

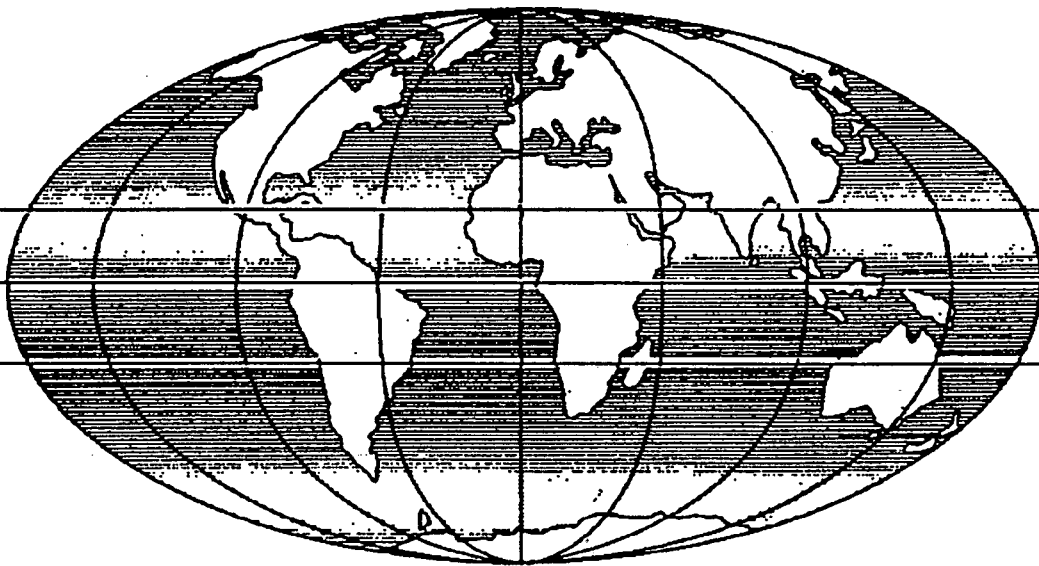


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by **G D Jacobs**



**Overseas Centre
Transport Research Laboratory
Crowthorne Berkshire United Kingdom**

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THE INCLUSION OF ACCIDENT SAVINGS IN HIGHWAY COST-BENEFIT ANALYSES

Dr G D Jacobs
Overseas Unit, TRRL, Crowthorne, Berks, RG11 6AU, England.

A INTRODUCTION

The objective of providing a new road may be to support a particular developmental activity, to provide fundamental links in a country's or a region's road network, or perhaps to meet a strategic need. Alternatively a road improvement may be proposed to increase the structural or volumetric capacity of an existing road to cope with higher traffic flows. Occasionally the objective of the road improvement may be, quite specifically, to improve it's safety. Depending on the objectives of the investment, the project will be appraised against different sets of criteria.

In order to appraise a project, estimates need to be made of the costs associated with the project and the benefits that are expected to occur. The benefits which might be considered are:-

- (i) direct savings on the costs of operating vehicles
- (ii) economies in road maintenance
- (iii) time savings by travellers
- (iv) reductions in road accidents
- (v) wider effects on the economic development of the region.

Historically highway cost-benefit analyses carried out on projects in Third World countries have tended to be based on operating cost savings only although in recent years time savings are becoming more common. Three reasons are usually put forward for excluding savings based on reductions in road accidents. These are:-

- (i) road accident costs are difficult to determine
- (ii) changes in road accident rates following a specific road improvement are difficult to predict
- (iii) even if accident benefits were to be included, their effect on the economic appraisal would be minimal.

After commenting on points (i) and (ii) above, this paper presents results of work carried out in a number of countries which indicate that economic benefits from reduced accidents may add significantly to Net Present Values or rates of return derived and that the ranking of alternative schemes may change with the inclusion of accident savings.

B METHODS OF COSTING ROAD ACCIDENTS

Whilst few people would deny the extent and importance of the road accident problems in developing countries, many planners, politicians and economists avoid the explicit quantification of the cost of accident prevention on the grounds that to do so would be

too difficult and indeed too controversial. If in fact accidents are not costed then the overall expenditure on road safety is unlikely to be "optimal". In particular, if road safety effects are ignored in transport planning and design then there will certainly be a severe under investment in safety. Even within a given transport budget, too much might be spent on some aspects of safety and too little on others. The inefficient allocation of resources in this way could certainly be avoided by the constant use of costs of accidents and values of accident prevention in highway and transport planning.

The question is then how are costs of accidents and values of accident prevention to be defined in principle and estimated in practice. In order to assist with this problem, the Overseas Unit is presently preparing a document advising developing countries on how to cost road accidents. Whilst no single method can be said to be ideal (not least because the definition of accident costs and values depends crucially upon the use to which they are put), two methods appear relevant. The first of these is the "value of risk change" approach in which one proceeds from the premise that the typical public sector investment in safety improvement, in effect provides each individual affected with a very small reduction in the risk of involvement in a fatal accident. The value of prevention of one accident involving one fatality is defined as the amount in aggregate that all the affected individuals in society are willing to pay for these small (marginal) risk reductions both for themselves and for those they care about. Whilst ideally suited for use in conventional cost-benefit analysis, the major difficulty with this method is deriving a value based in turn on complex questionnaires where individuals are asked to place a monetary value on what they would pay for very small reductions in accident risk.

The second acceptable method is the "gross output" (or "human capital") approach in which the cost of a traffic accident involving one fatality is treated as the sum of real resource costs (such as vehicle and property damage, medical and police costs) and the discounted present value of the victim's future output (based in turn on average current wage rates). The value of the prevention of an accident is correspondingly defined as the avoided cost. In this approach it is common to add a significant sum to reflect the "pain, grief and suffering" of the accident victim and those who care for him or her. This method has until recently been used by the British Department of Transport for the last twenty years or so and was used by the author in the case studies presented in this paper.

C PREDICTING CHANGES IN ACCIDENT RATES

Apart from the problem of costing road accidents, another reason put forward above for their common exclusion in highway cost-benefit analyses is that changes in accident rates following a specific road improvement are difficult to quantify. Indeed, few studies of factors affecting accident rates have been carried out in developing countries and at this stage, predictions cannot be made with any certainty. Also, many of the results indicate that findings from developed countries cannot be directly transferred to

the Third World because of the different physical, cultural and traffic conditions found in most developing countries.

In spite of this scarcity of data, specific comments on the effects of highway engineering improvements on accident rates in developing countries can be made and are described in Overseas Road Note 5... "A guide to road project appraisal" (TRRL Overseas Unit, 1988). In considering the effects of highway improvements on road accidents, Overseas Road Note 5 draws a distinction between:-

- (i) accident prevention resulting from improved standards of highway design and planning

and

- (ii) accident reduction resulting from low cost engineering counter measures introduced to improve the safety of specific sites.

Most highway design and safety studies in developing countries (TRRL Overseas Unit, 1988; Jacobs, 1976) have investigated the relationship between (personal injury) accident rates and geometric design characteristics for rural roads. In these studies, the number of junctions per kilometre, horizontal and vertical curvature and road width were found to affect accident rates. In one particular study (TRRL Overseas Unit, 1988) the construction of a dual carriageway road carrying up to 20,000 vpd was found to reduce injury accidents by up to 50% and fatal and serious accidents by about 25%. The effects of the different improvements in highway design are not additive and there is clearly a limit to the likely benefits that can be obtained from improved design. From the studies referred to above, it may be possible to expect up to a 40% reduction in accident rates on an existing road with comprehensive improvements in geometric design and planning. Although these studies only allow for broad estimates of accident reductions to be made for any given road improvement, the costs and benefits, can of course, be examined over a range of likely outcomes.

D THE EFFECTS OF INCLUDING ACCIDENT SAVINGS IN ECONOMIC APPRAISALS

In order to illustrate the effects of including accident savings in highway cost-benefit analyses, use is made of data collected by the Overseas Unit on projects undertaken in Cyprus and Jordan over the period 1982-84. As part of these studies it was necessary to cost road accidents either nationally or on specific roads under investigation. In all these projects the "gross output" or "human capital" method approval was used to cost accidents and in most cases costs were derived both with and without sums added to reflect pain, grief and suffering. As stated above, it is difficult to assess with any degree of accuracy the likely effects on accidents of specific highway improvements. Consequently results are presented such that economic benefits from reduced accidents are assessed over a range of possible percentage reductions in accidents. Information is also presented of a more "hypothetical" exercise carried out using data obtained from a project in India.

1. Feasibility studies in Cyprus

Over the period 1980 to 1986 the British transport consultants Hughes Economic Planning carried out a number of feasibility studies in Cyprus. These included a study of a proposed road improvement from Limassol (1982) the main port of Cyprus to Paphos, the centre of a thriving tourist industry (see Fig. 1) and an appraisal (1985) of the likely benefits which would result from an improved road link between the new dual carriageway running from Nicosia, to Limassol and the busy port of Larnaca. At the time of this study there were three roads all of relatively poor alignment linking the new road and Larnaca (see Fig. 1) and the options were to either improve routes A and C or routes B and C.

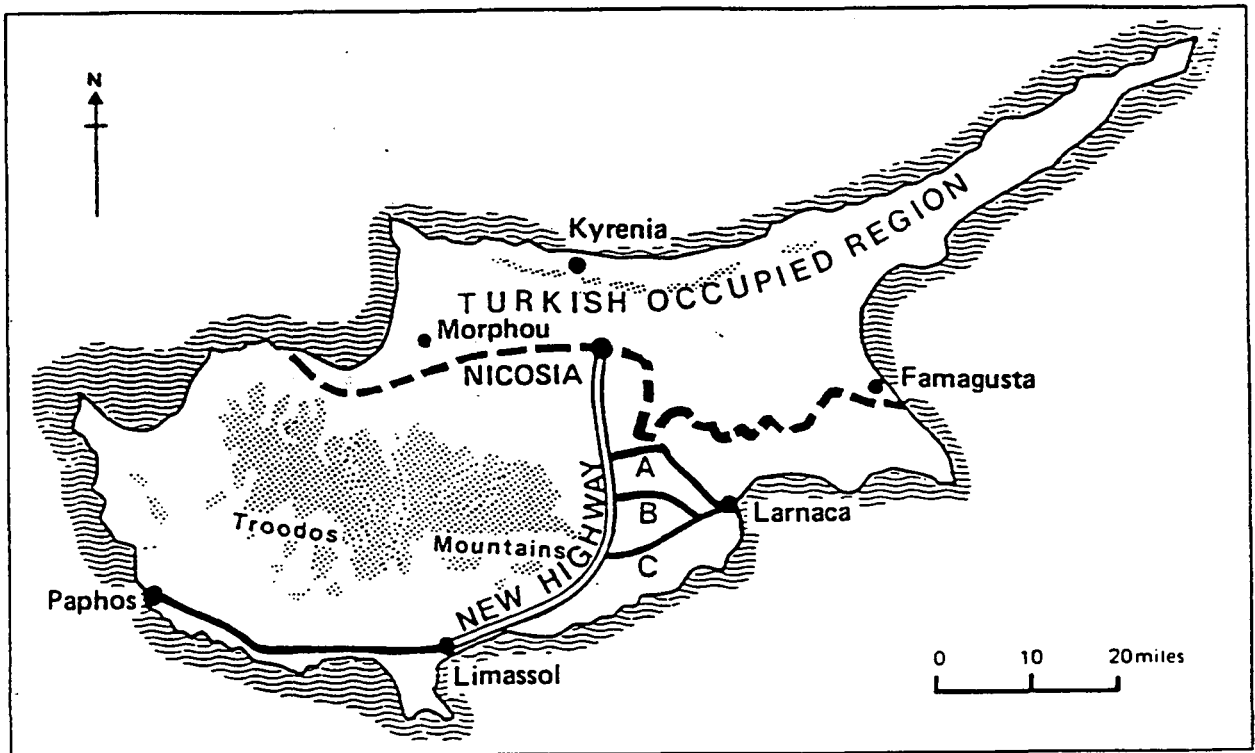


Fig. 1 Roads studied in Cyprus

The Overseas Unit was asked to assist in these two studies by providing estimates of road accident costs on each of the routes and the benefits likely to result from reduced accident rates following the proposed road improvements.

Having derived the above, the effect of including accident savings on the Net Present Value (NPV - defined as the total discounted net benefits estimated over the life of the project

minus total discounted costs) assessed by the consultants for the Limassol - Paphos Road was determined. The results are given in Figure 2. The proposed improvements to the highway included road widening from an average of 6 metres to 7.5 metres, a reduction in the number of junctions per kilometre from 1.7 to 1.5, improved sight distances and reduced road roughness. Earlier research work (Jacobs, 1976) carried out by the Overseas Unit suggests that the combined effect of these improvements might be to reduce accidents by some 25 - 35%. Thus the effect of including accident savings in the appraisal (with benefits covering the period 1984 - 2004) would be to increase the NPV, assessed at about £14.5 million at 1984 prices by 16 - 20% if accident costs included sums to reflect pain, grief and suffering and 10 - 15% if they did not.

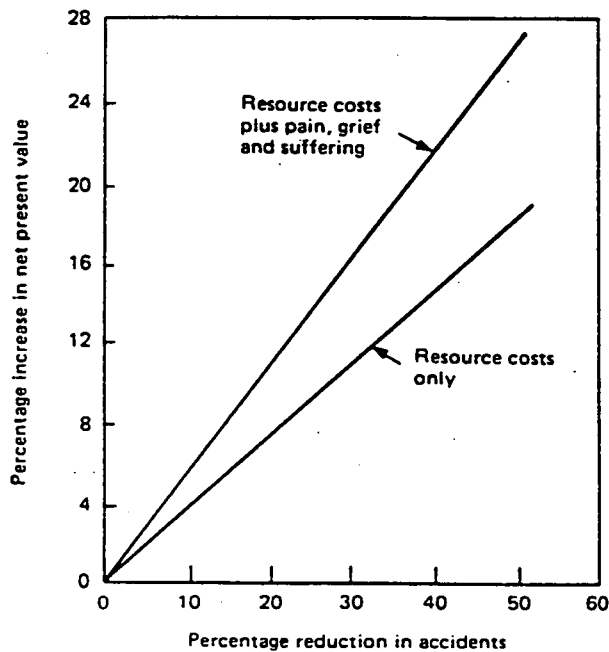


Fig. 2 Feasibility Study Limassol - Paphos Road
Cyprus 1982: percentage increase in net present value by including accident cost savings

In the appraisal carried out in 1985 the alternatives were to improve the alignment of existing routes with the road being

widened from 6 metres to either 7 metres or to dual carriageway standard. From the results given in Table 1, it can be seen that by including possible accident cost savings in the appraisals, the NPV's are increased by 10 to 25% depending on either the standard of improvement or the routes selected.

Table 1 Larnaca Link Study Cyprus 1985

OPTION	DESCRIPTION	Per cent increase in NPV by including accident savings
A + C	Both 7m	10
A + C	A = Dual carriageway C = 7m	15
A + C	Both dual	20
B + C	Both 7m	11
B + C	B = Dual carriageway C = 7m	16
B + C	Both dual	25

In these analyses therefore, it would appear that the inclusion of possible accident savings increases the derived Net Present Values significantly and that accident savings, when measured against the more traditional benefits from reduced vehicle operating costs, are by no means insignificant.

2. Feasibility studies in Jordan

Over the period 1980 - 1981 the British transport consultants Halcrow - Fox were involved in a range of transport projects in Jordan including feasibility studies of proposed major road improvements. Amongst these were proposed improvements to the roads from Salt to Suweilih and Zarqa to Rusaeifa (see Fig. 3). The former involved the upgrading of 8.4 km. of road from single to dual two-lane carriageway and the latter the upgrading of 2.2 km. of road from single to dual two-lane carriageway. The consultants estimated the first year rates of return of the proposed improvements using 1990 as the first year of full benefits.

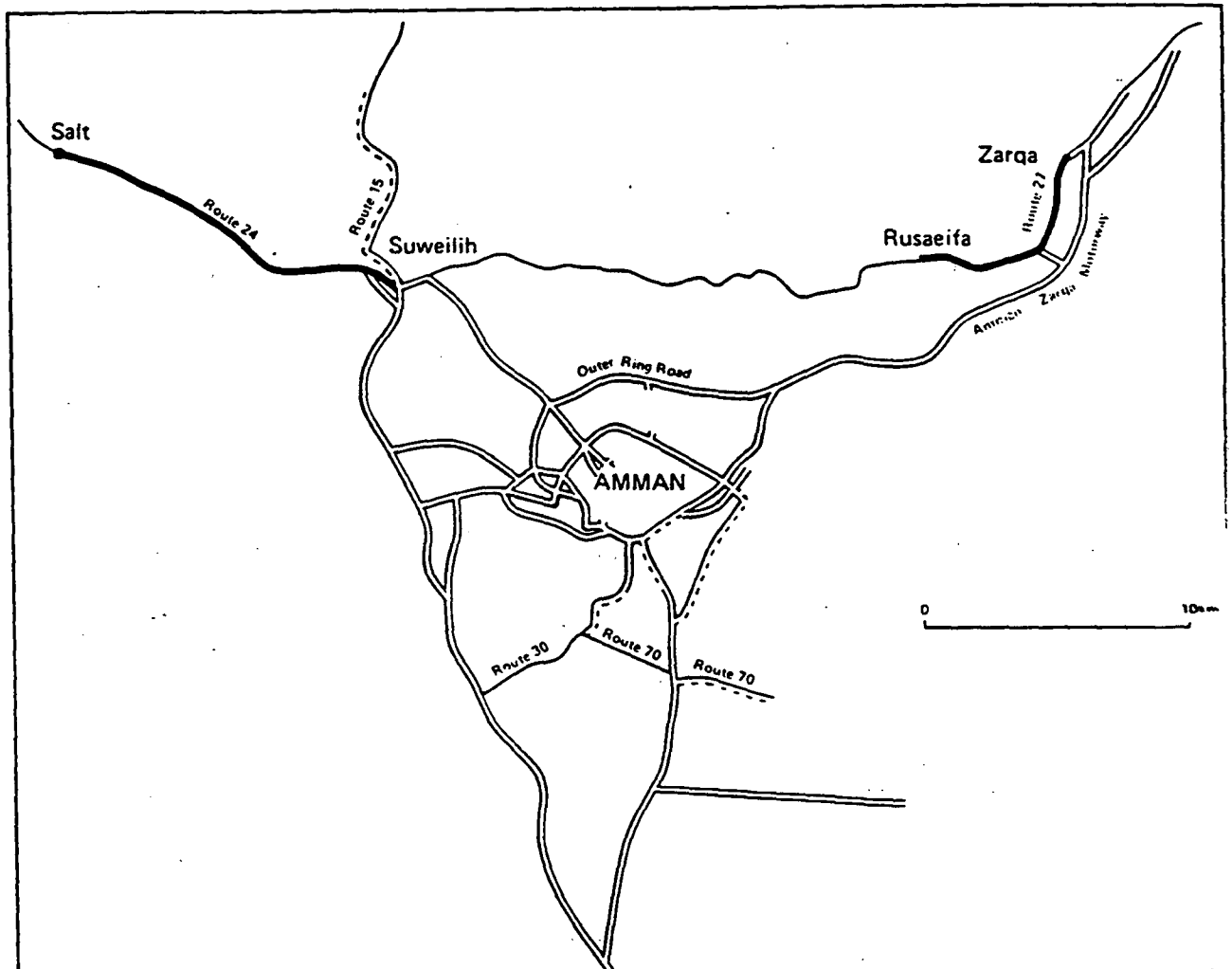


Fig. 3 Roads studied in Jordan

Whilst the studies by Halcrow - Fox were drawing to a close, joint British - German consortium were making a broad review of the transport sector in Jordan and they asked the Overseas Unit, TRRL to advise on road safety issues including the costing of road accidents. Using the data collected for this review it was thus

possible to determine the likely accident cost savings in two of the feasibility studies undertaken by Halcrow - Fox and the results are shown in Fig. 4 and Fig. 5.

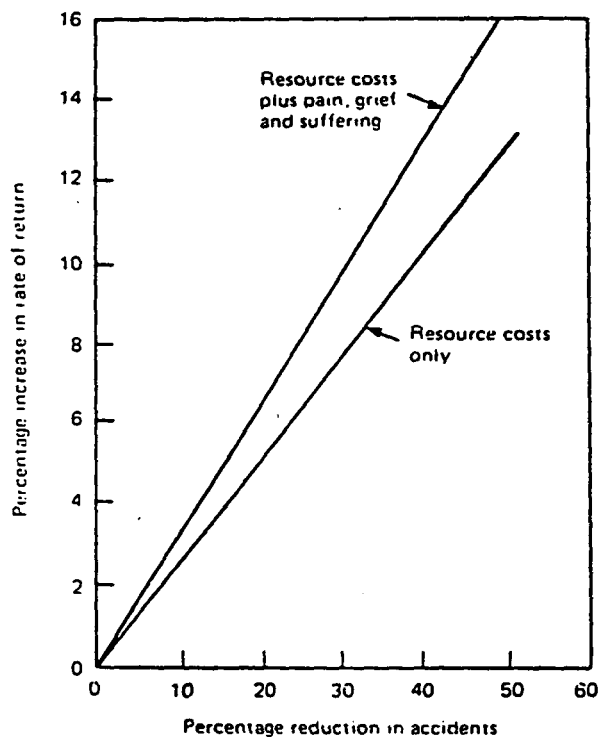


Fig. 4 Salt - Suweilih Road Jordan: percentage increase in first year rate of return by the inclusion of savings in accident costs

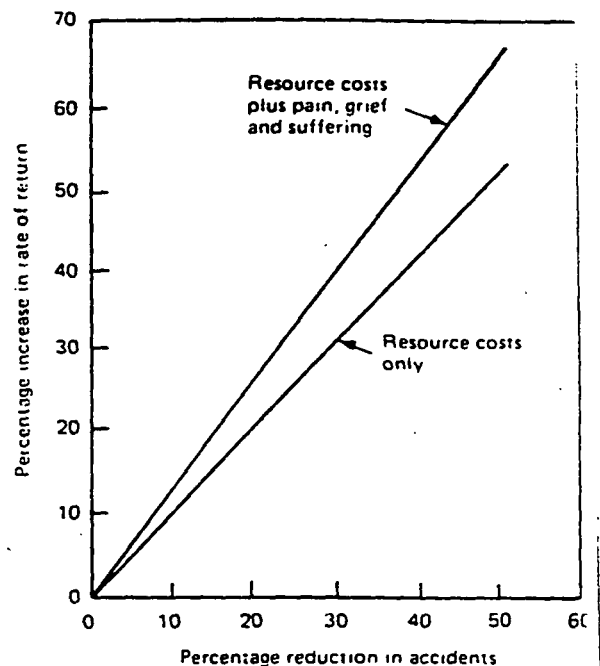


Fig. 5 Zarqa - Rusaeifa Road Jordan: percentage increase in first year rate of return by the inclusion of savings in accident costs

Work carried out by the Overseas Unit suggests that the upgrading of a single carriageway to dual carriageway may have the effect of reducing accidents by 30 to 50%. On the Salt to Suweilih road the effect of including accident savings might be to increase the estimated first year rate of return by 10 to 16% (assuming sums are included to reflect pain, grief and suffering). On the Zarqa to Rusaeifa road however possible increases range from 40 to 60%. In both cases (unlike those in Cyprus) benefits estimated by the consultants included time savings as well as changes in vehicle operating costs. Even so, possible savings from reduced accident rates are by no means insignificant and in the case of the Zarqa to Rusaeifa road represent almost 50% of benefits from time and operating cost savings. This road is in fact particularly dangerous with, on average, over 20 accidents taking place per kilometre of road per annum. In these circumstances it may well be that a project which appears not to be feasible (ie. with a first year rate of return below the discount rate) may become so by the inclusion of accident savings.

3. Case study in India

In order to determine the effects of including road accident savings on the ranking of projects, Hills and Jones-Lee (1981) used data from a study in India detailed by Adler (1971). Whilst the projects were, in the strictest sense "hypothetical", they were sufficiently typical of a Third World road improvement decision making task to form a legitimate basis for the analysis. The example was as follows.

Two cities in India, with populations of 1 million and 400,000 respectively, about 190kms apart, are connected by a two-lane stabilised gravel road. The highway authorities are considering a number of mutually exclusive schemes to improve conditions for traffic between the two cities. These are as follows:-

- Scheme A the "invest-nothing" case, with continued maintenance of the existing gravel road;
 - Scheme B paving the existing gravel road, with minor improvements to alignment and minimal local widening;
 - Scheme C paving the existing gravel road, together with substantial improvements to the width and alignment of the right of way, reconstruction of bridges, drainage culverts etc.
- and
- Scheme D the construction of an entirely new and shorter road with the existing road remaining in use, mainly for local traffic. The new highway will have some restrictions on access and a design speed of 100 km per hour throughout it's length.

In all the schemes, 1969 was used as the base-year with a time horizon of 1990: the monetary units used for costs were the Indian Rupee and Paisa (R1 = 100 Paisa) at 1969 prices and, where appropriate, take into account the foreign exchange costs (using a shadow weighting of 1.75). All are net of taxes and subsidies. A 12% per annum discount rate was used throughout.

As far as capital costs, vehicle flow, vehicle operating costs etc. were concerned assumptions were adopted that were realistic and representative of such schemes in developing countries. Following discussions with members of the World Bank who have direct experience of such schemes, it was assumed that Scheme B would raise accident-rates by 30%, Scheme C would have no effect on accident-rates, while Scheme D, which was purpose-designed on a new alignment, would incorporate a number of safety features which together would serve to reduce accident-rates by 30%.

The authors then examined the effect upon project-rankings of varying the cost of a fatal accident from 0 - 400,000 Rupees and of varying the ratio of fatal to non-fatal accident-costs from five to twenty. For all ratios of fatal to non-fatal accident costs,

variation in the cost of fatal accidents had a significant impact upon the Net Present Value of those projects that alter accident rates and, more significantly, had a substantial effect upon project-rankings. The results for an intermediate fatal / non-fatal accident cost ratio are summarised in Figure 6 and it can be seen that an increase in the cost of a fatal accident from 0 to say 150,000 Rupees serves to raise Scheme D from third to first place in the project-ranking.

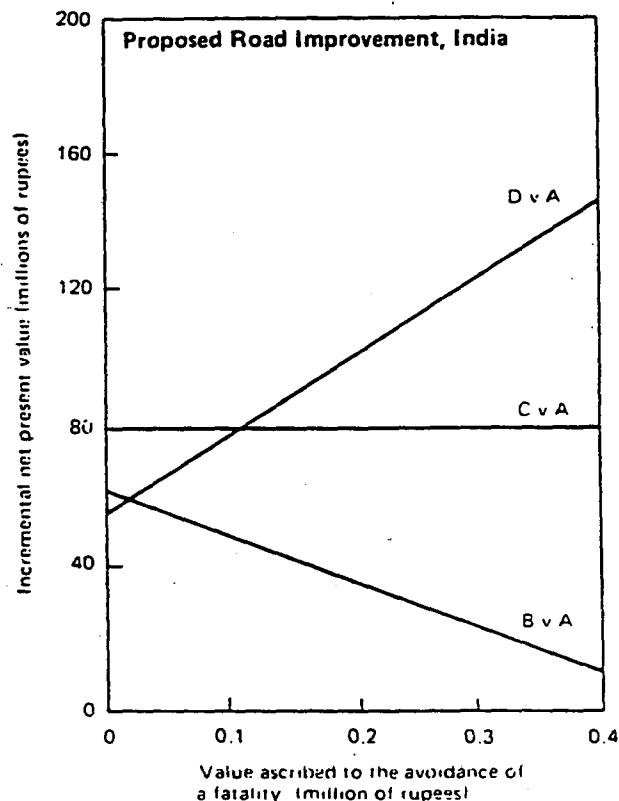


Fig. 6 The effect on overall net present value of accident-prevention (where a fatality is assumed to have a value 10 times that of an average injury)

F SUMMARY

Over the last ten years or so there has been a growing awareness of the seriousness of the road accident problem in developing countries. With scarce financial resources it is important to ensure that any safety improvements that are introduced to deal with this problem can be justified on a cost-effective basis. In order to do this and also to determine the amount of money in total that can justifiably be spent on road safety, it is essential that a recognised method be used to cost road accidents. The Overseas Unit TRRL is presently preparing a manual on how best to do this.

Another problem associated with the inclusion of accident savings in highway cost-benefit analyses is that changes in accident rates following a specific road improvement are difficult to quantify. Whilst it is true that relatively little work has been done on the relationships between accident rates and highway design in developing countries, sensitivity analysis can be used to determine for a given road improvement the possible benefits over a range of likely outcomes.

This approach has been used on a number of case studies with results presented in this paper. These analyses indicate that far from being a matter of subsidiary importance, the size of accident costs or values of accident prevention can (and in most cases almost certainly will) have a marked effect on both the ranking of transport projects, in terms of Net Present Value within mutually exclusive groups, and on the magnitude of net benefits generated by any given project. In short it would appear that the issue of the "appropriate" cost to associate with particular types of accidents - or values to place on their avoidance - is not one that can legitimately be ignored on the grounds that accident costs have little overall importance in project appraisal. The message of the sensitivity tests presented in this paper is that such costs are potentially very important indeed.

G ACKNOWLEDGEMENTS

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