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APPRAISING ROAD PROJECTS

A. CALCULATING THE BENEFITS

B. APPRAISAL WITHOUT DATA

C. FORECASTING ROAD USE

D. COST EFFECTIVENESS

E. LABOUR INTENSIVE SOLUTIONS

F. ALTERNATIVES

G. ADVICE AND REFERENCES

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A. Calculating the Benefits

1. The principal benefits arising from road investments can be divided into:

i. Road User Savings (or savings on vehicle operating costs)
ii. Reduced Maintenance Costs
iii. Time Savings
iv. Accident Savings
v. Induced Benefits

2. Induced traffic generation is frequently used as a measurement of benefit. On more careful thought, however, it will be realised that induced traffic generation must be a function of road user savings and/or time savings. However, it does remind us of an important point. That is, that the standard benefit (on LVOC) serves to restrict road improvements to those areas with greatest current traffic flows. Ultimately this tends to mean that all road investment could go into urban areas. The induced traffic approach does divert investment away from present centres of economic activity to areas with hitherto relatively unexploited potential.

i. Road User Savings

3. Of all the benefits these are the most easily measurable. However, "easily" is very much of a relative term for data on which to assess the savings on wear and tear of vehicles and/or their operating costs is desperately scarce.

4. The most useful study - which establishes relativities of savings for different types of vehicles, and roads is the TRRL Study of 1976 (Report 723) carried out in Kenya. The TRRL "User Manual" of their Road Transport Investment Model should also help for establishing a quantitative framework for calculating VOC savings. However, facts are more difficult to come by as they are country, or region specific. Perhaps the best source of data is to be found in Consultants' Reports as they usually need to carry out surveys of VOC when they prepare road improvement feasibility studies.

ii. Reduced Maintenance Costs

5. The commonest demand for high quality roads from LDCs arises from the desire to minimise maintenance costs. The system of financial responsibility makes

it desirable that Roads Departments, usually with limited budgets should press for quality roads with lower maintenance costs.

6. As a rough guide, paved roads maintenance costs can vary between 3% of the capital cost and 0.7% of their cost - but so much depends upon the amount of use made of roads that generalisations are dangerous - sufficient to say however that from an economic point of view maintenance costs are a few per cent points of the capital costs.

7. Feeder roads, with very little usage, can have maintenance costs of between 0.6% and 1.4% of the capital cost.

8. An assessment of the maintenance ability of the organisation responsible is always essential.

iii. Time Savings

9. In Ldcs the average value of time is lower than that in developed countries - indeed it could be argued that in many cases time has a zero cost.

10. However, every value is region specific, and in practice attempts at valuing time are not fruitful. The data is so thin that few studies, quite justifiably attempt this. Where it is thought this could be justified - possibly in urban areas, one could use the average minimum wage - although TRRL studies in Kenya showed that passengers in buses had incomes well above the average. One needs to be convinced that time saved will be used productively.

11. Generally, one would use time savings only where there was clear evidence that substantial savings would occur. For freight vehicles even an hour saved is unlikely to permit an additional trip. Time saved is rarely additive so time savings are likely to be minimised. Time savings should not be used when user savings already justify the benefit and should be ignored in all circumstances unless the time saving is substantial (say in excess of an hour). One possible proxy, when new roads are being considered, and when public passenger transport would follow, is to use fares paid by passengers on similar routes. In practice, however, few studies attempt this. Leisure time savings in Ldcs have not been included as a benefit on the philosophical grounds that as far as aid donors are concerned assistance is given to help people become more productive.

iv. Accident Savings

12. Evidence of the effect of road investment on accident incidence and severity is scanty for developing countries. Generally one may expect accidents to decrease if a wider road is envisaged; for urban roads we have evidence that the casualty rate increases as speed increases. On rural roads the number of junctions is the most important geometric aspect of the road affecting the incidence of accidents (see LR 732). As any road investment is likely to serve increasing volumes of traffic in the future the total number (but not per vehicle - km) of accidents is likely to increase. Estimates of accident costs in Ldcs are given in LR 206. The usual short-hand method of handling accidents in road appraisal is to include insurance costs in the vehicles operating cost figures and omit accident costs. Otherwise consult local insurance companies and add allowance for loss to society of foregone production by individual injured.

v. Induced Benefits

13. Normally one uses either user savings (VOC, time, accidents) or induced benefits but not both otherwise double counting occurs.

14. Induced benefits should be considered when

a. existing traffic volumes are low - as on feeder roads (if a road is carrying below about 75 vehicles per day user cost savings will rarely justify investment unless road construction and maintenance costs are exceptionally cheap);

b. There is no existing traffic, ie when penetration roads that will not carry diverted traffic are being appraised;

c. in the forecasting of future traffic;

d. where increased production will not necessarily be translated into generated traffic, eg when increased homestead consumption can be anticipated.

15. Indicators to look for are the extent of marketed production, the cost of transport as a proportion of total production costs and sale value of production, the extent of cultivable land not yet cultivated, the degree of landlessness, and for passenger travel the propensity to travel by similar groups of people elsewhere in the country, the importance attached to gaining education, and

the spatial relationship between service centres, town and the rural population. Many of these can only be judged "on site".

16. It is now becoming more common to bring in social benefits of roads - improved access to social facilities - schools and health centres. However, there is no practical way of measuring these benefits and since most investments have indirect beneficial effects it is not clear why they need singling out for roads. In any case there are always social costs to road improvement, disruption to present transport and social systems and it is far from clear why indirect benefits should be included but indirect costs excluded. However, the use of social facilities, unquantified, can be used as indications to measure the attractiveness of various possible feeder road options where no other distinguishing data exists.

B. Appraisal Without Data

17. In most cases quantitative data will be scarce and dubious and largely restricted to VOC. Under the circumstances one needs a system for cross checking the results. The most effective way of doing this is to estimate the capital cost of the road(s) and relate this to the total population - or the number of hectares under the influence of the road (admittedly both of these involve guesses), or indeed to the number of vehicles in the area.

18. Then by taking, as a rule of thumb, a first year rate of return of 10% we get some feel for the increased output or saving required to justify this investment. If, for example, the road cost £100 per annum per head for people with a per capita income of £50, it is hardly likely that a farm family of say 5 could possibly generate sufficient output to justify this investment. Possibly, and optimistically, a 10% increase in output might be achieved - though 5% would seem more sensible.

19. Other proxy's could be the additional tons of produce required if the annual costs were to be met - or the annual benefits which every vehicle would have to achieve in order to meet these costs.

20. While the system is crude it is surprisingly effective.

C. Forecasting Road Use

21. This is a particularly hazardous exercise. It depends on knowledge of the present vehicle population and traffic counts. The latter, as will be obvious, needs to be carefully checked if they are to be believed - for sampling results can be very misleading.

22. Higher degrees of variability are associated with lower daily traffic volumes. All daily traffic counts are subject to substantial variation (see LR 427, Table 2 and figures 1 and 2). Repeating counts improves reliability more than extending the duration of counts. Continuous traffic counts of less than a week are highly unreliable. Only if the traffic flow exceeds 1,000 vehicles/day and a count for one week is taken four times in the year there is a 95% chance that the recorded average daily flow will be within ± 10% of the true mean in Kenya.

23. The composition of traffic is very important: heavy vehicles incur much higher vehicle operating costs and inflict greater damage on the road than light vehicles. There is a general tendency for the proportion of heavy vehicles to decrease as the traffic flow increases (cf forecasting but beware of exceptions).

24. A distinction should be drawn between normal, diverted and generated traffic. Fuller user surplus benefits are attributed to normal and diverted traffic, but by convention only half the benefits to generated traffic.

25. Attempts to forecast increased output from an area are subject to tremendous speculation - and in practice increased agricultural output is unlikely to lead to significant freight traffic increase. Passenger traffic is likely to increase far more.

26. Owing to the considerable uncertainties it is sensible to do a few "back of the envelope" sensitivity analyses using the figure given in Table 2 of LR 427 of TH & RRL as guides for the upper and lower limits. In judging forecasts take note of any complementary investments anticipated in other sectors, restrictions on vehicle imports or operation, and traffic trends since 1973 oil price rise.

27. IBRD evaluation reports of traffic forecasting show no consistent divergence from forecasts - the forecast results varied very greatly - both over and under optimistic.

28. Perhaps the most useful piece of practical advice one can give is to ensure that new or improved road investment should not lead to sudden leaps in design standards - from a dirt track to a sealed highway unless it is absolutely clear that demand will increase commensurably (eg opening of a mine) - but that road improvement should take place on the basis of gradual improvement.

D. Cost Effectiveness

29. One of the most useful tasks in the approval stage is to ensure that once the objectives have been agreed that the most cost effective solution is pursued.

30. The costs of any particular design will depend upon:

i. Terrain - mountainous, hilly or flat.
ii. Soil strength - which will be determined by geology and rainfall.
iii. Traffic density - which will affect the surface depending on number and type of vehicle.

31. Generally speaking, most countries establish national design speeds for their roads. These vary depending upon whether the terrain is mountainous, hilly or flat.

32. The design speed, plus traffic density, will determine what the cost of the road should be. The relevance of design speed increases as area becomes more mountainous.

33. Design speed will determine:

i. The alignment - what curves will be acceptable to maintain the desired speed. Clearly a high design speed for mountainous country will be tremendously expensive and could only be justified if traffic is very heavy.

It is certainly possible, and desirable, to alter the design standard in extremely expensive constricted situations, accepting that traffic will slow down. Signs can be put up to warn traffic to do so. The width of the pavement will also be affected by volume of traffic, and speed. Finally the gradient could be an important cost factor - the UK has a maximum gradient of 10%.

ii. Foundations - these will vary with soil, geology and rainfall. Heavy rainfall, and light soils will require expensive investment if the roads are not to be swept away or rapidly eroded.

Traffic density will also be an important variable.

iii. Surface - surfaces can be of earth, gravel or bitumen. The appropriate surface will be determined by the amount and type of traffic using them and thus the cost of maintaining them.

34. The cost of maintaining a bitumen road costing about £60,000 might be around 2% per annum, with 200 vehicles per day. A gravel road costing £10,000 km with 200 vehicles per day could cost some 10% of the capital value in order to maintain it. But generally speaking, the costs of maintenance should vary between 2% and 5% of the capital cost.

35. Governments, and especially PWDs, who are not responsible for capital costs will go for higher capital costs so as to save themselves recurrent costs.

36. Every road has its own peculiar combination of circumstances which require adaptation to achieve the most cost effective solution. For example:

i. "Spot improvements" may be the most appropriate answer - since not all roads deteriorate uniformly - and it is possible to predict where they will do so (eg low lying areas, black cotton soils).

ii. Concentration on areas where traffic is greatest.

iii. Build one or two curves which do not conform to the set standard.

iv. Removal of a few blocks of rock which will improve sight distance without altering the curvature of the road.

v. Since bridges are far more expensive per metre than roads so a more circuitous road route might be justified.

vi. It is often fairly cheap to put a hard surface on a road which may lead to significant savings in maintenance but conventional design standards may then intervene and dictate that a tarmac road needs new sight standards and a new alignment. This could be costly. A solution is to use a gravel road alignment to a tarmac surface.

E. Labour Intensive Solutions

37. Where labour is in ample supply and it is possible to organise it, labour has been used instead of machinery. For low quality roads - if labour is likely to cost less than US$1 per day it can usefully be concentrated. In Honduras a labour intensive rural road scheme which took some two years to organise has been building roads to the following standards:

Design speed	40 km
Width	4 metres
Gradient	12%
Base	10-15 cm

38. New roads on hilly and mountainous terrain have cost US$8.500 and US$17.500 per km.

F. Alternatives

39. It is most important to consider the full range of alternatives in transport investment: frequently road construction or improvement is seen as a solution when other cheaper alternatives would achieve the same end result. Traffic management measures, such as white paint, centre lines, may be as effective as widening a road; storage instead of provision of year round access; faster turnround time for freight vehicles rather than faster running speeds; improved driver behaviour through propaganda measures rather than the improvement of road geometry to reduce accident, and so on.

ADVICE AND REFERENCES

1. Transport and Road Research Laboratory (Overseas Unit) and ODA Advisers.

2. Useful References:

   A Road Transport Investment Model for Developing Countries (LR 674)

   A Review of Traffic Counting Methods in Developing Countries (LR 427)

   A Study of Road Accidents in Selected Urban Areas in Developing Countries (LR 775)

   Comparative Accident Costs in Developing Countries (LR 206 UC)

   Tables for Estimating VOCs on Rural Roads in Developing Countries (LR 723)

   The Economic Analysis on Rural Road Projects - IBRD - Working Paper No 241.

   A Guide to Transport Planning Within the Roads Sector in Developing Countries. D Bovill, I Heggie and J Hine. HMSO