# Infrastructure Notes

## Transport, Water and Urban Development

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### Paving of Unpaved Roads
### Economically-Justified Paving Costs

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*Under certain circumstances, paving of unpaved roads may be economically justified. To help road agencies identify unpaved roads that may be potential candidates for paving, this Note presents typical scenarios in which paving may be examined as a valid investment option. This procedure should be considered no more than a first screening process, and candidate roads that pass this first screening should thereafter be subject to further investigation that would include a more rigorous economic evaluation and evaluation of other aspects of the proposed paving, notably the environmental and social aspects. Candidate roads that did not pass this first screening would not be subject to further examination, at least not for the time being, and candidate roads with marginal economic feasibility should be subject to a more rigorous economic evaluation with refined data.*

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**INTRODUCTION**

The economic evaluation measures the economic worth of a project in order to ensure an optimal allocation of resources. It quantifies the project economic benefits and costs and compares them to the benefits and costs of the "without project" alternative, which is to keep the road unpaved. Road agency and road user costs are computed for a defined analysis period, using constant prices as applicable to the first year, and the resulting flow of net benefits is discounted at a given discount rate. The project is economically justified if the present value of net benefits is positive at the given discount rate.

An economic evaluation of a proposed investment to upgrade an unpaved road to paved standard measures the worth of that investment to 'the economy', that is to the country. The resources that a country, or its roads agency, have for such works are nearly always insufficient for the total needs, and an economic evaluation is a critical step in the process of determining the optimal allocation of the available resources, in other words, which of the proposed projects should qualify for the available funding, and what is their priority and the optimal timing for the work.

The economic evaluation calculates and compares the economic benefits and costs 'with the project' (that is with the proposed paving) and 'without the project' (that is leaving the road in its present condition); the 'without the project' option - often a valid and acceptable option - is commonly called the 'do-nothing' or 'do-minimum' option.

The costs 'with the project' typically would be:

- the capital cost of the proposed paving,
- the road agency's costs (administration, operation and maintenance) of the paved road, and
- the road users' costs on the paved road.

The costs 'without the project' (the 'do nothing' case) typically would be:

- the road agency's costs (administration, operation and maintenance) on the 'existing' road, and
- the road users' costs on the 'existing' road.

The economists and their models view cost savings as benefits; for example if the costs to the road users (the truckers etc.,) would be less on the paved road than they would be on the unpaved road, then they would be economic benefits; the government/road department would need to check, however, that their policies ensure that the benefits to road users would be passed on to the producers/consumers, so that the paving would indeed benefit the 'economy' and not just the road users!. The economist would also be alert to possible benefits from generated traffic - traffic from (new) production that would not be worth while if the road were not paved

(because transport costs were too high), but would come into being because of the lower transport costs as a result of the paving,

For the analysis, the economist would develop, year by year for a period of say 15 or 20 years, a listing of (a) costs, and (b) benefits, comparing the 'with' option to the 'without' option. Since these costs and benefits occur in different years, the economist would apply 'discounted cash flow' techniques to bring them all to 'present value' - the discount rate used would normally be set by central government, so that candidate projects in different sectors of the economy (transportation, industry, agriculture, etc.) may be compared. If the analysis of a proposed paving were to yield a positive present value with the required discount rate, then that would be an indication that the paving would be economically justified.

A detailed economic evaluation of paving alternatives can be done using a road investment model such as:

- the Highway Design and Maintenance Standards Model (HDM-III) [(1)], which estimates over time the deterioration of paved and unpaved roads and the resulting road user costs and economic evaluation or

- the Low Volume Roads Economic Decision Model (RED) [(2)], which is customized for the economic evaluation of low volume roads.

This note presents the results obtained from applying RED to eight typical scenarios covering a range of 'existing' road conditions (that is 'without' project'), traffic intensities, road user costs and paving costs.

**THE SCENARIOS**

Eight scenarios have been examined in this Note. The number of variables in RED is large, so to keep this note within practical limits, two of the factors – 'terrain' and 'environment' – were held constant for all eight scenarios; 'terrain' was taken as flat and level, and 'environment' was taken as sub-humid. The remaining variables used in the scenarios were:

(a) Traffic Volume. Traffic volume was considered up to an Annual Average Daily Traffic (AADT) of 900, in increments of 100. Traffic composition was held constant at 70% trucks/buses and 30% light vehicles, for all flows. Traffic growth for all scenarios was taken at 3% per year.

(b) Maintenance Policy. The "without project" maintenance policy was based on frequency of grading of the unpaved road. Grading frequencies were considered from once/month to once/two years, and the corresponding average road roughness, which is a function of the traffic, environment, terrain, and surface material properties, was estimated using the tables presented on the Rural Transport Note #1. The resulting roughness levels for each grading frequency are expressed in terms of the International Roughness Index (IRI) and are shown on the x-axes in the figures for all the scenarios.

(c) Generated Traffic. Generated traffic is considered in some of the scenarios and is assumed to have a 'price elasticity' of one, that is a reduction in transport costs of x%, as a result of the paving, would result in an increase of x% in the traffic volume.

(d) Road User Costs. 'Road user cost' (RUC) typically includes:

- the depreciation and interest costs function of a new vehicle price
- fuel and tires cost
- maintenance labor and parts costs
- the passengers' time costs, and
- the inventory cost of the cargo while it is in transit

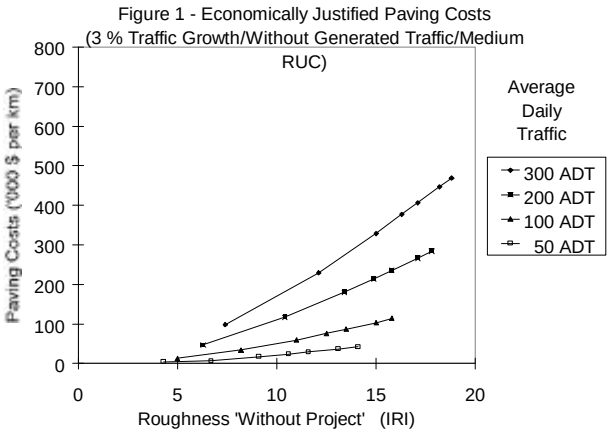
Three levels of road user cost - low, medium and high - are used. Medium road user costs are based on medium values of data collected worldwide on vehicle unit costs. Low road user costs are based on the 20 percent percentile of the values collected and high road user costs are based on the 80 percent percentile. For simplicity, in these scenarios, the economic cost of a new vehicle is taken as a proxy for road user cost as follows:

| Road User Costs | Economic New Vehicle Price ($, 1999 values) | | | | |
|---|---|---|---|---|---|
| | Car | Bus | Medium Truck | Heavy Truck | Articulated Truck |
| Low | 7000 | 35000 | 29400 | 42000 | 62300 |
| Medium | 10000 | 50000 | 42000 | 60000 | 89000 |
| High | 14000 | 70000 | 58800 | 84000 | 124600 |

(e) Paving Costs. The paving costs are expressed as the maximum (US$/km., 1999 values) that could be accepted, given the specific values of the other variables, to yield a positive present value using a discount rate of 12% (a discount rate commonly specified by governments).

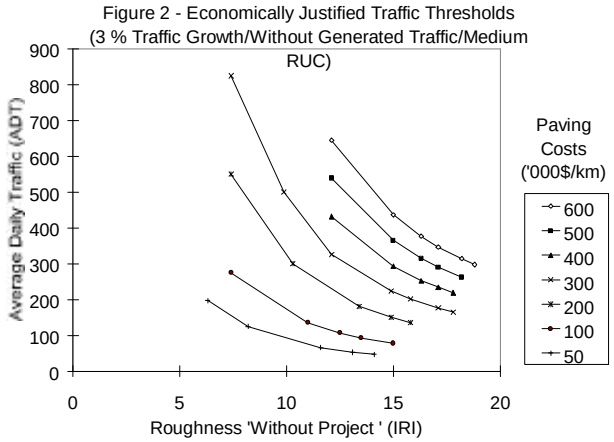
**SCENARIO 1**

Figure 1 shows the resulting paving costs (in thousands of dollars per km) that would be economically justified for a series of traffic levels and a series of "without project" average road roughness for a 3 percent traffic growth, without considering generated traffic, and for medium road user costs. For example, for a road with 200 vehicles per day, one can see that if the "without project" average road roughness is around 10 IRI, a paving project costing no more than around 100 thousand dollars per km is justified, but if the "without project" average road roughness is around 15 IRI, a paving project of around 200 thousand dollars is justified.



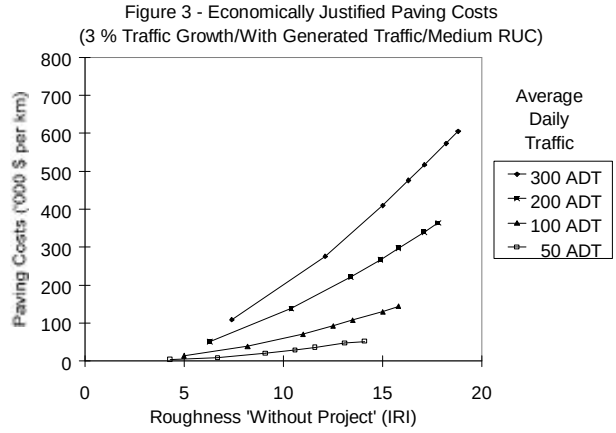

**SCENARIO 2**

Figure 2 presents the results differently. This time, the chart shows the resulting unpaved road Average Daily Traffic (ADT) threshold that would merit paving for a series of paving costs and a series of "without project" average road roughness for a 3 percent traffic growth, without considering generated traffic, and for medium road user costs. For example, one can see that with 200 thousand dollars per km, paving is justified if the traffic is 200 vehicle per day and the unpaved road average roughness is 15 IRI or paving is justified if the traffic is 400 vehicle per day and the unpaved road average roughness is 10 IRI. This highlights the importance of clearly defining the condition of the unpaved road under the "without project" scenario.




**SCENARIO 3**

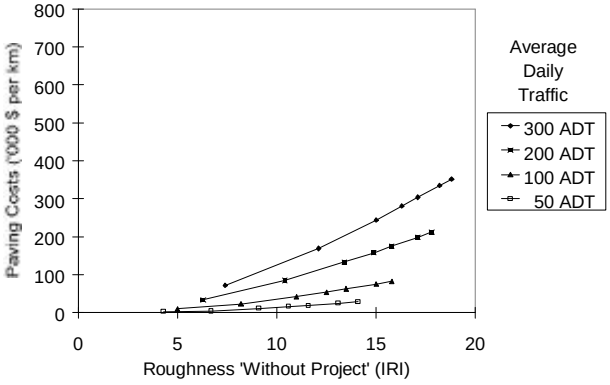
Figure 3 presents the same results as Figure 1, this time, including generated traffic. If the unpaved road is paved, road user costs will decrease substantially and some generated traffic could occur due to the fact that road users will travel a greater distance or take more trips. Figure 3 includes the benefits of this generated traffic considering a price elasticity of demand for transport equal to one. That is, for one percent decrease on road user costs there will be a one percent increase in traffic. Note that with generated traffic, for example, for a road with 200 vehicles per day, if the "without project" average road roughness is around 15 IRI, a paving project costing around 280 thousand dollars per km is justified (it was around 200 without generated traffic).



**SCENARIO 4**

The economic justification is also a function of the level of road user costs. Figure 4 presents the results for a low level of road user costs for the without generated traffic scenario. One can see that with 200 vehicles per day, if the "without project" average road roughness is around 15 IRI and without generated traffic, a paving project costing around 150 thousand dollars per km is justified

Figure 4 - Economically Justified Paving Costs
(3 % Traffic Growth/Without Generated Traffic/Low RUC)

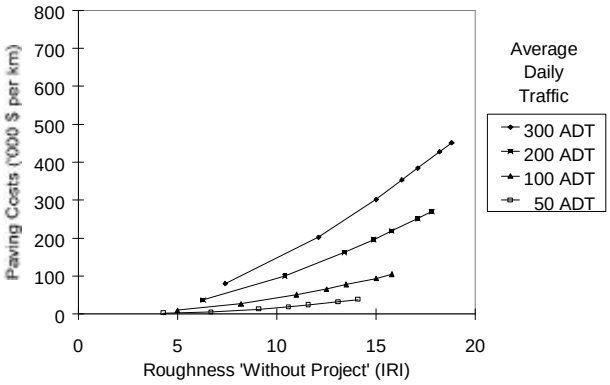



(it was around 200 with medium road user costs).

**SCENARIO 5**

Figure 5 present the results for a low level of road user

Figure 5 - Economically Justified Paving Costs
(3 % Traffic Growth/With Generated Traffic/Low RUC)

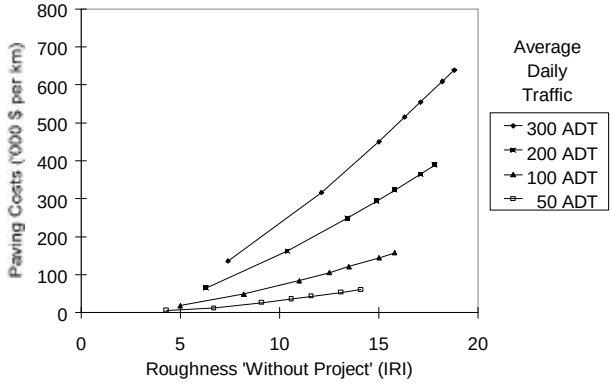



costs for the with generated traffic scenario.

**SCENARIO 6**

Figure 6 presents the results for a high level of road user costs for without generated traffic scenario. One can see that with 200 vehicles per day, if the "without project" average road roughness is around 15 IRI and without generated traffic, a paving project costing around 300 thousand dollars per km is justified (it was around 200 with medium road user costs).

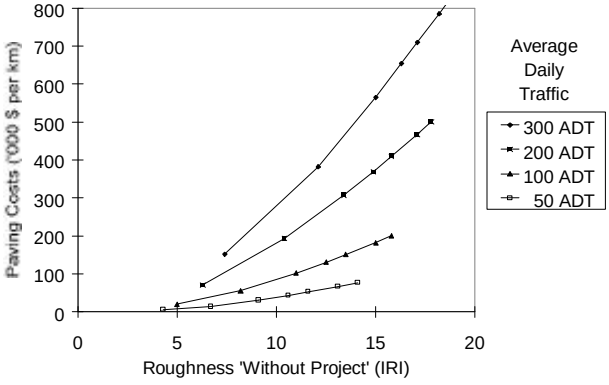
Figure 6 - Economically Justified Paving Costs
(3 % Traffic Growth/Without Generated Traffic/High RUC)




**SCENARIO 7**

Figure 7 present the results for a high level of road user costs for the with generated traffic scenario.

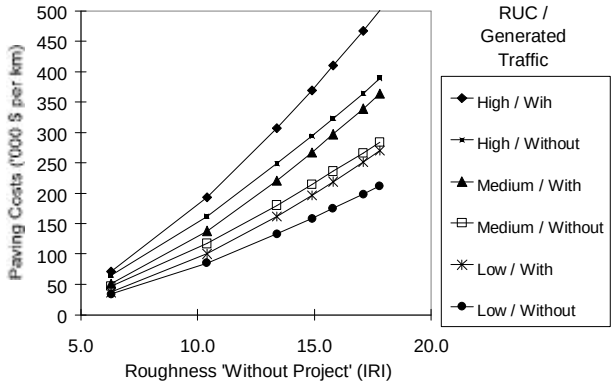
Figure 7 - Economically Justified Paving Costs
(3 % Traffic Growth/With Generated Traffic/High RUC)



## SCENARIO 8

Figure 8 presents for a road with 200 vehicles per day the comparison between the three levels of road user costs and the with and without generated traffic scenarios.

Figure 8 - Economically Justified Paving Costs
(200 Average Daily Traffic/3 % Traffic Growth)




## SUMMARY

In summary, this Note represents a cost-effective screening process by which a first judgment may be made as to the economic feasibility of paving a given unpaved road. If this screening test for a given unpaved road were 'positive' then it would be necessary to perform a more rigorous economic evaluation paying particular attention to the accuracy of the costs estimates, and of the projections for 'normal' traffic and generated traffic. It would also be necessary to examine the other aspects of the proposed paving - possible environmental effects (positive or negative), social effects, and the 'institutional effect, that is the impact that it would have on the operational working of the Roads Agency. If this initial screening revealed that the candidate paving was not economically feasible, paving should not be considered further at this time, and the Department should not incur further staff and other costs on analyzing the proposed paving.. (Conditions may change over time, of course, for example traffic volume may grow, and it may be prudent to screen the unpaved road again after, say, a few years). Candidate roads with marginal economic feasibility should be subject to a rigorous economic evaluation with refined data to reassess the feasibility.

The economic justification of paving a road is a function, among other factors, of the current daily traffic and growth rate, the "without project" maintenance policy with the corresponding road roughness (function of the traffic, environment, geometry, and gravel/earth material properties), the generated traffic, and the level of road user costs on a particular country (function of unit vehicle operating costs, vehicle utilization, vehicle characteristics, and road geometry). Therefore, a proper economic evaluation is needed for each particular case, which could be done with the HDM and RED models.

Information regarding typical unpaved roads roughness predicted by the HDM-III model road deterioration equations can be found on the Rural Transport Technical Note 1 and information regarding unpaved road roughness estimation by subjective evaluation can be found on the Rural Transport Technical Note 2.

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***TO LEARN MORE***

*1. Watanatada, Thawat, et al. 1987. The Highway Design and Maintenance Standards Model. The World Bank, Washington, DC*

*2. Archondo-Callao, Rodrigo, 1999. Low Volume Roads Economic Decision Model. The World Bank, Washington, DC*

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