UNIVERSITY OF LEEDS

This is a repository copy of *Sustainability Appraisal: The definition deficit*.

White Rose Research Online URL for this paper:
http://eprints.whiterose.ac.uk/43521/

Version: Submitted Version

**Article:**
Marsden, GR, Kimble, M, Nellthorp, J et al. (1 more author) (2009) Sustainability Appraisal: The definition deficit. International Journal of Sustainable Transportation, 4 (4). 189 - 211 . ISSN 1556-8318

https://doi.org/10.1080/15568310902825699

**Reuse**
Unless indicated otherwise, fulltext items are protected by copyright with all rights reserved. The copyright exception in section 29 of the Copyright, Designs and Patents Act 1988 allows the making of a single copy solely for the purpose of non-commercial research or private study within the limits of fair dealing. The publisher or other rights-holder may allow further reproduction and re-use of this version - refer to the White Rose Research Online record for this item. Where records identify the publisher as the copyright holder, users can verify any specific terms of use on the publisher's website.

**Takedown**
If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.

White Rose university consortium
Universities of Leeds, Sheffield & York

eprints@whiterose.ac.uk
https://eprints.whiterose.ac.uk/

*promoting access to White Rose research papers*

**Universities of Leeds, Sheffield and York**
**http://eprints.whiterose.ac.uk/**

This is an author produced version of a paper published in **International Journal of Sustainable Transportation.**

White Rose Research Online URL for this paper:

http://eprints.whiterose.ac.uk/435218/

**Paper:**
Marsden, GR, Kimble, M, Nellthorp, J and Kelly, C (2009) *Sustainability Appraisal: The definition deficit.* International Journal of Sustainable Transportation, 4 (4). 189 - 211.

http://dx.doi.org/10.1080/15568310902825699

*White Rose Research Online*
*eprints@whiterose.ac.uk*


# Sustainability Assessment: The Definition Deficit

| | |
|---|---|
| Journal: | *International Journal of Sustainable Transportation* |
| Manuscript ID: | UJST-2008-0016.R1 |
| Manuscript Type: | Full Paper |
| Date Submitted by the Author: | |
| Complete List of Authors: | Marsden, Greg; University of Leeds, Institute for Transport Studies<br>Kimble, Mary; University of Leeds, Institute for Transport Studies<br>Nellthorp, John; University of Leeds, Institute for Transport Studies<br>Kelly, Charlotte; University of Leeds, Institute for Transport Studies |
| Keywords: | sustainability, appraisal, targets, indicators |
| | |

For Peer Review Only

scholarONE™
Manuscript Central

# Sustainability Assessment: The Definition Deficit

Dr. Greg Marsden*, Mary Kimble, John Nellthorp, Charlotte Kelly

Institute for Transport Studies, 36-40 University Rd., University of Leeds, Leeds LS2 9JT

Tel: +44 (0)113 3435358

Fax: +44 (0)113 3435334

Corresponding Author

E-mail: G.R.Marsden@its.leeds.ac.uk

For Peer Review Only

**Abstract**

Much work has focussed on the development of indicator sets to monitor changes in the sustainability of transport. Such indicator sets are however, often quite divorced from those used in decision-making and fail to include clear sustainability goals to work towards. This research describes the development of a sustainability appraisal framework in conjunction with a series of key decision-makers in England. A case study of a real set of strategy options tested in a metropolitan area is outlined and the results used to assess the extent to which current strategy development in the UK produces the information required to both assess and communicate progress towards sustainability. The results suggest that although sustainability exists as a concept it is poorly defined. This definition deficit has serious implications for the types of strategies tested. First, information on some aspects of sustainability is not produced and so these aspects are marginalised. Secondly, the lack of policy goals and the dominant welfare economics assessment paradigm allow unsustainable strategies to be justified provided they perform better than an unsustainable 'do-minimum'. The paper concludes with some recommendations for the policy and research communities to bridge the current gap in thinking.

## 1. Introduction

Sustainability or Sustainable development has been commonly defined as "Economic and social development that meets the needs of the current generation without undermining the ability of future generations to meet their own needs" (WCED, 1987). This definition

highlights the three pillars of sustainable development; economic development, social development and ecological development under one societal goal of sustainability.

This paper focuses on the implementation of these principles to the transport sector within the United Kingdom. The UK has recently developed its second sustainable development strategy. The 2005 strategy recognised that "although the 1999 strategy stressed that these objectives had to be pursued at the same time, in practice, different agencies focused on those one or two most relevant to them. So a new purpose is needed to show how government will integrate these aims and evolve sustainable development policy" (DEFRA, 2005, p15). The revised principles are:

- "Living within environmental limits
- Ensuring a strong, healthy and just society
- Achieving a sustainable economy (*Ibid.*, p16)

Principles of good governance and the responsible use of sound science are also put forward which aligns the strategy with the global state of art (DEFRA, 2005).

In the July 2004 Transport White Paper (DfT, 2004a), the Department for Transport put in place a commitment to ensure that its appraisal techniques somehow capture the complexities of sustainable development in its broadest sense:

> "…an important underlying objective of our strategy is balancing the need to travel with the need to improve quality of life. This means seeking solutions that meet long-term economic, social and environmental goals. Achieving this objective will clearly contribute to the objectives of the UK sustainable development strategy. For example, we are working hard to deliver improvements in design and technology to improve air quality and reduce greenhouse gas emissions; and ***we will ensure that the wider impacts of future developments are reflected in appropriate appraisal methodologies***." (DfT, 2004a, p14, emphasis added)

This statement suggests that the current methods of assessing strategies and schemes do not capture the full range of sustainability concerns.

For Peer Review Only

Much work has focussed on the development of indicator sets to monitor changes in the sustainability of transport over time (Litman, 2007). However, in reviewing indicators for sustainability in 2003 Gudmundsson concluded that there was a substantial gap between sustainability indicators and indicator systems in use noting that "Even a perfect indicator system for sustainable mobility may be of little relevance if it has no bearing on actual decisions taken" (p.200).

This paper describes research undertaken to understand the gap between the current decision-making processes in transport and a clearly defined sustainability based assessment framework. To do this, the paper reviews the philosophical basis for current appraisal practice in transport and a sustainability-led approach and highlights key differences between the two paradigms (Section 2). An assessment framework that is consistent with sustainability goals was developed and tested with a range of key stakeholders and this is discussed and presented (Section 3). The sustainability framework was then applied alongside the current English assessment process to a set of strategy options that were being considered in an English metropolitan area. The research approach was not therefore one which sought to generate some theoretically optimal sustainable transport strategy but, rather, to consider under the current decision-making processes whether information on the different aspects of sustainability are considered, and if so how. Section 4 briefly introduces the strategies and some headline results and Section 5 compares the application of the two frameworks. The paper concludes, in Section 6, with a discussion of the definition deficit for sustainable transport and its implications for research and practice.

## 2. Current English Practice

This section presents the current English transport strategy assessment process and describes how it has evolved over time. This is compared to a sustainability-led assessment

For Peer Review Only

process.[1] A recent review of assessment processes in Europe (Bickel et al., 2005) suggests that there are four broad approaches to appraisal:

1. Cost-benefit-analysis;
2. multi-criteria analysis;
3. quantitative measurements without weighting of indicators; and
4. qualitative measurement or not covered in a formalized method.

Whilst different process are adopted in different countries the English approach has elements in common with most European assessment systems (Bickel et al., 2005) and many other international processes and the findings should therefore be of broader international relevance.

Current English appraisal practice has evolved gradually from the cost-benefit analysis (CBA) approach applied to early projects such as the M1 motorway and the Third London Airport. Initially, great efforts were made to monetise all relevant effects and the cost-benefit method was used to rank alternative schemes, however, from the late 1970s onwards it was recognised that there were significant environmental and social effects of transport projects which not only could not always be monetised, but were of interest to decision makers in their own right (ACTRA, 1978). Work then started in earnest on the development of Environmental Assessment for major projects, which has been presented alongside the CBA from the mid 1980s through to the present (Highways Agency *et al*, 1994; DfT, 2004b,c).

In 1997, the new Labour government asked that the appraisal information be brought together in a form that is useful for decision makers, and also that the scope of the appraisal reflect the government's five objectives for transport policy, namely safety, economy, environment, accessibility and integration. The framework developed to meet these needs, and portentously called the New Approach to Appraisal (or NATA), was the first objectives-led appraisal framework in English national appraisal practice. The findings from its first

[1] Different assessment approaches are developing in Scotland, Wales and Northern Ireland. We see little philosophical difference however with the English approach and for clarity use this approach for the paper





For Peer Review Only

application, the Trunk Roads Review were broadly positive: a statistical analysis suggested that the new information on reliability impacts and regeneration, for example, had played a significant role in the decisions made; the decision makers had placed significant weight on environmental factors too – in particular noise, landscape and heritage impacts; and the weight placed on the traditional cost-benefit items was broadly consistent with expectations (Nellthorp and Mackie, 2000). The 'NATA' approach has since been promulgated for regional strategies (DETR, 1999) and forms the framework for appraisal at a national level for any scheme >£5m (DfT, 2006a). There have been issues with its application to strategies however – whilst it does allow preferred strategies to be identified from within a set of strategy options these are not necessarily sustainable (Marsden, 2005a).

The assessment framework can be categorised as one which is made up of largely quantitative measures without weighting of indicators (option 3 from the list above). However, CBA has a clear priority as indicated in the project approval guidance. This states that BCR (Benefit Cost Ratio) forms the starting point for assessing value for money and that "understanding and estimating the implications of non-monetised impacts for value for money is by its nature very difficult. The impacts need to be significant relative to costs to change the value for money indicated by BCRs alone" (DfT, 2006b, p4).[2]

There is a significant philosophical and presentational difference between the approach to transport appraisal described above and one which reflects sustainability impacts. For policy relevant sustainable development decision-making the implications of a scheme or strategy are required to be understood over the period of the assessment. This is true of current appraisal practice. However, it is also essential to understand fully the position and direction of change of indicators of success at the end of the assessment period (Ekins and Simon, 2001). This position may need to be understood relative to current conditions (for example in the consideration of equity) or some forecast future benchmark position (for example where a target for the reduction of greenhouse gas emissions has been set). These differences are highlighted in Figure 1. The figure shows the impacts of a strategy on a form of toxic emissions. The dark-line indicates measured data, the thick dashed line the forecast level of

For Peer Review Only

emissions under some 'do-minimum' scenario and the thick dotted line the forecast level with the strategy. The black dots represent the current year position (A), the forecast position with the strategy implemented (B) and the position in the assessment year under 'do-minimum' (C). An assessment of the worth of the scenario would show that B < C and therefore the scenario has an emissions benefit under the current decision-making paradigm. However as B > A there is an implied environmental degradation which may compromise the sustainability of the strategy.

*Insert Figure 1 about here*

Of course, the assessment of sustainability is not as simple as comparing performance in the future with current performance. Alongside every indicator of sustainability there must be an indication of the direction of change from the current position that constitutes progress. In some cases there is a scientific basis on which a particular end goal can be quantified (e.g. number of days of moderate or high air quality), for others (e.g. increasing community participation) an end goal is less clear but a direction of change relative to past trends can be stated. In the case of the former, not only is it possible to state an end goal but it is often the case that time periods over which the government wishes to move to achieve these goals are set (targets). The policy relevant information is, in such cases, the difference between the assessment year value and the policy trajectory value – shown as B – D on Figure 1.

The sustainability literature does allow for these two approaches to be entirely convergent in a world where all forms of capital are tradable, prices or shadow prices exist for all measures and targets are set efficiently. Pearce (2000) for example provides an excellent review of the arguments and economics of weak and strong sustainability and we return to this issue in the conclusions. However, sustainability as conceived by the UK national strategy (and many others, Jeon and Amekudzi, 2005) is based around the normative approach presented in Figure 1. It is therefore important to feedback information on absolute progress and direction of change to decision-makers for schemes and strategies at the point when decisions are

[2] The guidance suggests that projects demonstrating a Benefit to Cost ratio in excess of 2 constitute





For Peer Review Only

being taken. This brings the consideration of sustainability a step forward from the current position of post-hoc reflection on sustainability indicators on an annual (or less frequent basis) that result from the sum of a series of policy decisions using a different (relative) decision-making framework.

The definition of sustainability and the assessment of progress is clearly a live debate. For example, we acknowledge that definitions are likely to vary across different geographical concepts and, over time, our understanding of what is or would be a sustainable state is emerging as is our ability to represent this in different indicators. Chambers et al. (2000) provide a good discussion of the range of considerations within this debate. We argue that this lack of clarity is important but it is also an inevitable part of the policy process that policy goals and expectations will shift over time (and this affects all assessment frameworks). It is most instructive to examine the decision-making epoch in question and ask whether the definition of sustainability and its subsequent application reflects the stated local sustainability goals. Our research therefore concentrates on what this means and how well specified this is in England at the current time.

### 3. Developing a Sustainability Assessment Framework

As outlined above, it is essential to have a clear idea of the goals of sustainable development. Indicators can then be selected to proxy progress towards those goals. A review of the principles of sustainable development was conducted (Kelly, 2005) to ensure that different perspectives on sustainability had been considered. Ultimately however it was felt that the research conducted here needed to be consistent first and foremost with the UK Sustainable Development strategy (DEFRA, 2005) and secondly with an interpretation of what this might mean for transport. For this, we took the Council of the European Union's definition of sustainable transport which states that a sustainable transport system:

- "Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations;

high value for money and most if not all of these projects will be funded.



For Peer Review Only

- Is affordable, operates fairly and efficiently, offers a choice of transport mode and supports a competitive economy, as well as balanced regional development; and
- Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise." (Council of the European Union, 2001)

We recognize that many definitions of sustainable transport exist but this definition provided a starting point to which the UK Department for Transport had already signed up.

Having adopted a definition, the sustainability assessment framework had to be defined. The indicators in the UK sustainable development strategy were developed to perform a monitoring role rather than to be used in ex-ante assessment. There was therefore a need to identify for each of the three pillars (and where relevant overlapping between pillars) a comprehensive suite of indicators.

An examination of the relationships between transport and the environment, economy and society was undertaken, ensuring that all of the aspects described by the UK sustainable development strategy and Council of the European Union definition were covered. Indicators were selected on the basis of three main principles:

- Relevance – whether they related to the stated definition of sustainability
- Controllability – the strength of the relationship between transport and the variable in question
- Availability – whether the indicator was already in use or able to be estimated using existing tools and data sets, allowing for post processing of data

Whilst for many of these relationships, the evidence base is well understood (e.g. the link between vehicle use, emissions, pollutant concentrations and health), for others it is the subject of pioneering research work (e.g. modelling the impacts of transport interventions on economic growth (see Oosterhaven and Elhorst, 2003 and Bröcker et al., 2004)). For some,

For Peer Review Only

the relationship is intuitive but the evidence base flimsy, unclear or non-existent (e.g. the impact of car use on social interactions). An approach was adopted to limit the selection of indicators to those areas where a strong relationship existed. Where this was the case existing indicators were used where possible. Where this was not possible, indicators were derived on the basis of best practice in the area (Marsden et al., 2005).

The range of indicators and the approach proposed were then taken to a range of stakeholders for discussion and review. The following stakeholders participated in the research:

*Insert Table 1 about here*

Table 2 shows the summary list of indicators produced as a result of the initial work and consultations. Full details of the derivation of the indicators and the process for agreeing the framework can be found in Marsden et al., 2005a; Kelly and Nellthorp, 2005; Lucas and Brooks, 2005 and Marsden, 2005. We make no claims as to the universal nature of these indicators but, given the degree of stakeholder discussion feel that this represented an acceptable definition for England at the time of the study.

*Insert Table 2 about here*

Central to the sustainability framework is a need to define the indicator, any appropriate disaggregation (e.g. when considering equity impacts) and a direction of change for the indicator. The list can be compared with the current NATA indicator list shown in Table 3.

*Insert Table 3 about here*

As well as differences in disaggregation and direction of change there are two key areas of difference between the NATA indicators and those put forward within this project:

- The sustainability framework covers the efficiency of environmental resource use which is not reflected in NATA. Pearce (2000) suggests that the efficiency of resource use is a common goal across proponents of both weak and strong sustainability approaches.

For Peer Review Only

- The coverage of social issues is far more comprehensive within the framework than is currently the case within NATA. These indicators are only meaningful when used as direct measures of change (rather than comparators with do-minimum figures).

It is worth noting that NATA also includes indicators relating to integration which we have discounted (as these lead to outcomes rather than being outcomes) and measures of journey ambience, increased option values and physical fitness. Journey ambience should be captured through actual (rather than theoretical) accessibility but current approaches are someway off from being able to achieve this. Option values, which consider the value placed on a transport option whether or not it is used, are again partly covered by accessibility although the degree to which these are really reflected warrants further research. Increased levels of physical activity are likely to be consistent with sustainable development. However, the framework already captures a shift towards less energy intensive modes (such as walking and cycling) through its resource efficiency indicators and the impacts of increased physical activity will have different benefits across different groups. For example, child pedestrians in lower social classes in the UK have a greater exposure to accident risk and accident rates four times those of the highest social groups (SEU, 2002). A more detailed understanding of the distribution of physical fitness benefits is still required (NICE, 2008).

We also highlight in Table 3 above that wider economic impacts have a role in NATA in the form of an Economic Impact Assessment. Similarly, there is a place in the proposed sustainability appraisal for a measure of real GDP per capita, as a longer-term aspiration (Table 2). There is an emerging literature on analysis of these impacts (including Oosterhaven and Elhorst, 2003 and Brocker et al., 2004) although they are not yet commonly calculated for projects or strategies and there was no such data available for the strategy tests in this study. Stakeholders suggested to us that there may be many types of economic impacts that could not be captured through our proposed short-term approach. We believe that in most cases, the majority of the benefits would be well represented by our approach but cannot rule out the need for further assessments being required.

For Peer Review Only

## 4. Strategy Tests

This research was designed to examine the extent to which current processes are consistent with the development and adoption of sustainable transport strategies. To that end, the project negotiated access to a set of existing strategy assessments developed independently by a metropolitan area in England. Three strategies were provided which had been developed and tested as the basis for determining the components of a preferred strategy which would be used for the short and medium term strategy presented in the mandatory Local Transport Plan. This was submitted to central government in 2006 as a five year strategy and outline for future infrastructure investment requirements. The strategies therefore represent the metropolitan area's view as to three appropriate strategy futures rather than an assessment by the research team as to what was sustainable. Many academic studies exist which attempt to develop and define optimal or sustainable transport strategies (Lautso et al., 2004, Emberger et al., 2008). The purpose of this assessment was to consider, given the current assessment framework, what information is produced and, under the current and proposed frameworks, how this information is presented and what gaps exist. This section briefly introduces the study area, the modelling tools and some headline results. Full details are available for study in Marsden et al. (2006).

### *4.1 Study Area*

The metropolitan area is around 500 square miles in area with a population of 2.5 million comprising a number of local district authorities which work together with a co-ordinating public transport agency to produce a local transport strategy. Land-use is a mix of high density urban areas, suburbs, semi-rural and rural locations with a predominance of urban living and travel patterns. The main city centre is a centre of regional importance but each of the local authorities has at least one major town centre giving a polycentric pattern. Rail and bus provide most of the public transport for the area although some light rail services exist.

### *4.2 Modelling tools available*

The metropolitan area employs a strategy planning model based on the DELTA-START land-use transport interaction modelling suite that was commissioned in 1996. The model

For Peer Review Only

allows for adjustments to choice of trip frequency, destination, mode and time of travel and location of business and residential activities. Actors in the model can choose to expand or contract their activities, change location (home and business) in response to changes in accessibility and environmental quality. Public transport operators can also respond to patronage changes via fare, frequency and vehicle size changes. The model is spatially aggregate with 47 zones covering the metropolitan area.[3] It included a high degree of detail for trip purposes (10) and modes of travel (8).

2006 was selected as the base year for the appraisal comparison with 2021 selected for the strategy comparison although data is available at five yearly intervals to consider direction of change. In addition to the strategic model traffic runs we were also provided with data on the approximate costs and profile of costs of the interventions for each of the scenarios.

The authority based its assessment on the outputs from the model outlined above. The research team identified a deficit in social indicators at the scoping stage and therefore sought to integrate the outputs from the land-use transport model with a new GIS based accessibility model (Accession™) which was available for the area. This software combines an access database of all public transport stops, services and timetables with GIS mapping capabilities so accessibility of different demographic groups to a range of key services can be calculated (described further in Lucas et al., 2007). 2006 data on service locations and public transport provision were provided and population characteristics were taken from the most recent census (2001). Assumptions were made about changes to public transport services on the basis of the data provided for each of the three scenarios. Key destination service locations remained fixed over time which is considered to be a substantial limitation.

### *4.3 Scenarios*

Three different model runs were provided as the basis for our analysis. The three runs contained differing degrees of public transport investment and demand management and, as such, provide a reasonably realistic panorama of policy futures. However, in selecting any three scenarios they cannot be fully representative.

[3] The model has since been upgraded to over 200 model zones which reflects the increasing





For Peer Review Only

*Scenario A – Business As Usual*

The first test, (Scenario A) represents a baseline scenario with the forecast of full implementation of the current agreed spending plan to 2011 and implementation of all committed major schemes. This test also included low assumptions on the effectiveness of behavioural change measures (such as car sharing and teleworking schemes on commuting trips and home shopping).

*Scenario B – High Public Transport Investment*

Scenario B represents all of the content of Scenario A plus major public transport investment from 2006 onwards. Major investments in bus and rail frequency and capacity were made in 2011 with additional increases in rail capacity in 2016. In 2016, these improvements were extended to the eleven other transport corridors. In addition an extension of current light rail was made, the addition of a tram-train and a core busway network were added from 2011 onwards.

*Scenario C – High Public Transport Investment and Demand Management*

Scenario C includes all of the public transport investment plus behaviour change as Scenario B but also includes an area-based charging scheme. All vehicles within the intermediate Ring Road formed around the Regional Centre would be required to pay £4 per day in 2016, rising to £5 per day in 2021 (1991 prices). Households living within the charging area were exempt from paying the full charge and paid 10% of the full charge.

**4.4 Headline Results**

This section provides a brief overview of some of the headline model outputs from the three scenarios for the base year and assessment year. Key changes in trip patterns, distance travelled, network speeds and emissions are shown in Table 4.

*Insert Table 4 about here*

computational resources available for strategy modelling.



For Peer Review Only

Scenario A has the highest number of motorised kms, largely as a result of having more car kilometres than the other two scenarios. Total trips are however lowest in this scenario, reflecting in particular the greater attraction of public transport in Scenarios B and C after the investments in 2011. Total trips from Scenario C are only slightly above those from Scenario A as a result of the introduction of road pricing. Total walk and cycle trips and walk and cycle trips as a percentage of total trips are higher under Scenario A, again reflecting some abstraction of walk and cycle journeys to public transport in B and C.

There is a decline in the average speed across the whole metropolitan area. The decline is more marked, as would be expected from the trip and vehicle km statistics, for the baseline Scenario A than for the more proactive public transport Scenario B. Scenario C with road user charging provides for only a small decline in overall average speed.

At this stage it is worth acknowledging that the assumptions surrounding freight kilometres and surrounding walk and cycle trips are limited. No investments in walk and cycle are included and the trip totals therefore reflect changes in their attractiveness as a result of interventions in other modes. Nonetheless, a slight decline in walk and cycle without further intervention remains a possible policy outcome. The freight model does not include a detailed set of assumptions about commodity flows and business development within the area and as such is a crude representation of freight changes in response to economic growth and other changes on the transport network.

## 5. Comparison of approaches

Section 2 highlighted the key philosophical differences between the current assessment paradigm and a sustainability assessment paradigm. This section brings together the practical differences of the results of the assessment with the current NATA based appraisal framework and the proposed sustainability assessment framework to examine the extent to which these differences are important. In so doing, it considers the following key questions:

- What information is not currently produced by the tools available?
- How do the results match up to the appropriate comparison benchmark where these exist?

For Peer Review Only

- How does the difference in the comparison benchmark affect the presentation of success/failure?
- Where is the definition of sustainability still insufficiently precise?

To help illustrate the discussion, Table 5 provides a qualitative summary of the results for Scenario C which, with a package of charging and public transport improvements, would a priori be presumed to be the most sustainable and it was the highest performing economic scenario in both frameworks. The results are presented relative to the current position (2006), policy targets for 2021 (where these are available) for the sustainability assessment and relative to the do-minimum scenario (Scenario A) for the NATA appraisal. The assessment provides a simple below (↓), neutral (~) or above (↑) assessment relative to the comparator and then offers an assessment as either positive (✓), neutral (~) or negative (✗) based on this information. Where a comparator is not relevant it is marked as n/r and where no data is available this is marked with n/a. Cells are shaded where common indicators are used in the NATA and the sustainability assessment frameworks but the outcome of the assessment process means that the outcomes are different.

*Insert Table 5 about here*

Several findings stand out from the assessment and comparison which can be grouped into two different categories. First, the mismatch between the requirements of the sustainability assessment and current practice and secondly, where there are overlaps, the assessment frameworks will lead the decision-maker to different conclusions.

**5.1 The Definition Deficit in Practice**

Three key issues emerge from mapping the current policy documents and the outputs available from the model to the sustainability assessment framework.

1. Many aspects of sustainability are not currently considered.

Section 3 discussed the differences between the frameworks. The practical assessment process highlights the importance of the lack of requirement to measure some of these indicators. Eight indicators were either not available or the quality of the data deemed to be insufficiently robust as to be reliable. In particular, the assessment of social sustainability is

For Peer Review Only

almost completely absent from the current process and that which was possible was generated through post processing by the research team rather than as a matter of course. It is worth noting that the indicator framework proposed here is parsimonious relative to others (Litman, 2007) and has been tested and agreed as both reasonable and attractive by a range of stakeholders (Table 1). These findings are of particular concern with reference to the maxim that "what counts is what is counted".

2. Where indicators are included policy targets are almost entirely absent

The only serious yardsticks for comparison within the sustainability assessment were the comparison with current (2006) levels and the direction of change (assessed by looking at the intervening years as well as the 2021 assessment year). Whilst for the local area policy targets are set for some indicators for the period to 2011 (e.g. air quality) for many others no targets exist either at a national or local level. For example, there is still no nationally agreed target for cutting climate change emissions from transport and, even were this to exist, no indication of the extent to which metropolitan transport strategies should contribute to such a target. Given the suggestions of a 60 to 80% cut that might be required in emissions (Brand and Boardman, 2008) it was possible to conclude for this exercise that the broadly neutral nature of the strategies assessed would not be on track. In reality however, this absence of clear framework for tackling (in this case) climate change emissions at different spatial scales makes it difficult for local, sub-regional or regional bodies to make a decision on whether their approach is sufficiently ambitious.

The lack of availability of data for assessing the social progress of transport strategies is noted above and there is, unsurprisingly, a corresponding lack of definition of what social progress might mean for transport in terms of reductions in transport inequalities might look like. The data collection and modelling processes have yet to be sufficiently oriented on this issue.

3. Disaggregation is difficult

The modelling approaches employed were quite aggregate with large zones. This makes the assessment of issues such as accessibility, walkability, noise, poverty and housing market effects difficult and their further disaggregation between social groups even more so.

For Peer Review Only

Although increasing the number of zones will improve some of these issues there is still a big gap between the level of detailed required to assess social and distributional impacts and those required to look at the principal travel time impacts of major transport investments. Envall (2008) concludes that one of the reasons little emphasis has been given to issues such as accessibility is that absolute travel time savings is the major justification of policies under cost-benefit based approaches whilst distributional effects are largely irrelevant.

### 5.2 Different assessment philosophy

The importance of the differences in assessment philosophy raised in Section 2 are highlighted in two main ways:

1. The comparison benchmark is critically important

Two examples from the environmental indicators present contrasting pictures here whilst also highlighting the importance of the comparison benchmark. $NO_x$ emissions fall substantially in all three scenarios as a result of improvements in vehicle fleet technology. The sustainability assessment suggests that the reductions are so large as to meet national $NO_x$ reduction goals[4] and to remove any air quality exceedences in the area. This is therefore scored as positive. By contrast under the NATA appraisal both scenarios B and C have slightly higher $NO_x$ emissions than scenario A by 2021 and so this is scored as slightly negative. The NATA approach suggests that minor changes in $NO_x$ even when policy and air quality targets are being met are valued equally to changes when standards are not met whereas the sustainability framework presents whether or not the goal is achieved. Annual $CO_2$ emissions presents a slightly different case. Here, Scenarios A, B and C all record very moderate increases in $CO_2$ emissions (which within the realms of model accuracy are scored as neutral in the qualitative assessment). Under the NATA framework these increases attract a small monetised penalty for scenario B relative to A and zero for Scenario C relative to A. The sustainability assessment notes that none of the scenarios provides either a reduction on 2006 levels or on any more ambitious policy targets (see Section 5.1). These examples both highlight the very clear importance of the nature of the comparison with which the decision-maker is faced. Given the current emphasis on a low-carbon transport policy (DfT,

[4] Consistent with nitrification concerns (see Marsden, 2005)





For Peer Review Only

2008) it is difficult to conclude that any of these scenarios are neutral, yet that is the information the current transport appraisal approach provides to a decision-maker.[5]

2. Is Capital Substitutable?

In the weak sustainability approach, it is acceptable to monetise environmental impacts and to combine them with consumer benefits, resource prices and construction costs etc. to provide an overall assessment of the net change in social, man-made and natural capital. In the example above Scenario B would for example have a present value carbon cost attributed to it of around 100k€ which would be dwarfed by the investment costs (2.1bn€) and user benefits (6.4bn€).

In the strong sustainability approach the lack of carbon reduction would be seen to be incompatible with the planet's absorption capacities and would not be accepted. It is not possible to resolve this debate within this paper. However, the results suggest that it is unlikely to be compatible to have a sustainable development strategy that is indicator, direction of change and target led and to have a transport assessment process which is still predominantly rooted in a fully tradable cost-benefit paradigm.

**6. Conclusions**

This paper has attempted to describe the key philosophical differences between a sustainability assessment for transport which is consistent with the aims of a national sustainable development strategy and that which is currently applied and has derived from traditional cost-benefit approaches. The framework, although not universal in its application, was developed and tested with stakeholders and in practice and compared with the current transport appraisal methods applied in England.

The research suggests that there are significant philosophical differences between a normative sustainability assessment as currently conceived and a comparative cost-benefit led approach. In particular it has been demonstrated that decision-makers will be presented with different interpretations of the same information under the two frameworks. Advantages

[5] More aggressive technological change assumptions are now available which would suggest that the strategy could reduce CO2 emissions but not by enough to be consistent with the UK's proposed carbon reduction pathway.





For Peer Review Only

can be argued for each approach but we should not pretend that a policy and goals oriented approach and a Benefit:Cost ratio maximising approach will take us to the same solutions.

The sustainability assessment approach should provide policy makers with information which is more in tune with measuring progress towards sustainability goals. Interestingly however, where we have tried to determine the detail rather than the rhetoric of sustainability goals we have found them to be absent. If sustainability assessments as conceived here are to make a real difference then indicators need clear directions of change and, for many, clear policy goals and indications of the distribution of changes across society. These will need to be determined at each scale where strategies are developed and they should be consistent (i.e. the sum of local carbon reductions should equal the national expectations).

There are many aspects of sustainability which are currently not covered in the assessment framework in England, but England is by no means alone in this regard. In particular, our understanding of social progress is weak. The experience from this research also suggests that the deficit in defining sustainability properly is further reflected in the lack of production of relevant information through modelling exercises. Given the resource requirements of providing all of the information which is already required this is not surprising. The implications are however that a more comprehensive coverage of sustainability measures should also be accompanied by a review of the evidence base required to assess these measures and the tools required to produce the estimates.

These issues are crucial to the future direction of sustainable transport if we are to close the gap between what we conceive as sustainable transport and what gets implemented in practice. As a first step, we might see all strategies being subject to a meaningful sustainability assessment before cost-benefit analysis is applied so that cost-benefit is only used to prioritise from a list of sustainable options. If such an approach is to have teeth it needs to be accompanied by a clearer definition of where we are going and what ‘sustainable’ actually means. This must be a clear priority for further research but also for implementation.

For Peer Review Only

## 8. References

ACTRA (1978), 'Report of the Advisory Committee on Trunk Road Assessment',. London: HMSO.

Bickel P., Burgess A., Hunt A., Laird J., Lieb C., Lindberg G., Odgaard T. (2005) HEATCO Deliverable 2 State-of-the-art in project assessment, http://heatco.ier.uni-stuttgart.de/ , Last accessed 24/11/08

Brand, C. and Boardman, B. (2008) Taming of the few – The unequal distribution of greenhouse gas emissions from personal travel in the UK, *Energy Policy*, **36**, 224-238

Bröcker, J., Meyer, R., Schneekloth, N., Schürmann, C., Spiekermann, K. and Wegener, M. (2004) 'Modelling the Socio-economic and Spatial Impacts of EU Transport Policy'. IASON (Integrated Appraisal of Spatial economic and Network effects of transport investments and policies) Deliverable 6. Funded by 5th Framework RTD Programme. TNO Inro, Delft, Netherlands.

Chambers, N., Simmons, C. and Wackernagal, M. (2000) Sharing Nature's Interest: Ecological Footprints as an indicator of sustainability, Earthscan publications ltd, London, ISBN 1 85383739 3.

DEFRA, Department of Environment, Food and Rural Affairs (2005) 'Securing the Future: delivering the UK sustainable development strategy'. London:TSO,

DETR, Department for Environment, Transport and the Regions (1999), 'Guidance on Methodology for Multi-Modal Studies'. London: DETR.

DfT, Department for Transport (2004a). 'The Future of Transport White Paper'. CM6234, London: Department for Transport

DfT, Department for Transport (2004b), 'Transport Analysis Guidance, Unit 3.3.1 The Environment Objective www.webtag.org.uk/webdocuments/3_Expert/3_Environment_Objective/3.3.1.htm, Last accessed 24/11/08

For Peer Review Only

DfT, Department for Transport (2004c), 'Transport Analysis Guidance, Unit 2.11 Strategic Environmental Assessment for Transport Plans and Programmes' http://www.webtag.org.uk/webdocuments/2_Project_Manager/11_SEA/index.htm, Last accessed 24/11/08

DfT, Department for Transport (2004d), 'Full Guidance on Local Transport Plans: Second edition'. London, Department for Transport.

DfT, Department for Transport (2006a), 'Transport Analysis Guidance'. www.webtag.org.uk, Last accessed 24/11/08

DfT, Department for Transport (2006b), Guidance on Value for Money, 25th January 2006, London, http://www.dft.gov.uk/about/howthedftworks/vfm/, Last accessed 24/11/08

DfT (2008) Towards a Sustainable Transport System, Department for Transport, London, Cm 7226, TSO, London

Council of the European Union (2001). 'Strategy for Integrating Environment and Sustainable Development into the Transport Policy'. Adopted by the ministers responsible for Transport and Communications at the 2340th meeting of the European Union's Council of Ministers, held in Luxembourg, April 4-5, 2001. http://corporate.skynet.be/sustainablefreight/trans-counci-conclusion-05-04-01.htm, Last accessed 24/11/08

Ekins, P. and Simon, S. (2001). "Estimating sustainability gaps: methods and preliminary applications for the UK and the Netherlands." *Ecological Economics*, **37**, 5-22.

Emberger, G., Shepherd, S.P., May, A.D. (2008) The Effects of Appraisal Methodology on the Specification of Optimal Urban Transport Strategies, *International Journal of Sustainable Transportation*, **2**(1), 58-75

Envall, P. (2008) 'Accessibility Planning: A Chimera?', PhD Thesis, University of Leeds, July 2008.

Ferrary, C. and Crowther, H. (2005) 'How realistic are sustainability appraisals? A review of research on the transport implications of regional policies for Yorkshire and Humber', *3rd Transport Practitioners Annual Meeting Aston University*, 6th July 2005

For Peer Review Only

Gudmundsson, H. (2003) 'Making concepts matter: sustainable mobility and indicator systems in transport policy', *International Social Sciences Journal*, **176**, pp199-217

Highways Agency, Scottish Office, Welsh Office and Department of the Environment for Northern Ireland (1994), 'Design Manual for Roads and Bridges, Volume 11: Environmental Assessment'. London: HMSO.

Jeon, C.M., and Amekudzi, A. Addressing Sustainability in Transportation Systems: Definitions, Indicators, and Metrics, *Journal of Infrastructure Systems*, March, 31-50, 2005, ASCE

Kelly, C. (2005) 'Sustainability Indicators, Appraisal of Sustainability Project Report', Institute for Transport Studies. Unpublished

Kelly, C. and Nellthorp, J. (2005) 'Economy Indicators, Appraisal of Sustainability Project Report', Institute for Transport Studies. http://www.its.leeds.ac.uk/projects/sustainability/project_outputs.htm Last accessed, 24/11/08

Litman, T. (2007) Well Measured: Developing Indicators for Comprehensive and Sustainable Transport Planning, www.vtpi.org/wellmeas.pdf

Lautso, K., Wegener, M., Spiekermann, K., Sheppard, I., Steadman, P., Martino, A., Domingo, R. and Gayda, S., (2004) Planning and research of policy for land use and transport for increasing urban sustainability (PROPOLIS), Final Report to the European Commission, Version 2.0, Contract No: EVK4-1999-00005

Lucas, K., Marsden, G., Brookes, M. and Kimble, M. (2007) 'An assessment and critique of capabilities for examining the long-term social sustainability of transport and land-use strategies', *Transportation Research Record*, **2013**, pp30-37

Lucas, K., and Brooks, M. (2005) 'Social Indicators, Appraisal of Sustainability Project Report', Institute for Transport Studies. Available at http://www.its.leeds.ac.uk/projects/sustainability/project_outputs.htm, Last accessed, 24/11/08

For Peer Review Only

Marsden, G. (2005a) The multi modal study transport investment plans. *Proceedings of Institution of Civil Engineers: Transport* **158** (2), 75-87

Marsden, G. (2005b) 'Environment Indicators, Appraisal of Sustainability Project Report'. Institute for Transport Studies. Available at http://www.its.leeds.ac.uk/projects/sustainability/project_outputs.htm, Last accessed, 24/11/08

Marsden, G., Kelly, C., Nellthorp, J., Lucas, K, and Brooks M. (2005) 'A framework for the Appraisal of Sustainability in Transport: Appraisal of Sustainability Project Report', Institute for Transport Studies. Avaiable at http://www.its.leeds.ac.uk/projects/sustainability/project_outputs.htm , Last accessed, 24/11/08

Marsden, G., Kelly, C. and Snell, C. (2006) 'Selecting indicators for strategic performance management', *Transportation Research Record,* **1956**, pp. 21-30

Marsden, G. Kimble, M., Nellthorp, J. And Kelly, C. (2007) Appraisal of sustainability in transport: Final Report, January, http://www.its.leeds.ac.uk/projects/sustainability/index.html, Last accessed, 24/11/08

Nellthorp J and Mackie PJ (2000) 'The UK Roads Review: a hedonic model of decision-making', *Transport Policy,* **7**(2), pp127-138.

NICE (2008) Physical activity and the environment: Guidance, National Institute for Health and Clinical Excellence, London, January, http://www.nice.org.uk/guidance/ , Last accessed 24/11/08

ODPM (2004) 'RSS Sustainability Appraisal of Regional Spatial Strategies and Local Development Frameworks', ODPM, 2004 (Consultation Paper)

ODPM (2005) 'Planning Policy Statement 1: Delivering Sustainable Development', HMSO, London

Oosterhaven, J. and Elhorst, J.P. (2003) 'Indirect Economic Benefits of Transport Infrastructure Investments'. In: Dullaert, W., Jourquin, B. and Polak, J.B. (eds) 'Across the

For Peer Review Only

border: Building upon a quarter century of transport research in the Benelux', De Boeck: Antwerpen.

Pearce, D. (2000). 'A framework for integrating concepts and methodologies for policy evaluation'. Rep. Prepared for DGXI European Commission

SEU (2002) Making the Connections: transport and social exclusion interim report May 2002, Social Exclusion Unit, http://www.cabinetoffice.gov.uk , pgs 12-13, Last accessed 24/11/08

WCED (1987) 'Our Common Future', World Commission on Environment and Development,

**Acknowledgments**

This research was funded under a grant from the Rees Jeffreys Road Fund and we gratefully acknowledge their support. We acknowledge the contribution of Dr Karen Lucas and Mike Brookes from the University of Westminster for their work on social indicators. We are also grateful to all of the participants in the research for their contributions which have improved the research and to the comments of the three referees. The opinions expressed within the paper however reflect the views of the authors.

For Peer Review Only

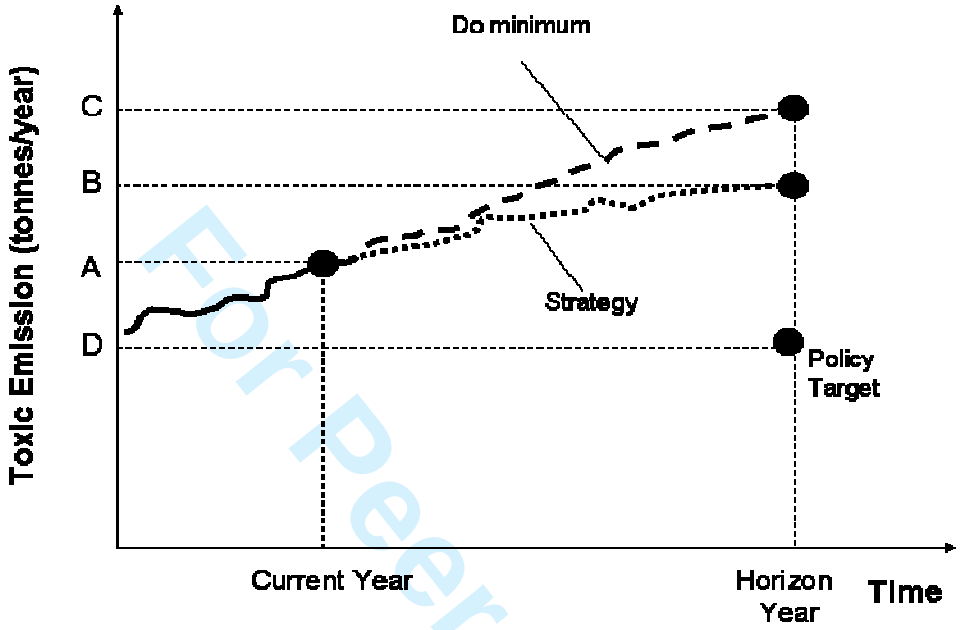


**Figure 1: Do-minimum and intervention assessment**

For Peer Review Only

**Table 1: Organisations commenting on the sustainability appraisal framework**

| Organisation | Role | Level |
|---|---|---|
| Department for Transport | Government Department responsible for planning and delivery of transport policy | National |
| Department of Environment, Food and Rural Affairs | Government Department responsible for development of sustainable development strategy | National |
| Office of the Deputy Prime Minister | Government Department responsible for planning policy and guidance | National |
| HM Treasury | Government Department with responsibility for setting budgets and national appraisal guidance | National |
| Sustainable Development Commission | Arms length body, government funded, responsible for monitoring progress towards the UK sustainable development strategy | National |
| Transport 2000 | Independent charity and lobby group promoting sustainable travel and transport | National/Local |
| Friends of the Earth | Independent charity and lobby group promoting sustainable travel and transport | International/National |
| Campaign to Protect Rural England | Independent charity and lobby group promoting the protection and enhancement of rural quality of life | National/Local |
| Yorkshire Forward | Government funded agency with responsibility for regional economic development | Regional |
| Yorkshire and Humber Assembly | Government funded body run largely by elected local councillors with responsibility for the development of Regional Spatial Strategy and appraising the sustainability of the strategy. | Regional |
| Government Office for Yorkshire and Humber | Government organisation responsible for liaison between local and national government | Regional |
| Passenger Transport Executive Group | Lobby group for major metropolitan transport authorities | National/Local |
| Environment Agency | Government funded agency with responsibility for flood defences and sites of scientific interest | National |
| Confederation of British Industry | Lobby group of British business interests | National/Local |

For Peer Review Only

## Table 2: Indicators suite for sustainability appraisal

| Environment | | | |
|---|---|---|---|
| **Area of Progress** | **Indicator of Progress** | **Disaggregation** | **Direction of change** |
| Pollutant Absorption Capacity | Total $CO_2$ emissions | - | Down – 20% cut by 2010 compared to 2000 levels and 60% by 2050 |
| | Cumulative Total $CO_2$ emissions | - | Down compared with existing annual rate played forward |
| | Total $NO_x$ emissions | - | Down – UK total to be 1,167 thousand tonnes by 2010 EU National Emissions Ceiling Directive |
| Resource Efficiency | Total non-renewable energy by all transport | - | Down |
| | Energy use per person-trip | Personal travel only | Down |
| | Energy use per tonne-km | Freight only | Down |
| Direct impacts on health | Exceedences of air quality objectives (NOx and/or PM10) | At risk groups (e.g. % of people suffering Chronic Heart Disease) | Down (standards set for 2005 and 2010) |
| Local quality of life | Number of residences exposed to aircraft noise above 57 LAeq,T | | Down |
| | Number of residences exposed to noise above 55dBA | | Down |
| Environmental Capital | Qualitative environmental capital score (7 point scale) | Landscape<br>Townscape<br>Heritage of Historic resources<br>Biodiversity<br>Water Quality | Cumulative impact of policies neutral or beneficial |

For Peer Review Only

| **Economy** | | | |
|---|---|---|---|
| **Area of Progress** | **Indicator of Progress** | **Disaggregation** | **Direction of change** |
| Standard of Living | Real GDP per Capita based on:<br>• *In the short term* – proxied by net benefits measured in the transport sector<br>• ***Long term aspiration* - Direct modelling of GDP using multi-sectoral models** | Business User Benefits<br>Consumer User Benefits<br>Reliability<br>Safety*<br>Operator Gains<br>Public Finance Balance | Increasing (strictly Non-decreasing) |
| **Society** | | | |
| **Area of Progress** | **Indicator of Progress** | **Disaggregation** | **Direction of change** |
| Poverty | Average real cost of journey to key destinations | By car and public transport | Reduced ratio between car-based and public transport options |
| Accessibility | Weighted journey times[a] to:<br>• key centres of employment;<br>• primary, secondary & further educational facilities;<br>• primary health care provider[b] & general hospital[c];<br>• key food shops | By car and public transport[d] | Reduced ratio between car-based and public transport options (which allows for both to improve) |
| Safety | Killed and Seriously Injured | Disaggregate by index of deprivation, teenage deaths by driving and child pedestrian deaths | Reduce number KSI by 40% (50% child KSI) by 2010 compared with the average for 1994-98 plus reduced disparity between social groups |
| | Recorded incidences of crime on public transport | None | Down overall and improved perceptions of safety |

[a] It may be advisable to also include cost of journey to these destinations with some indication of costs over e.g. £1 being non-affordable for low-income households and highlighting disparities in cost between car and public transport

[b] Doctor's surgery, health centre, NHS walk-in centre

[c] Hospital offering A&E and other key services

[d] Can also be disaggregated by particular relevant groups (e.g. health care facility by % of people suffering Chronic Heart Disease; primary school by % of children under 11 years; etc.) and also by housing tenure (the latter may be particularly in rural areas where low-income households are more likely to have higher levels of car ownership).



For Peer Review Only

| | | | |
|---|---|---|---|
| Walkability | Percentage of residents living within 1000m or 15-minute 'safe walk'[e] to key destinations (e.g. health, educational, leisure and cultural facilities, food shops, post office, etc.) | Can be disaggregated by particular relevant groups (e.g. primary school by % of children under 11 years). | Up |
| Housing | Real lowest 10% value of house prices within x minutes (based on average local journey times to employment) of:<br>a) The town centre and<br>b) Key centres of employment | Disaggregated by public transport and car | Down |

For Peer Review Only

[e] Determined by an official safe route. A safe cycle route to these destinations could also be included

For Peer Review Only

**Table 3: NATA indicators** (see www.dft.gov.uk/webtag)

| NATA Objective | NATA Sub-Objective | Assessment Indicators |
|---|---|---|
| Environment | Noise | Difference in population annoyed in Year 15 (option versus do-minimum)<br>Present value of change in noise (£) |
| | Local air quality | Aggregate change in emissions, $PM_{10}$ and $NO_x$ |
| | Greenhouse Gases | Aggregate change in emissions, $CO_2$ |
| | Landscape* | 7-point score*, based on character, environmental capital and impact |
| | Townscape* | 7-point score*, based on character, environmental capital and impact |
| | Heritage* | 7-point score*, based on character, environmental capital and impact |
| | Biodiversity* | 7-point score*, based on character, environmental capital and impact |
| | Water environment* | 7-point score*, based on character, environmental capital and impact |
| | Physical fitness | Change in the number of people walking or cycling >30mins |
| | Journey ambience | 7-point score*, based on various sub-factors, number of users affected |
| Safety | Accidents | Present value of change in accidents (£) |
| | Security | 7-point score*, based on 6 aspects of security, number of users affected |
| Accessibility | Community severance | 7-point score*, based on 4 levels of severance, number of users affected |
| | Option values | 7-point score*, based on service changes and number of people affected, or present value (£) |
| | Access to the transport system | 7-point score*, based on index of access to a car, proximity to public transport system |
| Economy | Public accounts | Present value of benefits net of costs (£) |
| | Business users and providers | Present value of benefits net of costs (£) |
| | Consumer Users | Present value of benefits net of costs (£) |

For Peer Review Only

| | | |
|---|---|---|
| | Wider Economic Impacts | Through an Economic Impact Assessment |
| | Reliability | Present value (£), or 7-point score*, based on standard deviation of journey time or flow/capacity ratio, and number of users affected |
| | Wider economic impact | Change in employment, GDP change |
| Integration | Transport interchange | 7-point score*, based on change in interchange quality, number of users affected |
| | Land-use policy | 3-point score*, based on integration of the proposal with local, regional and national plans |
| | Other government policies | 3-point score*, based on consistency with other policies |

* Large adverse; moderate adverse; slight adverse; neutral; slight beneficial; moderate beneficial; large beneficial.

* Adverse; neutral; beneficial.

For Peer Review Only

**Table 4: Summary of Key Scenario Results**

| Indicator | Units | 2006 | 2021 | | |
|---|---|---|---|---|---|
| | | Baseline | Strategy A | Strategy B | Strategy C |
| Car Kms | M/day | 30.3 | 33.2 | 31.8 | 30.9 |
| Public Transport Kms | K/day | 488 | 514 | 589 | 641 |
| Freight Kms | M/day | 13.7 | 15.8 | 16.0 | 16.0 |
| Car Trips | K/day | 8370 | 9170 | 9090 | 8780 |
| PT Trips | K/day | 2910 | 3040 | 3320 | 3520 |
| Walk& Cycle Trips | K/day | 1580 | 1470 | 1430 | 1460 |
| Average Speed AM Peak | Km/hr | 30.8 | 28.0 | 29.0 | 29.9 |
| $NO_x$ emissions | tonnes | 47 | 25 | 27 | 27 |
| Annual $CO_2$ emissions | tonnes | 11600 | 11800 | 12000 | 11800 |

For Peer Review Only

**Table 5: Appraisal Comparison**

| Indicator | Included in Sustainability Appraisal | Included in NATA | Policy Target | | Example Comparison Scenario C | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Relative to | | | | Sustainable? | NATA assessment |
| | | | Defined | Estimated | 2006 | Policy Target | Do Min | Direction Of change in 2021 | | |
| Noise | • | • | • | | Data available but unreliable | | | | n/a | n/a |
| $NO_x$ Emissions | • | • | • | | ↓ | ↓ | ↑ | ↓ | ✓ | × |
| Air Quality Exceedences | • | † | • | | ↓ | ↓ | | ↓ | ✓ | |
| $CO_2$ annual | • | • | | • | ~ | ↑ | ~ | ↓ | × | ~ |
| $CO_2$ cumulative | • | | | • | n/r | ↑ | | n/r | × | |
| Total Energy | • | | | | ~ | n/a | | ↓ | ? | |
| Energy/trip | • | | | | ↓ | n/a | | ↓ | ✓ | |
| Energy/tonne-km | • | | | | Data available but unreliable | | | | n/a | |
| Environmental Capital | • | • | | • | ~ | ~ | ~ | ~ | ~ | ✓ |
| Physical fitness | | • | | • | | | ↓ | | | × |
| Net Present Value (Sust) | • | | | | ↑ | n/a | | ↑ | ✓* | |
| Net Present Value (NATA) | | • | | | | | ↑ | | | ✓* |
| Real cost of journeys | • | | | | Data not available | | | | n/a | |
| Community Severance | | • | | | Data not available | | | | | n/a |
| Access to transport | | • | | | | | ↓ | | | × |
| Accessibility to destinations | • | | • | | ~ | ~ | | | ✓ | |
| Accidents | • | • | • | | Data not available | | | | n/a | n/a |
| Security/Crime | • | • | | | Data not available | | | | n/a | n/a |
| Walkability | • | | | | Data not available | | | | n/a | |
| Housing | • | | | | Data not available | | | | n/a | |

† = only included as a qualitative comment

n/a = not available

n/r = not relevant

* = highest ranking economy score (Scenario C)

For Peer Review Only