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# APPRAISING THE ENVIRONMENTAL EFFECTS OF ROAD SCHEMES

## A Response to the SACTRA Committee

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**ABSTRACT**

In this paper, we consider the range of environmental effects of roads and ways of valuing them in money terms. We conclude that environmental effects should be divided into strategic and local. The former, which are largely ignored by current appraisal practice, should be considered as part of an appraisal of the entire programme of road schemes in the course of the consideration of transport strategy. Local effects are dealt with in the Manual of Environmental Appraisal, but the list of effects there and advice on their treatment needs amplification.

We consider that techniques for the monetary valuation of environmental effects have improved greatly in recent years, and there remains considerable unexploited potential for the use of stated preference techniques. Nevertheless, we do not think it sensible to suppose that all environmental effects could or should be incorporated in a single Net Present Value calculation; rather we see a potential for the further application of decision support systems able to deal with more disaggregate information.

## 1. INTRODUCTION

This paper represents a collaborative response by members of the Institute to the invitation from SACTRA to provide evidence for its enquiry into the way in which the environmental effects of road schemes are assessed. We first consider the range of environmental effects of road schemes, dividing them into strategic effects, which are largely ignored by current procedures, and local effects. We then consider the extent to which these latter effects are adequately represented in current appraisal procedures. Following this, we discuss the case for use of monetary valuation of environmental effects and consider the reliability and appropriateness of the techniques currently available. We comment on the problem of decision-making in the face of a wide variety of types of information of varying degrees of certainty, before drawing together our conclusions.

## 2. ENVIRONMENTAL EFFECTS OF ROAD CONSTRUCTION - STRATEGIC ISSUES

We believe that the environmental effects of road construction are conveniently viewed under two broad headings. The first consists of those effects which may be viewed as strategic - i.e. the consequences of the decision to provide for a given volume of traffic, rather than to use pricing or other demand management measures to reduce the volume. Thus for instance the contribution of road transport to the production of greenhouse gases will be sensitive to the overall national and worldwide transport strategy, but not to decisions about individual road schemes. The second consists of the local effects of policies and projects, including those of providing for that volume of traffic by the construction of particular schemes. Even at this level we believe that there is a need for the examination and appraisal of a wider range of solutions to transport problems, including the development of alternative corridors and the potential role of alternative modes. We are very concerned that appraisal of trunk road schemes is often only undertaken at the level of small individual sections of route (such as bypasses) where everything but the precise routing and design is a foregone conclusion. We believe it is essential to appraise programmes as a whole, as well as their component parts.

In this section we concentrate on the strategic issues, which appear to be completely ignored in current road appraisal techniques.

### (a) The effects of air pollution on global warming

Transport gives rise to a number of pollutants which are currently believed to contribute to global warming through their action as "Greenhouse" gases. Such gases absorb the infrared radiation re-emitted by the earth's surface, while letting the shorter wave radiation from the sun through. This is thought to result in an overall increase in the temperature of the earth. These pollutants predominantly derive from petrol engine vehicles, in particular the motor car. The most important of these gases is carbon dioxide. Presently transport sources account for approximately 18.2% of carbon dioxide produced in this country (third place after power stations and industry; Worldwide Fund for Nature, 1989). Other Greenhouse gases produced by transport sources include nitrogen oxides, ozone and chlorofluorocarbons. It is likely that the levels of Greenhouse gases produced by transport sources will increase quite considerably in the near future, particularly if the Department of Transport's predictions concerning the likely increase in the number of vehicles are borne out.

Current means of reducing the pollutants emitted from motor vehicles, such as catalytic converters, lead free petrol, lean burn engines, modifications of the air: fuel ratio, restriction of evaporative emissions etc are not designed to reduce the levels of carbon dioxide emissions, and in fact in some cases results in higher volumes of this gas being produced than would otherwise be the case.

### (b) Destruction of the Ozone Layer

Certain gases, known as chlorofluorocarbons (CFC's) have been shown to react with the ozone molecules in a way which results in the destruction of these molecules. CFC's are produced as a result of two transport processes, firstly as a result of vehicle production and secondly as a result of the use of air conditioning in vehicles. CFC's accumulate in the atmosphere, where they can remain for substantial periods of time (between 70 to 120 years). Recent observations have revealed a thinning of the ozone layer of the atmosphere above both the north and south poles, which is thought to have been produced directly as a result of CFC emissions. Such an effect, were it to continue, may have catastrophic effects upon life as the ozone layer presently filters out harmful radiation from the sun.

### (c) Acid deposition

A number of the pollutants emitted by motor vehicles can directly and indirectly lead to an increase in the amount of acid deposition (both through acid rain and dry deposition). Acid salts and acids can be formed in the atmosphere as a result of the chemical transformation of Sulphur and Nitrogen oxides emitted by natural and man-made sources. Such acids and salts can then return to the earth through deposition. $NO_x$ emissions can be converted to nitric acid and contribute approximately one-third of the acidity in rainfall. Photochemical oxidants' such as ozone, are produced through reactions between hydrocarbons and other reactive organic compounds, nitrogen oxides and oxygen in the presence of sunlight. Such substances are suspected of playing a key role in the conversion of sulphur and nitrogen oxides into acids.

### (d) Synergistic effects of air pollutants

Most attention on air pollution problems has to date focused on individual pollutants and the types of effects they have on individual, on infrastructure, on wildlife etc. Many of these effects are well known. However, according to Linster (1989) "growing evidence is emerging that the whole problem may be much greater than the sum of its individual parts". She gives a number of examples of such effects including: a number of studies which have found adverse health effects from $SO_2$ and $NO_2$ in combination to be much more serious than from these pollutants individually; and a US National Academy of Sciences study which noted that high levels of $SO_2$ and coexisting particulate pollutants have been associated repeatedly with increases in respiratory morbidity and mortality rates.

### (e) Provision and disposal of materials for road transport

There are a large number of issues concerning the provision and disposal of materials which are used for road transport. We have concentrated on four which we consider to be especially important. These are quarrying and the provision of construction materials, oil extraction and refining, the use of non-renewable resources, in particular oil, and the problem of the disposal of derelict vehicles. These are considered in more detail below.

Quarrying and the provision of construction materials: This is fundamental to infrastructure provision, but has a number of negative effects upon the environment, particularly in areas of great scenic value.

Oil extraction and refining: With predicted increases in the number of vehicles the demand for oil will become greater. Extraction and refining have numerous associated problems, ranging from unsightliness to air pollution and oil spills.

Use of non-renewable resources: There is a finite supply of oil, and hence if, as seems likely, demand will continue to increase into the foreseeable future, the supply of oil in the longer term will pose a major environmental and resource problem, with the likelihood being that large scale production of syncrude from coal will become necessary.

Disposal of derelict vehicles: The more new vehicles we produce, the larger is the number of potentially derelict vehicles. Problems associated with these are how do we dispose of them, and how do we store them until they are disposed of. Problems arise during storage, including seepage of lubricants, battery acid etc.

### (f) Damage to Nature Conservation

The loss and damage of nature conservation sites such as SSSI's can be regarded as a strategic as well as a local issue. The roads included in the recently expanded roads programme threaten a large number of nature conservation sites including 161 SSSI's. A new road can damage a site with a subsequent loss of vegetation or wildlife, with the possible reduction below a minimum threshold for successful regulation or maintenance of the species or habitat.

If a species is confined to specific habitats then the risk of the loss of species is increased. The cumulative loss or modification of habitat might lead to extinction of rare and fragile ecosystems and reduce the ecological diversity and history of a country.

In summary, then, we regard these strategic environmental aspects of road schemes as extremely important, and see them as being almost entirely ignored by current procedures.

## 3. LOCAL ENVIRONMENTAL EFFECTS OF ROAD SCHEMES

The existing procedures for assessing these effects are set out in the Department's Manual of Environmental Appraisal (MEA). We understand that a revised version of MEA is about to be issued, but we have prepared these comments on the basis of the original 1983 version.

The coverage of MEA is summarised in Tables 1 to 3 of Part A Section 1. We consider below whether the MEA procedures are adequate in terms of:

(a) coverage of effects
(b) coverage of impact groups
(c) analysis of effects and use of thresholds.

(a) Coverage of effects

We identify the following omissions from the MEA summary table:

* vibration
* certain pollutants
* toxic chemicals
* sense of danger
* daylighting, privacy and glare
* planning blight.

Vibration, and infrasound, which generate similar psychological reactions, are of concern to a substantial minority of the public. Vibration problems are usually associated with poor road surfaces, and may well be an environmental problem which new infrastructure can alleviate. Infrasound is primarily produced by heavy vehicles, and can be a problem on both new and existing roads. Vibration can be measured, and infrasound both measured and predicted from traffic parameters. Social survey work has produced attitudinal dose-response relationships. There appears to be a strong case for including vibration and infrasound, at least where they appear likely to cause problems, and there appear to be no insurmountable difficulties in doing so.

Pollutants not included at present are carbon dioxide, dust and dirt, CFC's and asbestos. Carbon dioxide and CFC's are regarded as a strategic problem as discussed above. Dust and dirt, of which asbestos dust is a part, causes annoyance, soiling, and may have some health effects. Relationships with traffic parameters are much more uncertain, and it may therefore be difficult to include them in an environmental appraisal.

Toxic chemicals spills involving vehicles carrying toxic freight are relatively rare events, and incidents involving loss of life or serious injury are rarer. Nevertheless, these are the subject of considerable public concern. Emissions are likely to be more common but less serious than spills.

The issue is primarily one of risk of a rare event and costs associated with that event. Both of these are likely to vary between schemes, and should therefore be included in a comparative evaluation.

Danger is a factor of particular concern to pedestrians and cyclists. The 1972 National Environment Survey indicated that danger as a pedestrian was the most widely experienced environmental consequence of transport. In the circumstances, it is surprising that the Department should have chosen to investigate driver stress further, but not to study vulnerable road users' perceptions of danger. There have been some attempts to relate perception of danger to traffic parameters, but considerable further research is needed. As part of that research it will be necessary to distinguish between avoidable perceived danger and that which serves to protect the user. We recommend that such research be pursued as high priority.

Daylighting, invasion of privacy and glare are all effects of new infrastructure; in part they may also arise from existing traffic. While standards exist for daylighting, little is known about reactions to the other effects. There is a case for at least considering their inclusion.

Blight presents rather different problems for evaluation from other environmental effects, since it arises largely from the decision-making process rather than the scheme itself. It is, however, an issue of considerable concern, and needs to be more effectively treated.

(b) Coverage of impact groups

The MEA provides a detailed breakdown for impact groups inside buildings, and appears to cover all the effects relevant to each of them. It is much less thorough in its treatment of travellers, those with an intrinsic interest or strategic effects.

Travellers are treated, in MEA table 1, by considering driver stress and view from the road for driver, and amenity and severance for pedestrians and cyclists. Amenity is defined as "relative pleasantness" and is "concerned with the degree and duration of people's exposure to fear, noise, dirt and air pollution". In practice, these effects will arise in different ways, and will be amenable to different solutions. Failure to separate these effects makes the evaluation less useful, and may lead to an underemphasis on the environmental impact on these particularly vulnerable groups. No consideration is given to the effects of noise and pollution on vehicle users, yet evidence suggests that both may be serious sources of impact.

Intrinsic interests are primarily dealt with under Sections 4 and 5 of the appraisal framework by reference to public policy. It is debatable whether these statements of policy will necessarily reflect the full range of interests in the quality of an area. Strategic effects are considered above.

(c) Analysis of effects and use of thresholds

The Leitch report stressed the importance of limiting quantification to those situations where the units used were reliable and appropriate. In practice there is a tendency for the MEA to employ inappropriate quantification. The two most common problems are the use of numbers in such a way that they disguise the existence of unquantifiable effects, and the use of thresholds which ignore significant changes between or above them. Particular examples arise in the treatment of visual impact, community severance and driver stress.

Visual impact in practice involves a wide range of issues, including not only intrusion and obstruction, but aesthetic considerations, daylighting, glare and invasion of privacy. In practice the analysis focuses on description of intrusion and a calculation of obstruction, which can be quantified in terms of solid angle. There is a danger as a result that the other issues will be overlooked.

Severance is analysed by reference to a series of thresholds which appear to have no basis in the literature, and which suggest that severance which adds up to 250m to a pedestrian's journey or five minutes to a car journey is only "slight". There is a danger that such a categorisation will lead to lower values being ignored, even if it seems likely that they could influence patterns of movement as well as attitudes. If these thresholds are based on evidence it should be clearly quoted; if not the thresholds should either be clearly labelled as tentative or not applied until they can be substantiated.

Driver stress is similarly treated by a series of thresholds which are set out in three tables followed by a paragraph which indicates that they are for provisional guidance only. It seems likely that this paragraph will be overlooked, yet the thresholds given seem implausible. In particular it seems unlikely that all

motorways with a flow in excess of 1600 pcu/h and all single carriageway roads with a speed of under 50 km/h should have the same ("high") driver stress level. Again, these thresholds should either be withdrawn or substantiated.

Thus we believe that the Manual of Environmental Appraisal needs updating and extending, both to increase the range of effects and impact on groups covered and to amplify advice on analysing these effects. We hope that the new edition will attend to these issues.

## 4. THE CASE FOR MONETARY VALUATION

(a) Strategic issues

The publication of the Pearce report has brought to the forefront of attention the case for a wider use of monetary valuation of environmental goods. However, what is in our view a more important recommendation of the Pearce report has received less attention. This is the recommendation for the integration of sustainability into cost-benefit analysis (Pearce, Markandya and Barbier, 1989).

Sustainability can be defined as requiring that future generations be left a stock of environmental wealth no less than that existing at the present time. The exact interpretation of what this means is problematic, given the difficulty of valuing and adding together various forms of environmental wealth. Nevertheless, it is usually taken to mean that pollution must not exceed the assimilative capacity of the natural environment, and that depletion of one resource must be compensated for by the building up of stocks of another one.

In the case of transport the key issues concerning sustainability arise at the strategic level, and mainly concern the greenhouse effect and depletion of natural resources (especially oil consumption and destruction of sites of special scientific interest). Regarding the former, we believe that transport strategy needs to be viewed as part of an overall national and international strategy to achieve agreed targets for the reduction of greenhouse gas emissions. In the latter case, where we are dealing with non-renewable natural resources, shadow projects designed to offset the damage done by the projects in question (for instance creation of new habitats; energy conservation or development of renewable energy sources), need to be identified and undertaken, their costs being part of the cost of the projects or programme under appraisal.

The strategic pollution issue could in principle be handled by estimating the level of tax on each pollutant that would serve to reduce the total emission of it to a sustainable level. This tax would then act as an appropriate monetary valuation of emissions of that pollutant at the project level, on the basis that it represents the opportunity cost of being able to produce an equivalent amount of pollution from some other project. Similarly, resource depletion could be taken into account by including as part of the cost of the project the necessary expenditure on the "shadow" project, designed to compensate for any depletion of natural resources produced by the project in question.

However, given the enormous uncertainties involved, we doubt whether monetary valuation of effects such as emission of greenhouse gases is likely to be a sensible way forward, at least until an overall strategy for dealing with the problem has been developed, and we can begin to see the sort of sacrifices that will be necessary elsewhere if emission of greenhouse gases from transport systems is to continue to grow at its existing rate. We believe that issues such as the greenhouse effect and other strategic environmental effects of transport systems need to be addressed as

part of a broad strategy for coping with the problem of the rapidly growing demand for transport, a strategy which will need to consider a variety of policy measures including pricing, land-use planning and development of more environmentally friendly forms of transport.

(b) Local issues

In the case of local environmental effects, we believe that monetary valuation may have a more valuable part to play. A cost-benefit analysis is normally undertaken according to the principle that benefits are measured in terms of what the gainers are willing to pay for them, and costs in terms of the compensation losers require willingly to put up with those losses. If the benefits exceed the costs, the scheme should go ahead.

It has long been acknowledged in the literature that this approach to valuation will systematically favour the better-off, who obviously have a higher ability to pay, and will correspondingly require a greater amount of monetary compensation for a given disbenefit. The usual recommendation is that this problem should be dealt with either by the introduction of explicit weights according to the income group in question, or by the use of a disaggregate method of presentation of results, in which the effects on different income groups can be clearly seen and taken into account subjectively by the decision-taker (Nash, Pearce and Stanley, 1975).

Given the adoption of one of these procedures, we believe that monetary valuation of environmental effects can contribute to appropriate decision-taking, by giving information on the degree to which the affected parties are willing to give up environmental benefits to save time or money, and vice versa. Indeed, we regard the existing procedure of computing a Net Present Value which includes a monetary valuation of time and accident savings but excludes all environmental effects as being seriously misleading.

It is in the context of valuation of direct benefits or disbenefits in the form of damage to property or amenity, and in taking account of indirect values in the form of option, existence and bequest values, that we believe that techniques for monetary valuation of environmental effects have made their greatest advances, and it is to these that we turn in the next section.

## 5. METHODS OF VALUATION

The idea of attempting to put monetary values on the environmental effects of policy programmes and project developments is not new. In the UK past attempts however have tended to have been treated with suspicion and ridicule by the public. A notorious example occurred during the Third London Airport Enquiry when a crude attempt to put a monetary value on a Norman Church was made on the basis of fire insurance value. The mistakes of such crude approaches however have been learnt and considerable advancement has taken place over the past 20 years to develop methods to measure monetary valuations of environmental costs and benefits.

We first consider the categories of costs and benefit to which monetary valuation may be applied, before discussing the alternative methods themselves.

(a) Relevant categories of cost and benefit

Clearly in principle one could seek to value in money terms all the categories of cost and benefit listed in the MEA. It should be noted, however, that some important

categories of benefit identified in recent environmental economics literature are not included here. These consist of the value people place on conservation of a resource because they wish to preserve the option of being able to utilise it in the future (option value), because they wish to ensure its survival for future generations (bequest value) or because they simply wish to maintain its existence (existence value). Presumably these effects are most likely to be significant in the case of historic or beautiful buildings or areas, or rare habitats, and correspond to the Leitch framework category of effects on those with an intrinsic interest in the area. American evidence, using the contingent valuation method (below) suggests that in some cases these values may exceed the direct user benefits of the resource (Walsh, Loomis and Gillman, 1984).

Tables 1-3 previously described in Section 3 show the range of user-groups, classed as residents, travellers and users of facilities, which are recognised in the MEA. Under this current formulation an individual could appear in each of these user-groups. This can then require valuing a possible large number of attributes for the same individual.

This approach then generates a long list of isolated attributes which require separate valuation. An alternative approach is to think of individuals as belonging to a broader grouping, and who are exposed not to simple attributes in isolation but to a series of effects, which are integrated to form an environment (Hopkinson, Nash and Sheehy, 1990). Such an approach would be consistent with use of the contingent valuation method. The other methods of monetary valuation are more readily applied to individual attributes one at a time.

We now consider the alternative approaches in turn.

**(b) <u>The Alternative Cost Approach</u>**

The most longstanding approach to environmental valuation is the calculation of the cost of rectifying the damage or replacing the destroyed resource. If this course of action is actually undertaken as a result of the project then obviously it should form part of the cost of the project, and if it completely offsets the damage in question, then there is no further problem.

Often however, neither of these conditions is satisfied. For instance, in both West Germany and Sweden, money values are routinely placed on environmental effects of transport projects using these methods. An example is the valuation of noise nuisance in terms of the cost of double-glazing. If the double-glazing is not actually undertaken, then there is no evidence that the noise nuisance is valued that high; moreover double glazing offers other advantages including heat insulation. On the other hand it does not fully offset the problems of noise nuisance, for instance when windows are open or one is outside. Thus in practice this approach is often seriously flawed; one does not even know whether it is an under or over estimate of the true value.

An extension of this technique to nature conservation issues is offered by the "shadow project" approach (Klaassen and Botterweg, 1976). Destruction of a particular habitat is compensated by artificial creation of an identical habitat elsewhere. However in many cases (eg. ancient woodland) it may be doubted whether recreation is possible within a reasonable time frame or at all (Hopkins, 1989).

(c) Revealed Preference Methods

Revealed preference techniques involve observing and examining peoples' actual behaviour or their revealed preferences for environmental protection or goods. This relies on finding situations in which consumers have a choice between incurring money expenditure or suffering the ill effect in question. The two basic techniques are hedonic pricing and the travel cost method. The hedonic price method usually involves examining variations in house prices in relation to characteristics of the property and the neighbourhood including environmental attributes such as the level of traffic noise or the presence/absence of outdoor recreation areas.

The main advantage of the house price approach is that it examines the purchase of a commodity which usually involves considerable search and comparison of options with varying attributes. The technique also has a number of serious shortcomings. The most important of these are firstly it assumes that those householders under investigation have made a real choice and have perceived accurately the attributes of the available options and arrived at a satisfactory decision. Secondly the technique cannot identify possible option or non-use values for environmental benefits. Thirdly multi collinearity exists between a host of explanatory variables and mis-specification, leading to bias is always a potential problem. Accordingly the technique requires large sample sizes with adequate variation in the explanatory variables although even then the results can remain imprecise.

An alternative approach, the travel cost method, has been used extensively for valuing recreational facilities by observing expenditure on travelling to and gaining access to recreational sites. Difficulties arise again as many journeys are undertaken for multiple purposes, and the travel cost cannot be regarded solely as the price of obtaining access to a site. Moreover, travel cost may be misperceived and the value of time for recreational journeys is uncertain.

**(c) Hypothetical questioning techniques**

This approach is based upon the use of survey methods to elicit people's preferences for public goods. The surveys generally have three parts; firstly a detailed description of the good(s) being valued and the hypothetical circumstance under which it is made available to the respondent, secondly questions about the respondents characteristics and their use of the goods and thirdly, questions which elicit the respondents willingness to pay for the good being valued

Two methods have been proposed for measuring the value which people place upon the environment. Contingent Valuation Method (CVM) is a method widely used in the USA for determining how much respondents are willing to pay to prevent the destruction of an environmental asset or for environmental improvements such as cleaner air or less polluted water. The willingness to pay question typically takes a form similar to the following;

"What amount would you be willing to pay in taxes and higher prices each year to keep (or improve) the situation (with respect to some environmental amenity).." (from Mitchell and Carson, 1989, pp328).

The Stated Preference (SP) technique involves offering respondents a set of alternatives involving different combinations of attributes and costs and asking people to state which option they prefer or which they would choose. SP, although widely used in the UK for demand forecasting and valuing travel time savings, has been little used in the area of environmental valuation.

In both CVM and SP approaches it is recognised the two key elements are firstly the realism or plausibility of the hypothetical situations described and secondly the choice of payment vehicle. The strength of hypothetical questioning techniques is the ability to create, present and describe a range of different scenarios to an individual, and to explore situations, which do not currently exist and on which no past actual data on behaviour is available. Through the efficient design of alternative scenarios the investigator is able to extract the maximum information for a limited sample size.

In an environmental survey such scenarios might describe different levels of traffic noise in a residential area, some of which might lie outside the respondent's range of experience or familiarity. It is important however that the descriptions are relevant and meaningful to the respondent. Generally this involves presenting respondents with an amount of simple, though often technical data to indicate the meaning or effects of different levels of an impact.

As an addition to this approach the development in computer graphics and visualisation techniques is creating the possibility of simulating alternative environmental scenarios. Such techniques will be particularly important for any attempts to value the visual effects of project development, although past experience of environmental simulators is not altogether encouraging.

We do not believe that this is necessarily the best way to approach this issue and tends to overestimate the ability of the lay-person to follow detailed instructions and absorb information. Rather we support an approach which asks individuals to think about a series of situations which they themselves have experienced or could imagine and to use these as the basis for the valuation exercise. Such an approach has been developed in order to measure individuals' willingness to pay to secure road scheme alternatives which have environmental benefits relative to other schemes (Hopkinson et al, 1990). In a similar way this has been used by Schulz (1985), who asked 4,500 Berliners the maximum monthly sum they would be prepared to pay for different air qualities with the air quality characteristics described in terms of "Berlin air", "Small town air", "Smog" or "Holiday air".

There are worries that such surveys might suffer from numerous forms of response and non-response bias. Mitchell and Carson (1989) highlight three major types of response bias arising from:

(1) incentives to misrepresent true willingness to pay eg. strategic bias, compliance bias;
(2) implied cue values when the elements of the scenario are treated by the respondent as implying the correct value for the "good" eg. starting point bias, range bias;
(3) scenario mis-specification where the respondent does not interpret the scenario as the researcher intends it to be understood.

Our experience has found that in order to overcome (3) it is necessary to administer the survey using an interview rather than a questionnaire procedure when dealing with complex alternatives. With careful survey design it is possible to overcome or minimise most of the elements of (1) and (2). This said however we feel that hypothetical survey techniques work better in some circumstances and for some impacts than others. Following Cummings et al (1986) we share the belief that in order to obtain meaningful valuations it is necessary that:

(i) respondents are familiar with and understand the commodity to be valued;
(ii) respondents have some prior experience with the monetary valuation of the commodity;
(iii) a hypothetical market that is realistic is capable of being formulated.

This excludes from consideration those environmental effects which are not perceived directly by people (eg. carbon monoxide emissions) or else where the effects are complex and highly uncertain (eg. damage to the scientific value of an ecological site).

Given these reference operating conditions we believe that hypothetical questioning techniques could be used to obtain meaningful valuations of a number of local amenities which people are familiar with such as clean air, peace and quiet and recreational facilities. We feel that, whilst most people do not have any direct experience of valuing such goods, such issues form part of individuals decisions about where to live. We have previously discussed the problems with the hedonic price method. We believe however that a method which uses stated preference questions related to choice of housing between locations known to the respondent offers the potential of overcoming all the problems discussed above.

In conclusion we feel that enormous advances have been made in hypothetical survey techniques in the past few years and the evidence indicates that people are able to value certain environmental costs and benefits in money terms. We feel that such techniques could be used at the scheme specific level to provide meaningful valuations of a number of local effects which people are familiar. Further research is needed, but of all the techniques of environmental valuation, stated preference techniques offer the greatest unexploited potential.

## 6. THE DECISION-MAKING PROCESS

We have argued earlier that the incorporation of a greater degree of monetary valuation of environmental effects is feasible and can contribute towards better decision making in relation to trunk road schemes. It needs to be borne in mind, however, that the decision making process is the amalgamation of a series of interacting components and that to a large extent the process as a whole cannot be significantly stronger than the weakest of those components. In attempting to progress the treatment of environmental impacts in highway scheme appraisal, it is important to ensure that other relevant aspects of the assessment process as a whole remain consistent and appropriate to a potentially amended role. In particular, it is necessary to ensure that the overall evaluation framework is developed so as to ensure its ability to absorb, process and represent an enhanced information base on environmental impacts and their valuation in a way which is as helpful as possible to the decision making process. This is true independent of the precise way in which environmental effects are characterised and their relative importance established.

A recent investigation of trunk road appraisal techniques (Sanderson, 1989; 1990) has emphasised the varying social, political and administrative context within which highway investment decisions are made throughout Europe. Different approaches to evaluation are appropriate to different situations. At present, the UK's is one of the least formalised among the main European nations. It is worth asking whether some of the more formal methods that other nations are increasingly using have a role to play in the UK. Greater attention to environmental impacts is one step in this direction, but the process of gathering this information will almost inevitably generate further information to be weighed in the decision making process. It is

already the case that the Leitch framework generates a great deal of information and many would argue that this information can be difficult to process, evaluate and balance.

Recent rapid developments in computer technology are making feasible now a much greater role for computer-based decision support than has hitherto been possible, even in the context of decisions as complex as those posed by highway investment alternatives. We emphasise *support* for decision making and would wish to distinguish this clearly from the mechanisation of the decision making process through a series of mathematical formulae. There is a strong case for looking carefully at the ability of decision support to help cope with the data generated by the appraisal process, a *fortiori* if more quantitative information relating to environmental impacts is envisaged. It should be emphasised that, although we believe there is a case for extending the scope of monetary valuation within the appraisal process, we do not believe that any single weighted aggregation of a list of scheme effects can alone form a basis for good decision making. Any decision support system must present as clearly as possible information on the full range of money-valued and other inputs, allowing that information to be analysed in a variety of ways, both with and without aggregation.

Computer-based decision support has a role to play throughout the span of the design, evaluation and decision process. It should not be viewed as only relevant to final evaluation. In particular, there is a strong case for arguing that it is in the early stages of scheme design that many cost-effective changes could be induced to scheme options to improve their environmental characteristics. For this process, relatively broad-brush tools are needed which draw attention to potential problems and conversely point out aspects of scheme design which, in any particular location, appear unlikely to affect option ranking.

The second main way in which computer-based decision support is desirable is as an input to option ranking, at the various stages and in the various ways that this is progressively undertaken throughout the overall decision making process. Such support facilitates the sensitivity testing which should be central to decision making (see, e.g, Mackie et al, 1988). It encourages a recognition, too, of the uncertainty that surrounds many of the inputs to the appraisal process - uncertainties about values and uncertainties in forecasts - both of which merit explicit treatment.

The argument that a degree of formalisation of the processing of the data relevant to highway scheme appraisal is inconsistent with a decision making process that can be understood and supported by interested parties is in our view only valid against the extremes of quantification and mechanisation of the process. It is more valid to criticise the status quo for failing to use all the available tools to clarify the strengths and weaknesses of available options. Greater attention to the formal evaluation of environmental impacts should be complemented by a more up-to-date appreciation of what formal decision support can do to aid difficult decisions.

## 7. CONCLUSIONS

We have covered a wide range of issues in this paper; in this section we simply list our main conclusions.

(1) We believe it appropriate to divide the environmental effects of road schemes into strategic and local. Whilst we consider that there are deficiencies and omissions in current procedures for dealing with local effects, it is the complete lack of any procedures to deal with strategic issues that is the most serious concern.

(2) We believe that is necessary to think in terms of a hierarchy of decision levels, with environmental factors being important at all of them. At the top of this hierarchy is the formulation of an overall transport strategy which is sustainable - in other words, it forms part of an overall strategy to live within the constraints imposed by a desire to leave the next generation a stock of environmental wealth no less than that which we ourselves inherited.

(3) At the local level, we believe that the range of effects and impact groups need extending (for instance to cover vibration, sense of danger, loss of daylight and privacy) and that too much weight is placed on quantification by means of arbitrary thresholds.

(4) We doubt whether monetary valuation of environmental effects has a useful role to play in decision taking at the strategic level at the present time. What is needed is the development of a transport strategy, in terms of pricing, management, investment and land use planning, that forms part of a strategy for sustainable development for the economy as a whole.

(5) At the more local level, we do believe it would be useful if environmental effects could be valued in money terms, in order to shed light on the extent to which people are willing to sacrifice environmental amenity in order to gain time or cost savings or vice versa. We would stress that this still needs to be part of an appraisal of alternative local strategies for dealing with transport problems, and are concerned that appraisal often only takes place at the level of particular sections of road routes (eg an individual bypass) and does not look at alternative local strategies in terms of routes or modes.

(6) We believe that techniques of valuing environmental effects have improved enormously in recent years, and that in particular developments in stated preference techniques offer the prospect of more successful applications in this field. Nevertheless, the difficulties involved in obtaining reliable results should not be underestimated, and there is a need for much more research in this area.

(7) Whatever progress is made in valuing environmental effects, we do not believe that it is sensible to think that decision taking ever could or should be reduced to the calculation and comparison of NPV's. We believe that disaggregate forms of presentation of evidence, which make clearer the incidence of effects and the assumptions on which they are estimated, are much to be preferred. Indeed, we regard the current practice of quoting NPV's which include monetary valuation of some, but not all, non-financial costs and benefits, as being positively misleading.

(8) There will therefore remain a problem as to how to take decisions in the face of a large volume of evidence of varying reliability, and in this context we believe that computerised decision support systems offer the potential to assist in, though not replace, the weighing up of the costs and benefits of the alternative courses of action by the decision-makers in question.

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