Socio-Economic Impacts of Road Conditions on Low Volume Roads

S. Johansson
Roadscanners Sweden AB, Borlänge, Sweden

ABSTRACT: Traditionally the road conditions on low volume roads have been neglected. The main reason is the economic resources, which are insufficient to cover all the needs. But there are also other reasons why the low volume roads are kept back in the road maintenance programs. Used socio-economic models to describe the maintenance need, normally deal with road user costs consisting of time delay costs, vehicle costs and accident costs. But as the amount of traffic always is the dominating figure in the calculations the models will favour a very good condition on high volume roads and only keep the low volume roads alive. That will give the highest benefits for the society with the existing models. To change this, in order to give people living in rural areas better life conditions, there is a need for a new thinking to find alternative ways to describe the significance in having good road conditions especially in the rural areas. The first thing is to look at socio-economic impact in a wider meaning. There is a need to take a closer look at the social improvements for people living in rural areas if the road conditions are improved. Secondly there is a need to look at the health impacts, especially for professional drivers, if rural roads are left to deteriorate. By a literature survey, meetings and interviews with skilled people from Sweden, Finland, Norway and Scotland it is found how the socio-economic impacts are considered today by the road managers and what is going on for the future. The report will describe briefly the models used today, some calculations done with a Swedish model, work done and going on to improve the road conditions on low volume roads in the partner countries and in what way the road condition may affect personal health for road users.

KEY WORDS: Socio-economic impact, socio-economic models, low volume roads, road conditions.

1 INTRODUCTION

One task in the Roadex II project, which is a co-operated project on low volume roads in the Northern periphery of Europe, part-financed by the European Union, was to examine the socio-economic impacts of the road conditions on low volume roads. Regional road administration bodies in Scotland, Norway, Sweden and Finland participate in the project along with regional industries, such as forest industries and fishing industries. The aim of this task was to improve the understanding of the significance of the low volume roads and the road conditions for people in the rural areas of the Northern Periphery of Europe. Thereby we hope that more resources will be allocated to the low volume roads.
In rural areas the road network is in most cases the only possibility to move goods and people from one place to another. It is the vital nerve for many people in the Northern periphery. If the road does not work properly it will affect many urgent things in the society, like:

- Business profitability
- Investments
- Tourism
- Service levels
- The social life.

The road condition will also have a great impact on the road user in action. It will affect his behaviour on the road e g make him change speed, force him to do turning movements or even make him take another road if possible. It will also have impact on his economy. A road in bad condition will increase vehicle costs, increase travel time and might even give damage to the carried loads. It will also influence the accident rate and the comfort for the road users. This means that there are many reasons why the socio-economic consequences should be taken into consideration when allocating budgets for low volume roads, when selecting roads for maintenance and rehabilitation and when choosing maintenance strategies for the selected roads.

2 THE CONCEPT SOCIO-ECONOMIC IMPACT

Usually when talking about socio-economic impact in relation to road conditions we are looking at costs for road users and road managers. The road user costs are related to the road conditions. A road with high roughness and rutting causes bigger costs than an even road. To keep a road in good condition will cause costs for the road manager like rehabilitation costs and costs for planned and routine maintenance. The road managers are aiming for minimizing the total costs, which are the sum of the road user costs and the road manager costs. Socio-economic models of different types dealing with cost-benefit analyses are used for the purpose (CB-analyses, see fig 1). But as the amount of traffic always is the dominating figure in the calculations the models will favour a very good condition on high volume roads and only keep the low volume roads alive. That will give the highest benefits for the society with the existing models. Most of these models are working on road network level and are not suited to the low volume roads. In the Northern Periphery of Europe we are dealing in most cases with low volume roads, so the currently available models will not be useful to give good road conditions on this road category. Therefore it is needed to look at other complementary methods and models to justify a good road standard also on low volume roads. In this case there is a need to lay stress upon the social benefits of keeping roads in rural areas in good condition. The social benefits though are often very difficult to measure in monetary terms.

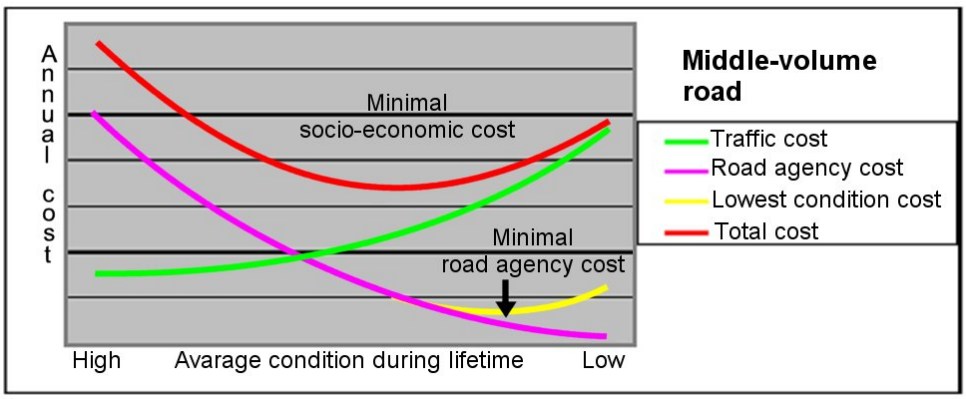

Figure 1 Usual model for minimizing socio-economic costs for road maintenance (1).

Different policies and strategies can be used to keep roads in a proper condition. One policy can be to introduce minimum road condition levels on different parameters like roughness and rutting, sometimes called "shame levels". These levels can be defined from accident risks, comfort considerations and road user costs. They can also be defined locally from social considerations for people living in rural areas. These people have a long way to go for public services, cultural events and all other needs. If the roads are in bad condition travel will be both long and uncomfortable. The road condition levels can also be defined from professional drivers' work environment requirements. The levels can be included in the Pavement Management Systems and be used to select maintenance candidates. They can also be included in the road maintenance codes and in the routine maintenance contracts. In this report we propose a new way to look at the standards for the low volume roads in rural areas based on societal needs rather than strict economy.

3 HANDLING OF SOCIO-ECONOMIC IMPACTS IN SWEDEN

In Sweden the Road Authorities have used socio-economic models to motivate budget needs in the discussions with the Transportation Department. The budget level should be high enough to keep the total costs for the society at the lowest possible level on long-term basis.

Work has been done by the Swedish National Road Administration to form a standard for road condition at maintenance, but it has not yet been finished (2). It was built up with limit values coming from three different main aims:

- Traffic safe practicability (for the road user)
- Preserving of road capital (for the road manager)
- Calculated profitability by a model (socio-economic calculation).

The purpose of the limit values for *traffic safe practicability* of the road condition is to preserve the practicability and to give an acceptable level of traffic safety and comfort. Here are some limit values:

- The roadway shall be free from cracks wider than 10 mm
- The roadway shall have a surface friction > 0,5
- Rutting as an average of 20 m shall be max 20 mm.

The limit values for *preserving of road capital* have the purpose to avoid premature deterioration. Here are a couple of examples:

- There shall be no cracks in the salted roads when the winter comes
- The formation of potholes shall be prevented
- The dewatering shall be working.

Some road condition values obtained by *calculated profitability by a model* are shown in table 1.

Table 1. Limit values for IRI, 20 m average.

ADT	IRI mm/m	
	≥ 90 km/h	≤ 70 km/h
> 4 000	4	5
2 000 – 4 000	4,5	5,5
500 – 2 000	5,5	6,5

For routine maintenance certain target standards are given regionally in the routine maintenance contracts. Regional policies are also used to limit the temporary load restrictions used at spring thaw.

4 HANDLING OF SOCIO-ECONOMIC IMPACTS IN NORWAY

In Norway the socio-economic model HIPS is used to find the optimal long-term road condition (3). That is when the total costs for the society are the lowest. The total costs are the sum of the road manager costs to maintain and to improve the road condition, and the road user costs. In this case the road user costs are time costs, vehicle operation costs, accident costs and the costs caused by road works. HIPS works only on road network level and can also be used to distribute the budgets between different road classes and Road Management Regions. Recent measurements have shown that the road condition in Norway today is somewhat worse than the goals defined by the Road Administration and that an increase in the road maintenance budgets is needed to reach the long-term socio-economically optimal road condition. By an increase of the budget level to 750 MNKr/year the long-term optimal road condition distribution will be reached within 20 years. Four different short-term scenarios are also surveyed:

- Extremely low budget 400 MNKr/year
- Low budget 600 MNKr/year
- Medium budget 750 MNKr/year
- High budget 850 MNKr/year.

For every budget level the optimization models will try to minimize the difference between the current condition and the optimal condition. The analyses of the four different budget levels are done over a 10-year period. Figure 2 shows the added costs for the road user depending on the budget level. The difference between the road user costs today and the long term road user costs is 265 MNKR/year.

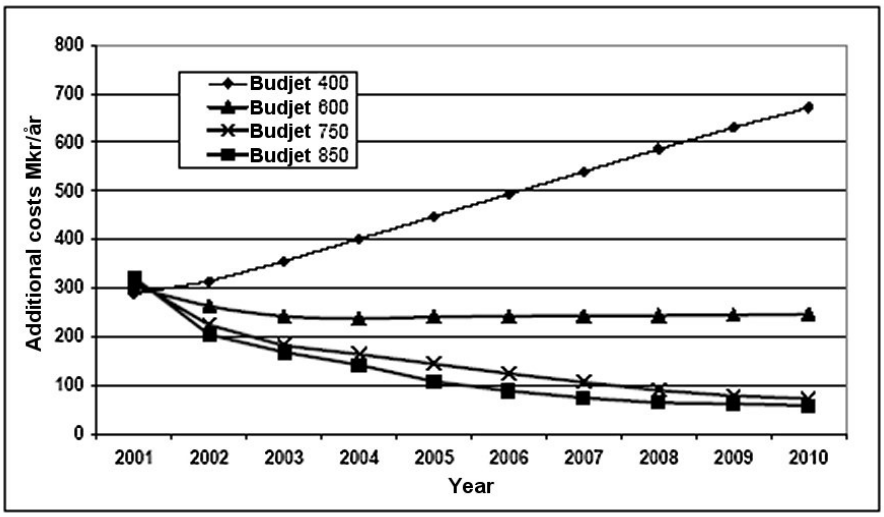

Figure 2 Additional costs for the road users depending on budget levels (3).

For routine maintenance contracts a national road condition standard is developed for use as "trigger values" at maintenance actions (4). An example of requirements on project level is shown in table 2. In Norway there are no temporary load restrictions at spring thaw. They were abolished in 1995 as a result of a big survey.

Table 2 Rutting and roughness. Aim for 90 % of a road project (4).

ADT	Rut depth (mm)		Roughness (IRI)	
	Highway	Other national roads	Highway	Other national roads
0-300		25		7,0
301-1 500	25	25	5,0	6,0
1 501-5 000	25	25	4,5	5,1
> 5 000	25	25	4,0	4,6

5 HANDLING OF SOCIO-ECONOMIC IMPACTS IN FINLAND

In Finland the Road Management uses a socio-economic model named HIPS to motivate money from the Ministry and to allocate money for the Regions (5). HIPS is used to calculate the road conditions on network level, which give the lowest total costs for the society. There is no special attention paid to the low volume roads in rural areas in the model. In Finland an interesting work is going on to get another view over the influence of the road condition on the whole society, which might change the view of the low volume roads. The work is done according to a "planning cube" which describes the "cells for policy" shown in figure 3 (6). The aim is to go through all the cells in the planning cube to form socio-economic road condition levels adapted to road user needs, goals of society and economy.

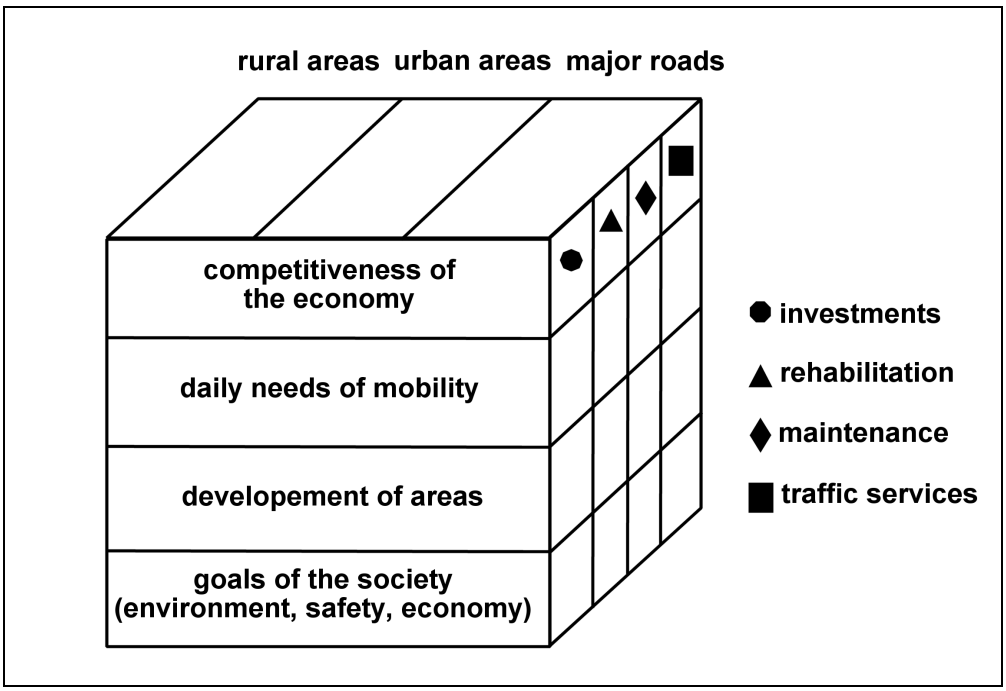

Figure 3 The Finnish "planning cube" (6).

In Finland, as in the other partner countries, there is an existing maintenance backlog as a consequence of insufficient budgets and this affects in the first place the condition on the low volume road network, which is verified by the results from a road user survey shown in figure 4.

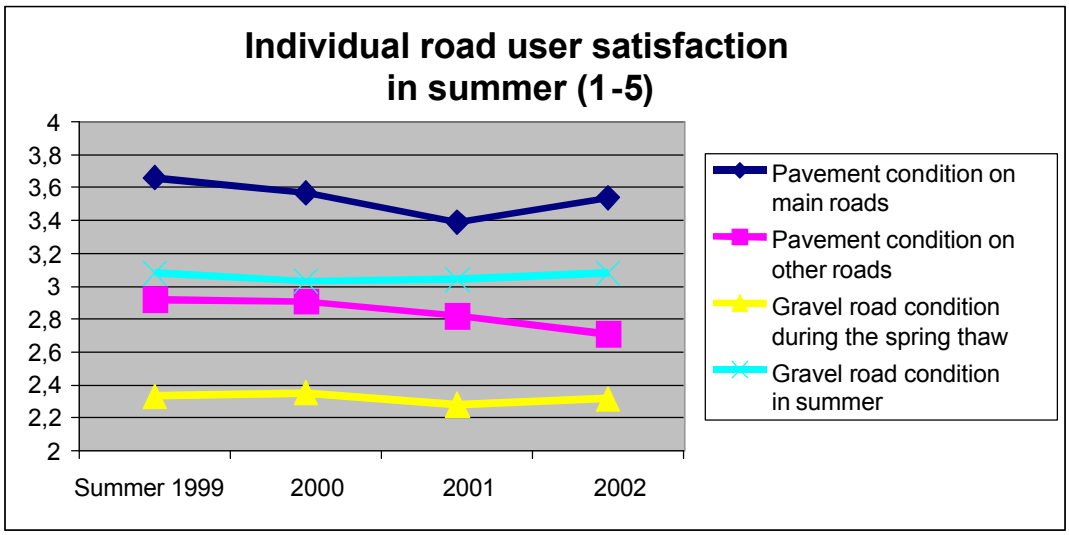

Figure 4 Individual road user satisfaction on road network summer condition 1999-2000 (6).

The Finnish Road Administration sets the road condition standards depending on amount of traffic and traffic speed. An example is shown in table 3 (7).

Table 3 Condition standards and permissible failure to meet them by traffic volume (7).

ADT	Surface condition		Structural condition		Permissable sub-standard roads* in %
	Roughness IRI in mm/m	Rut depth mm	Sum of defects m^2	Bearing capacity ratio in %	
< 350	5,5	-	140	70	18
350-1 500	4,1	20	80	70	14
1 500-6 000	3,5	20	60	70	7
> 6 000	2,5	20	30	70	7

* Roads, which do not meet the standard as a percentage of the road length in the ADT-class.

6 HANDLING OF SOCIO-ECONOMIC IMPACTS IN SCOTLAND

For the moment socio-economic models are not used regularly in the Road Maintenance Management in Scotland. When it comes to new investments in Transportation Infrastructure it is quite different. Then there is a requirement for a socio-economic survey as the basis for the final judgment of the investment candidates.

Much work is done in Scotland to find ways to preserve and develop small communities in rural areas. Fragile areas have been identified by means o f properties like population density, long term unemployment and income support (see fig 5).

An interesting project, run by the Scottish co-operative transportation organisation HITRANS, is named “Investments in lifeline rural roads” (8). The definition of a lifeline road is “A transport link which has no substitute, or where the substitute entails a considerable increase in time or money expenditures, where any diminution in the quality, reliability or availability of the former, is likely to have a significant impact on the social or economic viability of an affected community.” In the project nine key roads were identified as possible candidates for improvement. The candidates served areas of Highlands and Islands that suffer

from varying degrees of economic and social deprivation. The appraisal of each road was carried out according to the Scottish Transport Appraisal Guidance (STAG) (9) with complete analyses of Transport Economic Efficiency (TEE) and Economic and Locational Impacts (EALIs). Several of the selected roads were considered not to be in a 'fit-for-purpose' condition to offer a reasonably good accessibility to give sustained economic and social prosperity in the served societies. An upgrade in the road condition is needed to provide long-term sustainability. The economical analyses have shown that the benefits in a few cases are sufficient to cover the costs calculated over a period of 30 years. Additionally many of the proposed road schemes will give indirect benefits like increased employment, reduced transport costs and better accessibility to markets and customers.

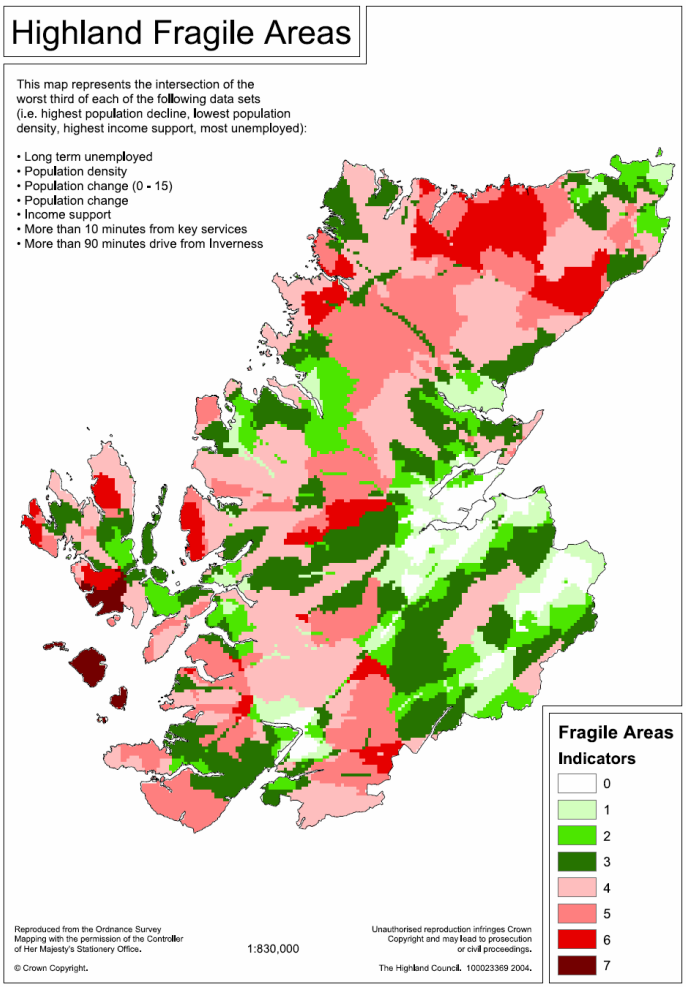

Figure 5 Fragile areas in the Highlands 2003 (from the Highland Council).

7 HEALTH ASPECTS OF ROAD CONDITIONS

There is also a need to look at the health impacts, especially for professional drivers, if rural roads are left to deteriorate. In a Swedish report named "Whole-body vibrations when riding on rough roads" (10) it is said that the road surface irregularities and texture will cause different types of strains to human beings because of e g noise, infra sound and shakings of the body. They can be divided into three different categories, for which criteria can be posed and limit values can be assessed:

- Feelings of discomfort
- Influence on activities (the ability of performance)

- Influence on health.

In a field test it was found that a level of about 5 mm/m in IRI required a very low speed to keep the vibrations at an acceptable level. Similar road surface conditions can be found also elsewhere in Sweden, especially in the Central and the Northern region. Figure 6 shows that the main parts of the roads with IRI ≥ 5 mm/m are low volume roads.

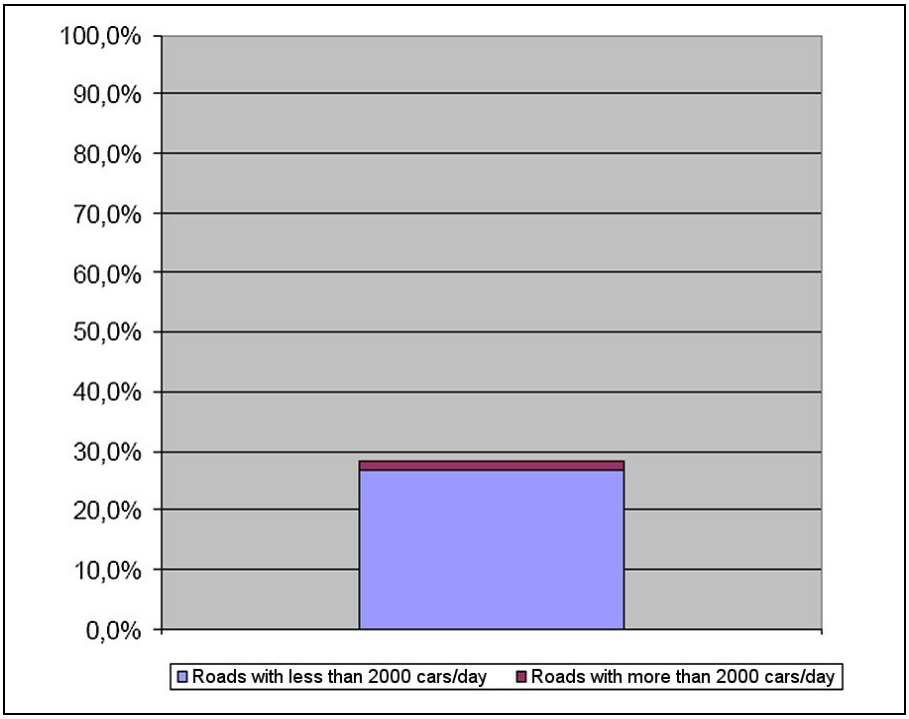

Figure 6 Paved state roads in Sweden with IRI20 > 3 mm/m. Blue colour AADT < 2 000; red colour AADT > 2000. Summer conditions (10).

The conclusions from Swedish research reports are that the major impacts on body vibrations of drivers are caused by the road surface irregularities. The vibrations vary depending on e g vehicle type, type of suspension, speed and wavelength of the roughness. It is found that uneven road surfaces are a probable reason for elevated risks for disturbance of the body movement mechanisms on professional drivers. The costs for the society from health problems caused by uneven road surfaces are not yet possible to calculate, but should be kept in mind as extra costs when calculating road user costs. Based on the results from a field study and a literature survey a "shame level" for the roughness expressed as IRI is recommended. The recommended value as an average of 20 m is $IRI_{20} < 3$ mm/m.

8 EXAMPLES OF MODELLING

A simple Swedish model for calculation of socio-economic costs on road network or project level was used to find suitable levels on low volume roads (11). The calculations of the road user costs included time costs, vehicle costs and accident costs. The road manager costs included costs for planned maintenance and for routine maintenance.

The key figure motivating a maintenance measure with respect to calculated profitability is the net present value quotient (NNK) defined as the summarized benefit minus the summarized costs capitalized to present values over a time period, divided by the costs. Or

simpler socio-economic benefits divided by socio-economic costs minus 1. Mathematically it can be described as follows:

$$NNK = \frac{\sum_{t=1}^{T} \frac{B_t}{(1+i)^t} - \sum_{t=1}^{T} \frac{C_t}{(1+i)^t} + \frac{S}{(1+i)^T}}{\sum_{t=1}^{T} \frac{C_t}{(1+i)^t}}$$

Where:
B = sum of profit as described above
C = sum of costs for measures and routine maintenance
S = rest values at the end of the time period
i = discount interest (used by SNRA 4%)
t = time period expressed in years
T = time horizon.

Costs in this case are related to need of resources to maintain a certain standard on a road project, which means in this case costs for maintenance measures and costs for routine maintenance and possible costs for rest values. The benefit in this case can be described as a reduction in traffic costs by a maintenance measure or a maintenance strategy, which improves the surface standard in terms like:

- Reduced time costs
- Reduced vehicle costs
- Reduced accident costs.

Maintenance measures or maintenance strategies for road projects are judged by SNRA to be profitable when NNK > 0,9. Then the projects should be performed if funds are available and no other projects have better NNK.

An example in calculation of the socio-economic costs from a small road named BD 799 with ADT 15 vehicles/day is shown in table 4 (12). As a comparison alternative (JA) a maintenance strategy of IRI 7,0 mm/m is used and the investigation alternatives (UA) are:

- UA1 giving a max IRI of 6,0
- UA2 giving a max IRI of 5,0
- UA3 giving a max IRI of 4,0
- UA4 giving a max IRI of 3,0.

Table 4 NNK-values for JA-IRI 7,0 and ADT 15.

JA	UA	IRI 6	IRI 5	IRI 4	IRI 3
IRI 7,0	NNK	4,9	- 0,6	- 0,88	- 0,96

The table shows that an IRI between 5,0 and 6,0 is a suitable standard level from a socio-economical point of view.

9 CONCLUSIONS AND RECOMMENDATIONS

The conclusions are that much work has been done and is going on in the socio-economic area in the partner countries. Target standards for the general road conditions and lowest acceptable standards are more or less expressed and socio-economic models are used for

budget discussions and budget distribution. But for the low volume roads there are still much work to do.

It is recommended to follow the Scottish example to sort out the fragile areas of the partner countries. Then to define the lifeline roads which are of critical importance for the people in the rural areas. This should be demonstrated to the politicians and used in the budget negotiations with the Transportation Departments in the partner countries to have an increased understanding for the low volume roads. Then the lifeline roads should be treated with special care in the maintenance and rehabilitation programs. It is also recommended to try to find a common standard for "shame levels" of the road conditions in the partner countries and to improve the models to better fit also the low volume roads.

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