Database of quantification and monetisation methodologies and value proxies for non-monetised benefits

Guidance and report

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Executive summary

This report presents the results of a time-limited literature search and review of valuation methods and value proxies that could be applied to items in the Waka Kotahi NZ Transport Agency benefits framework that are not currently monetised. The main objective of this research was to prepare a database of values and methodologies for quantification and monetisation of the currently non-monetised benefits. This report also provides guidance on how to use the database and implications for further monetary valuation.

We undertook a literature search and selected review sources most relevant to the list of currently non-monetised benefits provided by Waka Kotahi. Our search and subsequent review included new primary valuations and valuation methods used by other countries in their evaluation procedures.

Review of literature on valuation of currently non-monetised benefits

We looked at five countries with a long history of cost–benefit analysis (CBA) in situations similar to New Zealand's – Australia, Canada, Netherlands, Sweden and the United Kingdom (UK). In most countries, primary responsibility for roading rests with local government for local roads and public transport and a central government agency for the main highways and motorways. Local government road funding may be supplemented by the national government, using approved appraisal processes to secure funding for projects. Federal governments in Australia and Canada have funding streams and control access to that with their own appraisal requirements.

Most countries have limited monetary valuation beyond a core set of items covering capital and operating costs, savings in travel times, vehicle operating costs and transport crashes, and reductions in greenhouse gas emissions and noise. There is a wide variety in the range of non-monetised items covered by their frameworks, with very few of the same items covered in more than one or two countries.

The Waka Kotahi benefits framework has a greater degree of granularity in benefit definitions than in other countries' transport evaluations. This limits our ability to find exact matches in other countries for the benefits identified in the benefits framework.

Reliability of existing values from literature for use in New Zealand

Of the Waka Kotahi currently non-monetised benefits, monetisation in at least some other countries has been used for impacts on the water environment, land and biodiversity, resource efficiency, community cohesion (barrier effects), heritage and cultural sites, landscape and townscapes.

The suitability of these values for use in New Zealand depends on the quality of the source studies on which they are based, the appropriateness of adjustments made to convert them to New Zealand values and the closeness of the setting in the countries of origin to those found here.

Australia has a number of values for some of the impacts on biodiversity, water and social cohesion. These are mostly based on European source studies so may reflect both socio-economic and natural characteristics very different from New Zealand.

Canada has a few values for items similar to those in the benefits framework, but either defines them differently from the items in New Zealand or uses elements in cost calculations that have limited relevance to New Zealand (such as the gritting of icy roads as a source of contaminants in water).

The UK, Netherlands and Sweden have no values that look like a close fit for New Zealand use.

There are relatively few new empirical valuation studies that are specific to transport in the 12 impact categories. There are some that usefully demonstrate the application of a method to value protection against system vulnerabilities and changes in landcover, but the values are not suitable for use in New Zealand.

Feasibility and appropriateness of quantifying and monetising these benefits

Quantifying and monetising benefits depends on the characteristics of the benefit item and the possibility of providing a consistent set of estimates that could be included in an appraisal framework for use across New Zealand. Many of the items in the Waka Kotahi non-monetised benefits are likely to be localised and vary widely across the country, making it less likely that consistent standard values could be found for use in different parts of New Zealand.

Australian studies suggest that some of these impact items can be unbundled into separate parts, some of which could be suitable for valuation with widespread application. In biodiversity, for instance, following the European lead, they separate the impact of air quality deterioration in proportion to traffic volumes, as ubiquitous and capable of being assigned values that can be used anywhere. Other aspects of biodiversity, such as habitat loss or fragmentation, tend to be more unevenly distributed and not suited to generalised valuation. Australian guidance lumps these in with landscape, which is problematic, as the UK guidance that formerly included landscape values has now removed them because of the risk of double counting items covered in other values within its framework.

No other country looks specifically at access to opportunities or mode choices. There is potential for these to double-count impacts covered elsewhere in the benefits framework (eg wider economic benefits include widening of the labour market conferred by accessibility to a greater pool linking workers to jobs).

No other country attempts to put monetary valuation of values for indigenous ethnic communities through CBA processes. Such matters are taken into account in other mechanisms outside the CBA. Māori as Treaty partners may be better served by engagement and participation in the development of transport initiatives than in trying to weigh their preferences through valuation in a CBA.

Valuation approaches appropriate to each non-monetised benefit

We have examined the international literature on monetisation techniques. Broadly, they fall into two categories:

- market-based valuations and revealed preference valuations, which are relatively simple to do (given sufficient data) but are incomplete in not covering non-use values that attach to natural resources and heritage resources whose degradation would be irreversible
- stated preference valuations that use surveys of the population to reveal value, including non-use values.

Stated preference studies are survey-based and relatively costly to undertake and quite specific to their subject matter. They could provide existing values for benefit transfer, but empirical non-market value estimates in New Zealand are too few to reliably infer generalisable values for widespread use.

Overseas government agencies often prefer values appearing in transport appraisals to be drawn in declining order from market-based pricing, revealed preference methods and stated preference methods. Stated preference methods are recognised as the appropriate methods to use where there are significant non-use values, as is the case for some natural environment and cultural heritage sites, provided they are done well and take steps to control some well-documented sources of bias.

There are some Australian values for water and biodiversity impacts per vehicle kilometre travelled that roughly correspond to items in the Waka Kotahi benefits framework. Adjusted for exchange rate and income differentials across the country, they could be used to provide non-zero numbers for benefits of investments that reduce traffic numbers on heavily used roads. However, the numbers are all sourced back to European data so may not accurately reflect New Zealanders' preferences and values.

In general, attaching values to the benefits framework is most appropriate for impacts that are ubiquitous and relatively constant across the country. Impacts that are highly site-specific can be more effectively dealt with through project planning and later consent approval processes to minimise the adverse effects and maximise the benefits of the projects.

Other non-monetised benefits that might warrant inclusion

Other items valued overseas but not included in the benefits framework are punctuality and reliability of travel, the comfort and quality of travel for passengers and option values. Punctuality/reliability and comfort are partly covered but non-monetised by the Waka Kotahi current impact item 4.1 (short-term system vulnerabilities), and also appear monetised on the basis of travel time in impacts 5.1 (long-term system reliability) and 10.1 (user experience). This illustrates how definitions of what is being valued can vary markedly between countries, complicating the transfer of other countries' values to New Zealand settings. Option values appear in the UK's transport analysis guidance and are described as the WTP to preserve the option of using a transport service for trips not yet anticipated or currently undertaken by other modes over and above the expected value of any such future use, for example, option values are used if a scheme being appraised includes measures that substantially change the availability of transport services within a study area (eg the introduction or withdrawal of buses serving a particular rural area).

Guidance on using the values and methods in this report

We have compiled a sortable spreadsheet database of the current values we found, identifying subject matter, source and date, an extract of which is included in Appendix A.

Extending monetisation to currently non-monetised benefit items requires a choice between generating new values from primary research, which can be costly, or using less-customised results in benefit transfer. Suitably adjusted for the New Zealand context, benefit transfer is likely to be important to expand monetisation, but New Zealand has a limited pool of studies to draw on, which should be expanded.

Australia provides a range of values that might be drawn on in the short term. Australian agencies could be approached to find out more of their experience with using these values. In the longer term, Waka Kotahi could invest in a programme of primary valuations, perhaps in conjunction with other agencies in New Zealand with an interest in non-market valuation in the environment, to determine a coordinated approach to building up a pool of local estimates of widespread use.

Key points from the research

- There are values for some aspects of the Waka Kotahi 12 non-monetised impacts in other countries' guidance material that have not yet been adapted for use in New Zealand, for instance impact category headings, which vary across countries giving few perfect matches.
- There is not a large pool of new empirical valuation studies related to transport or the non-monetised impacts in the benefits framework.
- Benefit transfer is widely used overseas and is important for extending monetisation in New Zealand where primary evaluation is rare and often impractical to apply to all investment appraisals:
  - Databases of values have a role to play in enabling benefit transfer, but inevitably lead to some loss of detail, and also require resources to maintain and update them.
  - OECD recommends consultation on the values compiled in databases, and preparation of substantial guidance on how to use them and what their limitations are.
  - Overseas sources expand the range of values available for benefit transfer, but they will reflect preferences of their source countries, not those of New Zealanders.

- To obtain more values suitable for benefit transfer in New Zealand, more primary valuations are needed of the currently non-monetised impacts.
- For major impacts that could significantly affect a CBA result, primary valuation is desirable:
  - Revealed preference studies in this review show practical applications for some items among the 12 non-monetised impacts in the benefits framework.
  - Stated preference methods as described in this review are necessary where non-use values are likely to be significant, such as impacts on biodiversity, cultural heritage and some aspects of landscape.
  - Such studies take time, resourcing and specialist skills to do well, and doing more studies in New Zealand will require capability building.
- It would be beneficial for Waka Kotahi to invest in a programme of primary valuations to ensure contextually and culturally appropriate values are available for use in New Zealand.

Summary assessment

	Non-market benefit item	Values found	Usable in NZ	Value feasibility
2.1	Impact on perceptions of safety and security	No		Low
4.1	Impact on system vulnerabilities and redundancies	Yes	Maybe	High
7.1	Impact on water	Yes	Maybe	High
7.2	Impact on land and biodiversity	Yes	Maybe	High
9.1	Impact on resource efficiency	Yes	Yes	High
10.2	Impact on mode choice	No		Medium
10.3	Impact on access to opportunities	No		Low
10.4	Impact on community cohesion	Yes	Maybe	Medium
11.1	Impact on heritage and cultural values	No		Medium
11.2	Impact on landscape	Yes	No	Medium
11.3	Impact on townscape	No		Low
12.1	Impact on te ao Māori	No		Low

Abstract

This report reviews literature on methods and values used in transport investment appraisals to monetise benefits that are currently non-monetised in the New Zealand land transport benefits framework. Setting priority on values and valuation methods that have been assessed as sufficiently robust to be used in other countries' evaluation procedures, it describes the assembly of a database of values and valuation methods and provides guidance on how to use the database and build further monetary evaluation in New Zealand. A selective scan of transport evaluations in Australia, Canada, Netherlands, Sweden and the United Kingdom shows these countries' appraisals have a common core set of monetised items covering capital and operating costs and benefits focusing on savings in travel time, vehicle costs and the cost of transport crashes, and reductions in greenhouse gas emissions and noise. Beyond this, there is little similarity in what gets valued and how. Of 12 non-monetised benefits in the benefits framework, monetised values have been found for impacts on water, biodiversity, resource efficiency, community cohesion and landscape. Many of these impacts vary by local context so only part may be capable of yielding values that can be used widely across a broad range of investment appraisals. Non-market valuation methods are well established with known strengths and weaknesses, but they can be costly to implement. Benefit transfer drawing on existing values from New Zealand and overseas is likely to be the most practical means of expanding the range of monetised benefits but may require a collaborative approach from multiple agencies to commission work and increase the current relatively limited pool of suitable results in New Zealand.

1 Introduction

This report provides guidance on how to address the monetary valuation of items in transport appraisal that are not currently capable of monetary valuation. It is the result of a time-limited literature search and review of valuation methods applied or proposed for use in other countries' transport investment appraisal processes.

1.1 Background and purpose

The Waka Kotahi land transport benefits framework (benefits framework) contains two types of benefit: monetised and non-monetised. Monetised benefits have standard monetary values included in the *Monetised benefits and costs manual* (Waka Kotahi NZ Transport Agency, 2020a) and may also have qualitative and quantitative measures associated with them in the *Non-monetised benefits manual* (Waka Kotahi NZ Transport Agency, 2020b). Non-monetised benefits are those that cannot currently be monetised, and they are included only in the non-monetised manual.

The purpose of this report is to gain a better understanding of how to quantify and monetise currently non-monetised benefits included in the Waka Kotahi benefits framework and other potential non-monetised benefits that are not currently in the framework but potentially could be. We do this by a literature review of methods for monetising non-market effects to establish a database of value proxies and valuation methods that have been used in practice elsewhere.

The non-monetised benefits in the benefits framework of particular interest are outlined in Table 1.1. These include impacts on perceptions of safety, system resilience, natural environment, access to economic and social opportunities, the liveability of places and te ao Māori.

Table 1.1 Non-monetised benefits in the current Waka Kotahi benefits framework

Benefit cluster	Number	Non-monetised benefit item
Changes in perception of safety	2.1	Impacts on perceptions of safety and security
Changes in impact of unplanned disruption on access to opportunities	4.1	Impact on system vulnerabilities and redundancies
Changes in the natural environment	7.1	Impact on water
Changes in the natural environment	7.2	Impact on land and biodiversity
Changes in resource efficiency	9.1	Impact on resource efficiency
Changes in access to opportunities	10.2	Impact on mode choice
Changes in access to opportunities	10.3	Impact on access to opportunities
Changes in access to opportunities	10.4	Impact on community cohesion
Changes in liveability of places	11.1	Impact on heritage and cultural values
Changes in liveability of places	11.2	Impact on landscape
Changes in liveability of places	11.3	Impact on townscape
Changes in te ao Māori values	12.1	Impact on te ao Māori

Source: NZIER

1.2 Objectives

The objectives of this research were to:

- review theoretical and empirical literature on the valuation of non-monetised benefits currently in the benefits framework with respect to transport investments
- determine the extent to which it is possible and appropriate to quantify and monetise the current non-monetised benefits in the benefits framework
- identify other possible non-monetised benefits outside the framework that could warrant being included in it
- identify the valuation approaches appropriate to the monetisation of each of these currently non-monetised benefits and the conditions under which they can be used
- assess whether values found in the literature or used in other jurisdictions in transport appraisals can reliably infer values for such benefits in New Zealand
- compile a database of potential values to use from existing studies and suggestions for methods to use to generate new values to fill in the gaps, with assessment of their reliability for application to New Zealand conditions
- provide guidance on incorporating such monetisation methods in the benefits framework.

1.3 Approach to analysis

We approached this analysis by undertaking a literature review of recent papers describing official guidance to valuing benefits in transport appraisals in other jurisdictions and also theoretical and empirical academic papers that address these matters internationally. The literature review was conducted by NZIER's in-house library resources and staff in conjunction with the research team to identify the latest thinking on what methods exist and are being applied to monetising previously non-monetised benefits.

We assessed papers initially through high-level screening, which divided them according to their relevance to this research:

- We ascribed high relevance to papers that:
  - describe actual values and methods used in other jurisdictions' land transport appraisals
  - focus on multi-country surveys or comparisons of countries that reflect similarity to New Zealand's social conditions and concerns over land transport
  - illuminate the relative values of currently non-monetised items in the benefits framework
  - explain or justify the reasons for choice of valuation approach
  - demonstrate valuation techniques applicable to specific non-monetised items.
- We ascribed lower relevance to papers that:
  - are primarily theoretical and have not demonstrated practical application
  - describe applications in contexts not similar to New Zealand
  - are general textbooks and articles on cost–benefit analysis (CBA) with limited reference to the valuation of non-monetised benefits
  - are sources more than 15 years old (unless frequently cited by recent papers).

We examined high-relevance papers more closely to identify their key findings and considerations for establishing monetary values for currently non-monetised benefits. We paid particular attention to current practices in Anglophone jurisdictions of Australia, Canada and the UK and also those in the Netherlands and Sweden. From this, we prepared a synthesis of key issues from the literature from which to draw implications and relevance to the situation in New Zealand. We also prepared a searchable database of valuations and valuation methods with guidance on how to use it to inform valuation questions in New Zealand.

This report has been prepared within a limited timeframe. It should be considered as a first step in the process of developing guidance on the monetisation of currently non-monetised items and of ways of addressing current gaps in monetisation.

The summary tables of values in this report with potential for use in value transfer are indicative and should not be used unadjusted in a unit value transfer exercise.

1.4 Report structure

We start by framing the assessment of monetised values of benefits of transport investment in the context of transport appraisal, then proceed with the review of literature. We then look at options for expanding monetisation of the currently non-monetised benefits in the Waka Kotahi benefits framework before providing guidance on how to use the database for this purpose.

2 The assessment of economic values of transport benefits

Transport investment is a significant enabler of economic and social interactions in modern societies. To ensure new investments most effectively meet changing demands, most OECD countries employ a form of CBA to assist decisions on funding choices and ensure limited funding is used efficiently.

CBA is an application of welfare economics principles to normative questions around investment choices. It is based on the assessment of changes in welfare benefits and costs, expressing them all in the common currency of monetary values to calculate the net effect on the total economic wellbeing of society.

CBA is a social investment appraisal technique that looks beyond the private perspective of a project's proponents to assess the full effects across the affected community. As a modified investment appraisal process, its end point is an estimation of an activity's economic surpluses, net of costs and externality effects as far as they can be measured. Not all the items in a CBA can be calculated in monetary terms, but techniques of non-market valuation have been devised to extend the monetised CBA beyond the confines of items traded in markets.

The welfare effects are changes in wellbeing, which, in economic terms, are measured as producer surplus (increase in production profitability) and consumer surplus that results in expansion of people's consumption possibilities. This includes their access to market goods, publicly provided non-market goods and also services of the natural environment such as the quality of air and water, access to watchable wildlife and general amenity attributes.

Valuation in CBA is based on people's preferences expressed through prices of market goods or inferred through other means for non-market effects. The value of improvements in wellbeing is commonly inferred from the maximum amount of affected individuals' willingness to pay (WTP) for an improvement in wellbeing or the minimum amount of individuals' willingness to accept (WTA) as compensation for a drop in wellbeing. The sum of these amounts across the community indicates the societal value of gaining the improvement or bearing the drop. There is debate in some literature as to whether adjustments need to be made to account for compensating variation, which calculates change from the starting welfare position, or equivalent variation, which calculates change from the final welfare position, but 'under most circumstances, estimates of changes in consumer surplus, as measured by demand curves, can be used in CBA as reasonable approximations of individuals' WTP to obtain or to avoid the effects of a policy change' (Boardman et al., 2011, p. 75).

Monetisation has connotations of commercialisation, but that is not the purpose behind monetisation in CBA. Rather, it is to provide commensurable values for all significant impacts of an investment, and avoid the alternative of having some items implicitly treated as having zero value, or weighed up outside of the monetary analysis which may lead to inconsistent weightings across decisions.

2.1 Items in the framework of economic appraisal of transport

The Waka Kotahi current approach has its origins at least as far back as the 1970s when procedures for evaluating project proposals were first committed to guidelines to ensure appraisals could be performed consistently across a broad range of different projects. In 1977, Brian Cox of the Roading Division prepared a 15-page paper on economic appraisal of road transport investment projects describing the basic method of comparing roading costs of construction and maintenance with combined benefits for vehicle operating costs, time savings and crash costs, which appeared in a Ministry of Works and Development Circular Memorandum (Roading Division No. 90) (Cox, 1977). That was followed by the National Roads Board's 180-

page Road Research Unit Technical Recommendation TR9, The economic appraisal of roading improvement projects (Bone, 1986). This subsequently evolved into Transit New Zealand's Project evaluation manual, which in the 1990s was joined by a set of procedures for evaluating alternatives to roading (such as public transport services and provision for active travel). These two procedures were merged into the Waka Kotahi *Economic evaluation manual*, which was substantially revised in 2020 and has become the *Monetised benefits and costs manual* (Waka Kotahi 2020a).

The scope of these procedures expanded over time as better information emerged on the effects of transport investment. In the early days, the New Zealand evaluation framework emulated that of the UK's COBA model for CBA, which evolved from an initial narrow appraisal model in which time and operating costs were traded against capital and maintenance costs (Mackie, 2010) to a progressively broader assessment through:

- refining of values of user benefits and safety impacts
- incorporation of behavioural responses as elasticities for congestion and overcrowding
- extension to cover environmental externalities and wider economic impacts
- application across transport modes and to policy and investment packages
- creating a climate of opinion that accepts appraisal as independent input into decision processes without supplanting the decision takers' role.

In New Zealand, transport appraisal initially compared the costs of investment (including capital installation costs and on-going maintenance and renewal) against benefits measured principally as savings in the costs of transport over the sectors affected by the project, the principal benefits being savings in travel time, vehicle operating costs and incidence and severity of crashes and casualties. In 1990, the basis of valuation of fatal and non-fatal injuries from crashes was changed with the admission of a value of statistical life derived from a stated preference survey of respondents' WTP for small reductions in risk.[1]

Further benefits were added in subsequent refinements of the framework, such as avoidance of greenhouse gases and local nuisance effects like dust, noise and light pollution. The extension of analysis to include alternatives to roading led to consideration of health benefits from increased active travel through use of public transport and the improvement of travel reliability from the reduction of congestion. Not all these extensions were immediately capable of being monetised, but their presence and relative magnitude could be recorded in planning balance sheets viewed in conjunction with the monetised analysis.

The search for consistency has been a major driver behind these developments in appraisal procedures. It is also crucial to the two principal purposes that a CBA fulfils in:

- demonstrating an investment will be worthwhile and deliver benefits of greater value than its costs
- comparing the efficiency of an investment against that of other proposals competing for the same constrained funds. Greatest value from such constrained funds can be obtained by ranking proposals by their benefit–cost ratio (BCR) and funding projects with the highest ratios to the point where funds are fully committed to maximise the aggregate net present value across funds used.

The standard definition of a BCR is:

$$BCR = PV(B)/PV(I+C) \quad \text{(Equation 2.1)}$$

[1] This replaced the previously used human capital approach of valuing a fatality at the discounted value of forgone future lifetime earnings of the average aged casualty – an avoided cost valuation in the typology used in this report.

where PV is present value, B is benefits, I is capital investment and C is all other costs. For the purposes of the second bullet above, in comparing efficiency across options for fund allocation:

$$BCR = PV(B-C)/PV(I) \quad \text{(Equation 2.2)}$$

where items are defined as in equation 2.1 but non-capital costs are treated as negative benefits so as not to distort the apparent size of the capital constraint (Abelson, 2020).

With these formulations, it is important that all proposed projects, whether for road, rail, public transport or active transport, should be measuring benefits in a comparable way. It is also important that appraisals do not omit or understate benefits that might raise the ranking of individual projects by BCR if only their benefits could be more accurately measured and monetised – hence, the recent moves to include monetised values for benefits of active travel modes like walking and cycling, which could otherwise be undervalued and underfunded.

Risks of undervaluing and underfunding are always present if a substantial portion of benefits is not included in the quantified analysis but dealt with externally through more subjective weighting. Subjective weighting can vary according to whims of the assessor and lead to different projects with the same benefit gain having different effects on decisions made. This is inefficient and is a major driver for extending monetary valuation as far as is defensibly possible across items in a CBA.

2.2 Approaches to valuation in such frameworks

In economic terms, value is a measure of wellbeing, and valuation is the process of inferring value. The purpose of valuation is to establish the worth of using resources in particular ways and the relative values of using the same resources in different ways. By indicating which of the many different potential uses yields the largest return in benefits to people, valuation highlights the trade-offs in resource use choices and helps to improve the efficiency of resource allocation by maximising expected value obtained from available resources.

A first step in valuation is identifying the cause and effect associated with a project and the biophysical impacts of its delivery. For instance, roadworks involve soil disturbance, which leads to sedimentation of nearby waterways and affects the habitat of indigenous wildlife and may also exacerbate local flooding. Understanding the change of state caused by a project, both for the natural environment and the behaviour of the transport system and its users and bystanders, is fundamental to the type of valuation required. For the road system it is useful to think of provision and use of infrastructure giving rise to a number of external effects that are borne by third parties to travel user decisions: each user contributes to congestion that impacts on all other users of the system, and road use has effects on the surrounding environment, such as noise and emissions. The Waka Kotahi non-monetised benefits are externalities requiring non-market values.

The economic value that is required for the purposes of policy or project appraisal is the total value of a marginal change in the outcomes created by an investment, project or policy. Sometimes, that can be readily measured through market-based values, such as vehicle operation costs or the value of changes in greenhouse gas emissions. Cost items are routinely valued at their opportunity cost or value in their next-best alternative uses, but where the effect being valued is not regularly traded in a market, some non-market valuation is required to infer monetary values to expansion or detraction of benefits.

Internationally, there has been substantial work in developing non-market valuation techniques, particularly in the field of environmental economics and in valuing risks to health and safety. In the context of environmental economics, where there is potential for irreversible changes and extinctions foreclosing future potential uses and roles of natural environmental endowments, a critical construct has been the total

economic value (TEV) framework, giving effect to dimensions of value beyond those in market transactions, both use and non-use values (NZIER, 2018). The main components (Figure 2.1) are:

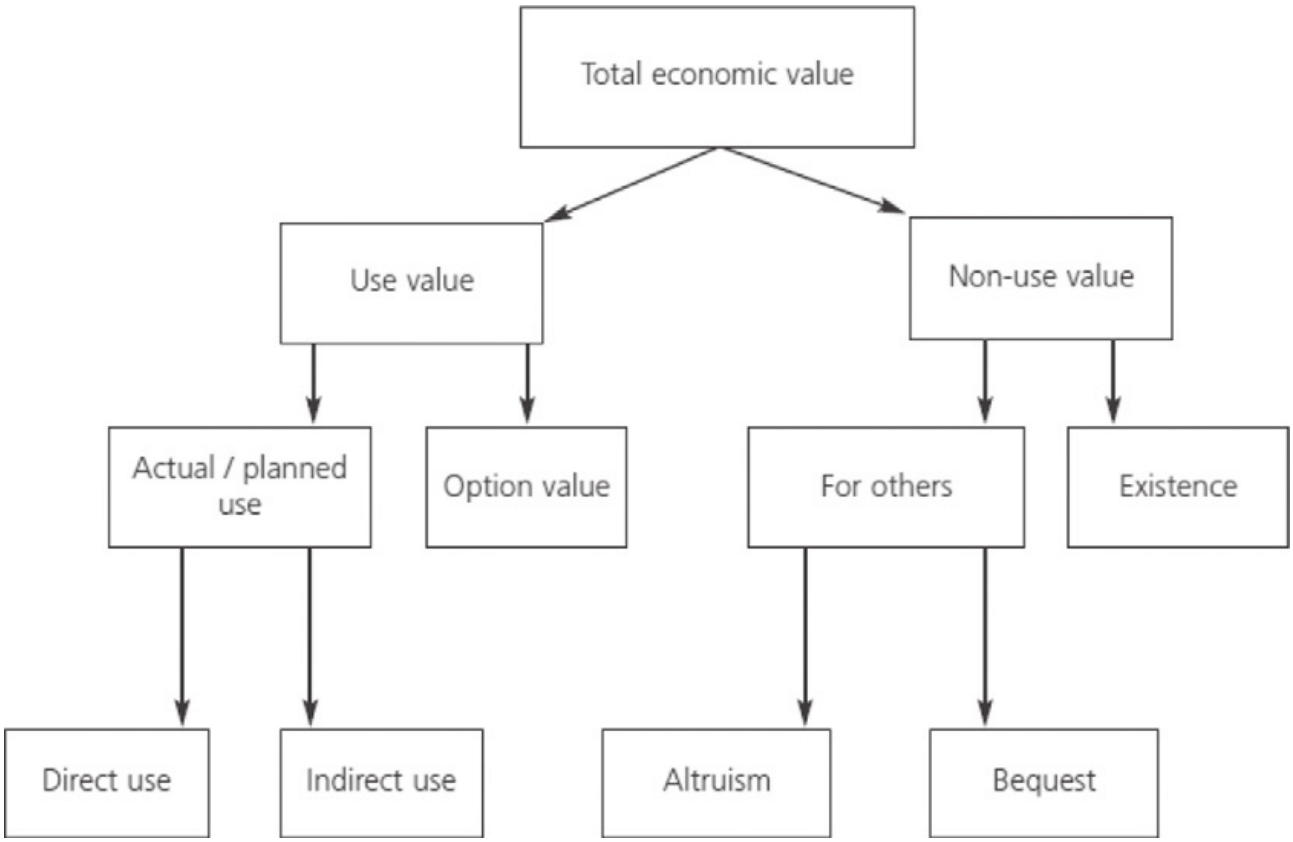
- current use values, sometimes split between direct use and indirect uses
- option values for future use
- non-use values (eg retention for altruism or bequest to future people, existence of species).

Within this framework, valuation is generally divided between:

- market-based techniques, including market prices for marketable goods and various cost estimates using market prices
- revealed preference techniques that rely on data on individuals' observable preferences for marketable goods, which include non-market attributes such as the value premium for houses located close to open green space or clean air zones
- stated preference methods that use carefully structured questionnaires of a sample of people to elicit individuals' preferences for a given change in a non-market attribute such as WTP to secure improvement in water quality in a lake (DEFRA, 2013).

There are a number of variants in each of these categories. The stated preference methods are based on surveys of affected populations and can be time-consuming and costly. A pragmatic and less costly alternative is to employ what are known as value transfer or benefit transfer techniques, which take valuations prepared in existing sources and adjust them to be applicable to closely similar new settings.

Figure 2.1 TEV framework used by DEFRA in the UK

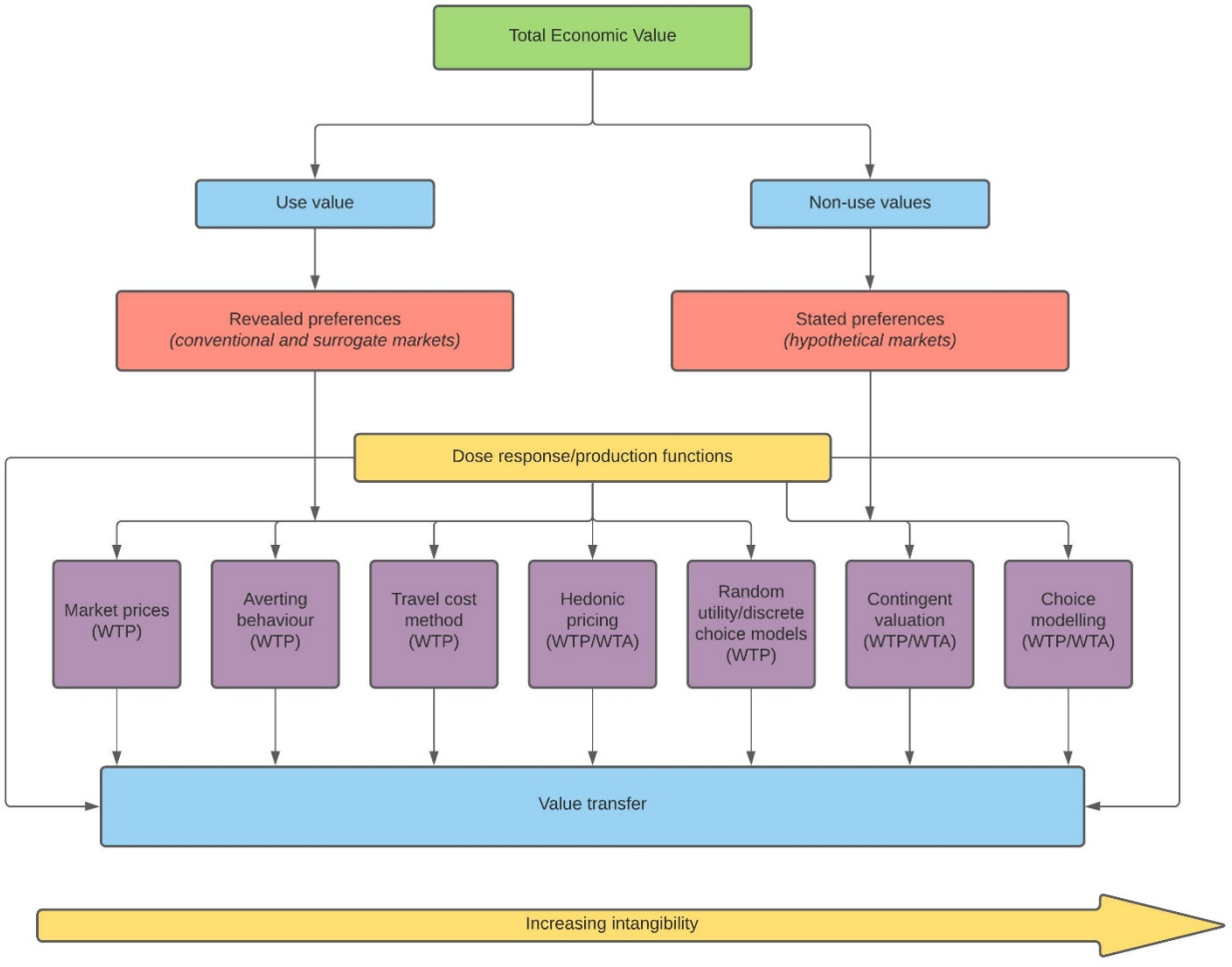


Source: DEFRA (2013)

When conducting an appraisal of a project or policy, the choice of valuation depends partly on what is the aspect at risk of change, which determines the relevant dimensions of value, and how difficult it is to obtain the relevant values of sufficient reliability for use in the evaluation. While market-based or revealed preference techniques may suffice for valuing resources that are in common supply, when dealing with effects that are potentially irreversible, such as degradation of the natural environment or sites of cultural heritage significance, it is more likely that significant non-use values will have to be considered. Only stated preference valuations can estimate such values, so this dictates the choice of valuation method.

Figure 2.2 shows the range of valuation approaches that may be used to estimate some or all components of TEV. The valuation process starts by identifying and quantifying a physical effect through a dose-response function (eg how water responds to a given level of discharge) or a production function (eg how water contamination affects some other productive process). Valuation then seeks to identify the value of change through estimating the effect on wellbeing through measures of WTP or WTA.

Figure 2.2 Valuation methods for estimating TEV



Source: DEFRA (2013)

Various effects can be valued using market price or cost-based valuation approaches such as:

- market prices (eg for changes in greenhouse gas emissions)
- avoided costs that would otherwise be incurred (eg travel time, vehicle costs)

- changes in productivity (eg increased profitability or economic rent from transport improvement)
- replacement costs or relocation costs (eg biodiversity offsets to compensate for habitat loss)
- preventive expenditures (eg costs of sound insulation against traffic noise).

Other effects need to be assessed with non-market valuation techniques such as:

- revealed preference techniques (eg hedonic pricing of house values, travel cost analysis of parks)
- stated preference techniques, including contingent valuation, conjoint analysis, choice modelling (eg on the value of protecting natural areas or proving access to them)
- subjective wellbeing/life satisfaction (SWB) valuation (eg how life satisfaction varies with inputs to it) (Commonwealth of Australia, 1995).

Traded private goods and services have market prices that cover current uses and sometimes option values as well. Public goods[2] commonly have no market values and require non-market valuation techniques. To obtain the full suite of current, future and non-use values requires stated preference valuation techniques such as contingent valuation, choice modelling or variants like conjoint analysis or contingent ranking. The more intangible the effects being valued, the more useful stated preference measures will be because of their ability to define scenarios of choice and obtain people's responses to them.

Revealed preference techniques such as hedonic pricing of house price variation with environmental attributes cover current use and some future use but not non-use values. Travel cost analysis covers only current use values, unless their questioning also captures intentions for future use, which is essentially a stated preference component.

Cost-based valuation methods cover current use and future use – the replacement cost method implicitly says the resource at risk is worth retaining for current and future uses. It does not explicitly value non-use values, but non-use sentiment may be implied in the decision to replace.

TEV can be used to consider environmental impacts in terms of the ecosystem services (ES) approach, an initiative arising out of the United Nations Millennium Ecosystem Assessment (2005). The ES approach classifies environmental goods and services as:

- provisioning services such as supply of food, fuel, fibre and water, which typically have market values
- regulating services such as water quality and quantity regulation, climate regulation and air quality regulation
- supporting services, such as soil formation, nutrient cycling and plant pollination by insects
- cultural services such as landscape and environmental spaces for recreational amenity and cultural and historical heritage.

The ecosystem services approach defines environmental impacts in terms of their effects on natural ecosystem functions, which in turn affect people's wellbeing in different ways. The regulating and cultural services do not typically have direct market values, so effects on them should be identified as far as possible and appropriately quantified and monetised using non-market valuation techniques. This approach lends

[2] In economics, a public good is defined as a good or service which is non-rival in consumption (one person's consumption does not preclude others from also enjoying its benefit) and non-excludable in supply (a supplier cannot practically charge for use and exclude non-payers). Hence, they are usually supplied by government or collective agency with recourse to taxing the community that benefits. National defence and local street lighting are common examples.

itself to viewing the environment as a source of a stream of beneficial services into the future or as a stock of natural capital assets that yield such services if their condition is maintained.

The question addressed by environmental valuation then becomes how are environmental goods and services to society affected by any changes to the natural assets? The ecosystems services approach is not a valuation method but rather an organising frame for describing environmental effects to which valuation methods can be applied.

Transport investments often have localised effects that need localised valuations to input into a CBA, but benefit transfer techniques can allow use of values obtained in similar situations elsewhere and are most readily applied to effects that are ubiquitous with impacts that are readily generalisable.

2.3 Scope of valuation

Appropriate valuation needs to be suited to the purpose of the analysis in which it appears. In common with CBA more widely, we assume the purpose of Waka Kotahi evaluations are to:

- ensure projects being considered are likely to yield positive net benefits
- compare alternative projects seeking funding from the Land Transport Fund to identify which offers best value for money as an aid to prioritising projects for selection.

Monetisation of benefits can aid both these purposes if it is done consistently. The challenge in extending monetisation into benefit categories that are currently non-monetised is to find value proxies or valuation methods that can be applied at low cost to give reliable values across benefit categories in which impacts are experienced locally but may have high variation across the country.

While the focus of this report is on economic valuation of effects that provide inputs into economic CBA, it is important to realise that economic evaluation of transport projects is not the only place in which non-monetised values may be given expression in the investment decision process. A positive CBA is a necessary but not sufficient condition to ensure a project proceeds. CBA is rarely a complete decision-making process and is usually considered alongside other considerations in the final deliberation on which investment projects should proceed. CBA sits within a larger decision-making framework that may take the form of a multi-criteria analysis (MCA) or, more recently, may be one component of a multi-step business case process.

Outside the investment decision-making process, large transport projects will be subject to local plans and rules such as those under the Resource Management Act (RMA), which require large projects to be notified and open to public consultation, subject to hearings before regional commissioners and potentially also to appeals to the Environment Court or higher courts. These processes involve a degree of scrutiny and some setting of implicit values that may lead to design adjustments for the project or requirements for mitigation in construction or use. These processes can imply a value for restraining impacts on the natural and social environment that gets realised in the costs of modifying the project design to comply.

How far to push monetisation in the benefits framework depends on how easy it is to do and the impact it will have on the uses made of the framework. It is important to anticipate where primary non-market valuation studies will be required and to allow sufficient time for their execution. It is also important to recognise the time, resources and skills required to undertake a reliable non-market valuation.

It would be economically most efficient to focus monetisation efforts on those items for which reliable values can be obtained at low cost and that potentially have widespread and significant impacts on the scale of estimated net benefits. For other items where the transaction costs of obtaining reliable values exceed the likely impact on net benefits, it may not be economically worthwhile to attach monetary values.

The bottom line is that, without quantification and monetisation, there is a risk that the impacts of investment will appear to have zero value in the monetised analysis, which for many cases will almost certainly be wrong and bias the results of the CBA. If impacts are assessed outside the monetised analysis through more qualitative or subjective scorings and weightings, the application of these methods by different analysts introduces inconsistency that undermines the appraisals' use for comparing alternative options for resource allocation.

3 Literature review

In this chapter, we describe our review of literature and its findings on other countries' coverage of benefits in their transport appraisals and on the characteristics, strengths and weaknesses of different methods of attaching values to non-market effects of transport-related projects. Specific values found for the Waka Kotahi benefits in Table 1.1 are discussed in chapter 4.

3.1 Process and outcome of literature search

Our review of international literature focused on keywords such as 'transport appraisal', 'non-market valuation', 'monetisation techniques' and 'economic evaluation'. This yielded a mix of official guidance from other countries on methods or values to apply to particular matters in an analysis and more-academic papers addressing the effectiveness of current procedures in covering potential benefits and costs or proposing new methods (with empirical application) that could be applied to make current investment appraisals more comprehensive.

3.2 Monetised benefits in different countries' transport appraisals

First, we considered the framework of economic assessment of transport investments by comparing the processes in five countries: Australia, Canada, the Netherlands, Sweden and the UK. All these countries use a variant of economic CBA as a key part of their assessments, although the scope of items covered and extent of valuation varies between them. Australia and Canada have variants of these approaches issued by both federal and state/provincial governments.

A recent review by Couture et al. (2016) across four CBA frameworks in different agencies in Canada, UK and the European Union (EU) shows broad similarity in the scope of monetisation of the core items in their transportation appraisals: changes in vehicle operating costs, safety, travel time, local air pollution and greenhouse gases. Beyond this core set, however, there is wide variety in what gets covered and what is monetised.

In Table 3.1, we have updated and expanded the table of Couture et al. (2016) to include the Waka Kotahi non-monetised benefits of interest to this study and corresponding items in the respective frameworks of the UK's Department for Transport (UKDfT), federal and state level guidance from Australia – the Australian Transport and Planning Committee (ATAP) and Transport for New South Wales (TfNSW) – and two provincial level guidelines from Canada, British Columbia (BC) and Metrolinx (which serves the Greater Toronto and Hamilton metropolitan area).

Comparing these other countries' processes with the Waka Kotahi current framework shows common coverage in quantified analysis of the conventional core of transport CBA – vehicle operating costs, travel time, crashes, greenhouse gases, local pollution and noise – but beyond that core, there is much wider variation in the coverage of items that are monetised, or remain non-monetised but discussed, or are not covered at all.

The Waka Kotahi benefits have a finer degree of granularity than those of the other five countries. The latter have some similarity to Waka Kotahi in qualitative discursive coverage of effects on water and biodiversity, but there is only occasional coverage across countries of matters such as resource efficiency and severance, and no other country addresses items like perceived safety and security or impacts on indigenous culture. This is not to say these items are not considered at all in the assessment of transport investments, but where they are considered, it is outside the monetised investment appraisal.

Table 3.1 Comparison of monetised (M) and discussed (D) benefits across countries' evaluation procedures

	Benefit item	Waka Kotahi	ATAP	TfNSW	UKDfT	BC	Metrolinx
2.1	Perceived safety and security	D					
	Security	D			D		
4.1	System vulnerabilities	D					
7.1	Water environment	D	M		D	D	D
7.2	Biodiversity	D	M		D		
9.1	Resource efficiency/energy	D				M	
9.1	Waste disposal	D				M	
10.2	Impacts on mode choice	D					
10.3	Access to opportunities	D					
	Accessibility	M			D		M
10.4	Cohesion/barrier/severance	D	M	M		D	
11.1	Heritage and cultural values	D		M			
	Historical environment				D		
11.2	Landscape	D	M		M		
11.3	Townscape	D		M			
11.4	Te ao Māori values	D					
	Wider economic value	M					
	Punctuality/reliability	D/M*	M		M		D
	Service frequency						D
	Comfort/quality	D/M*			M		D
	Affordability				D		
	Option value				M		
	Indirect tax revenue				M		
	Property/land value			M		M	M
	Land use/sprawl					D	M
	Residual asset value		M				

* Punctuality/reliability and comfort/quality are covered but non-monetised in the Waka Kotahi benefit item 4.1 System vulnerabilities, and also monetised in items 5.1 System reliability and 10.1 User experience of the transport system

Sources: Couture et al. (2016), WebTAG, ATAP, Transport for NSW, Victoria Transport Institute, British Columbia

Similar considerations apply in New Zealand. Just because an item like heritage or townscape is not monetised in the transport CBA does not mean it has no bearing on the project decision and it may still be weighed outside the quantified analysis, but the absence of a common method for monetising such items means they appear as zero value in the quantified analysis. That increases the risk of inconsistency in assessments across different proposals,

The economic evaluation helps Waka Kotahi select which proposals to fund, but it does not determine when or even whether they are built. Large projects require resource consent and will receive further scrutiny in RMA proceedings with attention to local detail and nuance that would be challenging to replicate within a framework of national appraisal guidance. As the main concern of such processes is with planning and legal matters, not valuation, decision makers are more likely to rely on values that have been used and shown to

be adequate to inform other official decisions elsewhere than to determine new values for themselves. Any monetised values developed by Waka Kotahi could be used to guide decisions in these other contexts (as has happened with land transport's value of statistical life).

3.2.1 Australia

Australia has been using CBA in its transport appraisals for over 40 years (Douglas & Brooker, 2013). The basic method has been largely unchanged over that time, but the role of CBA has shifted in the decision process from being a stand-alone document to a chapter in an environmental impact assessment or a section in a business case.

Transport appraisal is principally the responsibility of state government agencies, which have developed their own approaches to investment appraisal. However, they may also apply for funding for very large projects with strategic significance to commonwealth government agencies like Infrastructure Australia, which has its own appraisal processes that must be used for securing consideration for funding. The ATAP Steering Committee now issues guidance that includes parameters to be used for a range of items in the analysis (ATAP, n.d.). Other commonwealth involvement has come from research agencies such as the Bureau of Transport Infrastructure and Transport Research Economics (2014) and more recently from Austroads, a collective of the Australian and New Zealand transport agencies representing all levels of government set up to provide advice, information, tools and services to help its members improve transport outcomes.

Individual states and territories offer supplementary guidance to that of federal agencies to guide investment of their state-funded transport services. Transport for New South Wales is one agency that has publicly available details of monetised values for non-market effects (Transport for NSW, 2016).

ATAP issues guidance on values to use for soil and water pollution, biodiversity and landscape, and urban barrier effects expressed as values for different vehicle types proportional to vehicle kilometres travelled (ATAP, 2020). These are based on an earlier report from (Austroads, 2014), which in turn has adapted values from data prepared by CE Delft et al., (2011) drawn from all EU member states plus affiliated countries Norway and Switzerland. Although these impact values arise as costs for transport expansion, they also benefit investments that reduce the traffic levels along particular stretches of road. We discuss individual values in chapter 4.

3.2.2 Canada

Transport investment appraisal in Canada is handled by both the federal government and provincial government agencies. Procedures are similar but with some marked differences between the metropolitan centres in Ontario and more rural provinces.

Generally, these appraisals contain no environmental values other than those for emissions affecting air quality, greenhouse gas emissions and noise. This is so in the Greater Toronto and Hamilton metropolitan area, where Metrolinx embeds its economic analysis in a five-part business case procedure partly modelled on that in New Zealand (Johri & Routley, 2007). The economic analysis is based on CBA with two distinct aspects of transport investments:

- their impacts on the generalised cost of travel as perceived by users, covering effects on travel expense, travel time, reliability, comfort and amenity
- social costs of travel including the externalities of health and safety, air quality, greenhouse gas emissions and noise, although noise has not yet been monetised in the analysis (Metrolinx, 2018).

The Metrolinx guidelines contain health and safety parameters for walking and cycling with default values (Genter et al., 2008) that can be varied with the characteristics of a project and provide a way of differentiating projects by their accessibility characteristics. Generalised cost changes are used to calculate wider economic benefits of agglomeration and productivity improvements. The appraisal scope also includes impacts on land value uplift in its wider evaluation, but beyond considering an investment's impacts on noise, water, transport reliability and comfort in qualitative terms, it does not consider or monetise the range of further benefits in the Waka Kotahi framework.

Some provinces apply monetisation to the barrier effect (defined as a consequence of high traffic volumes) and severance (defined as the separation effect of new major infrastructure) and to effects on water quality (Litman, 2019). The Victoria Transport Policy Institute (2015) describes the methods used in British Columbia to make the monetary estimates, including impacts on water, barrier effects and resource costs of oil dependency, which it includes under the heading of security, but the focus of CBA remains on the core issues of travel time, travel costs and safety and the more readily measured environmental effects of emissions. There can be wide variation across provinces in the values applied within their frameworks. For example, in air quality parameters, the unit cost of a tonne of $PM_{2.5}$ varies from C$3,049 in rural Manitoba to C$32,743 in Ontario, reflecting the location specificity of the effects being valued (Metrolinx, 2018).

3.2.3 Netherlands

The Netherlands has a long history of using CBA and MCA in the appraisal of transport investments. To illustrate current practice, de Jong (2013) cites a recent CBA conducted by the Dutch Ministry of Infrastructure and Environment, in which a range of localised effects are not quantified or monetised but assigned a score that can be included in an MCA but not a CBA. These include effects on soil and water, nature, landscape and culture and spatial quality (de Jong, 2013).

Effects that are monetised for inclusion in the CBA include emissions, noise and traffic safety. The CBA also monetised the benefits of improved reliability and effects on the robustness of the network. However, in a dissertation comparing transport appraisal procedures in the Netherlands and the USA, Hanif bin Kamis (2014) cites other values for the non-monetised items in an analysis – €13 per household per year for landscape changes, €5 per year for the inheritance value of clean water, €4.25 per year per swimming visit in natural waterways – and much higher values per case of sickness attributable to pollution of the soil of €74,000 per disability adjusted life year due to cancer, €10,000 per IQ point change per exposed child and €1,820 per bone fracture.

3.2.4 Sweden

Sweden has used CBA in transport for the past 50 years and has a national reputation for focusing on transport safety. Its ministries are small by European standards, and the Transport Administration, a governmental agency, oversees investment appraisal (Eliasson, 2013).

CBA in Sweden started with the basic coverage of investment costs compared with savings in travel time, vehicle costs and safety and has subsequently moved tentatively into externalities (Andersson et al., 2018). To date, these are principally changes in greenhouse gas emissions and noise disturbance. A recurring problem with the practice of appraisals in Sweden has been understating the cost of investments, making large projects look more net beneficial than they are in reality.

The CBA for investment appraisal is part of a larger evaluation framework, effectively MCA. Guidelines are provided on handling project effects on things such as health or landscape that have not been quantified or given a value. No explicit weights are used for comparing effects from the different dimensions of the CBA,

and analysts have been unable to identify any consistency in the influence of these guidelines on priority setting (Andersson et al., 2018).

Since the late 1980s, stated preference valuations have been used for the values of traffic safety improvements, travel time savings and freight time savings. After 1995, subsequent evidence emerged of internal and external validity problems such as hypothetical bias, inconsistency between stated and actual behaviour and scope insensitivity in results, which could be overinflating benefit values. However, despite these methodological uncertainties, recent empirical studies comparing results of revealed preference and stated preference studies suggest they are not very different, and the ranking of investment proposals is robust to variations in the value of time savings, crash reductions and other impacts.

Non-market valuation does not yet extend to externalities beyond noise and greenhouse gas emissions, but such externalities have influence on project design through local planning processes. CBAs have relatively weak influence on decisions made, which often reflect political preferences for mega projects that override the CBA results (Andersson et al., 2018).

3.2.5 United Kingdom

The UK has long experience in using CBA in transport appraisals, dating back to the early 1960s and formalised by the Leitch Committee (Advisory Committee on Trunk Road Assessment) in 1978 (Mackie & Worsley, 2013). It has since evolved under various names as the COBA computer tool in the 1980s and the New Approach to Transport Appraisal (NATA) between 1998 and 2011, after which it was reformulated as the Transport Analysis Guidance (TAG) by the new government and was converted to a web-based tool (WebTAG). NATA explicitly lodged the CBA in a MCA with assessment summary tables intended to raise the prominence of environmental and social matters for decision makers. The TAG retains many of NATA's key principles and elements.

Appraisal is overseen by the Department for Transport but is also consistent with HM Treasury's Green Book guidance on government appraisal and evaluation (HM Treasury, 2020). Responsibility for transport investment is largely managed by local authorities, apart from the motorways and main trunk roads that are administered by Highways England and corresponding agencies in Scotland, Wales and Northern Ireland (Peeling et al., 2016).

Of the short selection of countries surveyed, the UK has the widest range of items in its appraisals after the Waka Kotahi framework. It has, however, a cautious approach to extending the monetary valuation within its CBA framework. In Table 3.2, there are fewer items monetised in the quantified CBA than there are impacts that are either currently not feasible to monetise or are monetised but kept outside the quantified CBA for transport, due to some doubt about consistency of the valuation for impacts such as those on landscape.

The UK includes consideration of security, historical heritage and landscape categories that resemble items in the Waka Kotahi benefits framework. However, security is more about network resilience and protection of transport infrastructure from attack than about user perceptions of security. Of these three items, landscape includes monetary valuation processes, but such valuations are not reported in the CBA although they can be used outside it – for example, in comparing options with different landscape impact in a cost-effectiveness framework. Further discussion of landscape valuation is given in section 4.1.6.

The UK's DfT has flagged particular concerns around the robustness of including landscape impacts within a CBA framework due to the risks of double counting and inconsistent measurement (Temple & eftec, 2019). This is because the scope of landscape impacts can include effects on the environment, amenity, recreation, wildlife, water quality and biodiversity, some of which are separate items in the UK's framework. In the context of the benefit clusters shown in Table 1.1, the UK's concern relates to managing the overlap between cluster 7 (natural environment) and 11 (landscape). Landscape impacts are an example of the general

challenge of capturing more costs and benefits within the monetised CBA framework in a way that ensures rigour and consistency without double counting.

Table 3.2 Appraisal summary table impacts

Impact category	Impacts that are typically monetised	Impacts that can be monetised but are not reported in the CBA	Impacts that are not currently feasible to monetise
Economy	Business users and private providers (including revenues)	Reliability impact on business users	
		Wider economic impacts	
Environment	Air quality	Landscape	Townscape
	Greenhouse gases		Historical environment
	Noise		Biodiversity
			Water environment
Social	Commuting and other users	Reliability for commuting and other users	Access to services
	Accidents	Option and non-use values	Affordability
	Physical activity		Severance
	Journey quality		Security
Public accounts	Cost to broad transport budget		
	Indirect tax revenues		

Source: Department for Transport (2018) – TAG Unit A1.1 2018

There has been some literature on the lack of widely established principles in government for handling non-monetised factors in presentation of CBA. This has even been identified as an issue by the National Audit Office. which recommended a more structured approach being included in the Treasury's Green Book (Spackman, 2013). It has also led to some promotion of greater use of deliberative MCA to ensure greater attention is given to impacts on minorities and raising consideration of their perspectives into the analysis.

3.3 Methods for attaching values to currently non-monetised benefits

As indicated in chapter 2, a range of valuation methods is available for estimating the value of currently non-monetised benefits. These include market and cost-based valuations, revealed preference methods that infer a value through related market behaviour and stated preference surveys. There is a vast literature on these non-market valuation methods in theory and in practice. Further details on them can be found in Bateman et al. (2002), Perman et al. (2011) and Boardman et al. (2011). In this section, we outline the characteristics of different non-market valuation methods, their strengths and weaknesses and their relevance for the transport effects in the Waka Kotahi benefits framework.

3.3.1 Market-based valuations

Market-based valuations are those that are primarily based on market prices of goods or services associated with the affected resource. Thus defined, they would also include a range of cost-based measures in which the basis of valuation is market-priced goods. They are also sometimes listed under the revealed preference heading, as markets are forums in which preferences are revealed. However, it is useful to distinguish direct

market-based valuations from revealed preference methods that obliquely infer value for an attribute not directly traded in a market. There is a broad typology of market and cost-based approaches to valuing the natural environment, as outlined in Table 3.3. These all infer a value for the environmental change from some associated change in observed market activity.

Table 3.3 Variations on cost-based valuation approaches

Technique	Approach	Examples of use
Avoided cost	Value of expected reduction in some future cost	Reduced expected damage and disruption from adverse natural hazard events from investing in stop banks; averted future health interventions from investment in public health measures
Change in productivity	Value change in environment at the change in output associated with it – effectively an opportunity cost for production of environmental degradation	Costs of land degradation set at lost agricultural output value; benefits of lower factory noise levels valued at increased production from lower absenteeism
Change in income	Value change in environment at the change in incomes associated with it	Costs of air pollution valued at attributable health costs comprising lost productivity, increased medical expense and fatalities
Replacement cost	Value change in environment at cost of replacing equivalent natural resources elsewhere	Costs of replacing access to houses lost by rerouting a highway taken as a measure of benefits of maintaining access
Relocation expenditure	Value change in environment at observed cost of relocation to maintain existing level of enjoyment	Cost of congestion inferred from firms' and households' WTP to relocate to less-congested locations

Source: NZIER (2018)

The avoided cost technique values the expected environmental damage as a value that people might place on avoiding such deterioration. If people are willing to pay more to avert damage than the damage cost (eg paying for peace of mind), this method understates value, but if they are willing to pay less, it overstates value. Such techniques are therefore considered to give only a rough order estimate of the value of the environment and exclude the higher-order components of TEV such as non-use value and option value.

Market prices can be used to capture the value of goods and services that are traded such as the value of forest products. However, valuing specimen trees as the volume of recoverable timber they contain is not a good measure of the landscape, biodiversity, cultural and other associative values that may attach to trees, particularly native trees like kauri that Māori consider as taonga. Market prices can act as proxies for direct and indirect use values but do not capture non-use values so will only provide a minimal expression of WTP.

Similar limitations apply to the various cost-based valuation techniques, including avoided cost, replacement cost and relocation expenditure. They can provide a value for monetising an impact but do not necessarily match closely with the value of the impact if, for instance, communities would not replace in full a lost amenity if they had to. Such cost- based methods are unlikely to provide the TEV of the impact, depending on the extent to which non-market dimensions like non-use value apply.[3] Such limitations apply to market

[3] Generally, we expect cost-based valuations not to cover non-use values, but exceptions may occur. For example, subscriptions to environmental protection organisations that might be used in avertive expenditure estimates implicitly include some non-use value component.

prices for traded goods and services and production function analysis of how much added production is obtained from increments of inputs derived from the environment.

The production function valuation technique treats a level of environmental quality as an input in firms' production functions so that changes in the quality or quantity of the environmental input can be valued at the change in productive output enabled by them (Perman et al., 2011). These approaches essentially estimate the economic rent in productive activities that can be attributed to these environmental inputs. Environmental benefits therefore have a positive value equal to the negative change in production cost arising as either a loss of output (opportunity cost) or use of more-costly inputs to maintain production. These techniques require good data and sound knowledge of how the environmental input affects production, which may limit their application because of data deficiency and wide variation in productivity across locations.

3.3.1.1 Strengths

An advantage of all market and cost-based methods is that they are based on real monetary values, which gives them credibility among decision makers, judges and the general public. They are often relatively simple to administer and can also be cost effective if data is readily to hand to implement them.

3.3.1.2 Weaknesses

Cost-based approaches are incomplete valuations, favoured more for their ease of implementation than for their accuracy. For some, like the damage cost avoided method, it is reasonable to argue that, if you know the expected damage from a contingency event (such as a flood) and have a solution that will lower expected damage over time, society will be better off by at least the expected value of damage avoided. Other methods are less clear cut – paying for a replacement of something that will be lost depends on the replacement being a complete substitute, which may not be the case. To be efficient, mitigation expenditures in principle ought to be provided to the point where the marginal cost of additional mitigation equals the marginal reduction in expected damage avoided, but this is rarely demonstrably the case in practice.

3.3.2 Revealed preference methods

Revealed preference approaches are valuations that infer expressed preferences from some observed aspect of behaviour). They are sometimes called surrogate market methods as they infer preferences for environmental goods and services from analysis of related market products.

The defining characteristics of all revealed preference methods is that they value non-market effects by observing market behaviour for some associated good. Hedonic pricing infers value for environmental characteristics like proximity to parks or the clarity of local air from the price of properties differentiated by these environmental characteristics. The value of sites for recreation is inferred from observations of the complementary good of travel to those sites. In avertive behaviour models, value of an effect such as noise is inferred from observations of spending on a substitute such as double glazing or sound baffling.

Table 3.4 Overview of revealed preference methods

Method	Revealed behaviour	Conceptual framework	Applications
Hedonic pricing method	Property purchases; job choice and wages for jobs of varying risk	Demand for products differentiated by non-market quality	Environmental quality; health and mortality risks
Travel cost methods	Participation in recreation activity at a chosen site	Household production of complementary goods (travel)	Recreation demand at single sites

Method	Revealed behaviour	Conceptual framework	Applications
Random utility models	Choice of site for recreation among several sites of varying quality and proximity	Household production of complementary goods (travel)	Recreation demand choices among multiple sites; values of change in individual attributes
Avertive behaviour models	Defensive spending to avoid harm; time and other opportunity costs	Household production of substitute goods	Value of reducing nuisances (noise), mortality and morbidity

Source: NZIER, drawing on OECD (2018)

An advantage of all revealed preference methods is that they are ultimately based on observed economic choices, which adds to their credibility among decision makers, judges and the general public. They provide actual data on how much people are willing to pay to secure a non-market good or defend themselves from a non-market bad, which has led some commentators to regard them as a more reliable indicator of people's preferences than stated preference methods. However, it is not necessarily easy to uncover these values in practice, and the relative reliability of different methods can vary on a case-by-case basis (OECD, 2018).

3.3.3 Revealed preference methods – hedonic pricing

Hedonic pricing is a commonly encountered revealed preference method that can be used to infer a shadow price for many non-traded goods that are associated with traded ones. It is most commonly applied to labour market analysis to determine the risk premium in wages for dangerous jobs and to housing to value environmental characteristics in the neighbourhood. It applies econometric analysis to house prices to infer the premium on properties with some environmental attribute, controlling for other attributes of house value. It depends on unbundling the contributions of each significant determinant of house prices to infer a marginal WTP for each characteristic, including non-market externalities like air quality and proximity to parks. It can be applied to positive characteristics (eg proximity to the sea) or negative characteristics (eg flood risk).

Hedonic pricing has conventionally been a data-intensive method, which has limited its applications to larger markets with high volumes of property transactions. However, recent developments in improved econometric techniques and the greater availability of panel data and cross-section data has enabled more refinement of analysis used and addressed the problem of omitted variables that can distort the values obtained for non-market attributes. Another recent development has been the use of geographic information systems (GIS) to improve the ability of hedonic regressions to explain variation in house prices not just by locational characteristics but also by issues such as topography and aspect of properties. These have the potential to improve the precision with which value is attributed to property characteristics (OECD, 2018).

3.3.3.1 Strengths

Like all revealed preference methods, an advantage of hedonic pricing is that it is based on observed economic choices, which adds to its credibility among decision makers, judges and the general public. It can also be cost effective if secondary data for estimation is readily available and suitable for analysis, as is the case for house characteristics and pricing data. It helps to account for influential variables that are missing in simple observational studies. It has potential for informing policy of the community benefits associated with infrastructure after it exists, such as location of facilities, access to opportunities that influence mode choice.

With new econometrics and GIS data, hedonic pricing methods can be applied flexibly to a wider range of situations than just a single location's proximity to a desirable environmental attribute. OECD (2018) cites a study of the amenity value of English nature that estimates the value of proximity to several different types of

natural land cover, providing a range of generalised values that might be used for value transfer (Gibbons et al., 2014).

3.3.3.2 Weaknesses

Hedonic pricing depends on assumptions of people's rationality in responding to market conditions, so it is susceptible to market imperfections distorting their responses (Perman et al., 2011). Imperfect information may affect people's assessment of the desirability of specific locations for the future and their ability to assess risks of future changes in the neighbourhoods under consideration. There are also challenges with estimating the welfare effects of non-marginal changes in the level of non-market goods in the neighbourhood, such as a change in available public open space or in the air quality experienced in an area. Hedonic pricing can also be data hungry in requiring large volumes of property transaction data over a period of time to control for a range of variable influences in the surrounding environment. It requires large market data covering a broad range of combinations of house attributes with environmental conditions and may exhibit multi-collinearity between variables in smaller datasets (Boardman et al., 2011). Such limitations may be alleviated by new econometric techniques and improved data.

Although a well-established method, hedonic pricing applications relevant to transport are limited to property value effects in proximity to transport routes or related environmental characteristics of locations. They do not cover non-use values or values not captured in property prices (eg values of a park to visitors from far beyond the park's influence on neighbouring properties).

3.3.4 Revealed preference methods – travel cost analysis

Travel cost analysis is one of the oldest of the non-market valuation methods. It was developed in the 1950s in the US to infer values of visits to parks and lakes for subsequent use in valuing recreational uses of reservoirs built by the US Army Corps of Engineers. It is a survey-based method that infers a price for unpriced recreation destinations from analysis of travel costs of a sample of those visiting them. It is a two-stage process, first establishing the relationship between visits and travel cost (mostly comprising travel distance costs, including travel time and fuel, but also including spending on ancillary services such as accommodation and other spending around the destination) and then using this to predict the visit rates at changed levels of price on the assumption that people would react to a destination entrance fee in the same way they do to changes in travel costs.

There are two variants of travel cost method: the original zonal model (ZTC), in which a visit is expressed as a rate per head of population in zones around the site, and a later individual method (ITC), which estimates the probability of an individual from a given location visiting the site. Both result in an estimated demand curve and consumer surplus.

There is also a hedonic travel cost method which, rather than being limited to demand at a single site, regresses travel costs on the bundles of characteristics associated with each of several potential destination sites. The demand for site characteristics and site quality is revealed by the site selections of users facing different attribute prices. The hedonic travel cost approach is more data intensive than single-site travel cost analysis and more complex than hedonic pricing and has been less frequently used.

Another extension of travel cost analysis is random utility modelling (RUM), which has become the standard method applied in the case of choices between multiple sites (OECD, 2018). RUM assumes that, faced with multiple recreational sites, people choose which site to visit according to their relative characteristics as well as travel distance. By including differences in site characteristics, RUM can test the effect of changing the quality or quantity of particular characteristics and may produce generalisable values for characteristics suitable for value transfer. Individuals are modelled as selecting between alternative sites according to their

travel cost and quality attributes in a conditional logit framework. This allows calculation of value of change in quality level or of complete removal or adding of sites.

3.3.4.1 Strengths

An advantage of all revealed preference methods is that they are ultimately based on real economic choices, which adds to their credibility among decision makers, judges and the general public. The structure of travel cost analysis is relatively simple to understand, and the estimate of value of visitor days resonates with the wider public.

The RUM approach is more useful as it allows estimation of the value of changes in site quality attributes as well as site closure, and it is informative of these effects across multiple sites. The estimated values of individual attributes across a range of different sites may provide a suitable basis for value transfer.

3.3.4.2 Weaknesses

In all the travel cost-related methods, only direct current use values are captured. Results exclude non-use values. They are specific to one or a number of sites in proximity, which may limit transferability of values to other settings with different patterns of demography and availability of substitute sites.

All travel cost analyses involve collection of primary data, which can be costly. That cost may be lower than running a stated preference survey as there is less need for such extensive pre-testing of the survey instrument (Fujiwara & Campbell, 2011). Costs will rise, however, if the survey needs repeated contact surveying at the site being studied at different times to account for seasonal variation.

In practice, travel cost analysis is weak in determining the value of marginal changes in the availability of the destination site. Both the ZTC and ITC methods provide estimates for the entire site rather than specific features (Boardman et al., 2011). The typical output is an average value per visitor day, which can be useful for assessing values of new recreational facilities such as at a new reservoir (the original use of travel cost analysis in post-war USA) but is less useful in considering the value of adjustment of facilities on site. Travel cost functions have limited uses in predicting changes in visits due to changing characteristics at a site, as they generally have little information about qualitative changes caused by factors such as on-site crowding or access route congestion. Problems also arise in attributing costs to multi-destination journeys, attaching value to travel time and choosing whether time at the destination is included in travel cost or not.

Random utility models are more informative in terms of quality attributes, but they are more data demanding and computationally challenging. RUM requires data on individuals' choice of sites, place of residence and socio-economic and demographic characteristics as well as trip cost information, some of which will need to be collected from on-site or off-site surveys. RUM does not directly explain changes in the total number of trips to a site because of a change in site quality, which may need to be assessed in a supplementary analysis to the RUM.

3.3.5 Avertive behaviour method

Although sometimes compared to production function methods in the market-based category, the avertive (or defensive) behaviour method is commonly included as a revealed preference method because of its similarity to hedonic pricing in inferring non-market values from observed behaviours for a related product. Whereas hedonic pricing infers value from a complementary product (eg a house as complementary to its location characteristics), avertive behaviour is based on the value of substitute products (eg sound baffling as a substitute for absence of traffic noise).

The avertive behaviour method is based on the premise that people can insulate themselves from a non-market bad by their behavioural choices. These choices include both defensive expenditures (installing

double glazing against noise) and non-spending behavioural choices that may incur an opportunity cost (OECD, 2018). The value of an environmental improvement is inferred from the measures taken to avert, prevent or defend against an impact. For instance, this approach would value noise at least as much as observed expenditure on installing sound baffling or value water quality at the cost of households purchasing nitrate filters to improve their water supply. The environmental attribute is treated as an input into a household production process (in the case of water filters), and the expenditure on the filter treatment is a measure of the benefit of reducing the externality of poorer quality. This method is approximate as avertive expenditure may provide more benefits than just the externality reduction (eg double glazing provides sound insulation and also heat insulation), and some avertive measures are not purchased in markets, such as householders' behaviour change and labour inputs (Boardman et al., 2011).

3.3.5.1 Strengths

An advantage of all revealed preference methods is that they are ultimately based on real economic choices, which adds to their credibility among decision makers, judges and the general public.

3.3.5.2 Weaknesses

Avertive behaviour valuations lack the precision of other non-market valuations. Defensive expenditures are commonly regarded as only partial or lower-bound estimates of an environmental bad – double glazing may reduce noise inside a building but does nothing to noise in the garden around it. They may also involve joint products, such as heat insulation as well as sound baffling from double glazing. Non-spending avertive behaviour can be difficult to identify and assign monetary value to, and it is also difficult to identify the degree of environmental improvement actually achieved or whether unobserved factors change the experienced improvement, creating a degree of buyer regret and unrealised value (OECD, 2018).

3.3.6 Stated preference methods – contingent valuation

The contingent valuation method (CVM) uses a survey to present a sample population with a questionnaire about their stated preferences for a hypothetical choice. Respondents answer according to their WTP for improvement or WTA (with compensation) a deterioration in outcome. It has been used as a market research technique to estimate the prices that people would be willing to pay for improvements in public services and is also used in non-market valuation as it can estimate use and non-use values.

At the core of a contingent valuation is the setting of a scenario that frames the choices over environmental outcomes. There is a wide range of options in how to administer the survey (interviews, mail-in questionnaires, online etc) and in how to ask the question, which can cause variation in results. A favoured method recommended by the National Oceanic and Atmospheric Administration (NOAA) Panel (Arrow et al., 1993) after the *Exxon Valdez* oil spill is to use a dichotomous choice, binary choice or referendum style CVM. In this, respondents are asked their WTP for a randomly assigned price for something on a take-it-or-leave-it basis, the responses to which are then used to estimate the probability of respondents accepting any particular price. This method yields results that are lower than those from open-ended money questions (Arrow et al., 1993). It overcomes some of the biases found in other CVM and is incentive compatible, increasing the likelihood of respondents giving honest answers rather than strategic ones (Boardman et al., 2011).

Although controversial in some quarters, CVM has gained increased acceptance among academics and policy makers as a versatile and powerful method of non-market valuation (OECD, 2018). Over decades-long evolution, techniques have emerged to create robust guidelines for reducing the biases associated with the method, such as avoiding using voluntary payment mechanisms that are prone to free-riding behaviours and strategic bidding rather than compulsory payment mechanisms like taxes and fees. Some issues such as respondents' loss aversion and cognitive challenges in dealing with small changes have also been shown

to exist in actual market behaviour and are not simply artefacts of CVM. Recent developments in online surveying have substantially reduced the cost of such studies, which can be quick to implement, avoid interviewer bias and offer flexibility in implementation with the ability to provide respondents with visual and sound prompts, for instance, to help clarify should contradictory responses emerge in the course of a respondent's answers.

Estimation of non-use values remains one of the method's weak spots, given the lack of alternative values with which to compare the estimates. As respondents are usually unfamiliar with valuing non-use values, they may be hesitant at first but can be shown to improve as they become more familiar with CVM. A variant method called learning design contingent valuation uses a double-bound dichotomous choice payment format applied repeatedly to mutually exclusive goods to allow for learning and experience in the valuation tasks (Bateman et al., 2008). This method suggests the last response in the series of valuations is more correct than the first. It also provides some counter to the observation that respondents may resort to shortcut heuristics rather than fully assessing all the trade-offs in complex choices because of the increased experience they gain in the additional rounds of questioning.

3.3.6.1 Strengths

The main strength of CVM is its versatility and scope in capturing use and non-use values. It is a flexible method that can be tailored to present direct choices in outcomes, so responses focus on the issue at hand. It can capture all aspects of TEV, including non-use value. The potential biases are well known and can be countered by good initial survey design.

3.3.6.2 Weaknesses

CVM has a number of well-documented biases such as hypothetical bias, strategic bias, starting point bias and warm glow effects (Perman et al., 2011). There are ways to reduce their impact on results but not eliminate them entirely. The wide disparity between WTP and WTA in empirical studies, which in principle should converge, is also a cause for concern.

Kahneman and Sugden (2005a) argue that, confronted with valuation questions about environmental subjects they are not used to valuing, respondents are more likely to express attitudes rather than preferences as required by economic theory. Respondents signifying a pro-protection attitude rather than an income-constrained WTP to protect the subject species may explain why the estimated annual average household WTP to protect a single site or species may appear high compared with the current average annual household spending on conservation-related activity.[4] They also consider contingent valuation to be highly vulnerable to focusing illusion, as designation of any object of utility can draw too much attention to it and inflate WTP responses.

Similar criticisms of contingent valuation are levelled by Fujiwara and Campbell (2011) in a report to HM Treasury on valuation techniques for social CBA. They suggest that contingent valuation respondents may be prone to mispredicting the future benefit from their choices, partly because of anchoring effects in the way the surveys are designed and partly because people are not good at accounting for their adaptation to changes in future circumstances that can change the value to them of future consumption.

Despite the criticism, there is widespread acceptance that, in the right circumstances and with the correct execution, CVM can provide reliable and policy useful results (Baker & Ruting, 2014). CVM is relatively uncontroversial in contexts involving use values, although it may overestimate them. Its accuracy in non-use value contexts is more controversial, although this is the context where it has the greatest potential to fill a

[4] See https://nzier.org.nz/publication/realistic-valuations-of-our-clean-green-assets

need for valuation. Developments in CVM research point to the ability to suppress the disadvantages, and the need for good-quality studies following best-practice guidelines, such as those found in Bateman et al. (2002) and Johnston et al. (2017). The CVM is of particular use when assessing impacts on public goods, the value of which cannot be uncovered using market-based or revealed preference methods (OECD, 2018).

3.3.7 Stated preference methods – choice modelling

Choice modelling is a survey style approach that presents survey respondents with a range of discrete multi-attribute alternatives from which to choose their most preferred alternative. The term 'choice modelling' covers a broad range of techniques, including contingent ranking, contingent rating and paired comparisons (Bateman et al., 2002). These methods, however, are better at identifying relative ranking of options rather than monetary valuation. One method that can provide monetary values is known as a discrete choice experiment (DCE), which is the only choice modelling approach that meets the requirements of welfare theory. It shares the strengths and weaknesses of contingent valuation but has some distinct characteristics of its own (OECD, 2018).

DCE assumes that any good can be described by a bundle of attributes and levels. It proceeds by defining a choice set of attributes and creating some options with varying mixes of attributes and levels (including a base option with no change from the status quo). Respondents are asked to select their preferred option, which may be repeated with varying levels of attribute with a monetary value included as one of the attributes. Analysis can then identify both the relative preference of the sample between alternative options but also the relative values for variations in the attributes across the options.

The analysis identifies the trade-offs respondents are making between the attributes and costs of the options. Choice modelling only needs to establish one cost attribute trade-off in its attribute set to estimate relative dollar values of all attributes, which may yield greater respondent participation rates than explicitly asking for dollar values in contingent valuation. Choice modelling can also be more informative than contingent valuation about the marginal value from small changes in the attribute mix.

In recent years, there have been improvements in statistical design, econometric analysis techniques and survey implementation (with the onset of online surveying). A remaining challenge is in dealing with attribute non-attendance – a situation where respondents consider only a subset of the attributes presented in each choice task. This can occur if respondents rationally choose to base their choices on only a subset of the information provided or if information overload/cognitive limits cause them to base their decisions on heuristic shortcuts or if respondents have lexicographic preferences that do not allow any trade-offs and no amount of compensation to steer their choice over changes in some attributes. It is also possible that respondents may display multiple decision rules guiding their choices. Such preference heterogeneity in decision processes may cause biased coefficients and monetary valuations if not allowed for. Some econometric models that better account for heterogeneity, such as nested logit, mixed logit or latent class, have been increasingly used in recent years (OECD, 2018).

3.3.7.1 Strengths

The main strength of choice modelling is its ability to capture use and non-use values and explore choices at some detail to identify marginal values of changes in different attribute mixes. It can be tailored to present direct choices in outcomes and offers scope in the design of questionnaires to reduce some of the causes of criticisms levelled at contingent valuation. Choice sets can include opposing outcomes (eg more wildlife from habitat protection or more jobs from habitat encroachment) and directly explore trade-offs through expressed preferences. Beyond this, OECD (2018) suggests the following advantages:

- Choice modelling has the ability to deal with situations where changes are multi-dimensional and trade-offs between dimensions are of particular interest – DCE measures the marginal changes of various components of a change.
- It focuses on attributes increasing the potential to generalise results for use in value transfer.
- Simultaneous presentation of the whole and parts of an outcome forces internal consistency on respondents' choices.
- In giving respondents multiple chances to express preferences for a good over a range of payment values, DCE is more informative than discrete choice CVM.
- In relying on preferences between attribute packages and avoiding explicit elicitation of respondents' WTP, DCE may be less prone to protest bids, strategic responses or yeah saying.

3.3.7.2 Weaknesses

The main weakness of DCE is that it places greater burden on respondents' cognitive abilities than CVM, raising the risk that they resort to simple rules of thumb (eg choosing according to one dominant attribute), which weakens the reliability of results to show relative preferences across attributes (Perman et al., 2011). It faces similar criticisms to other stated preference methods in being based on questioning about hypothetical scenarios, potential for focus illusion and for eliciting attitudes rather than realistic responses. The usefulness of the modelling depends on the credibility of the hypothetical scenario described by the attribute sets and the analysis of the responses.

Beyond this, OECD (2018) suggests the following weaknesses:

- The multiple complex choices between bundles with many attributes and levels – there is tension between the statistical efficiency of asking a large number of trade-off questions and the response efficiency of presenting smaller, simpler trade-offs to make it easier for respondents to answer.
- It is more difficult for DCE to derive values for a sequence of elements of a programme or policy compared with CVM alternatives.
- There is evidence to suggest the total value of a policy programme may not be equal to the simple addition of the results of a DCE valuation, including in the transport field, where research for London Underground and London Buses found the value of whole bundles of improvements was less than the sum of the values of component parts.
- It has been commonly observed in DCE that a disproportionate number of respondents choose the status quo or opt-out alternative, which could indicate status quo bias or an anchoring effect.
- As with all stated preference methods, welfare estimates from DCE are sensitive to study design, choice of attributes, levels chosen to represent them and the way choices are presented to respondents.

3.3.8 Subjective wellbeing/life satisfaction methods

In recent years, economists have been testing the direct valuation of life satisfaction or SWB as an alternative to the limitations of conventional non-market valuation. This experienced utility can be measured through retrospective valuation in which respondents' wellbeing depends on self-reported assessment of their satisfaction. Given sufficient data, econometric analysis can estimate how these satisfaction levels change with respondents' characteristics like age, income, gender and ethnicity and also their access to other contributors to wellbeing such as environmental quality and social engagement.

This is a marked change from previous economic practice that has conceived value in terms of decision utility, in which people's preferences, expressed through their choices, is the basis for establishing value either in the market for traded goods or by mimicking market-like processes in non-market valuation. Decision utility is based on anticipated outcomes of choices, and the validity of the approach rests on assumptions about respondents' ability to make rational choices about the future. If people have bounded rationality because they do not know enough about how choices for the future might play out, what they choose may not provide what they expect it to (Kahneman and Sugden, 2005).

One form of SWB valuation depends on regression of mean life satisfaction from surveys such as the New Zealand General Social Survey with other indicators of material standard of living and non-market outcomes like health, knowledge and skills, leisure and recreation, cultural identity and environmental quality. Given sufficient data, econometric analysis can give an indication of how wellbeing varies with availability of these other indicator matters and infer values on individual items. Another form of SWB valuation constructs a measure of wellbeing adjusted life year, which could be used to compare outcomes of different ways of reaching specified wellbeing gains over time. This is modelled on the quality adjusted life year (QALY) used in health and is called a WELLBY or WALY (Layard & Oparina, 2021). Like the QALY, this could be used as the outcome variable to compare different proposals with similar outcomes. However, as a QALY is a multi-dimensional construct of longevity and health functioning, not all QALYs are created equal – a combination of long life and low function can have an equivalent QALY to a combination of short life and high function. The same issue may arise with the WELLBY, depending on how it is calculated.

Because life satisfaction and subjective wellbeing studies are based on experienced utility, they avoid some of the problems with conventional non-market valuation, but not all of them. In a report for the UK Government, Fujiwara and Campbell (2011) compared the uses of revealed preference, stated preference and SWB valuations. They argue that preference-based methods have provided many valuations that have been useful for policy analysis but have also frequently resulted in implausible estimates. The newer life satisfaction approaches provide valuations that look implausibly high, but further research is under way to uncover explanations and means of adjusting the methodology.

Fujiwara and Campbell conclude that, even if the SWB-based valuations cannot be taken at face value for comparison with market values for goods or services, they can still enable comparison of the relative value of different non-market goods. In other words, although they may not fit in a full CBA, they could be useful for side analysis of the cost-effectiveness of different ways of reaching the same wellbeing outcome.

In a later study, Fujiwara elevates the SWB to being an alternative to stated preference non-market valuations (RICS, 2020).

In its Green Book, the UK Treasury says in paragraph 6.22, 'it may be appropriate to use subjective wellbeing as the outcome variable for Social Cost Effectiveness Analysis in certain circumstances…the methodology continues to evolve and it may be particularly useful in certain policy areas, for example community cohesion, children and families. Where valuations are considered robust enough for inclusion in Social CBA, benefits or costs must not be double counted, which could occur if a benefit or cost arising from a policy were counted by different valuation methods' (HM Treasury 2020, page 60).

Double counting is a critical caveat as subjective wellbeing covers the effects of many things in combination that conventional CBA itemises individually and then adds up. Because subjective wellbeing is an overall valuation, it can be difficult to know how it is affected by policy changes that act on individual policy inputs to processes that achieve a particular outcome. It may be possible with econometric analysis to determine how subjective wellbeing varies with changes in key variables, but the technique is still at a relatively early stage of development.

Although having endorsed interest in the SWB valuation approach in its publications (OECD, 2013), other authors for the OECD remain cautious. Although SWB approaches open up a new frontier for helping to monetise values for impacts of policies and investment projects, much less is known about the limitations and biases of the emergent SWB valuations than about revealed preference and stated preference methods that have a much longer history of research and application in economics (Sunstein, 2004).

Despite the inconsistency of SWB valuations with the other valuations used in CBA, the New Zealand Treasury has admitted eight values relating to the benefits of sport and recreation based on SWB into the valuations database in its CBAx tool to assist government agencies in their budget initiatives. These values could confer advantage in approving sporting bids over bids of other agencies without such values available. This will not affect the CBAs prepared using the Waka Kotahi benefits framework as long as land transport funding comes from the separate dedicated fund.

3.3.8.1 Strengths

The strengths of SWB valuation are that it offers a direct way of relating welfare outcomes to the inputs of income and social and environmental conditions that are thought to affect it. It is an approach that largely relies on secondary data (including general wellbeing surveys) without the need for specific surveying, so it can be cost-effective in generating values. It also has fewer survey-related biases than stated preference methods like contingent valuation and choice modelling (Fujiwara & Campbell, 2011).

3.3.8.2 Weaknesses

There is less-extensive history of the use of these methods and the biases and problems that affect results. There are difficulties in estimating the marginal utility of income and the marginal utility of non-market goods, which are central to the valuation. The method is also focused on a retrospective assessment of satisfaction with life experienced now rather than forward-looking preference for future consumption, so values are not consistent with other values based on decision utility used in CBA (Kahneman and Sugden, 2005). It would be difficult to attribute changes in subjective wellbeing to individual transport projects.

3.4 Benefit transfer methods

3.4.1 What is benefit transfer?

Benefit transfer, also known as value transfer, is the practice of using estimates from an existing valuation (the source study) and transferring or applying them to another situation (the target study). The benefit transfer method is useful when time and resources inhibit the ability to do targeted primary research (Allen & Loomis 2008; OECD 2018). It is not a direct substitute for the use of primary valuation of impacts of transport projects and policies (Rolfe et al., 2015). Benefit transfer is a paradox. Benefit transfer is the bedrock of practical policy analysis where policy analysts rarely have the luxury of time and resources to conduct primary valuation so analysts must fall back on adapting findings from existing studies. At the same time, benefit transfer will inevitably introduce subjectivity, value judgements and uncertainty as analysts are forced to make assumptions in addition to those that exist in the source study (OECD, 2018). In a world where primary valuation is scarce, benefit transfer is a pragmatic approach to evidence-driven analysis. This means analysts need guidance on two aspects of benefit transfer:

- How to execute benefit transfer as well as possible.
- What the limitations and inherent uncertainties might mean for the analysis it is being used for.

The potential for wide-ranging application of the benefit transfer method makes a widespread and high-quality understanding of the method important for informing advice, evidence and judgements required in the

decision-making process. Ensuring a high-quality understanding of the benefit transfer method includes knowing about the process, strengths and limitations when applying it (Johnston et al., 2017).

While benefit transfer has limitations and faces criticism, the practicality of benefit transfer makes it an influential and pervasive tool in the appraisal of the impacts of transport and other areas of governmental intervention, so much so that Johnston et al. (2017) conclude that improvements to the quality, consistency, practicality and accessibility of benefit transfer are among the most impactful and socially beneficial contributions economists can make because it is almost certain that benefit transfer will continue to be a central component of transport policy analysis and investment appraisal worldwide. In the absence of greater investment in primary valuation of transport impacts, better-quality benefit transfer and broader understanding of the method is a second-best route to improving the quality of appraisal and advice for decision makers.

3.4.2 Techniques for undertaking benefit transfer

There are four techniques for undertaking benefit transfer: naïve transfer**,** point transfer, functional transfer and meta-analysis (Allen & Loomis, 2008; Newbold et al., 2018; OECD, 2018).

Naïve transfer is a description of the direct application of borrowing a value from the source studies to the target study in an unadjusted way. The most common form of naïve benefit transfer is the direct use of mean or median values. Simplicity is the virtue of this technique (OECD, 2018) and trades off with the failure to account for important and relevant differences between the source studies and target studies. As a general rule, source and target study parameters are not identical, so good practice would be to limit the use of naïve transfer to initial assessment or scoping enquiries where the consequences of imprecision are low (OECD, 2018).

$$WTP_{target} = WTP_{source} \quad \text{(Equation 3.1)}$$

Point transfer with adjustment involves the direct transfer of a unit value estimate (such as an estimate of an hour of recreational activities) from source to target with only minor adjustments (eg adjusting for inflation or scale for income differences).

$$WTP_{target} = WTP_{source} \, x \, (Y_{target}/Y_{source}) \quad \text{(Equation 3.2)}$$

Functional transfer utilises the mathematical formulation from the source study and customises the inputs to tailor the estimation procedure to the topic of interest. This could involve adjusting the estimates for differences in thresholds, statistical relationships or demographic differences. The process of functional transfer requires quite detailed information about the derivation of the source estimates. Ideally, such information will be readily available or published alongside the source values. For example, one approach for functional transfer could be to adjust the values of the variables and the coefficients in the source equation for the value in the source study to new values that fit the target study, thereby recalculating the value for the target study, as shown below.

$$WTP_{source} = f(X,Y) = a_0 + a_1X + a_2Y \quad \text{(Equation 3.3)}$$
$$WTP_{target} = f(X,Y) = b_0 + b_1X + b_2Y$$

However, this kind of function technique for benefit transfer demands detailed information about the source study, inputs for the functional transfer for the target study and the ability to do the calculations accurately.

Thus, while functional transfers seem theoretically ideal, they are less accessible and practical for policy analysis (Johnston & Rosenberger, 2010; Newbold et al., 2018; OECD, 2018).

Meta-analysis uses the data and results from many studies to identify systematic relationships and common value across the range of studies. The strength of using meta-analysis for benefit transfer is the ability to draw on many source studies (Bergstrom & Taylor, 2006), but meta-analysis demands a large amount of information, which is not always possible to gather in a time-sensitive environment. It is also plausible the time and resources required to complete a meta-analysis of international sources could rival demands of a new primary valuation in a local setting. A meta-analysis should, however, have wider potential applications to different contexts than a new primary valuation for a specific setting.

The naïve or point transfer techniques are the easiest to apply and most used, but they do not account for differences in contextual factors like population characteristics, which might cause significant difference in values between the source and target study.

The functional transfer method can potentially account for contextual factors and is preferable to the point transfer method if it is done well, but it does depend on identifying and including key explanatory variables in the source study that can be used to predict the value in the target application. Non-market valuation studies often report insufficient context variables to enable this to be done (Loomis & Rosenberger, 2006).

Meta-analysis can vary from taking simple averages across a body of studies to econometric analysis of the results and context variables across numerous studies to work out the determinants of value across a wide range of settings. Any meta-analysis is preferable to a point transfer of a single study, and the multi-study meta-analyses are the strongest of all, but it takes a substantial investment in information and analysis to undertake such meta-analysis (Moeltner & Rosenberger, 2014).

3.4.3 Applying benefit transfer

The general steps to complete benefit transfer, using the unit benefit transfer method, are described in Table 3.5. The functional transfer method can also be used, but more often, source studies do not enable functional transfer to be undertaken so unit value transfer is used.

Table 3.5 Steps for conducting the benefit transfer method

Step	Action
Step 1	Define the target policy problem, policy site and population characteristics of those expected to be impacted
Step 2	Collect a range of similar source studies in the value table and others in the literature
Step 3	Screen the source studies for relevance – how close is the match between each source study and the target policy problem?
Step 4	Make any adjustments for inflation or other variables as required to align source and target setting – if a functional technique is being used, this is the step where the inputs to the equation are introduced and the results are estimated for the target study
Step 5	Summarise the selected source studies after any adjustments including the central value and the range
Step 6	Apply the central value from the source studies to the target policy problem and conduct sensitivity analysis using the range of source study estimates

Source: NZIER adapted from Rosenberger & Loomis (2017)

3.4.3.1 What are the challenges when applying benefit transfer?

There are three main challenges with the benefit transfer method. Conceptually, they are all sampling issues concerning how closely the sample resembles the population it is applied to and entail ensuring that:

- the source population from which estimates are drawn is similar in composition and preferences to the target population
- the site, product, impact or situations – what is being valued – in the source study and target study are the same in terms of scale and proximity to population
- the measures of welfare and property right characteristics are consistent so that the values in the source and target study are reasonably comparable (Loomis & Rosenberger, 2006).

The strength and reliability of the transfer will be undermined if there is not a high degree of similarity in the nature and population between the source study and target study. This could affect the creditability, persuasiveness and ability to defend the results on the target study or policy analysis. Therefore, investing time in searching for source studies that are 'close' to the target study is important. The need to take time to ensure some level for fundamental consistency between the source and target study has implications for the cost-effectiveness of the benefit transfer method. Doing benefit transfer well is much more than finding a value for the marginal cost or benefit of interest and then adjusting for inflation or purchasing power or both. The benefit transfer method requires meaningful consideration of the context of the source and target areas.

UK Government guidelines suggest that unit values are best suited to sites that are very similar in all respects (eftec, 2009). When dissimilarities between the source and target sites increase, value function (using generic variables) is preferable for addressing greater heterogeneity between sites and providing lower errors.

It is valid to ask how accurate benefit transfer needs to be in CBA. The answer depends on the magnitude and consequence of the decision guided by the analysis that incorporates benefit transfer. Simply put, the more important the decision and the greater the influence of the benefit transfer component, the more the accuracy of the benefit transfer matters. In practice, increasing accuracy of benefit transfer needs careful choice of source studies and primary valuations and increasing the extent of sensitivity analysis associated with the benefit transfer components and the overall analysis. OECD (2018) recommended increasing the sensitivity analysis as the consequences of the analysis increase on a spectrum that starts with initial insights and moves along to screening/scoping, policy decisions and then ends at compensation/damages estimates. Transport appraisal typically sits somewhere between scoping and a policy decision. However, the final decisions on long-lived infrastructure may warrant much greater accuracy due to the longevity of the effects and the potential consequences for the transport network.

3.4.4 Sources of bias

The benefit transfer approach is as vulnerable to bias as any other form of appraisal. Bias in the benefit transfer approach can come from the source method and the source sample. For example:

- responses on issues could be gathered during periods of heightened public debate or particular economic conditions such as a recession, which could affect households' WTP for recreation or environmental settings
- some WTP surveys are legitimately interested in responses from specific subgroups (eg ethnic groups).

Such sources of bias imply that considerable care is warranted when applying the benefit transfer approach particularly in the investigation of the appropriateness of the source study relative to the context and objectives of the target study.

3.4.5 The role of value databases

Value databases are becoming more common in transport appraisal and elsewhere in policy analysis. The drive towards the development of value databases is understandable. Databases are practical and time-saving devices but they should only be used as a guide to the range of potential studies available to consider in the process of benefit transfer. Because databases are easy to use and often made accessible to the public, there is a real and material risk of misusing the values they contain (Johnston et al., 2015). Therefore, returning to the source study to consider the appropriateness of the value should be a priority.

The OECD recommends that value databases should be accompanied by clear guidance on use and values should only be included after being widely consulted upon (OECD, 2018). This means that the investment in developing, maintaining and preparing a database should be substantial to support pragmatic appraisal. This report could act as a form of scoping exercise for the development of a Waka Kotahi database. A key lesson from the preparation of this report is not to underestimate the time and effort needed to search and review source studies across so many different domains.

Until recently, Lincoln University hosted a New Zealand non-market valuation database, which contained details of a wide range of non-market valuation techniques. In a 2018 review, this included 114 studies giving values for aspects of the natural environment, of which 31% were valuing recreation, 31% environmental protection in some form, 10% water quality, 5% landscape aesthetics and 23% sundry other aspects (including biodiversity, biosecurity, health and safety values) (NZIER, 2018). That review also found other non-market valuation studies that were not on the database, but it concluded that the studies were too few, too varied in their specific subject matter and too variable in the methods used to generate them to provide much confidence in drawing generalisable values for benefit transfer.

At the time of writing this report, the non-market valuation database was not accessible on the web due to IT problems, and it is not known when or even if it will be restored. Professor Geoff Kerr at Lincoln University has the source information on file, but it is not available on a searchable web-based database. We remain hopeful that the non-market valuation database will become accessible again. The lesson here is that databases need support to remain accessible and up to date.

The Environmental Valuation Reference Inventory (EVRI) is a searchable storehouse of empirical studies on the economic value of environmental assets and human health effects, hosted in Canada. In reviewing the EVRI database, we did not find any studies that could assist with the Waka Kotahi non-monetised benefits that are the subject of this study. A search using the keyword ‘transport’ yielded 263 studies without any exclusions (eg by date or publication type.) Only 180 of these were primary studies, and the rest were mostly benefit transfer applications or, in 10 cases, meta-studies (studies of studies). Filtering the search results with the keyword ‘transport’ to exclude studies more than five years old and studies that are not primary valuation left only 14 primary studies. Of those 14, none were related to transport effects linked to non-monetised benefits. The topics include air pollution, health impacts, natural impacts not linked to transport policy or developments and urban development. This shows that primary valuation of the impacts of transport is quite rare. Such scarcity is consistent with our experience trying to find primary valuations to monetise the Waka Kotahi non-monetised benefits. The implication of the scarcity of values available to be considered for benefit transfer is that the Waka Kotahi most realistic option to develop a database of values for the currently non-monetised benefits is to commission bespoke research.

3.4.6 The on-going need and prospects for benefit transfer

While the foregoing has identified a series of limitations with benefit transfer, these vary with the context in which it is being used. In one sense, benefit transfer is widely used in the current Waka Kotahi benefits framework and all its predecessors, as there are very few values that are customised to individual projects.

All the valuations of vehicle operating costs and emissions and travel time savings are assumptions based on a mix of empirical studies and data collected from contexts that may not be exactly replicated by the projects being assessed, so they are transferring values from a source context to a target one. Concerns about benefit transfer have arisen particularly in respect to environmental valuation because of the wide variation in environmental conditions that can affect the outcomes and because decisions based on these numbers may result in environmental changes that are irreversible or that last a very long time.

Rolfe et al. (2015) review the practice and performance of benefit transfer across Australia and New Zealand and conclude that it is patchy. Applications are limited by the small pool of source studies to draw on and the difficulty in establishing environmental protection functions that enable establishment of credible policy scenarios. While the case for benefit transfer remains strong, there has been limited action by local and national governments to embed the rigorous policy evaluation that would increase demand for reliable source studies to support benefit transfer.

3.4.6.1 Strengths

The strength of value transfer is that it can offer expedient and low-cost solutions to the sourcing input parameters and functional relationship for transport appraisal, thus avoiding the cost and time required to complete primary research in each appraisal (Rolfe et al., 2015; Johnston & Rosenberger, 2010; Johnston et al., 2015).

3.4.6.2 Weaknesses

The major weakness of value transfer is the lack of safeguards available to ensure the values and transfer approach are appropriately used; the ease of lifting a value from a source and applying it in the target appraisal leaves the method susceptible to misuse. In this sense, the strength of value transfer can also be a risk to producing robust and relevant results. The responsibility of robust consideration of the appropriateness of the value transfer from source to target lies squarely on analysts and technical reviewers. It is incumbent on analysts using value transfer to provide bounds on the estimates.

This presents a challenge when databases of values are widely available (Johnston et al., 2015). Whose role is it to make sure the values have been used appropriately and consistently? How can rigour be evaluated and maintained in the context of the practicalities of supporting the widespread application of CBA in transport appraisal, research and policy analysis?

3.5 Other methods proposed in literature

In MCA, weightings in the decision process are not subject to monetisation but are informed by other means such as:

- scorings against pre-determined criteria
- deliberative processes such as citizen juries, which place a sample of the population in the role of considering impacts and determining preferences in more depth than is possible in large-sample surveys
- expert opinion.

MCA can be viewed as a supplement to CBA, providing a means of ordering issues that it is not feasible to subject to monetary valuation. It can also be an alternative to CBA, effectively replacing the reliance on preferences expressed through market-like processes in determining values, or as a broader process in which CBA is embedded as one of the criteria (Department of Communities and Local Government, 2009). MCA is, however, more oriented to aiding decisions by orderly assessment of considerations than to revealing the value of individual inputs into the process. While it may reflect implicit values of its analysts, it is

not an explicit valuation method. It elevates the preferences of a few over the wider population preferences reflected in market or non-market valuations.

Mouter (2020) examines participating value evaluations in the context of urban mobility investments as either adjuncts to CBA or as an extension that wraps around CBA. This is a form of MCA that is more about the basis of decision making than revealing the value of different forms. Mouter reports its results differ from a CBA, with slightly higher weighting for non-motorised vehicle benefits.

Other methods identified in this literature review are primarily concerned with ordering impacts of transport in a consistent fashion, such as Transport for London's Valuing Urban Realm Toolkit and its Pedestrian Environment Review System, which track changes in physical environment with changes in perceived attributes like safety and sense of place (Boffa Miskell, 2017).

Some literature shows that, in the long shadow of the global financial crisis after 2008, project appraisals have been presented with details on impacts for economic growth and job creation. Such impacts are outside the scope of conventional CBA and cover a tightly defined measure of economic activity rather than the broader return on societal investment of the resources used. Nevertheless, where concerns about economic recovery from a shock are high, politicians, government agencies and other decision makers want to see such information as well as CBA results. Such information crept into the assessment summary tables under the UK's NATA (Mackie, 2010) and also into the business case framework used by Metrolinx in the Toronto and Hamilton metropolitan area (Metrolinx, 2018). While it is appropriate that such economic impacts can appear in a multi-criteria framework such as NATA or a business case, they are fundamentally different from the values that appear in CBA and should not be incorporated into a CBA framework.

3.6 Implications for New Zealand and transport

In a New Zealand context, the Treasury has been developing its Living Standards Framework (LSF) as a wider measure of wellbeing than conventional economic measures like GDP or disposable income. The LSF employs 43 indicators across 12 domains of economic and social conditions and has stock measures of natural capital, financial capital, human capital and socio-cultural capital to indicate sustainability over the long term. In its current form, this is more a means of tracking achievement against indicators over time than a method of identifying value.

The Treasury has also developed its web-based CBAx tool to assist government departments preparing their budget initiatives. This tool currently has limited overlap with the Waka Kotahi evaluations, but as CBAx becomes more embedded in government processes, there is potential for it to establish practices and expectations around evaluations that may impinge on other government assessments, including in transport.

This section has shown there is a variety of non-market valuation methods that could be applied to transport benefits of varying complexity, coverage and cost. As shown in Table 3.6, in summary these are:

- stated preference measures, which are versatile and widely applicable and the only measures to capture non-use values but are also survey based, costly and subject to a range of biases
- revealed preference measures, of which hedonic pricing of house values could provide values of urban amenity, but require large datasets to be successful, and travel cost analysis has limited uses tied to a specific purpose – the valuation of recreation sites
- cost-based measures, which are varied and flexible but dependent on the data available on dose-response impacts in specific areas, so transferability of values is open to question
- benefit transfer, which draws on either local or international sources and is the least costly source of values but also the most likely to be poorly executed and there are limited local values (Marsh and Mkwara, 2013).

Table 3.6 Summary of advantages and disadvantages of non-market valuation methods

Valuation method	Description	Advantages	Disadvantages
Market prices	Demand functions using observed prices from market transactions	Marginal value of changes using real market data	Only value marketed products; affected by market imperfections
Cost-based methods	Estimates of avoided costs or replacement costs	Use real market data; simple to explain and cost-effective	Not full WTP or WTA; exclude non-use value
Productivity methods	Opportunity cost of change in inputs to productive processes	Use real market data; capture direct and indirect values	Data intensive; focused on market production, not externalities or non-use values
Avertive behaviour methods	Observed defensive spending or non-spending avertive behaviour	Use real market data and observed market behaviour	A partial measure of privately controllable effects; not total value of externalities or impacts on the less well off
Hedonic pricing	Regression analysis of property market prices with environmental characteristics	Uses real market data and simple to explain	Data intensive; covers private benefit, not wider externalities or non-use values
Travel cost method	Estimates demand for visits to a recreation site from sample survey of visitors' travel costs	Uses real market data from specific site survey; visit values simple to explain	Estimates current use value for whole site, not marginal changes or non-use value
Random utility method	Estimates visitors' choice to sites of varying travel distance and site characteristics	Uses real market data from visitor surveys and marginal variation with site features	Requires granular data to identify value variation with features; omits non-use values
Contingent valuation	Estimates respondents' WTP or WTA for a change in outcomes from a sample survey	For single attribute impacts: versatile, survey-based direct estimates of both use and non-use values	Complexity limited by respondents' capacity; costly due to survey and controlling bias but online surveys becoming common
Contingent ranking/conjoint analysis	Survey-based method to find respondents' rank preferences between alternative outcomes	Well established in market research and transport service studies	Not a full valuation; survey can be costly but analysis less than CVM or choice experiment method
Discrete choice experiment modelling	Survey-based method to find respondents' preferred attribute mix, including WTP	For multiple attribute impacts: versatile, survey-based estimates of both use and non-use values of separate attributes	Complexity limited by respondents' capacity and survey structure that adds cost but online surveys becoming common
Benefit or value transfer	Existing values transferred to new settings by unit transfer, function transfer or meta-analysis	Can draw on wide range of local or international sources; cost-effective	Depends on finding source studies close to target application; often used crudely
Social wellbeing	Regression of subjective life satisfaction responses with income and other contributory factors	Becoming more widely applied and can be cost-effective, using secondary data	Marginal utility of income and/or non-market goods is challenging

Source: NZIER

4 Evidence of monetisation of the Waka Kotahi non-monetised benefits

In this section, we delve into the details of non-monetised impacts in the literature and cover three important components of the aims of the research:

- the nature of the non-monetised impacts and their relationship with transport
- the extent that other jurisdictions discuss, monetise and recommend values for non-monetised benefits
- values that exist in the literature and whether they could be adapted/adopted for use in New Zealand.

We also cite a number of monetised results for transport's impacts on some aspect of the environment. These impacts would appear as costs of new infrastructure added to the environment and as benefits for investments that reduce the traffic loads on infrastructure routes in question.

4.1.1 Perceptions of safety

Item 2.1 in the benefits framework on perceptions of safety and security is about user experience and perception of the transport system, particularly relating to safety and security. We assume this is distinct from perceptions of security, which may also contribute to resilience and security.

Perception of safety is a behaviour modifier rather than a direct impact. Most other jurisdictions do not appear to identify impacts on perceptions of safety, let alone monetise them. The UK's transport evaluation includes a security item, but this relates to protection of infrastructure against bombing disruptions.

There is some evidence of more focus on this impact at subnational level. For instance, Transport for London uses a Valuing Urban Realm Toolkit (VURT) in combination with its Pedestrian Environment Review System (PERS) to track changes in the physical environment against perceived attributes like safety and sense of place. While VURT can be applied by council officers, PERS requires public space auditors to assign scoring factors to public realm attributes in what is effectively a form of MCA. Boffa Miskell (2017) trialled such an approach in Auckland in a report to the council.

The effectiveness of such methods for valuation of impacts requires further investigation. Recent decisions by local authorities in New Zealand and elsewhere to opt for shared tracks for pedestrians and cyclists largely as a cost saving relative to providing dedicated tracks or allowing e-scooters to use footpaths with minimal definition or enforcement of any road rules for these new activities appears to violate a long-held traffic management principle of grade separation for traffic of different speeds. While there have been some reports of the impacts of these developments on safety, particularly aimed at the scooterists themselves, reports on the extent to which encroachment of wheeled vehicles onto footpaths reduces perceived security and use by pedestrians were not found in the literature search.

4.1.2 Impact of unplanned disruption on access to opportunities

Item 4.1 in the benefits framework is about reducing the risk of communities not being able to access social and economic opportunities due to unexpected outages. This risk can be reduced by either reducing vulnerabilities to outage or increasing the options to work around them when they occur with added redundancy in the system.

There have been reports about the cost of damage and reconstruction after the Christchurch and Kaikōura earthquakes, but these focus on insured damage to infrastructure rather than the disruption of business and social activity in the immediate aftermath of disruption, which can be a substantial component of the impact

of natural disasters. The recent earthquake experience does indicate the importance of the local setting to the values of disasters. The Kaikōura earthquake had a larger magnitude than the Christchurch quakes but, being centred on a rural area, caused much less damage in general, and proportionately, a much higher share of damage accrued to transport infrastructure with the severance of arterial road and rail routes.

Other network infrastructure industries account for resilience and redundancy in their networks. For instance, the electricity industry uses a value of lost load to value the risk around failures in particular components of its network and to prioritise where network strengthening is required. Transport traffic flows may be less predictable than electrical currents but there may be lessons to be learned from the grid investment tests employed by Transpower New Zealand in identifying weak spots on its system.

Studies on the value of transport resilience appear to be rare. This seems partly related to the polymorphous nature of what constitutes resilience. In a review for Waka Kotahi, Money et al. (2017) identified 15 concepts in the definitions of resilience measures. Therefore, the development of generalisable values for resilience depends specifically on what is meant by resilience.

Wang et al. (2018) estimated the WTP to improve the resilience of New York's transport system. Choice modelling was used to estimate the WTP to avoid disruption of the multi-modal transport network due to natural disaster (specifically a hurricane). Disruption of the transport network was defined by the percentage of the transport system being operative in the days and weeks following the storm. Respondents were asked about their WTP for an improved level of operation in the period following the storm, with reference to a base case scenario. We note that the level of disruption included effects such that the transport system was not operative after one to two days and only 50% operative after three to five days following the storm. In the context of New York, being the largest city in the US, the level of disruption is material (not a minor breakdown of one link). The study found that the average WTP for avoiding disruption in the transport system was US$75–450 annually. However, the result had a bimodal distribution. Individuals who had historical experience of disruption were willing to pay US$120–775 annually, whereas those who had not been directly affected in the past were willing to pay US$15–50 annually (Table 4.1). The aggregated results had wide ranges because they reflect multiple scenarios of WTP for more-resilient network operation, where the resilience is reflected in faster recovery of the network operation compared with the base scenario.

Table 4.1 Simulated annual WTP for different scenarios of New York transport system recovery

	Annual WTP US$			Operative levels after the event by duration			
Scenario	**All**	**No prior experience**	**Some prior experience**	**1–2 days**	**3–5 days**	**1 week**	**2 weeks**
Base	NA	NA	NA	0%	5%	25%	70%
Scenario 1	$76.8	$14.27	$122.79	0%	10%	40%	80%
Scenario 2	$169.66	$30.91	$272.04	0%	20%	60%	90%
Scenario 3	$149.64	$19.88	$250.58	10%	30%	60%	80%
Scenario 4	$305.29	$51.22	$490.90	10%	50%	80%	100%
Scenario 5	$261.68	$31.60	$438.43	30%	50%	70%	90%
Scenario 6	$322.40	$43.50	$534.75	50%	50%	80%	100%
Scenario 7	$295.88	$27.65	$506.12	50%	60%	70%	90%
Scenario 8	$388.75	$44.29	$65.38	50%	70%	90%	100%
Scenario 9	$377.28	$29.40	$655.84	70%	80%	90%	90%
Scenario 10	$455.11	$45.07	$776.00	70%	90%	100%	100%

Source: Wang et al. (2018)

The method is very promising, and the approach could be adapted to complete primary valuation of the WTP for improving the resilience of the transport system in New Zealand's cities. Unit transfer of these values to application in New Zealand is not recommended for two main reasons. First, New Zealand does not have metropolitan transport systems comparable to the complexity and scale of New York. Second, income differences between New York and New Zealand are radically different, so any adjustments made would need to allow for that.

This study shows that the resilience of the transport system can be valued. We would recommend this approach be considered for future research in New Zealand, alongside other suggestions in McWha & Tooth (2020).

4.1.3 Changes in the natural environment

4.1.3.1 Water

Item 7.1 in the benefits framework on impacts on water is broadly defined to cover impacts on water quality and flow during the construction and operation of transport infrastructure. It potentially includes surface run-off, accidental spillages, erosion and sediment discharges and interrupted overland flows.

Most jurisdictions do not appear to monetise the impacts of transport on water. ATAP (2020) cites values for the impact of run-off on soil and water quality that differentiate by vehicle type and vary across settings (Table 4.2).

Table 4.2 Impact of run-off on soil and water quality

$/1,000 vkm	Car	Bus	LCV	HCV
Urban	2.9	34.0	3.9	31.0
Rural	0.3	0.4	0.1	11.0

Source: ATAP (2020)

These are values derived from benefit transfer, the details of which are sourced from Austroads (2014) and ultimately from European values. Some relativities between these different items look unusual. The difference in the impact of buses in rural and urban areas is substantially larger than that of heavy commercial vehicles or any other category. While rural roads carry less traffic and have lower concentration of run-off, they generally lack the stormwater collection systems found in urban areas to steer run-off away from surrounding soils and waterways. More information is required on the origins of these values and the circumstances of how the damage costs were derived before applying such values to other urban and rural settings.

The Victoria Transport Policy Institute (2015) gives values for water pollution per vehicle kilometre based on US estimates of the costs of run-off. As these include costs of road grit and salt for de-icing purposes, these estimates may not be a close match to New Zealand transport's contaminant run-off characteristics.

The impact of transport on water can affect the latter's value in many ways. Run-off into water may affect:

- the current use value of water as an extractable input for irrigation, industry and potable supply
- the current use value of water in situ as a source for recreation and cultural uses (mahinga kai)
- the integrity of natural habitats and constituent species for which the public may hold non-use value both for their potential for future uses and their continuing existence into perpetuity.

Water impacts may therefore affect all the components in the TEV framework.

Stated preference methods would be required to cover all aspects of TEV. Recently, some choice modelling has been undertaken in New Zealand to assess public preferences for water protection (Tait et al., 2016). This was specific to cleaning up water by reducing agricultural run-off. These values are specific to the cause and may differ from public preferences for reducing the types of run-off generated by transport projects.

There have been other stated preference studies on the value of water clarity and on water as ecological habitats or locations for sport fishing, but not enough in New Zealand to derive robust representative values from meta-analysis. There are also some cost-based valuations such as the value of avoided treatment costs of keeping catchment areas in native vegetation rather than improved pastures subject to grazing (Department of Conservation, 2006).

Marsh and Mkwara (2013) reviewed the state of non-market valuation with respect to water in New Zealand, noting that the limited number of reliable studies in New Zealand covers only a few of the varieties of ecosystem service. They cited 35 non-market valuation studies of freshwater in New Zealand but concluded none of the values in their review met the criteria that would make them suitable for benefit transfer. They also cited the views of other practitioners that it is difficult to find studies of a quality to support value transfer and that, given the experience in various Environment Court cases, the New Zealand judiciary is a considerable distance from accepting non-market valuation or value transfer. They present values derived for nine different water-related activities with very large values in some instances, indicative of a high variability in underlying estimates due to a mixture of methods being used (NZIER, 2017).

4.1.3.2 Land and biodiversity

Item 7.2 in the benefits framework is concerned primarily with indigenous vegetation, ecosystems and habitats of indigenous species and negative impacts of transport infrastructure such as fragmentation of habitats, connectivity, availability and quality of ecosystems, diversity of native flora and fauna and biosecurity.

Most of the other evaluation systems examined do not monetise biodiversity impact, although some require it to be qualitatively discussed. An exception is ATAP (2020), which has values for air pollution impact on biodiversity that it converts to dollars per 1,000 vehicle kilometres travelled (Table 4.3).

Table 4.3 Impact of air quality on biodiversity

$/1,000 vkm	Car	Bus	LCV	HCV
Urban	0.7	5.6	30.3	11.0
Rural	0.0	0.0	0.0	1.1

Source: ATAP (2020)

These values are derived from benefit transfer and ultimately sourced from European data. The result that shows light commercial vehicles in urban areas having an impact value almost three times that of heavy commercial vehicles is unexpected. These values are for only a subset of impacts of biodiversity – the local disturbance to natural ecosystem functions caused by discharges that reduce air quality around transport arteries. Such impacts are ubiquitous, and if they have relatively constant values across local settings, they could be suitable for value transfer. It would be useful to ask the Australian agencies about their experiences in using them.

These values do not address higher-level biodiversity impacts such as habitat fragmentation, habitat loss and species extinction. Such matters are more likely to vary by location and require the full impact on non-use values and TEV to inform the investment appraisals. This would mean commissioning a stated

preference study designed to provide a broad sweep of results on how infrastructure encroachment onto natural habitats affects the social value of biodiversity.

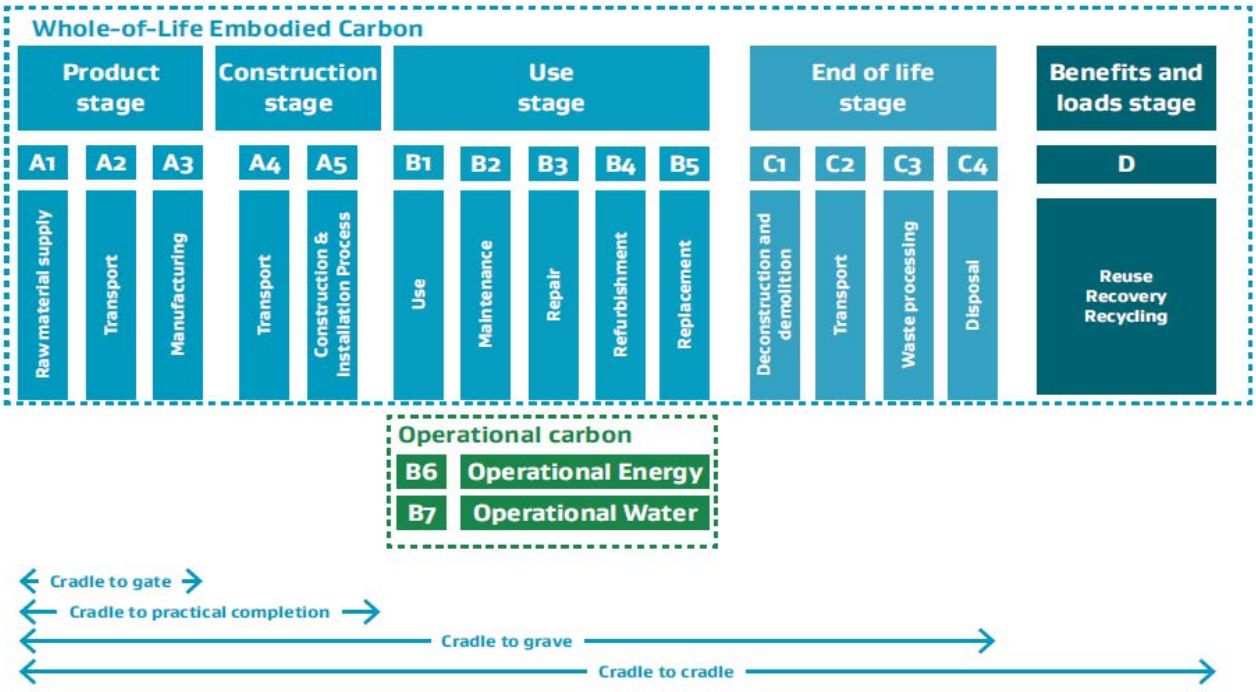
4.1.4 Changes in resource efficiency

Item 9.1 in the benefits framework on impacts on resource efficiency considers the sustainable sourcing and use of materials, waste minimisation and accounting for embodied carbon and energy use in the network.

Conceptually, this is about the life cycle analysis of resources used in transport, their embodied carbon emissions and other sustainability matters around land transport infrastructure. This is different and separate from the life cycle analysis for mode choice, travel demand and vehicle ownership. The focus for Waka Kotahi is on the whole-of-life embodied carbon emission from the extraction of source materials, transportation, construction, maintenance/renewal and end-of-life processes. There is also a potential circular economy as road infrastructure can use and create opportunities for reuse and recycling of materials.

The concept of whole-of-life analysis has been part of the broader sustainability discourse in New Zealand for some time, but implementation and development of practical and mature approaches to applying this is still developing. The Ministry of Business, Innovation and Employment published a framework for whole-of-life assessment for building construction. The framework could be applied to transport infrastructure construction (Ministry of Business, Innovation and Employment, 2020).

Figure 4.1 Whole-of-life assessment



Source: Ministry of Business, Innovation and Employment (2020)

Internationally, the embodied carbon of road and rail infrastructure has been assessed (Bai et al., 2019; Jackson & Brander, 2019; Karlsson et al., 2020). The broad set of relevant findings for application in New Zealand include that:

- embodied carbon is commonly measured in units of CO_2e per kilometre or lane-kilometre, which is consistent with the way New Zealand might approach the measurement of embodied carbon and

comparable to how it is thought about regarding the social cost of carbon in transport (Waka Kotahi NZ Transport Agency, 2020a)

- estimates for the embodied carbon vary significantly depending on the site scenarios (Jackson and Brander, 2019; Bai et al., 2019; Karlsson et al., 2020).

We have found one further reference to resource use efficiency from Canada (Victoria Transport Policy Institute, 2015). This provides value transfer estimates from the US of per vehicle-kilometre costs of oil import dependency, defined broadly to include military action to protect supply lines and the social, health and environmental impacts. This value is not relevant for value transfer to New Zealand.

4.1.5 Changes in access to opportunities

4.1.5.1 Impacts on mode choice

Item 10.2 in the benefits framework on impacts on mode choice is about things that may encourage or dissuade people to select a particular mode.

Changes in mode choice can include changes in the mode of transport in passenger and freight transport or changes in ancillary facilities like transport hubs of interchanges. Changes in mode choice in passenger transport are driven by travel time and directness – having to change buses on the commuting route is less desirable for incentivising modal shift than a direct public transport route. The impact of increased opportunities on mode choice depends on a number of factors including:

- the mode choices
- the nature of the modal shift
- the relative impacts generated by modal shift
- the level of uptake in modal shift.

The impacts of changes to access to opportunities can potentially be changes that are both positive and negative. For example, the expansion of a high-speed rail network could lead to a modal shift from private car to rail and be associated with a reduction in fuel consumption, vehicle emissions and exposure to road safety risks. Similarly, access to a private vehicle when one has not been available before could expand the list of potential job opportunities but also determine the transport impacts of the mode choice (Gurley & Bruce, 2005; Raphael & Rice, 2002).

When the number of modes, the direction of modal shift and potential impacts are considered, the large number of scenarios make it a large and difficult task to assess all the possible transport impacts. Therefore, making generalisation about the values that could be used to reflect the impacts of access to opportunities on mode choice is a step too far. This benefit requires consideration of case-by-case transport impacts in terms of the economic, social and environmental effects.

The response to the COVID-19 pandemic and moving between lockdowns provided a natural experiment in enforced mode shifting and recovery to normal conditions (Wen et al., 2021). That provided no monetary values but does provide information relevant to mode shifts in response to temporary disruptions.

4.1.5.2 Impacts on access to opportunities

Item 10.3 in the benefits framework on impacts on access to opportunities concentrates on the integration of land use and transport to provide equitable access to transport that enables participation in employment, volunteering, leisure and social activities.

A fundamental expectation of improved transport infrastructure is reducing costs of transactions across a territory, widening the geographic reach of labour and businesses in finding input sources and outlets for their services. This economic enhancement may also be recorded as part of wider economic benefits of transport, and we have found no literature valuing this as separate from wider economic benefits.

4.1.5.3 Impacts on social cohesion

Item 10.4 in the benefits framework on impacts on community cohesion is about the long-term resilience and connectedness of communities (as distinct from the short-term focus of item 4.1 discussed in section 4.1.2). Severance and isolation are principal components of measuring this benefit.

Transport literature refers to barrier effects and severance, sometimes distinguishing them as follows:

- barrier effect – the reduction in connectedness across a transport artery due to traffic density
- severance – the reduction in connectedness or additional cost of detouring due to a new transport artery severing previous connecting routes.

These barrier effects are monetised in Australia. ATAP (2020) provides costs of additional vehicle kilometres on a road in urban areas only (Table 4.4). Transport for NSW (2020b) provides values for removal of vehicles. Both use benefit transfer, but the source studies and adjustments are unclear.

Table 4.4 Barrier and separation impacts of motorised vehicles on pedestrians and cyclists

$/1,000 vkm	Car	Bus	LCV	HCV
Urban area costs (ATAP 2020)	1.0	15.0	4.5	23.0
Removal of vehicles (TfNSW 2020b)	0.78	0.0	1.8	0.0

In the UK, Anciaes et al. (2018) used a stated preference method to estimate an average WTP per person for reducing traffic levels from high to medium of £1.08 and from medium to low of £0.78. They also estimated a value per walk trip of reducing lanes on a road crossing from three to two of £1.28 and from two to one of £1.00. These values have not yet been used in official guidance on transport appraisals.

Severance can in principle be measured by estimating diversion costs imposed by the new transport artery interrupting traffic flows to either side and potentially by applying elasticities to travel between the two parts of the diverted community. Such an approach does not appear to have been used in practice for appraisals.

More broadly, social cohesion can refer to the inclusiveness of a society or the extent of economic and social disparities in the community. The value of greater inclusiveness could incorporate many aspects of community life such as:

- a reduction in loneliness
- increased participation in a club or sports team
- civic engagement and participation.

Similarly, cohesion could be interpreted as a reduction in economic and social disparities such as:

- more-equitable access to healthcare and reduced disparity in health outcomes
- changes in socio-economic deprivation and poverty
- changes in access to educational opportunities
- change in disparate unemployment and underemployment rates.

These cohesion effects reflect broad societal outcomes caused by many more factors than transport infrastructure. The relationship with transport is likely to vary widely with variation in other factors.

Values for a reduction in loneliness and increased participation in a club or sports team have recently been added to Treasury's CBAx value database. These values were provided by Sport New Zealand and have been based on a subjective wellbeing valuation (Simetrica & Jacobs, 2019). Their inclusion in the CBAx database enables Sport New Zealand budget initiatives to look more beneficial, which may confer an advantage for their bids when compared against other agencies that cannot include such benefits. As outlined above, subjective wellbeing valuations tend to be large and are incompatible with other values in a CBA. They do not provide a solution to monetising the impacts of transport infrastructure on social cohesion.

4.1.6 Changes in liveability of places

4.1.6.1 Heritage and culture

Item 11.1 in the benefits framework on the impact on heritage and cultural values is described as the benefit of diverse heritage and cultural values that make up New Zealand's population. Cultural values, including spiritual values, are a deeper experience of a place that transcends amenity associations and is distinct from commemorative associations.

Heritage can be treated in economics in the same way as biodiversity in that the social valuation question hinges on the community's WTP to protect an endowment stock of assets of cultural value – biodiversity components in one case and heritage sites and artifacts in the other. The valuation question therefore centres on the communities' WTP to protect or improve the extent or condition of this stock of assets. For heritage, extension may not be possible (barring new archaeological discoveries), but the valuation approach would be the same. While there may be a role for market or cost-based valuations to indicate a minimum value for heritage sites, stated preference methods would be needed for TEV.

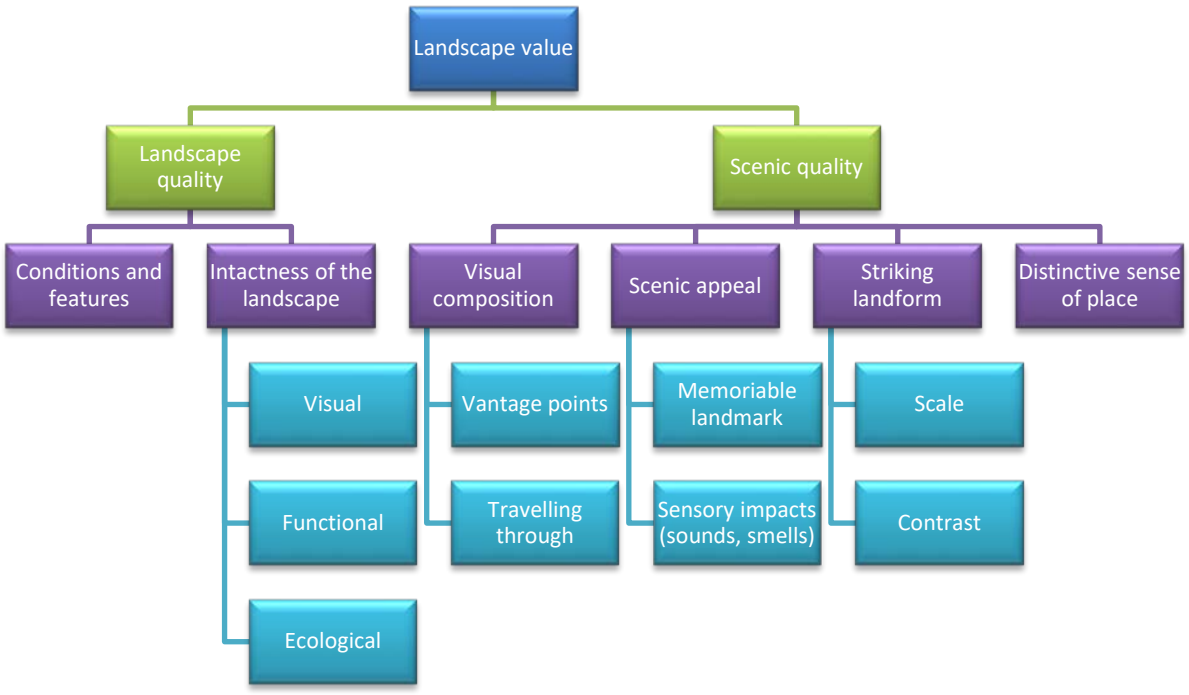
Transport for NSW (2020) reports a choice modelling study suggesting that people are willing to pay $3.60 per year per 1% increase in the proportion of places publicly accessible and $1.35 per person per year per 1% increase in the proportion of heritage places in good condition. This is the only example we have found of heritage being valued. The UK's framework does provide for discussion of heritage, but many of these will be specific to the particular site at risk. For instance, decisions have recently been made to reroute major roads around Stonehenge – a site of such historic significance both at national and international level that a survey of public WTP is not needed to confirm its high value for protection.

4.1.6.2 Landscape

Item 11.2 in the benefits framework on the impact on landscape is primarily about rural settings and covers more than just a physical tract of land or a view or scene but also a reflection of the relationship between people and place. It includes both the characteristics and perceptions of the land that give a sense of place to people living in it or visiting it. It may overlap somewhat with item 11.1 discussed in section 4.1.6.1.

Landscape is an important factor in the liveability of a place or neighbourhood. The aim of capturing the benefits of landscape on the liveability of a place is in principle admirable. In practice, the benefits of landscape are fraught with complexity, blurred definitions and risk of double counting and inconsistent valuation. What do we mean by landscape? In a review of an ecosystem services approach to valuing impact of transport developments on landscape, Temple and eftec (2019) showed the landscape value could conceptually be divided into landscape quality and scenic quality (Figure 4.2). Landscape quality includes visual benefits, functional use benefits and ecological benefits. Scenic quality includes visual composition, unique features of interest or combinations of features and striking formations.

Figure 4.2 The components of landscape value



Source: Temple and eftec (2019)

In a study of urban vegetation, Sung-Kwon et al. (2018) found that WTP for urban afforestation outcomes varied significantly across socio-demographic groups, and preferences were not consistent in a way that was generalisable outside the study neighbourhood.

In a non-transport study from Poland, Laszkiewicz et al. (2019) found evidence of a positive relationship between apartment prices and proximity to urban green space using a hedonic pricing approach. They concluded people were willing to pay more for the luxury of living closer to urban green space. The results showed estimated WTP for the proximity to parks and forests varied among apartment price sub-segments. The WTP for proximity to parks ranged from NZ$4 to $997 per square metre while the WTP for proximity to forests ranged from about NZ$8 to $26 per square metre. In the context of transport infrastructure, this study shows WTP for green space and urban amenity can be estimated and influences peoples' choices about trade-offs, which is also relevant to the spatial aspect of transport decisions.

In a different approach, Gibbons et al. (2014) apply a hedonic price method to a million house sale transaction records in England to estimate the amenity value associated with proximity to several different land covers, on a national scale. Their results suggest that environmental variables such as location within designated protection areas or the extent of gardens, green space and areas of water in proximity are highly statistically significant, and quite large in economic magnitude. Results are presented as price premium in relation to average house price varying with the proportion of land in different land uses in an area, and also variations with increasing distance from open water or other environmental features. Showing variation in externality values with density of cherished land covers, such estimates can be adapted to the impacts of development of transport infrastructure. The values and land cover types are specific to the English landscape and do not apply to New Zealand, but the approach could be adapted for generating value estimates in New Zealand.

The scope for overlap, double counting and inconsistent valuation methodologies in the assessment of landscape values is clear when the components of landscape values are defined. It is not clear how the

impacts of transport on landscape should be standardised, because there is likely to be a threshold below which these impacts may not change the integrity of the landscape in question. For example, adding a lane metre of roading might have little impact on the landscape values unless unique landscape features were destroyed in the process.

Another issue is whether landscape values depend on the number of people experiencing the landscape and how often they individually experience it. The economics behind the non-market valuation method of travel cost analysis suggests unit value and numbers experiencing a place are both crucial to the aggregate value of a destination, which includes both the landscape setting and the recreational opportunities it offers. Temple and eftec (2019) recommended that assessment of transport impacts on landscape values sit outside CBA of transport investment due to the risk of double counting, inconsistent valuation of the components that make up landscape value and the overall difficulty in developing a cogent view on generalisable impact values.

4.1.6.3 Townscape

Item 11.3 in the benefits framework on the impacts on townscape cover the benefits of form and character of the built and non-built urban environment and how their perception generates a sense of place or identity. This includes urban morphology and other aspects of urban form beyond the effect of heritage and architecture.

In the UK, DEFRA (2013) presented estimates of WTP per person per month of improvements in trees in the urban area of £2.33 and of quiet spaces within the urban area of £1.37. These estimates, however, have not been adopted for use in the Department for Transport's WebTAG guidance.

Transport for NSW (2020) presented amenity benefits for improvements to public spaces, based on economic benefits that occur when people on foot spend time in public spaces rather than just passing through. This was based on Transport for London's Valuing Urban Realm Toolkit (VURT) and its Pedestrian Environment Review System (PERS) which track changes in physical environment with changes in perceived attributes, like safety and sense of place. PERS requires public space auditors to assign scoring factors to public realm attributes. VURT and PERS were trialled by Boffa Miskell in a 2017 report for Auckland Council. That report provided estimates of annual and lifetime benefits of increased pedestrian footfall in three case studies in Auckland. It concluded that although VURT and PERS could be readily applied in New Zealand urban settings, the weightings were based on British surveys which would need to be replaced with New Zealand survey data (Boffa Miskell, 2017).

4.1.7 Changes in te ao Māori values

Item 12.1 in the benefits framework is about the impacts of transport investments and programmes in a te ao Māori view, which evolves with changes in circumstances and technology and reflects historical and contemporary influences. Decision makers should be aware of the views of tāngata whenua (the iwi or hapū with customary authority over a particular area) as it relates to the location and influence that their programme or project may have.

4.1.7.1 Applications in the literature

This is a uniquely New Zealand benefit category and we have found nothing remotely like it in our international literature review. International literature and experience note that monetary valuations can elevate Western values over indigenous values (Farley, 2012). Indigenous peoples often take a holistic view of environment and community that makes both the unitising of natural resources and direct comparison of competing projects difficult.

Models have been developed that attempt to identify additional or different values in resource descriptions and thereby highlight to others the importance of these additional dimensions to Māori. Harmsworth & Awatere (2013) suggest Māori have a holistic perspective with a strong sense of ecosystems and their services expressed through concepts such as the mauri of waterways and also refer to more formal models for taking these into account. These include:

- the Mauri Model (Kepa & Morgan, n.d.), which has been applied to land transport and geothermal projects and overlays statistics with subjective measures of perceived relative good and bad requiring careful interpretation
- the Mauri Compass (Ruru, n.d.), with its human/fishery/vegetation dimensions that emphasise holistic and interdependent sets of relationships and the reciprocal obligations aspect of the Māori belief system, which needs subjective measures for each of the dimensions in its current form
- the Cultural Health Index (Tipa & Teirney, 2006), which captures values for past importance (as far as it is remembered/known at least), current mahinga kai productivity and contemporary utility in a pragmatic set of measures but relies on subjective values for a limited number of dimensions.

The New Zealand Treasury has been building on work done for the Tax Working Group in linking He Ara Waiora to the four capitals of its Living Standards Framework (The Treasury, 2018). None of these models is yet at the stage of easy operationalisation and incorporation with economic modelling for investment appraisals. Even if they could be readily and consistently applied, there would still be a process of translating Māori values and preferences identified in such models into economic values so that any change in Māori values implied by a project is given due weight in the economic analysis that is neither undervalued nor overvalued.

In resource management consenting and plan change settings, which may arise with large transportation infrastructure and other developments, it is now commonplace for a cultural impact assessment to be undertaken alongside other impact assessments relating to ecology, visual impact and economics. These cultural impact assessments are largely about identifying impacts perceived by Māori, areas of particular significance to Māori, the level of consultation undertaken and preferences for mitigation to be undertaken. Unless there is a specific financial harm expected, these analyses do not express impacts in economic terms.

There appears some hesitancy in the literature in imposing a TEV framework and non-market valuation approaches to matters of importance to Māori, who may find the idea of monetary valuation and trade-offs objectionable and prefer to engage in participatory deliberative processes to guide decisions and courses of action. However, where Māori represent a significant percentage of the population, having an appropriate value for how they stand to be affected by resource use decisions could be important for the effective outcome of decisions made.

An article by Miller et al. (2015) describes application of choice modelling to estimate the cultural values of freshwater for Māori and non-Māori, with reference to water quality suitable for the customary gathering of food. The results suggest there is a positive WTP amongst the general population sample for Māori cultural attributes (mahinga kai sites)[5] but that the Māori respondents valued improvements in food gathering more than a third higher than the sample at large. The study's authors suggest the higher Māori value should be treated as indicative only because of a relatively low number of Māori responses. However, culturally important resources

[5] Note, however, that the paper's results suggest the general samples' WTP for improving mahinga kai sites from poor to below average has a higher value (but also wider confidence interval) than its WTP for improving from poor to above average (with a narrower confidence interval). This result is counter-intuitive and not explained in the paper.

could be undervalued if valuations do not attempt to value them, which requires finding a culturally significant attribute (like mahinga kai sites) and designing a survey to obtain a high response rate.

Protection of mahinga kai sites sits within the provisioning functions of the ecosystems services framework, and high values may reflect greater willingness to engage with surveys that affect something that is a familiar part of their consumption activities. Valuing issues more abstract or unfamiliar, such as biodiversity protection, is more challenging for all respondents, particularly for features of the natural environment that have special cultural or spiritual associations.

While te ao Māori values are unique to New Zealand, there have been some attempts overseas to value impacts affecting indigenous peoples. Kant et al. (2016) applied a combination of life satisfaction surveys linked to ecosystem services to value the impacts on two First Nations peoples in Canada. The results clearly confirm the importance of social, cultural and land-use activities for the wellbeing of First Nations peoples, and there were very high elasticities of life satisfaction with respect to traditional diet, gathering quality, social ties and recognition of these activities in laws related to land use. The study did not estimate monetary values of social, cultural and natural land use, recognising that monetisation is antithetic to the basic values of First Nations peoples, but it did demonstrate how using primary data collected through participatory methods at community level can yield information about indigenous people's concerns.

4.1.7.2 Further research

Economic and transport appraisal is interested in distributional impacts (Broadman et al., 2017), but the incorporation of non-Western paradigms is an emerging challenge that will take time to mature. The potential to incorporate values that reflect Māori perspectives is a much bigger task than mere valuation. It is an issue that goes to the heart of how economists think about research. Edward Leamer (1998) describes the components of economic enquiry as questions, theory and data. The incorporation of changes in te ao Māori values has to start with asking the right questions from the right perspective.

The Western world view that has dominated transport is subject to challenge as a monocultural perspective in a diverse community. It also does not necessarily reflect the principles of the Treaty of Waitangi 1840 between the Crown and Māori, which are:

- partnership in research about impacts on Māori and their value
- participation through meaningful Māori engagement in the research process
- protection of Māori values, ethics and perspectives in transport research (Boulton et al., 2013).

This implies a process of kaupapa Māori research in the context of transport. According to Tuhiwai Smith (2021, p. 250), 'Engaging in a discussion about research as an Indigenous issue has been about finding a voice, or a way of voicing concerns, fears, desires, aspirations, needs and questions as they relate to research. When Indigenous peoples become the researchers and not merely the researched, the activity of research is transformed. Questions are framed differently, priorities are ranked differently, problems are defined differently, and people participate on different terms.'

4.1.7.3 Are we there yet?

The consideration of how indigenous values might be reflected in transport appraisal is admirable, but in terms of Leamer's three components of research, transport appraisal is still grappling with the questions, theory and data. This is an area that is very much in its global and local infancy. Further work is needed to establish the research framework on the impacts of transport from an indigenous perspective and completing enough primary valuation to draw values from.

The proper treatment of Māori values in the context of Treaty principles is an issue that is bigger than the transport context. At present, there is no clear indication of what monetisation might be appropriate, and that will come only with further research with meaningful Māori involvement. That will evolve with other government practice in implementing Treaty principles.

Incorporating indigenous perspectives into the assessment of wellbeing and CBA is an emerging field with many challenges. The development of thinking and research in this field will continue for some time. Key challenges include:

- how to approach the collectivism that is fundamental to many indigenous perspectives in the context of individualism of economics and western paradigm (Kant et al., 2016)
- the recognition of the importance of preserving land-use opportunities from an indigenous perspective, where a loss of land-use opportunities is seen as a loss of collective wellbeing (Kant et al., 2016)
- incorporating indigenous knowledge of landscapes that have allowed people to live off the land for generations (Sangha et al., 2020)), which, in the context of transport appraisal, could mean incorporating a long-term perspective on the costs, benefits and risks associated with transport routes and changes in land use.

4.2 Robustness of estimates and suitability for inclusion in CBA

What attributes does a value require to fit use in a transport impacts database?

Throughout this review of methods and values of transport impacts, it has become apparent that not all the situations in the benefit cluster are amenable to deriving values or ranges of values that could be safely added to a database for use in transport appraisals. For example, benefit clusters that have multiple dimensions and the associated impacts resulting from transport interventions are less well suited to being represented by a single or narrow cluster of values in some form of value database. Changes to access to opportunities can have many possible impacts on travel behaviour (mode choice, vehicle ownership, travel distance, travel time and travel cost), which will in turn shape land use, economic effects, environmental impacts and social outcomes. Capturing all the possible scenarios in a single value or even a range of values would be difficult to do robustly because of the many dimensions of behaviour change and associated outcomes. It also has potential for double counting other items covered in the framework.

Therefore, the first attribute for something that is consistent with a database is a value to reflect a single outcome or intermediate input rather than the result of a complex multi-dimensional relationship. While single values are often the result of multi-dimensional formulae, the single value embodies or reflects the specific context and functional parameters of the equation the result was derived from, which limits its transferability to other contexts.

The second attribute for a value in a transport impacts database is that it must be generalisable to a broad range of uses within the appraisals that might call on a specific benefit cluster. For example, an absolute value for a marginal change in biodiversity due to the impacts of a transport intervention should be generalisable enough that it holds true for different species in the context of New Zealand’s biodiversity.

4.3 Other values feasible of monetising and inclusion

Other items valued overseas but not included in the benefits framework are punctuality and reliability of travel and the comfort and quality of travel for passengers and option values.

Both reliability and comfort and quality of travel for passengers are covered in the current Waka Kotahi benefits framework as item 5.1 (impact on system reliability in the long term), item 4.1 (impact on system

vulnerabilities and redundancies – resilience in the short term) and item 10.1 (impact on user experience of the transport system). This raises a question about the validity of benefit transfer when the definition of what is being valued varies markedly between countries and their evaluation frameworks.

4.4 Summary of recent valuation results

The table below summarises recent empirical results from some of the studies reviewed in this report. None of the valuations is an exact match for the impact categories in the benefits framework, but they do have values that could contribute to providing partial values under these categories. None of these values is suitable for direct value transfer to a New Zealand context, but they illustrate the types of values obtainable from the methods reviewed in this report.

Table 4.5 Examples of new valuations related to the benefit categories

Benefit category	Source	Date	Value characteristics	Values
4.1 Impact on system vulnerabilities and redundancies	Wang et al. *Analyzing willingness to improve the resilience of New York City's transportation system*.	2018	Annual willingness to pay for improved transport system resilience per person (US dollars)	$15–$50 no prior experience
				$120–$775 with prior experience
				$75–$450 combined experience groups
10.4 Cohesion / severance	Anciaes et al. 'A stated preference model to value reductions in community severance caused by roads.'	2018	Application of stated preference to estimate value of reductions in community severance of transport infrastructure	Value per walk trip of reducing vehicle lanes: from 3 to 2 is £1.28;
				from 2 to 1 is £1
				adding a central median strip is £1.08
				reducing traffic levels from high to medium is £1.08
				from medium to low is £0.76
11.2 Impact on landscape	Gibbons et al. 'The amenity value of English nature: a hedonic price approach.	2014	Implicit house price premium (and percentage change in house value) of a 1% increase in share of land cover, GBP (2008 values)	Freshwater/ wetlands £694 (0.36%)
				Enclosed farmland £115 (0.06%)
				Broadleaf woodland £376 (0.19%)
				Coniferous woodland £232 (0.12%)
11.3 Townscapes	Boffa Miskell. *Value of the urban realm toolkit for Auckland.*	2017	Economic benefits for improvements to public spaces when people on foot spend time in public spaces	In NZ$/year per 1% rise in foot traffic:
				Queen Street $3,500;
				Karangahape Road current footpath $228

Benefit category	Source	Date	Value characteristics	Values
			rather than just passing through	Karangahape Road wide footpaths $816;
				O'Connell Street $260
12.1 Impact on te ao Māori	Miller et al. 'Estimating indigenous cultural values of freshwater: a choice experiment approach to Māori values in New Zealand.'	2015	Willingness to pay for a change in wellbeing per year (over a five-year timeframe) - NZ$/year in 2015	Improved customary gathering all groups $28.10
				Improved customary food gathering Māori $40.69
				Improved macro-invertebrate index from fair to excellent: all groups $122.55

5 Guidance on using monetary values

In this chapter, we distil some guidance on how to use the database of methods and values to attach monetary values to currently non-monetised items. This includes applying some feasibility criteria to the methods and values obtained to ensure they provide a good fit to the non-monetised items. It also requires guidance on whether a non-monetised item is worth attempting to monetise, given its characteristics and likely scale in the overall analysis.

5.1 Purpose of seeking values for non-monetised benefits

In this report we have reviewed valuation methods and value proxies for currently non-monetised benefits in the benefits framework for economic evaluation of investments. The purpose of such evaluations is to:

- confirm benefits are likely to exceed costs, which ideally requires all significant impacts to be monetised
- identify and select the highest yielding proposals, which requires consistency in valuation.

The purpose of monetary valuation is to put all significant impacts on a common basis for analysis. Without valuation an item has zero value in the analysis, and its significance risks being overlooked, biasing results.

The economic evaluation forms part of a larger decision-aiding process and is not the only place in which non-monetised impacts may be taken into account in proposal design. Other guidance available on how to put proposals together and what design standards to meet also addresses non-monetised impacts. The economic evaluation is not the only element in the decision process for what gets built and how, as there are other elements in the Waka Kotahi investment decision-making framework that assess and prioritise National Land Transport Programme investments. There are also the external influences of RMA processes and institutions that may investigate these impacts in detail.

The focus of this report is on what can feasibly be monetised in the benefits framework, what values can be picked up to do this, what methods exist to generate new primary values and whether it would be worthwhile to do so given the cost of valuations and the likely impact on the economic evaluation.

In economic terms, valuation is an expression of society's preferences for outcomes from available resources. The principal measure of valuation is WTP, which is evident in market transactions but absent for non-market goods and services that nevertheless contribute to social wellbeing, such as the quality of the environment and people's security in going about their business and lives. Consistent values are also helpful in handling trade-offs that need to be made when unlimited wants come up against limited resources to apply in meeting them.

CBA is a way of weighing up alternative uses of resources, which articulates choices and effects on societal wellbeing. Wellbeing is expressed as the economic surplus generated by an investment as economic surpluses for consumers and producers, net of externality effects falling outside the investment's ambit. Valuation in CBA is based on people's preferences expressed through prices of market goods or inferred through other means for non-market effects.

Table 5.1 summarises potential for monetisation in the benefits framework.

Table 5.1 Potential for monetisation in the benefits framework

Value	Description	Inclusion elsewhere	Comments
Perceptions of safety	An assessment of risk – a behaviour modifier rather than a direct impact	Not included elsewhere	No clear method or primary valuations Requires surveys to establish impact of perception and effect on wellbeing
Impact on system vulnerabilities and redundancies	About reducing the risk of communities not being able to access social and economic opportunities due to unexpected outages	Discussed in two countries, but not valued	A potential set of impacts that are too broad to be valued in a generalisable way. But one study found on valuing improvement in resilience in areas at risk of high impact disruption.
Impacts on the natural environment	Environmental impacts of transport infrastructure and travel behaviour	Widely discussed and monetised	Specificity is important here – understanding which are the key impacts on the natural environment (water quality/quantity, biodiversity, air quality, soil quality and flora/fauna)
Changes in resource efficiency	Resource efficiency considers the sustainable sourcing and use of materials, waste minimisation and accounting for embodied carbon and energy use in the network	Discussed and valued	Can be estimated and valued using the comparison of the embodied carbon in alternatives using lifecycle analysis and the social cost of carbon; international values may not reflect the embodied carbon in the design and maintenance of New Zealand's transport infrastructure; the literature also shows values are sensitive to design parameters
Changes in access to opportunities	A catch-all cluster that could include social cohesion, community severance, barrier effects, mode switching and labour effects	Discussed but not valued	The impacts of changes to access to opportunities are case specific and not readily generalisable.
Impacts on the liveability of places	Place-based impacts of transport in three categories: heritage impacts, townscape impacts and landscape impacts	Discussed and valued in a few cases; however, landscape values are excluded from transport appraisal	The value of heritage and townscape have been valued in the UK but are not included in WebTAG guidance for transport appraisal – adopting these values for New Zealand using value transfer would not be appropriate for the differences in population size and preferences; valuing landscape impacts suffers from potential double counting of items covered elsewhere and internal inconsistency. Some objective measures of landscape change (eg extent of protected areas) are feasible for valuation using revealed preference methods that could be adapted to New Zealand's context
Changes in te ao Māori	In the context of the Treaty, how can the impact of transport on Māori values be incorporated?	Some limited discussion and applications are limited to environmental impact not specific to transport	Given there are a very limited number of primary valuations that include indigenous or Māori results for environmental impacts and none specific for transport analysis, this element of transport appraisal is in its local and global infancy

5.2 How has monetisation been approached elsewhere?

The literature review includes comparison of other transport appraisal processes in five other countries: Australia, Canada, Netherlands, Sweden and the UK. This comparison suggests the Waka Kotahi benefits framework has a greater degree of granularity in its benefit definitions than those used in other countries' transport evaluations. This limits the number of exact matches in other countries for the benefits identified in the benefits framework. It also limits these countries as likely sources for benefit transfers, unless benefit categories become more closely aligned across countries.

The appraisal process is similar across countries. Most of the selected countries have limited monetary valuation in their transport evaluations beyond a core set of monetised items covering capital and operating costs, savings in travel times, vehicle operating costs and transport crashes and reductions in greenhouse gas emissions and noise. There is a wider variety across countries examined in the range of non-monetised items covered by their frameworks.

Of the Waka Kotahi currently non-monetised benefits, monetisation in at least some other countries has been used for impacts on the water environment, biodiversity, resource efficiency and waste disposal, social cohesion and barrier effects, heritage and cultural sites, landscape and townscapes. Many of these valuations are for only a small part of a benefit category – townscapes are not valued explicitly, but some individual components (such as reducing traffic density) have been.

Most of the values come from Australia, which provides a range of values on a $/1,000 vehicle kilometres travelled basis, differentiated by different classes of vehicle. These values are based on benefit transfer, from values ultimately sourced from Europe. The precise context from which they are drawn is not explicit in the Australian documents. These could be easily adapted for use in New Zealand, but they reflect European valuations of impacts and will not reflect the preferences of New Zealanders.

No other country looks specifically at access to opportunities or mode choices. There is potential for these to be double counting impacts covered elsewhere in the evaluation framework (eg labour market broadening conferred by accessibility to a greater pool linking workers to job overlaps with wider economic benefits).

No other country attempts to put monetary valuation of values for indigenous ethnic communities. Such matters are taken into account in other mechanisms such as planning rules, as is the case in New Zealand with cultural impact assessments under the RMA. We have found one overseas study that uses a life satisfaction survey approach to infer preferences of indigenous people (but without estimating monetised values).

Valuation methods used for monetising non-market effects include the following:

- Market and cost-based methods are relatively inexpensive to apply (given suitable sources of secondary data) but are recognised as being incomplete, not capturing the full WTP for the effects being valued and also excluding the non-use values that may be significant for impacts that have irreversible effects such as on cultural heritage or the natural environment.
- Revealed preference methods infer a value for non-market goods from spending on associated market goods and fall principally into two divisions:
  - Hedonic pricing is a regression analysis of house prices that seeks the value of environmental attributes while controlling for other house characteristics. Given sufficient data, this can be a cost-effective and reliable technique, but it does not cover non-use values and the value captured is essentially that accruing to private owners, excluding wider values (such as those of users of a park who do not live nearby).

  - Travel cost analysis is a survey-based method that analyses visitors' travel costs to estimate the value of a park. Its use is specific to this purpose.
- Stated preference methods, principally contingent valuation and choice modelling are survey-based methods that directly ask people their WTP for given outcomes or ask about their preferences for different combinations of attributes in a multi-attribute scenario from which the relative value of each attribute can be estimated. These methods can capture non-use values but tend to be subject-specific and costly due to the survey component.
- Benefit transfer (or value transfer) is the process of using values already estimated.

5.3 Which items are most feasible to monetise in CBA?

The economic evaluations of transport investments serve two principal purposes, which are to:

- give confidence that an investment will result in benefits of higher value than its costs
- compare the net benefits from different proposals vying for the same investment funds to help guide selection of projects likely to yield the highest net benefits from a constrained budget.

For both purposes, it is important that valuations be made consistently across proposals under evaluation. Variations in net present value should be driven by characteristics of the respective proposals, such as the number of people who benefit and the costs of providing those benefits, rather than variation in the way values are derived.

The feasibility of further monetisation depends on what the largest problem areas are in current appraisals and what it would take to resolve them. Criteria for selection include the following:

- The effort put into monetisation should be less than the benefit expected to be delivered by it:
  - Where are the problem areas in the current evaluation?
  - Would they be solved by changing values in the monetised appraisal, or would they always be open to contesting at a later stage and hold up investments?
- Are there suitable sources available for benefit transfer?
  - To what extent are values available for benefit transfer generalisable impacts, those showing significant local variation, stand-alone items or those that are only observed as part of a multi-attribute item (like landscape)?
  - What has been the practical experience of these values in the countries that use them? Have the values achieved acceptance and foreclosed the contesting of results, or has the use of values raised incompatibility issues with other parts of the appraisal?
- Are there ways of reorganising benefit categories to cover more effects through valuations applied?
  - Can stated preference studies deliver reliable higher-level preferences that can be used more widely than the situation-specific studies that have predominated?

Transport infrastructure investment provides two types of benefit:

- One type is reasonably consistent across different situations, such as the vehicle operating cost savings or the emission of greenhouse gases.
- The other type has effects that are highly variable according to local context, such as emissions impacting on local air quality, impacts of run-off into waterways or the barriers created by infrastructure for communities on either side.

The consistent benefits are more amenable to monetisation, as national values can be set as defaults with minor variation around them to cover local circumstances. Impacts that vary more widely with local conditions are poorly represented by such default values and require more customised values for the situations they face.

Another factor affecting suitability for valuation is the attenuation between the cause and the effect being counted as a benefit. For example, impacts on water quality can to some extent be standardised to the effects of materials discharged by passing traffic that accumulate on trackways and pass into the natural environment and waterways. The rate of infiltration into water may vary with ground conditions, soil type, slope and vegetative cover, and the economic impact of water quality changes will vary with surrounding population, uses made of water and the availability of substitute sources for uses such as recreation. The externality consists of two parts: the generation of effects by transport activities on their immediate surroundings and the attributes of the receiving environment and its ability to handle these effects and mitigate their impacts on human activities. It is conceivable to have a two-part value for such externalities – a standard part for the generation of effects and a non-standard part for the characteristics of receiving environment. This is evident in some of the values in this report, which distinguish between urban and rural values for externalities.

Impacts on water is a category that could be amenable to such valuation treatment, with a clear causal link between the transport change and the wider effect. Barrier effects and severance is another, where the presence of a barrier adds costs and severs physical connection between communities either side in a fairly predictable way. The variable aspect is the number of transactions it interferes with and the changes in behaviour it causes, which varies with the size and functions of communities either side.

Other current benefit categories, however, are more attenuated than this, with second and third-order effects influenced by more than just the transport improvement, creating a risk of over-attributing impacts to the transport change.

Benefits that have been monetised elsewhere provide a guide to what is feasible here. These include:

- impacts on water quality
- impacts on biodiversity, with possibly separable values for disturbance effects of air quality, noise and lighting, which may be ubiquitous and generalisable, and higher-level impacts for habitat fragmentation, habitat loss and extinction, which are more location specific and variable
- barrier and severance effects.

Landscape has also been valued overseas, but this is now being questioned for encroaching on a number of other benefit areas and raising the risk of double counting. Widening accessibility and improvements in townscape and development of the public realm in urban areas is also likely to overlap with consideration of other sources of wider economic benefit.

A number of studies look at potential benefits from improving the public realm of townscapes, increasing foot traffic and generating revenues and land value rises from increased business so generated. These measures have attracted more support from local government than central government agencies. While there are many claims of districts being rejuvenated by such public realm improvements, it is not clear how these verify true trade expansion rather than trade relocation from less-favoured parts of the urban area.

5.4 How to use monetised values in assessments

We have compiled a sortable spreadsheet database of the current values we have found, identifying subject matter, source, date and type of valuation employed. There are 37 publications containing values related to

the Waka Kotahi benefit categories, including five on water, four on biodiversity, one on resource efficiency, one on access to opportunities, eight on cohesion/barrier effects, one on heritage and culture, eight on landscape and five on townscapes, two on system vulnerabilities and two on indigenous values. Not all of these include monetary values. Of the 34 that do, 22 are ascribed to benefit transfer, five to revealed preference methods, seven to stated preference methods. No values have been found for perceptions of safety and security.

The database extract in Table A.1 contains a number of values that are being used in assessments overseas, mostly in Australia but also some in Canada and the UK. These raise the possibility of using such values for benefit transfer in New Zealand, given some adjustment.

Criteria for successful applications of benefit transfer are that the:

- sources of primary studies use adequate data, sound methods and correct empirical techniques in making their estimates
- basic commodity being valued in the target application and the source locations is equivalent
- populations affected in the target application and the source location should be similar
- baseline and modelled changes with and without the item being valued should be similar
- values are appropriately adjusted for timing, currency equivalence and other differences between the source and intended use locations.

Most of the values identified in this report are not accompanied by details of their source material so cannot be confirmed as meeting these criteria. If the criteria are not met, there is an increased risk of errors in the benefit transfer. They may be used as indicative of what values in New Zealand might be, but all are deficient in defining the context in which they have been estimated and have limited use for benefit transfer. They do, however, provide some indication of the types of values that could be assembled, given sufficient resources to estimate them for New Zealand conditions.

However, benefit transfer is a second-best option to direct primary estimation – a practical, lower-cost way of finding value than doing primary evaluation for each impact. Internationally, official guidance appears to prefer values appearing in transport appraisals to be drawn, in declining order, from market prices, revealed preference methods and stated preference methods (HM Treasury, 2020). Stated preference methods are established for some hard-to-value matters such as the value of statistical life, and they are recognised as the appropriate methods to use where there are significant non-use values, as is the case for some natural environment and cultural heritage sites, as long as methods are sound and steps taken to control well-documented sources of bias.

Because primary valuation using stated preference or revealed preference techniques is costly, benefit transfer is likely to be more widely used in future, but that benefit transfer needs to draw on a wider range of value estimates than has been available in the past.

5.5 What is required to make wider monetisation feasible?

Extending monetisation to currently non-monetised benefit items requires a choice between generating new values from primary research, which can be costly, and extending benefit transfer using less-customised results. Benefit transfer suitably adjusted for context is likely to be important to expand monetisation, but there is a limited pool of New Zealand studies that should be expanded to increase relevance of values to draw on.

Reviews of the state of non-market valuation in New Zealand have pointed to a lack of coordinated effort among central government agencies and local government about what data needs to be collected to get a better idea of the value of non-monetised items. As primary valuation is expensive, this has resulted in a scattering of ad hoc studies commissioned by separate agencies for their own purposes, which are difficult to subject to meta-analysis to obtain a coherent picture of values and how they change with circumstances around the country.

Waka Kotahi has been one of the more active agencies commissioning specific studies for its evaluation purposes, such as the value of improvements in transport safety or travel time. In dealing with the currently non-monetised benefits arising from water quality or biodiversity, there are other agencies that have a stronger interest and there is potential for more collaborative efforts across agencies developing a bigger, more widely transferable set of values with uses in more than just transport appraisals.

A recurring issue with non-market valuation from stated preference methods is concern about the size of values obtained being over large because of focus illusion or the effect of part-whole bias causing responses to be insensitive to differences in scale of what is being valued. A consequence of this is that values for preserving individual sites or species can look very high relative to the household income available to support such preservation and also high compared with the aggregate spending on conservation activity that can be identified across New Zealand at large. One way around this is to approach valuation as a multi-stage process, first establishing respondents' WTP for environmental protection in general and then narrowing down to identify preferences for different types of protection within that.

What non-market valuation in New Zealand needs is a wider set of valuations of environmental improvements in various domains where values are derived by comparable methods that are amenable to meta-analysis to establish variation in values around the country. Given enough such studies, it could also be possible to examine how values are driven by location variations in context around the country so that the effects of local variation can be incorporated into project appraisal.

As shown in Figure 5.1, stated preference studies will be required to obtain the TEV of benefits that include a strong component of non-use value, such as valuing protection against irreversible impacts on land, water, biodiversity and heritage. Market and cost-based valuations will suffice for issues like resource efficiency, impacts on accessibility and community cohesion/severance. Impacts on te ao Māori may not be amenable to any monetary valuation at all but may be better approached through more deliberative processes of consultation with them. That may be better handled through the local assessments under the RMA than in investment appraisals or through research with meaningful Māori involvement.

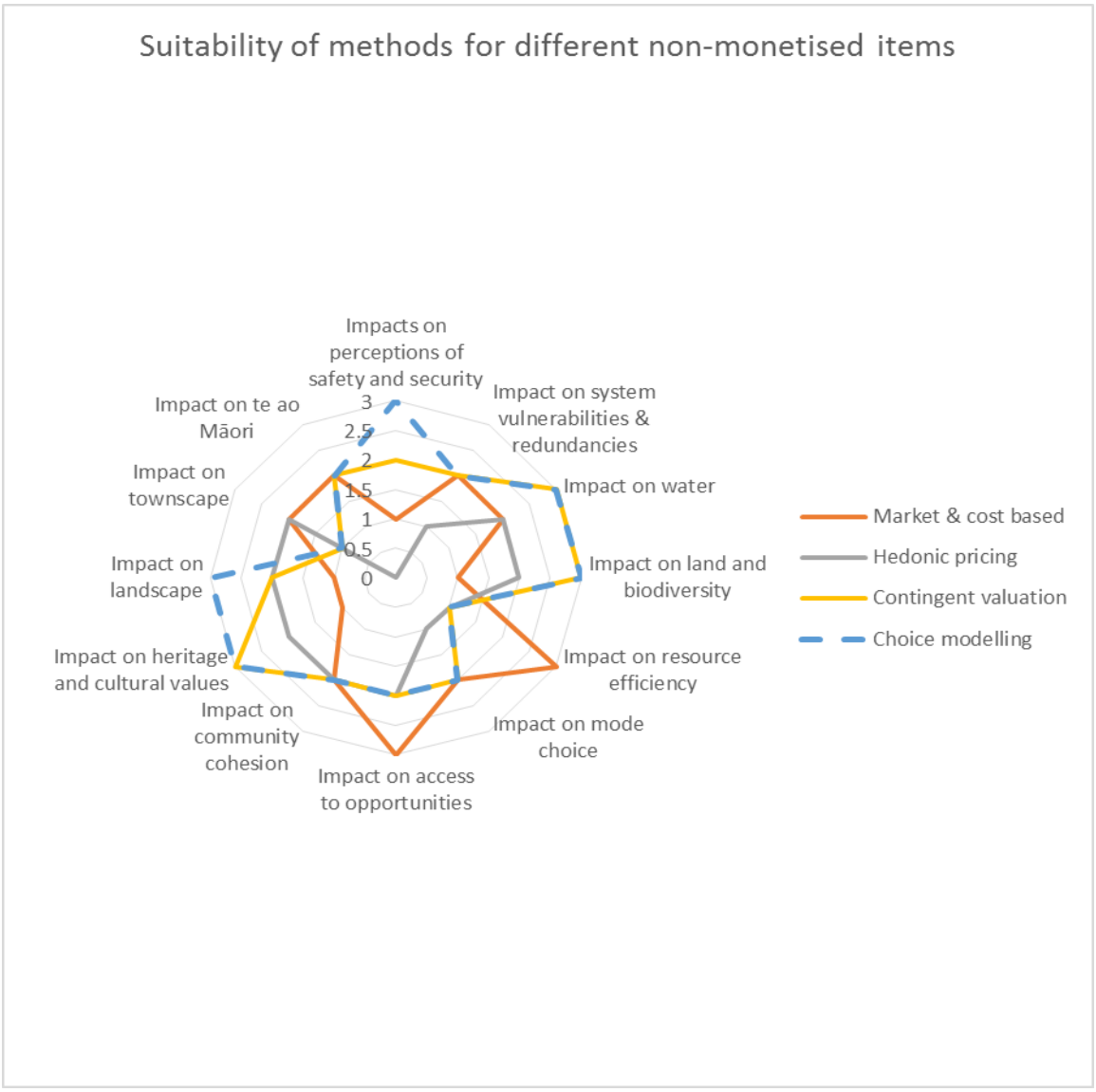
To make monetisation more feasible requires a wider choice of local monetised values for impacts that reflect variation across the country. It requires a more concerted effort than hitherto to accumulate such values into a routinely updated database that is available for both transport and other agencies' assessments. The Treasury's CBAx model and value database provides an example of what could be provided. That database, however, is primarily to assist in preparation of general budget bids, and it is never likely to have much focus on the types of benefits identified for transport.

Until New Zealand develops a larger pool of local valuation studies, benefit transfer will be dependent on finding suitable values from overseas jurisdictions where the definition of things being valued and the context in which values are derived may be quite different from those in New Zealand. The definitional problem could be reduced by aligning transport benefit categories in New Zealand with those overseas, but benefit transfer would still depend on knowing enough about how the values were created to adjust them to suit New Zealand conditions.

A first step in verifying feasibility of extending benefit transfer from international sources would be to contact transport agencies that use these values directly to learn about their experience with them. A number of values in this report are sourced to Austroads in Australia, which may provide greater detail on these values than has been possible in this report.

A second step would be to convene a forum of non-market valuation practitioners in New Zealand, to discuss the feasibility of replicating some of the revealed preference and stated preference applications reviewed in this paper. Then plans could be made for prioritising primary valuation studies that would be feasible and yield a range of values for currently non-monetised benefits of most use for transport appraisals.

Figure 5.1 Application of non-market valuation methods to benefit categories



Source: NZIER

6 Conclusions and recommendations

The main objective of this research was to prepare a database of values and methodologies for quantification and monetisation of the currently non-monetised benefits in the Waka Kotahi benefits framework. The research completed the following activities:

- reviewed theoretical and empirical literature on the valuation of non-monetised benefits
- determined the extent to which it is possible and appropriate to monetise currently non-monetised benefits
- identified other benefits outside the current framework that could warrant inclusion in it
- identified valuation approaches that could be used to monetise non-monetised benefits.

The research output included a database of values from existing studies that could be used or adapted for the Waka Kotahi benefits framework, and guidance on how such valuation methods can be used.

6.1 Conclusions

Most of the countries that were the focus of the literature review – Australia, Canada, Netherlands, Sweden and the UK – had a common core set of items in their transport appraisal frameworks, covering capital and operating costs and benefits comprising savings in travel times, vehicle operating and crash costs, and reductions in greenhouse gas emissions and noise.

The benefits framework defines its benefits with greater granularity than in the other countries examined, so it is difficult to find close matches for all of them in the international literature. There are values for some aspects of the benefit framework's 12 non-monetised impacts in other countries' guidance material, which have not yet been adapted for use in New Zealand. But there is not a large pool of new empirical valuation studies related to transport or the non-monetised impacts as defined in the benefits framework.

Some, but not all, of the other countries covered other benefits related to the benefits framework, such as impacts on the water environment, land and biodiversity, resource efficiency, community cohesion (barrier effects), heritage and sites of importance for cultural, heritage or landscape reasons. How these benefits are defined, and the data available for doing so affects the feasibility of monetising these benefits and of adapting such values for use in New Zealand.

Extending monetisation to currently non-monetised benefit items involves making a choice between generating new values from primary research, which can be costly and time-consuming, or using less customised results from studies already undertaken in what is known as benefit transfer. This review did not find many close comparators to the non-monetised benefits in the benefits framework. But benefit transfer could be important for providing values for some benefits, pending suitable adjustment of overseas studies for the New Zealand context, and expansion of the pool of customised values drawn from New Zealand studies producing values that can be transferred from one location to others.

Developing databases of values helps in enabling benefit transfer, but databases inevitably lead to some loss of detail, and also require resources to maintain them and update them. The OECD recommends consultation to prioritise the values compiled in databases, and preparation of substantial guidance on how to use them and account for their limitations. Overseas sources expand the range of values available for benefit transfer, but they will reflect preferences of their source countries, not those of New Zealanders.

Monetisation techniques fall broadly into two categories, those based on market data which are relatively simple to do but incomplete in not covering non-use values attached to environmental and heritage matters

and stated preference methods that use surveys to reveal the populations' held values, including non-use values. Where non-use values are likely to be significant, stated preference methods are the only appropriate valuation methods, and recent literature shows substantial advances in these methods for controlling well-documented sources of bias in these methods.

The database compiled in this report reflects the limited availability of existing studies and value proxies in the New Zealand and international literature. Broadly speaking Waka Kotahi seems to be at the frontier of seeking to monetise some benefits. Extending monetisation in the benefits framework will require additional New Zealand valuation studies of items as defined in the framework.

6.2 Recommendations

To extend monetisation of currently non-monetised items in the benefits framework

- Examine how significant an effect there would be in adapting existing values from other countries' guidance material for some aspects of the Waka Kotahi 12 non-monetised impacts.
- Consider where new primary valuations would be most useful in monetising the currently non-monetised impacts, to increase the range of values suitable for benefit transfer in New Zealand.
- Establish a priority set of contextually and culturally appropriate values for use in New Zealand for Waka Kotahi to invest in a programme of primary valuations to provide them.

7 References

Abelson, P. (2020). A partial review of seven official guidelines for cost-benefit analysis. *Journal of Benefit-Cost Analysis*, *11*(2), 272–293. http://dx.doi.org.wcl.idm.oclc.org/10.1017/bca.2020.3

Allen, B. P. & Loomis, J. B. (2008). The decision to use benefit transfer or conduct original valuation research for benefit–cost and policy analysis. *Contemporary Economic Policy*, *26*(1), 1–12. https://doi.org/10.1111/j.1465-7287.2007.00066.x

Anciaes, P. R., Jones, P. & Metcalfe, P. J. (2018). A stated preference model to value reductions in community severance caused by roads. *Transport Policy*, *64*, 10–19. https://doi.org/10.1016/j.tranpol.2018.01.007

Andersson, H., Hultkrantz, L., Lindberg, G. & Nilsson, J.-E. (2018). Economic analysis and investment priorities in Sweden's transport sector. *Journal of Benefit-Cost Analysis*, *9*(1), 120–146. https://doi.org/10.1017/bca.2018.3

Arrow, K., Solow, R., Portney, P. R., Leamer, E. E., Radner, R. & Schuman, H. (1993). *Report of the NOAA panel on contingent valuation* (p. 67).

ATAP. (n.d.). *Australian Transport Assessment and Planning (ATAP) guidelines*. Retrieved 12 May 2021 from https://www.atap.gov.au/home

ATAP. (2020). *PV5 – Environmental parameter values*. https://www.atap.gov.au/sites/default/files/documents/atap-pv5-environmental-parameter-values-080221.pdf

Austroads. (2014). *Updating environmental externalities unit values.* (Technical report AP-T285-14). https://austroads.com.au/publications/environment/ap-t285-14/media/AP-T285-14_Updating_Environmental_Externalities_Unit_Values.pdf

Bai, J., Qu, J., Maraseni, T. N., Wu, J., Xu, L. & Fan, Y. (2019). Spatial and temporal variations of embodied carbon emissions in China's infrastructure. *Sustainability*, *11*(3), 749. https://doi.org/10.3390/su11030749

Baker, R. & Ruting, B. (2014). *Environmental policy analysis: a guide to non-market valuation* [Productivity Commission Staff Working Paper]. Productivity Commission, Government of Australia. https://www.pc.gov.au/research/supporting/non-market-valuation/non-market-valuation.pdf

Bateman, I. J., Burgess, D., Hutchinson, W. G. & Matthews, D. I. (2008). Learning design contingent valuation (LDCV): NOAA guidelines, preference learning and coherent arbitrariness. *Journal of Environmental Economics and Management*, *55*(2), 127–141. https://doi.org/10.1016/j.jeem.2007.08.003

Bateman, I. J., Carson, R. T., Day, B., Hanemann, M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S. & Pearce, D. W. (2002). *Economic valuation with stated preference techniques: a manual.* Edward Elgar Publishing Ltd.

Bergstrom, J. C. & Taylor, L. O. (2006). Using meta-analysis for benefits transfer: theory and practice. *Ecological Economics*, *60*(2), 351–360.

Boardman, A., Greenberg, D., Vining, A. & Weimer, D. (2011). *Cost-benefit analysis –concepts and practice* (vol. 1–4th). Prentice Hall.

Boffa Miskell. (2017). *A value of the urban realm toolkit for Auckland?* Auckland Council. https://www.boffamiskell.co.nz/downloads/publications/Boffa_Miskell_VURT_Report_Final.pdf

Bone, I. (1986). *The economic appraisal of roading improvement projects*. Road Research Unit, National Roads Board.

Boulton, A., Tamehana, J. & Brannelly, T. (2013). Whānau- centred health and social service delivery in New Zealand: the challenges to, and opportunities for, innovation. *Mai Journal*, *2*(1), 18–32.

Broadman, A. E., Greenberg, D. H., Vining, A. R. & Weimer, D. L. (2017). *Cost-benefit analysis: concepts and practice*. Cambridge University Press.

Bureau of Transport Infrastructure and Transport Research Economics (2014). *Overview of project appraisal for land transport*. https://www.atap.gov.au/sites/default/files/overview_of_project_appraisal_for_land_transport.pdf

CE Delft & Infras & Fraunhofer ISI. (2011). *External costs of transport in Europe, update study for 2008*. CE Delft.

Commonwealth of Australia. (1995). *Techniques to value environmental resources: an introductory handbook*.

Couture, L.-E., Saxe, S. & Miller, E. J. (2016). *Cost-benefit analysis of transportation investment: a literature review* (p. 16).

Cox, B. E. (1977). *Economic appraisal of roading improvement projects* [Circular memorandum (Roading Division 90)]. Ministry of Works and Development.

de Jong, G. (2013). *International comparison of transport appraisal practice: annex 3 The Netherlands country report* (p. 15). University of Leeds, Institute for Transport Studies.

DEFRA. (2013). *Local environmental quality: valuing the neighbourhood in which we live* (p. 44). Department for Environment, Food and Rural Affairs. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/226561/pb14015-valuing-local-environment.pdf

Department for Transport. (2018). *TAG: Transport appraisal process*. https://www.gov.uk/government/publications/webtag-transport-appraisal-process-may-2018

Department of Communities and Local Government. (2009). *Multi-criteria analysis: a manual*. HMSO.

Department of Conservation. (2006). *The value of conservation: What does conservation contribute to the economy?* (p. 20).

Douglas, N. & Brooker. (2013). *A review of transport project appraisal in NSW Australia*.

eftec. (2009). *Valuing environmental impacts: practical guidelines for the use of value transfer in policy and project appraisal.* [Report prepared for the Department for Environment, Food and Rural Affairs]. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/862945/Value_transfer-tech-summary.pdf

Eliasson, J. (2013). *International comparison of transport appraisal practice: annex 4 Sweden country report* (p. 12). University of Leeds, Institute for Transport Studies.

Eyles, L., Porter, J., Farmer, A. & Day, B. (2019). *Valuation of landscape impacts of transport interventions & mitigations using an ecosystem services approach* (p. 94). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/942839/valuation_of_landscape_impacts_of_transport_interventions-document.pdf

Farley, J. (2012). Natural capital. In R. Craig, J. Nagle, B. Pardy, O. Schmitz, & W. Smith (Eds.), *Ecosystem management and sustainability: volume 5*.

Fujiwara, D. & Campbell, R. (2011). *Valuation techniques for social cost-benefit analysis: stated preference, revealed preference and subjective well-being approaches : a discussion of the current issues*. HM Treasury. http://research.dwp.gov.uk/asd/asd5/greenbook_valuationtechniques.pdf

Genter, J. A., Donovan, S. & Petrenas, B. (2008). *Valuing the health benefits of active modes* (Waka Kotahi NZ Transport Agency research report 359). https://www.nzta.govt.nz/resources/research/reports/359/

Gibbons, S., Mourato, S. & Resende, G. M. (2014). The amenity value of English nature: a hedonic price approach. *Environmental and Resource Economics, 57*(2), 175–196. https://doi.org/10.1007/s10640-013-9664-9.

Gurley, T. & Bruce, D. (2005). The effects of car access on employment outcomes for welfare recipients. *Journal of Urban Economics*, *58*(2), 250–272. https://doi.org/10.1016/j.jue.2005.05.002

Hanif bin Kamis, M. (2014). *Comparative analysis of transportation project appraisals: a comparison between the Netherlands and the United States*. University of Technology.

Harmsworth, G. R. & Awatere, S. (2013). Indigenous Māori knowledge and perspectives of ecosystems. In J. Dymond (Ed.), *Ecoosystem services in New Zealand – conditions and trends* (p. 13). Manaaki Whenua Press.

HM Treasury. (2020). *Green book: central government guidance on appraisal and evaluation*. https://www.webarchive.org.uk/access/resolve/20201125231833/https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/938046/The_Green_Book_2020.pdf

Jackson, D. J. & Brander, M. (2019). The risk of burden shifting from embodied carbon calculation tools for the infrastructure sector. *Journal of Cleaner Production*, *223*, 739–746. https://doi.org/10.1016/j.jclepro.2019.03.171

Johnston, R. J., Boyle, K. J., Adamowicz, W. (Vic), Bennett, J., Brouwer, R., Cameron, T. A., Hanemann, W. M., Hanley, N., Ryan, M., Scarpa, R., Tourangeau, R. & Vossler, C. A. (2017). Contemporary guidance for stated preference studies. *Journal of the Association of Environmental and Resource Economists*, *4*(2), 319–405. https://doi.org/10.1086/691697

Johnston, R. J. & Rosenberger, R. S. (2010). Methods, trends and controversies in contemporary benefit transfer. *Journal of Economic Surveys*, *24*(3), 479–510. https://doi.org/10.1111/j.1467-6419.2009.00592.x

Johnston, R. J., Rosenberger, R. S., Rolfe, J. & Brouwer, R. (2015). Benefit transfer: the present state and future prospects. In R. J. Johnston, J. Rolfe, R. S. Rosenberger & R. Brouwer (Eds.), *Benefit transfer of environmental and resource values: a guide for researchers and practitioners* (pp. 553–574). Springer Netherlands. https://doi.org/10.1007/978-94-017-9930-0_24

Johri, A. & Routley, M. (2007). A comprehensive business case framework for evaluating transit projects. *Paper prepared for presentation at the SES – Best practices in urban transportation planning session of the 2017 Conference of the Transportation Association of Canada St. John's, NL*. https://www.tac-atc.ca/sites/default/files/conf_papers/johria_-_a_comprehensive_business_case_framework_for_evaluating_transit_projects.pdf

Kahneman, D. & Sugden, R. (2005a). Experienced utility as a standard of policy evaluation. *Environmental and Resource Economics*, *32*, 161–181.

Kahneman, D. & Sugden, R. (2005b). Experienced utility as a standard of policy evaluation. *Environmental and Resource Economics*, *32*(1), 161–181. https://doi.org/10.1007/s10640-005-6032-4

Kant, S., Vertinsky, I. & Zheng, B. (2016). Valuation of First Nations peoples' social, cultural, and land use activities using life satisfaction approach. *Forest Policy and Economics*, *72*, 46–55. https://doi.org/10.1016/j.forpol.2016.06.014

Karlsson, I., Rootzén, J. & Johnsson, F. (2020). Reaching net-zero carbon emissions in construction supply chains – analysis of a Swedish road construction project. *Renewable and Sustainable Energy Reviews*, *120*, 109651. https://doi.org/10.1016/j.rser.2019.109651

Kepa, T. K. & Morgan, B. (n.d.). *The mauri model*. http://www.mauriometer.com/userfiles/NgapunaFinalReport.pdf

Laszkiewicz, E., Czembrowski, P. & Kronenberg, J. (2019). Can proximity to urban green spaces be considered a luxury? Classifying a non-tradable good with the use of hedonic pricing method. *Ecological Economics*, *161*, 237–247. https://doi.org/10.1016/j.ecolecon.2019.03.025

Layard, R. & Oparina, E. (2021). *Living long and living well: the WELLBY approach*. 18.

Leamer, E. (1998). *Questions, theory and data, foundations of research: How do economists do economics*. Cheltenham, UK: Edward Elgar.

Litman, T. (2019). *Evaluating public transit benefits and costs: best practices guide* (p. 143). Victoria Transport Policy Institute.

Loomis, J. B. & Rosenberger, R. S. (2006). Reducing barriers in future benefit transfers: needed improvements in primary study design and reporting. *Ecological Economics*, *60*(2), 343–350.

Mackie, P. (2010). *Cost-benefit analysis in transport: a UK perspective* (OECD/ITF Joint Transport Research Centre Discussion Papers No. 2010/16; OECD/ITF Joint Transport Research Centre Discussion Papers,vol. 2010/16). https://doi.org/10.1787/5km4q8j8m2f6-en

Mackie, P, & Worsley, T. (2013). *International comparisons of transport appraisal practice: overview report* (p. 29). University of Leeds, Institute for Transport Studies.

Marsh, D. & Mkwara, L. (2013). *Review of freshwater non-market valuation studies*. Dept of Economics, Waikato University.

Metrolinx. (2018). *Business case guidance: volume 2*.

Millennium Ecosystem Assessment. (2005). https://www.millenniumassessment.org/en/Synthesis.html

Miller, S., Tait, P. & Saunders, C. (2015). Estimating indigenous cultural values of freshwater: a choice experiment approach to Māori values in New Zealand. *Ecological Economics*, *118*, 207–214. https://doi.org/10.1016/j.ecolecon.2015.07.031

Ministry of Business, Innovation and Employment. (2020). *Whole of life embodied carbon emissions reduction*.

Moeltner, K. & Rosenberger, R. S. (2014). Cross-context benefit transfer: a Bayesian search for information pools. *American Journal of Agricultural Economics*, *96*(2), 469–488. http://www.jstor.org/stable/24476562

Money, C., Bittle, N., Makan, R., Reinen-Hamill, R. & Cornish, M. (2017). *Establishing the value of resilience* (NZ Transport Agency research report 614, p. 65).

Mouter, N. (Ed.). (2020). *Standard transport appraisal methods: volume 6* (1st ed.). Academic Press. https://www.elsevier.com/books/standard-transport-appraisal-methods/mouter/978-0-12-820821-2

Newbold, S., Simpson, R. D., Massey, D. M., Heberling, M. T., Wheeler, W., Corona, J. & Hewitt, J. (2018). Benefit transfer challenges: perspectives from U.S. practitioners. *Environmental and Resource Economics*, *69*(3), 467–481. http://dx.doi.org.wmezproxy.wnmeds.ac.nz/10.1007/s10640-017-0207-7

NZIER. (2017). *Capturing natural capital in decision making updated stocktake of recent literature.* (A report to The Treasury and Natural Resource Sector Agencies). https://www.treasury.govt.nz/sites/default/files/2018-08/LSF-capturing-natural-capital-in-decision-making.pdf

NZIER. (2018). *What's the use of non-use values? Non-use values and the investment statement* (A report to The Treasury). https://www.treasury.govt.nz/sites/default/files/2018-08/LSF-whats-the-use-of-non-use-values.pdf

OECD. (2013). *OECD guidelines on measuring subjective well-being*. OECD. https://doi.org/10.1787/9789264191655-en

OECD. (2018). *Cost–benefit analysis and the environment: further developments and policy use*. OECD. https://doi.org/10.1787/9789264085169-en

Peeling, J., Palmer, D., Booth, C. & Abell, R. (2016). *The value of the trunk road network to society and the economy in Scotland* (p. 91).

Perman, R., Ma, Y., Common, M., Maddison, D. & MacGilvray, J. (2011). *Natural resource and environmental economics* (4th ed.).

Raphael, S. & Rice, L. (2002). Car ownership, employment, and earnings. *Journal of Urban Economics*, *52*(1), 109–130. https://doi.org/10.1016/S0094-1190(02)00017-7.

RICS. (2020). *Measuring social value in infrastructure projects: insights from the public sector*. https://www.rics.org/globalassets/rics-website/media/knowledge/research/insights/measuring-social-value_1st-edition.pdf

Rolfe, J., Bennett, J. & Kerr, G. (2015). Applied benefit transfer: an Australian and New Zealand policy perspective. In R. J. Johnston, J. Rolfe, R. S. Rosenberger & R. Brouwer (Eds.), *Benefit transfer of environmental and resource values*, *14*, 85–100. Springer-Science+Business Media, Dordrecht Netherlands. https://doi.org/10.1007/978-94-017-9930-0_5.

Rosenberger, R. S. & Loomis, J. B. (2017). Benefit transfer. In *A primer on nonmarket valuation* (pp. 431–462). Springer.

Ruru, I. (n.d.). *The mauri compass*. http://www.gdc.govt.nz/assets/CommitteeMeetings/14-254-X1-Appendix.pdf

Sangha, K., Duvert, A., Archer, R. & Russell-Smith, J. (2020). *Unrealised economic opportunities in remote indigenous communities: case studies from Northern Australia* (SSRN Scholarly Paper ID 3596050). Social Science Research Network. https://doi.org/10.2139/ssrn.3596050

Simetrica & Jacobs. (2019). *Sport NZ – wellbeing value methodology note* (p. 16).

Spackman, M. (2013). *Handling non-monetised factors in project, programme and policy appraisal* (p. 37).

Sung-Kwon, H., Ju-Mi, K., Hyun-Kil, J. & Sang-Woo, L. (2018). Monetary valuation of urban forest attributes in highly developed urban environments: an experimental study using a conjoint choice model. *Sustainability*, *10*(7), 2461. http://dx.doi.org.ezproxy.otago.ac.nz/10.3390/su10072461

Sunstein, C. R. (2004). *Cost-benefit analysis and the Environment* (John M. Olin Program in Law and Economics working paper no. 227: Coase-Sandor working paper series in law and economics, p. 48). University of Chicago Law School. https://doi.org/10.1787/9789264085169-en

Tait, D. P., Miller, D. S., Rutherford, P. & Abell, W. (2016). *Non-market valuation of improvements in freshwater quality for New Zealand residents, from changes in stock exclusion policy* (p. 58) (MPI technical paper no: 2017/08). Ministry for Primary Industries.

Temple & eftec. (2019). *Valuation of landscape impacts of transport interventions & mitigations using an ecosystem services approach* (p. 94) (A report for Department of Transport).

The Treasury. (2018). *He ara waiora/A pathway towards wellbeing* ((DP 18/11)). The Treasury. https://www.treasury.govt.nz/publications/dp/dp-18-11

Tipa, G. & Teirney, L. (2006). *A cultural health index for streams and waterways: April 2006*. Ministry for the Environment. http://www.mfe.govt.nz/publications/cultural-health-index-streams-and-waterwaystech-report-apr06

Transport for NSW. (2016). *Principles and guidelines for economic appraisal of transport investment and initiatives. Transport economic appraisal guidelines (March 2016)* (p. 354).

Transport for NSW. (2020a). *Economic parameter values*. [Interactive resource]. Transport for NSW. http://www.transport.nsw.gov.au/node/10546.

Transport for NSW. (2020b). *Movement and place evaluator's guide: estimating placemaking benefits of transport projects in business cases.* Transport for NSW.

Tuhiwai Smith, P. L. (2021). *Decolonizing methodologies: research and indigenous peoples*. Zed Books. http://ebookcentral.proquest.com/lib/otago/detail.action?docID=6605401

Veitch Lister Consulting. (2019). *Land transport and place benefits – a conceptual framework* [Prepared for NZ Transport Agency].

Victoria Transport Policy Institute. (2015). Evaluating transportation benefits. In *Transportation cost and benefit analysis II – evaluating transportation benefits*.

Waka Kotahi NZ Transport Agency. (2020a). *Monetised benefits and costs manual*.

Waka Kotahi NZ Transport Agency. (2020b). *Non-monetised benefits manual*. https://www.nzta.govt.nz/resources/non-monetised-benefits-manual/

Wang, C., Sun, J., Russell, R. & Daziano, R. A. (2018). Analyzing willingness to improve the resilience of New York City's transportation system. *Transport Policy*, *69*, 10–19. https://doi.org/10.1016/j.tranpol.2018.05.010

Wen, L., Sheng, M. (Selena) & Sharp, B. (2021). The impact of COVID-19 on changes in community mobility and variation in transport modes. *New Zealand Economic Papers*, 1–8. https://doi.org/10.1080/00779954.2020.1870536

Appendix A: Database of values and valuation methods

Table A.1 Value estimates for specific benefit categories

Source	Date	Value characteristics	Value ranges	Waka Kotahi benefit
ATAP *PV5 – Environmental parameter values*	2020	Soil and water pollution – impact of run-off on water and soil quality	$/1,000 pkm: Car 1.9; Bus 3.6; Rail 0.8; $/1,000 vkm: Car 2.9; Bus 34	7.1 Impact on water
ATAP *PV5 – Environmental parameter values*	2020	Soil and water pollution – impact of run-off on water and soil quality	$/1,000 pkm: Car 0.2; Bus 0.04; Rail 0.01; $/1,000 vkm: Car 0.3; Bus 0.4	7.1 Impact on water
ATAP *PV5 – Environmental parameter values*	2020	Soil and water pollution – impact of run-off on water and soil quality	$/1,000 tkm: LCV 18; HCV 2.8; Rail 0.5; $/1,000 vkm: LCV 3.9; HCV 31	7.1 Impact on water
ATAP *PV5 – Environmental parameter values*	2020	Soil and water pollution – impact of run-off on water and soil quality	$/1,000 tkm: LCV0.2; HCV 1.0; Rail 0.01; $/1,000 vkm: LCV 0.1; HCV 11	7.1 Impact on water
Victoria Transport Policy Institute 'Evaluating transportation benefits'	2015	Water pollution and hydrologic benefits	$/1,000 vkm: Car 8.70; LCV 8.70; Bus 8.70; Electric car 4.35; Electric bus 4.35	7.1 Impact on water
ATAP *PV5 – Environmental parameter values*	2020	Biodiversity – impact of air pollution on natural ecosystems	$/1,000 pkm: Car 0.4; Bus 0.6; Rail 0.01; $/1,000 vkm: Car 0.7; Bus 5.6	7.2 Impact on biodiversity
ATAP *PV5 – Environmental parameter values*	2020	Biodiversity – impact of air pollution on natural ecosystems	$/1,000 pkm: Car 0; Bus 0; Rail 0; $/1,000 vkm: Car 0; Bus 0	7.2 Impact on biodiversity
ATAP *PV5 – Environmental parameter values*	2020	Biodiversity – impact of air pollution on natural ecosystems	$/1,000 tkm: LCV 1.5; HCV 21.0; Rail 0.01; $/1,000 vkm: LCV 30.3; HCV 11	7.2 Impact on biodiversity
ATAP *PV5 – Environmental parameter values*	2020	Biodiversity – impact of air pollution on natural ecosystems	$/1,000 tkm: LCV 0; HCV 0.1; Rail 0.0; $/1,000 vkm: LCV 0; HCV 1.1	7.2 Impact on biodiversity
Victoria Transport Policy Institute 'Evaluating transportation benefits'	2015	Resource costs, which include macroeconomic impacts from importing resources; security of supply risks, including military and political costs of maintaining access to resources; health risks from crashes and exposure illnesses in production and distribution; depletion of non-renewable resources; financial subsidies to fossil fuel industries (environmental damages from resource extraction, processing and transport are excluded to avoid double counting).	$/1,000 vkm: Average car 23.61; Compact car 19.26; Electric car 9.94; LCV 31.07; Diesel bus 119.30; Electric bus 39.77; Motorcycle 9.32; Bicycle 0.00	9.1 Impact on resource efficiency

Source	Date	Value characteristics	Value ranges	Waka Kotahi benefit
Transport for NSW: *Movement and place evaluator's guide: estimating placemaking benefits of transport projects in business cases*	2020	Land use and land value uplift benefit (page 50). This section starts by quoting the NSW Treasury 2017 p 59, which says benefit of land value uplift in areas surrounding a project should be excluded from a CBA … because in most cases land value would reflect the capitalisation of an increased output stream that is already included in other benefits, such as producer or consumer surpluses. It then ignores this to conclude land value uplift may be valid in rare cases and appropriate for mass transport station precincts. Nowhere does it acknowledge that business growth around new stations may be due to value relocation rather than value creation, ie largely transfer effects irrelevant to a CBA.	Some examples of land value uplift attributed to transport changes [by methods not specified] are 21.4% LV uplift around Westlink M7 motorway (1993–2012); 49.1% for M1 Motorway Brisbane (2000–2012); Heavy rail: -42 to +40%, ave 6.9% (up to 2015); Light rail: -19% to 30%, ave. 9.5%; Bus rapid transit -5% to 32%, ave. 9.7%; Gold Coast Light Rail, CAGR range -1.85% (0.5km catchment) to 0.23% (0.5 to 1km catchment); Sydney metro 9% to 29% depending on station catchment	10.3 Access to opportunities
Transport for NSW: *Movement and place evaluator's guide: estimating placemaking benefits of transport projects in business cases*	2020	Increased bicycle trips: provides non-monetised approaches to quantify increased bicycle trips due to active transport infrastructure and increased bicycle trips due to population density changes. Also, monetary estimates for increased cycling ambience from infrastructure provision (page 42).	In cents per minute, values include: Off-road segregated cycle track 12.36; On-road segregated cycle track 5.25; On-road non-segregated cycle lane 5.22; Wider lane 3.18; Shared bus lane 1.35	10.4 Cohesion
Transport for NSW: *Movement and place evaluator's guide: estimating placemaking benefits of transport projects in business cases*	2020	Benefit of removing traffic (page 45)	In cents per vkm, benefit of removing a light vehicle is 3.37 for air pollution, 1.10 for noise and 0.78 for urban separation. The benefit of removing a heavy vehicle is 16.50 for air pollution, 2.75 for noise and 1.84 for urban separation.	10.4 Cohesion/ severance
Anciaes et al. *Transport Policy 64:* 10-19	2018	Application of stated preference to estimate value of reductions in community severance/barrier effect of transport infrastructure	Value per walk trip of reducing vehicle lanes from 3 to 2 is £1.28; from 2 to 1 is £1; of adding a central median strip is £1.08; of reducing traffic levels from high to medium is £1.08 and from medium to low is £0.76; value of speed limits <50km/h is £0.45	10.4 Cohesion/ severance

Source	Date	Value characteristics	Value ranges	Waka Kotahi benefit
ATAP *PV5 – Environmental parameter values*	2020	Additional costs in urban areas – barrier and separation effects of motorised traffic on pedestrians, cyclists etc	$/1,000 pkm: Car 3.2; Bus 1.6; Rail 0.8; $/1,000 vkm: Car 1.0; Bus 15	10.4 Impact on community cohesion
ATAP *PV5 – Environmental parameter values*	2020	Additional costs in urban areas – barrier and separation effects of motorised traffic on pedestrians, cyclists etc	$/1000 tkm: LCV 20; HCV 2.0; Rail 0.3; $/1000 vkm: LCV 4.5; HCV 23	10.4 Impact on community cohesion
ATAP *PV5 – Environmental parameter values*	2020	Additional urban barrier effects	$/1,000 pkm: Car 3.2; Bus 1.6; Rail 0.8; $/1,000 vkm: Car 5.1; Bus 15	10.4 Impact on community cohesion
ATAP *PV5 – Environmental parameter values*	2020	Additional urban barrier effects	$/1,000 tkm: LCV 20; HCV 2.0; Rail 0.3; $/1000 vkm: LCV 4.50; HCV 23	10.4 Impact on community cohesion
Victoria Transport Policy Institute. 'Evaluating transportation benefits'.	2015	Barrier effects	$/1,000 vkm: Cars, LCVs and motorbikes 8.70; Bus 14.29; Bicycle 0.62; no differentiation between internal combustion and electric vehicles	10.4 Impact on community cohesion
Transport for NSW: *Movement and place evaluator's guide: estimating placemaking benefits of transport projects in business cases*	2020b	Heritage benefits, comprising value derived from individual perceptions measured by individuals' WTP; value derived from social interaction with heritage valued through the functions and social purposes it serves; intrinsic value of heritage reflecting right to exist independent of any public evaluation (page 38)	Choice modelling suggested accessibility of places is valued at $3.60 per 1% increase in the proportion of places publicly accessible per person per year; condition of places is valued at $1.35 per 1% increase in the proportion of places in good condition per person per year	11.1 Heritage and cultural liveability
Veitch Lister Consulting: *Land transport and place benefits* [for Waka Kotahi]	(2019)	Identifies that literature does not offer single definition of liveability – rather, it is shaped by local preferences and needs; liveability is a balance of positive externalities acting on secondary non-transport markets and negative externalities from the presence and use of transport infrastructure	0	11.1 Heritage and cultural liveability
ATAP *PV5 – Environmental parameter values*	2020	Nature and landscape – impact of infrastructure on existing habitats	$/1,000 pkm: Car 0.3; Bus 0.1; Rail 0.09; $/1,000 vkm: Car 0.4; Bus 1.0	11.2 Impact on landscape
ATAP *PV5 – Environmental parameter values*	2020	Nature and landscape – impact of infrastructure on existing habitats	$/1,000 pkm: Car 3; Bus 1.1; Rail 0.8; $/1,000 vkm: Car 4; Bus 10	11.2 Impact on landscape
ATAP *PV5 – Environmental parameter values*	2020	Nature and landscape – impact of infrastructure on existing habitats	$/1,000 tkm: LCV 12; HCV 0.3; Rail 0.02;	11.2 Impact on landscape

Source	Date	Value characteristics	Value ranges	Waka Kotahi benefit
			$/1,000 vkm: LCV 2.8; HCV 3.1	
ATAP *PV5 – Environmental parameter values*	2020	Nature and landscape – impact of infrastructure on existing habitats	$/1,000 tkm: LCV 0.1; HCV 2.9; Rail 0.2; $/1,000 vkm: LCV 0; HCV 32	11.2 Impact on landscape
Transport for NSW: *Movement and place evaluator's guide: estimating placemaking benefits of transport projects in business cases*	2020b	Amenity benefits for improvements to public spaces: economic benefits that occur when people on foot spend time in public spaces rather than just passing through (pages 32–35)	In cents per person per minute ($2019), ranging from 0.554 to 2.677, depending on the degree of attribute improvement. The Pedestrian Environment Review System has been used in the UK, Australia and New Zealand, but a drawback is reliance on stated preference results from UK, using BT to Australia and New Zealand	11.3 Townscape
Transport for NSW: *Movement and place evaluator's guide: estimating placemaking benefits of transport projects in business cases*	2020b	Value of green space presentation where benefit of green space is defined as AreaGS * ValuGS + Land Value Uplift(%) * LV(total in affected area)	$1,750/$m^2$; Land value uplift 5%	11.3 Townscape
DEFRA. *Local environmental quality: valuing the neighbourhood in which we live*	2013	Application of stated preference to value different attributes of the local environment, establish current situation for each attribute and WTP to improve it	Estimated WTP for an improvement, per person per month is: Light pollution £0.63; Light intrusion £0.34; Odour £2.33; trees £2.33; quiet areas £1.37	11.3 Townscape
Eyles et al. Valuation of landscape impacts of transport interventions and mitigations using an ecosystem services approach	2019	Aimed to inform the methodology for the Department of Transport for valuing landscape impacts of transport infrastructure. The definition landscape value used is very broad, encompassing functional services of landscape quality (eg ecological services) and scenic quality (eg amenity, recreational, visual values).		11.3 Townscape

Appendix B: Glossary

Term	Definition
ATAP	Australian Transport Assessment and Planning
Benefit-cost ratio (BCR)	The ratio of benefits over costs used to measure investment yield
Benefit transfer	Using estimates from an existing valuation (the source study) and transferring or applying them to another situation (the target study)
Choice experiment method	A stated preference valuation of attribute mixes
Contingent ranking	A stated preference method of rank ordering preferences
Contingent valuation method (CVM)	A stated preference valuation of alternative outcomes
Cost-benefit analysis (CBA)	The economic process of social investment appraisal
Discrete choice experiment (DCE)	A survey style modelling approach that presents survey respondents with a range of discrete multi-attribute alternatives from which to choose their most preferred alternative
HCV	Heavy commercial vehicle
Hedonic pricing	A revealed preference valuation based on analysis of property prices
Individual travel cost (ITC) analysis	Estimates the probability of an individual from a given location visiting a site
LCV	Light commercial vehicle
Market-based valuations	Valuations that are primarily based on market prices of goods or services associated with the affected resource
Multi-criteria analysis (MCA)	Where weightings in the decision process are not subject to monetisation but are informed by other means such as, scoring against pre-determined criteria, citizen juries or expert opinion
NATA	The UK Governments' New Approach to Transport Appraisal (1998–2011)
pkm, pkt	Passenger kilometres travelled (abbreviation varies across literature)
Random utility modelling (RUM)	A type of travel cost analysis that assumes people choose which site to visit according to the site's relative characteristics as well as travel distance
Revealed preference valuations	Valuations that infer non-market values from associated market goods
Stated preference valuations	Valuations that directly survey respondents on how much they value outcomes
Subjective wellbeing/life satisfaction (SWB)	An approach to wellbeing valuation based on how life satisfaction varies with inputs to it (including income)
TfNSW	Transport for New South Wales
tkm	Tonne kilometres travelled
Total economic value (TEV)	The sum of current use, future use and non-use values of a resource
Travel cost analysis	A revealed preference valuation of park visits based on visitors' travel costs
Value transfer	Using estimates from an existing valuation (the source study) and transferring or applying them to another situation (the target study)
Vkm, vkt	Vehicle kilometres travelled (abbreviation varies across literature)
Willingness to accept (WTA)	A measure of value of compensation for bearing a negative outcome
Zonal travel cost (ZTC) analysis	Visitation is expressed as a rate per head of population in zones around the site