De la Vega, M.C.L., Urrutia, A.M., 2001. HDPI: A Framework for Pollution-Sensitive Human Development Indicators. *Environment Development and Sustainability* 3: 199-215

Delvin, N.J., Scuffham, P.A., Bunt, L.J., 1997. The Social Costs of Alcohol Abuse in New Zealand. *Addiction* 11: 1491-1505

Department of Conservation, 2005. Department of Conservation Annual Report - For the Year Ended 30 June 2005. Wellington, New Zealand, 160 p. http://www.doc.govt.nz/Publications/001~Corporate/046~Annual-Report-(for-year-ended-30-June-2005).pdf [19.05.06].

Department of Conservation, 2006. Pests and Weeds - General Information. http://www.doc.govt.nz/Conservation/002~Animal-Pests/001~Pests-and-Weeds-General-Information.asp [4.05.06].

Department of Conservation and Ministry for the Environment, 1998. Restoring the Dawn Chorus. Wellington, New Zealand.

Department of Environment Sport and Tourism, 1996. State of the Environment Report Australia. DEST, Canberra.

Department of Labour, 2008. Working Long Hours in New Zealand: A Profile of Long Hours Workers Using Data from the 2006 Census. Department of Labour, Wellington.

Department of Statistics, 1993. New Zealand Social Trends: Work. Department of Statistics, Wellington.

Desai, M. 1995. Greening of the HDI? *In,* MacGillivray (ed.). Accounting for Change pp21-36. New Economics Foundation, London.

Dietz, S., Neumayer, E., 2006. Some Constructive Criticisms of the Index of Sustainable Economic Welfare. In: P. A. Lawn (Editor), Sustainable Development Indicators and Public Policy: Assessing the Policy-Guiding Value of Sustainable Development Indicators. Edward Elgar Publishing, Northampton, USA, pp. 186–206.

Dodds, C., Colman, R., 1999. The Cost of Crime in Nova Scotia. Module Three of Measuring Sustainable Development: Application of the Genuine Progress Indicator to Nova Scotia. GPI Atlantic, Canada.

Dodds, C., Colman, R., 2001. Income Distribution in Nova Scotia, Executive Summary. Genuine Progress Index for Atlantic Canada, Canada.

Dominati, E., Patterson, M., MacKay, A. 2010. A Framework for Classifying and Quantifying the Natural Capital and Ecosystem Services of Soils. *Ecological Economics,* 66:9 1858-1868.

Dravitzki, V., Lester, T., 2006. Economics Drove Our First Sustainable Urban Transport System and the Unsustainable One that Followed. Opus International Consultants, Central Laboratories. Lower Hutt, Wellington.

Easterlin, R., 2003. Explaining Happiness. Proceedings of the National Academy of Sciences, 100 (19): 11176–11183.

Easterlin, R., Angelescu, L., 2009. Happiness and Growth the World Over: Timeseries Evidence on the Happiness-Income Paradox. Retrieved from: http://ftp.iza.org/dp4060.pdf

Easton, B., 1996. Income Distribution. A Study of Economic Reform: The Case of New Zealand. North Holland Books, pp.101-138. http://www.eastonbh.ac.nz.

Else, A., 1996. False Economy: New Zealanders Face Conflict Between Paid and Unpaid Work. Tandem Press, Birkenhead, New Zealand

Eisner, R., 1990. The Total Incomes Systems of Accounts. Chicago University Press, Chicago.

El Serafy, S.E., 1989. The Proper Calculation of Income from Depletable Natural Resources. In: Y. Ahmad, S. E. Serafy, and E. Lutz (Editors), Environmental Accounting for Sustainable Development. pp. 10–18. World Bank, Washington DC.

El Serafy, S., 2002. The "El Serafy" Method for Estimating Income From Extraction and Its Importance for Economic Analysis. http://www.ngps.nt.ca/registryDetail_e.asp?CategoryID=169.

Environment Bay of Plenty Regional Council, Rotorua Lakes Protection and Restoration Action programme http://www.ebop.govt.nz/Water/Lakes/Rotorua-Lakes.asp [22 May 2007].

Environment Bay of Plenty Regional Council, 2006. Government Help Needed to fund $170 million Rotorua lakes costs. 21.06.06. http://www.boprc.govt.nz/Water/Lakes/Media-Releases-and-Articles.asp [15.09.06].

Environment Canterbury, 2009. Christchurch air emissions data supplied by Teresa Aberkane

Environment Waikato, Whangamarino wetland. http://www.ew.govt.nz/enviroinfo/water/wetlands/casestudies/whangamarino.htm [15 May 2007].

Environment Waikato, 2002. Regional Pest Management Strategy 2002–2007. Environment Waikato, Hamilton. http://www.ew.govt.nz/policyandplans/rpmsintro/rpms2002/index.asp.

Environment Waikato, 2006. Water Quality Glossary . http://www.ew.govt.nz/enviroinfo/water/lakes/lakesglossary.htm [7.06.06].

Envision New Zealand, 2003. Resourceful Communities. A Guide to Resource Recovery Centres in New Zealand. 110 p.

Evans, L., Grimes, A., Wilkinson, B., Teece. D., 1996. Economic Reform in New Zealand 1984-1995: The Pursuit of Efficiency. *Journal of Economic Literature*, 34 (4), 856-1902.

Farm Environment Award Trust, 2004. Work Out the Cost of Managing Waterways on Your farm. http://www.ew.govt.nz/enviroinfo/water/documents/fea1.pdf.

Ferlay, J., Bray, F., Pisani, P., Parkin, D. M., 2001. Cancer Incidence, Mortality and Prevalence Worldwide. ARC Press Lyon.

Ferrier, D.A.,Marks, P., 1982. Wastewater Treatment and Disposal Practices: Working party sub-theme lead paper. Presented at Water in New Zealand's Future: proceedings of the Fourth National Water Conference, Auckland.

Finlayson, C.M., D'Cruz, R., Davidson, N.J. (collators), 2005. Ecosystem Services and Human Well-being: Water and Wetlands Synthesis. World Resources Institute: Washington, DC.

Fisher, G., Kjellstrom, T., Kingham, S., Hales, S., Shrestha, R., Sturman, A., Sherman, M., O'Fallon, C., Cavanagh, J.E., and Durand, M., 2007. Health and Air Pollution in New Zealand. Health Research Council of New Zealand, Ministry for the Environment, Ministry of Transport Wellington.

Fisher, G., Kjellstrom, T., Woodward, A., Hales, S., Town, I., Sturman, A., Kingham, S., O'Dea, D., Wilton, E., O'Fallon, C., Scoggins, A., Shrestha, R., Zawar-Rewa, P., Epton, M., Pearce, J., Sturman, J., Spronken-Smith, R., Wilson, J., McLeod, S., Dawson, R., Tremblay, L., Brown, L., Trout, K., Eason, C., and Donnelly, P., 2005. Health and Air Pollution in New Zealand: Christchurch Pilot Study. Health Research Council, Ministry for the Environment, Ministry of Transport.

Fisher, G.W., Rolfe, K.A., Kjellstrom, T., Woodward, A., Hales, S., Sturman, A. P., Kingham, S., Petersen, J., Shrestha, R., and King, D., 2002. Health Effects due to Motor Vehicle Air Pollution in New Zealand. Report to Ministry of Transport.

Fisher, I., 1906. Nature of Capital and Income. A.M. Kelly, New York.

Fitzgerald, J.E., Skam, A.W., Thom, N G., 1973. Air Pollution in Auckland; Now and in the Future. *Clean Air* (7/1): 6–9.

Fordham, R.A., Ogden, J. 1974. An Ecological Approach to New Zealand's Future. Proceedings of the New Zealand Ecological Society, Supplement Volume 21 pp 7-31.

Forgie, V., McDonald, G. Zhang Y., Patterson, M., Hardy,D., 2008. Calculating the New Zealand Genuine Progress Indicator. In, Sustainable Welfare in the Asia-Pacific: Studies Using the Genuine Progress Indicator., Lawn ,P and Clarke, M (eds) pp 126 - . Edward Elgar, Cheltenham.

Friedman, M., Grawert, A.C., Cullen, J., 2017. Crime trends: 1990-2016. Brennan Centre for Justice, School of Law, New York University, New York.
Galbraith, J. K., 1999. The Affluent Society (3rd ed.). Penguin Economics, London.
Gemmell, N., Gill, D., Nguyen, L., 2016. The Changing Size of the State in New Zealand, 1900-2015. Working Paper 04/2016, Victoria University, Wellington.
Gendall, P., Massey University Department of Marketing, and International Social Survey Programme, 2001. New Zealanders and the Environment: International Social Survey Programme. Massey University, Palmerston North.
Gibbard, R., Roygard, J., Ausseil, O., Fung, L., 2006. Water Quality Trends in the Manawatu-Wanganui region 1989–2004. Horizons Regional Council, Palmerston North, NZ.
Gil,S., Sleszynski, J., 2003. Index of Sustainable Economic Welfare for Poland. *Sustainable Development* 11:1 47-55
Gleeson-White, J., 2014. Six Capitals. The Revolution Capitalism Has to Have - Or Can Accountants Save The Planet? Sydney: Allen & Unwin.
Gravitas Research and Strategy Limited, 2005. Quality of life in New Zealand's Largest Cities: Residents' Survey Prepared for Quality of Life Project Team and Ministry of Social Development. http://www.bigcities.govt.nz/pdf2004/Quality_of_Life_2004_full_report.pdf.
Guenno, G., Tiezzi, S., 1998. The Index of Sustainable Economic Welfare (ISEW) for Italy. University of Siena, Department of Economics, Siena.
Hackwell, K., Bertram, G., 1999. Pests and Weeds: A Blueprint for Action. New Zealand Conservation Authority, Wellington, NZ, 71 p.
Hales, S., Town, G., Kejellstrom, T., Woodward, A., 1999. Daily Mortality in Relation to Weather and Air Pollution in Christchurch, New Zealand. *Australian and New Zealand Journal of Public Health*, 24:1 89-91.
Hamill, K., 2006. Snapshot of Lake Water Quality in New Zealand. ME number: 776, Opus International Consultants for Ministry for the Environment, Wellington.
Hamilton, C., Saddler. H., 1997. The Genuine Progress Indicator: A New Index of Changes in Well-Being in Australia. Discussion Paper N.14. Australian Institute, Canberra
Hamilton, C. 1999. The Genuine Progress Indicator Methodological Developments and Results from Australia. *Ecological Economics, 30*, 13–28.
Hamilton, C., Denniss, R., 2000. Tracking Well-Being In Australia. The Genuine Progress Indicator. Discussion Paper No. 35, The Australia Institute.
Hamilton, K., 1994. Green Adjustments to GDP. *Resources Policy*, 20, 158-168.
Hamilton, K., 1996. Pollution and Pollution Abatement in the National Accounts. *Review of Income and Wealth,* 42, 291-304.
Han, T., Sinha, R.P., Hader,P., 2003. Effects of Intense PAR and UV Radiation on Photosynthesis, Growth and Pigmentation in The Rice-Field Cyanobacterium *Anabaena* sp. *Photochemical and Photobiological Sciences* 2, 659-654
Hatfield-Dodds, S., 1997. Towards a Science of Sustainability: Improving the Way Ecological Economics Understands Human Well-Being. *Ecological Economics* 23 95-111.
Hatfield-Dodds, S., 2005. Decision Support for Highly Contested Choices: The Role of Monetised Values and other Metrics in the Pursuit of Sustainability. Presented at Australia New Zealand Society for Ecological Economics, Palmerston North, New Zealand.
Haynes, R.J., 1995. Soil Structural Breakdown and Compaction in New Zealand Soils http://www.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/land-management/soil-structure/soilcomp.htm.
Hecht, J.E., 2005. National Environmental Accounting: Resources for the Future. RFF Press, Washington D.C.
Hillebrand, E. 2009. Poverty, growth and inequality over the next 50 years. Food and Agriculture Organisation, United Nations.
Hicks, J., 1939. The Foundations of Welfare Economics. *The Economic Journal, 49*, 696-712.

Henzell, J., 2007. American was Likely Source of Didymo. The Press, 18 August 2007.

Hicks, D. M., Hankar, U., McKerchar, A.I., Basher, L., Lynn, I., Page, M, and Jessen, M. 2011. Sediment Flux, Morphology and River Management, pp. 81-142. *Journal of Hydrology* 50:1 81-142

Hirsch, E.D., Kett, J. F., Trefil, J., 2002. The New Dictionary of Cultural Literacy, Third Edition. Houghton Mifflin Company, Boston, USA.

Huser, B., Patterson, M.G., Killerby, P., 2016. Towards a Wellbeing Index for the Waikato Region – Promoting Evidence to Inform Decision-making and Public Accountability. *Planning Quarterly* 200: 8-144

Hyman, P., 1994. Women and Economics – A New Zealand Feminist Perspective. Bridget Williams Books, Wellington.

International Energy Agency, 2008. Energy Technology Perspectives. Scenarios and Strategies to 2050 OECD/IEA, Paris.

Jackson, T., 2009. Prosperity Without Growth. Earthscan. London.

Jackson, T., Laing, F., MacGillivray, A., Marks, N., Ralls, J., Stymne, S., 1997. An Index of Sustainable Economic Welfare for the UK 1950-1996. University of Surrey, Centre for Environmental Strategy, Guildford.

Jackson, T., Stymne, S., 1996. Sustainable Economic Welfare in Sweden: A Pilot Index 1950-1996. Stockholm Environmental Institute, Stockholm.

Jackson,T., McBride, N., Abdallah, S., Marks, N. 2008. Measuring Regional Progress: Regional Index of Sustainable Economic Well-being for all English Regions.

Jollands, N., Lermit, J., Patterson, M., 2004. Decomposition of Energy: GDP Ratio Changes: An Improved Divisia Approach to Account for Energy Quality. *International Journal of Energy, Environment and Economics,* 12:1 1-31.

Junankar, P.N., Kapuscinski, C.A., 1992. The Costs of Unemployment in Australia. EPAC Background Paper No. 24, AGPS, Canberra, Australia.

Kelsey, J. 1993. Rolling Back the State: Privatisation of Power in Aotearoa/New Zealand. Bridget Williams Books, Wellington

Kennedy, R., 1968. Address to the University of Kansas. 18 March 1968, Lawrence, Kansas, USA.

Kerr, T., Costanza, R., Erickson, J., Fligger, K., Adams, A., Adams, C., Altschuler, B., Balter, S., Fisher, B., Hike, J., Kelly, J., McCauley, M., Montone, K., Rauch, M., Schmiedeskamp, K., Saxton, D., Sparacino, L., Tusinski, W., Williams, L., 2004. Estimates of the Genuine Progress Indicator (GPI) for Vermont, Chittenden Country and Burlington, form 1950 to 2000. *Ecological Economics*, 51, 139-155.

King, C.M. (Editor), 1990. The Handbook of New Zealand Mammals. Oxford University Press, Oxford, 600 p.

King, C.M., 2001. Advances in New Zealand Mammalogy, 1990–2000. *Journal of the Royal Society of New Zealand*, 31:298.

Kirk, A. (Editor), 1982. Water Pollution. National Water and Soil Conservation Organisation, Wellington.

Kirkland, W.T., 1988. Preserving the Whangamarino Wetland - An Application of the Contingent Valuation Method. Massey University, Palmerston North, New Zealand.

Kirkland, W.T., 1988. Preserving the Whangamarino Wetland: An Application of the Contingent Valuation Method: A Thesis Presented in Partial Fulfilment of the Requirements for the Degree of Master of Agricultural Science. Massey University, Palmerston North, New Zealand.

Krausse, M., Eastwood, C., Alexander, R. R., 2001. Muddied Waters: Estimating the National Economic Cost of Soil Erosion and Sedimentation in New Zealand. Landcare Research, Lincoln, New Zealand.

Kubiszewski, I., Costanza, R., Franco,C., Lawn,P., Talberth, J., Jackson,T., Aylmer, C., 2013. Beyond GDP: Measuring and Achieving Global Genuine Progress. *Ecological Economics,* 93: 57-68

Kumar, P. (ed.), 2010. TEEB: The Economics and Ecosystems and Biodiversity: Ecological and Economic Foundations. Earthscan, London/Washington D.C.

Kuschel ,G., Metclafe, J., Wilton, E., Guria, J., Hales, S., Rolfe, K., Woodward, A., 2012. The Updated Health and Air Pollution in New Zealand Study. Volume 1: Summary Report. Health Research Council of New Zealand, Ministry for Transport, Ministry for the Environment, New Zealand Transport Agency, Wellington.

Kuznets, S., 1962. How to Judge Quality. The *New Republic* (20 October 1962):29–32.

Kuznets, S., 1934. National Income, 1929-1932. 73rd US Congress, 2d session, Senate document no. 124, page 7. http://library.bea.gov/u?/NI_reports,539

Land Transport New Zealand, 2006. New Zealand Motor Vehicle Registration Statistics 2005. Palmerston North, New Zealand.

Larned, S., Scarsbrook, M., Snelder, T., and Norton, N., 2005. Nationwide and Regional State and Trends in River Water Quality 1996–2002. MFE 590, Ministry for the Environment, Wellington, 112 p.

Larned, S., Scarsbrook, M., Snelder, T., Norton, N., Biggs, B., 2004. Water Quality in Low-Elevation Streams and Rivers of New Zealand: Recent State and Trends in Contrasting Land-Cover Classes. *New Zealand Journal of Marine and Freshwater Research*, 38:347–366.

Lawn, P.A., 1999. On Georgescu-Roegen's Contribution to Ecological Economics. *Ecological Economics*, 29:1 5–8.

Lawn, P.A., 2003. A Theoretical Foundation to Support the Index of Sustainable Economic Welfare (ISEW), Genuine Progress Indicator (GPI), And Other Related Indexes. *Ecological Economics,* 44:1 105–118.

Lawn, P., 2004. An Assessment of the Valuation Method Used to Calculate the Index of Sustainable Economic Welfare (ISEW), Genuine Progress Indicator (GPI), and Sustainable Net Benefit Index (SNBI). Environment, Development and Sustainability. 7, 185-208.

Lawn, P.A., 2005. Workshop on Genuine Progress Indicators. Presented at Australia New Zealand Society for Ecological Economics Conference "Ecological Economics in Action", Massey University, Palmerston North, New Zealand, December 11–13, 2005.

Lawn, P., 2006. Sustainable Development: Concept and Indicators. In: P. Lawn (Editor), Sustainable Development Indicators in Ecological Economics. Edward Elgar, Cheltenham, United Kingdom.

Lawn, P., 2007a. Frontier Issues in Ecological Economics. Edgar Elgar Publishing, Cheltenham, United Kingdom.

Lawn, P., 2007b. A Stock-Take of Green National Accounting Initiatives. *Social Indicators Research*, 80:427–460.

Lawn, P.A., Clarke, M., 2006. Measuring Genuine Progress: An Application of The Genuine Progress Indicator. Nova Publishers.

Lawn, P.A., Clarke, M., 2008. Sustainable Welfare in the Asia-Pacific. Studies Using the Genuine Progress Indicator. Edward Elgar, Cheltenham, United Kingdom.

LCDB1, no date. New Zealand Land Cover Database. Terralink International Limited

LCDB2, 2004. New Zealand Land Cover Database. Terralink International Limited

Ledgard, S. F., 2001. Nitrogen Cycling in Low Input Legume-Based Agriculture, With Emphasis On Legume/Grass Pastures. Plant and Soil, 228:43–59.

Le Heron, R., Pawson, E., 1996. Changing Places: New Zealand in the Nineties. Longman Paul, Auckland, New Zealand.

Leipert, C., 1989. Social Costs of the Economic Process and National Accounts: The Example of Defensive Expenditures. *Journal of Interdisciplinary Economics*, 3:27–46.

Lenzen, M., Murray, J., Sack, F., Wiedmann, T., 2007. Shared Producer and Consumer Responsibility – Theory and Practice. *Ecological Economics,* 61:27–42.

Lequiller, F., Blades, D., 2006. Understanding National Accounts. Economica, France

Leung, C., Destrmau,D., Pambudi, D., Bealing, M., 2017. Benefits from Auckland Road Decongestion. New Zealand Institute for Economic Research, Wellington.

Livingston, M. E., Biggs, B. J., and Gifford, J. S., 1986. Inventory of New Zealand lakes: Part I North Island and part II South Island. Wellington.

Loughhey-Webb, B., 2015. The Welfare Reforms of the Fourth (1990-99) and Fifth (2008-2014) National Governments: A Critical Analysis and Evaluation. Unpublished Master of Arts Thesis, University of Otago, Dunedin.

LRI v1, 1975-79. National Water and Soil Conservation Organisation. New Zealand Land Resource Inventory Worksheets, 1st ed. 1:63,360.

Lucas, R.E., Clark, A.E., Georgellis, Y., Diener, E., 2004. Unemployment Alters the Set Point for Life Satisfaction. *Journal of the American Psychological Society*. 15:1 8-13

Maclaren, J., Wakelin, S., 1992. Carbon Sequestration by New Zealand's Plantation Forests - The Long Term View. Forest Research Institute, Rotorua.

Maler, K., 1991. National Accounts and Environmental Resources. *Environmental and Resource Economics*, 1, 1-15.

Mankiw, N., 1999. Macroeconomics (4th edition). Worth Publishers, New York.

Markey, S., 2006. Alien Possums Gobbling New Zealand Forests, Birds. National Geographic News.

Maslow, A., 1943. A Theory of Human Motivation. *Psychological Review,* 50: 370-396

Max-Neef, M., 1995. Economic Growth and Quality of Life: A Threshold Hypothesis. *Ecological Economics, 15*:2, 115-118. doi:http://www.sciencedirect.com/science/journal/09218009

Maxwell, G., 2009. Changing Crime Rates?. Presentation to Institute of Policy Studies, 27 February 2009. Victoria University of Wellington, Wellington.

Mazin, I., 2006. Correlation between the Gini Index and the Observed Prosperity. 2006 APS March Meeting, http://meetings.aps.org/link/BAPS.2006.MAR.A33.7. Baltimore, MD, USA.

McConnell, C., Brue, S., 2004. Microeconomics: Principles, Problems and Policies. Part 5: Microeconomic Issues and Policies. Chapter 21: Income Inequality and Poverty. McGraw-Hill Professional, ISBN:0072875615.

McColl, R.H.S., 1982. Water Quality in Agricultural Areas - The Prospects for Management of Diffuse Pollution Sources. Presented at 'Water In New Zealand's Future'. Institution of Professional Engineers New Zealand - Royal Society of New Zealand, Water Conference

McColl, R.H S., Hughes, H. R., 1981. The Effects of Land-Use on Water Quality – A Review. Ministry of Works and Development, Water and Soil Miscellaneous Publication 23. www.rsnz.org/publish/nzjmfr/1989/16.pdf

McDonald, G.W., Patterson, M.G. 2003. Ecological Footprints of New Zealand Regions. Environmental Reporting Technical Paper. Ministry for the Environment. Wellington, New Zealand. 162 pp. ISBN 0-478-24085

McDonald, G., Patterson, M. G., 2004. Ecological Footprints and Interdependencies of New Zealand Regions. *Ecological Economics,* 50: 49–68.

McDonald, G., Patterson, M. G. 2006. Development of a New Zealand Physical Input Output Table. Technical Publication of the New Zealand Centre for Ecological Economics , Massey University, Palmerston North.

McDonald, G., Forgie, V., MacGregor, C., 2006. Treading Lightly: Eco-Footprints of New Zealand's Ageing Population. *Ecological Economics*, 56:3 424-439.

McDonald G, Forgie V, Zhang J, Robbie A, Smith N., Hampson N., 2010. A Genuine Progress Indicator for the Auckland Region: Summary Report and Valuation Methodology. Auckland Regional Council, Auckland.

McGillivray, M. (Editor). 2007. Human Well-Being: Concept and Measurement. Palgrave Macmillan, New York

McKee, F.M., Song, Z., Wanberg, C.R., Kinicki, A.J., 2005. Psychological and Physical Well Being During Unemployment: Our Meta-Analytic Study. *Journal of Applied Psychology* 53-76, 90:1

Menneer, J.C., Ledgard, S.F., Gillingham, A.G., 2004. Land Use Impacts on Nitrogen and Phosphorus Loss and Management Options for Intervention. Client Report prepared for Environment Bay of Plenty, 52 p. http://www.ebop.govt.nz/water/media/pdf/land%20use.pdf.

Michalos, A. C., Smale, B., Labonté, R., Muharjarine, N., Scott, K., Moore, K., Swystun, L., Holden, B., Bernardin, H., Dunning, B., Graham, P., Guhn, M., Gadermann, A.M., Zumbo, B.D., Morgan, A., Brooker, A.-S., Hyman, I., 2011. The Canadian Index of Wellbeing. Technical Report 1.0., Univerisity of Waterloo, Ontario.

Ministry of Agriculture, Various dates. Freshwater Catch. Ministry of Agriculture, Wellington.

Ministry of Agriculture and Forestry, 2005. Situation and Outlook for New Zealand Agriculture and Forestry: 2005. ISBN 0-478-29805-6, Ministry of Agriculture and Forestry. Wellington, New Zealand. http://www.maf.govt.nz/mafnet/rural-nz/statistics-and-forecasts/sonzaf/.

Ministry of Business, Innovation and Employment, 2017. How Bad is the Current Recession? Labour Market Downturn Since the 1960s. Ministry of Business, Innovation and Employment, Wellington. https://web.archive.org/web/20141215020411/http://www.dol.govt.nz/publications/discussion-papers/current-recession/desc-1.asp [July 2017]

Ministry of Economic Development, 2007. New Zealand Energy Data File. June 2007. Ministry of Economic Development, Wellington, 172 p. www.med.govt.nz/energy/info/ [July 2007].

Ministry of Economic Development, 2007a. Energy Greenhouse Gas Emissions 1990–2006. ISSN 1173-6771, Ministry of Economic Development, Wellington, 48 p. www.med.govt.nz.

Ministry of Economic Development, 2007b. New Zealand Energy Data File. June 2007. Ministry of Economic Development, Wellington, 172 p. www.med.govt.nz/energy/info/ [July 2007].

Ministry of Education, 2007. Total Investment in Education. Ministry of Education, Wellington. www.educationcounts.edcentre.govt.nz

Ministry for the Environment, 1997. The State of New Zealand's Environment. Ministry for the Environment, Wellington.

Ministry for the Environment, 2000. New Zealand Inventory of Dioxin Emissions to Air, Land and Water, and Reservoir Sources. Ministry for the Environment, Wellington.

Ministry for the Environment, 2001a. A Guide for the Management of Closing and Closed Landfills in New Zealand. Ministry for the Environment, Wellington.

Ministry for the Environment, 2001b. Survey of Regional Council River Water Quality Monitoring Programmes.http://www.mfe.govt.nz/publications/ser/tech-report-70-freshwater-nov01.html [27/9/06].

Ministry for the Environment, 2001c. Valuing New Zealand's Clean Green Image. Ministry for the Environment, Wellington.

Ministry for the Environment, 2004. Landfill Full Cost Accounting Guide for New Zealand. Ministry for the Environment, Wellington.

Ministry for the Environment, 2006. Gentle Footprints: Boots 'n' all. http://www.mfe.govt.nz/publications/ser/gentle-footprints-may06/html/page5.html [19.06.06].

Ministry for the Environment, 2007a. Groundwater Quality in New Zealand. State and trends 1995–2006 ME 831 Ministry for the Environment, Wellington.

Ministry for the Environment, 2007b. New Zealand and Climate Change. Ministry for the Environment, Wellington.
http://www.mfe.govt.nz/issues/climate/work-programmes/nz-climate-change.html [21 May 2007].

Ministry for the Environment. 2007b. Environment New Zealand 2007b. Ministry for the Environment, Wellington.

Ministry for the Environment, 2007 New Zealand's Greenhouse Gas Inventory 1990–2006: The National Inventory Report and Common Reporting Format. ME number: 811. ISSN: 1177-4436 (Print). Ministry for the Environment, Wellington.

Ministry for the Environment, 2008. New Zealand's Greenhouse Gas Inventory 1990–2006: An Overview. ISBN: 978-0-478-30222-6, ME number: 872, Ministry for the Environment, Wellington. www.mfe.govt.nz

Ministry for the Environment, 2015. Environment Aotearoa 2015. Data to 2013. Ministry for the Environment, Wellington. ISBN: 978-0-478-41298-7 (Online), ISBN: 978-0-478-41299-4 (Print)

Ministry for the Environment, 2016. The New Zealand's Greenhouse Gas Inventory 1990–2015. ISSN: 1179-223X (electronic.) ME number: 1309, Ministry for the Environment, Wellington, NZ, 20 p.

Ministry for the Environment, 2017. Briefing to Incoming Ministers of Environment and Climate Change. Making Aotearoa New Zealand the most Liveable Place in the World. New Zealand Government, Wellington.

Ministry of Forestry, 1998. Indigenous forestry. Sustainable management. Ministry of Forestry Wellington.

Ministry of Health, 2005. Health Expenditure Trends in New Zealand 1992-2003. Ministry of Health, Wellington.

Ministry of Primary Industries, 2017. Situation and outlook for Primary Industries – March 2017. Ministry for Primary Industries, Wellington.

Ministry of Social Development, 2006. Work, Family, and Parenting Study: Research Findings. Ministry of Social Development, Wellington.

Ministry of Social Development, 2010. The Social Report. Ministry of Social Development, Wellington

Ministry of Social Development, 2016. The Social Report. Ministry of Social Development, Wellington.

Ministry of Social Development, 2017. Briefing Report for the Incoming Minister of Employment. Ministry of Social Development, Wellington.

Ministry of Transport, 1996. Land Transport Pricing Study: Environmental Externalities. Discussion Paper. 179 p. Ministry of Transport, Wellington.

Ministry of Transport, 2008. Modelled Data on Vehicle Kilometres Travelled, 1979–2000. Email from Ministry of Transport, Wellington.

Ministry of Transport, 2009. Understanding Transport Costs and Charges: Value of Statistical Life – Is the Current Value of Safety for The New Zealand Too Low? Ministry of Transport, Wellington.

Ministry of Transport, 2014. Driver Travel: New Zealand Household Survey Driver Travel: 2010 -2013. Ministry of Transport, Wellington.

Ministry of Works, 1971. Local Authority Sewage Disposal and Sewerage Statistics. Ministry of Works, Wellington.

Ministry of Works, 1976. Local Authority Sewage Disposal and Sewerage Statistics. Ministry of Works, Wellington.

Ministry Of Works, 1981. Local Authority Sewage Disposal and Sewerage Statistics. Ministry of Works,, Wellington.

Möller, J., 1990. Unemployment and Deterioration of Human Capital: A Labour Market Model with Hysteresis Implications. *Empirical Economic*s, 15: 199-215.

Morrison, A., 1996. The Employment Contracts Act and its Economic Impact. Parliamentary Library Background Paper Number 16. Parliamentary Library, Wellington

Mosley, M.P., 1982. New Zealand River Temperature Regimes. Ministry of Works and Development, Water and Soil Miscellaneous Publication 36, 87 p. Ministry of Works and Development, Wellington

Murdoch, H., 2006. Report Identifies 12 Toxic Sites. The Press, Christchurch.

National Water and Soil Conservation Organisation, 1983. Wetlands: A Diminishing Resource. A report for the Environmental Council. National Water and Soil Conservation Organisation Wellington.

Ndebele, T., 2009. A Case Study of the Restoration and Preservation of the Pekapeka Swamp: An Application of the Contingent Valuation Method in Measuring the Economic Value of Restoring and Preserving Ecosystem Services in an Impaired Wetland. A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master in Philosophy in Economics at Massey University, Palmerston North, New Zealand.

Ndebele, T., Forgie, V. 2017. Estimating the Economic Benefits of a Wetland Restoration Programme in New Zealand: A Contingent Valuation Approach. *Economic Analysis and Policy* 55: 75-89.

Neumayer, E., 2000. On the Methodology of ISEW, GPI and Related Measures: Some Constructive Suggestions and Some Doubt on the 'Threshold' Hypothesis. *Ecological Economics*, 34: 347–361.

Neumayer, E., 2001. The Human Development Index and Sustainability – A Constructive Proposal *Ecological Economics* 39: 101-114

Neumayer, E., 2003. Weak versus Strong Sustainability (2nd edition). Edward Elgar, Cheltenham.

Neumayer, E., 2007. Sustainability and Well-being Indicators. In M. Mcgillivray (Ed.), *Human Well-Being: Concept and Measurement*. Houndmills, Basingstoke, Hampshire; New York: Palgrave Macmillan in association with the United Nations University-World Institute for Development Economics Research.

Neumayer, E., 2013. Weak versus Strong Sustainability: Exploring the Limits of Two Opposing Paradigms. (4th edition).Edward Elgar, Cheltenham.

New Zealand Centre for Advanced Engineering, 2008. Regional Energy Survey 2006. Environment Canterbury, Christchurch.

New Zealand Foreign Affairs and Trade, 2017. Briefing for Incoming Minister for Climate Change. New Zealand Government, Wellington.

New Zealand Health Information Services, 2003. Official statistics. Ministry of Health, Wellington. www.nzhis.govt.nz.

New Zealand Health Information Services, 2005. Official statistics. Ministry of Health, Wellington.

New Zealand Institute of Economic Research, 1998. Parallel Importing: A Theoretical and Empirical Investigation, Report to Ministry of Commerce. New Zealand Institute of Economic Research, Wellington.

New Zealand Institute of Economic Research, 2005. The Economic Environment of Waihi - A Review. Report to Hauraki District Council, Wellington. http://www.marthamine.co.nz/PDF/NZIER_Report_Mar_05.pdf.

New Zealand Parliament, 2007. Employment Relations (Flexible Working Hours) Amendment Bill – Second Reading. Order Paper, Debates (Hansard), Questions, Daily Progress, Journals, 641, 11624.

New Zealand Police, 2006. New Zealand Police Annual Report. New Zealand Police, Wellington.

New Zealand Productivity Commission, 2018. Low Emissions Economy. Final Report. New Zealand Productivity Commission, Wellington.

New Zealand Transport Agency, 2018. Economic Evaluation Manual. New Zealand Transport Agency, Wellington. ISBN 978-0478-4078-2

Ng, Y-K., 2004 Welfare Economics: Towards a More Complete Analysis. Palgrave MacMillan, New York

Nichols, L., 2007. Ministry refuses to give $6m to Clean Toxic Stream. The Dominion Post http://stuff.co.nz/4022900a7693.html.

Nimmo-Bell and Company Limited, 2003. An Economic Evaluation of Land Use Change Options in the Rotorua Lakes District. 73 pp. http://www.ebop.govt.nz/water/media/pdf/lake_okareka_economic_reports.pdf.

O'Connor, M., 2009. Macro-Economic Welfare and Sustainability Indicators – An Appraisal of the Genuine Progress Indicator and its Implementation for New Zealand. Unpublished Report, New Zealand Centre for Ecological Economics, Massey University, Palmerston North

National Institute of Water and Atmospheric Research, 2006. National River Water Quality Network National Monthly Median Data 1989–2004. [8 March 2006]. National Institute of Water and Atmospheric Research, Wellington.

Nordhaus, W., Tobin, J., 1972. Economic Research: Retrospect and Prospect: Economic Growth (General Series, no 96). National Bureau of Economic Research, Washington.

Nordhaus, W. D., 1994. Managing the Global Commons. The Economics of Climate Change. MIT Press, Cambridge, Massachusetts.

O'Brien, M., 2008: Poverty, Policy and the State: Social Security Reform in New Zealand. The Policy Press, University of Bristol, Bristol.

O'Dea, D., 2000. The Changes in New Zealand's Income Distribution. The Treasury Working Papers 00/13. New Zealand Treasury, Wellington.
O'Hara, P., Freney, J., Ulyatt, M., 2003. Abatement of Agricultural Non-Carbon Dioxide Greenhouse Gas Emissions: A Study of Research Requirements. 177.
OECD, 1995. OECD Roadside Noise Abatement. OECD Scientific Expert Group, OECD, Paris.
OECD, 2008. Growing Unequal? Income Distribution and Poverty in OECD Countries. OECD Publishing, Paris.
OECD, 2008. Handbook on Constructing Composite Indicators: Methodology and User Guide. OECD, Paris Retrieved from http://www.oecd.org/std/42495745.pdf
OECD, 2012. Income Distribution – Country Tables. OECD, Paris.
OECD, 2013a. *How's Life? 2013: Measuring Well-being*. Retrieved from: http://www.oecdilibrary.org/economics/how-s-life-2013_9789264201392-en
OECD, 2013b. OECD Better Life Index 2013. Retrieved from: http://www.oecdbetterlifeindex.org/
OECD, 2016. Skills Matter: Further Results from the Survey of Adult Skills. OECD, Paris.
OECD, 2017. OECD Economic Surveys: New Zealand 2017. OECD, Paris. ISBN: 9789264277120
O'Quinn, R. and Ashford, N., 1996. Growing Kiwis – Upcoming New Zealand Elections. National Review. October 14.
Palma, R., 2008. Environmental and Social Values from Plantation Forests: A Study in New Zealand with Focus on the Hawke's Bay Region. University of Canterbury, Christchurch.
Parfitt, R., 2005. The 100-year Manawatu Flood Event – One Year On: A Soils Perspective. *Soil Horizon*s, 11:2.
Parfitt, R. L., Schipper, L. A., Baisden, W. T., Elliot, A. H., 2006. Nitrogen Inputs and Outputs for New Zealand in 2001 At National and Regional Scales. *Biogeochemistry*, 80 :71–88.
Parkes, J., Murphy, E., 2003. Management of Introduced Mammals in New Zealand. *New Zealand Journal of Zoology*, 30: 335–359.
Parkyn, S., 2004. Review of Riparian Buffer Zone Effectiveness. MAF Technical Paper No: 2004/05. http://www.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/resource-management/review-riparian-buffer-zone-effectiveness/index.htm.
Parliamentary Commissioner for the Environment, 2002. Creating Our Future - Sustainable Development for New Zealand. 182 pp. Parliamentary Commissioner for the Environment, Wellington http://www.pce.govt.nz/reports/allreports/1_877274_03_8.pdf [13.11.06].
Parliamentary Commissioner for the Environment, 2005. Growing for Good: Intensive Farming, Sustainability and New Zealand's Environment, 238 pp. Parliamentary Commissioner for the Environment, Wellington.
Parliamentary Commissioner for the Environment, 2006. Changing Behaviour: Economic Instruments in the Management of Waste. 102 pp ISBN: 1-877274-60-7, Office of the Parliamentary Commissioner for the Environment, Wellington. www.pce.govt.nz [10 August 2006].
Patterson, M.G., 2002. Headline Indicators for Tracking Progress to Sustainability in New Zealand. 110 pp. ISBN 0-478-24057-0, Ministry for the Environment, Wellington http://www.mfe.govt.nz/publications/ser/tech-report-71-sustainability-mar02.html.
Patterson, M.G. 2006. Selecting Headline Indicators for Tracking Progress to Sustainability in a Nation State. In P. Lawn (Ed.), *Sustainable Development Indicators in Ecological Economics* (pp. 421-448). Edward Elgar, Northampton.
Patterson, M.G., 2012 Optimisation Model to Estimate Potential Energy Savings in The New Zealand Economy. 356pp. Massey University, Palmerston North. ISSN 2253-1858 (print)
Patterson, M.G., Cole, A., 1999. Assessing the Value of New Zealand's Biodiversity. Occasional Paper 1, School of Resource and Environmental Planning, Massey University, Palmerston North.
Patterson M.G, Cole A.O., 2013. Total Economic Value of New Zealand's Land-Based Ecosystems and their Services. In Dymond J.R, (ed). Ecosystem Services in New Zealand – Conditions and Trends. Manaaki Whenua Press, Lincoln, New Zealand.

Patterson, M.G., Richardson, J., Hardy, D., Smith, H., 2017 The Real Economics of the Adaptation to Climate Change on the Tahamata Dairy Farm – Assessing Future Scenarios from an Integrated Economic Production and Ecosystem Services Valuation Approach. 69pp. Publication (under review). Completed for the national science challenge ‘Deep South’ for the project ‘ Risk Management Planning for Climate Change Impacts on Maori Coastal Ecosystems and Economies’ School of People Environment and Planning, Massey University, Palmerston North

Paulin, J., Searle, W., Knaggs, T., 2003. Attitudes to Crime and Punishment: A New Zealand Study. Ministry of Justice, Wellington.

Payton, I.J., 2000. Damage to Native Forests. In: T. L. Montague (Editor), The Brushtail Possum: Biology, Impact and Management of an Introduced Marsupial. pp. 111–125. Manaaki Whenua Press, Lincoln, New Zealand.

Payton, I.J., Forester, L., Frampton, C. M., Thomas, M. D., 1997. Response of Selected Tree Species to Culling of Introduced Australian Brushtail Possums *trichosurus vulpecula* at Waipoua forest, Northland, *New Zealand Biological Conservation*, 81: 247–255.

MacIntyre, A., Allison, N. and Penman, D. 1989. Pesticides: Issues and Options for New Zealand, Ministry for Environment, Wellington.

Peyroux, C.E., Bussen, L. S., Costello, S. B., Dirks, K. N., 2015. Traffic Pollution While Commuting – Does Commute Mode Matter? *Weather and Climate,* 35: 2-12

Phillips, C., Marden, M., 2006. Soil Conservation - Is the Renaissance Coming? *Soil Horizons* 14 :2.

Pigou, A. C., 1932. The Evonomics of Welfare, 4th edition. Macmillan, London.

Piketty, T., 2014. Capital in the Twenty-First Century. Harvard University Press, Cambridge, Massachusetts.

Point Carbon, 2006. Carbon 2006 Towards a Truly Global Market. www.pointcarbon.com.

Ramsey, F.P., 1928. A Mathematical Theory of Saving. *Economic Journal*, 38 (152): 543–559.

Ramanathan, B., 1999. Environment Sensitive Human Development Index: Issues and Alternatives. *Indian Social Science Review,* 1: 193-201

Rankin, K., 1991. Gross National Product Estimates for New Zealand 1859-1939. Working Paper Series 1/91. Graduate School of Business and Government Management, Victoria University of Wellington.

Rankin, K., 1993. The New Zealand Workforce: 1950-2000. *New Zealand Journal of Industria*l *Relations*, 18:2 214-235

Rawls, J., 1972. A Theory of Justice. Oxford University Press, Oxford.

Rees, W., 2000. Eco-footprint Analysis: Merits and Brickbats. *Ecological Economics*, 32:3 71–374.

Renouf, K.A. 2013. Riparian Buffer Zones of the Canterbury Agricultural Landscape and their Effectiveness for Nitrogen and Phosphorus Retention. Master of Science in Ecology Thesis, University of Canterbury, Christchurch.

Repetto, R.,W,M., Wells, M., Beer, C., Rossini, F., 1989. Wasting Assets: Natural Resources in The National Income Accounts. World Resources Institute, Washington, D.C.

Reserve Bank of New Zealand, 2004. Monetary Policy Statement, June 2004. Reserve Bank of New Zealand, Wellington.

Roper, T., Thompson, A., 2006, Estimating the Costs of Crime in New Zealand in 2003/04. New Zealand Treasury Working Paper 06/04. New Zealand Treasury, Wellington.

Rose, A.B., Pekelharing, C.J., Platt, K. H., 1992. Magnitude of Canopy Dieback and Implications for the Conservation of Southern Rata-Kamahi (*Metrosideros Umbellata-Weinmannia Racemosa*) Forests, Central Westland, New Zealand. *New Zealand Journal of Ecology*, 16:23–32.

Rotorua District Council, 2005. A High-Level Call Will Go Out for Government Assistance to Help Pay For The “Absolutely Horrendous” Cost of Improving Water Quality in the Rotorua Lakes. http://www.rdc.govt.nz/News+and+Events/Latest+News/Government+help+needed+to+fund +170+million+Rotorua+Lakes+costs.htm?print=true.

Rutledge, D.T., Price, R., Ross, C., Hewitt, A., Webb, T., 2010. Thought for Food: Impacts of Urbanisation Trends on Soil Resource Availability in New Zealand. Proceedings of the New Zealand *Grassland Association,* 72: 241-246

Sagar, A., Najam, A., 1996. Sustainable Human Development: A Zero-Sum Game? Boston University. Cambridge, Massachusetts.

Salinger, M. J., Mullan, A. B., 1999. New Zealand Climate: Temperature and Precipitation Variations and their Links with Atmospheric Circulation. *International Journal of Climatology*, 19: 1049-1071.

Sandhu, H.S., Wratten, S.D., Cullen, R., and Case, B., 2008. The Future of Farming: The Value of Ecosystem Services in Conventional and Organic Arable Land. An Experimental Approach. *Ecological Economics*, 64, 835-848

Sanson, R., Cook, A., and Fairweather, J., 2004. A Study of Smallholdings and their Owners. MAF Policy, Wellington.

Scarsbrook, M.R., McBride, G., B., 2003. The Evolving Roles of Long-Term Monitoring Programmes in Water Resource Management: A New Zealand Case Study. Presented at Monitoring Tailor-Made (MTM) IV, St. Michielsgestel, The Netherlands, 15–18 September 2003. http://www.mtm-conference.nl/mtm4/docs/Sh_Scarsbrook.pdf [20.09.06].

Schwartz, J., 2004. Air Pollution and Children's Health. *Pediatrics,* 113:1037–1043.

Sen, A., 1985. Commodities and Capabilities. North-Holland, New York. ISBN 9780444877307.

Sen, A., 1999. Development as Freedom. Anchor Books, London.

Sen, A., 2008. Capability and Well-being. In D. Hausman (Ed.), The Philosophy of Economics. An Anthology (Vol. Third Edition, pp. 270-294). Cambridge: Cambridge University Press.

Simon, J. L., 1996. The Ultimate Resource 2. Princeton University Press, Princeton, New Jersey.

Singleton, J., 2005. An Economic History of New Zealand in the Nineteenth and Twentieth Centuries. EH.Net Encyclopaedia, edited by Robert Whaples. February 10, 2008. http://eh.net/encyclopedia/article/singleton.nz

Smith, C., 2018. Treasury Living Standards Dashboard: Monitoring Intergenerational Well-being. The Treasury, Wellington.

Smith, N.J., McDonald, G.W. 2007. Ecological Footprints of New Zealand Regions. Environmental Reporting Technical Paper. Ministry for the Environment. Wellington, New Zealand.

Smith N., McDonald G., 2008. Ecological Footprints of New Zealand and its Regions 2003/04. NZCEE Research Monograph Series – No. 14. New Zealand Centre for Ecological Economics, Palmerston North. ISBN 978-0-9582949-1-1. ISSN 1176-7251.

Solow, R.M., 1974a. The Economics of Resources or the Resources of Economics. *American Economic Review*, 64:2 1–14.

Solow, R.M., 1974b. Intergenerational Equity and Exhaustible Resources. Review of Economic Studies, Symposium: pp29–46.

Sparling, G. P., Wheeler, D., Vesely, E.-T., Schipper, L. A., 2006. What Is Soil Organic Matter Worth? *Journal of Environmental Quality*, 35: 548–557.

Spash, C., Stagl, S., Getzner, M., 2005. Exploring Alternatives for Environmental Valuation. In: Alternatives for Environmental Valuation. Routledge, Oxon.

Spigel, R. H., Viner, A. B., 1992. Lakes. In: M. P. Mosley (Editor), Waters of New Zealand. New Zealand Hydrological Society Inc, Wellington, NZ, pp. 305–334.

Spoonley, P., 2010. New Ways of Working: Changing Labour Markets in the 21st Century New Zealand. In, " Beyond Skill: Institutions-Organisations and Seven Capability". Edited by Bryson, J. pp 79-102. Palgrave McMillan. London, New York.

Spoonley, P., Dupius, A., de Bruin, A., 2006. Work and Working in the Twenty-First Century New Zealand. Dunmore Press, Palmerston North

Statistics New Zealand, 1980. Inter-Industry Study of the New Zealand Economy 1971-72. Statistics New Zealand, Wellington.

Statistics New Zealand, 1983. Inter-Industry Study of the New Zealand Economy 1976-77. Statistics New Zealand, Wellington.
Statistics New Zealand, 1988. New Zealand Official Yearbook 1986/87. Statistics New Zealand, Wellington.
Statistics New Zealand, 1989. Inter-Industry Study of the New Zealand Economy 1981-82. Statistics New Zealand, Wellington.
Statistics New Zealand, 1990. New Zealand Official Yearbook 1988/89. Statistics New Zealand, Wellington.
Statistics New Zealand, 1991. New Zealand Official Yearbook 1990. Statistics New Zealand, Wellington.
Statistics New Zealand, 1991a. Inter-Industry Study of the New Zealand Economy 1986-87. Statistics New Zealand, Wellington.
Statistics New Zealand, 1993. New Zealand Official Yearbook 1992. Statistics New Zealand, Wellington.
Statistics New Zealand, 1993a. Measuring Up – New Zealanders and the Environment. Statistics New Zealand, Wellington.
Statistics New Zealand, 1995. New Zealand Official Yearbook 1994. Statistics New Zealand, Wellington.
Statistics New Zealand, 1999a. New Zealand Official Yearbook 1998. Statistics New Zealand, Wellington.
Statistics New Zealand, 1999b. Incomes: Income Distribution in New Zealand. Statistics New Zealand, Wellington
Statistics New Zealand, 1999c. Effects of Changing from de facto Population Estimates to Resident Population Estimate. Statistics New Zealand, Wellington.
Statistics New Zealand, 2000. New Zealand Official Yearbook 2000. Statistics New Zealand, Wellington.
Statistics New Zealand, 2000a. Upgraded National Accounts: Commentary. Statistics New Zealand, Wellington.
Statistics New Zealand, 2000b. New Zealand Official Yearbook 1999. Statistics New Zealand, Wellington.
Statistics New Zealand, 2000c. Government Spending on Culture 1990-1999. Statistics New Zealand, Wellington.
Statistics New Zealand, 2001. Crime in New Zealand. Statistics New Zealand, Wellington.
Statistics New Zealand, 2001a. Measuring Unpaid Work in New Zealand 1999. Statistics New Zealand, Wellington.
Statistics New Zealand, 2001b. Inter-Industry Study of the New Zealand Economy 1995-96. Statistics New Zealand, Wellington.
Statistics New Zealand, 2001c. New Zealand Time Use Survey 1999. Statistics New Zealand, Wellington.
Statistics New Zealand, 2001d. Crime in New Zealand. Statistics New Zealand, Wellington.
Statistics New Zealand, 2002a. Agriculture in New Zealand, Statistics New Zealand, Wellington. Wellington.http://www.stats.govt.nz/analytical-reports/agriculture-in-nz/default.htm
Statistics New Zealand, 2002b. Monitoring Progress Towards a Sustainable New Zealand. Statistics New Zealand, Wellington.
Statistics New Zealand, 2002c. Table 2.01 Number of Farms, Selected Agricultural Land Use and Fertiliser Applied. Statistics New Zealand, Wellington.
Statistics New Zealand, 2004. Household Economic Survey, 1985-1998, 2001, 2004. Statistics New Zealand, Wellington.
Statistics New Zealand, 2005. New Zealand Household Labour Force Survey 1986-2005. Statistics New Zealand, Wellington.
Statistics New Zealand, 2006. Census of Population and Dwellings. Statistics New Zealand, Wellington
Statistics New Zealand, 2006a, Information about the National Accounts. Statistics New Zealand, Wellington.
Statistics New Zealand, 2006b. New Zealand Income Survey, Statistics New Zealand, Wellington. Statistics New Zealand, 2004b. New Zealand Long Term Data Series (LTDS): Labour Market, Unemployment and Unemployment Rate. Statistics New Zealand, Wellington.

Statistics New Zealand, 2008. Demographic Trends 2007. Statistics New Zealand, Wellington.
Statistics New Zealand, 2010. New Zealand Official Yearbook, 107th edition. Statistics New Zealand, Wellington.
Statistics New Zealand, 2011. Time Use Survey 2009/10. Statistics New Zealand, Wellington
Statistics New Zealand, 2011a. Key Findings on New Zealand's Progress Using a Sustainable Development Approach: 2010. Retrieved from http://www.stats.govt.nz/browse_for_stats/snapshots-of-nz/Measuring-NZ-progresssustainable-dev-%20approach/key-findings-2010.aspx
Statistics New Zealand, 2014. Measuring Capital Stock in the New Zealand Economy. Statistics New Zealand, Wellington.
Statistics New Zealand, 2014a. Commuting Patterns in Auckland: Trends from the Census of Population and Dwellings 2006–13. Statistics New Zealand, Wellington.
Statistics New Zealand, 2016. Using National Accounts Input-Output Tables: For National Accounts Input-Output Tables: Year Ended March 2013. Retrieved from: www.stats.govt.nz
Statistics New Zealand, 2017. New Zealand Progress Indicators. Unemployment Rate. Statistics New Zealand,Wellington. http://www.stats.govt.nz/browse_for_stats/snapshots-of-nz/nz-progress-indicators/Home/Economic/Unemployment-Rate.Aspx [July 2017]
Statistics New Zealand, 2018. Ozone Concentrations in the Stratosphere. Ozone Concentrations in the Stratosphere. New Zealand's Environmental Reporting Series. Statistics New Zealand, Wellington. http://archive.stats.govt.nz/browse_for_stats/environment/environmental-reporting-series/environmental-indicators/Home/Atmosphere-and-climate/ozone-concentrations.aspx
Statistics New Zealand, 2018a. Income Inequality Using Gini Coefficient. Statistics New Zealand,Wellington. http://archive.stats.govt.nz/browse_for_stats/snapshots-of-nz/nz-Social-Indicators/Home/Standard%20of%20living/Income-Inequality.Aspx
Stephenson, G., Card, B., Mark, A., McLean, R., Thompson, K., and Priest, R., 1983. Wetlands, A Diminishing Resource: A Report for The Environmental Council. Soil and Water Miscellaneous Publication No. 58, Ministry of Works and Development, Wellington.
Stern, N., 2006. Stern review: The Economics of Climate Change. HM Treasury, 579 p. http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate _change/stern_review_report.cfm.
Suades-González ,E., Gascon, M., Guxens, M. Sunyer, J., 2015. Air Pollution and Neuropsychological Development: A Review of the Latest Evidence. *Endocrinology* 156: 3473-3482.
Stiglitz, J.E., Sen, A., Fitoussi, J.-P., 2009. Report by the Commission on the Measurement of Economic Performance and Social Progress. http://www.insee.fr/fr/publications-et-services/dossiers_web/stiglitz/doccommission/RAPPORT_anglais.pdf
Stockhammer, E., Hochreiter, H., Obermayr, B., and Steiner, K., 1997. The Index of Sustainable Economic Welfare (ISEW) As an Alternative to GDP In Measuring Economic Welfare. The Results of The Austrian (Revised) ISEW Calculation 1955-1992. *Ecological Economics*, 21: 19–34.
Talberth, J., Cobb, C., Slattery, N., 2006. The Genuine Progress Indicator 2006 – A Tool for Sustainable Development. Redefining Progress, San Francisco, California.
Talberth, J., Cobb, C., Slattery, N., 2007. The Genuine Progress Indicator 2006: A Tool for Sustainable Development. Redefining Progress, Oakland, California.
Talberth, J., & Cobb, C., 2010. Sustainable Development and the Genuine Progress Indicator: An Updated Methodology and Application in Policy Settings. In Ukaga Okechuk the wu, Maser Chris, & Reichenbach Mike (Eds.), Sustainable Development. Principles, Frameworks, and Case Studies. Boca Raton: CRC Press, Taylor & Francis Group
Tate, K.R., Wilde, R.H., Giltrap, D. J., Baisden, W. T., Saggar, S., Trustrum, N., Scott, N.A., Barton, J. P., 2005. Soil Organic Carbon Stocks and Flows in New Zealand: System Development, Measurement and Modelling. *Canadian Journal of Soil Science*, 85: 481–489.

TEEB, 2013. The Economics of Ecosystems and Biodiversity for Water and Wetlands. London and Brussels, Institute for European Environmental Policy (IEEP) & Ramsar Secretariat, 78pp

The European Commission, European Parliament, Club of Rome, OECD, and WWF, 2007. Beyond GDP: Measuring Progress, True Wealth and the Well-Being of Nations. http://www.beyond-gdp.eu/index.html [9 October 2007].

The Ministry of Commerce (China) and the Ministry of Foreign Affairs and Trade (New Zealand), 2004. The Joint Study Report on a Free Trade Agreement Between China and New Zealand. Ministry of Foreign Affairs and Trade, Wellington.

The New Zealand Government, 2002. Growing an Innovative New Zealand. Wellington, 64 pp. http://www.beehive.govt.nz/innovate/innovative.pdf [13.11.06].

The Treasury, 2008. New Zealand Economic and Financial Overview 2008 (Nzefo08). The Treasury, Wellington.

The Treasury, 2011. *Working Towards Higher Living Standards for New Zealanders* (Vol. New Zealand Treasury Paper 11/02). The Treasury, Wellington.

The Treasury, 2014. Briefing to the Incoming Minister of Health. The Treasury, Wellington.

The Treasury, 2016. Financial statements of the Government of New Zealand for the Year Ended 30 June 2016. ISBN: 978-0-947519-30-8 The Treasury, Wellington.

Transfund, 1997. Project Evaluation Manual. Transfund, Wellington.

Turner, R. K., Paavola, J., Cooper, P., Farber, S., Jessamy, V., Georgiou, S., 2003. Valuing Nature: Lessons Learned and Future Research Directions. *Ecological Economics*, 46: 493–510.

University of Auckland and Victoria University, 2015. Regional Commute Times for Adult New Zealanders, 2015 - The New Zealand Attitudes and Values Survey, University of Auckland, Auckland.

United Nations, 2014. System of Environmental-Economic Accounting 2012 —Central Framework. United Nations, New York.

UNDP, 2007.Measuring human development: A Primer. United Nations Development Programme, New York. http://hdr.undp.org/en/media/primer_intro.pdf.

UNDP, 2010.Human Development Report 2010 – The Real Wealth of Nations: Pathways to Human Development. United Nations, New York. http://hdr.undp.org/sites/default/files/reports/270/hdr_2010_en_complete_reprint.pdf

UNEP, 2006. Environmental Effects of Ozone Depletion and its Interactions with Climate Change: 2006 Assessment. United Nations Environment Programme, Nairobi.

van der Ploeg, S., De Groot, R. S., Wang, Y. 2010. The TEEB Valuation Database: Overview of Structure, Data and Results Foundation for Sustainable Development, . Wageningen, Netherlands.

Venetoulis, J., Cobb, C., 2004. The Genuine Progress Indicator 1950-2002 (2004 update). Sustainability Indicators Program, 22 pp. Redefining Progress, San Francisco, California. www.RedefiningProgress.org.

Victor, P., 2008. Managing Without Growth. Slower By Design, Not Disaster. Edward Elgar. Cheltenham.

Vroman, W., 2002. Measuring Unemployment Benefit Percipiency in New Zealand. The Urban Institute, Washington.

Wackernagel, M., Rees, W. E., 1996. Our Ecological Footprint: Reducing Human Impact on the Earth. New Society Publishers, Philadelphia.

Walsh, P., 2005. The Oxford Companion to Philosophy. Oxford University Press, Oxford. The

Waikato Regional Council, 2014. Waikato Progress Indicators – Tupuranga Waikato: Summary. Waikato Regional Council, Hamilton.

Waikato Regional Council, 2014. Development of the Waikato Progress Indicators. Waikato regional Council Technical Report2104/44. Waikato Regional Council, Hamilton.

Ward, C., Cairns, I., Anderson, D., 1996. Land Use Change – Are Current Policies Adequate?, Ministry of Agriculture and Forestry. http://www.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/land-management/land-use-change/land.htm#E13E1.

Waring, M., 1999. Accounting for Nothing: What Meaning That You and What Woman Are Worth (2nd Edition). University of Toronto Press, Toronto.

Waugh, J., 2007. Report on the Whangamarino Wetland and its Role in Flood Storage on the Lower Waikato River. Department of Conservation, Hamilton.

Wellington Regional Council, 2005. Measuring up the State of the Environment Report for the Wellington Region 2005.

Wellington Regional Strategy Office, 2011. Wellington Region Genuine Progress Index (GPI)2001-2010. http://www.wrs.govt.nz/assets/WRS/Publications/Wellington-Region-Genuine-Progress-Index-GPI-2001-2010.pdf

Wellington Regional Strategy Office, 2014. Wellington Region Genuine Progress Index (WRGPI)2001-2013. Retrieved from http://www.gpiwellingtonregion.govt.nz/assets/WRGPI2001-2013.pdf

Weuve, J., Puett, R.C., Schwartz, J., Yanosky J. D., Laden, F., Grodstein, F., 2012. Exposure to Particulate Air Pollution and Cognitive Decline in Older Women. *American Medical Association*, 172: 219-227

White, B.R., 2007. Growth in the New Zealand Geothermal Industry. Presented at New Zealand Geothermal Workshop 2007, Auckland, NZ, 19–20 November 2007.

Williams, M., 2007. PCE20 Parliamentary Commissioner for the Environment Forum. Wellington,

Willis, K., Garrod, G., Scarpa, R., Powe, N., Lovett, A., Bateman, I., Hanley, N., Macmillan, D., 2003. The Social and Environmental Benefits of Forest in Great Britain. Centre for Research in Environmental Appraisal and Management. Pp 1–36. University of Newcastle.

Wilson, J., Anielski, M., Seidel, C., 2007. Genuine Wealth Assessment of Alberta's Stewardship Programs. http://esrd.alberta.ca/waste/wastemanagement/documents/WealthAssessmentStewardship-Jul31-2007.pdf

Wilson, J., Tyedmers, P., 2013. Rethinking What Counts. Perspectives on Wellbeing and Genuine Progress Indicator Metrics from a Canadian Viewpoint. *Sustainability: Science, Practice and Policy,* 5 187-202.

Wilson, M., Liu,S., 2008. Non-Market Value of Ecosystem Services Provided by Coastal and Nearshore Marine Systems. In, Patterson, M.G. and Glavovic, B. "Ecological Economics of the Oceans and Coasts". pp 119-139. Edward Elgar, Cheltenham, United Kingdom.

Woodward, A., Hales, S., de Wet, N., 2001. Climate change: Potential Effects on Human Health in New Zealand. ISBN 0-478-24043-0 Ministry for the Environment, Wellington. N.Z. www.climatechange.govt.nz.

World Bank, 2007. World Development Indicators. World Bank, Washington DC.

World Health Organisation, 2004. Health Effects of UV Radiation. http://www.who.int/uv/health/en/

Worley Consultants Limited, 1992. Potentially Contaminated Sites in New Zealand: A Broad Scale Assessment. Ministry for the Environment, Wellington.

Yang, B., Lester, D., 1995. Suicide, Homicide and Unemployment. *Applied Economic Letters,* 2: 278-279

Zhang, X,. Liu, X., Zhang, M. Dahlgren, R.A., Eitzel, M., 2010. A Review of Vegetated Buffers and a Meta-analysis of Their Mitigation Efficacy in Reducing Nonpoint Source Pollution. *Journal of Environmental Quality*, 39: 76-84

Zolotas, X., 1981. Economic Growth and Declining Social Welfare. New York University Press, New York.

Appendix I: Cost Estimation of Non-Point Source Pollution of Rivers – A Riparian Margin Approach

Non-point source pollution can be simply defined as water pollution that is caused by widely dispersed and diffuse sources of pollutants. The approach used to quantify the economic cost of 'nonpoint source' pollution is based on the 'avoided cost' approach[99]. That is, in specific terms, the cost establishing a riparian buffer zone alongside rivers to intercepting anthropogenic nutrients, sediments and other detrimental material such as pesticides was estimated. Although other methods of 'avoiding' impacts of 'non-point source' water pollution exist, including reducing livestock numbers, none of these other methods were considered as effective across a whole range of pollutants as riparian planting, and usually they were more costly [100].

This riparian margin approach was therefore used to calculate the economic cost of non-point source pollution of rivers in New Zealand:

***Step 1: Calculate the Total River Length Adjacent to Pastoral Farming*.** The total low-elevation river length in New Zealand is approximately 195,200 km and is classified by the River Environment Classification (REC) as: 73% pastoral, 19% natural, 6% exotic forest, and 2% urban. This means approximately 142,496 km of river are classified as pastoral, and therefore their total length for both riverbanks was calculated to be 284,992 km.

***Step 2: Assumed Riparian Buffer Characteristics*.** There is much debate over the ideal width of riparian zones, but it is generally accepted that the wider the buffer, the more successful it will be at removing sediment and nutrients (Parkyn, 2004). The width of the zone should increase as the slope length, angle and clay content of the adjacent land increases, as these factors affect soil drainage (Parkyn, 2004). Buffers of 20–30 m width can remove almost 100% of nitrate, while forested buffers of 10 m have achieved over 70% removal of nitrogen (Parkyn, 2004). The Auckland Regional Council has set the optimal buffer width of 15–20 m, which is sufficient to develop a self-sustaining buffer of native vegetation (Auckland Regional Council, 2001). Zhang *et al.* (2010) undertook a literature review and meta-analysis of the efficacy of riparian margins in removing nitrogen, phosphorus, sediments and pesticides. This meta-analysis was based on 73 studies published in peer-reviewed journals of which 63 were original studies in 10 were literature reviews. Zhang *et al*.'s (2010) plotted and undertook a nonlinear regression analysis of the removal efficacy (%) versus riparian buffer width (refer to Figure 22.2). From these plotted data, in our analysis we selected a buffer width of 15 m as being 'optimal' in that it removed nearly all of sediments, and about 80% of the nitrogen and phosphorus – beyond a 15

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[99] The 'avoided cost' approach to economic valuation estimates the 'costs of action/s taken to avoid damages' with the appropriate 'action' in this particular case being the planting of a riparian buffer zone on both banks of the specified length of rivers. Other economic valuation methods are available, such as contingent valuation methods (willingness to pay and willingness to accept compensation), which some may argue are a truer measurement because they are directly based on stated social preferences. Whilst there is some merit in these arguments, at least from theoretical point of view, actually applying such methods in this GPI analysis, would be very difficult and expensive. In this context, the 'avoided cost' approach was used as data is readily available and accurate, and furthermore, could be argued that if a policy decision was made to establish riparian margins in New Zealand, that in itself is a statement of social preference.

[100] The economics of the cost of establishing a riparian buffer zone, are made more favourable, by taking account of other benefits apart from intercepting anthropogenic nutrients, sediments and pesticides – these other benefits include for example creating habitats and corridors for valuable species, shading the river water to improve the habitat quality of valuable species, bank stabilisation, moderating water flow to reduce the impact of floods, and carbon sequestration.

m riparian buffer there were significant diminishing marginal increments (%) of the removal of nitrogen and phosphorus. [101]

***Step 3: Annual Cost of Riparian Margins Planting, Fencing and Maintenance*.** Cost estimates for riparian planting were obtained from the Farm Environment Award Trust worksheet, for working out the cost of managing waterways on a farm (Farm Environment Award Trust, 2004). This information was provided on the Environment Waikato website to assist farmers making riparian management decisions. This cost of establishing riparian margins included: fencing costs[102], cost of trees planted[103], maintenance and other costs[104], and labour costs, over a 25 year period. When annualised the cost of planting, fencing and maintenance was calculated to be: $\$_{2014}$ 338,510,415/yr.

***Step 4: Annual Cost of Lost Production due to Riparian Margins in New Zealand*.** Fencing off a riparian zone results in a loss of productive farmland throughout New Zealand:

= 15 m (width) × 284,992,000 m (length)
= 4,274,880,000 m^2 or 427,488 ha

Agricultural statistics (from Statistics New Zealand) show that as at 30 June 2002, there were 9,207,001 hectares of tussock, danthonia, grassland, arable crop land, fodder crop land and fallow land used for sheep and cattle grazing. This compares with 1,878,532 hectares of dairy farming. This means that as a proportion, sheep and beef farming occupied approximately 83% of the land area, while dairy farming occupied the remaining 17%. The value-added estimates (in NZ$\$_{2003}$) were obtained from the Nimmo-Bell report about the economic impact of water quality induced changes to land use and tourism in the Rotorua Lakes catchments (Nimmo-Bell and Company Limited, 2003). Loss of value added for dairy farming = $\$_{2003}$ 6,600 per hectare per year. Loss of value added for sheep and beef farming = $\$_{2003}$ 1,100 per hectare per year.

The loss in value is calculated by multiplying 83% of the land area by the value added estimate for sheep and beef farming, and 17% of the land area by the value added estimate for dairy farming, as below:

(427,488 ha × 0.83) × $1,100/ha/yr = $390,296,544 lost value added from sheep and beef +
(427,488 ha × 0.17) × $6,600/ha/yr = $497,641,536 lost value added from dairy farming.
This sums to a total annual loss of value added from agricultural farming of: $\$_{2003}$ 869,938,080/yr or $\$_{2014}$ 1,138,006,505

Step 5: Total Cost of Riparian Margins. Total cost for this riparian management strategy over the 1970 to 2014 period:

= (Planting, Fencing & Maintenance per year + Lost Production per year) x 44 years
= ($\$_{2014}$ 338,510,415/yr + $\$_{2014}$ 1,138,006,505/yr) x 44yr
= $\$_{2014}$ 64,966,744,457

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[101] A larger riparian margin of 20 to 25 m would remove almost all of the nitrogen, phosphorus and sediments, but this would come a significant cost increase – in order to be conservative in our costings in the study we therefore selected 15 m as the assumed riparian buffer width.

[102] An electric fence has a life expectancy of 25 years. To make allowance for this, plus other additional expenses, the cost per metre has been estimated at $2004 3.20 per metre or $3,200/km.

[103] Number of trees = 1,068,720,000 trees (15 m riparian zone, at 2 m spacing), At a cost of $3.50 per tree and $2 labour per plant: 1,068,720,000 trees × $20045.50 per tree = $5,877,960,000.

[104] Maintenance and other costs include gates, earthworks, culverts, stock crossings, extension of existing water supplies to provide water for stock, pest control, annual electricity, and annual maintenance (removing excess vegetation from the non-grazed side).

***Step 6: Total Cost of Riparian Margins, Apportioned to Each Year from 1970 to 2014*.** Water pollution levels from non-point sources vary over time with farm management practices. To allow for this variation in non-point source pollution between 1970 and 2014, the total cost of riparian planting (from Step 5) was apportioned to each year. This 'apportionment' of the total cost was pro-rated the *by estimated the total nitrogen run-off for each year* based on data and OVERSEER calculations [105,106,107] provided by Parfitt and his colleagues (Parfitt *et al*., 2006; Parfitt, 2008; Parfitt *et al*., 2012)[108]. This apportionment of costs provided a time-series from 1970-2014 for the cost ($) of nonpoint source water pollutants generated in the respective years – refer to Figure 22.5 and Table 22.3.

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[105] Nitrogen run-off and leachate was used as a proxy for 'non-point source pollution' because it was the only available and consistent time-series we could generate for 'non-point source pollutants' for the period 1970 to 2014. Ideally, phosphorus (which is the other pollutant as well is nitrogen) that plays an important role in the eutrophication of rivers, and therefore should also be included in the time-series. Putting aside the issue of lack of a time-series for phosphorus data, deriving a proxy index that would include both nitrogen and phosphorus pollutants is complicated by in some cases rivers being nitrogen limited, and some other cases being phosphorus limited, as well as there being interactions between these two factors (McDowell *et al*., 2009; Parliamentary Commissioner for the Environment, 2013). The approach of converting nitrogen and phosphorus to 'eutrophication equivalents' by applying a fixed ratio of their relative eutrophication effects, is recommended by some. However, this approach was considered too simplistic, given the complex biogeochemistry makes the relative roles of phosphorus and nitrogen vary from site to site, and hence 'eutrophication effects' ratio is never fixed.

[106] Nitrogen leachate and run-off' from livestock expressed in terms of N tonnes for each year from 1970-2014 was calculated as follows:

Step 6.1: Estimates of kgN/head were calculated for each type of livestock (lactating dairy cattle, dry dairy cattle, beef cattle, sheep, deer) varying per year (1970 to 2014). These data were obtained from Parfitt *et al*. (2006) and Parfitt (2008).

Step 6.2: Estimates of the numbers of the head of livestock. This generated a matrix of livestock numbers (lactating dairy cattle, dry dairy cattle, beef cattle, sheep, deer) per year (1970 to 2014).

Step 6.3: Estimates of N pollutants by each type of livestock per year. These data were obtained by multiplying each type of livestock the by kgN/head (from Step 6.1) by head numbers of each type of livestock (from Step 6.2). This generated a matrix of nitrogen leachate and run-off produced by each type of livestock (columns) by years from 1970 to 2014 (rows).

Step 6.4: Total N pollutants for each year (1970 to 2016) were obtained by summing the rows in the matrix generated by step 6.3.

[107] Nitrogenous fertiliser use (1970-2014) was obtained from various sources, including past New Zealand Yearbooks, to generate a time-series from 1970 to 2014 of tonnes nitrogenous fertilisers used in New Zealand.

[108] Based on information from (Roger Parfitt, 2008, pers. comm.) the data were weighted so that for 1997 to 2000, and on average over 1970 to 2014, it attributed 80% to stock effects and 20% to fertiliser impacts.

Appendix II: Cost Estimation of Point Source Pollution of Rivers

Point source pollution can be simply defined as water pollution from a single identifiable source such as discharge from a pipe. The approach here was to use Biological Oxygen Demand (BOD) levels as a proxy for point source water pollution in rivers. The rationale for this was that BOD levels have been declining throughout New Zealand, which Scarsbrook (2006) and others attributed to reduced loads in point-source pollutants. Hence, the following four step method was used to calculate point-source water pollution of rivers from 1970 to 2014:

Step 1: Estimation of BOD levels in Rivers for each Year from 1970 to 2014. NIWA's (2006) BOD_5 (ppm) readings, taken at 77 different locations in New Zealand, between 1989 and 2002 were used to extrapolate a trend in BOD back to 1970, and forward to the 2003 to 2014 period. Regression analysis of the NIWA's BOD data from 1989 to 2002 a consistent linear trend – refer to Figure II.1. Using the regression equation $y = 0.6340 - 0.01658X_1$ BOD values were estimated for the years 1972 to 1987 and 2003 to 2014.

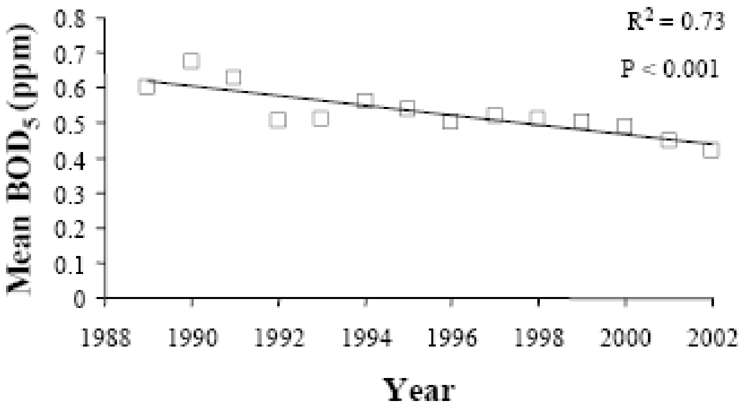

Figure II.1 Mean BOD_5 in New Zealand Rivers 1988–2002
Source: (Scarsbrook and McBride, 2003)

Whilst extrapolating trends beyond the data boundaries is not ideal, it was necessary due to a lack of alternative data. The derived trend is however corroborated by other information such as the reduction in the number of dairy factories releasing effluent into natural waterways in the 1970s (Ferrier and Marks, 1982) and data on investment in sewage infrastructure. The government provided generous sewage subsidies between 1969 and 1981 to encourage local authorities to install new treatment plant, and to improve existing facilities (Ferrier and Marks, 1982). By 1982, 78% of New Zealand's population was regarded as having a satisfactory form of sewage disposal, though organic pollution from animal excreta (including human sewage) continued to be the main source of water degradation (Kirk, 1982). Furthermore, during the 1970s and 1980s tighter legislative requirements, especially the Water and Soil Conservation Act 1967, resulted in restrictions on the volumes of trade wastes fed into waterways, either directly or after primary treatment. This led to a steady improvement in the wastewater practices of the major industrial groupings (Ferrier meat works was still of concern in the early 1980s (Kirk, 1982), and as stock numbers were at a record high for New Zealand at this time, had a significant impact.

Step 2: Total Cost of Point Source River Pollution. These data showed that nitrogen loading of point-source water pollutants was 10,200 tonnes for 1992, which represented 10.2% of the nitrogen loading from non-point source water pollutants from agricultural sources. Since it was calculated in the previous section that the total cost of non-point source water pollution of rivers, over the entire 1970 to 2014 period, was $\$_{2014}$ 64.97 billion; it can then be implied that $\$_{2014}$ 6.63 billion (10.2%) was the total cost of point source river pollution over the same period. [109]

***Step 3: Total Cost of Point Source River Pollution, Apportioned to Each Year from 1970 to 2014*.** Data from Step 1 on point source water pollution (based on a BOD proxy) and data from Step 2 (on total cost of point source water pollution for the total period 1970 to 2014) were used to calculate the cost of point source water pollution for each year from 1970 to 2014. This annual cost is calculated using the following formulae:

$$\text{Cost}n = (BOD_5 n / \text{BOD}_5\ \Sigma_{1970\text{-}2014}) \times \text{Total Cost}\ (\Sigma_{1970\text{-}2014})$$

Where:

Cost$n$ = Cost of point source river pollution or any given year n

Total Cost ($\Sigma_{1970\text{-}2014}$) = total cost of point source water pollution, summed across all of the years in the study period from 1970 to 2014. This number is $\$_{2014}$ 6,627 million, which was calculated in Step 2.

BOD_5n = Five day biological oxygen demand in ppm for New Zealand for a given year *n.* This number for a given year *n* was calculated in Step 1.

$BOD_5\ \Sigma_{1970\text{-}2014}$ = Five day biological oxygen demand in ppm for New Zealand, summed across all of the years in the study period from 1970 to 2014. This sum total ($BOD_5\ \Sigma_{1970\text{-}2014}$) was calculated by adding up all of the annual BOD values for each individual year from 1970 to 2014 using data from Step 1.[110] This sum total can be divided by the number of years of the study period to obtain the mean biological oxygen demand per year.

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[109] This calculation assumes that the ratio of point source to nonpoint source river pollution in New Zealand rivers, on average over the 1970 to 2014 period, was the same as the (known) ratio of point source to nonpoint nitrogen loadings into surface waters for 1992. By examining time series data (e.g., Figure 22.4), and knowing 1992 was at the midpoint of the 1970 to 2014 period, this seems to be a reasonable assumption.

[110] In strict terms, an intensive variable such as BOD5 ppm, should not be added up. However: (1) This was carried out above for pedagogical reasons; (2) by taking a giving year's BOD5, and then by measuring its deviation from the overall mean BOD5 for the entire period, provides a ratio for apportioning the total cost (1970-2014) to that given year. By undertaking this calculation, the same numerical results are obtained, as those using the above formulae.

Appendix III: Cost Estimation of Water Pollution of Lakes

Cost estimates for improving the water quality of the Rotorua lakes, were extrapolated to cover all other lakes classified as eutrophic or worse as determined by Livingstone *et al*.'s (1986) Inventory of New Zealand Lakes. In addition, the cost estimates to maintain the water quality of Lake Taupo were counted. Accordingly, the following method was therefore used to calculate the economic cost of the pollution of lakes in New Zealand:

Step 1: Cost ($/ha) Improving the Water Quality of Rotorua Lakes. The cost for improving the water quality in the four Rotorua lakes is $\$_{2006}$144.20 million over a 20 year period. These lakes cover an area of 124.83km^2 in total. [111] The cost per km^2 for improved water quality is therefore approximately $\$_{2006}$1.16 million per km^2.

Step 2: Cost ($) Improving the Water Quality of Lake Taupo. The total cost of maintaining water quality in Lake Taupo = $\$_{2006}$ 72 million + $\$_{2006}$ 83 million = $\$_{2006}$ 155.00 million. [112]

Step 3: Total area (ha) of all Other Eutrophic Lakes in New Zealand. The publication 'Inventory of New Zealand Lakes' (Livingston *et al*., 1986) classified lakes in New Zealand according to their trophic state. By definition, lakes classified as eutrophic have unsatisfactory water quality as their nutrient concentrations exceed water quality guidelines and toxic algal blooms are common. We have estimated the total area of lakes in New Zealand requiring treatment by summing the surface areas of lakes classified as eutrophic or worse than eutrophic in this inventory. This gives a total surface area for lakes requiring mitigation of 314.245 km^2 .

Step 4: Cost ($) Improving the Water Quality of all other Eutrophic Lakes in New Zealand. Multiplying the total surface area (from Step 3) by the average cost per km^2 (from Step 1) gives:

$$314.245 \text{ km}^2 \times \$1.16 \text{ million km}^2 \text{ per} = \$_{2006}\, 363.01\text{m}$$

It is implicitly assumed this calculation that the known 'cost per km^2' to improve the eutrophic lakes water quality in New Zealand is the same as the cost per km^2 to improve the water quality of Lake Rotorua

Step 5: Total Cost ($) Improving the Water Quality of All Lakes in New Zealand. This is the sum of the cost of improving the water quality of the Rotorua Lakes (Step 1); Lake Taupo (Step 2) and all other Lakes (Step 4). That is, the total estimated cost of improving lake water quality of all lakes in New Zealand to an acceptable standard is therefore: $\$_{2006}$ Rotorua lakes + $\$_{2006}$ Lake Taupo + $\$_{2006}$ All Eutrophic Lakes (except Rotorua Lakes) = $\$_{2006}$ 144.20m+$\$_{2006}$ 155.00m+$\$_{2006}$ 363.01m = $\$_{2006}$ 662.21m = $\$_{2014}$ 791.29m.

Step 6: Apportionment of Total Cost ($) to Annual cost ($/yr). To allow for variation between 1970 and 2014, the total cost of$\$_{2014}$ 791.29m for lake water pollution (Step 5) was apportioned over this

[111] The cost of restoring the Rotorua lakes to water quality levels of the 1960s has been estimated to be $170 million over 20 years (Environment Bay of Plenty Regional Council, 2006). An estimated $144.2 million is needed to clean up the four worst affected lakes – Rotoiti, Rotorua, Rotoehu and Okareka (New Zealand Herald, March 26, 2008).

[112] Strategies to maintain the current water quality in Lake Taupo have been estimated at $200672 million over a 10 year period, funded by rates in the Region, and a further $200683 million over a 15 year period from central government (Environment Waikato, 2003).

period on the basis of annual nitrate leaching and run-off estimates calculated by Parfitt *et al.* (2006) using OVERSEER and nitrogen fertiliser application estimates.

Appendix IV: Loss of Non-Renewable Resources

Cautionary Note

Other Genuine Progress Indicators have been constructed to include the depletion of non-renewable resources as a cost. For the New Zealand Genuine Progress Indicator, we have excluded 'depletion, or loss of non-renewable resources' from our calculations, but we have included data on the loss of non-renewable resources here in Appendix IV, so that readers can include in the New Zealand GPI as a cost, if they so wish. There are two related reasons for not including the loss of non-renewable resources in the New Zealand GPI. First, analysts include 'non-renewable resources' in the GPI, so that they can simultaneously measure both 'welfare or well-being' and 'sustainability[113]'. Our argument is that this is an unjustifiable conflation of two concepts into one indicator, and that is better to measure 'well-being' and 'sustainability' by using separate indicators. [114] Second, and related to the first point, in economics sustainability is normally measured in terms of change of capital 'stock' (natural, manufactured capital, social capital, financial capital); welfare is normally measured in terms of a flow (e.g., ecosystem services produced per year); and it simply is not the correct to add up a 'stock' plus a 'flow' or even add up a 'change of stock' because they are in different units

What to include?

This study has collected data on the major metallic and non-metallic minerals extracted by mining and quarrying between 1970 and 2006, and on oil and gas extraction. As there are large remaining reserves of those non-metallic minerals mined in New Zealand, present consumption levels will not impact on future income-generation capability. Only four non-renewable resources – gold, silver, oil and gas – are being extracted at such a rate that known reserves will be exhausted in the near-term future. Estimates of potential reserves for metallic and non-metallic minerals by Christie and Brathwaite (1999) indicate that at the current average annual extraction rate gold and silver are at risk of depletion. As Table IV.1 shows, known oil and gas reserves in New Zealand are also being rapidly depleted (Ministry of Economic Development, 2007).

Data available

The following data is available for inclusion in the 'loss of non- renewables' component:

1. **Gold and Silver***:* Gold and silver extraction quantities from Official Year Books (various years). The value of gold and silver extracted was in the Official Year Books for 1970–1993 and on the Crown Minerals website for 2003–2006. From 1994–2002, gold was valued as per the international price of gold increased by 2%. The overlap periods in the data series indicated New Zealand gold prices received were approximately 2% higher than the international price. From 1994 to 2002 silver was valued as per the international price less 5%. This is because the overlap period in the data series indicated New Zealand silver prices were approximately 5% less than the international price. Estimates of reserves of gold and silver were taken from Christie and Braithwaite (1999). Extraction costs were taken as 80% of total revenue based on the 1983/84 Census of Mining and Quarrying (Official Year Book, 1986/87) and data provided by Newmont Mining for Martha Mine (NZIER, 2005).
2. **Oil:** The annual quantity of oil extracted and estimates of reserves is from the Energy Data File (Ministry of Economic Development, 2007). To calculate the revenue generated from oil extraction import volumes and CIF[115] prices were used from 1974 to 1984. Prices in 1970, 1971,

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[113] Indeed, Cobb and Cobb (1994) in developing their predecessor to the GPI, held the position that their indicator 'Index of Sustainable Economic Welfare (ISEW)', measured progress to both the goals of 'welfare' and 'sustainability'.

[114] Patterson (2002) outlines a range of indicators that can measure sustainability and welfare. Patterson's (2002) recommendation to the Ministry for Environment, was that the 'ecological footprint' is an easy to construct indicator of ecological sustainability, albeit one with some theoretical limitations.

[115] "CIF" means in relation to freight that the seller pays costs, freight, and insurance against the buyer's risk of loss or damage in transit to the destination.

1972 and 1973 were scaled based on crude oil prices light for Saudi-Arabian Light as the 1974 price was considerably higher than in previous years. Prices per barrel from 1985 to 2005 were based on crude oil import prices to New Zealand (Statistics New Zealand, INFOS series). Extraction costs were taken as 75% of revenue based on the Census of Mining and Quarrying figures for the years from 1985/86 to 1988/89 (Official Year Book, 1992).

3. ***Gas:*** The annual production of gas and estimates of reserves is from the Energy Data File (Ministry of Economic Development, 2007). To calculate the revenue generated from gas extraction, reported profit and loss figures for the National Gas Corporation were used from 1972 to 1981 (Official Year Book, 1981, 1982, 1983). As the state run corporation made a reported loss between 1972 and 1976 it was assumed that no profit was made in 1970 and 1971. From 1982 on, industrial gas prices were used to determine revenue. Prices from 1982 to 1990 were based on the relative price differential between commercial and industrial gas prices for modelled data between 1990 and 2000.

How to include

A number of different methods can be used to value non-renewable resources:

1. **Stockhammer Method.** This method calculates the value-added component of the extraction sector as the 'resource rent'. As fossil fuels and minerals can only be exploited once, this is regarded as equivalent to the dollar value of stock lost (Stockhammer *et al*., 1997: 29). The cost is attributed to the point in time when the resource depletion took place, rather than when any shortage occurs. This approach assumes that current supply and demand provide a measure of future value; this will be true for some minerals, but not for others.
2. **El Serafy Method**. This is the most widely recognised economic method for valuing non-renewable resources. For extractive industries that are depleting non-renewable resources (or even for renewable resources where extraction exceeds regeneration, and resources are in fact 'mined'), income is not considered to be the profits from the sale, but the yield on the annuity that can be purchased with those receipts'. El Serafy refers to the money gained from selling an asset after extraction costs as revenue. He then determines how much of the revenue (R) from extraction in any one year can be estimated as true income (X) and be consumed now, and how much is loss of capital (or user cost) that needs to be put aside to generate income in the future when the stock is depleted. To achieve this, estimates of the size of the reserve (in physical volume) and how long it will last (based on current extraction practice) are required. An estimate of the future market interest rate is also required, as this determines how much of the true income (R–X) needs to be set aside and reinvested to sustain future income. An interest rate of 2% has been used as such a low rate approximates the anticipated regeneration rate of the renewable resource to be **cultivated** to replace the depleted non-renewable resource. This satisfies the strong sustainability condition, namely constant natural capital. As such, the finite series of non-renewable resources that can be used for production purposes equals the infinite series of renewable resources made available by the replacement asset (Lawn, 2006). El Serafy's (2002) "primary concern in proposing this method was not environmental, but economic, with the purpose of obtaining more accurate estimates of income…" for use in the SNA.

Table IV.1 Non-Renewable Resources in New Zealand and Expected Lifespan

	Potential Reserves (tonnes) 2005	Average Annual Extraction	Life expectancy (yrs)
Metals			
Gold	260	9.7 tonnes (1999–2005)	26
Silver	126	29 tonnes (1999–2005)	4
Cadmium	*not given*	11 tonnes (1970–1973)	
Copper	3 million	75 tonnes (1970–1973)	41,000
Iron Ore	3 million	714 tonnes (1970–1988)	4,200
Magnetite (Iron sand)	861 million	2 million tonnes (1999–2005)	406
Tungsten Ore	16302	13 tonnes (1970–1989)	4200
Zinc	1.6 million	1422 tonnes (1970–1973)	1,645
Non-metals			
Amorphous silica	very large		
Basalt	*not given*	13 tonnes (1982–1986)	
Bentonite	19 million	9083 tonnes (1999–2005)	203
Building and dimension stone	very large		
Clay	very large		
Pebbles including scoria	very large		
Diatomite	7 million	121 tonnes (1999–2005)	57,925
Dolomite	70 million	38985 tonnes (1999–2005)	1,789
Greenstone	*not given*		
Limestone	very large		
Magnesite	*not given*		
Perlite	120 million	4421 tonnes (1999–2005)	27,133
Pumice	very large		
Rock, gravel	very large		
Salt	renewable		
Sand	very large		
Serpentine	18 million	tonnes (1999–2005)	286
Silica sand	very large		
Sulphur	5 million	2 tonnes (1999–2005)	30,000
Zeolite	very large		
Fossil fuels			
Coal	7214 million	4.5 million tonnes (1999–2005)	1618
Oil	97.15 mmbbls	9.6 mmbbls (1999–2005)	10
Gas	1842 Bcf	174 Bcf (2000–2005)	10

Data Sources:

1. Christie and Brathwaite (1999)
2. Ministry for Economic Development's (2007) Energy Data File

3. **Lawn Method**. This method that was developed by Lawn, is a variation of the El Serafy method, and also calculates the user cost of non-renewable resource depletion. Rather than using an estimate of future market interest rates, Lawn applies a discount rate of 2%, on the assumption that 2% approximates the regeneration rate of most renewable **resources**, over the average period of time that non-renewable resources can realistically be extracted from a site. This determines the percentage of revenue that can be categorised as 'user cost' and the percentage of net receipts that is real income. This user cost component is then adjusted for price increases, as scarcity is expected to increase non-renewable prices over time. Lawn also increases the non-renewable price to reflect argument of Daly and Cobb "that non-renewable resource availability is not only a function of the relative and absolute scarcity of resources, but is also a function of the cost of exploration and extraction activities" (Clarke and Lawn, 2005). Thus, according to Daly and Cobb, the cost of exploration and extraction should also be included in the calculation of user costs

because both constitute a great deal more than the 'regrettable necessities' associated with the depletion of non-renewable resources.

4. **Replacement Cost method. T**his method values non-renewable resources as the cost of developing substitute renewable resources, to provide similar services. This approach assumes all non-renewable resources are substitutable. Non-renewable resources are priced at the cheapest present day substitutable renewable resource value, as this is when the scarcity impact occurs. These prices are then adjusted, if necessary, to reflect anticipated future scarcity, and the interests of future generations.

Our study has used the El Serafy (1989) method to determine the loss of natural capital for the four critical resources being depleted in New Zealand (gold, silver, oil and gas). This method is a 'weak sustainability' approach but regarded as more robust than the 'strong sustainability' replacement approach (Neumayer, 2003). A low discount rate has been used to replicate more closely the regeneration rate of most renewable resources. The proportion of revenue from extraction that needs to be put aside to generate a permanent income stream once the resource is depleted was calculated for each year for the four resources, then summed and adjusted for inflation.

Not all GPIs use the El Serafy method. In their research, Hamilton (2000) and Anielski and Rowe (1999) assume that metallic and non-metallic minerals are fully substitutable and can be replaced or recycled economically – no loss value is therefore placed on their extraction or consumption. They take a less optimistic view of fossil fuel energy sources (oil and gas) and assume that as future generations will not have access to energy in such quantities, or at such low costs, an allowance, which they base on the anticipated future value of a barrel of oil, is required for oil and gas depletion.

Table IV.2 Loss of Non-Renewable Resources: Total and Per Capita, 1970 to 2014

Year	Loss of Non-Renewable Resources $_{2014}$ million	Loss of Non-Renewable Resources $_{2014}$ per person	Year	Loss of Non-Renewable Resources $_{2014}$ million	Loss of Non-Renewable Resources $_{2014}$ per person
1970	0	0	1989	216	65
1971	0	0	1990	238	71
1972	0	0	1991	298	85
1973	0	0	1992	317	90
1974	0	0	1993	337	94
1975	0	0	1994	288	80
1976	14	5	1995	265	72
1977	37	12	1996	335	90
1978	24	8	1997	418	111
1979	7	2	1998	326	85
1980	7	2	1999	342	89
1981	23	7	2000	404	105
1982	97	30	2001	485	125
1983	92	29	2002	406	103
1984	155	48	2003	347	86
1985	252	77	2004	301	74
1986	246	75	2005	356	86
1987	190	58	2006	429	102
1988	204	62			

Findings

Table IV.2 provides data on the economic valuation loss of non-renewable resources that could be included in the New Zealand GPI, if so wished. This could be useful if there is to be a comparison between the New Zealand GPI and the GPIs for other countries, to then include this loss of non-renewable resources component. However, as previously discussed, if the purpose of this New Zealand GPI exercise is to measure aggregate welfare or well-being for New Zealand, we do not recommend the inclusion of the non-renewable resources' component, and in any case it is a relatively small component amounting to $\$_{2014}$ 429 million or $\$_{2014}$ 102 per person for the year 2006.

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