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A Genuine Progress Indicator for the Auckland Region -

Valuation Methodology

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A Genuine Progress Indicator for the Auckland Region - Valuation Methodology

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Prepared for
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1 Introduction

The Genuine Progress Indicator (GPI) as a measure of human welfare is a concept that is becoming increasingly popular. Over the last decade, the GPI has been promoted internationally as an alternative measure to the Gross Domestic Product (GDP). 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 does GDP. 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 (Talbert et al., 2007). Among the nations for which a GPI has been developed are the US, UK, Germany, Australia, China and India.

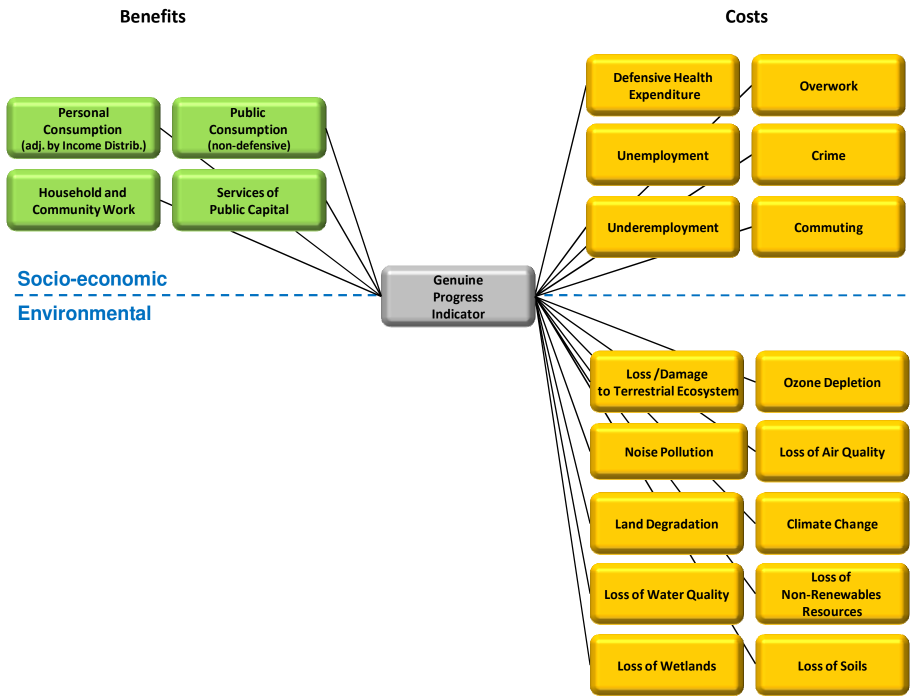
In January 2009 the Auckland Regional Council (ARC) contracted the New Zealand Centre of Ecological Economics (NZCEE) and Market Economics Ltd (MEL) to develop a GPI for the Auckland region covering the time period 1990 to 2006. This work builds on NZCEE and MEL's soon-to-be-released National GPI project,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

This technical report describes in detail the data and methods used to estimate the Auckland region GPI for the period 1990 to 2006.[1] The starting point for the valuation of the Auckland region GPI is total personal consumption expenditure across the Auckland region for each year of the study. A total of twenty 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 (see Figure 1). The majority of these components, such as defensive expenditures of health, unemployment, under-employment, over-employment, 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 with regionalised 'top-down' data from the national study in the absence of Auckland region-specific data.

The remainder of the report describes each component of the Auckland region GPI.

[1] It is worth noting that these methodologies have already been independently peer reviewed by leading international GPI practitioners.

Figure 1: Components of the Auckland region GPI



2 Total Personal Consumption

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

There is no Auckland region primary data available on the personal consumption expenditure. Instead we assume that the personal consumption expenditure of each Aucklander depends directly on the level of his, or her, income. Total regional personal consumption is 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 regional level

IPC^r and IPC^n are the average weekly income per capita for the Auckland region and the nation, respectively

CPC^n is the consumption per capita at constant 2006 dollars for the nation, and

Pop^r is the population in Auckland region.

The multiplication of average Auckland 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 the years 1998–2006 were extracted from the Statistics New Zealand (SNZ) web tool Table Builder.[2] Personal income data for the period from 1990–2006 was not available. However, average wage rate data was available from Statistics New Zealand's Quarterly Employment Survey (QES), and so the ratio of the regional average wage rate to the national average wage rate was used in determining personal income ratio.

Personal consumption per capita in constant 2006 dollars for the entire study period was calculated by dividing the total personal consumption in constant 2006 dollars by the population from the national GPI study. Regional population was estimated based on the SNZ de facto population and resident population time series.[3]

For the period 1990–2006, total personal consumption in the Auckland region has been estimated to be $\$_{2006}$430,639 million (see Table 1).

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

[3] 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 per cent, representing the estimated average difference between the two measures at the national level (Statistics New Zealand, 1999a).

Table 1: Auckland region total personal consumption, 1990–2006

Calendar Year	**Personal consumption** (NZ$$_{2006}$ million)
1990	18,220
1991	18,072
1992	18,279
1993	18,881
1994	20,371
1995	21,486
1996	23,051
1997	24,115
1998	25,838
1999	26,583
2000	27,956
2001	27,851
2002	29,049
2003	30,928
2004	33,805
2005	33,446
2006	32,708
Total	**430,639**

3 Income Distribution

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

It is inevitable that the income of individuals will differ depending on the value placed on their work and the common consensus of the importance of this work in society. However, if most of the income and spending power of the nation is in the hands of only a small percentage of the total population, the well-being of the majority is likely to be lower than had the distribution been more broadly based and equitable. Furthermore, 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 also 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 the Personal Consumption component 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 coefficients have been applied in line with other international GPI studies and with other studies that have been undertaken for the New Zealand context (Easton, 1996; Statistics New Zealand, 1999b).[4]

Gini coefficients are typically determined by taking the difference between a straight line representing income equality and a Lorenz Curve (see 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 3 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.

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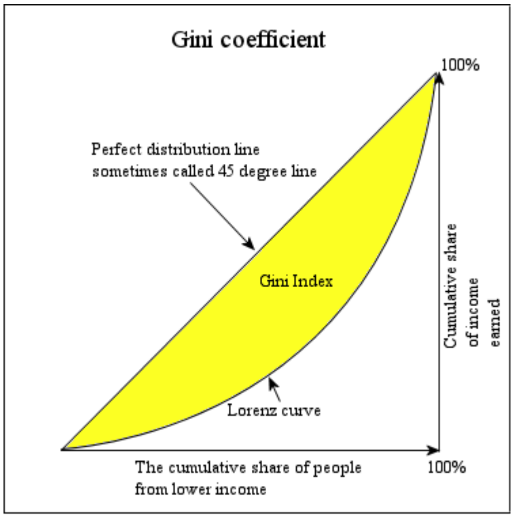
[4] The Gini coefficient was, for example, applied by Anielski & Rowe (1999) in the calculation of the United States GPI. Gini coefficients, *G*, are calculated using this formula:

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

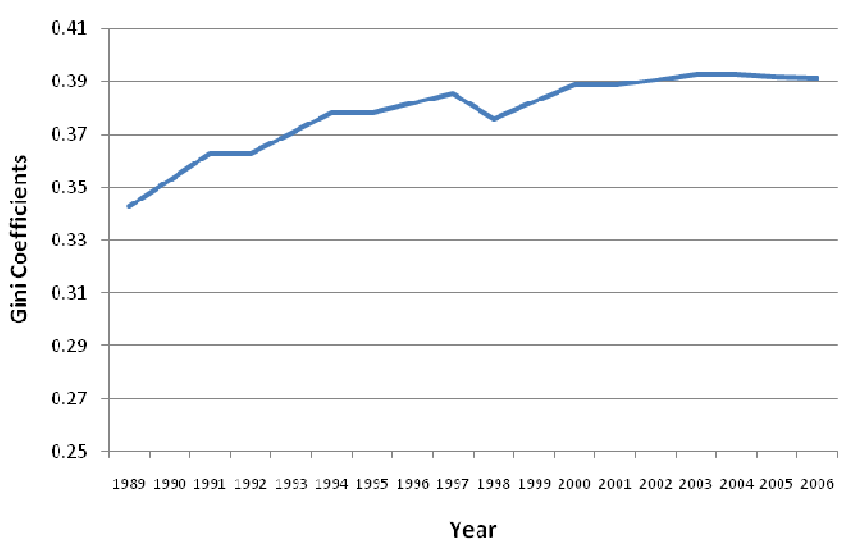
where n is the number of income groups (Quintiles), i is the rank value in ascending order (1 to 5) and X_i is the average annual income in each income interval (Buchan, 2002),

Figure 2: Lorenz Curve



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 coefficients have ranged between 0.357 and 0.402 for the 26 years since 1989; by comparison, the Auckland region Gini coefficients show a range of between 0.342 to 0.392 (see Figure 3).

Figure 3: Auckland region Gini coefficients, 1989–2006



The inclusion of a measure of income inequality in the Auckland 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 2004.[5] For the gaps in the income distribution data, coefficients were then estimated using geometric growth rates from the derived coefficients and the 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 the Auckland region in 2004, for example, the 2004 Gini coefficient of 0.3927 was multiplied by 100 and then divided by the 1989 base year Gini coefficient of 0.3409.[6] The resulting number, 115, represents the Income Distribution Index value for 2004.

The Auckland 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 Auckland region, 1990–2006

Calendar Year	Gini Coefficient	Income Distribution Index
		1989=100
1990	0.3525	103
1991	0.3626	106
1992	0.3626	106
1993	0.3704	109
1994	0.3784	111
1995	0.3784	111
1996	0.3819	112
1997	0.3855	113
1998	0.3757	110
1999	0.3821	112
2000	0.3885	114
2001	0.3885	114
2002	0.3906	115
2003	0.3927	115
2004	0.3927	115
2005	0.3920	115
2006	0.3913	115

[5] Job Reference number: ANM24602 (Statistics New Zealand, 2009b).
[6] The 1989 national Gini coefficient was set to be the base year Gini coefficient.

4 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 that answer by 100, as follows:

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

where:

WPC^r is the weighted regional personal consumption for the Auckland region at constant 2006 dollars
PC^r is the regional personal consumption at constant 2006 dollars, and
DI is the Distribution Index.

For the period 1990–2006, the weighted personal consumption in the Auckland region has been estimated to be $\$_{2006}$384,052 million (see Table 3).

Table 3: Auckland region's weighted personal consumption, 1990–2006

Calendar Year	Weighted Personal Consumption (NZ$ million)
1990	17,622
1991	16,991
1992	17,186
1993	17,378
1994	18,354
1995	19,359
1996	20,576
1997	21,329
1998	23,445
1999	23,720
2000	24,529
2001	24,438
2002	25,352
2003	26,847
2004	29,345
2005	29,085
2006	28,494
Total	**384,052**

5 Public Consumption – Non-Defensive

As with the treatment of personal consumption, public consumption (i.e. general government expenditures) is treated as a positive component of the GPI. However, one of the main differences between the GPI and the GDP is that only government expenditures 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, and both health and education spending. 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 Auckland region were derived using the Generating Regional Input–Output Table (GRIT) method devised by Jensen et al. (1982) at the University of Queensland. Specifically, government expenditure is recorded in the input–output table under the 'local and central government consumption' final demand category. Input–output data was available for the period 1989/90 to 1998/99, and also 2000/01 and 2003/04. The intervening years between 1999 and 2001 were filled by applying a moving average. 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 judgement 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 well-being. 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 Auckland region has been estimated to be $\$_{2006}$111,073 million (see Table 6).

Table 4: Public consumption by expenditure category (% of total public expenditure), 1990-2006

	Services to Land Transport	Public Admin	Sanitary and Similar Services	Education Services	Health Services	Social and Community Services	Recreation and Cultural Services	TOTAL Allocated	Unallocated	TOTAL
	%	%	%	%	%	%	%	%	%	%
1990	3.1	40.2	2.0	22.7	23.2	4.3	4.4	100.0	0.0	100.0
1991	4.4	41.4	1.7	23.1	21.9	3.4	4.0	100.0	0.0	100.0
1992	4.4	41.5	1.6	23.7	21.1	3.5	4.2	100.0	0.0	100.0
1993	4.5	41.3	1.7	23.1	21.9	3.4	4.0	100.0	0.0	100.0
1994	4.7	41.7	1.7	21.1	23.2	3.5	4.1	100.0	0.0	100.0
1995	4.8	41.2	1.8	20.8	23.7	3.3	4.2	100.0	0.0	100.0
1996	5.6	38.4	1.7	22.4	23.7	3.7	4.6	100.0	0.0	100.0
1997	5.4	38.7	1.7	21.5	24.4	3.6	4.7	100.0	0.0	100.0
1998	4.1	27.0	1.6	24.8	28.1	3.4	4.5	93.5	6.5	100.0
1999	5.9	39.8	1.5	20.0	25.1	3.5	4.3	100.0	0.0	100.0
2000	5.5	32.5	1.3	21.8	29.0	3.4	4.1	97.6	2.4	100.0
2001	5.0	25.1	1.2	23.5	33.0	3.3	3.9	95.1	4.9	100.0
2002	5.1	25.5	1.3	25.0	31.2	3.4	3.8	95.3	4.7	100.0
2003	5.1	25.5	1.3	25.0	31.2	3.4	3.8	95.3	4.7	100.0
2004	5.3	25.8	1.3	26.4	29.4	3.4	3.7	95.4	4.6	100.0
2005	5.3	25.8	1.3	26.4	29.4	3.4	3.7	95.4	4.6	100.0
2006	5.3	25.8	1.3	26.4	29.4	3.4	3.7	95.4	4.6	100.0

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 per cent 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 per cent over the study period. Overall, it has been assumed that 95 per cent of expenditure on public administration is for non-defensive purposes.	95%
Sanitary and 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 per cent 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 per cent 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 per cent of public expenditure on health is non-defensive.	90%
Social and Community Services	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 per cent 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: Auckland region's non-defensive public consumption, 1990–2006

Calendar Year	Public Consumption Expenditure (Non-Defensive) (NZ$$_{2006}$ million)
1990	5,170
1991	5,134
1992	5,207
1993	5,288
1994	5,392
1995	5,684
1996	6,059
1997	6,561
1998	6,005
1999	7,097
2000	6,761
2001	6,857
2002	7,188
2003	7,413
2004	8,063
2005	8,402
2006	8,793
Total	**111,073**

6 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 well-being 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, and health, crime and psychological costs (Hamilton and Denniss, 2000). These are described in brief below.

6.1 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, however, is already captured in the GPI through an impact on personal and public consumption.

6.2 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.

6.3 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 welfare 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.

6.4 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.

6.5 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) which, in turn, lead to a reduction in well-being 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 quantify the psychological effects of unemployment as the cause and effect relationships between unemployment and stress and trauma are not well understood; also 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 well-being, the unemployed were separated into five categories, as shown in Table 7.

Table 7: Unemployment types

Type	Actively Seeking Work	Available for Work	Cannot find a job
Official unemployment	Yes	Yes	Yes
Frictional unemployment	Yes	Yes	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, 2005); thus, individuals in this category, and their families, 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 well-being, and so the estimated figures for frictional unemployment have 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 per cent. Therefore, 1.3 per cent has 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 per cent. For this discrete period, 0.25 per cent 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 (Hirsch, Kett and Trefil, 2002). In this study, only the psychological costs of unemployment associated with discouraged workers are assessed. The cost of under-employment is discussed in the next component, while data restraints prevent 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:

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

where:

TC' is the total cost of regional unemployment

UH^r represents regional total unemployed hours per week
C is the cost ($) per hour, and
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 Auckland region seeking full-time work, and
UHP^r is the unemployed hours per week for people in the Auckland 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 Auckland 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 terms 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 Auckland 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 Auckland region.

In turn, CU^r is calculated as:

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

where:

OUR' and *FUR'* represent the official unemployment and fractional unemployment rates of the Auckland region, respectively, and

LF' 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

B is unemployment benefits per week, and

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 SNZ web tool INFOSHARE; the regional HLFS provided unemployment counts for 1990–2006 according to the moving average December year; the official unemployment rate was also obtained from the regional HLFS Unemployment Rate, with rates again according to the mean December year; and 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 per cent for the entire study period.

Data pertaining to the hidden unemployment count was taken out from regional HLFS customised from SNZ,[7] and refers to those people who are available to work but not actively seeking work, including seeking through newspapers only,[8] discouraged and other.[9] 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, multiplying this by the percentage of unemployed seeking full-time work, and, in turn, multiplying that answer 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 Auckland region, the unemployed people

[7] Job reference number: GRB24516 (Statistics New Zealand, 2009c).

[8] 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.

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

seeking full-time work , as sourced from the regional HLFS in the Auckland region was divided by total regional unemployed.[10]

For those seeking part-time work, their hours of involuntary leisure were calculated by taking the unemployment figures generated in Step 1, multiplying this by the percentage of unemployed seeking part-time work, and, in turn multiplying that answer 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 as described previously, i.e. dividing the unemployed people seeking for part-time work as sourced from the regional HLFS in the Auckland 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 system,[11] respectively, and deflated to a constant value based on the Consumer Price Index (CPI). The cost of an hour of involuntary leisure time is expressed as the difference between the minimum real wage rate and the unemployment benefits received. The average cost per hour of involuntary leisure for that period was then applied as a proxy for the remainder of the study period.

For the period 1990–2006 , the cost of unemployment in the Auckland region has been estimated to be $\$_{2006}$2634 million (see Table 8).

[10] Job reference number: GRB24749 (Statistics New Zealand , 2009d).

[11] 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 Auckland 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 Hour (NZ$2006)	Cost of Unemployment (NZ$2006 million)
1990	7%	34,000	6,314	13,693	41,379	1,409,008	2.16	158
1991	11%	55,900	6,375	17,700	67,225	2,316,812	2.10	253
1992	12%	55,200	6,240	16,900	65,860	2,304,802	2.09	251
1993	10%	48,100	6,381	16,300	58,019	2,017,410	1.77	187
1994	8%	40,700	6,697	16,300	50,303	1,741,432	1.66	151
1995	6%	29,100	6,878	14,000	36,222	1,229,799	1.58	101
1996	5%	29,400	7,350	15,400	37,450	1,232,729	1.51	97
1997	7%	39,500	7,551	17,800	49,749	1,636,349	1.51	129
1998	7%	41,300	7,562	18,900	52,638	1,668,358	2.21	193
1999	6%	35,100	7,605	15,700	43,195	1,402,299	1.99	146
2000	6%	32,700	7,591	15,100	40,209	1,299,105	2.30	155
2001	5%	29,800	7,906	16,300	38,194	1,225,921	2.20	141
2002	5%	29,100	8,049	15,900	36,951	1,181,228	2.33	144
2003	4%	24,400	7,930	11,600	28,070	885,528	2.26	104
2004	4%	24,300	8,313	14,000	29,987	938,786	2.23	109
2005	4%	23,900	8,397	16,200	31,703	996,181	2.73	142
2006	4%	24,600	8,643	14,900	30,857	963,960	3.45	173
Total		**597,100**	**125,783**	**266,693**	**738,010**	**24,449,706**		**2,634**

7 Cost of Under-employment

Under-employment 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 under-employment as a proxy for estimating the value psychological costs arising out of under-employment.

The total cost of under-employment, TC', is calculated as:

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

where:

U' is total part-time employees looking for full-time work in the Auckland region
H' is hours sought per week per part-time employee in the Auckland region
C' is the regional cost ($) per hour, and
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

Under-employment population statistics for the study period were taken from customised SNZ regional HLFS. Arguably, under-employment may include both (1) part-time employees looking for full-time work, and (2) part-time employees wanting more work.[12] In calculating the cost of under-employment, only the statistics for part-time employees looking for full-time work were assessed.[13]

Estimation of additional hours required

For the years 1990–2006, the number of part-time workers,[14] as defined by number of hours worked per week, was also extracted from customised SNZ's HLFS database[15] and converted to a percentage profile (see 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 of year in the study period.

[12] Job reference number: GRB24516 (Statistics New Zealand, 2009e).
[13] 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.
[14] In SNZ's (2009e) Household Labour Force Survey, part-time workers are defined as those people working less than 30 hours each week.
[15] Job reference number: GRB24516 (Statistics New Zealand, 2009f).

Table 9: Profile of part-time hours

	Current hours worked: 1-9 (5)	Current hours worked: 10-19 (15)	Current hours worked: 20-29 (25)
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: Figures in brackets are the midpoint for each time band.

Estimation of hourly cost

The average hourly wage rate is considered to be the opportunity cost of one under-employed 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 from the Earnings and Employment Survey (INFORSHARE).16 Quarterly data was annualised using moving averages 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 under-employed 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 constant 2006 dollars.

For the period 1990–2006, the cost of under-employment in the Auckland region has been estimated to be $\$_{2006}$1,681 million (see Table 10).

[16] 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 under-employment.

Table 10: The cost of under-employment in the Auckland region, 1990–2006

Calendar Year	Part-time Employed People Looking for Full-time Jobs	Total Hours Sought per Year	Hourly Wage Rate $(\text{NZ}\$_{2006})$	Cost of Under-employment $(\text{NZ}\$_{2006}\ \text{million})$
1990	2,900	3,244,799	18.82	61
1991	5,200	5,881,839	19.61	115
1992	4,800	5,496,282	20.18	111
1993	4,300	4,743,680	20.42	97
1994	4,600	5,151,003	20.15	104
1995	3,300	3,694,131	19.82	73
1996	4,000	4,501,370	19.84	89
1997	5,400	6,160,503	20.36	125
1998	6,300	7,129,553	20.93	149
1999	6,300	6,990,872	21.61	151
2000	4,300	4,730,102	21.34	101
2001	4,900	5,276,839	20.94	110
2002	4,200	4,426,203	21.21	94
2003	3,300	3,529,138	21.56	76
2004	4,600	4,980,080	21.72	108
2005	2,300	2,465,941	21.79	54
2006	2,600	2,812,775	21.85	61
Total	**73,300**	**81,215,109**		**1,681**

8 Cost of Overwork

There are many potential personal and national benefits associated with the provision of work. However, there is 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 Auckland region
OH^r is the number of overtime hours worked per week in the Auckland region
C^r is the cost ($) per hour, and
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 HLFS.[17] 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.[18] 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.

[17] Job reference number: GRB24516 (Statistics New Zealand, 2009g).

[18] 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: Hours worked per week per person

Hours Worked per Week per Person	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
Midpoint of Hours Worked per Week per Person Category	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 was 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.[19] 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 overworking.

The average overwork hours per week per person in the 50 hours and over category is estimated by subtracting 50 hours from the average hours worked per week per person. 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. However, 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 their job. Therefore, in placing a value on an hour of overtime, it seems most appropriate to use the average wage rate, as previously determined for the cost of under-employment.

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

For the period 1990–2006, the cost of overwork in the Auckland region has been estimated to be $\$_{2006}$19,270 million (see Table 12).

[19] 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 Auckland region, 1990–2006

Calendar Year	GPI Defined Overworked People	Total Hours Overworked per Year	Hourly Wage Rate	Cost of Overwork
			(NZ$ $_{2006}$)	(NZ$ $_{2006}$ million)
1990	76,100	39,678,540	18.82	747
1991	76,500	39,887,100	19.61	782
1992	78,500	40,929,900	20.18	826
1993	84,000	43,797,600	20.42	894
1994	98,400	51,305,760	20.15	1,034
1995	102,700	53,547,780	19.82	1,061
1996	114,900	59,908,860	19.84	1,188
1997	110,800	57,771,120	20.36	1,176
1998	114,000	59,439,600	20.93	1,244
1999	110,100	57,406,140	21.61	1,241
2000	115,500	60,221,700	21.34	1,285
2001	115,800	60,378,120	20.94	1,264
2002	117,200	61,108,080	21.21	1,296
2003	114,300	59,596,020	21.56	1,285
2004	115,300	60,117,420	21.72	1,306
2005	120,900	63,037,260	21.79	1,373
2006	111,200	57,979,680	21.85	1,267
Total	**1,776,200**	**926,110,680**		**19,270**

9 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: there are the stocks owned by trading enterprises (e.g. electricity and gas supply infrastructure) whose services are charged to consumers directly, and 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. Thus the formula used to estimate the value of the services, S, is:

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

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 Auckland region and New Zealand, respectively, and

Pop^r and Pop^n are the regional and national populations.

For the period 1990–2006, services of public capital in the Auckland region has been estimated to be $\$_{2006}$49,830 (see Table 13)

Table 13: Services of public capital in the Auckland region, 1990–2006

Calendar Year	Services of Public Capital (NZ$\$_{2006}$ million)
1990	2,520
1991	2,435
1992	2,396
1993	2,352
1994	2,430
1995	2,505
1996	2,528
1997	2,609
1998	2,711
1999	2,857
2000	2,951
2001	3,079
2002	3,273
2003	3,476
2004	3,634
2005	3,907
2006	4,168
Total	**49,830**

10 Value of Household and Community Work

Some of the most essential work undertaken in a society to facilitate national well-being is performed without monetary payment in compensation. Importantly, unpaid household work (caring for children, home decoration, food preparation and so on) makes a large contribution to human welfare. 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, p. 8) 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 that 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 Auckland region.

The following five steps are used to calculate the value of household and community work in the Auckland region:

Step 1: Determine residential population by age and sex

The regional resident population by age (in five-year cohorts) and sex for each year ended 30 June was obtained from SNZ for the years 1996–2006.[20] This data was then grouped into 12 categories as shown 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+

As data of the same type was not available for the earlier years of the study, reference was made to SNZ's 1991 Census usually-resident population count by age (five-year cohort) and sex[21] and to the de facto resident population estimates for the years 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 estimates.[22] The resident

[20] Job reference number: JOW24622 (Statistics New Zealand, 2009i).
[21] Job reference number: JOW24622 (Statistics New Zealand, 2009j).
[22] 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

population by age–sex cohort for the remaining years (1990 and 1992–1995) was estimated by taking the total resident population and disaggregating into age-sex cohorts based on the 1991 population structure.

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 more than 8500 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 (see Section 26.2).

Next, data on resident population by age–sex category 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.

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	Physical care
		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

converted to resident estimates by applying an inflator of 2 per cent, representing the estimated average difference between the two measures (Statistics New Zealand, 1999c).

Table 16: Time use (minutes) by age–sex cohorts, 1999

Sex	Male							Female						
Age	**0-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**	**Total**	**0-24**	**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
Care-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
Purchasing Goods and 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
Unpaid 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 cost – 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.[23] 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 from Table 17 include:[24]

- Around 90 per cent 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 per cent 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 lifestyles and time use patterns.
- All formal unpaid community work and 50 per cent 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 hourly wage rate, $\$_{1999}$10.56, used to represent a general housekeeper was estimated from the national wage rate, $\$_{1999}$9.60. (See Step 3 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 datasets,[25] namely NZSCO51211 Housekeeper (Private Service) and ANZSCO811412 Domestic Housekeeper.[26] The average ratio of the regional total personal income for housekeepers to that of national value for 2001 and

[23] 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*.

[24] 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, and shopping for household items is work, but window shopping is not (Hamilton and Denniss, 2000). For such reasons, we count only 50 per cent of informal community work as leisure, but none of the formal community work.

[25] Job reference number: ANM24573 (Statistics New Zealand, 2009k).

[26] A 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 Not Elsewhere Classified (nec) (Statistics New Zealand and Australian Bureau of Statistics, 2006) Therefore it is reasonable to use both to estimate the average hourly wage rate for a housekeeper.

2006 was used to factor up or down the time series of the national housekeepers' average hourly wage rate developed for the New Zealand GPI. For example, the average ratio of the Auckland region to the New Zealand housekeepers' total personal income was 1.10. The national housekeepers' hourly wage rate of each year for the period from 1990 to 2006 was therefore multiplied by 1.10 to determine the average hourly wage rate for housekeepers in the Auckland region.

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 Auckland region has been estimated to be $\$_{2006}$156,419 million (see Table 18).

Table 17: Percentage of time deemed non-leisure by sex–age cohorts

Sex	Male						Female					
Age	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 Auckland region, 1990–2006

Calendar Year	Value of Household and Community Work (NZ$$_{2006}$ million)
1990	7,439
1991	7,811
1992	7,883
1993	7,856
1994	8,146
1995	8,397
1996	8,626
1997	8,945
1998	9,361
1999	9,594
2000	9,915
2001	9,713
2002	9,882
2003	10,436
2004	10,507
2005	10,738
2006	11,170
Total	**156,419**

11 Private Defensive Expenditure on Health

In the Public Consumption component described earlier, defensive expenditure that does not contribute to an improvement in well-being is excluded. However, in the case of Personal Consumption, defensive expenditure on health that does not contribute to well-being is included. The purpose of Component L 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 also 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) data[27] was used to scale down the national private-defensive expenditure on health as follows:

$$PDHC^r = PDHC^n \times \frac{HC^r_{HES}}{HC^n_{HES}}$$

where:

$PDHC^r$ and $PDHC^n$ are the regional and national private defensive expenditure on health, respectively, for GPI, and

HC^r_{HES} and HC^n_{HES} are the household expenditure on health from the Auckland region and New Zealand HES.

Regional and national household expenditure on health 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 so, at the regional level, may produce dubious results.

For the period 1990–2006, the private defensive expenditure on health in the Auckland region has been estimated to be $\$_{2006}$1493 million (see Table 19).

[27] Job reference number: ANM24602 (Statistics New Zealand, 2009h).

Table 19: Private defensive expenditure on health in the Auckland region, 1990–2006

Calendar Year	Private Defensive Expenditure on Health (${\text{NZ\$}}_{2006}$ million)
1990	67
1991	72
1992	78
1993	75
1994	76
1995	74
1996	81
1997	84
1998	87
1999	90
2000	92
2001	93
2002	97
2003	101
2004	106
2005	110
2006	112
Total	**1,493**

12 Cost of Commuting

As the Auckland region increasingly urbanises it is inevitable that people will spend more time and money getting to and from work — a result of greater distances travelled and increased traffic congestion. In the calculation of GDP, the direct costs of commuting are counted as a positive contribution. However, such expenditure, as well as the time spent commuting, is a drain on well-being because it limits funds available for consumption and time available for productive work and leisure. Hence, the costs associated with commuting are a negative parameter in the GPI.

When calculating the costs of commuting, two negative contributions to well-being associated with commuting are taken into account. These are the direct costs made by commuters in the pursuit of getting to work (e.g. vehicle purchases, petrol, vehicle maintenance, bus and train fares), and the value of time spent commuting in terms of lost productive hours in work or lost leisure time (i.e. time costs). However, it must also be acknowledged that there are other less tangible costs associated with commuting, such as the stress and frustration caused by sitting in traffic, and that these are 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 sector[28]
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 travelled.[29]

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.

Total employment counts by commuting mode were extracted from SNZ's New Zealand Official Year Book for each census year in the study period. The Time Use Survey (1999) provides the

[28] 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.
[29] Data formulated from New Zealand Travel survey (Ministry of Transport, 2006).

average minutes spent per day on commuting by mode. A decreasing rate of 2.5 per cent per annum is then used to extrapolate the figures for all other missing years. A cost of commuting of $\$_{1998}$7 per hour in 1998 is inflated by the CPI to estimate the costs for missing years.[30] The cost of commuting is the total of each year's direct and time costs. The CPI by transportation was used to convert the nominal values to constant 2006 dollars.[31]

In the absence of regional data, the national cost of commuting was scaled down to the regional level using the ratio of regional-to-national household expenditure on transportation as extracted from the regional HES database.[32] The mathematics is as follows:

$$CC^r = CC^n \times \frac{HC^r_{HES}}{HC^n_{HES}}$$

where:

CC^r and CC^n are the regional and national direct cost of commuting, respectively, for GPI, and

HC^r_{HES} and HC^n_{HES} are the household expenditure on transportation extracted from the Auckland region and New Zealand HES.

The time cost at 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:

$$TC^r = TC^n \times \frac{TT^r_{MOT}}{TT^n_{MOT}}$$

where:

TC^r and TC^n are the regional and national time cost of commuting, respectively, for GPI, and

TT^r_{MOT} and TT^n_{MOT} are the hours travelled per year to work by private and public transport in the Auckland region and in New Zealand, respectively, as taken from Ministry of Transport database.

Data of the hours travelled per year by destination (work) by mode (private car, public transport etc.) was prepared by the Ministry of Transport, based on their Household Travel Survey. Two pieces of data were available: for 1997/98, and the average for the period for 2003–2007. The average ratio for these two data points was used in the scaling process.

For the period 1990–2006, the cost of commuting in the Auckland region has been estimated to be $\$_{2006}$21,871 million (see Table 20).

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

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

[32] Job reference number: ANM24602 (Statistics New Zealand, 2009h).

Table 20: The cost of commuting in the Auckland region, 1990–2006

Calendar Year	Cost of Commuting
	(NZ$$_{2006}$ million)
1990	926
1991	944
1992	961
1993	915
1994	981
1995	1,129
1996	1,219
1997	1,266
1998	1,333
1999	1,320
2000	1,314
2001	1,354
2002	1,466
2003	1,603
2004	1,705
2005	1,719
2006	1,714
Total	**21,871**

13 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 Auckland 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 well-being as it represents a property transfer (from the owner to the thief), and not a loss. However, given 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. Therefore, we value property loss resulting from robbery, burglary and theft.

Property damage
The cost of arson, wilful damage to property and the like.

Preventative expenditure:
The cost of insurance premiums, alarms and the like.

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 Auckland 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 component. 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.

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. However, these district offences are based on New Zealand Police Areas, which are different to the standard regional boundaries. A concordance between New Zealand Police Area and SNZ Regional Council boundaries were developed using mesh-block data provided by SNZ. These figures were then rescaled using a multiplier of 4.66 in order to better reflect the actual number of offences (both recorded and unrecorded) in each year. [33]

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 offence for the year 2004 was derived by dividing the estimated total cost of those offences on the private sector[34] for that year by the estimated number of property offences as reported by Roper and Thompson (2004).[35] Finally, the estimated 2004 value of $\$_{2004}$2357 was inflated to $\$_{2006}$2458 at constant 2006 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.[36]

Step 2: Cost of crime for years 1990–1997
There is no regional data available on the numbers of offences 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 Auckland region cost of crime was valued, on average, as 35 per cent of the total New Zealand cost of crime. This ratio is multiplied by each year's real total New Zealand cost of crime and, in turn, backcast to give a regional cost of crime for the years prior to 1998.

For the period 1990–2006, the cost of crime in the Auckland region has been estimated to be $\$_{2006}$19,687 million (see Table 21).

[33] 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.
[34] Roper and Thompson (2004) estimated the total cost of crime for NZ in 2004 was $9.14 billion. Subtracted from this figure were the costs to the public sectors (23 per cent), all private sector costs from violent offences (23 per cent), sexual offences (11 per cent) and other (14 per cent).
[35] This cost also includes the private expenditure on insurance premiums, alarms and the like.
[36] The cost per property/serious traffic crime is initially estimated at $\$_{2004}$2317 for the March year, but this translates to $\$_{2004}$2357 for the December year when adjusted by the IPD.

Table 21: The cost of crime in the Auckland region, 1990–2006

Calendar Year	Cost of Crime (NZ$$_{2006}$ million)
1990	1,071
1991	1,167
1992	1,214
1993	1,209
1994	1,170
1995	1,216
1996	1,248
1997	1,238
1998	1,195
1999	1,105
2000	1,100
2001	1,111
2002	1,182
2003	1,180
2004	1,051
2005	1,087
2006	1,144
Total	**19,687**

14 Loss and Damage to Terrestrial Ecosystems

Terrestrial ecosystem loss in the Auckland region is from two main sources: indigenous forest change, and pests and weeds.

Indigenous forest change

Indigenous forest change covers high growth and regrowth. From 1970 onwards there has been some loss of high growth in the Auckland region, but considerable loss of regrowth (which covers manuka and kanuka, plus seedlings such as kauri and totara). This loss was mainly on freehold land and took place up to the mid-1980s when subsidies to farmers were removed.

Loss of indigenous forest represents a long-term loss of habitat for native birds, biodiversity, passive value (existence, bequeath, option) and recreation value. Each hectare lost is a loss not just in the year of the clearance but for every subsequent year. Therefore data has been summed from 1970 onward.

The loss of indigenous forest in the Auckland region has been estimated using data on indigenous forest and scrub loss for 1977–79 and 1984 that was prepared for the Rodney Ecological District (Froude et al., 1985). Data for a similar boundary was extracted for 1996/97 and 2000/01 from the Landcover Database 1 (LCDB1) and the Landcover Database 2 (LCDB2). The Rodney Ecological District accounted for 75 ha of the estimated 117 ha of indigenous forest, broadleaf indigenous hardwoods, and manuka and kanuka loss in the Auckland region between the two data points available, i.e. 1996/97 (LCDB1) and 2000/01 (LCDB2) (see Appendix III.) The ratio of 75 ha to 117 ha (1:1.56) was used to scale the hectares of indigenous forest lost in the Rodney Ecological District up to the Auckland region.

Each hectare of indigenous forest lost is valued at $\$_{1994}$717 or $\$_{2006}$903 per annum as per Patterson and Cole (1999) (see Table 22). The passive or non-use value used ($\$_{1994}$104/ha/annum) is that of a forest park, which is considerably lower than that of a national park ($\$_{1994}$871/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.

Table 22: Net Value of Loss of Indigenous Forest Ecosystems

	Description	Indigenous Forest NZ$$_{1994}$/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 = Passive value covers existence, bequeath and option values.

Source: Patterson and Cole (1999).

Pests and weeds

GPIs for other countries do not include the environmental cost of pests and weeds. This category has been included for New Zealand 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, and does not cover naturally occurring ecological change.

The cost of pests and weeds to the Auckland region has been based on annual defensive expenditure required to control plant and animal pest invasion. The defensive expenditure is the financial cost of resources required to restrict pest and weed populations. The bulk of defensive expenditure in New Zealand is to control rather than eradicate. Estimates for the Auckland region are based on the national figure, which estimates that production loss from plant and animal pests cost New Zealand $\$_{1999}$840 million per year, or approximately 1 per cent of GDP, in 1999 (Hackwell and Bertram, 1999). The reduced agricultural output as a result of plant and animal pests is not included because this is taken into account by decreased personal consumption.

Hackwell and Bertram (1999) assembled tables that estimate defensive expenditures by central and regional governments on pest control between 1991 and 1999. From 2000 onwards, expenditure by the Department of Conservation on species and habitat protection (Annual Reports, Vote Conservation and Vote Biosecurity) and by MAF on border control and quarantine statistics (Annual Reports, Vote Biosecurity) was used. The Auckland region's share of central government and private spending is based on its percentage of total regional council expenditure. Regional council spending for 1991–1998 is estimated from Hackwell and Bertram (1999, Table 3) and for 2000–2006 from ARC biosecurity expenditure.

Table 23: Pest-related Auckland region expenditure, 1990–2006

Year	ARC Portion of NZ costs ($\$_{2006}$ million)	Regional Household Expenditure ($\$_{2006}$ million)	ARC Expenditure ($\$_{2006}$ million)	Total for Auckland Region ($\$_{2006}$ million)
1990	16	7	1	24
1991	16	7	1	24
1992	20	7	1	27
1993	17	7	1	24
1994	20	7	1	28
1995	28	7	2	38
1996	28	8	2	38
1997	35	8	2	45
1998	35	8	2	45
1999	57	8	3	68
2000	81	8	4	93
2001	73	8	4	85
2002	85	8	4	97
2003	87	8	4	100
2004	78	8	4	90
2005	83	9	4	95
2006	79	9	4	91

Adapted from Hackwell and Bertram 1999, p. 53.

Notes: 1. Agricultural security was excluded as production related.
2. 1991–1999 in $\$_{1999}$ million.

Table 23 gives pest-related expenditure estimates for the period 1990–2006 for the Auckland region. Tb-vector control is included as this benefits indigenous forests and wildlife as well as human ‘productive’ activity (Hackwell and Bertram, 1999, p. 61). Total regional council expenditure has been estimated as $\$_{1999}$20–25 million per year between 1991 and 1999 (Hackwell and Bertram, 1999). The Auckland region costs have been taken as a portion of this, based on figures for regional council expenditure (Hackwell and Bertram, 1999, p. 55). From 2000 onwards, ARC expenditure is as provided by ARC. 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 $\$_{1997}$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 $\$_{1997}$40 million for research up to 1997. From 1998 onwards, the estimate is $\$_{1998}$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).

Hackwell and Bertram report that households in New Zealand also incur costs to control insect, animal and plant pests in both their houses and gardens (Hackwell and Bertram, 1999, p. 56). This study used Hackwell and Bertram's (1999) estimate of $\$_{1999}$20 per household per year for pest-related spending, which was multiplied by the number of households in the Auckland region.

All expenditures were then summed to give an estimate for total defensive expenditure from 1991 to 2006 (see Table 23). 1990 was assumed to be the same as 1991. Annual defensive pest-control expenditures were then converted to constant 2006 dollars.

For the period 1990–2006 the total cost of terrestrial ecosystems has been estimated at $\$_{2006}$1264 million (see Table 24).

Table 24: Total value of forest biodiversity loss, 1990–2006

Year	Loss of Indigenous Forest ($\$_{2006}$ million)	Pest and Weed Cost ($\$_{2006}$ million)	Total Cost of Lost Terrestrial Ecosystems ($\$_{2006}$ million)
1990	14	24	38
1991	14	24	38
1992	14	27	42
1993	14	24	39
1994	15	28	43
1995	15	38	52
1996	15	38	53
1997	15	45	60
1998	15	45	60
1999	15	68	83
2000	15	93	108
2001	15	85	100
2002	15	97	113
2003	15	100	115
2004	15	90	106
2005	15	95	110
2006	15	91	106
Total			**1264**

15 Loss of Wetlands

The draft report 'Assessment of Change in Wetlands in the Auckland region: 1980s to 2006' by Karen Denyer (completed in October 2008) is the most informative recent review of wetlands in the Auckland region. This study used the 20-year-old WERI (Wetlands of Representative and Ecological Importance) dataset as a baseline to determine the extent to which the WERI wetlands are still present in the Auckland region. The analysis found that almost all of the WERI wetlands are still present, but provided no information on their condition in terms of pests and weeds or if there had been any reduction in scale. Only 1 per cent (2 wetlands) appears to have been completely or substantially drained and cleared. This loss would be compensated by the new wetlands in the Auckland region that have been restored or created.

There is a possibility that wetlands not included in the WERI database (<1 ha) have been drained or reduced in size but no actual data is available to quantify this.

According to the LCDB1 and LCDB2 landcover databases between 1996/97 and 2000/01 there was no change in wetland area. (See Appendix III.)

16 Loss of Soils

Soils in the Auckland region are naturally fertile and support a range of agricultural, forestry and horticultural activity. The Auckland region is the second smallest in New Zealand, covering 524,764 ha, but with the largest population, estimated at 1.37 million in 2006 or 33 per cent of New Zealand's population. A significant proportion of the land in the Auckland region is urban, with farmland located to the north and south. The Auckland region 'overshoots' its useful land area by about a factor of three, which means it is not ecologically self-sufficient and depends on land appropriated from other regions and overseas (Smith and McDonald, 2008). 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 recognises that the built environment contributes to the well-being of New Zealanders, shown by an increase in the personal consumption component of the GPI to reflect building construction and property transactions. However, if natural capital is depleted by erosion or expansion onto agricultural land, this side of the balance sheet must also be accounted for.

Rural land values in the Auckland region reflect potential for urbanisation. However, because the Auckland region 'overshoots' its land area, consideration needs to be given to maintaining agricultural land for growing fresh food close to final consumers and 'closing the loop'. This concept incorporates the close-proximity reuse of organic waste generated by urban areas to maintain soil fertility and promote sustainable urban living (Paulin and O'Malley, 2005).

The GPI adjusts for the loss of soils resulting from two economic activities: the loss of fertile soil to the built environment, and erosion from agricultural land.

The loss of fertile soil to the built environment

The loss of agricultural land to urban encroachment is measured from 1970 because, once lost, the loss of the flows of ecosystem services associated with that land continues to exist. The expansion of the built environment in New Zealand has resulted in the permanent loss of some of the most fertile soils in the country.

ARC provided estimates of urban area in the Auckland region for 1979, 1987, 2001 and 2006. A second-order polynomial curve fits these points well and allowed estimation of a time series for urban area from 1970 to 2006.

A study to quantify the economic value of ecosystem services associated with highly modified arable landscapes in Canterbury, New Zealand, by Sandhu et al. (2007) estimated the total economic value to be between $\$_{2005}$1792/ha/yr and $\$_{2005}$20,254/ha/yr for conventional farmland. For the Auckland region GPI, an average of $\$_{2005}$11,023/ha/yr (or $\$_{2006}$11,290/ha/yr) was used to value farmland lost to built-up uses. The ecosystem services valued 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 onward.

When land used extensively for market gardening or arable cropping is poorly managed, soil degradation in the form of pugging, capping, or severe compaction can take place. Loss of soil structure has been reported in the Pukekohe area from intensive market gardening but only for small areas. Continuous cropping is a localised and infrequent land use in New Zealand (Sparling et al., 2006, p. 549), so again the extent of damage is limited. According to Haynes (1995), in most cases where soils have been severely compacted by poor cultivation practices, at least 20 years under well-managed ryegrass-clover pasture will restore their original structure. As soil degradation can be rectified over time, this is regarded as an economic cost to production, rather than an asset loss, and is therefore not included in the GPI.

Soil erosion

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 its geologically young landforms, tectonism, steep topography and 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: (1) the permanent loss of the asset (i.e. soil) for use, and (2) 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 also because data is not available.

Erosion causes permanent long-term loss of productive capacity and a number of external effects not captured by market values including impacts on landscape quality, siltation of dams, rivers and estuaries, and reduced biodiversity and water quality. Erosion costs have been calculated using the number of tonnes of sediment lost from both farming and subdivision, and multiplying this total by the estimated cost per tonne of erosion damage in New Zealand.

<u>a) Farming</u>

The change in area of farmland in the Auckland region has been estimated based on current land measures adjusted annually by estimated loss to urban uses. Erosion resulting from farming has two main impacts: (1) the permanent loss of the asset (i.e. soil) for use, and (2) 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). Three impacts of agriculture-induced erosion have been allowed for in the valuation: (1) permanent loss to future agricultural output, (2) the downstream costs imposed on other sectors, and (3) the cost of defensive expenditure undertaken to prevent further erosion.

The erosion rates used for the calculations are from the report ‘Predicting sediment loss under proposed development in the Waiarohia catchment’ (ARC, 2003) (see Table 25).

Table 25: Predicted mean annual sediment loss (kg/ha/yr) in a range of scenarios

Scenario	Description	Sediment Loss	Efficiency
Baseline	Pasture	448	
1	Bare Earth	14,425	
2	Bare Earth & Pond	4,793	67%
3	Bare Earth & Restrictions	9,991	31%
4	Bare Earth & Buffer	11,554	20%
5	Bare Earth & Pond & Restrictions	3,450	76%
6	Bare Earth & Pond & Buffer	3,848	73%
7	Bare Earth & Buffer & Restrictions	7,924	45%
8	Bare Earth & all 3 controls	2,817	81%

Source: ARC (2003).

Krausse et al. (2001, p. 38) estimated the annual economic cost of erosion and sedimentation in New Zealand in 1998 to be $\$_{1998}$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 $\$_{1998}$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 per cent (75 million tonnes) of the total in 1998. Therefore, 36 per cent of $\$_{1998}$126.7 million ($\$_{1998}$86.41 million) has been used here, which equates to $\$_{1998}$1.15 or $\$_{2006}$1.37 per tonne of erosion (see Table 26). The total area of farmland in the Auckland region has been estimated using the LCDB1 and LCDB2 databases.

Table 26: Estimate of the cost of agricultural erosion in New Zealand

	Total cost of erosion (natural and land-use induced) ($\$_{1998}$ million)	**Proportion of total erosion costs assigned to land use** %	**Total cost of erosion assigned to land use** ($\$_{1998}$ million)
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	5.85
Treatment of reticulated water	2.8	36	1.00
Water storage loss	0.2	36	0.07
Navigation	7.5	36	2.69
Water conveyance (irrigation)	0.6	36	0.22
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	0.83
Total	**126.7**		**86.41**

Source: Krausse et al. (2001).

Notes:

- Agricultural production loss: occurs on only farms and includes losses to vegetative production and animal performance. As erosion scars can take 100 years to reach 80 per cent of their former productivity (Parfitt, 2005), mass movement erosion ($\$_{1998}$12.5 m) has been included as 100 per cent. Surface erosion accounts for the remaining cost ($\$_{1998}$24.5 m) and it is assumed this soil is either washed or blown away and the loss permanent so 100 per cent 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 per cent related to agriculture land-use erosion.
- Private property damage: includes direct damage to buildings and dwellings from erosion. Of this, 36 per cent 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 per cent 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 unlikely to be damaged by erosion sourced from agriculture land use, so 36 per cent of this cost was assigned.
- Recreation facility damage: this is most likely to be impacted on by natural erosion events, and so only 36 per cent 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 per cent and land-use effects were responsible for 36 per cent.

b) Subdivision

Erosion from subdivision has been calculated from the area of land being converted from farmland to urban purposes annually using the erosion rate for 'Bare earth and restrictions' given in **Table** 25. The impact of subdivision erosion is predominantly not on the property concerned, but rather on waterways and estuaries in the Auckland region.

Table 27: Estimate of the cost of subdivision erosion in the Auckland region

	Total cost of erosion (natural + land-use induced)	**Proportion of total erosion costs assigned to land use**	**Total cost of erosion assigned to land use**
	($$_{1998}$million)	(%)	($$_{1998}$million)
Damage costs			
Private property damage	5.7	36	2.1
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	5.85
Treatment of reticulated water	2.8	36	1
Water storage loss	0.2	36	0.07
Navigation	7.5	36	2.69
Water conveyance (irrigation)	0.6	36	0.22
Avoidance/Prevention costs			
Regional authority expenditure	18.5	100	18.5
Road preventative maintenance	2.3	36	0.83
Total	**81.4**		**41.1**

Erosion related to agricultural land use accounted for 75 million tonnes of the 209 million tonnes of total soil loss in 1998. The 75 million tonnes of erosion has been costed at $\$_{1998}$1.15 or $\$_{2006}$1.37 per tonne. Erosion costs resulting from subdivision cover off-property impacts only (i.e. lost production costs are excluded). Erosion as a result of subdivision costs have been estimated at $\$_{1998}$0.55 or $\$_{2006}$0.65 per tonne.

The costs used for erosion are conservative given that the value given by Krausse et al. (2001) excludes a number of other costs that could be included if there were sufficient data. Soil, especially soil with high organic matter content, provides ecosystem services that include improved water storage and release, biodiversity protection, and also 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 1990–2006, the total cost of soil loss has been estimated at $\$_{2006}$1113 million (see Table 28).

Table 28: Cost of loss of soil from urban expansion and erosion, 1990–2006

Year	Annual loss of soil to erosion	Cumulative soil loss from erosion since 1970	ARC urban area	ARC annual loss to urbanisation	Cumulative loss to urbanisation since 1970	Sandhu et al. (2007) loss	Total cost of soil loss
	($\$_{2006}$ million)	($\$_{2006}$ million)	(ha)	(ha)	(ha)	($\$_{2006}$ million @ $11,290/ha)	($\$_{2006}$ million)
1990	0.16	3.32	45,192	254	2773	31.3	34.63
1991	0.16	3.48	45,459	267	3040	34.3	37.80
1992	0.16	3.63	45,738	279	3319	37.5	41.10
1993	0.16	3.79	46,029	291	3610	40.8	44.55
1994	0.16	3.95	46,332	303	3913	44.2	48.13
1995	0.16	4.10	46,648	316	4229	47.7	51.85
1996	0.16	4.26	46,976	328	4557	51.5	55.71
1997	0.16	4.42	47,316	340	4897	55.3	59.71
1998	0.16	4.57	47,668	352	5250	59.3	63.84
1999	0.16	4.73	48,033	365	5614	63.4	68.12
2000	0.16	4.88	48,410	377	5991	67.6	72.53
2001	0.16	5.04	48,799	389	6380	72.0	77.08
2002	0.15	5.19	49,200	401	6782	76.6	81.76
2003	0.15	5.35	49,614	414	7195	81.2	86.59
2004	0.15	5.50	50,040	426	7621	86.0	91.55
2005	0.15	5.66	50,478	438	8059	91.0	96.65
2006	0.15	5.81	50,928	450	8510	96.1	101.89
Total							**1113.50**

17 Loss of Air Quality

Fine Particulate Matter (PM_{10}) measures have been used to calculate the cost of air pollution in the Auckland region between 1990 and 2006. [37] 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 and 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.

The 1995 study on air quality carried out by Auckland Regional Council attributed 86 per cent of the total annual ambient air pollutants in the Auckland region to motor vehicles (Auckland Regional Council, 1997, p. 20). Although the analysis methodology varied between the 1995 and 2004 studies, transportation was again the largest contributor to PM_{10} emissions in 2004, at 53 per cent. Domestic heating accounted for 34 per cent, and the industrial/commercial sector contributed the remaining 13 per cent (Auckland Regional Council, 2006).

Weather and climate influence the concentrations of parameters in the atmosphere, and it is acknowledged that patterns apparent over just a few years may not reflect longer trends. The air quality changes identified in Auckland region over the 1993–2006 period included:

- Emissions of oxides of nitrogen have risen slightly, as a result of the increased numbers of all types of vehicles in the fleet.
- SO_2 emissions have risen slightly, but from a fairly low baseline. This is a result of increased diesel-fuel consumption from the increased numbers of diesel vehicles. This trend has been countered by the reductions in the sulphur content of fuels since the introduction of the Fuel Standards Regulations in 2001.
- PM_{10} and volatile organic carbon (VOC) emissions have fallen slightly, due to a shift away from coal and wood for both domestic heating and industrial use.

Average PM_{10} data for 1994–2005 (ARC Air Quality Data CD, May 2006) was used to calculate an index to show the trend in air pollution in the Auckland region, and this trend was assumed to be present between 1990 and 2006. The number of deaths from PM_{10} in the Auckland region in 1996 has previously been estimated at 436 (with a range of 284–619) per annum (Fisher et al., 2007, Table 5-2). Based on change in the PM_{10} index and change in population in the area, the estimated number of deaths each year was calculated for the 1990–2006 period and the economic impact of this estimated using the Fisher et al. (2007) study. The $-value was adjusted to avoid double-counting costs already allowed for elsewhere in the GPI. These numbers are given in Table 29.

[37] Greenhouse gas emissions and ozone depletion are accounted for elsewhere in the GPI. Although greenhouse gases, including carbon dioxide (CO_2), 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.

Table 29: Annual cost of air pollution in New Zealand in 2001, by source and effect (excluding background effects) and GPI Adjustment

Effect	Domestic ($$_{2001}$ million)	Vehicle ($$_{2001}$ million)	Industrial ($$_{2001}$ million)	Total ($$_{2001}$ million)	Adjusted for GPI ($$_{2001}$ million)
Mortality (PM_{10}), NO_2	267	310.5	98.3	675.8	277.5
Mortality (CO)	52.5	64.5	16.5	133.5	54.8
Bronchitis and related	66.5	40.6	8.7	115.8	47.6
Respiratory/cardiac admissions	1.2	0.7	0.2	2.1	0.7
Cancer	14.3	16.5	4.5	35.3	14.5
Restricted-activity days	101.7	61.7	13.3	176.7	92.2
Total	**503.2**	**494.6**	**141.5**	**1,139.20**	**487.3**

Source: Fisher et al. (2007, Table 10-8) and own calculations.

The economic impact of air pollution calculated by Fisher et al. (2007) for New Zealand in 2001 was $$_{2001}$1139.2 million. These estimated effects are for all New Zealand, not just the main cities. The health impact assessment in the study examined 67 urban areas, which were chosen based on their size, local activities, and/or monitoring data that show high levels of air pollution. The study areas comprise 2.7 million people (as of the 2001 census), or 73 per cent of the population of New Zealand (Fisher et al., 2007, S2). Health impact estimates are based on exposures derived from modelling and validated against monitoring and published dose-response relationships. Mortality rates are based on the dose-response work of Künzli et al. (2000), [38] which extrapolated an increase in mortality of 4.3 per cent for every additional 10μg in annual average PM_{10} concentration. Although that study was not New 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 their 'willingness to pay' for air quality improvements. A recent study by the National Occupational Health and Safety Advisory Committee put the value of a life in New Zealand at $$_{2004/05}$3.9 million (Access Economics et al., 2006, p. 27). Fisher et al. (2007) used the Land Transport New Zealand value of statistical life (VoSL) of $$_{2004}$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.

As the group most generally affected by air pollution tend to be the older age group, Fisher et al. (2007) assumed a loss of five years would be typical for air pollution. The working value used by Fisher et al. (2007) was $$_{2004}$2.725 million per statistical life (VoSL) over a 44-year lifespan. Using a 6 per cent discount rate, the loss of five years of life was valued at $$_{2004}$750,000 per person 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 $$_{2004}$308,000 per person for a loss of five years of life ($$_{2001}$2.725million/44 years × 5 years).

[38] 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).

Chronic bronchitis is 10 per cent of the value attributed to mortality as per Fisher et al. (2007). For respiratory/cardiac hospital admissions, a cost of $\$_{2004}$150/day per 7-day time period was allowed – this covers inconvenience only as health treatment costs and loss of income are covered elsewhere. Finally, the cost of restricted-activity days has been reduced by 20 per cent to remove 'work loss' days as this cost is already reflected in reduced GDP. After adjustment, the total cost for New Zealand comes to $\$_{2004}$487.3 million for 2001.

For the period 1990–2006, the total cost of air pollution has been estimated as $\$_{2006}$2976 million (see Table 30).

Table 30: Estimated annual cost of air pollution, 1990–2006

Year	PM_{10} index	ARC population	Estimated deaths	Total cost ($\$_{2001}$ million)	Total cost ($\$_{2006}$ million)
1990	27.1	948,269	432	163	**181**
1991	26.4	975,772	434	164	**182**
1992	25.7	992,055	430	163	**180**
1993	25.1	1,010,329	426	161	**179**
1994	24.4	1,041,766	428	162	**179**
1995	23.7	1,084,589	433	164	**182**
1996	23.1	1,123,241	436	165	**183**
1997	22.4	1,151,850	434	164	**182**
1998	21.7	1,172,707	429	162	**180**
1999	21.1	1,188,915	421	159	**177**
2000	20.4	1,205,673	414	157	**174**
2001	19.7	1,226,969	407	154	**171**
2002	19.1	1,263,480	405	153	**170**
2003	18.4	1,300,576	402	152	**169**
2004	17.7	1,328,601	396	150	**166**
2005	17.1	1,351,503	388	147	**163**
2006	16.4	1,376,075	379	144	**159**
Total					**2976**

Notes: 1. Estimated for year-ending December

18 Land Degradation

Land degradation in the Auckland region is from two main sources: waste to landfill, and contaminated sites.

Economic activity in New Zealand has left a legacy of an estimated 1500 seriously contaminated sites (landfills, service stations, sawmills, timber treatment plants, railway yards, engine works, metal industries and chemical manufacturers), and thousands more with some level of contamination (Ministry for the Environment, 1997). 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, and
- cross-subsidisation of waste disposal by ratepayers.

Land degradation impacts on the well-being of Aucklanders in a number of ways: toxic chemicals and leachate[39] from the sites can have undetected health effects; the sites cannot be used for other purposes; property values in the vicinity of landfills are reduced; and the cost of remediation is often covered by the tax payer, which diverts government expenditure from other more beneficial uses.

Until the 1980s, most New Zealand landfills were no more than tips or dump sites, which were often poorly sited, designed and managed (Ministry for the Environment, 2001, p. 1). Landfill sites receive contaminated material and, when poorly managed, can have serious environmental consequences from leachate discharge and stormwater 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”.

Waste to landfills and the estimated cost of cleaning up contaminated sites in New Zealand are used as proxies for the annual environmental cost of land degradation. Providing pesticides, herbicides and timber treatment to the forestry, farming and horticulture sectors has left large

[39] Liquid that drains or leaches from a landfill.

clean-up costs as well as damage to the health of people and the environment. Businesses, such as old gasworks, petrol stations and drycleaners, as well as households have left behind an unwanted legacy.

Waste to landfill

This method assumes the environmental impact of solid waste is a function of the quantity of waste that makes its way to landfill sites. The volume of solid waste sent to landfill is considerably less than what is produced, as most farms and many businesses bury their rubbish onsite. Nevertheless, placing a value on each tonne of waste to landfill allows us to take this form of pollution into account, even though it is not comprehensive.

Municipal solid waste data for 1990–2006 comes from the ARC for years ended June. The figures have been converted to years ending December to be consistent with other data. A small amount of waste dumped in the Auckland region comes from outside the Auckland region (estimated as 2 per cent from the data provided). This amount has not been removed from the total tonnage as the Auckland region has to assimilate the environmental impact associated with this. Since 2005/06 the Auckland region has been disposing of some solid waste in the Environment Waikato area. This amount is excluded from the total as Environmental Waikato benefits from this economic activity so therefore assumes responsibility for the environmental impact.

The valuation should reflect the true cost of waste disposal rather than the actual amount charged. Past waste-disposal charges cannot be used for valuation, as many councils charged on the basis of landfill operating costs which underestimated the true cost. 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 the cost of the land and its development, as well as costs to cover management, administration and organisational overheads, pollution control, planning and resource consents, operation of the landfill, and 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, it does not include the indirect or social costs of solid waste disposal that may impact at a global rather than local scale.[40]

This GPI study used the cost of disposing of a tonne of waste at the Kate Valley regional landfill ($\$_{2005}$125 per tonne, or $\$_{2006}$128 per tonne) because the FCA guide was used extensively to check costs when the landfill was proposed (Centre for Advanced Engineering, 2005). The Kate Valley landfill disposal cost is at the upper end of the major city costs as can be seen from Table 31.

[40] For example, electronic waste generated in New Zealand, if sent overseas, can cause pollution in the receiving country. "Externalities are costs (or benefits) that are borne by (or accrue to) society in general, and which in the past have not generally been accounted for in decisions relating to landfills. Because legislation requires waste managers to avoid, remedy or mitigate some effects, some externalities are internalised – or taken into account – in the financial costs of landfill development, operation and aftercare through the resource consent process" (Ministry for the Environment, 2004, pp.21–22).

Table 31: Disposal cost per tonne at major city landfills

Landfill	$\$_{2005}$ per tonne
Auckland (Redvale)	90.00
Hamilton	95.50
Wellington (Southern)	101.00
Christchurch (Kate Valley)	125.00
Dunedin (Environwaste)	75.00

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

Contaminated sites

In the late 1980s it was estimated around 86,000 tonnes of hazardous waste were dumped per year (Statistics New Zealand, 1993). Of the 7200 sites (excluding timber treatment sites) identified as contaminated, about 20 per cent were considered to be high risk to human health and/or the environment (Statistics New Zealand, 1993). Large-scale contamination of sites by industries has been controlled since the introduction of the Resource Management Act (RMA) in 1991.

A study by Worley Consultants Ltd published in 1992 identified 7800 locations in New Zealand that could be potentially contaminated. Of these, approximately 1856 were located in the Auckland region. The estimated cost of remediating all New Zealand sites was given as $\$_{1992}$1644 million. For the New Zealand GPI the temporal pattern of pollution at the major contaminated sites has been used to spread the $\$_{1992}$1644 million estimate on an annual basis 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 recent annual cost of contamination has been low – a result of tighter requirements of the RMA (1991). 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.

The Auckland region share of contaminated sites is $\$_{1992}$392 million and these have been apportioned over time in the same way as the New Zealand $\$_{1992}$1644 million (see Table 32).

Table 32: Number and estimated cost of remediating contaminated sites

Category	Number – NZ	Number – ARC	Cost – NZ ($\$_{1992}$ million)	Cost – ARC ($\$_{1992}$ million)
High risk	1580	376	515	123
High risk – timber treatment	600	142	105	25
Moderate/slight risk	5620	1338	1000	238
Site assessment costs			24	6
Total	**7800**	**1856**	**1644**	**392**

Source: Worley Consultants Limited, 1992, 8.1.

The assessment of risk and costs are set out in Table 32. The uncertainty of the estimate is given as ± 50 per cent (Worley Consultants Limited, 1992, 6.8).

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 for land degradation for the Auckland region.

For the period 1990–2006, the total cost of land degradation has been estimated at $\$_{2006}$1917 million (see Table 33).

Table 33: Total value of land degradation, 1990–2006

Year	Waste to landfill	Kate Valley cost per tonne	Contaminated sites costs	Total
	(tonnes)	($\$_{2006}$ million)	($\$_{2006}$ million)	($\$_{2006}$ million)
1990	610,000	78	9.28	87
1991	546,500	70	8.59	79
1992	524,000	67	7.90	75
1993	590,000	76	7.21	83
1994	687,500	88	6.52	95
1995	773,000	99	5.83	105
1996	816,500	105	5.14	110
1997	866,000	111	4.45	115
1998	956,000	122	3.76	126
1999	964,971	124	3.07	127
2000	953,019	122	2.38	124
2001	938,762	120	2.38	123
2002	965,160	124	2.38	126
2003	1,038,954	133	2.38	135
2004	1,132,627	145	2.38	147
2005	1,054,563	135	2.38	137
2006	939,210	120	2.38	123
Total				**1917**

19 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 per cent 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 the Auckland region's annual greenhouse gas emissions between 1990 and 2006. As greenhouse gases remain in the atmosphere for a lengthy period of time, these emissions will impact on future generations and should be assigned as a cost to the period the economic activity that generated the GHG emissions took place.

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 rising sea levels, 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 Auckland region have been estimated for each of the years 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 (see Figure 4).

The value of $\$_{2006}44$ per tonne of carbon dioxide was used based on the Stern Review marginal social cost of carbon of US$30 per tonne for a 450 ppm CO_2-e goal (Stern, 2006, p. 304). At an average 2005 exchange rate of $\$_{2005}0.70$ to US$1.00, this equates to $\$_{2005}42.6$ for 450 ppm CO_2-e. This value is similar to the December 2005 EU Emissions Trading Scheme price, which was about €20 per tonne (Point Carbon, 2006, p. 42). A recent study using scenario modelling estimated technologies already in existence, or at an advanced state of development, could bring global CO_2 emission back to current levels by 2050 at a marginal cost of up to $US\$_{2005}50$ per tonne ($NZ\$_{2005}71$) (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.

The steps undertaken in estimating Auckland region's emissions were as follows:

Energy

Major electricity generation occurs at Southdown (from 1997) and Otahuhu B (from 2000). Emissions from Southdown were taken from annual reports (assuming a constant rate of emissions per GWh). Emissions from Otahuhu were estimated as 33 per cent of national emissions from gas-power generation facilities, based on the power of the station and power of all gas facilities in the country during the period.

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.

Industrial processes

The major industry in the Auckland region in this category is steel manufacture. Because all New Zealand steel manufacture occurs in the Auckland region, emissions have been taken directly from the Energy Greenhouse Gas Emissions Inventory (MED, 2008).

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 Auckland region for 2002 and 2007 (Statistics New Zealand, various years). The average of these two dates as a fraction of national application was 2 per cent, so Auckland region emissions from fertiliser application were calculated as 2 per cent of national emissions from New Zealand's Greenhouse Gas Inventory 1990–2006. While agricultural area has clearly reduced in the Auckland region over the period of analysis, fertiliser emissions are relatively small (less than 35 kt CO_2e/yr).

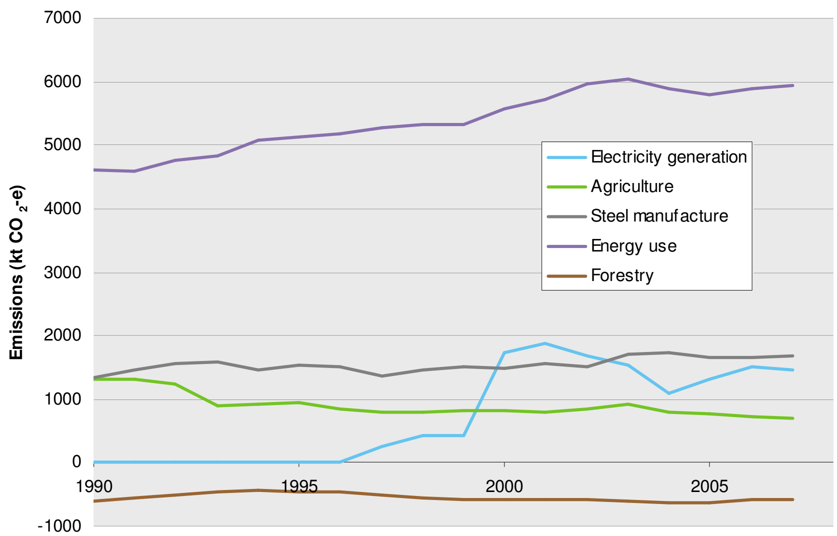
Land use, land-use change and forestry (LULUCF)

The area of plantation forestry in the Auckland region has been between 2 and 3 per cent of the national total over the period of analysis (Statistics New Zealand, various years). We have assumed Auckland forestry is identical in composition to the national average, and therefore estimated Auckland region sequestration as between 2 and 3 per cent 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 Auckland region.

Waste and Solvents

This category contributes less than 3 per cent to national emissions. Due to a lack of data for the Auckland region, we have not included this category in the analysis.

Figure 4: Auckland region GHG emissions and sequestration, 1990–2007



The valuation of environmental damage from CO_2 emissions is calculated using the marginal social cost per tonne of CO_2-e emitted into the atmosphere. The marginal social cost 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.

The cost of climate change is determined by the level of emissions and the carbon price used for the analysis. The value of $\$_{2006}$44 per tonne of carbon dioxide as per the Stern Review was multiplied by the estimated annual GHG emissions for the Auckland 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, i.e. 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 policy implemented to reduce carbon emissions, as these will lower the marginal damage costs. The extent of this cost change over the 1990–2006 period has not been estimated.

For the period 1990–2006, the total cost of greenhouse gas emissions has been estimated at $\$_{2006}$5951 million (see Table 34).

Table 34: Total value of long-term climate change, 1990–2006

Year	CO_2 equivalent emissions (Gg)	Carbon price per tonne ($$_{2006}$)	Cost of climate change ($$_{2006}$ million)
1990	6,662	44	293.1
1991	6,802	44	299.3
1992	7,080	44	311.5
1993	6,876	44	302.5
1994	7,024	44	309.1
1995	7,167	44	315.4
1996	7,085	44	311.7
1997	7,255	44	319.2
1998	7,435	44	327.1
1999	7,481	44	329.2
2000	9,000	44	396
2001	9,450	44	415.8
2002	9,386	44	413
2003	9,571	44	421.1
2004	8,853	44	389.5
2005	8,979	44	395.1
2006	9,149	44	402.5
Total			**5,951.10**

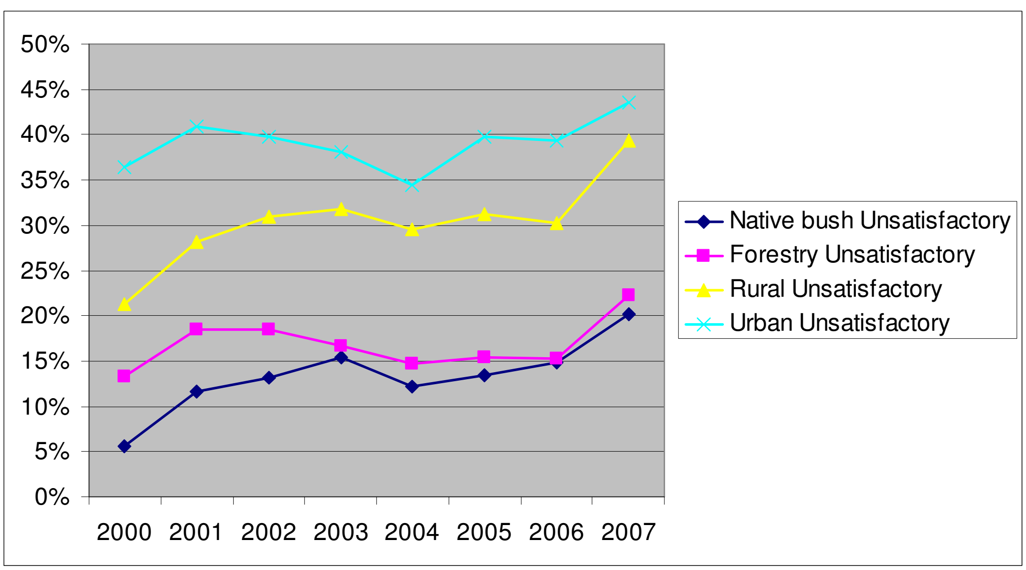
20 Loss of Water Quality

The inclusion of degrading water quality in the New Zealand 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 calculation for change in water quality used in the GPI has been based on remedial action, reflecting 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. Nor does it 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 time frames, if recovery is possible at all.

While water is probably the most monitored feature of the New Zealand environment (Ministry for the Environment, 1997), extrapolating trend data is not easy. Determining water quality is difficult as both temperature and flow rate vary annually due to changing weather patterns and these factors affect the assimilation capacity of water (Salinger and Mullan, 1999; Larned et al., 2005). Despite water quality being seen by the general public of New Zealand as the biggest environmental issue in the country, there are no established water standards from which to estimate environmental damage.

Water quality data from the Auckland region for 2000–2007 indicates that water quality has been rated as unsatisfactory in all land cover categories, but mostly in urban and rural areas. Trends for native bush and forestry are relatively similar and assumed to be at levels where the causes are from natural occurrences and therefore not able to be managed (see Figure 5). The two main measures recorded as 'Unsatisfactory' are turbidity and temperature.

Figure 5: Unsatisfactory water quality ratings, 2000–2007



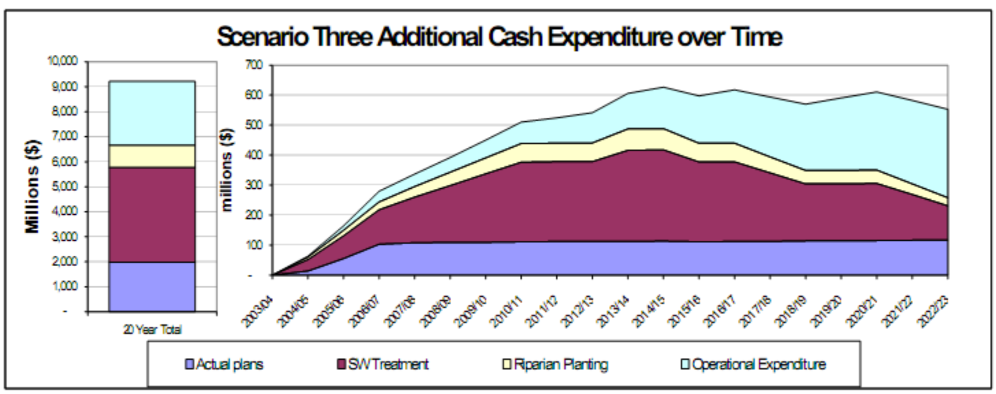
The limited time series available indicates that the trend for urban areas has not changed markedly over time, while for rural areas there appears to be an increase in the number of unsatisfactory test results.

The annual cost of loss of water quality for the Auckland region has been based on the recent PricewaterhouseCoopers report that estimated the cost of undertaking action to remediate poor water quality in the Auckland region at $\$NZ_{2003}$9208 million over a 20-year period (Infrastructure Auckland and Pricewaterhouse Coopers, 2004). This includes $\$_{2003}$6661 million for capital expenditure and $\$_{2003}$2547 million for operating and maintenance (Infrastructure Auckland and Pricewaterhouse Coopers, 2004, p. 39). The proposed remediation mechanisms include riparian planting on natural stormwater flow pathways, and construction and retrofitting of receiving stormwater ponds.

Three different scenarios were quantified in the Pricewaterhouse Coopers report. Scenario One 'Status Quo' does not prevent continued degradation of water quality in harbours and streams (Infrastructure Auckland and PricewaterhouseCoopers, 2004, p. 31). Scenario Two targets priority catchments for remedial treatment (Infrastructure Auckland and PricewaterhouseCoopers, 2004, p. 33) and improves some water quality.

The costs used for the GPI are as given under Scenario Three (shown in Figure 6), which achieved the most desired outcomes for water quality. This provided all catchments and their receiving environments to be managed by means of wetland ponds and riparian planting for stormwater treatment.

Figure 6: Required expenditure to improve Auckland region water quality, 2003/04–2020/21



Source: Infrastructure Auckland and PricewaterhouseCoopers, 2004.

For the GPI this total cost of $\$_{2003}$9208 million is allocated equally to each of 20 years, giving a figure of $\$_{2006}$498 million per year.

For the period 1990–2006, the total cost of loss of water quality has been estimated at $\$_{2006}$8463 million (see Table 35).

Table 35: Annual cost of water quality remediation, 1990–2006

Year	Total cost ($$_{2006}$ million)
1990	498
1991	498
1992	498
1993	498
1994	498
1995	498
1996	498
1997	498
1998	498
1999	498
2000	498
2001	498
2002	498
2003	498
2004	498
2005	498
2006	498
Total	**8463**

21 Ozone Depletion

Most GPIs include the costs of ozone depletion because it represents a long-term environmental impact of economic activity with consequences for human health. Because of its southern location, New Zealand is vulnerable to increased solar ultraviolet radiation, the main consequence of ozone depletion. 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 (NIWA) 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 (UV) 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). Reduced ozone in the atmosphere has been shown to be the main cause of increased UV (McKenzie, 2007). While it is known that ozone depletion has an impact on the well-being of New Zealanders (death from melanoma alone was estimated at more than $\$_{2006}$200 million in 2006), it has to be remembered that the GPI only measures the impact of economic activity in Auckland region. In 1986, before restrictions were introduced under the Montreal Protocol (UNEP, 1987), New Zealand's total emissions of ozone-depleting gases (mostly CFCs) was 2100 tonnes, or less than 0.002 per cent of global emissions (McCulloch et al., 1994). If the total cost of ozone depletion was measured in terms of health effects in New Zealand (estimated at $\$_{2006}$200 million in 2006), emissions generated in New Zealand would only be responsible for $\$_{2006}$0.4 million. Given this small cost, inclusion of the costs of ozone depletion for the Auckland region is not warranted.

22 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. Non-renewable mineral resource depletion represents the consumption of income-generating capital and results in running down capital to boost current income. The monetary transactions generated from the sale of natural resources and the employment generated from extraction add to GDP; however, current accounting mechanisms make no adjustment to the overall level of national well-being by the depletion of these natural assets. If a country depletes natural capital by extracting renewable resources at a rate exceeding its natural regenerative capacity (by failing to reinvest enough of the proceeds from non-renewable resource depletion to establish renewable resource substitutes) and by generating waste levels that exceed the environment's waste assimilation capacity, it cannot expect to sustain the same level of consumption in the future (Lawn, 2007). 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. Furthermore, depletion is encouraged by accounting systems that count the liquidation of natural capital wealth as income.

Estimations of the value of non-renewable resources vary significantly, depending on whether a 'strong' or 'weak' sustainability approach is taken. What distinguishes these sustainability approaches 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 (for example, developing solar, wind and geothermal substitutes for oil and gas). The weak sustainability approach assumes investment in other forms of 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, and non-renewable and renewable natural capital) is positive.

Advocates of strong sustainability also 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). Much of the debate over the valuation of non-renewable resources relates to what constitutes a permanent loss, i.e. what is substitutable and what is non-substitutable. An often expressed viewpoint is that non-renewable mineral resources are not 'resources' until a use is derived for them 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 replacement future income-generating capital sources this can be 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.

The Auckland region does not have large quantities of non-renewable resources and relies instead on imports from overseas and other parts of New Zealand. Rock, gravel and sand (aggregate) make up most of the volume of minerals extracted in the region (see Table 36). As population and economic growth increases, the need for aggregate also increases. Transport costs are a major component of aggregate costs so local supply is important. The concentrated urban nature of the Auckland region makes it difficult to develop resources with environmental effects acceptable to those living nearby (Barker et al., 2006). As a result, demand has increased at the same time as urban development has restricted the establishment of new quarries. Therefore, supply is not the limiting factor – for example, a total of 630 million cubic metres of basalt are available in the Auckland urban area but production has virtually ceased due to planning restrictions (Barker et al., 2006).

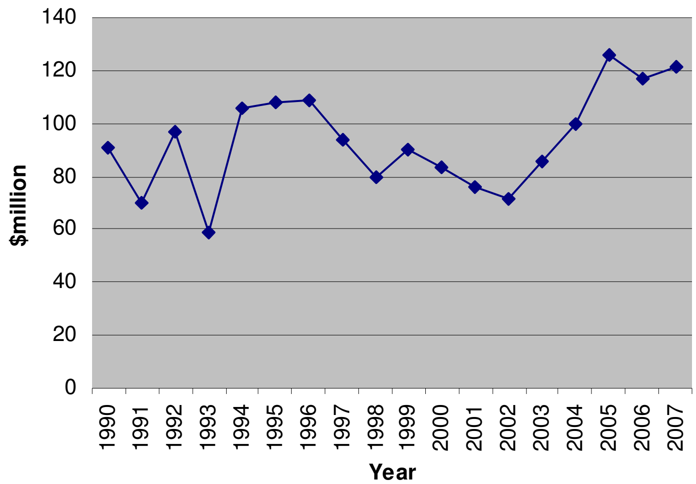
Table 36: Average mineral extraction Auckland region, 1998–2007, and New Zealand reserves

Minerals extracted in Auckland region	**Potential reserves in NZ**	**Average extraction in Auckland region, 1998–2007** (tonnes)
Basalt		not given
Building and dimension stone	very large	933
Clay for brick, tiles etc.	very large	13,043
Clay for pottery and ceramics		222
Decorative pebbles including scoria	very large	37,190
Limestone for agriculture	very large	140,371
Limestone for industry and roading		22,721
Recycled Material		20,051
Rock for reclamation and protection		284,111
Rock, sand and gravel for building		2,402,727
Rock, sand and gravel for roading		3,528,227
Rock, sand, gravel and clay for fill	very large	954,082
Sand for industry	very large	420,912
Silica Sand	very large	37,838
Zeolite	very large	23,537

Source: Based on 1998 quantities from Christie and Brathwaite (1999).

Mineral extraction data for 2000–2007 for the Auckland region was obtained from Crown Minerals (Crown Minerals, 2008). This gave a yearly estimate of the value of the minerals extracted. Data for 1990–1993, 1998 and 1999 was obtained from Mining Production Statistics (emailed). The years 1994–1997 were estimated from the other data. The final series is shown in Figure 7.

Figure 7: Annual value of minerals extracted in the Auckland region



Source: Crown Minerals (2008).

Loss of non-renewable resources is generally calculated on the basis of the percentage of total profit that would need to be put aside and reinvested to ensure a similar level of income could be generated after the resource had been depleted (El Serafy, 1991). This is an example of the weak sustainability approach, which assumes all forms of capital are substitutable. The Auckland region extracts mostly rock, sand, and gravel for building, reclamation work and roading. These resources are readily available from elsewhere in New Zealand (and even renewable in some parts of the country). Depletion of the Auckland region reserves will require bringing rock, sand and gravel from further afield so an allowance has been made for additional future transport costs. Assuming the profit margin for the extraction industry in the Auckland region is 20 per cent (a generous amount), using the principles propounded by El Serafy we have put aside 5 per cent of this to cover future transport costs.

While there will be an additional economic cost to the Auckland region from having to transfer aggregate from further afield, the loss of this natural capital is not likely to impact on the future well-being of Aucklanders because the resources are readily available from elsewhere in New Zealand. The environmental effects from additional transport will be offset from the environmental gains from not having extraction take place in the Auckland region.

For the period 1990–2006, the total cost of non-renewable loss has been estimated at $\$_{2006}$18.3 million (see Table 37).

Table 37: Annual cost of non-renewable resource extraction, 1990–2006

Year	Extraction	Value	Value	Profit 20%	Transport allowance 5%
	(tonnes)	($million)	($\$_{2006}$ million)	($\$_{2006}$ million)	($\$_{2006}$ million)
1990	8,178,873	91	122	24	1.2
1991	6,344,180	70	93	19	0.9
1992	7,799,924	97	127	25	1.3
1993	8,128,493	59	75	15	0.7
1994	9,703,005	105	133	27	1.3
1995	9,960,390	108	134	27	1.3
1996	10,007,676	109	131	26	1.3
1997		94	113	23	1.1
1998	7,602,978	79	94	19	0.9
1999	8,633,959	90	107	21	1.1
2000	7,125,550	83	96	19	1.0
2001	6,261,000	76	84	17	0.8
2002	6,877,500	72	79	16	0.8
2003	7,443,426	86	93	19	0.9
2004	8,404,580	100	104	21	1.0
2005	9,635,230	126	129	26	1.3
2006	8,190,111	117	117	23	1.2
Total					**18.3**

23 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 exposed to noise and in 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:

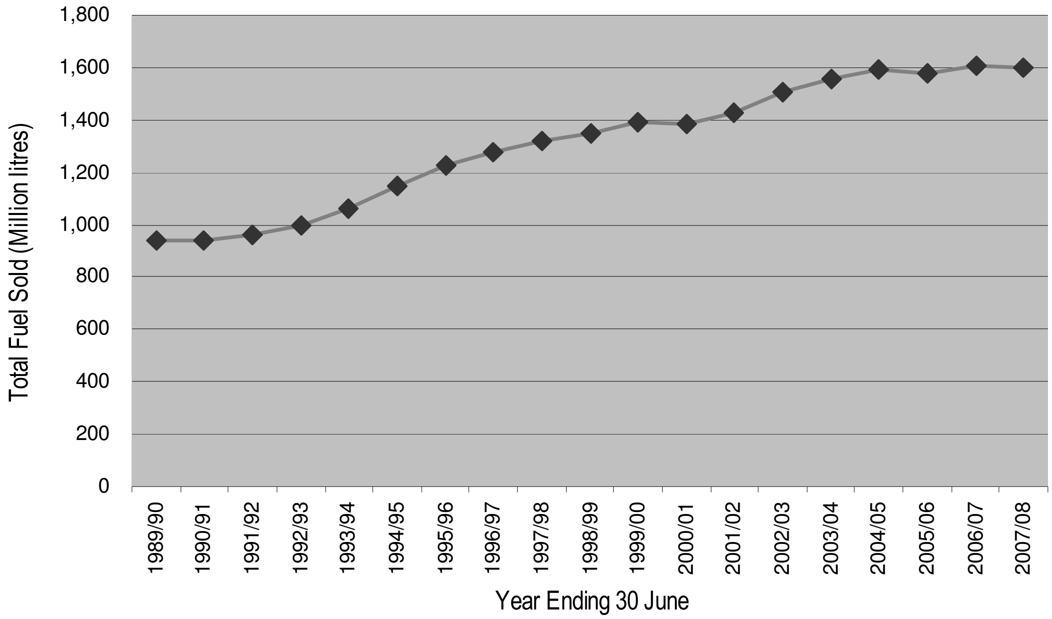
- productivity losses due to poor concentration, communication difficulties or fatigue due to insufficient rest
- health-care costs to rectify loss of sleep, hearing problems or stress.
- lowered property values, and
- reduction in psychological well-being.

A recent survey on the quality of life in New Zealand's 12 largest cities found just over a quarter of residents (26%) 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%), than those living elsewhere in New Zealand (21%) (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 Auckland 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 changes in intensity of noise, fuel consumption in the Auckland region has been used as a proxy. Given that most people in New Zealand live in urban areas and that car ownership levels are high, a significant proportion of the population experience noise associated with traffic. Fuel use is also associated with stationary motors, which are another generator of noise. In large urban areas, high-density development as well as urban spread (which increases car dependency) mean people live close to traffic noise (Statistics New Zealand, 1999). According to Statistics New Zealand, the largest contributor to increased kilometres travelled by vehicles is the car; however, kilometres travelled by light commercial vehicles and heavy commercial vehicles have also increased (Statistics New Zealand, 2002). Figure 8 gives the increase in annual fuel consumption between 1989/90 and 2007/08. Vehicles may have become quieter during this period but there have also been efficiency gains in fuel consumption to offset this. In addition, more densely populated urban areas expose more people to noise over longer periods.

Figure 8: Annual consumption of petrol and diesel, 1989/90–2007/08



Source: ARC Amalgamated Fuel Stats (personal communication).

To calculate the GPI for the Auckland region, this study used Annual Fuel Sales 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, and estimated the total annual social cost of noise pollution from vehicles is between $\$_{1995}$230 million and $\$_{1995}$2650 million, with the best estimate being $\$_{1995}$290 million per year (Ministry of Transport, 1996, 38). The total social cost is defined as private costs plus externalities. According to the research, the $\$_{1995}$290 million was derived from a pilot study of road traffic exposure in an Auckland suburb with a range of road networks. A marginal damage function for noise was estimated and then combined with residential property values to generate estimates of the total social cost ranging from $\$_{1995}$1480 million to $\$_{1995}$17,000 million, with a best estimate of $\$_{1995}$1850 million. This cost was then annualised using a discount rate of 6.4 per cent. The distribution of traffic noise costs was calculated over 15 urban centres, with a strong weighting (65 per cent) given to the urban centres Wellington, Christchurch and Auckland (Ministry of Transport, 1996, pp. 25–39). The Auckland region proportion of the $\$_{1995}$290 million was $\$_{1995}$124 million, equivalent to $\$_{2006}$153 million.

The amount of $\$_{2006}$153 million was divided by the million litres of fuel consumed in 1995–96 to reach a cost of $\$_{2006}$0.124 million per million litres (i.e. approximately 12 cents per litre). Variation in the volume of noise each year has been allowed for by multiplying the cost of noise per million litres of fuel in 2006 dollars by the fuel consumed annually.

For the period 1990–2006, the total cost of noise pollution has been estimated at $\$_{2006}$2696 million (see Table 38).

Table 38: Annual cost of noise, 1990–2006

Year	Fuel Consumed	Cost of noise for Auckland	Cost of noise for Auckland	Noise cost	Noise cost based on vehicle kilometres travelled
	(million litres)	($\$_{1995}$ million)	($\$_{2006}$ million)	($\$_{2006}$ million/ million litres)	($\$_{2006}$ million)
1989/90	938				117
1990/91	940				117
1991/92	958				119
1992/93	996				124
1993/94	1064				132
1994/95	1147				143
1995/96	1229	124	153	0.124	153
1996/97	1280				159
1997/98	1321				164
1998/99	1348				168
1999/00	1392				173
2000/01	1384				172
2001/02	1426				178
2002/03	1504				187
2003/04	1558				194
2004/05	1595				199
2005/06	1581				197
Total					**2696**

24 Outstanding Issues

This study represents a first step in creating a GPI for the Auckland region. It is unique because it is one of the first studies to develop fully evaluated Genuine Progress Indicators within the New Zealand context. Moreover, the resulting measure is among only a few sub-national GPIs to be developed globally. It is the opinion of the authors that the Auckland region GPI is also unique because it represents a more meaningful indicator of well-being or 'genuine progress' than regional GDP. This is because GPI does not arbitrarily place a zero value on the goods and services derived from social and ecological capital, which are essential ingredients in the well-being of any society (Cobb et al., 1995). At this point, it is worth noting that the contribution presented in this report has its feet firmly grounded on the detailed, meticulous and comprehensive work nearing completion in the soon-to-be-released national GPI study. It also builds on past efforts aimed at improving measurement of national well-being or genuine progress.

However, this study represents only a first, and early, step in measuring genuine progress in the Auckland region. There are a number of outstanding theoretical, methodological and empirical issues with the Auckland region GPI that are beyond the scope of the current study to address. In the remainder of this report several major issues are further discussed and relevant recommendations provided. The issues are split into three categories: (1) theoretical, (2) methodological and (3) empirical. Relevant recommendations are also given to address the issues identified.

24.1 Theoretical Issues

Selection of components for inclusion

The arbitrary nature of what is included or excluded in GPI is perhaps the most fundamental theoretical issue of the GPI. For example, other countries' studies have included additional socio-economic components, such as the cost of gambling. The GPI could also include other issues such as the cost of alcoholism and drug abuse, child abuse, or money laundering and fraud etc. as categories separate from the cost of crime. A lack of international standards specifying what to include in GPI has led to arbitrary decisions regarding which components to include. 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 is required on what is appropriate to include in the Auckland region GPI. Moreover, a key focus of this debate should be on what Aucklanders conceive to be key determinants of their welfare.

Definition of system boundaries

System boundaries create further complications as some issues (e.g. internet crime and fraud) may be experienced by a victim in New Zealand, yet committed by a criminal based overseas. The system boundary issue is even more problematic for environment sectors. 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.

Definition of defensive expenditures
Another factor which could have significant impact on the Auckland 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 does 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 problematic. Often, as is the case in this study, value is dependent upon implied or imputed benefits and 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 in fact invaluable. Nevertheless, it is 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 Auckland region's welfare.

Selection of an appropriate base year
The selection of an appropriate base year from which to conduct the valuation 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 or service become less than the marginal costs incurred as a result of the loss of that resource. This is a task fraught with difficulties such as lag effects, cumulative effects and compounding data paucity.

24.2 Methodological Issues

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 the majority of the unemployed, and underemployed, are unskilled. Incomplete valuations, such as the omission of the psychological costs associated with unemployment, mean that components are 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 Section 24.3).

Lack of Standardised Valuation Methodologies

A disadvantage of the current methodology of calculating a GPI is the lack of standardised systems and international comparability. The researcher has to decide which items will be incorporated in the methodology of the index and which valuation methods are best to employ. Both decisions are usually made on the basis of data availability. There are currently efforts underway to standardise core components of the GPI across nations – refer, for example, to Lawn and Clarke (2008).

24.3 Empirical Issues

Paucity of region 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 also, importantly, information on the causal mechanisms responsible for any change in components. However, it must, be acknowledged that the System of National Accounts, from which the GDP indicator is extracted, has been developed over a 70-year-plus period, with definitions and accounting procedures evolving along the way. Under ideal circumstances, data 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

Accuracy of the calculations could be increased by the application of sensitivity tests. To aid in interpreting the accuracy of the findings, standard statistical errors should 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.

25 References

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26 Appendices

26.1 Appendix 1: 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, because 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 of domestically produced goods and services at market prices.[41] 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 more precise to study GDP at real prices. Therefore, an inflation adjustment can make comparison of variables across different time periods more meaningful. In this report, two price indices are utilised to translate nominal to real values: (1) the Consumer Price Index (CPI), and (2) 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 an index number of 1000 – this is the benchmark against which average prices in other years are compared. For example, if the index number for a year is 1150, then prices in that particular year may be said to have increased by 15.0 per cent from the base year.

[41] 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 Consumer Price Index (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. Therefore, it is 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 normalised to 1000 (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).[42] 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 (see Table A.1).

[42] Refer to *Macro Economics* (fourth edition), (Mankiw, 1999, p. 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

26.2 Appendix 2: Rebasing and Bi-Proportional Balancing Methods

Rebasing Method

The Rebasing Method may be mathematically described as:

$$D = \frac{A}{B} \times C$$

where:

A is the original data for the desired year
B is the original data for the new base year
C is the new data assigned for the new base year, and
D is the 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 A.2: 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 ÷ 999 = 0.9389 (3 d.p.). Multiplying this result by 1000 gives the modified CPI value for 2004, i.e. 939.

Bi-proportional Table Balancing Method

Tables A.3 to A.8 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 A.3 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 A.4 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 = 0.9 (1 d.p.) (last column of Table A.4). Each row element in Table A.4 is then multiplied by the corresponding row ratio e.g. 17.3 × 0.93 = 16.3, 39.1 × 0.93 = 36.8, and so on.

Table A.3: Time use by age cohort for males performing household work in 1999 (million hours) – known row and column totals

	12-24	25-34	35-44	45-54	55-64	65+	Target Total
Food preparation							264.3
Indoor cleaning							145.5
Grounds							180.2
Home maintenance							172.8
Household administration							29.4
Production of goods							3.3
Gathering food							16.3
Travel							24.1
Other							28.8
Target Total	80.6	128.4	163.9	152.7	138.1	210.4	874.1

Table A.4: Time use by age cohort for males performing household work in 1999 (milion hours) – Indicative Base Year Estimates

	12-24	25-34	35-44	45-54	55-64	65+	Estimated Total	Target Total	Ratio
Food preparation	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 maintenance	12.3	25.6	32.6	30.4	27.5	37.8	166.2	172.8	1.0
Household administration	2.6	4.4	5.6	5.2	4.7	8.5	30.9	29.4	1.0
Production of goods	0.2	0.5	0.6	0.6	0.5	0.9	3.4	3.3	1.0
Gathering 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	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 A.5 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 A.5). Each column element in Table B.4 is then multiplied by the corresponding column ratio e.g. 36.8 × 1.03 = 38.0, 21.2 × 1.03 = 21.9 and so on. The resulting matrix is shown in Table A.6.

Table A.5: Time use by age cohort for males performing household work in 1999 (million hours) – 1st Iteration

	12-24	25-34	35-44	45-54	55-64	65+	Estimated Total
Food preparation	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 maintenance	13.0	26.9	34.3	32.0	28.9	39.7	174.7
Household administration	2.5	4.2	5.4	5.0	4.5	8.2	29.8
Production of goods	0.2	0.5	0.6	0.6	0.5	0.9	3.3
Gathering 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	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 A.6: Time use by age cohort for males performing household work in 1999 (million hours) – 2nd Iteration

	12-24	25-34	35-44	45-54	55-64	65+	Estimated Total	Target Total	Ratio
Food preparation	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 maintenance	17.9	27.8	35.5	33.0	29.9	33.2	177.2	172.8	1.0
Household administration	3.5	4.3	5.5	5.2	4.7	6.9	30.0	29.4	1.0
Production of goods	0.3	0.5	0.6	0.6	0.5	0.8	3.3	3.3	1.0
Gathering 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	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			

Tables A.7 and Table A.8 are derived in a similar manner. 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 A.7: Time use by age cohort for males performing household work in 1999 (million hours) – 3rd Iteration

	12-24	25-34	35-44	45-54	55-64	65+	Estimated Total
Food preparation	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 maintenance	17.6	27.4	35.0	32.6	29.4	32.8	174.7
Household administration	3.5	4.3	5.5	5.1	4.6	6.8	29.8
Production of goods	0.3	0.5	0.6	0.6	0.5	0.8	3.3
Gathering 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	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 A.8: Time use by age cohort for males performing household work in 1999 (million hours) – 4th Iteration

	12-24	25-34	35-44	45-54	55-64	65+	Estimated Total	Target Total	Ratio
Food preparation	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 maintenance	17.7	27.4	35.0	32.6	29.5	32.7	174.7	172.8	1.0
Household administration	3.5	4.3	5.5	5.1	4.6	6.8	29.8	29.4	1.0
Production of goods	0.3	0.5	0.6	0.6	0.5	0.8	3.3	3.3	1.0
Gathering 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	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			

26.3 Appendix III LCDB1 and LCDB2 land use for Auckland region

Table A.9: LCDB1 and LCDB2 land use for Auckland region

	Class	1996/97 (ha)	2000/01 (ha)	Difference (ha)
1	Built-up Area	40354	41683.3	1329.3
2	Urban Parkland/ Open Space	8825.8	8788.5	-37.3
3	Surface Mine	739.6	744.9	5.3
4	Dump	81.2	59.2	-22
5	Transport Infrastructure	656.9	660.4	3.5
10	Coastal Sand and Gravel	5132.7	5132.7	0
11	River and Lakeshore Gravel and Rock	14.6	14.6	0
12	Landslide	1.6	1.6	0
13	Alpine Gravel and Rock	11.3	11.3	0
20	Lake and Pond	2114.6	2116.8	2.2
21	River	286.9	286.9	0
22	Estuarine Open Water	12,443.90	12,443.90	0
30	Short-rotation Cropland	6386.9	6386.9	0
31	Vineyard	755	755	0
32	Orchard and Other Perennial Crops	2132.2	2132.2	0
40	High-Producing Exotic Grassland	248,981.00	246,993.20	-1987.7
41	Low Producing Grassland	1855.3	1789.4	-66
45	Herbaceous Freshwater Vegetation	671.9	671.9	0
46	Herbaceous Saline Vegetation	2165.6	2078.9	-86.7
47	Flaxland	28	28	0
51	Gorse and Broom	943.7	949.6	5.9
52	Manuka and or Kanuka	43,575.50	43,531.30	-44.2
54	Broadleaved Indigenous Hardwoods	17,817.80	17,756.50	-61.3
56	Mixed Exotic Shrubland	605.8	605.8	0
57	Grey Scrub	20.1	20.1	0
61	Major Shelterbelts	154.6	154.6	0
62	Afforestation (not imaged)		176.2	176.2
63	Afforestation (imaged, post LCDB 1)	4405.6	866.4	-3539.2
64	Forest Harvested	4242.2	8151.1	3908.9
65	Pine Forest – Open Canopy	5853.5	12,676.50	6823
66	Pine Forest – Closed Canopy	32,939.70	26,545.50	-6394.2
67	Other Exotic Forest	3775.7	3775.7	0
68	Deciduous Hardwoods	301.2	297.6	-3.7
69	Indigenous Forest	68,435.70	68,423.70	-12.1
70	Mangrove	8054.4	8054.4	0
	Total area	**524,764.50**	**524,764.50**	**0**