

A Genuine Progress Indicator for the Waikato Region

Valuation Methodology Technical Report

**Prepared for:
Environment Waikato**

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June 2010

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Introduction

The Genuine Progress Indicator (GPI) is a concept becoming increasingly popular world-wide as a measure of human welfare. Over the last decade the GPI has been promoted internationally as an alternative to the Gross Domestic Product (GDP) measure. The GPI was first developed in 1995 by the non-profit organisation Redefining Progress. Like its forerunner, the Index of Sustainable Economic Welfare (ISEW), the GPI is promoted on the grounds that it attempts to undertake a more holistic measure of welfare than GDP (Daly and Cobb, 1989; Cobb *et al*, 1995; Daly, 1996; Anielski and Rowe, 1999; Lawn, 2003). It incorporates aspects of the non-market economy, separating welfare enhancing benefits from welfare detracting costs, correcting for the unequal distribution of income, and distinguishing between sustainable and unsustainable forms of consumption (Talberth *et al*. 2007). Among the nations for which an ISEW or GPI has been developed are the US (Anielski and Rowe, 1999), UK (Jackson *et al*, 1997), Germany (Diefenbacher, 1994), Australia (Hamilton and Denniss, 2002), China (Wen *et al*, 2008), India (Lawn, 2008) and Canada (Nova Scotia Province) (PannoZZo *et al*, 2009).

In June 2009 Environment Waikato (EW) contracted the New Zealand Centre of Ecological Economics (now Ecological Economics Research New Zealand; EERNZ) and Market Economics Ltd (MEL) to develop a GPI for the Region covering the time period 1990 to 2006. This work builds on EERNZ and MEL's soon-to-be-released National GPI project and previously released Auckland Region GPI study which have respectively been funded by the Foundation of Research, Science and Technology (under the 'Sustainable Pathways' programme; contract number MAU0306) and Auckland Regional Council. There are two key outputs of the Waikato Region study: (1) this technical report describing in detail the data and methods used to estimate the Waikato Region GPI, and (2) a summary report outlining the major findings and trends/patterns in the Waikato Region GPI.

This technical report describes in detail the data and methods used to estimate the Waikato Region GPI for the period 1990 to 2006¹. The starting point for the valuation of the Waikato Region GPI is total personal consumption expenditure across the Waikato Region for each year of the study. A total of nineteen additional socio-economic and environmental components of welfare are then taken into account, with every component representing either, an addition to, or subtraction from, the total personal consumption expenditure figures for each year (Figure 1).

The majority of these components, such as defensive expenditures² of health, unemployment, underemployment, overemployment, crime, commuting, loss/damage to terrestrial ecosystems, ozone depletion, noise pollution, climate change, and so on represent costs or subtractions. On the positive side, the contributions of public consumption, household and community work, and services of public capital represent benefits or additions. The methodologies used to value these components principally rely on region specific 'bottom-up' data, but are supplemented

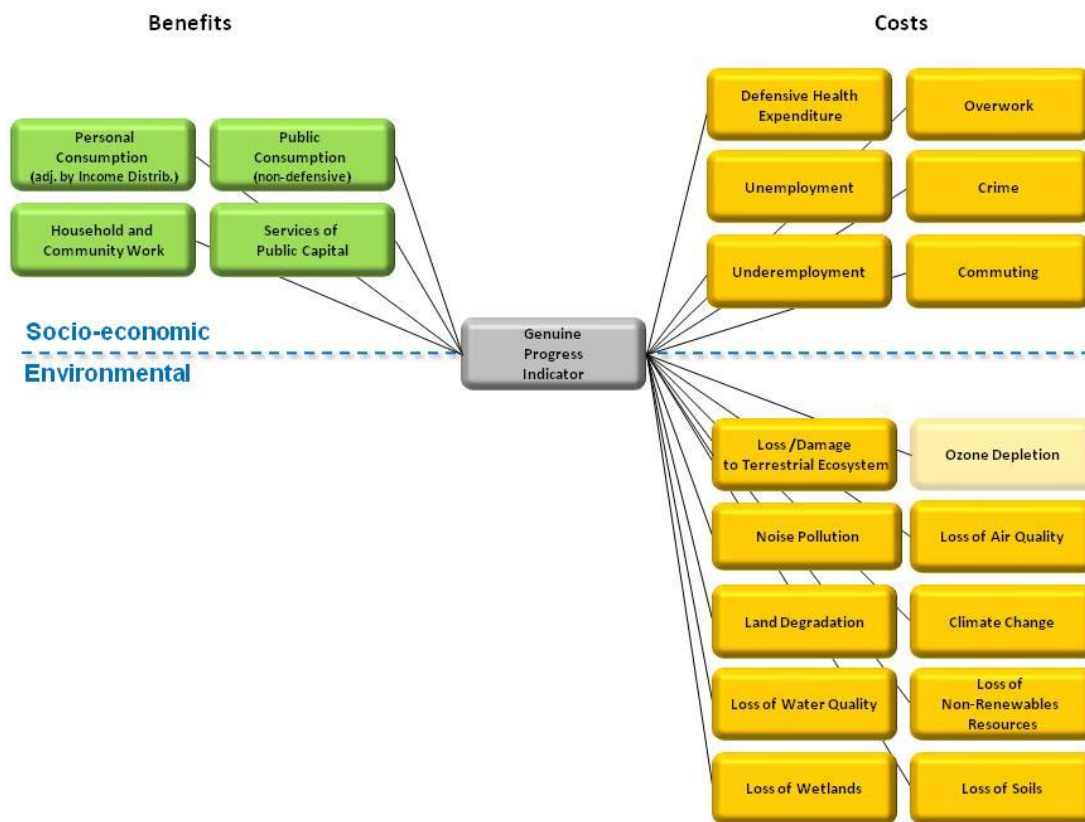
¹ These methodologies are the same as those employed for the New Zealand GPI which has been independently peer reviewed by leading international GPI practitioners including Eric Neumeyer (London School of Economics), Martin O'Connor (Professor of Reeds, University of Versailles) and other researchers that cannot be named.

² Defensive expenditures is 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."

with regionalised ‘top-down’ data from the national study in the absence of data specific to the Waikato Region.

The remainder of the report describes each component of the Waikato Region GPI.

Figure 1: Components of the Waikato Region GPI



Total Personal Consumption

The ability of individuals in a society to access goods and services that improve quality of life is one of many ways to measure wellbeing and prosperity. For example, a society where the majority of people have the ability to access the internet is likely to have a higher quality of life than a society where the majority cannot access such a service. In many instances, accessibility is directly related to an ability to pay, which in turn, is a function of personal wealth. With this relationship in mind, personal consumption expenditure is used as the starting point for calculating the Waikato Region GPI based on the premise that, other aspects of life notwithstanding, a higher level of expenditure indicates a higher level of wellbeing.

There is no Waikato Region primary data available on personal consumption expenditure. We instead assume that the personal consumption expenditure of each resident in the Waikato Region depends directly on the level of his, or her, income. Total regional personal consumption is therefore defined according to the following equation,

$$C^r = \frac{IPC^r}{IPC^n} \times CPC^n \times Pop^r$$

where C^r is the total personal consumption at the regional level, IPC^r and IPC^n is respectively the average weekly income per capita for the Waikato Region and the nation, CPC^n is the consumption per capita at constant 2006 dollars for the nation, and Pop^r is the population in Waikato Region. The multiplication of average Waikato Region consumption per capita by total regional population gives the estimates of total regional personal consumption.

Regional and national average weekly income for all people (aged 15 years and over) for years 1998-2006 were extracted from the SNZ web tool Table Builder.³ Personal income data for the period from 1990 to 1998 was not available. However, average wage rate data was available from SNZ's Quarterly Employment Survey (QES). The ratio of regional average wage rate to national average wage rate was used in place of a personal income ratio for the missing data years.

Personal consumption per capita at constant 2006 dollars for the entire study period was calculated by dividing the total personal consumption at constant 2006 dollars by population from the National GPI study. Regional population was estimated based on the SNZ *de facto* population and resident population time series.⁴

For the period 1990-2006 total personal consumption in the Waikato Region has been estimated to be \$₂₀₀₆119,281 million (Table 1).

³ The original source of the data is the New Zealand Income Survey which has run annually since July 1997 (Statistics New Zealand, 2009a).

⁴ There were two measurements carried out by SNZ for the given resident population time series: '*de facto*' estimates for the period prior to 1996 and 'resident' estimates after 1994. In order to obtain a single time series, the *de facto* estimates were converted to resident estimates by applying an inflator of 2 percent representing the estimated average difference between the two measures at the national level (Statistics New Zealand, 1999a).

Table 1: Waikato Region Total Personal Consumption, 1990-2006

Calendar Year	Personal consumption
	(NZ\$ ₂₀₀₆ mil)
1990	5,942
1991	5,850
1992	5,841
1993	5,968
1994	6,216
1995	6,315
1996	6,576
1997	6,741
1998	6,792
1999	6,973
2000	7,225
2001	7,212
2002	7,757
2003	7,827
2004	8,514
2005	8,669
2006	8,863
Total	119,281

Income Distribution

Whilst the wellbeing 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 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 wellbeing of the majority is likely to be lower than had the distribution 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. The purpose of this component is therefore to weight personal consumption in order to account for differences in income distribution over time.

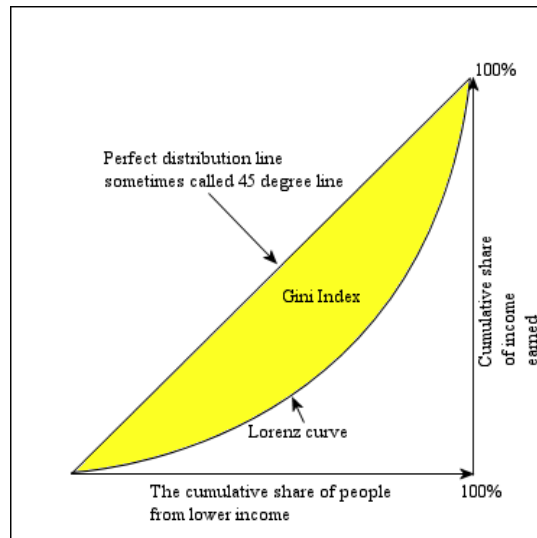
There are a number of methods identified for adjusting personal consumption expenditure to account for income inequality. In this study, Gini Coefficients⁵ have been applied in line with other international GPI studies and other studies undertaken in the New Zealand context (Easton, 1996; Statistics New Zealand, 1999b)

Gini coefficients are typically determined by taking the difference between a straight line representing income equality and a Lorenz Curve (Figure 2), which describes the distribution of income among quintiles of the population (Kerr *et al.*, 2004). The Gini coefficient represents the ratio between the yellow highlighted area in Figure 2 and 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 quintile.

⁵ The Gini coefficient was, for example, applied by Anielski & Rowe (1999) 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 (Quintiles), i is the rank value in ascending order (1 to 5) and X_i is the average annual income in each income

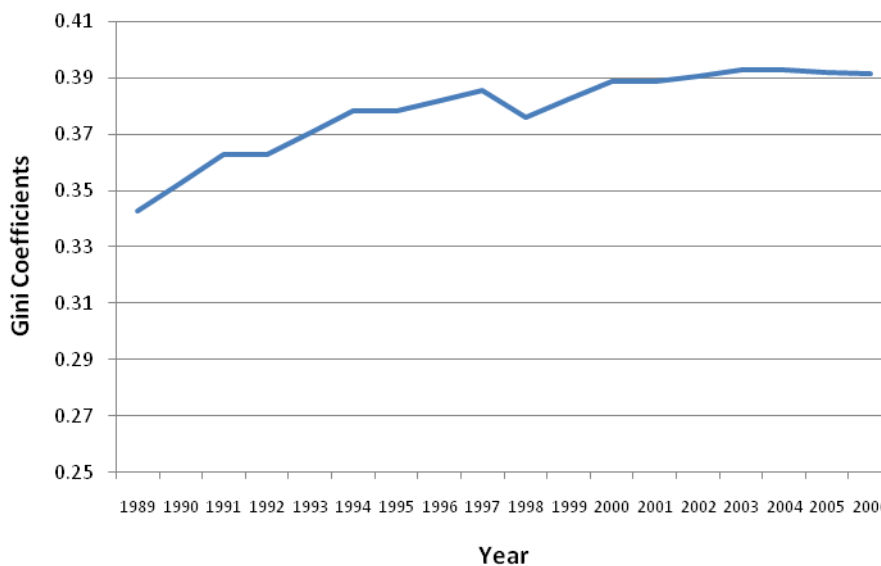
interval (Buchan, 2002),
$$G = \frac{\sum_{i=1}^n (2i - n - 1) X_i}{n \sum_{i=1}^n X_i}.$$

Figure 2: 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. In New Zealand, the Gini coefficient has ranged between 0.36 and 0.40 for the 26 years since 1989. By comparison, the Waikato Region Gini coefficients shows a range of between 0.35 to 0.40 (Figure 3).

Figure 3: Waikato Region Gini Coefficients, 1989 – 2006



The inclusion of a measure of income inequality in the Waikato Region GPI is achieved by adjusting the personal consumption time series by the change in the Gini coefficient from a

1989 base year. First, Gini coefficients were calculated for 6 of the 18 years in the study period based on regional income distributions by quintile data obtained from the Household Economic Survey for 1989, 1992, 1995, 1998, 2001 and 2004⁶. For the gaps in the income distribution data, coefficients were then estimated using geometric growth rates from the derived coefficients and national Gini coefficients trend.

An 'Income Distribution Index' was then derived from the calculated Gini coefficients. 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 for Waikato Region in 2004, for example, we multiplied the Gini coefficient in 2004 (0.40) by 100 and then divided by the 1989 base year Gini coefficient⁷, 0.34. The resulting number, 117, represents the Income Distribution Index value for 2004.

The Waikato Region Gini coefficients, and Income Distribution Index, from 1990-2006 are given in Table 2.

Table 2: Gini Coefficients and Income Distribution Index for the Waikato Region, 1990-2006

Calendar Year	Gini Coefficient	Income Distribution Index
		1989 _{NZ} =100
1990	0.3457	101
1991	0.3540	104
1992	0.3540	104
1993	0.3529	104
1994	0.3518	103
1995	0.3518	103
1996	0.3598	106
1997	0.3681	108
1998	0.3681	108
1999	0.3825	112
2000	0.3975	117
2001	0.3975	117
2002	0.3987	117
2003	0.4000	117
2004	0.4000	117
2005	0.3993	117
2006	0.3986	117

⁶ Job Reference number: ANM24602 (Statistics New Zealand, 2009b).

⁷ The 1989 national Gini coefficient was set to be the base year Gini coefficient.

Weighted Personal Consumption

Personal consumption 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,

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

where WPC^r is the weighted regional personal consumption for the Waikato Region at constant 2006 dollars, PC^r is the regional personal consumption at constant 2006 dollars and DI is the Income Distribution Index.

For the period 1990-2006 the weighted personal consumption in the Waikato Region has been estimated to be \$₂₀₀₆107,934 million (Table 3).

Table 3: Waikato Region's Weighted Personal Consumption, 1990-2006

Calendar Year	Weighted Personal Consumption
	(NZ\$ ₂₀₀₆ mil)
1990	5,859
1991	5,634
1992	5,625
1993	5,765
1994	6,025
1995	6,121
1996	6,230
1997	6,244
1998	6,291
1999	6,215
2000	6,197
2001	6,186
2002	6,632
2003	6,671
2004	7,256
2005	7,401
2006	7,581
Total	107,934

Public Consumption – Non-Defensive

As with the treatment of personal consumption, public consumption (i.e., general government expenditure) is treated as a positive component of the GPI. One of the main differences between the GPI and the GDP, however, is that only government expenditure for non-defensive purposes are included in the GPI. Defensive expenditure is 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 focus of this component is therefore on valuing public consumption expenditures excluding those expenditures necessary to address the unwanted side-effects of the socio-economic process. This includes central and local government expenditure, including health and education. This information is only available at the national level.

In this study government expenditure has been estimated using data taken from input-output tables. Regional input-output tables for Waikato Region were derived using the Generating Regional Input-Output Table (GRIT) method devised by Jensen *et al.* (1979) at the University of Queensland. Specifically, government expenditure is recorded in the input-output table under ‘local and central government consumption’ final demand category. Annual input-output data was available for the period 1989-90 to 1998-99 and also the years 2000-01 and 2003-04. The intervening years of 2000, 2002 and 2003 were filled by applying a moving average and data was extrapolated from 2004 to 2006.

Table 4: Waikato Region Public Consumption by Expenditure Category (% of Total Public Expenditure), 1990-2006

	Services to Land Transport	Public Admin	Sanitary & Similar Svcs	Education Services	Health Services	Social & Comm-unity Svcs nec	Recreation & Cultural Svcs	TOTAL Allocated	Unallocated	TOTAL	TOTAL
	%	%	%	%	%	%	%	%	%	%	\$ ₂₀₀₆ mil
1990	3.1	40.2	2.0	22.7	23.2	4.3	4.4	100.0	0.0	100.0	1,988
1991	4.4	41.4	1.7	23.1	21.9	3.4	4.0	100.0	0.0	100.0	1,958
1992	4.4	41.5	1.6	23.7	21.1	3.5	4.2	100.0	0.0	100.0	1,973
1993	4.5	41.3	1.7	23.1	21.9	3.4	4.0	100.0	0.0	100.0	1,991
1994	4.7	41.7	1.7	21.1	23.2	3.5	4.1	100.0	0.0	100.0	2,004
1995	4.8	41.2	1.8	20.8	23.7	3.3	4.2	100.0	0.0	100.0	2,087
1996	5.6	38.4	1.7	22.4	23.7	3.7	4.6	100.0	0.0	100.0	2,099
1997	5.4	38.7	1.7	21.5	24.4	3.6	4.7	100.0	0.0	100.0	2,245
1998	5.1	26.3	1.9	25.4	28.7	4.0	4.5	95.9	4.1	100.0	2,335
1999	5.9	39.8	1.5	20.0	25.1	3.5	4.3	100.0	0.0	100.0	2,377
2000	6.1	32.2	1.5	22.1	28.8	3.5	4.1	98.2	1.8	100.0	2,364
2001	6.3	24.6	1.5	24.1	32.5	3.5	3.9	96.5	3.5	100.0	2,505
2002	6.2	24.6	1.5	24.8	31.3	3.8	4.0	96.2	3.8	100.0	2,519
2003	6.2	24.6	1.5	24.8	31.3	3.8	4.0	96.2	3.8	100.0	2,598
2004	6.1	24.5	1.5	25.6	30.0	4.1	4.1	95.9	4.1	100.0	2,713
2005	6.1	24.5	1.5	25.6	30.0	4.1	4.1	95.9	4.1	100.0	2,827
2006	6.1	24.5	1.5	25.6	30.0	4.1	4.1	95.9	4.1	100.0	2,959

Once the regional general government consumption was established, and 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. Table 4 records the percentage contribution of each category to public consumption.

Once public consumption expenditure by category had been determined, a judgment is required as to the defensive proportion of each category's expenditure. These judgements were made for the New Zealand GPI 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 across regions (see Table 5).

For the period 1990-2006 non-defensive public consumption in the Waikato Region has been estimated to be \$₂₀₀₆36,845 million (Table 6), 93 percent of total public consumption expenditure.

Table 5: 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 Administration	Expenditure on public administration comprises the administration, 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, drainage and pest control 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 socio-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 as commercial undertakings. It is assumed that 100 percent of public expenditure on education is non-defensive.	100%
Health Services	Expenditure on health services encapsulates all activities, both government and private, concerned in providing 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%

Table 6: Waikato Region's Non-Defensive Public Consumption, 1990-2006

Calendar Year	Public Consumption Expenditure (Non-Defensive)
	(NZ\$ ₂₀₀₆ mil)
1990	1,852
1991	1,824
1992	1,839
1993	1,856
1994	1,868
1995	1,945
1996	1,956
1997	2,092
1998	2,175
1999	2,215
2000	2,203
2001	2,334
2002	2,347
2003	2,420
2004	2,528
2005	2,635
2006	2,757
Total	36,845

Cost of Unemployment

A society where there are people who want to work, but are unable to do so, is one that is not fulfilling its potential wellbeing and prosperity. The far-reaching impacts of unemployment on an economy mean that its measurement, in GPI terms, straddles a number of factors including loss of output, deterioration of human capital, loss of public sector income, health, crime and psychological costs (Hamilton and Denniss, 2000). These are described in brief below.

- *Loss of Output.* Unemployment occurs when labour, a factor of production, is not fully utilised due to the unavailability of suitable jobs. Consequently, there is an associated loss of economic output. This loss is however already captured in the GPI through an impact on personal and public consumption.
- *Deterioration of Human Capital.* Unemployment, especially long-term unemployment, deteriorates a society's human capital (Möller, 1999). Coupled with such deterioration is a reduction in the productivity of the economy, and in turn, its level of consumption. This reduced consumption, like the loss of economic output, is also reflected in the GPI in terms of personal and public consumption.
- *Loss of Public Sector Income.* Higher unemployment leads to a loss of income, through lower tax revenues, and an increase in the expenditure (e.g. higher social benefits) by central and local government. As a result, the public sector has a reduced spending power (tax revenue net of expenditure) and consumes less. These losses are captured within the GPI through public consumption.
- *Direct Health and Crime Costs.* The economic hardship resulting from unemployment can lead to poorer living conditions and deterioration in health. Additionally, an increase in criminal activity is associated with higher rates of unemployment (Davidmann, 1996; Hamilton and Denniss, 2000). Both of these downstream consequences are captured in the GPI under the health and the cost of crime components.
- *Psychological Costs.* Unemployment can induce, or exacerbate, a range of psychological problems (e.g. mental illness, stress) and family problems (e.g. breakdown, homelessness) (Junankar and Kapuscinski, 1992; Davidmann, 1996), in turn, leading to a reduction in wellbeing for society as a whole, not just those directly affected. It is these costs which are measured in this component of the GPI.

It is difficult to value the psychological effects of unemployment as the cause and effect relationships between unemployment and stress and trauma are not well understood and the data upon which to base such an analysis is not readily available. Consequently, a more indirect method has been adopted, based on valuing the involuntary leisure time that unemployment brings.

To obtain an accurate measure of the number of people unemployed, and thus potentially suffering a loss of psychological wellbeing, the unemployed were separated into five categories, as shown in Table 7 and discussed further below.

Table 7: Unemployment Types

Type	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

The ‘official unemployed’ category includes those persons actively seeking and available for work (Statistics New Zealand, 2009c) and, thus, may be suffering some emotional stress. Within the official unemployment 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 wellbeing. The estimated figures of frictional unemployment have therefore been excluded from the calculation of unemployment in this component. In New Zealand, the 1950s–1970s are regarded as years of full employment, 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 the majority of the years of the study. For the period 1970–1978, however, unemployment 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 is discussed in the next component, while data restraints prohibit any assessment of the costs resulting from workers being underutilised.

The method used to calculate the cost of unemployment closely follows the method used to calculate the cost of unemployment under the New Zealand GPI study, thus, only the psychological costs of unemployment associated with unemployed workers (official unemployment – frictional unemployment + hidden unemployment) are assessed.

The full formula for estimating the psychological costs of unemployment per annum is as follows,

$$TC^r = UH^r \times C \times 52.14$$

where TC^r is the total cost of regional unemployment, UH^r represents regional 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^r is calculated as,

$$UH^r = UHF^r + UHP^r$$

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

$$UHF^r = U^r \times UF^r \times 37.5$$

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

$$UHP^r = U^r \times UP^r \times 20$$

where U^r is total regional unemployment, UP^r is the proportion of unemployed people in the Waikato Region seeking part-time work and 20 represents involuntary leisure hours per week per unemployed person seeking part-time work. Total unemployment, U^r , is defined as,

$$U^r = CU^r + HU^r$$

where CU^r is costly unemployment and HU^r represents hidden unemployment in the Waikato Region. In turn, CU^r is calculated as,

$$CU^r = (OUR^r - FUR^r) \times LF^r$$

where OUR^r and FUR^r represent the official unemployment and fractional unemployment rates of the Waikato Region respectively, and LF^r is the total regional 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 and B is unemployment benefits per week. The 37.5 constant approximates the number of hours worked per week and is used to convert dollars per week into hourly estimates.

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 regional official unemployment count was extracted from the regional Household Labour Force Survey (HLFS) through the SNZ web tool INFOSHARE. The regional HLFS provided unemployment counts 1990 to 2006 according to the moving average December year.
- The official unemployment rate was also obtained from the regional HLFS Unemployment Rate. Again data sources reported unemployment rates according to the mean 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 1.3 percent for the entire study period.
- Data pertaining to the hidden unemployment count was taken out from regional HLFS customised from SNZ⁸ and refers to those people who are available to work, but not actively seeking work, including seeking through newspapers only⁹, discouraged and other¹⁰. These data series are only available for the period 1990–2006. 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: The 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, multiplied by the percentage of unemployed seeking fulltime work, and, in turn, multiplying by 37.5 (representing the hours in a full working week). In order to estimate the percentage of unemployed seeking full-time work (as opposed to part time work) in the Waikato Region, the unemployed people seeking for full-time work as sourced from the regional HLFS¹¹ in the Waikato Region was divided by total regional unemployed.

⁸ Job reference number: GRB24516 (Statistics New Zealand, 2009c).

⁹ 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.

¹⁰ This is predominantly people who place themselves on a mail-out list, but take no action in finding employment.

¹¹ Job reference number: GRB24749 (Statistics New Zealand, 2009d).

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, the same method was applied by dividing the unemployed people seeking part-time work as sourced from the regional HLFS in the Waikato Region by total regional unemployed.

Step 3: The cost of involuntary leisure time

The cost of involuntary leisure time was assumed to be the same as that at the national level. The minimum wage rate and unemployment benefits for the period 1990–2006 were taken from SNZ’s Official Year Book and SNZ’s INFOS system¹², respectively, and deflated to a constant value based on the Consumer Price Index (CPI) (Appendix I). 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.

For the period 1990–2006 the cost of unemployment in the Waikato Region has been estimated to be \$₂₀₀₆917 million (Table 8).

¹² The minimum wage rate was extracted for different years from the New Zealand Official Year Book. As a cross-check the final data series has also been compared with Chapple (1997). 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), was used to estimate unemployment benefits per week. Refer to Vroman (2002) for further definitional information on unemployment benefits in New Zealand.

Table 8: The Cost of Unemployment in the Waikato Region, 1990-2006

Calendar Year	Official Unemployment Rate	Official Unemployment Numbers	Frictional Unemployment Numbers	Hidden Unemployment Numbers	GPI Defined Unemployment Numbers	Unemployed Hours per Week	Cost per Unemployed Hours (NZ\$ ₂₀₀₆)	Cost of Unemployment (NZ\$ ₂₀₀₆ mil)
1990	8%	14,100	2,235	6,635	18,500	551,056	2.16	70
1991	11%	17,700	2,171	8,300	23,829	706,800	2.10	88
1992	11%	17,300	2,082	8,500	23,718	709,471	2.09	88
1993	10%	17,100	2,138	8,500	23,463	720,340	1.77	75
1994	8%	13,800	2,161	6,900	18,539	554,142	1.66	54
1995	7%	11,900	2,275	5,300	14,925	423,293	1.58	41
1996	7%	11,900	2,275	5,900	15,525	401,171	1.51	39
1997	7%	12,000	2,229	5,400	15,171	393,509	1.51	38
1998	8%	13,500	2,194	6,600	17,906	522,266	2.21	69
1999	8%	13,400	2,233	5,700	16,867	457,854	1.99	57
2000	6%	11,300	2,369	4,600	13,531	345,750	2.30	52
2001	6%	10,700	2,358	4,400	12,742	317,071	2.20	46
2002	5%	10,000	2,407	5,400	12,993	326,439	2.33	50
2003	5%	8,400	2,427	4,800	10,773	254,905	2.26	39
2004	3%	5,600	2,275	3,400	6,725	171,127	2.23	25
2005	4%	7,400	2,346	3,600	8,654	192,953	2.73	37
2006	3%	6,400	2,521	4,400	8,279	198,885	3.45	46
Total		202,500	38,697	98,335	262,138	7,247,032		917

Cost of Underemployment

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 proxy for estimating the value psychological costs arising out of underemployment.

The total cost of underemployment, TC^r , is calculated as,

$$TC^r = U^r \times H^r \times C^r \times 52.14$$

where U^r is total part-time employees looking for full-time work in the Waikato Region, H^r is hours sought per week per part-time employee in the Waikato Region, and C^r is the regional 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.

Estimation of part-time workers looking for full-time work

Underemployment population statistics for the study period were taken from customised SNZ regional HLFS. Arguably underemployment may include (1) both part-time employees looking for full-time work and (2) part-time employees wanting more work¹³. In calculating the cost of underemployment, only the statistics for part-time employees looking for full-time work were assessed¹⁴.

Estimation of additional hours required

For the years 1990–2006 the number of part-time workers¹⁵, as defined by number of hours worked per week, was also extracted from customised SNZ's HLFS database¹⁶ and converted to a percentage profile (Table 9). 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 for each year in the study period.

¹³ Job reference number: GRB24516 (Statistics New Zealand, 2009e).

¹⁴ 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 exists regarding the number of hours desired by part-time workers who wish to work additional hours, but not necessarily full-time.

¹⁵ In SNZ's (2009e) Household Labour Force Survey, part-time workers are defined as those people working less than 30 hours each week.

¹⁶ Job reference number: GRB24516 (Statistics New Zealand, 2009f).

Table 9: Profile of Part-Time Hours

	Current hours worked: 1-9 (5) ¹	Current hours worked: 10-19 (15) ¹	Current hours worked: 2-29 (25) ¹
Average % Profile 1987-2005 (individual annual profiles used in calculation)	27	36	37
Additional hours required to reach full-time status	32.5	22.5	12.5

Note 1: Figures in brackets are the mean hours currently worked.

Estimation of hourly cost

The average hourly wage rate is considered to be the opportunity cost of one underemployed hour. A time series for the average hourly wage rate was formulated from two sources: ordinary time hourly rate by region from the Quarterly Employment Survey (INFOS Series: QESQ.SDRA9B) and Earnings and Employment Survey (INFORSHARE)¹⁷. Quarterly data was annualised using moving average for both series. To achieve consistency between the datasets, the Quarterly Employment Survey data was rebased to align to the Earnings and Employment Survey data.

To value the total additional hours of work sought for each year, the number of underemployed was multiplied by the average hours sought 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 2006 constant dollars.

For the period 1990-2006 the cost of underemployment in the Waikato Region has been estimated to be \$₂₀₀₆822 million (Table 10).

¹⁷ There are three different hourly rates given in both surveys: ordinary time hourly, overtime weekly and total (ordinary time + overtime) hourly. In this study the ordinary hourly rate has been used as the value of an hour of underemployment.

Table 10: The Cost of Underemployment in the Waikato Region, 1990-2006

Calendar Year	Part-time Employed People Looking for Full-time Jobs	Total Hours Sought per Year	Hourly Wage Rate (NZ\$ ₂₀₀₆)	Cost of Under-employment (NZ\$ ₂₀₀₆ mil)
1990	2,000	2,340,093	12.64	41
1991	3,000	3,490,029	13.30	63
1992	2,700	3,116,566	13.87	58
1993	2,600	2,999,981	14.13	56
1994	2,400	2,808,368	14.16	52
1995	2,300	2,667,653	14.29	48
1996	2,000	2,255,979	14.59	40
1997	2,200	2,454,843	15.08	45
1998	2,300	2,558,336	15.59	48
1999	2,800	3,102,330	16.02	60
2000	3,200	3,519,665	16.25	67
2001	2,400	2,806,056	16.36	52
2002	2,100	2,446,983	16.74	45
2003	1,800	2,002,257	17.32	38
2004	1,700	1,945,627	17.96	37
2005	1,400	1,548,222	18.47	30
2006	2,000	2,172,079	19.41	42
Total	38,900	44,235,068		822

Cost of Overwork

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 associated with overwork is not included elsewhere. Valuing this loss is the focus of this component.

The valuation of the annual loss of leisure hours due to overwork is based on the following calculation,

$$CO^r = OH^r \times C^r \times 52.14$$

where CO^r is the cost of overwork in the Waikato Region, OH^r is the number of overtime hours worked per week in the Waikato Region, and C^r 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.

Estimation of the number of overwork hours worked per week

Annual December year raw data on persons employed by hours worked per week for their primary job were extracted from customised SNZ regional HLFS¹⁸. Persons employed are categorised into nine groups according to the number of hours worked: 1-9 hours, 10-19 hours, 20-29 hours, 30-34 hours, 35-39 hours, 40 hours, 41-44 hours, 45-49 hours and 50 hours and over. 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.¹⁹ On average, persons within the 50 hours and over category worked 60 hours per week for the period between 1986 and 2006. As a summary, Table 11 shows the average hours worked per week per person for each time band.

¹⁸ Job reference number: GRB24516 (Statistics New Zealand, 2009g).

¹⁹ 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 (Statistics New Zealand, 2009g). 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 11: Average Hours Worked per Week per Person

Time Bands	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
Average Hours Worked per Week per Person	5	14.5	24.5	32	34.5	40	42.5	47	60

A judgement is now required as to the number of hours worked per week above which constitutes overwork. To help inform this decision it has been noted that while 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.²⁰ Alternatively, social policy expert, 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, (2006) and the Department of Labour (2008) to define long working hours. In light of these studies, we assume that any hours worked over the 50 hour mark constitute overwork. 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.

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 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 work 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, as previously determined for the cost of underemployment.

Finally, the values of overwork calculated for the study period are deflated by the IPD to constant 2006 dollars (Appendix I).

For the period 1990-2006 the cost of overwork in the Waikato Region has been estimated to be \$₂₀₀₆6,486 million (Table 12).

²⁰ 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).

Table 12: The Cost of Overwork in the Waikato Region, 1990-2006

Calendar Year	GPI Defined Overworked People	Total Hours Overworked per Year	Hourly Wage Rate	Cost of Overwork
			(NZ\$ ₂₀₀₆)	(NZ\$ ₂₀₀₆ mil)
1990	35,900	18,718,260	12.64	329
1991	34,300	17,884,020	13.30	322
1992	32,400	16,893,360	13.87	314
1993	34,300	17,884,020	14.13	335
1994	34,700	18,092,580	14.16	334
1995	37,600	19,604,640	14.29	352
1996	42,600	22,211,640	14.59	398
1997	36,700	19,135,380	15.08	350
1998	33,500	17,466,900	15.59	326
1999	41,900	21,846,660	16.02	420
2000	47,900	24,975,060	16.25	474
2001	43,300	22,576,620	16.36	420
2002	44,800	23,358,720	16.74	433
2003	46,100	24,036,540	17.32	454
2004	42,000	21,898,800	17.96	419
2005	38,300	19,969,620	18.47	381
2006	42,100	21,950,940	19.41	426
Total	668,400	348,503,760		6,486

Services of Public Capital

This component values the economic benefits from services gained from the use of public capital stocks. 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; secondly, 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. Non-market goods and services, however, such as amenity and recreational services provided by national parks, are not taken into account in the national accounts nor elsewhere in the GPI. They are instead valued in this component. Importantly, it is only the non-defensive services of public capital stocks that are of interest in this category.

The national 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 general 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 ratio of regional population to national population was used to scale down the national value of services of public capital because of the paucity of public capital stock data at regional

level. This assumes that the free services of public capital provided to the people in the area are proportional to population in the area. The estimation process is described below,

$$S^r = S^n \times \frac{Pop^r}{Pop^n}$$

where S^r and S^n are the services of public capital for the Waikato Region and New Zealand respectively, and while Pop^r and Pop^n are regional and national population.

For the period 1990-2006 services of public capital in the Waikato Region has been estimated to be \$₂₀₀₆15,636 million (Table 13).

Table 13: Service of Public Capital in the Waikato Region, 1990-2006

Calendar Year	Services of Public Capital
	(NZ\$ ₂₀₀₆ mil)
1990	901
1991	861
1992	841
1993	818
1994	826
1995	822
1996	809
1997	824
1998	848
1999	884
2000	903
2001	928
2002	970
2003	1,018
2004	1,057
2005	1,129
2006	1,196
Total	15,636

Value of Household and Community Work

Some of the most essential work undertaken in a society to facilitate national wellbeing 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. 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 the Waikato Region.

The following five steps are used to calculate the value of household and community work in the Waikato Region.

Step 1 Determine residential population by age and sex

For the years 1996-2006, regional resident population by age (five-year cohort) and sex for each year ended 30 June was obtained from SNZ²¹. This data was then grouped into 12 categories as show in Table 14.

Table 14: Population by Age-Sex Cohort

Male	Female
0-24	0-24
25-34	25-34
35-44	35-44
45-54	45-54
55-64	55-64
65+	65+

²¹ Job reference number: JOW24622 (Statistics New Zealand, 2009i).

As data of the same type was not available for the earlier years of the study, reference was made first to SNZ's (1) the 1991 Census usually resident population count by age (five-year cohort) and sex²² and (2) *de facto* resident population estimates for the year 1990-1995. The ratio of total *de facto* resident population to total population in 1991 was then used to factor up the 1991 census population data for each age-sex category to the resident population estimates²³. Resident population by age-sex cohort for the remaining years was estimated as follows:

- 1990, 1992-1995: total resident population disaggregated by the profile in 1991

Step 2 Determine time spent on household and community work in 1999 base year

Between 1 July 1998 and 30 June 1999, SNZ conducted New Zealand's first major time use survey (Statistics New Zealand, 2001a). The survey involved a sample of over 8,500 residents aged 12 years and over and required each participant to fill out 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, 2001b). Furthermore, it applied detailed activity classifications to identify unpaid household and community work.

The data provided by the survey provided the basis for estimating time spent on household and community work during a 1999 base year. The data was first disaggregated by age-sex cohort according to the categories specified in Table 15. The figures for the major time use categories were taken directly from the survey, while estimates for the sub-categories (equivalent to the blue figures within Table 16) were balanced using the Bi-proportional Balancing Method presented in Appendix II.

Next, data on resident population by age-sex cohort was used to scale-up the average time use figures for the sample covered by the New Zealand Time Use Survey, so as to derive estimates of the total national time allocated to household and community work. Inherent in this method is an assumption that the average time spent on household and community work is consistent within a particular age-sex category. The results are presented in Table 16.

²² Job reference number: JOW24622 (Statistics New Zealand, 2009j).

²³ There were two measurements carried out by SNZ for the given resident population time series: '*de facto*' estimates for the period prior to 1991 and 'resident' estimates after 1991. In order to obtain a single time series, the *de facto* estimates were converted to resident estimates by applying an inflator of 2 percent representing the estimated average difference between the two measures (Statistics New Zealand, 1999c).

Table 15: Statistics New Zealand's Time Use Survey Categories, 1999

GPI Component	Time Use Survey Category	Time Use Survey Sub-Category
Household Work	Household work	Food preparation
		Indoor cleaning
		Grounds (gardening)
		Home maintenance
		Household admin.
		Production of goods
		Gathering food
		Travel
		Other
		Care-giving for household members
Being available		
Playing		
Teaching		
Educational help		
Travel		
Other		
Purchasing goods and services for own household		Purchasing
		Travel
Community Work	Unpaid work outside of the home	Formal
		Informal

Table 16: Time Use (minutes) by Sex-Age Cohorts, 1999

Sex Age	Male							Female						
	12-24	25-34	35-44	45-54	55-64	65+	Total	12-24	25-34	35-44	45-54	55-64	65+	Total
Household Work	37	76	92	104	140	177	95	72	153	182	185	223	221	164
Food preparation	11	23	27	31	42	59	29	26	58	69	70	85	92	63
Indoor cleaning	8	13	16	18	24	27	16	28	60	71	72	87	78	63
Grounds (gardening)	6	15	19	21	28	44	20	8	18	21	22	26	28	19
Home maintenance	8	16	20	22	30	28	19	3	4	5	5	6	5	5
Household admin.	2	3	3	3	5	6	3	3	5	6	6	7	6	5
Production of goods	0	0	0	0	1	1	0	1	2	3	3	3	3	3
Gathering food	1	1	2	2	3	3	2	0	0	1	1	1	1	0
Travel	1	2	3	3	4	5	3	1	2	2	2	2	2	2
Other	1	3	3	3	5	6	3	2	4	5	5	6	6	4
giving for Household Members	5	27	36	12	9	5	16	28	99	81	20	9	4	44
Physical care	2	10	13	4	3	2	6	14	52	43	10	5	2	23
Being available	0	2	2	1	1	0	1	1	5	4	1	0	0	2
Playing	1	6	9	3	2	1	4	4	15	12	3	1	1	7
Teaching	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Educational help	0	1	2	1	0	0	1	1	4	4	1	0	0	2
Travel	1	6	7	2	2	1	3	5	18	14	3	2	1	8
Other	0	1	2	1	0	0	1	1	5	4	1	0	0	2
nd Services for Own Household	22	27	30	28	31	39	28	37	44	46	47	44	43	43
Purchasing	13	16	18	17	19	24	17	24	29	30	31	29	28	28
Travel	8	10	12	11	12	15	11	13	15	16	16	15	15	15
paid Work Outside of the Home	14	23	28	30	43	43	28	15	30	36	44	68	40	36
Formal	6	10	12	13	19	19	12	6	13	15	19	28	17	15
Informal	8	13	16	17	24	24	16	9	18	21	26	39	23	21

Step 3 Monetary estimates of the value of household and community work for 1999

Several approaches have been identified for assigning monetary value to unpaid household work (see, for example, Statistics New Zealand, 2001b), these include opportunity cost and market replacement cost (including replacement costs individual function and replacement cost general housekeeper) methods. In this study, the housekeeper replacement method is adopted on the basis of data availability and ease of calculation.²⁴ This means that the value of unpaid household and community work is determined by multiplication of the annual amount of time (in hours) spent on household and community work (excluding any leisure component) by the general housekeeper wage rate representing the value of an hour of work in each year.

In order to remove the leisure component of the time recorded within Table 16, a set of assumptions were made regarding the proportion of time spent within each time-use category that may be deemed non-leisure. The salient points to note include (refer to Table 17)²⁵:

- 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.

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 regional hourly wage rate, \$₁₉₉₉9.99, used to represent a general housekeeper was estimated from the national wage rate \$₁₉₉₉9.60 (see step 4 for more estimation details).

Finally, the IPD time series was used to deflate the resulting nominal values to real terms expressed in 2006 dollar terms.

Step 4 Estimation of regional housekeeper hourly wage rate

The regional housekeeper hourly wage rate was derived from two customised SNZ Census of Population and Dwelling (2001 and 2006) occupation datasets²⁶, namely NZSCO51211

²⁴ The housekeeper replacement method was also adopted in the calculation of the Australian GPI (Hamilton and Denniss, 2000) and in the SNZ (2001b) report *Measuring Unpaid Work in New Zealand 1999*.

²⁵ Researchers in this area have generally adopted the rule, developed by Margaret Reid in 1934, that household work includes those activities that “might be replaced by market goods and services, if circumstances such as income, market conditions and personal inclinations permit the services being delegated to someone outside the household group”. Thus, meal preparation is work, while consumption of meals is not. Shopping for household items is work, but window shopping is not (Hamilton and Denniss, 2000). For such reasons, we count only 50 percent of informal community work as leisure, but none of the formal community work.

²⁶ Job reference number: ANM24573 (Statistics New Zealand, 2009k).

Housekeeper (Private Service) and ANZSCO811412 Domestic Housekeeper²⁷. The average ratio of regional total personal income for housekeeper to that of national value for 2001 and 2006 was used to factor up or down the time series of national housekeeper average hourly wage rate developed for the New Zealand GPI. For example, the average ratio of Waikato Region to the New Zealand housekeeper total personal income was 1.04. The national housekeeper hourly wage rate of each year for the period from 1990 to 2006 was therefore multiplied by 1.04 to determine the average hourly wage rate for Waikato Region housekeepers.

Step 5 Valuing household and community work before and after the 1999 base year

As no primary data relating to time use exists beyond 1999, time use estimates for the remaining years were made by adjusting the base data in accordance with known changes in the age-sex cohorts of the New Zealand population. The average time spent on activities by individuals in each age-sex cohort is assumed to remain the same as for the 1999 year. Finally, all values were converted to constant 2006 dollars.

For the period 1990-2006 the value of household and community work in the Waikato Region has been estimated to be \$₂₀₀₆45,907 million (Table 18).

²⁷ Domestic housekeeper cleans, cooks and performs other housekeeping tasks in private residents. NASCO 511211 is partially mapped to ANZSCO811412 and partially mapped to Personal Service Workers nec (Statistics New Zealand and Australian Bureau of Statistics, 2006). Therefore it is reasonable to use both to estimate h average hourly wage rate for housekeeper.

Table 17: Percentage of Time Deemed Non-leisure by Sex-age Cohorts

Sex Age	Male						Female					
	12-24	25-34	35-44	45-54	55-64	65+	12-24	25-34	35-44	45-54	55-64	65+
Household Work												
Food preparation	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Indoor cleaning	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Grounds (gardening)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Home maintenance	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Household admin.	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Production of goods	50%	50%	40%	20%	20%	20%	70%	40%	30%	20%	20%	20%
Gathering food	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Travel	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Other	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Care-giving for Household Members												
Physical care	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Being available												
Playing	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Teaching	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Educational help	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Travel	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Other	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Purchasing Goods and Services for Own Household												
Purchasing	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Travel												
Unpaid Work Outside of the Home												
Formal	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Informal	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%

Table 18: The Value of Household and Community Work in the Waikato Region, 1990-2006

Calendar Year	Value of Household and Community Work
	(NZ\$ ₂₀₀₆ mil)
1990	2,427
1991	2,522
1992	2,528
1993	2,496
1994	2,560
1995	2,549
1996	2,554
1997	2,628
1998	2,727
1999	2,774
2000	2,842
2001	2,740
2002	2,757
2003	2,891
2004	2,898
2005	2,947
2006	3,065
Total	45,907

Cost of Private Defensive Expenditure on Health

In the Public Consumption component above, defensive expenditure that does not contribute to an improvement in wellbeing is excluded. In the case of Personal Consumption, however, defensive expenditure on health that does not contribute to wellbeing is included. The purpose of this component is therefore to remove the value of private defensive expenditure on health from the GPI.

Due to a paucity of regional level data on private expenditure on health this must be estimated. The ratio of the regional household expenditure on health to the national household expenditure on health, both extracted from the customised SNZ regional Household Economic Survey (HES) data²⁸ was used to scale down the national private-defensive expenditure on health as follows,

$$PDHC^r = PDHC^n \times \frac{HC_{HES}^r}{HC_{HES}^n}$$

where $PDHC^r$ and $PDHC^n$ are the regional and national private defensive expenditure on health respectively for GPI, while HC_{HES}^r and HC_{HES}^n are the household expenditure on health from the Waikato Region and the New Zealand HES.

Regional and national household expenditure on health datasets from the HES were not used directly in measuring the private expenditure on health because the HES data represents only a sample of the population, and at the regional level, may produce dubious results.

For the period 1990-2006 the private defensive expenditure on health in the Waikato Region has been estimated to be \$₂₀₀₆362 million (Table 19).

²⁸ Job reference number: ANM24602 (Statistics New Zealand, 2009h).

Table 19: Private Defensive Expenditure on Health in the Waikato Region, 1990-2006

Calendar Year	Private Defensive Expenditure on Health
	(NZ\$ ₂₀₀₆ mil)
1990	16
1991	17
1992	19
1993	18
1994	18
1995	18
1996	20
1997	20
1998	21
1999	22
2000	22
2001	23
2002	23
2003	24
2004	26
2005	27
2006	27
Total	362

Cost of Commuting

As the Waikato Region increasingly urbanises it is inevitable that people will spend more time and money getting to and from work; a result of increased traffic congestion for example. 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 wellbeing 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 wellbeing associated with commuting are taken into account. Firstly, direct costs made by commuters in the pursuit of getting to work (e.g. vehicle purchases, petrol, maintenance, bus and train fares); and secondly, the value of time spent commuting in terms of lost productive hours in work or lost leisure time (i.e. time costs). It must be acknowledged however that there are other less tangible costs associated with commuting such as the stress and frustration caused by sitting in traffic which is not reflected in GPI due to difficulties in measurement.

In the New Zealand GPI, the direct costs of commuting, CC , are calculated as follows,

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

where Pr represents expenditure on private transportation, the first 0.10 constant incorporates a depreciation rate across the entire private transportation sector²⁹, Pu represents expenditure on public transportation, and 0.23 and the second 0.10 constant represent the share of expenditure on 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 travelled³⁰.

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 from the HES (Statistics New Zealand, 2004). The percentages of household expenditure for private and public transportation were extracted from the study of Dravitzki and Lester (2006).

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.

²⁹ 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.

³⁰ Data formulated from New Zealand Travel survey (Ministry of Transport, 2006).

Total employment counts by commuting mode were extracted from SNZ's Official Year Book for each census year in the study period. The Time Use Survey (1999) provides the average minutes spent per day on commuting by mode. A decreasing rate of 2.5 percent per annum is then used to extrapolate the figures for all other missing years. A cost of commuting of \$₁₉₉₈7 per hour in 1998³¹ is inflated by the CPI to estimate the costs for missing years. The cost of commuting is the total of each year's direct and time costs. The CPI for transportation was used to convert the nominal values to constant 2006 dollars.³²

In the absence of regional data the national costs of commuting were scaled down to the regional level using the ratio of regional-to-national household expenditure on transportation as extracted from the regional HES database³³. The calculation is as follows,

$$CC^r = CC^n \times \frac{HC_{HES}^r}{HC_{HES}^n}$$

where CC^r and CC^n are the regional and national direct cost of commuting respectively for GPI, while HC_{HES}^r and HC_{HES}^n are the household expenditure on transportation extracted from the Waikato Region and the New Zealand HES. While the time cost at the national level was scaled down by the ratio of regional hours travelled to work by employed people to that of the national level as follows,

$$TC^r = TC^n \times \frac{TT_{MOT}^r}{TT_{MOT}^n}$$

where TC^r and TC^n are the regional and national time cost of commuting respectively for GPI, while TT_{MOT}^r and TT_{MOT}^n are respectively the hours travelled per year to work by private and public transport in the Waikato Region, and in New Zealand, from the Ministry of Transport database.

Hours travelled per year by destination (work) by mode (private car and public transport etc) data were prepared by the Ministry of Transport based on their Household Travel Survey. Data was available for two time periods; the average for 2003-06 and the average for 2003-2007. The average ratio for these two data points was used in the scaling process.³⁴

For the period 1990-2006 the cost of commuting in the Waikato Region has been estimated to be \$₂₀₀₆6,371 million (Table 20).

³¹ This is based on the hourly value for car and motorcycle drivers undertaking non-work travel (i.e. not travel to and from work) from 1997 Project Evaluation Manual (PFM2), Appendix A4. (Transfund New Zealand, 1997).

³² The percentage given in Dravitzki and Lester (2006) are categorised by high income and low income for some certain years. The average percentage is computed and applied in the GPI study.

³³ Job reference number: ANM24602 (Statistics New Zealand, 2009h).

³⁴ Household Travel Survey is designed to be an ongoing survey, taking 3-4 years to get sample sizes to be statistically significant. Hence MoT cannot provide annual data for each year but only the average.

Table 20: The Cost of Commuting in the Waikato Region, 1990-2006

Calendar Year	Cost of Commuting
	(NZ\$ ₂₀₀₆ mil)
1990	271
1991	277
1992	281
1993	266
1994	285
1995	329
1996	355
1997	369
1998	387
1999	383
2000	381
2001	393
2002	427
2003	468
2004	498
2005	502
2006	500
Total	6,371

Cost of Crime

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 in the Waikato Region. 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 captured in the Public Consumption component of the GPI, only the following private costs associated with property are considered in this component:

- *Property Loss.* It could be argued, in strict economic terms, that theft does not result in any loss of wellbeing 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.*

Medical 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 accounted for in the Public Consumption and in the Private Defensive Expenditure on Health components. The trauma experienced by the victims of crime in terms of psychological distress, heightened anxiety and feelings of insecurity can seriously curtail individuals' 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 Waikato Region 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.

Only the private costs associated with property crime are considered in this component³⁵. 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 offences and C is cost per offence in the private sector.

³⁵ Private preventative expenditure on crime (the cost of insurance premiums, alarms and the like) is excluded in this component as this is included in personal consumption expenditure.

Step 1: Cost of crime for the years 1998-2006

Estimation of the total number of property and serious traffic offences

District annual recorded offences for the period from 1989 to 2007 were extracted from SNZ using Table Builder. These district offences are however based on New Zealand Police Areas, which is different to the standard regional boundaries. A concordance between New Zealand Police Area and SNZ Regional Council boundaries were developed using meshblock data provided by SNZ. These figures were then rescaled using a multiplier of 4.66³⁶ in order to better reflect the actual number of offences (both recorded and unrecorded) in each year.

Cost per property and serious traffic crime in the private sector

We assume that the regional cost per crime is the same as the national average. The national average cost per property/serious traffic crime for the year 2004 was derived by dividing the estimated total cost of those offences on the private sector³⁷ for that year by the estimated number of property and serious offences as reported by Roper and Thompson (2004).³⁸ Finally, the estimated 2004 value of \$₂₀₀₄2,357 was inflated to \$₂₀₀₆2,458 at 2006 constant dollars by the IPD. This average cost per offence is assumed to be the same (in real terms) through the remainder of the study period.³⁹

Step 2: Cost of crime for years 1990-1997

There is no regional data available on offence numbers for the years 1990-1997. In order to estimate the regional cost of crime, a ratio of real regional cost of crime to real national cost was calculated for each of the years 1998-2006. Empirically the Waikato Region cost of crime was valued, on average, as 11 percent of total New Zealand cost of crime. This ratio is multiplied by each year's real total New Zealand cost of crime and, in turn, back cast to give a regional cost of crime in for the years prior to 1998.

For the period 1990-2006 the cost of crime in the Waikato Region has been estimated to be \$₂₀₀₆5,921 million (Table 21).

³⁶ 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 4.66 when only property is considered. It is assumed that this multiplier remains the same across regions.

³⁷ Roper and Thompson (2004) estimated the total costs of crime for NZ in 2004 are \$9.14 billion. Subtracted from this figure were the values of all public sectors (23 percent), all private sector costs by violent offences (23 percent), sexual offences (11 percent) and other (14 percent).

³⁸ This cost also includes the private expenditure on insurance premiums, alarms and the like.

³⁹ The cost per property/serious traffic crime is initially estimated at \$₂₀₀₄2,317 for the March year. This translates to \$₂₀₀₄2,357 for the December year when adjusted by the IPD.

Table 21: The Cost of Crime in the Waikato Region, 1990-2006

Calendar Year	Cost of Crime
	(NZ\$ ₂₀₀₆ mil)
1990	322
1991	351
1992	365
1993	364
1994	352
1995	366
1996	375
1997	372
1998	413
1999	385
2000	343
2001	321
2002	338
2003	314
2004	291
2005	311
2006	339
Total	5,921

Environmental Components Introduction

The environmental categories included are standard for GPIs produced in other countries with the exception of the pest and weed inclusion. This is unique to the New Zealand GPI as introduced species are a significant aspect of environmental degradation in New Zealand. The following table lists other components considered for inclusion and why they have not been covered.

Environmental Category	Not covered by GPI and why not covered
Marine over-fishing and degradation	<p>New Zealand has an Exclusive Economic Zone 16 times the land area and to quantify this resource realistically has not been attempted for this first version of the GPI. The following are not covered due to lack of data and valuation methodology:</p> <ul style="list-style-type: none"> Depletion of fish stocks Saline wetlands Damage to coastal ecosystems Impacts of aquaculture Loss of endangered species Estuaries/harbours pollution with sewage and chemicals Introduced exotic organisms, e.g., toxic algae blooms
Amenity/landscape loss	<p>Loss of natural landscape due to rail, roads, motorways, pylons, wind farms, mining, deforestation, buildings etc. Amenity value is subjective e.g. some people like the visual appearance of windfarms while others dislike the visual intrusion. There is also a lack of data and valuation methodology.</p>
Species loss/decline	<p>Loss of species as a result of habitat change, introduction of predators and disease. Difficulty in estimating loss of terrestrial fauna, marine biota and flora between 1990 and 2006. Could possibly use expenditure on key species protection, e.g., kiwi, kokako.</p>

As ecosystems provide free services that contribute to our well-being on a continuous basis the loss that occurs from destruction or damage, or the benefits gained from restoration, impacts over a longer time period than the year in which it occurs. Appendix IV gives the time scales across which environmental costs have been summed. We have taken 1970 as the point where sustainable activity became unsustainable.

Cost of Loss and Damage to Terrestrial Ecosystems

Terrestrial ecosystem loss in the Waikato Region is from two main sources: (i) indigenous forest change, and (ii) pests and weeds.

(i) Indigenous Forest Change

Loss of indigenous forest and native scrubland represents a long-term loss of a range of ecosystem services including: habitat for native birds, endemic biodiversity, landscape amenity, passive value (existence, bequeath, option)⁴⁰, climate regulation and recreation value. As the ecosystem services are lost not just in the year of the clearance but for every subsequent year loss is measured cumulatively from 1970 onward.

Indigenous timber milling and conversion of forest/scrub to agriculture was common place in the Waikato Region in the early 1970's. Public pressure in the late 1970s resulted in legislation changes which reduced milling in State forests towards the end of the decade and ultimately halted it altogether. In 1978 a decision was made to cut the supply of native timbers from the West Taupo forests (the bulk of which are in the Waikato Region) from a maximum of 60,000m³ per year to 6,000m³ per year. A three year moratorium was placed on logging in the north block of Pureora State Forest⁴¹ and part of the Waihaha block (New Zealand Forest Service, 1978, p.38). This prevented selective logging in a stand containing giant totara trees and the endangered kokako. In 1982 legal protection was given to the entire Pureora and Waihaha forests (Froude *et al.*, 1985). Reductions in milling also resulted when price controls on indigenous timber were lifted in 1978. This curbed wasteful uses such as for chipping and pulp and paper (Froude *et al.*, 1985). In 1985 the newly elected Labour government followed up on its election promise and introduced a policy to halt all logging of *virgin* indigenous State forest in the North Island. This was subsequently extended to protection of all remaining North Island indigenous State forests (Froude *et al.*, 1985).

Between 1975 and 1984 indigenous forest production from State forests in the North Island declined by 94 percent which represented a decline in the Crown's share of total North Island production from 64 percent to 17 percent (Froude, 1985, p.28). The bulk of the government's indigenous forest resource was transferred to the Department of Conservation in 1987. Milling still took place in private indigenous forests as the decrease in State supply and increased market prices put pressure on private and Maori forests (Froude *et al.*, 1985, p.28). Land Development Encouragement Loans also encouraged milling and clearing on private lands. Between 1978 when it was introduced and 1982 when it ceased the Land Development Encouragement Loans funded in New Zealand the clearing of 30,361 ha of native forest and 37,101 ha of scrub and brushweed which was an average of 13,500 ha per year (Froude *et al.*, 1985, Table 9.4). "Under the scheme, loans for approved work were arranged by the Rural

⁴⁰ Passive value is value not related to the actual use of biodiversity and is usually made up of (i) existence value which is the amount an individual is willing to pay to preserve biodiversity though they may never want to use that biodiversity (ii) bequeath value which is the willingness to pay to ensure future generations have the benefit of the biodiversity (iii) option value which is the willingness to pay to preserve biodiversity for some unforeseen future use.

⁴¹ The annual cut from the Pureora State Forest in 1978 was 46,000m³ Higham, J., Menzies, P., 1978. Social and economic impact of indigenous forestry in the Pureora area. Business Development Centre, University of Otago, Dunedin.

Bank and so long as the farmer cleared and maintained the area involved for a determined period of time, the loan was written off. While in most instances sustained production was achieved, in others the total exercise was a disaster with large areas of steep native scrubland cleared only to erode or revert to weeds such as broom, gorse or tauhini” (Worsley, 1999, p.30)

Actual data for measuring the loss of indigenous forest and native scrub is not available for the Waikato Region. Estimates which are supported by qualitative information have been made as follows:

1. The Waikato regional boundary was overlaid on LRI maps to establish indigenous cover for 1977 (LRIV1, 1975-79). LRI data was extracted for classes M1, M6, N, N1, N2, N3, N3a, N3b, N4, N4a, N4b, N5, and the area of indigenous cover summed for each polygon.⁴²
2. For the same boundary area, indigenous forest, broadleaf indigenous hardwoods, and manuka/kanuka totals were summed to get data points from LCDB1 and LCDB2. The loss between 1996/97 (LCDB1, no date) and 2001/02 (LCDB2, 2004) was an average of 121 ha per year (Appendix III).
3. There was an estimated 1,029 ha per year loss between 1977 (LRI) and 1996/97 (LCDB1).
4. The same annual rate of loss was assumed for 1970 to 1976 as between 1977 and 1996/97 giving a total of 28,804 ha loss between 1970 and 1997. The indigenous roundwood removal pattern for the North Island (Statistics New Zealand, 2007) was used to apportion the 28,804 ha yearly between 1970 and 1997. Roundwood extracted from the King Country made up 90 percent of the indigenous wood extracted from the Waikato/Coromandel/King Country region and in 1972 this amounted to 88,711m³ (Ministry of Works, 1973) out of a total 222,000m³ for the North Island.
5. The rate of loss from 2003 to 2006 was assumed to be the same as for 1996/97 to 2001/02 (121 ha/yr).

An estimate of the Indigenous forest cover for the 1970s could potentially be more accurately estimated using the new LUCAS database (Newsome and Shepherd, 2009). The LUCAS methodology employed satellite and other photographs to map indigenous forest cover as at 1990. Getting the data via LUCAS was not possible for this research as the cost was prohibitive.

Each hectare of indigenous forest lost is valued at \$₁₉₉₄717 or \$₂₀₀₆903 per annum as per Patterson and Cole (1999) (Table 22). The ecosystem services valued are those set out in this table. The passive or non-use value used (\$₁₉₉₄104/ha/annum) is that of a forest park which is considerably lower than that of a national park (\$₁₉₉₄871/ha/annum) as generally forest parks do not have the same level of unique biodiversity, outstanding landscapes and/or cultural features as found in national parks. Much of the early milling in the Region was in forests with national

⁴² If whole area is ‘a’ (indigenous) then 100 percent is included. If there is more than one class cover then the sum of the minima of ranges was taken and the remainder split equally between each land cover type.

park standard biodiversity but there is insufficient data to make an appropriate split so all has been assumed as forest park. This will underestimate the extent of the loss.

Table 22: Net Value of Loss of Indigenous Forest Ecosystems

Description		Indigenous Forest
		(\$ ₁₉₉₄ NZ /ha/annum)
Indirect		
Climate regulation	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global or local level.	154
Erosion control	Retention of soil within an ecosystem	215
Soil formation	Soil formation processes	18
Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess nutrients	153
Biological control	Trophic-dynamic regulators of populations	7
Direct		
Recreation	Provides opportunities for recreational activities	63
Cultural	Provides opportunities for non commercial activities	3
Passive	Biodiversity loss - non-use	104 ^a
Total		717

a= Value covers existence, bequeath and option values
Source: Patterson and Cole (1999)

(ii) Pests and weeds

GPI's do not generally include the environmental cost of pests and weeds. This category has been included as introduced invasive plant and 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), means that flora and bird species have evolved lacking defensive mechanisms to deter grazing and 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 the damage from human interference only not naturally occurring ecological change.

The cost of pests and weeds to the Waikato Region has been based on annual defensive expenditure required to control plant and animal pest invasion. The main plant pests in the Region include woolly nightshade, wild ginger, *Eleagnus*, mistflower, moth plant, privet and Bartlettina. Grey and crack willow is also through wetlands (EcoFX and Gerry Kessels & Associates, 2000). The main animal pests are possums, goats, rabbits and mustelids.

The bulk of defensive expenditure is to control rather than eradicate in New Zealand. Defensive expenditure was estimated at NZ₁₉₉₇\$440 million per year, or approximately 0.45 percent of GDP in 1997 (Hackwell and Bertram, 1999). Agricultural production losses are excluded from the GPI calculations as this is taken into account by decreased personal consumption. Tb vector control is included as this benefits indigenous forests and wildlife as well as human 'productive' activity (Hackwell and Bertram, 1999, p.61).

Hackwell and Bertram (1999) assembled tables which estimate defensive expenditures by central and regional governments on pest control between 1991 and 1998. 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). The New Zealand government funds a wide range of research into pest-related topics; however, limited data availability has 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 up to 1997. From 1998 onwards the estimate is \$37 million per year (MAF Biosecurity New Zealand, 2007). "The funding pool has been essentially static for some years which, in real terms, equates to a decline in funding" (MAF Biosecurity New Zealand, 2007, pp.10-11). Waikato Region's annual share of central government and private spending is based on its percentage of total New Zealand Regional Council expenditure per year. Total Regional Council expenditure varies from \$18-25 million per year between 1991 and 1998 (Hackwell and Bertram, 1999).

Waikato regional expenditure on pest control for 1996/97 to 2006/07 came from Regional Pest Management Strategies. Estimates of expenditure between 1991 and 1996 come from Table 3, 'Regional Council Spending on Management of Animal and Plant Pests' (Hackwell and Bertram, 1999, p.55). Adjustments were made for 1995 and 1996 as the data was considered an underestimate. Households in New Zealand also incur costs to control insect, animal and plant pests in both their houses and gardens. 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 in the Waikato Region.

Table 23 gives pest-related expenditure estimates for the period 1990-2006 for Waikato. As there was no data available 1990 was assumed to be the same as 1991. Annual defensive pest-control expenditures were converted to \$NZ₂₀₀₆ and added to estimated loss of indigenous forest to get the total loss for terrestrial ecosystems for 1990 to 2006.

Table 23: Pest-Related Waikato Region Expenditure, 1990-2006

Calendar Year	EW portion of Central Govt costs	Regional Household Expenditure	EW Expenditure	Total for EW
	(NZ\$ ₂₀₀₆ mil)	(NZ\$ ₂₀₀₆ mil)	(NZ\$ ₂₀₀₆ mil)	(NZ\$ ₂₀₀₆ mil)
1990	39	2	2	44
1991	39	2	2	44
1992	32	2	2	36
1993	30	2	2	34
1994	22	2	1	26
1995	18	3	1	22
1996	20	3	1	24
1997	21	3	1	25
1998	21	3	1	25
1999	28	3	1	32
2000	29	3	1	33
2001	31	3	1	35
2002	57	3	3	63
2003	65	3	3	71
2004	73	3	3	79
2005	76	3	3	83
2006	83	3	4	90
Total				765

Source: Hackwell and Bertram (1999). 1991 to 1999 in NZ\$₁₉₉₉ m.

For the period 1990 to 2006 the total cost of terrestrial ecosystems has been estimated at \$1,259 million (Table 24).

Table 24: Total Value of Terrestrial Ecosystem Loss, 1990-2006

Calendar Year	Loss of indigenous forest	Pest and weed cost	Total cost of lost terrestrial ecosystems
	(NZ\$ ₂₀₀₆ mil)	(NZ\$ ₂₀₀₆ mil)	(NZ\$ ₂₀₀₆ mil)
1990	27	44	70
1991	27	44	71
1992	27	36	64
1993	28	34	62
1994	28	26	54
1995	29	22	51
1996	29	24	53
1997	29	25	55
1998	30	25	54
1999	30	32	61
2000	30	33	63
2001	30	35	65
2002	30	63	93
2003	30	71	101
2004	30	79	109
2005	30	83	113
2006	30	90	120
Total			1,259

Cost of Loss of Wetlands

The Waikato Region has three of the six New Zealand wetlands of international importance. The Kopuatai Peat Dome at 10,201 ha, is the largest unaltered restiad peat bog in New Zealand and globally unique. The area is managed by the Department of Conservation and was listed as a Ramsar site in December 1989. The Whangamarino wetland which covers over 7,000 ha is the second largest bog and swamp complex in the North Island and includes 5,923 hectares of peat bog, swampland, mesotrophic lags, open water and river systems. Water levels changed when the Lower Waikato-Waipā Flood Protection Scheme was instigated in 1961 and the hydrology of the wetland has been impacted by sand extraction and hydro-power generation on the Waikato River. The Whangamarino wetland is part of a major storage area for flood control and an important habitat for fish migrating to and from the sea via the Waikato River (Cromarty, 1996). The Firth of Thames/Tikapā Moana wetland, listed as a Ramsar site in January 1990, is exposed at ebb tide and covers 8,927 hectares of shallow estuarine water and mudflats, shell banks, grass flats, mangrove forest, salt marsh and freshwater swamp margins (Department of Conservation, n.d.-a).

The GPI measures the loss of freshwater wetlands from 1970 onwards. It is estimated that there were 356,516 ha of wetlands in the Waikato Region prior to settlement based on soil type (Ausseil *et al.*, 2008). There are now just 28,226 ha or 7.9 percent remaining (Ausseil *et al.*, 2008). The vast majority of 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, p.7.37). Wetland conversion was encouraged by the government with the Rural Banking and Finance Corporation funding Improvement Loans, Livestock Incentive Schemes and Land Development 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 1990's, conversions were taking place associated with dairying and urbanisation.

The wetlands that remain in the Region are degraded as a result of sediment and nutrient inputs from the surrounding catchment, invasive weed, livestock and pests such as koi carp and catfish. Pest fish species are prolific and difficult to control (Department of Conservation, n.d.-b).

Measuring the change in wetlands in the Waikato Region is somewhat speculative, as time series data on the loss of wetlands have not been collected. Comparison between studies that have been done is difficult, as definitions of what constitutes a 'wetland' vary over time.

In their GPI calculation for the USA, 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 percent of the wetlands in most American states were in an unmodified condition. By comparison, at this time less than 15 percent 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).

Only the hectares of wetlands lost since 1970 has been valued for the Waikato GPI, therefore the valuation is very conservative. We have assumed that 1970 levels were reasonably sustainable – from the viewpoint that flood protection, habitat, recreation, water retention, etc., services were adequately provided by remaining wetlands. Wetland loss from 1970 onwards is cumulative as the ecosystem services lost from a hectare of wetlands is an ongoing cost each year.

Ogle and Cheyne (1981) based on vegetation data collected for LRI between 1972 and 1978 estimated the area of wetlands in the lower Waikato river basin and the Hauraki Plains. The undeveloped wetland (swamp, sedges, rushes, manuka) covered 33,810 ha and the area of developed wetland (pasture crops and pines) covered 197,104 ha. The Landcare Research calculated figure of 28,226 ha of remaining wetland in 2002 was the most recent estimate for remaining wetland available (Ausseil *et al.*, 2008).

The 33,810 ha of wetland was taken as the 1975 figure (mid-point of data collection 1972 to 1978). The annual rate of decline between 1975 and 2002 was therefore 207 ha per year. Prior to 1975 this same rate of decline (207 ha per year) was assumed. Applying a 207 ha per annum loss gives a figure for 1995 of 29,674 ha which corresponds well with the 29,722 ha estimate for freshwater wetlands from Leathwick, Clarkson and Whaley (Leathwick *et al.*, 1995). The loss of wetland from 2002 onward is assumed to be the same rate as wetlands formation so there is no overall change.

To apply a monetary value to wetlands, the Patterson and Cole (1999) assessment of the value of New Zealand's biodiversity was used. As set out in Table 25 the Patterson and Cole (1999) study takes into account a broad range of ecosystem functions for wetlands. For the valuation it is assumed that when land is converted from wetlands to agricultural land, there is a decrease in the ecosystem services provided, but not a reduction to zero as agricultural land also provides ecosystem services. Therefore, the difference in ecosystems services existing before and after the conversion of the wetland to agriculture is used to value each hectare of wetland lost.

The New Zealand-based study by Patterson and Cole draws on values from Costanza *et al.* (1997), which are primarily from the United States. The total value of New Zealand wetlands is estimated at \$₁₉₉₄35,053 per ha per annum, and the total ecosystem value for agricultural land is estimated at \$₁₉₉₄1,583 per ha per annum. Therefore, the net loss from converting wetland to agricultural land is estimated at \$₁₉₉₄33,470 per ha per annum or \$₂₀₀₆42,184 per ha per annum. This per ha value is similar in magnitude to the per ha value from a recently completed Contingent Valuation study for the restoration and preservation of the Pekapeka Swamp in Hawke's Bay. Here 'willingness-to-pay' values ranged from \$NZ17,898 per ha per year to \$NZ45,866 per ha per year (Ndebele, 2009).

Table 25: Net⁴³ Wetlands Ecosystem Values based on Patterson and Cole (1999)

Description		Wetlands	Agriculture	Wetlands Net
		(\$ ₁₉₉₄ NZ /ha/annum)	(\$ ₁₉₉₄ NZ /ha/annum)	(\$ ₁₉₉₄ NZ /ha/annum)
Indirect				
Gas regulation	Regulation of atmospheric chemical composition	464	12	452
Disturbance regulation	Capacitance, damping, and integrity of ecosystem response to environmental fluctuations	12,699		12,699
Erosion control	Retention of soil within an ecosystem	0	430	-430
Soil formation	Soil formation processes	0	2	-2
Water regulation	Regulation of hydrological flows	54	5	49
Water supply	Storage and retention of water	13,331 ^[1]		13,331
Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess nutrients	2,910	153	2,757
Pollination	Habitat for resident and transient populations	0	44	-44
Biological control	Trophic-dynamic regulators of populations	0	40	-40
Refugia	Habitat for resident and transient populations	765		765
Direct				
Recreation	Provides opportunities for recreational activities	855	3	852
Cultural	Provides opportunities for non commercial activities	3,084	3	3,081
Passive	Not related to actual use of biodiversity	890	890 ^[2]	0
Total		35,053	1,583	33,470

Descriptions as in Costanza et al. (1997)

[1] 80 percent of water supply only. Remaining 20 percent assumed to be on a paid for basis and included in GDP (see Patterson and Cole, 1999: 20).

[2] The Patterson and Cole study does not put a value on the Passive contribution made by agricultural

land. For the GPI it is argued that agricultural land has a high scenic value in New Zealand so it has been valued at equal to that of wetland.

For each year the marginal loss is given a higher value due to scarcity. The dollar value per ha (expressed in real \$₂₀₀₆) was adjusted by 2 percent per annum from 1970 onwards.

For the period 1990 to 2006 the total cost of wetland loss has been estimated at \$3,496 million (Table 26).

⁴³ Net Wetland ecosystem value reflects the difference between ecosystem services provided by unmodified wetlands and those provided by the agricultural land that wetlands have been converted to.

Table 26: Total Cost of Wetland Loss, 1990-2006

Calendar Year	Remaining wetland	Annual loss of wetland	Cumulative annual loss of wetland	Per ha value of wetland (2% increase per annum)	Total cost of wetland lost per year
	(hectare)	(hectare)	(hectare)	(NZ\$ ₂₀₀₆)	(NZ\$ ₂₀₀₆ mil)
1990	30,708	207	4,343	38,910	139
1991	30,501	207	4,550	39,704	147
1992	30,294	207	4,757	40,514	156
1993	30,087	207	4,964	41,341	164
1994	29,881	207	5,170	42,184	173
1995	29,674	207	5,377	43,028	182
1996	29,467	207	5,584	43,889	191
1997	29,260	207	5,791	44,766	200
1998	29,053	207	5,998	45,662	210
1999	28,846	207	6,204	46,575	219
2000	28,640	207	6,411	47,507	229
2001	28,433	207	6,618	48,457	239
2002	28,226	207	6,825	49,426	249
2003	28,226	0	6,825	50,414	249
2004	28,226	0	6,825	51,423	249
2005	28,226	0	6,825	52,451	249
2006	28,226	0	6,825	53,500	249
Total					3,496

Cost of Loss of Soils

The Waikato Region is the fourth largest in New Zealand with a total land area of 2.5 million hectares (Environment Waikato, 1998). As shown in Table 27 soils in the Region support a range of agriculture, arable, forestry and horticultural activity.

Table 27: Waikato Region Agricultural Landuse (2007)

Agricultural Landuse	Hectares
Grassland	1,140,847
Tussock and danthonia	3,331
Grain seed and fodder crop	18,134
Horticultural land	9,791
Plantations of exotic trees intended for harvest	281,845
Mature native bush	64,638
Native scrub and regenerating native bush	42,536
All other land	39,231
Total land	1,600,354

Source: Statistics New Zealand, 2007

Agricultural soils are ‘natural capital’ and an asset to be maintained and protected so they can continue to support a variety of land-use options in the future. Sustainable land management in rural and urban areas is threatened by inappropriate subdivision and associated activities, erosion, management decisions leading to over-grazing, under- or over-application of fertiliser, and other practices that result in the land being used beyond its sustainable capacity. The GPI increases the personal consumption component to reflect the monetary benefits from building construction, agricultural production, forestry output, property transactions, etc. However, if natural capital is depleted as a result of generating these benefits, this side of the balance sheet must also be accounted for.

The GPI adjusts for the loss of soils resulting from two economic activities: (i) the loss of fertile soil to the built environment, and (ii) erosion from agricultural land. The loss has been estimated from 1970 onwards because, once lost, the loss of the flows of services of agricultural soils is on-going and 1970 was taken as the start point for calculations.

(i) The loss of fertile soil to the built environment

Loss of soils in the Waikato Region has been predominantly land suited to arable use (Class I-IV as assessed in the Land Use Capability (LUC) classification in the New Zealand Land Resource Inventory (LRI v1, 1975-79). Table 28 gives data points to show land use change

over the 15 years 1991-2006. Only land change from rural to subdivided land in Classes I-IV has been included as a loss of natural capital as this is the valuable agricultural land. As Table 28 shows the rate of loss of arable land is increasing overtime. A curve was fitted to these data points to estimate the annual loss of land to subdivision for the 1970 to 2006 time period.

Table 28: Land Change in Waikato Region, 1991-2006

Year	Total ha land change	Percentage Class I-IV	Total ha change Class I-IV	Average loss per year Class I-IV
1991-1996	1,864	67%	1,249	250
1996-2001	2,181	75%	1,636	327
2001-2006	2,936	85%	2,496	499

Source: Environment Waikato, n.d.

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 \$₂₀₀₅1,792/ha/yr and \$₂₀₀₅20,254/ha/yr for conventional farmland. For the Waikato Region GPI an average of \$₂₀₀₅11,023/ha/yr (\$₂₀₀₆11,290/ha/yr) was used to value farmland lost to built-up uses. This is likely to be conservative as land in the Region around urban areas is well suited to dairy farming and the total economic value is likely to be closer to the upper range value estimated by Sandhu *et al.* (2007). The estimated ecosystem services 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). For each year, the total loss is the cumulative sum of the current year's loss, plus previous years' losses, from 1970.

(ii) Erosion from agricultural land

Loss of soil via erosion can be from either natural causes or from unsustainable land-use practices. Not all soil erosion can be attributed to economic activity as New Zealand has a high background erosion rate resulting from geologically young landforms, tectonism, a steep topography and a maritime climate. It is estimated that the total input of river suspended sediment to the New Zealand coast is about 209 million tonnes per year (Hicks and Shankar, 2003). Much of this comes from areas that are not farmed. Only erosion as a result of farming as an economic activity has been included. Erosion resulting from farming has two main impacts: (i) the permanent loss of the asset (soil) for use, and (ii) damage that requires defensive expenditure by other sectors of the economy to correct, such as additional water treatment for silt removal or loss of water quality (Krausse *et al.*, 2001). There is also erosion associated with construction and deforestation activities, but this is not included as it is dwarfed by erosion from farming and data are not available.

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. Erosion costs have been 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 and Betts, 2007). The model covers sedimentation of waterways and soil transfer to the marine environment. Soil loss from forestry is included, but no account is taken of the extra soil loss in conversion from forestry to pasture. The model does not take into account wind erosion, but this is small by volume, compared to water erosion (Dymond, Landcare Research, pers. comm., 2007).

The total area of farmland in the Waikato Region was obtained from Statistics New Zealand (Infos AGRA.SGAJRC) for 1990–1996 and 2002–2006. Years in between have been estimated. The percentage of farmland in grassland was assumed to be 70 percent based on the average of the 4 years of data from Agricultural Census Surveys (Statistics NZ, 1994, 2002, 2003, 2007). In the valuation the following impacts of agriculture-induced erosion have been allowed for: (i) permanent loss to future agricultural output, (ii) the downstream costs imposed on other sectors, and (iii) the cost of defensive expenditure undertaken to prevent further erosion. Most erosion takes place on-farm and most erosion control efforts are to maintain farm productivity. However, off-farm damage from erosion is generally greater than on-farm damage (Phillips and Marden, 2006) and the downstream costs and defensive expenditure are imposed on other societal members.

Krausse *et al.* (2001, p.38) estimated the annual economic cost of erosion and sedimentation in New Zealand in 1998 to be \$126.7 million. This estimate covers the “total impact regardless of erosion cause or type” (Krausse *et al.*, 2001, p.14). As this erosion cost is the result of both natural activity and agricultural land use, the \$126.7 million figure has been reduced. There were an estimated 209 million tonnes of soil lost in 1998 (Krausse *et al.*, 2001), and we have assumed this to be a typical year. Agricultural land use-related erosion accounted for 36 percent (75 million tonnes) of the total in 1998, therefore, 36 percent has been used to proportion the total cost of erosion where relevant (Table 29). This equates to \$₁₉₉₈1.15 or \$₂₀₀₆1.37 per tonne of erosion.

Table 29: Estimate of the Cost of Agricultural Erosion in New Zealand

	Total cost of erosion (natural and land-use induced)	Proportion of total erosion costs assigned to land-use	Total cost of erosion assigned to land-use
	(\$ ₁₉₉₈ mil)		(\$ ₁₉₉₈ mil)
Damage costs (lost production, repair costs)			
Agricultural production loss	37.0	100%	37.0
Farm infrastructure damage	5.6	100%	5.6
Private property damage	5.7	36%	2.0
Road/rail infrastructure damage	26.3	36%	9.5
Utility network damage	0.8	36%	0.3
Recreational facility damage	0.4	36%	0.1
Defensive expenditure from sediment effects			
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
Soil conservation costs			
Regional authority expenditure	18.5	100%	18.5
East Coast Forestry (ECF) from 1991	2.7	100%	2.7
Road preventative maintenance	2.3	36%	0.8
Total	126.7		86.4

Source: Krausse et al. (2001)

Notes on Table 29:

- Agricultural production loss: occurs on farms only and includes losses to vegetative production and animal performance. As erosion scars can take 100 years to reach 80 percent of their former productivity (Parfitt, 2005), mass movement erosion (\$12.5 million) has been included as 100 percent. Surface erosion accounts for the remaining cost (\$24.5 million) and it is assumed this soil is either washed or blown away and the loss permanent so 100 percent of the estimated cost is used.
- 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 percent related to agriculture land-use erosion.

- Private property damage: includes direct damage to buildings and dwellings from erosion. Of this, 36 percent was assumed to be related to agriculture land-use erosion.
- Road and rail infrastructure damage: covers damage to the transport network from erosion. Of this, 36 percent was assumed to be related to agriculture land-use erosion.
- Utility network damage: major erosion-related damage relates to slips dislocating poles or lines for telephone and electricity generation. Due to utility location in settled areas this is likely to be damaged from agriculture land-use sourced erosion so 36 percent of this cost was assigned.
- Recreation facility damage: this is most likely to be impacted on by natural erosion events so 36 percent of the damage cost was assigned to land-use.
- For the defensive expenditure from sediment effects it was assumed that natural erosion accounted for 64 percent and land-use effects were responsible for 36 percent.

The costs used for erosion are conservative given that the Krausse *et al.* (2001) monetary value excludes a number of 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, plus the ability to filter and degrade wastes. Erosion as a result of agricultural production also causes a loss of visual amenity due to the scarred landscape, damage to aquatic life, loss of traditional food sources, loss of recreational use, the need for research into erosion prevention, and flood prevention. Neither the direct nor indirect costs of these activities have been included.

For the period 1990 to 2006 the total cost of soil loss has been estimated at \$5,040 million (Table 30).

Table 30: Cost of loss of soil from urban expansion and erosion, 1990-2006

Calendar Year	Annual Loss of soil to erosion	Cumulative loss from erosion	EW annual loss to urbanisation	Cumulative loss since 1970	Loss from Sandhu et al (2007) @ \$11,290/ha	Total soil loss cost
	(NZ\$ ₂₀₀₆ mil)	(NZ\$ ₂₀₀₆ mil)	(hectare)	(hectare)	(NZ\$ ₂₀₀₆ mil)	(NZ\$ ₂₀₀₆ mil)
1990	9	178	178	1,400	16	194
1991	9	187	196	1,596	18	205
1992	10	197	216	1,812	20	217
1993	11	207	236	2,047	23	230
1994	9	217	257	2,304	26	243
1995	9	226	279	2,583	29	255
1996	9	235	302	2,884	33	268
1997	9	244	326	3,210	36	280
1998	9	253	350	3,560	40	294
1999	9	263	376	3,937	44	307
2000	9	272	403	4,340	49	321
2001	9	281	431	4,771	54	335
2002	9	290	460	5,230	59	349
2003	9	299	489	5,719	65	364
2004	9	308	520	6,239	70	378
2005	9	317	551	6,791	77	393
2006	9	325	584	7,375	83	408
Total						5,040

Cost of Loss of Air Quality⁴⁴

Fine Particulate Matter (PM₁₀) measures have been used to calculate the cost of air pollution in the Waikato Region between 1990 and 2006. Though not so readily detectable by the senses, 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 (Hales *et al.*, 1999). In addition to increasing the mortality rate, fine particles also increase hospital admissions and emergency department visits, school absences, lost work days and can restrict activity (Auckland Regional Council, 2006, p.4). The analysis here assumes a direct and linear trend for air pollution, but in reality there are large year-to-year variations.

In the Waikato Region the main sources of PM₁₀ are vehicles, home heating, and industry, with home heating being the largest contributor in most monitored airsheds in the Region (Environment Waikato, 2007).

PM₁₀ data were available for eight urban areas starting in various years – the earliest being 1998 – and running till 2008 (EW, pers. comm., 26 August 2009). The data for each of these towns was extrapolated back to 1990 using a simple linear regression to give a complete time-series for 1990–2008 for each town. The urban area with the longest data series was Hamilton, which – mostly because it has the largest population in the Waikato Region – also had the highest expected number of deaths from air pollution in the region⁴⁵. Mortality and Restricted-Activity Days (RADs) rates per unit of PM₁₀ per capita were back-calculated from the results given by Fisher *et al.* (2007) for each of the five urban areas with more than three years of data (Hamilton, Taupo, Tokoroa, Te Kuiti, Matamata). These rates were applied to time-series of PM₁₀ and population from 1990–2008 to obtain estimated deaths and restricted-activity days for the Region.

The economic impact of air pollution calculated by Fisher *et al.* (2007) for New Zealand in 2001 was \$1,139.2 million. The estimated effects are for all of New Zealand – not just in the main cities. The health impact assessment in that study examined 67 urban areas chosen based on either their size, local activities, and/or monitoring data that shows high levels of air pollution. The study areas comprise 2.7 million people (as of the 2001 census), or 73 percent of the population of New Zealand (Fisher *et al.*, 2007, S2). Health impact estimates are based on exposures which they derived from modelling, and then validated against monitoring and published dose-response relationships. Mortality rates are based on the dose-response⁴⁶ work of Künzli *et al.* (2000), which extrapolated an increase in mortality of 4.3 percent for every additional 10µg in annual average PM₁₀ concentration. Although that study was not New

⁴⁴ Greenhouse gas emissions and ozone depletion are accounted for elsewhere in the GPI. Although greenhouse gases, including carbon dioxide (CO₂), are sometimes referred to as ‘air pollution’, they are not pollutants in the traditional sense, and do not generate the local effects usually associated with air pollution.

⁴⁵ According to Fisher *et al.* Fisher, G., Kjellstrom, T., Kingham, S., Hales, S., Shrestha, R., Sturman, A., Sherman, M., O’Fallon, C., Cavanagh, J.E., Durand, M., 2007. Health and Air Pollution in New Zealand. Health Research Council of New Zealand, Ministry for the Environment, Ministry of Transport Wellington, NZ., “The overall burden of health effects is borne by the larger urban areas, principally because of the size of the populations.”

⁴⁶ The dose-response relationship is the relationship between the dose (or quantity of exposure) and the proportion of individuals in an exposed group that develop a specific effect due to exposure (Yassi *et al.*, 2001 cited in Fisher *et al.* 2007)

Zealand specific, the results are regarded as applicable, though likely to be conservative, to New Zealand (Fisher *et al.*, 2007).

Putting a value on life, as has been done for the air quality calculations, is problematic but common. Life valuation studies are highly susceptible to framing effects. For example, people's 'willingness-to-pay' for road safety improvements can be very different from that for air quality improvements. A study by the National Occupational Health and Safety Advisory Committee put the value of a life in New Zealand at \$₂₀₀₄₋₂₀₀₅ 3.9 million (Access Economics *et al.*, 2006, p.27). Fisher *et al.* (2007) used the Land Transport New Zealand value of statistical life (VoSL) of NZ₂₀₀₄\$2.725 million. This value was derived from a 'willingness-to-pay' study carried out by Guria (1991). The estimate is largely based on sample surveys of what New Zealanders were 'willing to pay' to buy road safety for their families. This value reflects personal loss, but does not include lost economic output.

As the group most generally affected by air pollution tend to be the older age group, Fisher *et al.* (2007) assumed a loss of 5 years would be typical for air pollution. The working value used by Fisher *et al.* (2007) was \$2.725 million per statistical life (VoSL) over a 44-year life span. Using a 6 percent discount rate, the value for loss of five years of life of \$750,000 per person was arrived at for death from air pollution. To be consistent in approach, this GPI study has not applied discounting to years of life. Hence the value per loss of life is less at \$308,000 per person for a loss of 5 years of life (\$2.725 million/44years x 5 years).

Restricted-activity days have been estimated as \$220 for a 'work loss' day and \$60 for a 'minor restriction' day by Fisher *et al.* (2007). To avoid double-counting the number of restricted-activity days has been reduced to exclude 'work loss' days as this cost is already reflected in reduced GDP.

Using values of \$308,000 per death and \$60 per restricted-activity day, the costs of air pollution for the Waikato Region are shown in Table 31.

For the period 1990 to 2006 the total cost of air pollution for the Waikato Region has been estimated as \$₂₀₀₆443 million.

Table 31: Estimated annual cost of deaths and restricted-activity days (RADs) attributed to air pollution, 1990–2006

Calendar Year	Estimated Waikato Region deaths	Estimated Waikato Region minor restriction RADs	Total cost	
			(NZ\$ ₂₀₀₁ mil)	(NZ\$ ₂₀₀₆ mil)
1990	48	106,436	20	22
1991	48	108,065	20	22
1992	49	109,316	20	23
1993	50	110,713	21	23
1994	51	112,438	21	23
1995	51	114,233	21	24
1996	53	118,351	22	24
1997	55	120,965	23	25
1998	56	125,193	23	26
1999	58	128,878	24	27
2000	54	119,109	22	25
2001	59	131,832	25	27
2002	61	135,901	25	28
2003	63	139,695	26	29
2004	71	160,529	30	33
2005	62	140,045	26	29
2006	73	162,844	30	34
Total				443

Cost of Land Degradation

The real costs associated with solid waste and contaminant generation from both households and businesses as a result of economic activity are often not experienced until a later period in time. The GPI allocates solid waste and contamination of land to the period of time the pollution was most likely generated. Waste to landfills and the estimated cost of cleaning up contaminated sites are used as proxies for this cost.

Economic activity in the Waikato has left a legacy of contaminated sites (landfills, service stations, sawmills, timber treatment plants, railway yards, engine works, metal industries, and chemical manufacturers). Such contaminated sites are the result of:

- Previously accepted and lawful disposal methods which have since been deemed inappropriate.
- Poor systems for managing and using hazardous chemicals.
- Unregulated industries that produce waste without adequate disposal systems.
- Unlawful disposal methods.
- Disposal at landfills being more cost effective than reducing waste.
- Cross-subsidisation of waste disposal by ratepayers.

Contaminated sites impact on the environment in a number of ways. Toxic chemicals and leachate⁴⁷ from the sites can have undetected health effects, the sites cannot be used for other purposes, property values in the vicinity of contaminated sites are reduced, and the cost of remediation is often covered by the tax payer which diverts government expenditure from other more beneficial uses. Providing pesticides, herbicides and timber treatment to the forestry, farming and horticulture sectors has left large clean-up costs as well as damage to the health of people and the environment.

Landfill sites receive contaminated material and, when poorly managed, can have serious environmental consequences from leachate discharge and stormwater run-off. Many Municipal Solid Waste (MSW) sites in New Zealand prior to the Resource Management Act (RMA) (1991) were gullies with streams flowing through that were not managed to a high standard and as a result pollution from these sites still seeps into groundwater and run-off. According to the Ministry for the Environment (2001, p.9), 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 bioaccumulative compounds”.

⁴⁷ Liquid that drains or leaches from a landfill.

(i) Waste to landfill

This method assumes that the environmental impact of solid waste is a function of the quantity of waste that makes its way to landfill sites. The measured volume of solid waste sent to landfill (household and industrial) is less than what is produced, as most farms dispose of their rubbish onsite by burial.

Data for solid waste for 1995/96 gave an estimate of 150,702 tonnes to Municipal landfills in the Waikato Region (Waste Not Consulting, 2005). Data available for 2004 gave an estimate of 221,000 tonnes, 2005: 218,000 tonnes and 2006: 222,000 tonnes (Sinclair Knight Merz Ltd, 2007). These figures do not include industrial waste. Industrial waste for 2006 was estimated at 155,000 tonnes (Sinclair Knight Merz Ltd, 2007).

As no annual data is available for the Waikato Region the annual average waste per head of population for New Zealand was used (Ministry for the Environment, 2008) and multiplied by the Waikato Region population statistic to get annual figures. This gave a figure of 297,747 tonnes for 2006 compared to the reported 377,000 tonnes (Sinclair Knight Merz Ltd, 2007) which is 21 percent less so costs are likely to be underestimated. Since 2005/06 the Auckland Region has been disposing of solid waste in the Hampton Downs landfill which is in the Waikato Region. This amount is added to the total as the Waikato Region benefits from this economic activity so therefore assumes responsibility for the environmental impact.

Monetary valuation should reflect the true cost of waste disposal rather than the actual amount charged. An estimate of the true costs of disposing waste into landfills was obtained from the report 'Changing behaviour: Economic instruments in the management of waste?' (Parliamentary Commissioner for the Environment, 2006). A system of full cost accounting (FCA) has been developed 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). FCA encourages both waste reduction initiatives and the minimisation of environmental effects by ensuring full environmental costs are, as far as practicable, reflected in the charges applied (Ministry for the Environment, 2004, p.3). However, while this approach is more comprehensive taking into account social, environmental and cultural costs covered by the consent process and monitoring requirements there are many costs not able to be valued. Neither does it include the indirect or social costs of solid waste disposal that may impact at a global rather than local scale.⁴⁸

The Waikato GPI study used the cost of disposing of a tonne of waste at the Kate Valley regional landfill (\$₂₀₀₅125 per tonne or \$₂₀₀₆128 per tonne) because the FCA guide was used extensively to establish costs when the landfill was proposed (Centre for Advanced Engineering, 2005). The Kate Valley landfill cost is at the upper end of disposal costs as can be seen from Table 32.

⁴⁸The GPI is calculated within regional or national boundaries. Therefore electronic waste generated in New Zealand and sent overseas which causes pollution in the receiving country is not covered .

Table 32: Disposal cost per tonne at major city landfills

Landfill	\$ ₂₀₀₅ per tonne
Auckland (Redvale)	90.0
Hamilton	95.5
Wellington (Southern)	101.0
Christchurch (Kate Valley)	125.0
Dunedin (Environwaste)	75.0

Source: Parliamentary Commissioner for the Environment, 2006, p.31

(ii) Contaminated sites

Work is undertaken in the Waikato Region each year to reduce the number of contaminated sites (Table 33). The exact cost of this is not recorded and costs vary significantly at each site depending on the extent of contamination. For some sites remedial action has amounted to hundreds of thousands of dollars while for others it has been minimal – just the cost of a digger and truck to remove the contamination. Since the introduction of the RMA in 1991 site contamination by industry has been controlled.

Table 33: Remediated Contaminated Sites in the Waikato Region

Year	Number remediated per year	Cumulative Total
1998	7	7
1999	11	18
2000	27	45
2001	10	55
2002	20	75
2003	3	78
2004	13	91
2005	22	113
2007	18	131
2008	15	146

Source: Environment Waikato, 2009c

A study by Worley Consultants Ltd, published in 1992, identified 7,200 potentially contaminated locations in New Zealand. Of the 7,200 sites identified 520 were located in the Waikato Region. Approximately 114 of these were considered of high risk to human health and/or the environment (Worley Consultants Ltd, 1992). An investigation of contamination from the use of timber treatment chemicals in New Zealand was carried out at the same time. It identified there were approximately 600 sawmill and timber treatment sites where Pentachlorophenol (PCP) was widely used for 30-40 years as an anti-fungal agent (National Task Group, 1992). PCP use ceased in 1988 as worker health concerns became known but residues remained in soils, sludge, sawdust and groundwater (National Task Group, 1992). The number of high risk timber treatment sites in the Waikato Region was taken to be 15 percent based on the percentage of New Zealand wood processing plants located in the Region in 1999.

The Waikato Region share of contaminated site costs as calculated by Worley Consultants Ltd is shown in Table 34. The uncertainty of the estimate is given as ± 50 percent (Worley Consultants Limited, 1992, p. 6.8).

Table 34: Number of and estimated cost of remediating contaminated sites

Category	Number NZ	Estimated Number EW	Cost NZ (NZ\$ ₁₉₉₂ mil)	Cost EW (NZ\$ ₁₉₉₂ mil)
High risk	1,580	114	515	29
High risk – timber treatment	600	92	105	16
Moderate/slight risk	5,620	406	1,000	72
Site assessment costs			24	2
Total	7,800	612	1,644	119

Source: Worley Consultants Limited, 1992, Table 6.3 and Section 6.4

The Waikato Region's contaminated sites costs have been apportioned annually in the same way as the New Zealand \$₁₉₉₂1644 million. For the New Zealand GPI the temporal pattern of pollution at major contaminated sites was used to spread the \$₁₉₉₂1644 million estimate annually between 1951 and 1988. The remedial cost for each site was divided by the number of years in operation. Costs were summed on an annual basis across all sites and the percentage of the total cost occurring in each year used for apportioning purposes. It has been assumed that the more recent annual cost of contamination has been low – a result of tighter requirements of the RMA (1991). For New Zealand this has been estimated at \$10 million per year since 2000 and accounts mainly for accidental spills and low-level effects from industry. A linear trend was used to estimate annual costs for the 1989 to 1999 period.

For the GPI, the cost of solid waste to landfill and the cost of remedial action to remove contamination from known sites have been summed to arrive at the annual estimates of pollution from solid waste in New Zealand.

For the period 1990 to 2006 the total cost of pollution from solid waste has been estimated at \$800 million (Table 35).

Table 35: Total Cost of Pollution from Solid Waste, 1990-2006

Calendar Year	Waste to landfill	Cost/ tonne as per Kate Valley	Contaminated sites costs	Total Cost
	(tonnes)	(NZ\$ ₂₀₀₆ mil)	(NZ\$ ₂₀₀₆ mil)	(NZ\$ ₂₀₀₆ mil)
1990	294,832	38	3	41
1991	297,698	38	3	41
1992	301,345	39	2	41
1993	303,794	39	2	41
1994	305,893	39	2	41
1995	308,237	39	2	41
1996	304,293	39	2	41
1997	301,680	39	1	40
1998	299,170	38	1	39
1999	296,326	38	1	39
2000	293,043	38	1	38
2001	289,629	37	1	38
2002	286,373	37	1	37
2003	293,466	38	1	38
2004	301,068	39	1	39
2005	776,507	99	1	100
2006	806,747	103	1	104
Total				800

Cost of Climate Change

Increased fossil fuel use, cement manufacturing, deforestation and farming have led to a global rise in carbon dioxide 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. While accounting for only 0.2 percent of the world's total greenhouse gas (GHG) emissions, New Zealand ranks 11th in the world on a per-capita basis (Ministry for the Environment, 2007). The GPI takes into account Waikato Region's annual greenhouse gas emissions between 1990 and 2006 as greenhouse gases remain in the atmosphere for a lengthy period of time. This environmental damage is treated by the GPI as an externality attributable to the period of the economic activity that generated the GHG emissions rather than a cost that can be passed on to future generations.

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. This study has used the methodology used in other GPI studies which assumes the dollar value of New Zealand's greenhouse gas emissions between 1990 and 2006 equate with the loss of future well-being generated by climate change.

The greenhouse gas emissions for the Waikato Region have been estimated for each year 1990–2006 based on data in the New Zealand Greenhouse Gas Inventory 1990–2006 (Ministry for the Environment, 2008), MED's Energy Greenhouse Gas reports (MED, 2008), EECA's Energy database (EECA, 2004), and other sources.

The valuation of environmental damage from CO₂ emissions is calculated using the marginal social cost per tonne of CO₂-e emitted into the atmosphere - referred to as the social cost of carbon (SCC). This is a measure of the full global cost today of an incremental unit of carbon dioxide (or equivalent amount of other greenhouse gases) emitted now, summing the full global cost of the damage it imposes over the whole of its time in the atmosphere (Price *et al.*, 2007). The SCC reflects "the total (discounted) value of all future damage arising from that tonne of emissions" (Neumayer, 2000, p.354). Greenhouse gas emissions are therefore not accumulated over time.

Although the SCC is relatively straight forward in principle, in practice it is difficult to ascertain an appropriate value for the SCC because the amount of damage done (both now and in the future) by each incremental unit of carbon in the atmosphere will depend on the outcome of complex system interactions that will vary according to current and future concentrations of GHGs in the atmosphere.

The value of \$NZ₂₀₀₆50 per tonne of carbon dioxide was used based on the Stern Review SCC of \$US₂₀₀₀30 per tonne for a 450ppm CO₂-e stabilisation goal (Stern, 2006, p.304). The average \$US/\$NZ exchange rate from 1990 to 2006 was \$NZ0.58 to \$US1.00, which equates to \$NZ51.72 for 450 ppm CO₂-e. In a recent study using scenario modelling it was estimated technologies already in existence, or at an advanced state of development, could bring global CO₂ emission back to current levels by 2050 at a marginal cost of up to USD₂₀₀₅50 per tonne (\$NZ₂₀₀₅71) (International Energy Agency, 2008). There are numerous prices for carbon that

could be applied as tradable instruments have different risks and volume volatility and operate in a range of global markets. An international price per tonne of carbon is used as climate change is an externality of global proportions and the marginal damage from an extra tonne of GHG is the same regardless of where it comes from. Exchange rate fluctuations for the New Zealand dollar impact significantly on the New Zealand price per tonne.

The steps undertaken in estimating Waikato Region's emissions were as follows:

Energy

Major electricity generation occurs at Huntly and the geothermal fields Wairakei, Ohaaki, Poihipi, Rotokawa, and Mokai. Huntly only used coal between 1990 and 2006, and was the only coal-fired electricity generation plant in New Zealand. Coal and fugitive geothermal emissions data were both taken directly from the MED's Energy Greenhouse Gas report (MED, 2008).

The EECA Energy End-Use Database (EECA, 2004) provides estimates of energy use by region. These have been converted to emissions using standard emission factors. This same proportion of national energy-use emissions (excluding electricity generation) has been used over the period 1990–2006.

Agriculture

Livestock numbers for sheep, beef cattle, dairy, deer, pigs, goats and horses (Statistics New Zealand) were multiplied by year-specific, implied, per-head emission factors derived from the spreadsheets accompanying the national inventory (Ministry for the Environment, 2008).

Nitrogen fertiliser application figures were only available for the Waikato Region for 2002 and 2007 (Statistics New Zealand, Various years). The average of these two dates as a fraction of national application was 21 percent, so Waikato Region emissions from fertiliser application were calculated as 21 percent of national emissions from New Zealand's Greenhouse Gas Inventory 1990–2006.

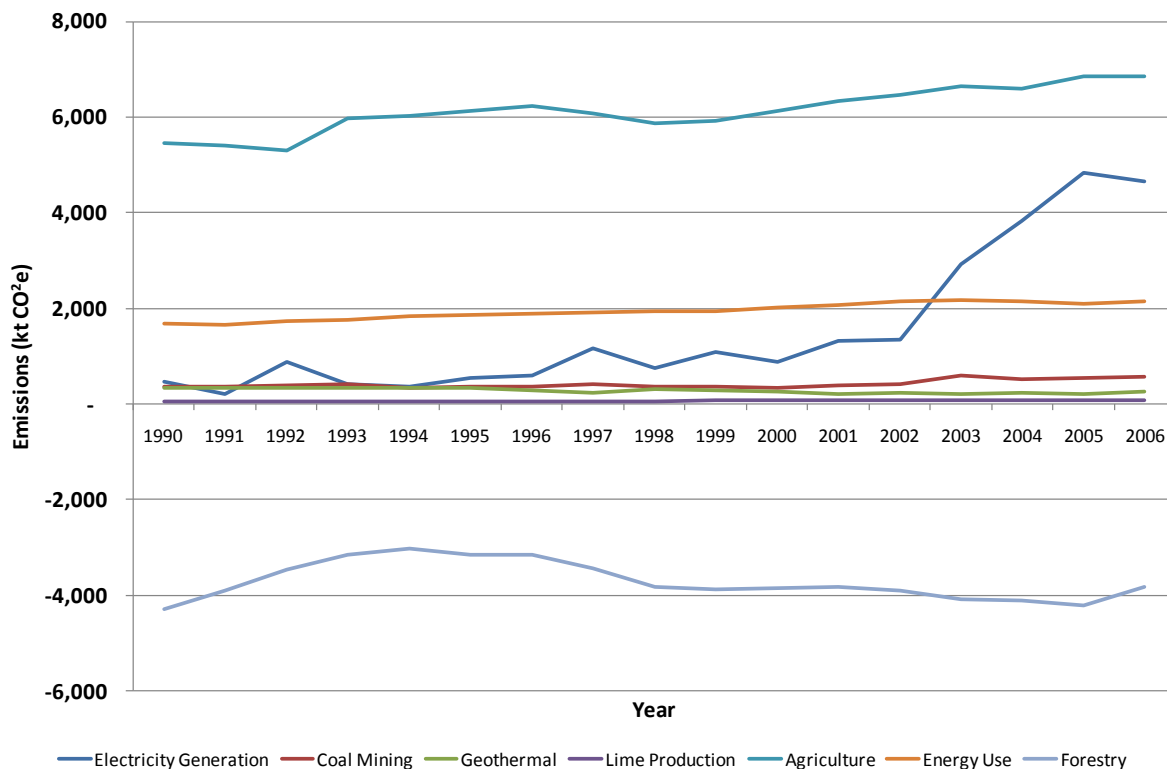
Land use, land-use change and forestry (LULUCF)

The area of plantation forestry in the Waikato Region has decreased over the period of analysis from 21 percent in 1994 to 16 percent in 2007 (Statistics New Zealand, Various years). We have assumed a linear trend over 1990–2006, and that Waikato forestry is identical in composition to the national average, and therefore estimated Waikato Region sequestration as a proportion of the national total sequestration from New Zealand's Greenhouse Gas Inventory 1990–2006 (Ministry for the Environment, 2008). We have excluded emissions from other land-use and land-use change emissions, which are expected to be insignificant in the Waikato Region.

Waste and Solvents

This category contributes less than 3 percent to national emissions. Due to a lack of data for the Waikato Region, we have not included this category in the analysis. Trends for the Region for these categories between 1990 and 2007 and shown in Figure 4.

Figure 4: Waikato Region GHG Emissions and Sequestration, 1990-2006



The cost of climate change is determined by the tonnes of emissions released and the carbon price. The value of \$₂₀₀₆74 per tonne of carbon dioxide (as per the Stern Review) was multiplied by the estimated annual GHG emissions for the Waikato Region.

It could 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 positive stock of carbon still resident in the atmosphere – the higher the historically accumulated carbon concentration in the atmosphere, the higher the social damage caused by each additional unit of emitted carbon (Neumayer, 2000, p.355). The social cost of carbon would therefore rise over time due to increases in marginal damage costs. At the same time, the actual price of carbon can be influenced by economic activity and policies implemented to reduce carbon emissions. The extent of this cost change over the 1990–2006 period has not been estimated.

For the period 1990 to 2006 the total cost of greenhouse gas emissions has been estimated at \$5,672 million (Table 36).

Table 36: Total Value of Long-term Climate Change, 1990-2006

Calendar Year	Net CO ² equivalent emissions	Carbon price per tonne	EW Cost of climate change
	(Gg)	(NZ\$ ₂₀₀₆)	(NZ\$ ₂₀₀₆ mil)
1990	4,070	50	204
1991	4,152	50	208
1992	5,220	50	261
1993	5,825	50	291
1994	5,930	50	297
1995	6,150	50	307
1996	6,232	50	312
1997	6,437	50	322
1998	5,473	50	274
1999	5,775	50	289
2000	5,851	50	293
2001	6,562	50	328
2002	6,800	50	340
2003	8,546	50	427
2004	9,265	50	463
2005	10,391	50	520
2006	10,752	50	538
Total			5,672

Cost of Loss of Water Quality

The inclusion of water quality in the GPI is essential as the availability of clean water is fundamental to every aspect of life. The quality of water is of prime importance to anyone intending to drink water, swim, eat fish, provide water for livestock and food processing, or base their business on tourism. The valuation of water quality for 1990–2006 is problematic because although degradation is known to have occurred there is no recognised way to estimate a dollar value for this deterioration.

The Waikato Region has long term river water quality records from 113 sites starting as early as 1987 for some sites. The impact of land use on waterways in the Region is evident in the Waikato River, the country's longest river. Power stations on the river have impacted water quality by contributing arsenic and slowing water flow which encourages phytoplankton growth. Water quality which is good leaving Taupo deteriorates to not good enough for swimming from Hamilton City to the coast due to high E Coli levels from farm and stormwater runoff, farm dairies and sewage treatment plants. Any drinking water extracted from the Waikato river requires a high level of treatment (Environment Waikato, 2009b). Some water quality measures improved between 1990-2006 with decreases in dissolved colour, biochemical oxygen demand, arsenic, boron and ammonia. Change was attributed to better wastewater management over the past 20 years at known point source discharges (e.g. Hamilton and Taupo wastewater treatment plants, Kinleith mill, Wairakei power station). These improvements were countered by increases in concentrations of nitrate, total phosphorus, E. coli and enterococci from more intensive land-use. These represent deteriorations and major contamination problems (Vant, 2008).

Increases in Nitrate (NO_3) and Dissolved Reactive Phosphorus (DRP) are considered to be of greatest concern for water quality in the Waikato as elevated concentrations of these nutrients are responsible for excessive growth of aquatic plants and algal blooms (Environment Waikato, 2006). The main source of these elements in waterways is attributed to agricultural production. Table 37 gives monitoring results from a range of waterways in the agriculture-intensive Waikato Region.

Table 37: Trends in Water Quality in the Waikato Region

Significant DRP increase in waterway	28%
Significant DRP decrease in waterway	19%
Significant Nitrates increase in waterway	33%
Significant Nitrates decrease in waterway	20%

Source: Gibbard et al., 2006

Rules governing dairy farm effluent treatment were changed in 1994 to restrict effluent disposal to waterways. Farmers converted to land-based disposal but there has been no corresponding improvement in water quality. It has been estimated that reducing nitrogen leaching rates for dairy farms to 26 kg N/leached/ha/yr and sheep and beef farms to 12 kg N/leached/ha/yr would be required to prevent further degradation of water quality in hydro lakes on the Waikato River (Vant, 2006). A recently completed report by AgFirst modelled

scenarios for dairy farms of different intensities and found that farms that were very intensively managed had a reduction in return on investment if N leaching limits were imposed. These farms have a higher profitability than typical. For farms of medium or low intensity changing farm practices to reduce N leaching had the potential to increase in profitability on some farms while others had small reductions in profitability (AgFirst Waikato, 2009). The calculation for change in water quality used in the GPI has been based on remedial action, which reflects the cost of righting or offsetting damage realised at a particular point in time. This does not truly reflect the real cost of damage, as it makes no allowance for damage to the ecology of the waterways over the period. It also does not reflect the cumulative effects of damage over time, or the fact that thresholds may be breached and recovery may need to take place over extended timeframes, if recovery is possible at all.

For the GPI, separate valuations have been conducted for change in water quality for rivers (Part I) and lake water (Part II). This study did not value change in groundwater quality as there is insufficient data. Groundwater issues are discussed briefly at the end of the chapter.

Part I River Water Quality

It is not possible to calculate precisely the extent that water quality deviated from acceptable standards between 1990 and 2006; nor is it possible to place an exact dollar value on this cost. For these reasons, to calculate the cost of river water degradation, the more holistic approach of estimating the monetary cost of establishing riparian margins to prevent non-point pollution has been used. Riparian planting reduces nutrient flow and provides some shade for waterways which cools water temperatures. Point pollution costs have been linked to this cost.

Table 38 from Cooper (1992, cited in Ministry for the Environment, 1997), shows 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.

Table 38: Estimated yearly nitrogen loadings to New Zealand surface waters, 1992

	(tonnes)
Non-point sources	122,000
Agriculture	100,000
Native forest	15,000
Exotic forest	7,000
Point Sources	10,200
Agriculture	7,000
Sewage/urban	2,400
Pulp and paper	800

Source: Ministry for the Environment 1997: p.7.38

Riparian planting is currently the main approach to reducing water degradation as set out in the Clean Streams Dairy Accord. Poor water quality has been linked particularly to the intensification of dairy farming in lowland areas (Ministry for the Environment, 1997). This finding was corroborated by a report published in 2005 that gathered results from 996 regional council and NIWA monitoring sites between 1996 and 2002 (Larned *et al.*, 2005). Lowland rivers surrounded by pasture did not compare well with other waterways.

The following pertains to the *non-point method* of calculating river water quality:

Step 1:

The total low-elevation river length in the Waikato Region classified as pastoral is approximately 19,486 kms. The total bank length of rivers is therefore 38,972 km.

Step 2:

There is debate over the ideal width of riparian zones, but generally 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 percent of nitrate, while forested buffers of 10 m have achieved over 70 percent removal of N (Parkyn, 2004). 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).

This study assumes a riparian management strategy involving the construction of a single-wire electric fence and the planting of a 15-m-wide strip of native vegetation.

Step 3:

Cost estimates for riparian planting were obtained from the Farm Environment Award Trust worksheet for working out the cost of managing waterways on your farm (Farm Environment Award Trust, 2004). This information was provided on the Environment Waikato website to assist farmers making riparian management decisions.

Fencing = \$₂₀₀₄1.60 per metre or \$1,600/km (2.5 mm wire, No. 2 round posts at 8 metre spacing). 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). 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.

Fencing costs:

The total length of river is 19,486 km. Therefore, the total length of the river bank is twice the river length, which is 38,972 km.

At \$3,200/km = cost of \$₂₀₀₄124,710,400

Converting this to \$₂₀₀₆ = \$124,710,400 × (1000/959)
 = \$130,042,127

Number of plants:

Calculations for a 15 m riparian zone:

At 2 m spacing, this is 7.5 trees wide

Number of trees long = 38,972,000 m of bank ÷ 2 m spacing
= 19,486,000 trees long

Total number of trees = 7.5 × 19,486,000
= 146,145,000 trees

Planting Costs:

At a cost of \$3.50 per tree and \$2 labour per plant, planting would cost:

Total cost of planting = 146,145,000 trees × \$₂₀₀₄5.50 per tree
= \$803,797,500

This cost in \$₂₀₀₆ = \$803,797,500 × (1000/959)
= \$838,162,148

Step 4:

Fencing off a riparian zone results in a loss of productive farmland.

= 15 m (width) × 38,972,000m (length)
= 584,580,000 m² or 58,458 ha

Agricultural statistics (Statistics New Zealand) show that as at 30 June 2007, there were 1,600,354 hectares of farmland in the Waikato Region (Infos AGRA.SGAJRC). Of this, as shown in Table 39, dairy farming occupied 431,719 hectares.

Table 39: Hectares in dairying in the Waikato Region

LIC herd analysis district	Total effective hectares 2006/07
Franklin	28,101
Waikato	74,132
Hamilton City	983
Waipa	60,542
Otorohanga	43,109
Thames-Coromandel	8,577
Hauraki	42,123
Matamata-Piako	93,324
South Waikato	41,311
Taupo	30,844
Waitomo	8,673
Total	431,719

Source: Livestock Improvement 2006/07

This means that as a proportion, sheep and beef farming occupied approximately 73 percent of the land area, while dairy farming occupied the remaining 27 percent. The value-added estimates (in NZ\$₂₀₀₃) were obtained from the Nimmo-Bell report on 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 = \$₂₀₀₃6,600 per hectare. Loss of value added for sheep and beef farming = \$₂₀₀₃1,100 per hectare.

The loss of agricultural land value is calculated by multiplying 83 percent of the land area by the value added estimate for sheep and beef farming, and 27 percent of the land area by the value added estimate for dairy farming, as below:

$$(58,458 \text{ ha} \times 0.73) \times \$1,100/\text{ha} = \$46,941,774 \text{ lost value added from sheep and beef} +$$

$$(58,458 \text{ ha} \times 0.27) \times \$6,600/\text{ha} = \$88,739,244 \text{ lost value added from dairy farming}$$

This sums to a total loss of value added from agricultural farming of \$135,681,018.

Converting this NZ\$₂₀₀₃ figure into NZ\$₂₀₀₆: $\$135,681,018 \times 1000/925 = \$146,682,182$.

Step 5:

Multiplied over the time period (from 1990 to 2006 inclusive) gives a total value added cost of $\$146,682,182/\text{year} \times 17 \text{ years} = \$2,493,597,088$.

Step 6:

Total cost for this riparian management strategy:

$$= \text{electric fence} + 15\text{-m strip of riparian planting} + \text{loss of farm land}$$

$$= \$130,042,127 + \$838,162,148 + \$2,493,597,088 = \$_{2006}3,462\text{million}$$

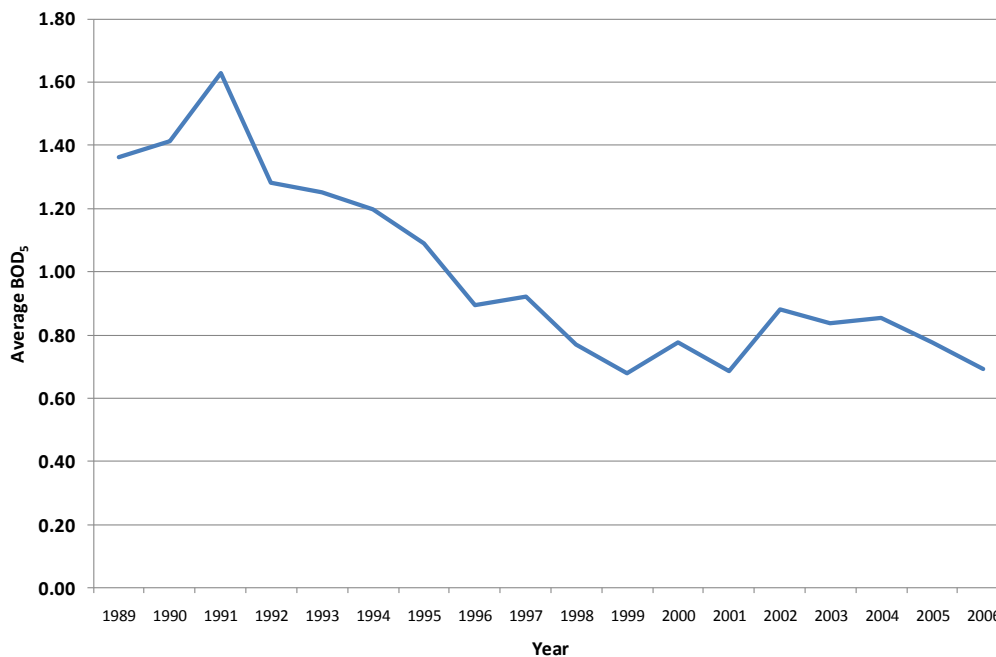
Step 7:

Water pollution levels from non-point sources vary over time with farm management practices. To allow for variation between 1990 and 2006, the total cost of riparian planting (Step 6) was proportioned over this period on the basis of annual nitrate leaching and run-off estimates from Waikato stockunits as calculated by Parfitt *et al.* (2006) and nitrogen fertiliser application estimates (O'Hara *et al.*, 2003). The split used was calculated from the OVERSEER model and attributed 80 percent to stock effects and 20 percent to fertiliser impacts (Roger Parfitt, 2008, pers. comm.). While water degradation caused by agricultural land use would have taken place before 1990, the impact of this has not been calculated.

The following pertains to the *point method* of calculating river water quality:

The contribution of point source pollution to the annual nitrogen loading of surface waters in New Zealand is estimated at 10.2 percent of agricultural non-point sources (see Table 38). This ratio was used to get the total monetary value of loss of water quality between 1990 and 2006 from point source pollution (assumed to be 10.2 percent of \$3,462 million or \$353 million) for the Waikato Region. To allow for changes in water quality over the 1990–2006 period, this study has extrapolated and applied the trend, as shown in Figure 5, of Biochemical Oxygen Demand (BOD₅) in the Waikato River to this amount.

Figure 5: Mean BOD₅ in the Waikato River, 1989–2006



Source: Environment Waikato, 2009

The trend gives pollution damage from point sources declining over time but damage still occurring, for example, from elevated phosphorous levels in treated sewage returned to waterways.

Part II Lake Water Quality

The Waikato Region has many shallow lakes that are eutrophic as a result of the conversion of forested land to agriculture. The drainage of wetlands, farming to lake perimeters and runoff from fertilizers and animal excrement all accelerate nutrient enrichment and siltation. Also located within the Region is Lake Taupo which has water quality among the best in the North Island. Lake Taupo is a popular tourist destination and while water quality is still good it is deteriorating which is a major concern.

An assessment of lake water quality undertaken by Jenkins and Vant (2006) covered larger lakes in the Region and rated them as High, Medium or Low for water quality. There were 3 lakes with high water quality, 7 with medium water quality and 21 covering a total of 62.51 km² with low water quality. There were 12 other lakes covering 1.68 km² that were not classified.

To calculate the cost of lake water degradation in the Region, estimates for the cost of cleaning up Lake Taupo and the Rotorua lakes have been used.

Strategies to maintain the current water quality in Lake Taupo have been estimated at \$₂₀₀₃72 million over a 10 year period, funded by rates in the Region, and a further \$₂₀₀₃83 million over a 15 year period from central government (Environment Waikato, 2003).

It has been estimated that the cost of restoring the Rotorua lakes to water quality levels of the 1960s would 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). As shown in Table 40 these lakes cover a total surface area of 124.83km².

Table 40: Surface areas of Rotorua lakes km²

Lake	Total surface area (Km ²)
Rotorua	79.78
Rotoiti	33.48
Rotoehu	8.11
Okareka	3.46
Total	124.83

The following pertains to the calculating lake water quality:

Calculations

Step 1:

The cost for improving the water quality in the four Rotorua lakes is \$144.2 million. These lakes cover an area of 124.83km² in total. The cost per km² for improved water quality is therefore approximately \$1.15 million. If this is spread over 20 years the annual cost is \$57,758 per km². This per km² annual cost has been applied to the 62.51 km² of lakes with low water quality in the Waikato Region for 17 years (the study period).

Total cost: $\$57,758 \times 62.51 \times 17 = \$_{2003}61.38$ million or $\$_{2006}66.37$ million.

Step 2:

The total cost of maintaining water quality in Lake Taupo = \$72 million + \$83 million = \$155 million.

Step 3:

Total cost of lake water pollution in the Region = $\$_{2006}66.37$ million+ \$155 million = \$221.37 million.

Step 4:

To allow for variation between 1990 and 2006, the total cost of lake water pollution (Step 3) was proportioned over this 17 year period on the basis of annual nitrate leaching and run-off estimates calculated by Parfitt *et al.* (2006) and nitrogen fertiliser application estimates (O'Hara *et al.*, 2003). The split used was calculated from the OVERSEER model and attributed 80 percent to the stock effects of animals in the Waikato Region and 20 percent to fertiliser impacts (Roger Parfitt, 2008, pers. comm.).

Groundwater

The quality of groundwater in the Waikato Region is generally satisfactory but there are some supplies contaminated with nitrates, pesticides bacteria and the invasion of seawater (Environment Waikato, 2009a). In the Waikato the most common chemical contaminants found in community water supplies with near or above the maximum acceptable values for drinking water are:

- nitrate
- arsenic
- boron
- metals produced from corroding pipes (for example, zinc and copper).

High levels of arsenic and boron are found naturally in geothermal areas such as Taupo. Nitrate contamination is the result of an increase in the amount of waste water discharged onto land and higher stocking rates. In the Waikato Region, more than 9 percent of 198 sites monitored for nitrates in 2004 failed the acceptable standard for drinking water. These sites are mainly shallow aquifers located near market gardens and intensive farming (Ministry for the Environment, 2006). The maintenance of high quality groundwater is very important, as it is the source of drinking water. Reductions in the quality of groundwater also affect the Region's lakes and streams, as many are fed by underground aquifer systems (Ministry for the Environment, 1997). While the importance of groundwater is acknowledged, it has not been possible to estimate the monetary value of groundwater degradation due to a lack of methodology and data.

For the GPI the total monetary cost of loss of water quality was taken as the sum of the river (point and non-point sources) and lake water quality valuations.

In 2008 a settlement deed signed by the Crown and Waikato-Tainui guaranteed iwi a \$210 million fund the clean up the Waikato River.

For the period 1990 to 2006 the total cost of degraded water quality has been estimated at \$4,036 million (Table 41).

Table 41: Loss of water quality, 1990-2006

Calendar Year	Non-point source river pollution	Point source river pollution	Lakes pollution	Total cost of water degradation
	(NZ\$ ₂₀₀₆ mil)	(NZ\$ ₂₀₀₆ mil)	(NZ\$ ₂₀₀₆ mil)	(NZ\$ ₂₀₀₆ mil)
1990	142	30	9	181
1991	145	35	9	189
1992	150	27	10	187
1993	164	27	11	201
1994	175	25	11	212
1995	187	23	12	222
1996	189	19	12	220
1997	186	20	12	218
1998	191	16	12	220
1999	198	14	13	225
2000	209	17	13	239
2001	227	15	14	256
2002	246	19	16	280
2003	257	18	16	291
2004	264	18	17	299
2005	272	16	17	306
2006	260	15	17	291
Total				4,036

Cost of Ozone Depletion

Most GPIs include the cost of ozone depletion because it represents a long-term environmental impact of economic activity with consequences for biological and human health. Reduced ozone in the atmosphere has been shown to be the main cause of increased UV (McKenzie, 2007). Because of its southern location, New Zealand is vulnerable to increased solar ultraviolet radiation. The hole in the ozone layer currently covers a substantial area over Antarctica, and modelling studies by the National Institute of Water and Atmospheric Research have confirmed that the Antarctic ozone hole is a major contributor to the lower summer ozone levels measured over New Zealand (Ajtić and Connor, 2004).

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 (Armstrong, 1994 cited in Woodward *et al*, 2001). While it is known that ozone depletion has an impact on the well-being of New Zealanders (death from Melanoma cancer alone was estimated at more than \$200m in 2006), the causes are mostly generated off-shore and the GPI *only measures the impact of economic activity within a country*. In 1986, prior to restrictions being introduced under the Montreal Protocol (UNEP, 1987), New Zealand's total emissions of ozone-depleting gases (mostly Chlorofluorocarbons (CFC)) was 2,100 tonnes, or less than 0.002 percent of global emissions (McCulloch *et al.*, 1994). CFC consumption was phased out by 1 January 1996 and Hydrochlorofluorocarbons (HCFC) consumption has reduced from 726.4 metric tonnes in 1995 to 345.8 in 2006 metric tonnes a decrease of 52% (Minister of Commerce and Minister for the Environment, 2009). Increases in methyl bromide imports during this period have reduced the ozone benefits but not negated them. If the total cost of ozone depletion was measured in terms of health effects in New Zealand (\$200m in 2006), emissions generated in New Zealand would be responsible for an environmental cost of just \$0.4m in 2006.

Therefore inclusion of the costs of ozone depletion in the Waikato Region GPI is too small to justify.

Cost of Loss of Non-Renewable Resources

The theoretical underpinning of the GPI is the need to maintain the asset base from which to generate a sustainable economic income. Natural resource depletion represents the consumption of income-generating capital and results in running down assets to boost current income. If a country depletes natural capital by extracting renewable resources at a rate exceeding natural regenerative capacity and fails to reinvest enough of the proceeds to establish renewable income substitutes or generates waste levels that exceed assimilation capacity it cannot expect to sustain the same level of consumption in the future (Lawn, 2007b). National accounts allow for the depreciation of man-made capital, but treat natural capital as an infinite resource that cannot be depleted. As the global population grows, and societies become more materialistic, natural capital, rather than man-made capital, is rapidly becoming the scarce resource. Depletion is encouraged by accounting systems that count the liquidation of natural capital wealth as income (Daly, 1996).

The revenue from the sale of any asset should not be counted as income if the sale reduces the ability to generate the same level of income in the future. Therefore, an adjustment needs to be made in the GPI to allow for the depletion of non-renewable assets. National accounting systems encourage higher consumption of natural resources than is economically warranted if the derived income is inflated. “False levels of estimated income and inflated consumption cannot obviously be sustained since the very source of revenue diminishes with extraction” (El Serafy, 2002, p.3).

Estimations of the value of non-renewable resources can vary significantly, depending on whether a ‘strong sustainability’ or ‘weak sustainability’ approach is taken. What distinguishes the strong from the weak sustainability approach to non-renewable resource use is that strong sustainability proponents want to invest a sufficient share of the proceeds from non-renewable resource use into the development of renewable resource substitutes so these can replace the diminishing supply of non-renewable resources (e.g., solar, wind and geothermal substitutes for oil and gas). Advocates of ‘strong sustainability’ require “the preservation of the physical stock of those forms of natural capital that are regarded as non-substitutable (so-called critical natural capital)” (Neumayer, 2003, p.25). The ‘weak sustainability’ approach assumes that investment in any form of income-generating capital is an adequate substitute for the depletion of natural resources. Therefore, to sustain a given level of well-being and national income, an economy needs only ensure the total net investment rate in all forms of capital (man-made, human, non-renewable natural and renewable natural capital) is positive.

Much of the debate over the valuation of non-renewable resources relates to what constitutes a permanent loss, that is, what is substitutable and what is non-substitutable. Some argue non-renewable *energy* resources are not readily substitutable (Anielski and Rowe, 1999; Hamilton and Denniss, 2000) and as technology runs on energy, with fossil fuels providing the main source of cheap energy, depletion is a significant cost to future generations. As past and present exploitation of fossil fuels has allowed people on modest incomes to enjoy the lifestyle of the rich it is anticipated there will be severe impacts when supplies are less plentiful.

Another view-point is that non-renewable mineral resources are not ‘resources’ until a use is derived by technology, and as such they should be treated as substitutable (Ray, 1984, p.75 cited in Neumayer, 2003, p.49). Resource extraction increases the well-being of a country, and if the income generated is used wisely and includes investment in future replacement income-

generating capital sources, this is positive. Non-renewable resources represent a long-term asset; however, if they are never extracted, they represent an unrealised asset, and do not contribute to well-being.

Predicting the future demand and value of non-renewable resources is difficult. With non-renewable resources, technological progress has increased the efficiency of exploration, extraction and processing, enabling the flow of resources to increase. As a consequence, despite concerns about the depletion of natural resources, prices of nearly all natural resources have fallen over time at the same time as their use has increased (Simon, 1996). While flow-based market forces outweigh stock-based market forces in the short run, the opposite takes place in the long run. As the stock-based forces catch up, the price of the resource rises steeply, regardless of how much is supplied. The price paths of many non-renewable resources resemble a J-curve where as much as half of a non-renewable resource can be exhausted yet the market price scarcely differs from the initial market price (Lawn, 2007a). This differs from other types of goods where price increases gradually as a result of scarcity, and this encourages replacement, recycling, and more efficient use.

This study has collected extensive data on the major metallic and non-metallic minerals extracted by mining and quarrying in the Waikato Region (see Table 42). As there are large remaining reserves of the non-metallic minerals it is anticipated that present consumption levels will not impact on future income-generation capability. Or in other words the opportunity cost to future generations associated with consumption now is not regarded as significant enough to warrant inclusion in the GPI.

Reserves of platinum group metals exist in the Waikato Region but there is no current mining or exploration. Lead and zinc were mined from the small Tui Mine near Te Aroha but this ceased in 1974 (Crown Minerals, n.d.-d). Titanomagnetite reserves are substantial and at the current level of extraction estimated to last for approximately 368 years (calculated from Crown Minerals, n.d.-d). Only two resources – gold and silver – are being extracted at such a rate that known 1998 reserves as identified by Christie and Braithwaite (1999, p.58) of 64 tonnes of gold and 308 tonnes of silver are likely to be exhausted in the near-term future. For these two resources the revenues generated from extraction contain a large component of depreciation of the natural resource stock, which does not represent genuine income and therefore needs to be accounted for in the GPI.

For calculations gold and silver extraction quantities and value came from the Crown Minerals data and website (Crown Minerals, 2009). From 1994–2002 gold was valued as per the international price of gold increased by 2 percent. The overlap periods in the data series indicated New Zealand gold prices received were approximately 2 percent higher than the international price. From 1994 to 2002 silver was valued as per the international price less 5 percent as the overlap period in the data series indicated New Zealand silver prices were approximately 5 percent less than the international price. Extraction costs were taken as 80 percent of total revenue based on the 1983/84 Census of Mining and Quarrying (Statistics New Zealand, 1986/87) and data provided by Newmont Mining for Martha Mine (NZIER, 2005).

Table 42: Mineral and Non-Mineral Resources in Waikato and Expected Lifespan

	NZ Potential Reserves (tonnes) 2006 *	Location in Waikato	Average annual extraction of resource in the Waikato	Life expectancy (yrs) in Waikato
Metals				
Gold	34		4 tonnes (1990–2006)	8.5
Silver	77		25 tonnes (1990–2006)	3
TitanoMagnetite (Iron sand)	810 million	Large deposits. Extend from Kaipara Harbour to Wanganui ²	2.2 million tonnes (1990–2006)	368
Platinum group metals		Piopio and Thames areas ³	Not mined	
Non-metals				
Peat	not given		47,209 tonnes (1990-1996)	
Bentonite	19 million		30 tonnes in 2003	
Building and dimension stone	very large		11,118 tonnes (1990-2008)	
Clay	very large		19199 tonnes (1990-2008)	
Pebbles including scoria	very large		38,998 tonnes (1994-1996)	
Limestone	very large	Best quality large-tonnage deposits in south Waikato ⁴	793,915 tonnes (1990-2008)	
Perlite and	120 million	Large resources Rotorua-Taupo area ⁴	1,896 tonnes (1990-1996)	
Zeolite	very large			
Pumice	very large	Large resources Taupo Volcanic Plateau ⁴	50,307 tonnes (1990-2008)	
Rock, gravel, sand	very large		5,243,950 tonnes (1990-2008)	
Sand for industry	very large		302,222 tonnes (1990-2008)	
Serpentine	18 million		29,198 tonnes (1990-2007)	
Silica sand	very large		98 tonnes in 1996	
Sulphur	5 million	Large resources in region. No major production ⁴	2,368 tonnes (1990-1994)	
Coal	7,214 million	Large deposits ¹	1,716,478 tonnes (1990-2008)	

* based on 1998 quantities from Christie and Brathwaite (1999) less average extraction.

¹ (Crown Minerals, n.d.-a); ² (Crown Minerals, n.d.-c); ³ (Crown Minerals, n.d.-d) ⁴ (Crown Minerals, n.d.-b)

The El Serafy (1989) method which is the most widely recognised economic method for valuing non-renewable resources has been used to determine the loss of natural capital for the two critical resources being depleted in the Waikato (gold and silver). The “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 System of National Accounts] (El Serafy, 2002, p.5).

With the El Serafy (1989) method 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. This method is a 'weak sustainability' approach but regarded as more robust than the 'strong sustainability' replacement approach (Neumayer, 2003). A low discount rate of 2 percent, (Lawn, 2006) has been used for the Waikato GPI as this rate more closely replicates the regeneration rate of most renewable resources. This more closely satisfies the desired strong sustainability condition, namely constant natural capital. The intention is that the finite series of non-renewable resources consumed for production purposes equals the infinite series of renewable resources made available by the replacement asset (Lawn, 2006). 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 gold and silver, then summed and adjusted for inflation.

This method adjusts for depreciation of the natural resource stock but does not make an allowance for environmental damage from extraction. Environmental damage from extraction can be considerable and is to some extent covered in the GPI by the contaminated sites allowance in the land degradation category.

Not all GPIs use the El Serafy method or value mineral extraction. 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, therefore there is no loss value placed on their extraction or consumption.

Geothermal Extraction

As mentioned previously energy sources can be treated differently when calculating a GPI as energy is regarded as an essential component of modern day living. The Waikato Region has extensive geothermal reserves used to generate energy. Modern re-injection technology allows these reserves to be maintained but there is still a high degree of direct heat extraction. Older power generation plants based on extraction (as at Wairakei) resulted in land subsidence⁴⁹ and pollution of the Waikato River where mercury and arsenic concentrations in the river exceeded World Health Organisation levels for potable water. While recent upgrades have resulted in some conversion to re-injection damage to geothermal resources has occurred. Geothermal extraction has impacted on ecosystems and caused subsidence. Costs associated with this include \$700,000 spent by Taupo District Council on subsidence investigation (Taupo District Council, 2003). Based on this an allowance of \$1 million per year for damage as a result of geothermal extraction has been made.

For the period 1990 to 2006 the total cost of non-renewable resource use has been estimated at \$281 million (Table 43).

⁴⁹ While this is disputed by Contact Energy the Environment Court placed conditions for monitoring and compensation as part of the renewal of the Resource Consent issued in 2006.

Table 43: Non-renewable resource use in the Waikato Region, 1990-2006

Calendar Year	Gold User cost (2% interest rate)	Silver User cost (2% interest rate)	Total User cost (2% interest rate)	Geothermal allowance	Total User Cost
	(NZ\$ mil)	(NZ\$ mil)	(NZ\$ mil)	(NZ\$ mil)	(NZ\$ ₂₀₀₆ mil)
1990	5	0	5	1	9
1991	5	0	5	1	8
1992	17	1	17	1	24
1993	18	1	19	1	25
1994	14	1	15	1	20
1995	15	1	16	1	21
1996	15	1	16	1	20
1997	11	1	12	1	16
1998	5	1	7	1	9
1999	5	1	6	1	8
2000	9	1	10	1	13
2001	11	1	12	1	15
2002	13	1	15	1	17
2003	10	1	12	1	14
2004	13	2	14	1	16
2005	20	3	22	1	24
2006	19	3	22	1	23
Total					281

Cost of Noise Pollution

Noise pollution refers to unwanted or offensive sounds coming from a variety of sources including: industry, activities such as lawn mowing, recreational events, people communicating, animals, etc. 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, there has been an increase in the number of people who are exposed to noise and the duration of exposure due to increased urban living. 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:

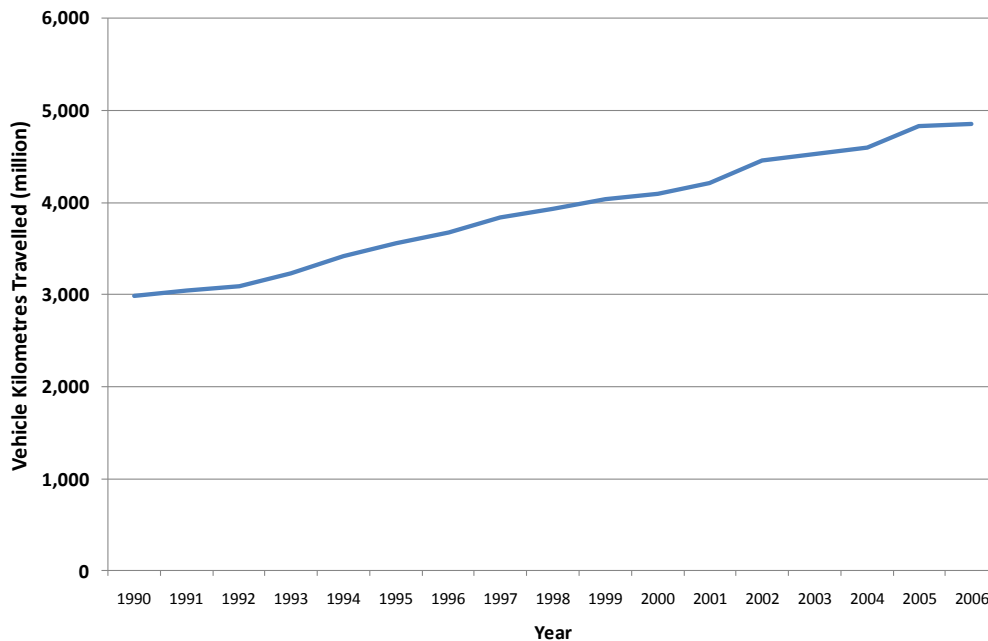
- Productivity losses due to poor concentration, communication difficulties or fatigue due to insufficient rest.
- Health care costs to rectify loss of sleep, hearing problems or stress.
- Lowered property values.
- Reduction in psychological well-being.

A recent survey on the quality of life in New Zealand's 12 largest cities found just over a quarter of residents (26 percent) stated that noise was a concern. Residents in these cities were significantly more likely to perceive a problem with noise pollution in their local area (31 percent), than those living elsewhere in New Zealand (21 percent) (Gravitas Research and Strategy Limited, 2005).

Although noise is a significant environmental problem, it is difficult to quantify associated costs. In addition, measuring the extent of the increase in noise pollution in the Waikato Region between 1990 and 2006 is not possible due to lack of data. While property values can be affected if noise levels are extreme, for most people noise is an uncompensated cost. Noise is present even in small urban settlements in New Zealand, where ribbon development with road and rail networks in close proximity to houses is common.

As no data is available to calculate absolute noise levels or change in intensity, the vehicle kilometres travelled (vkt) in the Waikato Region has been used as a proxy. Given that most people 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) means that people live close to traffic noise (Statistics New Zealand, 1999). Vehicles may have become quieter but more densely populated urban areas result in more exposure to noise over longer periods. According to Statistics New Zealand, the largest contributor to increased kilometres travelled by vehicles is the car; however kilometres travelled by light commercial vehicles and heavy commercial vehicles have also increased (Statistics New Zealand, 2002). Figure 6 gives an estimate of the increase in kilometres travelled between 1990 and 2006 for the Waikato Region. Data for 2000 to 2006 was obtained from the Ministry of Transport (Ministry of Transport, 2009). Between 2000 and 2008 the Waikato Region accounted for approximately 12 percent of New Zealand's road vehicle kilometres travelled and this percentage was used to apportion national data for the years 1990 to 1999.

Figure 6: Estimated Vehicle kilometres Travelled in Waikato Region, 1990-2006



Source: MoT, 2009 - Transport volume: Vehicle travel "Road VKT" TV001 2001-2006. 1990 to 2000 based on Waikato regions percentage of New Zealand total.

To calculate the GPI for Waikato Region, this study used annual vkt and noise cost estimates from the 1996 Land Transport Pricing Study (Ministry of Transport, 1996). That study researched environmental externalities associated with motor vehicle use for New Zealand, and estimated the total social cost ranging from \$₁₉₉₅1,480 million to \$₁₉₉₅17,000 million, with a best estimate of \$₁₉₉₅1,850 million. A marginal damage function for noise was estimated and then combined with residential property values to generate these figures. This cost was then annualised using a discount rate of 6.4 percent to give an annual social cost of noise pollution from vehicles between \$₁₉₉₅230 million and \$₁₉₉₅2,650 million with the best estimate being \$₁₉₉₅290 million per year (Ministry of Transport, 1996, p.38). The total social cost is defined as private costs plus externalities. The distribution of traffic noise costs was calculated over 15 urban centres, with a strong weighting (65 percent) given to the urban centres Wellington, Christchurch and Auckland (Ministry of Transport, 1996, pp.25-39). In this study the annual social cost of traffic noise for Hamilton urban area only was estimated to be \$₁₉₉₅11 million or \$₂₀₀₆14 million (Ministry of Transport, 1996, p.38). For the Waikato Region overall the social cost of traffic noise of 1.2₂₀₀₆cents per kilometre travelled in 1995 was applied as in the New Zealand GPI (Table 44).

The vkt travelled in the Region was used as an index to calculate the annual cost of noise pollution for each year.

For the period 1990 to 2006 the total cost of noise pollution has been estimated at \$797 million.

Table44: Annual cost of noise, 1990–2006

Calendar Year	Estimated Waikato vehicle kilometres travelled	New Zealand 1995 noise cost	Waikato annual noise cost
	(km mil)	(NZ\$ ₂₀₀₆ /vkm)	(NZ\$ ₂₀₀₆ mil)
1990	2,984		36
1991	3,040		36
1992	3,094		37
1993	3,228		39
1994	3,423		41
1995	3,563	0.012	43
1996	3,672		44
1997	3,836		46
1998	3,927		47
1999	4,041		48
2000	4,098		49
2001	4,207		50
2002	4,459		54
2003	4,532		54
2004	4,601		55
2005	4,831		58
2006	4,855		58
Total			797

Discussion and Recommendations

Beyond GDP

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 (Stiglitz et al., 2009; 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, the originator of 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: 29). GDP measures market production rather than well-being which consists of both economic and non-economic factors and is progress defined by Walsh (2005) as “living and faring well” or “flourishing”. According to Stiglitz et al. (2009: 21) conflating GDP with well-being “can lead to misleading indications about how well-off people are and entail the wrong policy decisions”.

Alternative approaches to measuring well-being

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 very similar in nature Index of Social and Economic Welfare (ISEW). These measures are not the only alternative approaches available, others include:

System of Economic-Environmental Accounting (SEEA)

The System of Economic-Environmental Accounting, first released in 1993 and revised in 2003, is an add-on to SNA and includes environmental accounts (or green accounts) as satellite accounts. These accounts, the development of which has 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, using mostly biophysical measures. SEEA does not include measures of national well-being that include social criteria (Hecht, 2005). Data availability is a problem and SEEA has not been sufficiently developed to be extensively used.

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 is that Green NNP does not indicate a level of output that can be sustained indefinitely (Lawn, 2007b).

Quality of Life Measures

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.

Other 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. In New Zealand quality of life studies are carried out on a regular basis in large cities (Gravitas Research and Strategy Limited, 2005). 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.

Ecological Footprint (EF)

Ecological footprint studies (see McDonald and Patterson, 2004; Rees, 2000; Wackernagel and Rees, 1996) compare the carrying capacity of a country’s natural environment (biocapacity) with the nation’s resource consumption levels (ecological footprint). The EF of a nation is the “area of productive land and water ecosystems required to produce the resources that the population consumes and assimilate the wastes that the population produces, wherever on Earth that land and water may be located” (Rees, 2000: 371). It therefore gives a measure of whether a nation’s natural capital is sufficient to support the population living in the country or whether there is an ecological deficit and as a result natural capital is being consumed or assimilation capacity is being exceeded. If a country has an ecological footprint greater than the amount of productive land in its territory this can indicate dependency on the flows of ecosystem services from other countries as it is possible for a country to maintain its own natural capital stock by consuming the natural capital of other countries. The EF is a useful biophysical indicator but does not allow for the limiting aspects of certain critical resources and as it is specific to natural resources is not a comprehensive measure of well-being (Lawn, 2007b).

Genuine Savings Index

Genuine savings is one of the simplest measures based on the concept that sustainability depends on maintaining the value of assets. Genuine savings 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 Indicators (World Bank, 2007). 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 resources by either reconstituting natural capital or 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 natural capital (Lawn, 2007b).

Monetary versus biophysical approaches to measurement

Constructing a GPI using physical change or indices rather than monetary valuations is possible but the large number of categories in a GPI makes interpreting overall trends difficult. Biophysical change is measured in the GPI and reported on in the technical reports. It is then monetised and aggregated for ease of interpretation. Using an index system is also possible. This type of normalisation of multiple raw data sets allows comparison over time and the aggregation of multiple indicators to create composite indices. Using this approach a benchmark is selected against which longitudinal data is compared and converted to a numeric score on a scale (see Anielski, 2001 for more detail).

Gaps and recommendations for improvements

Theoretical Matters

Selection of components for inclusion

Unlike in the calculation of, say, GDP, there are currently no international standards specifying the method in which a GPI is to be calculated. This means that the types of socio-economic/environmental benefits or costs included in any particular GPI calculation are to a large degree left to the discretion of the persons undertaking the study. This somewhat arbitrary nature of the GPI is perhaps its most fundamental theoretical issue. For example, studies in other countries have included additional socio-economic components, such as the cost of gambling. The GPI could also include issues such as the cost of alcoholism, drug abuse, child abuse, money laundering and fraud etc as separate categories from the cost of crime. It can be noted further that the comparison of GPIs between countries is complicated by variances in social problems experienced, and also variances over time. For example, internet crime was unheard of prior to the 1990s. Further debate will be beneficial in regards to what are the appropriate components to include in the Waikato GPI. Moreover, a key focus of this debate should be on what Waikato Region resident's conceive are key determinants of their welfare.

Definition of system boundaries

System boundaries create further complications in the calculation of a GPI as some issues (e.g. internet crime and fraud) may be experienced by a victim in New Zealand, yet committed by a person based overseas. The system boundary issue is perhaps the most problematic in regards to the calculation of the environmental components of the GPI. For example, New Zealand does not produce or consume a high volume of ozone-depleting substances, but as a nation we are more exposed to the impact of damage to the ozone layer than most other countries. Similar arguments can be made concerning the potential consequences of climate change where the impacts of burning fossil fuels in other nations may have a profound impact on our climate.

In the calculation of future GPIs, further consideration could be given to the most appropriate system boundaries for the study.

Definition of defensive expenditures

Another factor which could have an important impact on the Waikato Region GPI valuation is the definition given to ‘defensive expenditures’. Commentators, such as Hamilton and Denniss (2000), note that the definition on what constitutes a defensive expenditure, or the degree to which an activity is considered defensive, is largely an arbitrary decision. Often, for example, only anecdotal or *ad hoc* information exists for setting the degree to which a component is defensive. Moreover, in those cases where anecdotal or *ad hoc* information do not exist, then the analyst implementing the component is left to make a judgement or assumption.

Monetary valuation of non-market externalities

Assigning a monetary value to many social and environmental goods and services is often problematic. Frequently, as is the case in this study, value is dependent upon implied or imputed benefits/costs. The benefits derived from ecosystem services such as climate regulation, for example, cannot be adequately captured in economic markets due to the intangible nature of the services provided. In this case, economists typically rely on non-market valuation techniques such as willingness-to-pay, hedonic pricing, and travel cost methods. Unfortunately, there are many well known limitations associated with the application of these methods (see, for example, Khan (1995) for further details). It is also worth noting that many commentators argue that it is inappropriate to place economic values on social and environmental goods and services that are ‘invaluable’. It is, however, the opinion of the authors that without valuations many of the components included in this study would remain unaccounted for, or at least undervalued, in Waikato Region’s welfare.

Selection of an appropriate base year

The selection of an appropriate base year from which to conduct the valuation from is critical in determining the quantum of several GPI components. The valuation of components such as the loss and damage to terrestrial ecosystems and loss of soils rely on accurately determining the point in time when the marginal benefits gained from depleting (or drawing down) an environmental good/service become less than the marginal costs incurred as a result of the loss of that resource. This is a difficult task fraught with difficulties such as lag effects, cumulative effects and compounding data paucity.

Aggregation

The GPI is a measure of well-being not a sustainability indicator. When it comes to the environment the GPI advocates ‘strong sustainability’ – that is, keeping intact natural capital assets for the use of future generations. However, by aggregating all the categories into a single monetary index the GPI implies ‘weak sustainability’ is acceptable. For example, a single index can be interpreted as indicating higher levels of employment are compensation for loss of natural capital, such as water quality.

Methodological Matters

Partial or incomplete valuation of components

Assumptions made in estimating the GPI are open to debate (Neumayer, 2000; Lawn, 2003; Constanza *et al.*, 2004). The cost of unemployment and underemployment, for example, is determined using an average wage rate per hour. This is likely to be an overestimate as a vast majority of the unemployed, and underemployed, are unskilled. Incomplete valuation such as the omission of the psychological costs associated with unemployment mean that components are of only partially, rather than fully, accounted for. While full cost accounting of all sub-components of a component is not possible, it is however important that all major sub-components are evaluated. The key barriers to full cost accounting are difficulties associated with measurement and insufficient data (see below).

Lack of standardised valuation methodologies

The comparability of different GPI studies is often limited because, as described above, currently no international standardised valuation method exists. This means that in calculating a GPI, the researcher must decide both which items will be incorporated in the index, and which valuation methods are best to employ. These decisions are typically made on the basis of data availability. It should, however, be noted that here are currently efforts underway to standardise core components of the GPI across nations – refer, for example, to Lawn and Clarke (2008).

Empirical Matters

Paucity of regional data

The paucity of regional data is a significant obstacle to rigorous GPI calculations. It is recommended that a regional database of information sources pertaining to each socio-economic and environmental component be created. This database would record not only bottom up primary data for improving the construction of the GPI, but importantly also information on the causal mechanisms responsible for change in components. It is, however, acknowledged that in comparison, the System of National Accounts from which the GDP indicator is extracted developed over a period of 70 year plus years, with definitions and accounting procedures evolving along the way. Under ideal circumstances, information for development of component accounts would be based on regularly collected data. Furthermore, the development of regional GPIs would be a nationwide exercise supported by statistical data sources from Statistics New Zealand.

Data accuracy and certainty

To aid in interpreting the accuracy of the findings, standard statistical errors could be added where possible to component valuations with a sensitivity analysis undertaken to allow for feasible ranges of values. Alternatively, a Monte Carlo analysis could be undertaken to provide certainty bounds for component valuations and for the overall aggregate indicator.

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Appendix I - Inflation Adjustments

As explained by Mankiw (1999), with inflation, a dollar today has less value than a dollar at a previous point in time. At a personal level, a consumer's purchasing power decreases when prices increase, particularly if their income remains constant over time. Thus, even with ever-increasing income, an individual's well-being will not necessarily be better off due to rising costs of living, since more spending is required to retain a constant level of consumption through time. It is more accurate to explore a consumer's inter-temporal expenditure behaviour without price change interference. To this end, economists typically measure consumption through time in real (constant) terms.

At an economy wide level, GDP similarly measures the total flow of goods and services. It is obtained by summing all domestically produced goods and services at market prices⁵⁰. GDP typically changes due to an increase or decrease in price or quantity (volume). It does not accurately reflect how well the economy can satisfy the demand from different sectors. For instance, if all prices double without any changes in quantities, GDP would double. Thus, it would be misleading to say that the economy's ability to satisfy demands has doubled, because the quantity of every good produced remains the same. As a result, real GDP, the value of goods and services measured using constant prices, is utilised by economists to avoid this anomaly. Real GDP records what would have happened to expenditure on output if quantities had changed, but prices had not.

As for all the other economic variables, it is also more precise to study their characteristics at real prices. An inflation adjustment therefore makes comparison of variables across different time periods more meaningful. In this report, three price indices are utilised to translate nominal to real values, namely: (1) the Consumer Price Index (CPI), (2) an Implicit Price Deflators (IPD).

Price Indices

Also as explained by Mankiw (1999), price indices are used to measure inflation and typically appear in one of two forms: (1) the Paasche and (2) the Laspeyres indices. The former index is utilised with a changing basket of goods and services, while the latter is utilised with a fixed basket of goods and services. These indices measure the change in prices between time periods for a set of goods and services. Each index records how a set of prices for a basket of goods and services has changed over time. A price index uses one number to represent the prices being charged for various goods and services across a wide range of outlets and locations. The average price level of goods and services for a given base year is assigned to an index number of 1,000. This is the benchmark to which average prices in other years are compared. For example, if the index number for a year is 1,150, then prices in that particular year may be said to have increased by 15.0 percent from the base year.

⁵⁰ Note only goods and services used for final consumption are included i.e. goods and services used in intermediate production are excluded.

Consumer Price Index

The CPI is the most commonly used measure of inflation. It is a time-series measuring the weighted average of prices of a specified set of goods and services purchased by consumers in each year. Statistics New Zealand (SNZ), like most other countries, calculates the CPI as a Laspeyres index; the price of a basket of goods and services as purchased by private households, related to the price of the same basket in the base year. It is therefore a measure of the changing cost of purchasing a fixed basket of goods and services, which represents the average expenditure pattern of New Zealand households for the index base year (Statistics New Zealand, 2000b). In this report, the SNZ raw CPI time series (June 2006 quarter = 1000) was used, as obtained from the New Zealand Information Network for Official Statistics (INFOS) series CIPQ.SE9A. The quarterly values (March, June, September and December) were transformed to annual (December) values based on moving averages. The raw data series was then rebased to December 2006 as the base CPI year using the Rebasing Method (refer to Table A.1).

Implicit Price Deflators

The IPD, as derived from GDP, assigns changing weights to the prices of all domestically produced goods and services in an economy. Unlike the CPI, the IPD allows for change in the composition of the basket of goods over time, in particular with changes in people's consumption and investment patterns. The IPD is computed as the ratio of nominal to real GDP. Again, the price in the base year is normalized to 1,000 (Mankiw, 1999).

There are two sets of IPD data series available from INFOS (SNBQ.S4N & SNCQ.S6DB15). The first of the series is the Fixed Weighted IPD based at 1992 prices for the period 1983–1999, while the other is the Chain Linked IPD based at 1996 prices for the period 1988–2006 (Statistics New Zealand, 2000a)⁵¹. A conjoint series at 1996 prices covering 1983–2006 was formed from the two overlapping sets of data using the Rebasing Method. A final rebasing of the conjoint series was required to ensure all values were expressed in December 2006 dollars. This final conjoint series was also developed in March 2006 dollars covering 1983–2006 (refer to Table A.1).

⁵¹ Refer to Macro Economics (fourth edition), (Mankiw, 1999, pp 23) for details on the difference between Fixed Weighted and Chain Linked data series).

Table A.1 Consumer Price Index and Implicit Price Deflator

Year	CPI	IPD
	2006=1000	2006=1000
1990	719	749
1991	738	753
1992	745	763
1993	755	785
1994	768	793
1995	797	810
1996	815	831
1997	825	835
1998	835	841
1999	834	844
2000	856	865
2001	879	902
2002	902	912
2003	918	925
2004	939	959
2005	967	976
2006	1,000	1,000

Appendix II - Rebasing and Bi-Proportional Balancing Methods

Rebasing Method

The Rebasing Method may be mathematically described as:

$$D = \frac{A}{B} \times C, \text{ where}$$

A = Original data for the desired year

B = Original data for the new base year

C = New data assigned for the new base year

D = Modified data for the desired year

The modified data for the desired year, D , was derived from the original data series by first choosing a new base year and assigning a corresponding new base number. The ratio of the desired year data, to the base year data, was then derived from the original data series. By multiplying the new assigned base number, the modified data was computed for the desired year. This adjustment ensures that the percentage movements between years will remain the same.

Table B.1 Rebasing Method Example

Dec-03	917	918
Dec-04	938	939
Dec-05	967	967
Dec-06	999	1,000

In this example, the CPI is rebased from June 2006–December 2006 for the year ending December 2004. This is undertaken by dividing the original CPI for 2004, 938, by the original CPI for the new base year 2006, 999, i.e. $938 \div 999 = 0.9389$ (3 d.p.). Multiplying this result by 1000 gives the modified CPI value for 2004, i.e. 939 (0 d.p.).

Bi-proportional Table Balancing Method

Tables B.2-B.7 provide an example of the Bi-proportional Table Balancing Method as applied in generating the household time use estimates by age cohort for males. Table B.2 provides time use estimates (in millions of hours) of total household work by age-cohort (in the

columns) and total household work by category (in the rows). Using the indicative time use estimates in Table B.3 it is then possible to calculate row ratios for household work by category. The row ratio for food preparation is, for example, $264.3 / 283.7 = 0.93$ (2 d.p.) (last column of Table B.4). Each row element in Table B.3 is then multiplied by the corresponding row ratio e.g. $17.3 \times 0.93 = 16.3$, $39.1 \times 0.93 = 36.8$, and so on.

Table B.2: Time Use by Age Cohort for Males Performing Household Work in 1999 (mil hours) - Known Row and Column Totals

	12-24	25-34	35-44	45-54	55-64	65+	Target
Food prep							264.3
Indoor cleaning							145.5
Grounds							180.2
Home maint.							172.8
Hh admin							29.4
Prod of gds							3.3
Gather food							16.3
Travel							24.1
Other nec							28.8
Target Total	80.6	128.4	163.9	152.7	138.1	210.4	874.1

Table B.3: Time Use by Age Cohort for Males Performing Household Work in 1999 (mil hours) - Indicative Base Year Estimates

	12-24	25-34	35-44	45-54	55-64	65+	Estimate Total	Target Total	Ratio
Food prep	17.3	39.1	49.9	46.5	42.1	88.8	283.7	264.3	0.9
Indoor cleaning	12.4	21.5	27.5	25.6	23.1	38.9	149.0	145.5	1.0
Grounds	10.2	26.7	34.0	31.7	28.7	65.8	197.1	180.2	0.9
Home maint.	12.3	25.6	32.6	30.4	27.5	37.8	166.2	172.8	1.0
Hh admin	2.6	4.4	5.6	5.2	4.7	8.5	30.9	29.4	1.0
Prod of gds	0.2	0.5	0.6	0.6	0.5	0.9	3.4	3.3	1.0
Gather food	1.2	2.4	3.1	2.9	2.6	4.7	16.8	16.3	1.0
Travel	1.7	3.6	4.5	4.2	3.8	6.9	24.8	24.1	1.0
Other nec	2.0	4.3	5.4	5.1	4.6	8.3	29.7	28.8	1.0
Estimated Total	60.0	127.9	163.3	152.1	137.6	260.7			

The resulting values are transferred to Table B.4 and column ratios are then computed by dividing the estimated time use by each age cohort (i.e. column sum) by the known time use total for each age cohort. The column ratio for 25–34 year old males is, for example, $128.4 / 124.2 = 1.03$ (2 d.p.) (last row of Table B.4). Each column element in Table B.4 is then multiplied by the corresponding column ratio e.g. $36.8 \times 1.03 = 38.0$, $21.2 \times 1.03 = 21.9$ and so on. The resulting matrix is shown in Table B.5.

Table B.4: Time Use by Age Cohort for Males Performing Household Work in 1999 (mil hours) - 1st Iteration

	12-24	25-34	35-44	45-54	55-64	65+	Estimated Total
Food prep	16.3	36.8	47.0	43.8	39.6	83.7	267.2
Indoor cleaning	12.2	21.2	27.1	25.3	22.8	38.3	147.0
Grounds	9.4	24.6	31.5	29.3	26.5	60.9	182.2
Home maint.	13.0	26.9	34.3	32.0	28.9	39.7	174.7
Hh admin	2.5	4.2	5.4	5.0	4.5	8.2	29.8
Prod of gds	0.2	0.5	0.6	0.6	0.5	0.9	3.3
Gather food	1.1	2.4	3.0	2.8	2.5	4.6	16.4
Travel	1.7	3.5	4.5	4.2	3.8	6.8	24.3
Other nec	2.0	4.2	5.3	5.0	4.5	8.2	29.1
Estimated Total	58.5	124.2	158.7	147.8	133.7	251.2	
Target Total	80.6	128.4	163.9	152.7	138.1	210.4	
Ratio	1.38	1.03	1.03	1.03	1.03	0.84	

Table B.5: Time Use by Age Cohort for Males Performing Household Work in 1999 (mil hours) - 2nd Iteration

	12-24	25-34	35-44	45-54	55-64	65+	Estimated Total	Target Total	Ratio
Food prep	22.4	38.0	48.6	45.2	40.9	70.1	265.3	264.3	1.0
Indoor cleaning	16.9	21.9	28.0	26.1	23.6	32.1	148.6	145.5	1.0
Grounds	13.0	25.4	32.5	30.3	27.4	51.0	179.5	180.2	1.0
Home maint.	17.9	27.8	35.5	33.0	29.9	33.2	177.2	172.8	1.0
Hh admin	3.5	4.3	5.5	5.2	4.7	6.9	30.0	29.4	1.0
Prod of gds	0.3	0.5	0.6	0.6	0.5	0.8	3.3	3.3	1.0
Gather food	1.6	2.4	3.1	2.9	2.6	3.9	16.5	16.3	1.0
Travel	2.3	3.6	4.6	4.3	3.9	5.7	24.4	24.1	1.0
Other nec	2.8	4.3	5.5	5.1	4.6	6.8	29.2	28.8	1.0
Estimated Total	80.6	128.4	163.9	152.7	138.1	210.4			

In a similar manner Table B.6 and Table B.7 are then derived. As successive iterations are performed the ratio values approach unity. Typically after only 5–10 iterations the results obtained are sufficient for practical purposes.

Table B.6: Time Use by Age Cohort for Males Performing Household Work in 1999 (mil hours) - 3rd Iteration

	12-24	25-34	35-44	45-54	55-64	65+	Estimated Total
Food prep	22.6	38.3	48.9	45.6	41.2	70.6	267.2
Indoor cleaning	16.7	21.7	27.7	25.8	23.3	31.8	147.0
Grounds	13.2	25.8	33.0	30.7	27.8	51.7	182.2
Home maint.	17.6	27.4	35.0	32.6	29.4	32.8	174.7
Hh admin	3.5	4.3	5.5	5.1	4.6	6.8	29.8
Prod of gds	0.3	0.5	0.6	0.6	0.5	0.8	3.3
Gather food	1.6	2.4	3.1	2.9	2.6	3.8	16.4
Travel	2.3	3.6	4.6	4.3	3.9	5.7	24.3
Other nec	2.8	4.3	5.5	5.1	4.6	6.8	29.1
Estimated Total	80.5	128.3	163.9	152.6	138.1	210.7	
Target Total	80.6	128.4	163.9	152.7	138.1	210.4	
Ratio	1.00	1.00	1.00	1.00	1.00	1.00	

Table B.7: Time Use by Age Cohort for Males Performing Household Work in 1999 (mil hours) - 4th Iteration

	12-24	25-34	35-44	45-54	55-64	65+	Estimated Total	Target Total	Ratio
Food prep	22.6	38.3	48.9	45.6	41.2	70.5	267.2	264.3	1.0
Indoor cleaning	16.7	21.7	27.7	25.8	23.4	31.7	147.0	145.5	1.0
Grounds	13.2	25.8	33.0	30.7	27.8	51.6	182.1	180.2	1.0
Home maint.	17.7	27.4	35.0	32.6	29.5	32.7	174.7	172.8	1.0
Hh admin	3.5	4.3	5.5	5.1	4.6	6.8	29.8	29.4	1.0
Prod of gds	0.3	0.5	0.6	0.6	0.5	0.8	3.3	3.3	1.0
Gather food	1.6	2.4	3.1	2.9	2.6	3.8	16.4	16.3	1.0
Travel	2.3	3.6	4.6	4.3	3.9	5.7	24.3	24.1	1.0
Other nec	2.8	4.3	5.5	5.1	4.6	6.8	29.1	28.8	1.0
Estimated Total	80.6	128.4	163.9	152.7	138.1	210.4			

Appendix III - LCDB1 and LCDB2 Landuse for Waikato Region

Class	1996/97	20001/02	Difference
	(ha)	(ha)	(ha)
1 Built-up Area		48.52	
1 Built-up Area	17,352.41	17,734.40	430.51
2 Urban Parkland/ Open Space	4,439.08	4,508.79	69.71
3 Surface Mine	2,081.16	2,114.82	33.66
4 Dump	81.89	81.89	-
5 Transport Infrastructure	1,346.94	1,360.57	13.63
10 Coastal Sand and Gravel	3,398.62	3,398.62	-
11 River and Lakeshore Gravel and Rock	531.77	531.77	-
12 Landslide	27.28	31.43	4.15
13 Alpine Gravel and Rock	8,401.78	8,401.78	-
14 Permanent Snow and Ice	205.23	205.23	-
15 Alpine Grass-/Herbfield	63.97	63.97	-
20 Lake and Pond	74,955.82	75,006.38	50.57
21 River	7,332.60	7,332.60	-
22 Estuarine Open Water	5,220.20	5,220.20	-
30 Short-rotation Cropland	13,914.28	14,002.14	87.86
31 Vineyard	72.12	72.12	-
32 Orchard and Other Perennial Crops	2,242.53	2,242.53	-
40 High Producing Exotic Grassland	1,288,638.67	1,276,963.16	- 11,675.51
41 Low Producing Grassland	13,271.32	10,329.62	- 2,941.69
43 Tall Tussock Grassland	11,571.34	11,571.34	-
44 Depleted Tussock Grassland	748.23	748.23	-
45 Herbaceous Freshwater Vegetation	6,509.09	6,509.09	-
46 Herbaceous Saline Vegetation	1,764.59	1,764.59	-
47 Flaxland	382.47	382.47	-
50 Fernland	646.14	646.14	-
51 Gorse and Broom	12,957.76	12,030.34	- 927.43
52 Manuka and or Kanuka	110,722.56	110,438.41	- 284.15
53 Matagouri	3.74	3.74	-
54 Broadleaved Indigenous Hardwoods	41,227.95	41,140.45	- 87.51
55 Sub Alpine Shrubland	6,542.51	6,542.51	-
56 Mixed Exotic Shrubland	2,892.86	2,892.86	-
57 Grey Scrub	54.22	54.22	-
61 Major Shelterbelts	1,087.91	1,087.91	-
62 Afforestation (not imaged)		4,080.16	4,080.16
63 Afforestation (imaged, post LCDB 1)	13,577.80	10,624.02	- 2,953.78
64 Forest Harvested	32,010.90	66,172.72	34,161.83
65 Pine Forest - Open Canopy	48,269.72	67,437.35	19,167.63
66 Pine Forest - Closed Canopy	219,029.78	179,407.04	- 39,622.74
67 Other Exotic Forest	12,779.54	13,407.38	627.84
68 Deciduous Hardwoods	12,417.84	12,414.72	- 3.12
69 Indigenous Forest	473,855.10	473,623.48	- 231.62
70 Mangrove	2,446.06	2,446.06	-
Total area	2,455,075.76	2,455,075.76	-

Appendix IV - Environmental Measurement Periods

	Cost and benefit timeframe
Cost of Loss and Damage to Terrestrial Ecosystems	
i) Indigenous forest	1970-2006
ii) Pests and weeds	1990-2006
Cost of Loss of Wetlands	1970-2006
Cost of Loss of Soils	
i) Fertile soil to the built environment	1970-2006
ii) Erosion	1970-2006
Cost of Loss of Air Quality	1990-2006
Cost of Land Degradation	1990-2006
Cost of Climate Change	1990-2006
Cost of Loss of Water Quality	1990-2006
Cost of Ozone Depletion	
Cost of Loss of Non-renewable Resources	1990-2006
Cost of Noise Pollution	1990-2006