GENERAL DIRECTORATE OF HIGHWAYS

TRAFFIC SAFETY PROJECT

METHODS AND VALUES FOR APPRAISAL OF TRAFFIC SAFETY IMPROVEMENTS

April 2001

SWEROAD

Foreword

The purpose of this report is mainly to propose a suitable method for appraisal of minor road safety improvements, mainly black spot projects, and monetary values for estimated accident and casualty reductions.

It must be observed that the report represents only the beginning of the work leading up to more definite methods and values. It gives, however, some indications both for the short-term and long-term perspective. We hope the report will give some inspiration for future work.

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Ankara, April 2001

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Contents

Page

Foreword **1**

Summary **3**

1 Introduction **5**

2 Appraisal methods **5**

2.1 Basic methodology 5
2.2 Present methodology 10
2.3 Methods for prioritising 10
2.4 Conclusions 12

3 Accident values **13**

3.1 Background 13
3.2 Present accident values 16
3.3 Accident data 17
3.4 Suggested improvements of accident values 20
3.5 Willingness-to-pay study, example from Sweden 29
3.6 Conclusions 31

4 Other values **31**

4.1 Road maintenance costs 31
4.2 Vehicle operating costs 31
4.3 Time values 31
4.4 Other missing values 34

5 Conclusions **35**

6 References **37**

7 Appendices **38**

Summary

The purpose of this report is to propose a method that can be used for prioritising traffic safety measures. In order to do this, different methods of calculating benefits and how to value effects are studied.

The present calculations of consequences of safety measures used at the Karayolları Genel Müdürlüğü (KGM) are in principle correct. However, smaller adjustment of calculation methods and how the effects are being valued can improve the quality. By using the available statistics more extensively and diversified, combined with using international experiences, improvements can be made. At present Benefit Cost Ratio, Net Present Value and Internal Rate of Return are calculated. Benefit Cost Ratio is proposed as the most appropriate method to use for appraising black spot improvements.

The most important issue in prioritising safety measures, is to estimate and maximize the Benefit Cost Ratio – which normally means that smaller, more efficient solutions will be prioritised first. This will also maximize the total Net Present Value.

All calculations are made using a discount rate of 15 %, which is rather high. A high discount rate means that the length of the economic life period for a project will have a limited effect. This means that projects with a shorter economic life have an advantage against larger projects with longer life expectancies. A higher discount rate also means that the traffic and economic growth will have a smaller impact

We propose that the existing accident costs are diversified into rural and urban values, as well as for degree of severity. The official police and Gendarme road traffic fatality statistics are being corrected for those injured in a traffic accident that later die in hospital using information from the Ministry of Health. The correction means that the fatalities reported by police and Gendarme should be multiplied by a factor of 1.51, and that the number of injuries reported should be multiplied by a factor of 0.97.

Values of risk of getting killed or injured in a road accident are suggested, but since no Turkish values or surveys concerning this exist, we estimate a Turkish risk value using the Swedish values corrected with the relation of GNPs in Turkey and Sweden. This gives a risk value of TL 107,000 million for a fatality and TL 3,700 million for an injury, both at the price level of 1999.

Introducing a risk value means that the consumption should be deducted from the loss of production being the result of an injury or fatality. The individual consumption is estimated to be about 75 % of a persons production. The net production loss for an average fatality is estimated to be TL 3,430 million (1999), and for an average injury to TL 1,325 million (1999).

The results of the new approach to value accidents are shown in the table on the next page, all values in the price level of 1999.

Accidents		Material cost	Risk value	Total
RURAL AREAS	Fatal accident	13,973	235,959	249,931
	Injury accident	6,741	9,432	16,173
	Prop. damage	813	0	813
URBAN AREAS	Fatal accident	8,716	161,889	170,605
	Injury accident	3,796	6,865	10,661
	Prop. damage	286	0	286

The proposed calculation method and the new estimates of accident values have been included in a simple Excel sheet that can be used for appraisal of road safety measures.

This report represents the beginning of improvements and should more be seen as an inspiration by showing the possibilities that can be utilized by KGM in the future. There are examples of short-term and simple improvements as well as more long-term and complicated ones.

Values of other effects are briefly studied. An approach to value travel time is suggested, but we have not been able to find validated data needed to make more definite suggestions.

1 Introduction

Most investments are made because it has been estimated that they will yield larger benefits than costs. There are different methods to calculate this, and they vary between private and public investments.

For public investments, cost-benefit calculations with socio-economic monetary values and costs are normally used. The aim is to calculate the net economic benefit to the nation and its inhabitants, and to achieve an economic optimisation for project investment decisions. Costs and benefits are appraised by how they accrue to the economy as a whole.

The general steps leading to a cost-benefit analysis (CBA) are:

1. Identify the goals
2. Specify measures to reach the goals
3. Identify the effects of the measures
4. Value the relevant effects
5. Make a cost-benefit analysis

To value the effects you can use market price, willingness to pay or substitution prices.

If comparing investments with one dominating effect (e.g. road safety), you can calculate the effectiveness per unit, hence avoiding setting a monetary value.

At present The Karayolları Genel Müdürlüğü (KGM) calculates Internal Rate of Return (IRR), Net Present Value (NPV) and Benefit-Cost Ratio (BCR) for safety projects using monetary values for fatalities, injuries and property damage.

Within KGM there is also a method to calculate costs and benefits of other types of road investment projects. Besides costs of accidents, this method includes vehicle operating costs (from HDM III, Highway Design and Maintenance model) and costs of road maintenance. For some projects, a multi-criteria analysis is made together with the CBA. The multi-criteria model used is called the Smart-model.

2 Appraisal methods

2.1 Basic methodology

The purpose of appraisals is to select the road measures, which give the highest return of positive effects. This can be done by calculating single effects, weighted multiple effects, using economic values for different effects, or multi-criteria analysis. Using:

- single effects means that you calculate one effect only and do not consider other effects,
- weighted multiple effects means that you calculate each effect separately and then weigh them together in order to get one single value and/or unit,

- economic values means that you give a monetary value to each of the calculated effects, which then can be added up,
- multi-criteria analysis means that you use some kind of non-monetary grading system for each effect, which in some cases can be added up to one value.

The economic calculation methods (or indicators) mostly used are:

- Net Present Value (NPV)
- Internal Rate of Return (IRR)
- Benefit/Cost Ratio (BCR)
- Net Benefit/Cost Ratio (NBCR)

A very thorough or full cost-benefit analysis should theoretically include all costs and benefits for society. For road investments projects, the most common are:

- Accidents costs
- Travel time cost
- Vehicle operating costs
- Emission costs
- Other environmental costs
- Investment costs
- Maintenance cost

In addition, there might be other interesting effects, such as market effects. These are, however, often very difficult to calculate. It is also disputed whether these effects are newly generated or mainly a change of distribution or location of available effects in society as a whole.

NPV is the benefits of a project minus its costs, both for the duration of the economic lifetime of the project, and can be calculated according to the following: **(formula 2.1)**

$$NPV = \sum_i \frac{B_i}{(1+0.01r)^{(\text{benefit year} - \text{discount year})}} - \frac{\sum_i C_i * (1+0.01r)^{(\text{opening year} - \text{investment year})}}{(1+0.01r)^{(\text{opening year} - \text{discount year})}}$$

where:

B_i = the value of the net benefits year i
r = discount rate in percent (%)
C_i = investment costs year i
i = year
Discount year: all effects are discounted to this year, so different projects can be compared even if the projects are opened in different years.
Opening year: the year, in which the project is opened for use.
Investment years: the years during which the investment is paid for.

The different parts of the formula can be explained as follows:

$\Sigma_i C_i * (1 + 0.01\ r)^{(\text{opening year} - \text{investment year})}\ (=C_o)$

If the investment is spread over more than one year, the formula above calculates the investment cost discounted to the opening year, where i is the years when the investment is paid for.

$(1 + 0.01\ r)^{(\text{benefit year} - \text{discount year})}$

The above formula is used when calculating the present value (for the discount year) of the benefits and the costs for each year. In the same way the investment costs are discounted from the opening year to the discount year using:

$(1 + 0.01\ r)^{(\text{opening year} - \text{discount year})}$

If one would like to consider a general annual growth (p %) that will increase the values of the effects. Such an increase can be considered when calculating B (which is the net benefit) as: **(formula 2.2)**

$$B = \Sigma_i \frac{B_i\,(1+0.01p)^{(\text{benefit year} - \text{discount year})}}{(1+0.01r)^{(\text{benefit year} - \text{discount year})}}$$

The general growth can be both a yearly increase of the monetary values of the effects or an annual traffic growth.

Normally, one investment is compared with the present situation, but it is also possible to calculate a more general NPV, comparing two different investment alternatives, calculated as: **(formula 2.3)**

$$NPV_{a-b} = \Sigma_i \frac{B_{i(a-b)}}{(1+0.01r)^{(\text{benefit year} - \text{discount year})}} - \frac{\Sigma_i C_{i(a-b)}*(1+0.01r)^{(\text{opening year} - \text{investment year})}}{(1+0.01r)^{(\text{opening year} - \text{discount year})}}$$

where:

> a and b are the two different investment alternatives and the benefits and costs are the difference between them for each year.

One weakness of the NPV is that larger investments tend to yield larger NPV's than smaller investments. It is, therefore, most justified to use NPV when you compare two different alternative solutions with available funds which do not compete with other projects.

IRR can be calculated as follows (using the same notation as for NPV, see above): **(formula 2.4)**

$$\sum_i \frac{B_i}{(1+0.01\ irr)^{(\text{benefit year} - \text{discount year})}} - \frac{\sum_i C_i * (1+0.01\ irr)^{(\text{opening year} - \text{investment year})}}{(1+0.01\ irr)^{(\text{opening year} - \text{discount year})}} = 0$$

This equation is normally solved by using trial and error, or by using the standard functions in Excel.

The IRR is the discount rate for which NPV equals 0, and subsequently it indicates how large the discount rate can be before the project is no longer economically viable. It can be used to appraise projects in unstable economies, as it can be said to indicate the safety margin.

If, during a planning process, you would like to compare different investment projects with a given discount rate, it is more feasible to calculate the benefit/cost ratio, **BCR**: **(formula 2.5).**

$$BCR = \sum_i \frac{B_i}{(1+0.01r)^{(\text{benefit year} - \text{discount year})}} \Big/ \frac{\sum_i C_i * (1+0.01r)^{(\text{opening year} - \text{investment year})}}{(1+0.01r)^{(\text{opening year} - \text{discount year})}}$$

A BCR greater than 1 means that the project is profitable and a value below 1 indicates that the project causes a loss to society. A BCR value of 1.4 indicates that the project will render a profit of 40 % more than the invested amount. The major advantage with BCR is that it is easier to understand and to calculate than IRR.

NBCR is an alternative to BCR where the net benefits (benefits – costs) are divided by the costs. NBCR has the break-even point at 0, compared with BRC where it is 1.

However, lack of monetary values and sufficiently detailed models sometimes make a full cost-benefit calculation less usable. If one effect is the major interest, the other effects can be either ignored or considered without being included in the calculation.

This method can preferably be used when you prioritise actions towards one goal, within a given budget. In this case the other goals are less interesting and there is no competition against other goals for funds.

As a rough estimate the **cost-effectiveness** of road safety actions can be used to appraise a safety project or to prioritise between different safety measures or projects. This value can be calculated in numerous ways, of which three examples are given below:

1. Investment cost/Number of less fatalities during the first year: cost per reduced number of killed persons.
2. Investment cost/Number of less accidents during the first year: cost per reduced accidents.
3. Number of less fatalities + injuries/Discounted investment cost over the projects lifetime: yearly cost per reduced fatality + injury over the projects lifetime.

If the investment consists of a measure which will result in a substantial yearly maintenance cost, the present value of this cost can be added to the investment cost in 1-3 above.

However, it is normally considered to be most correct to calculate the relation between benefits and costs. The net present value (NPV), internal rate of return (IRR) or benefit/cost ratio (BCR) can be calculated in this case using the reduced accident costs as the only benefit (e.g., due to calculation problems and lack of data) but considering the investment cost and, when relevant, the maintenance cost. Another possibility is to use an engineering estimate of how large the influence of the non-valued effects should be when choosing between alternative solutions or prioritising between projects.

The **discount rate** used for calculations of costs and benefits is very important and has a major influence on all results. At present, KGM uses 15 %, while some agencies use 12 %, according to our information. Lowering from 15 % to 12 % would make an increase of the benefits with more than 20 % (depending on the traffic growth) for a project with an expected economic life period of 20 years.

A discount rate of 15 % is rather high and means that especially long-term investments are more difficult to justify. High discount rates are mostly due to an uncertain future economic development. Often, the Ministry of Finance in a country decides the discount rate and normally there is no reason to use other values.

A higher discount rate means that a longer life period will have a smaller effect, hence projects with shorter economic life periods have an advantage against larger projects with longer life expectancies.

A higher discount rate also means that future traffic growth will have a smaller impact.

Normally, some kind of “**tax factor”** needs to be added to the values to obtain the correct results in a cost-benefit analysis. There are mainly two types of tax factors.

The first tax factor considers that all resources used have a value reflecting how much the consumers are prepared to pay. Normally, goods that are purchased have a value added tax (VAT). Therefore, all components in a cost-benefit analysis should include VAT. This tax factor should also be used in Turkey, with a VAT on average estimated to 17 %.

Sometimes a second tax factor is used. This factor is normally referred to as “marginal cost of public funds”. Marginal cost of public funds relates to the fact that government financed investments are considered to imply an efficiency loss within the socio-economics, partly because they compete against private investments (which often have a higher profit) and partly because they reduce the space for private consumption. It also normally covers that an increase of tax revenue by the margin leads to a loss in welfare of the society. This tax factor should be used for all activities financed over the state budget. Accordingly, all public investments and maintenance, costs of government hospitals or health insurance etc., should include this second tax factor. Setting this value, however, is a difficult task. The presence and value of a second tax factor is dependant on the efficiency of the public sector compared with the private. The existence of such a difference is not evident. The other parts of the second tax factor are less disputed, but since the factor is difficult to assess, it is recommended not to include this tax factor at present.

2.2 Present methodology

At present KGM uses different methods for calculation, one for road safety projects and another for other road investments.

For road safety projects a cost-benefit analysis is made with the change in safety costs as the only benefit. An Excel spread sheet is used to calculate the costs of accidents in a situation where nothing is done and in the situation where a measure has been taken. Then, the difference is the total benefit. Based on this, and by using the investment cost, NPV, IRR and BCR are calculated for a given discount rate, traffic growth and appraisal period.

For other road investment projects, the procedure is very much the same, except that vehicle operating costs and road maintenance costs are included in the calculations.

These calculations at present seem to have almost no impact on the prioritising of road safety projects. Normally, the number of black spot projects are selected from severity and other indices to an amount equal to the available budget. Sometimes two alternatives are prepared, one high-cost alternative and one low-cost alternative. If the budget is high, the high-cost alternative is chosen and if it is low, the low-cost alternative is selected. If the budget only allows for some high and some low-cost alternatives, the selection of high-cost solutions is often made by order of severity of the accidents. If an accident has received special attention in media or aroused a political interest, this accident spot can sometimes get high priority and more expensive measures are used than what is cost-effective.

2.3 Methods for prioritising

2.3.1 General methodology

Normally, the needs of measures are greater than the available means and therefore a suitable balance must be struck between the needs and what can actually be implemented. When doing this, the most positive effects from available funds should be attained. Sometimes there are relevant reasons to diverge from the estimated “optimal” order of priority, but having a list with the measures prioritised after benefits and costs will make the decision-maker aware of the cost of the diversion.

There are many ways to prioritise, but only three will be described in the following:

1. After values in monetary terms / CBA
2. After non-monetary effects / Cost-effectiveness CEA
3. A combination of the two

2.3.2 Using cost-benefit analysis (CBA)

The different methods to calculate benefits from a road project have different use and advantages. Looking at a total budget level, the NPV should be maximised, but looking at project level, the BCR should be maximised in order to find the project that contributes mostly to the NPV in relation to the investment cost. Hence it is recommended that BCR should normally be used for prioritising of black spot improvements. The NPV gives the highest total value of net benefits. If you prioritise according to NPV, you will often prioritise large projects, because they tend to yield large net benefits even if the BCR is low. Especially if there is a long list of projects with different alternatives, it becomes difficult to optimise the NPV for the total list.

IRR and BCR give about the same order when projects and alternatives are being prioritised. IRR is more difficult to understand. BCR is easier to grasp. If BCR is 1, the benefits are equal to the costs. If BCR is 2 the benefits are twice as large as the costs. IRR on the other hand, shows how high the discount rate can be without making the project unprofitable. For large, single projects, where a financier needs to determine the risk of the project, IRR can be useful. However, to prioritise between alternative measures or projects, BCR is easier to understand.

When there are different alternatives for each site, it should be considered that low-cost alternatives in most cases tend to give higher BCRs than high-cost alternatives. As there normally are many black spots in need of funds for improvement, the leading principle should be to use low-cost alternatives for all sites in order to be able to eliminate as many black spots as possible. This principle will normally yield the highest total NPV within a certain budget frame. The only case, when a more costly alternative should be used, is when the marginal BCR for the more expensive alternative exceeds the BCR for the best alternative use of funds for other sites.

2.3.3 Using cost-effectiveness analysis (CEA)

If traffic safety has a special budget there is no need to make a full cost-benefit analysis for prioritising between safety measures and other investments.

Even if the primary goal of the safety budget is to reduce the number of accidents, injuries and fatalities in road traffic, it is still of interest to society to make these measures efficient not only concerning safety but also from all other aspects.

The problem when making a full cost-benefit analysis is that it requires monetary values for at least all major effects. For Turkey, as mentioned before, there are values for safety, vehicle operating costs and road maintenance. The major effects not valued at present are travel time and environmental issues, such as emissions, noise and barrier effects. Setting values to emissions is normally a difficult task and some specialists argue that it is not even possible. Environmental issues may be better dealt with using multi-criteria analysis. From experiences in other countries, time value is one of the larger contributors to the total valued effect in the cost-benefit analysis.

It would be a good long-term strategy, besides improving the existing values, to start using values of time. However, in the shorter perspective it is probably sufficient to value the safety effects when prioritising safety projects. The alternative to value the safety effects would be to determine "weighting" factors between accidents, property damage accidents, accident with injuries/injured and accidents with fatalities/fatalities. This however, is very close to a valuation in monetary terms.

Therefore, the present approach used by the KGM, calculating cost-benefit using values for safety only, is the most suitable one in the short-term perspective. However, improvements of the calculations and the values used should be made.

For cost-effectiveness the marginal effect may be used in a similar way as described under 2.3.2.

2.3.4 Analyze both monetary and non-monetary values

Normally, monetary values for all effects are not available. Even for important effects values may be missing, simply because some effects are very difficult to value in monetary terms. This does not mean that these effects should not be considered.

Very often when you intend to make a full cost-benefit analysis there will be effects that do not have any monetary values. These effects can, together with the calculated BCR of the valued effects, make a basis for a total appraisal of the project's viability.

Another way is to use multi-criteria analysis in which you list all positive and negative effects and assign some kind of non-monetary valuation scheme that may vary between different effects.

2.4 Conclusions

We suggest that the present method used at KGM for black spots, that calculates the benefit-cost ratio using only the costs of accidents and investments, is used until the valued effects at least also include the value of time. If a safety measure leads to substantial yearly maintenance costs, we recommend that the present value of this should also be included.

It should be considered to complement these calculations with the marginal benefit-cost ratio. This should then be used when setting the priorities of the complete list of black-spot measures and when there are alternative solutions for many sites. If BCR is strictly used for prioritising, the need to use marginal BCR may not be worth the effort. It should then be observed, however, that low-cost improvements tend to yield higher BCRs than more expensive solutions.

For other than traffic safety projects, it is also recommended that the present approach used by KGM should be used (that is to calculate a benefit-cost ratio using as many valued effects as available, together with multi-criteria analysis).

As KGM at present has the HDM-IV program, this can actually be used for some of these calculations, if properly calibrated.

3 Accident values

3.1 Background

The costs of casualties can be divided into three types:

- Direct costs
- Indirect costs
- Risk value

Direct and indirect costs are also referred to as material costs.

Direct costs
Direct costs are costs actually paid by someone, such as:

- **Property damage costs,** costs of repair of vehicles and other damages on private or public property, such as road signs.
- **Hospital costs,** the sum of costs of hospitalisation, other medical treatment instantly and in the future as a result of an injury, medicine, other medical necessities, need for help/care in the home and transport.
- **Administration costs,** costs of insurance companies and costs over the state budget for police and courts that can be referred to traffic accidents.

Indirect costs
Indirect costs are costs not directly paid by anyone. The indirect costs used in relation to accidents are loss of production, or in the case that a risk value is being used, the loss of net production (gross production minus consumption).

The production loss is the value of the amount of goods and services that a person would have been able to produce if that person had not experienced an injury or fatal accident.

The value is estimated as the salary of that person plus the employer's additional cost if any (employer's tax on the salary to the person, costs of social and health insurance, retirement costs etc., paid by the employer on top of the salary).

The present value of the production can be calculated using the following formula:
(formula 3.1)

$$\text{Present value of production} = A * W * \frac{(1 + 0.01*p)^{A}}{(1 + 0.01*r)^{A}}$$

where:

A = average years of production lost due to the fatal accident
W = average annual income (incl. employers additional costs)
p = expected yearly average production increase in the general economy (%)
r = discount rate (%)

The GNP per capita can substitute the average income. If you use the average income from statistics, this does not always consider unemployment. If you use GNP per capita, this is not a problem.

A more advanced method would be to use the following formula to calculate the present value for each person, considering their sex (s), injured at the age of (a): **(formula 3.2)**

$$\text{Present value of production} = S * W_{a,s} + \sum_{n=a}^{N} \frac{P^{n}_{a,s} * G * W_{n,s} * (1 + \rho)^{n-a}}{(1 + r)^{n-a}}$$

where:

S = part of the average annual income lost because of the traffic accident during the year the accident happened
$W_{n,s}$ = average annual income for person of the sex (s) in the age (n)
N = retirement age –1
$P^{n}_{a,s}$ = the probability of a person of the sex (s) in the age (a) to live to the age (n)
G = level of disability due to the accident (fatal = 100 %)
r = discount rate (%)
ρ = expected yearly average production increase in the general economy (%)

However, at present the first approach is recommended. To the value of production, the value-added tax (VAT) should be added.

If a risk value is used that includes the value of consumption, the value of lost consumption must be reduced from the value of lost production. The net production loss should then be used.

Risk value
The risk value reflects the pain and suffering of the victim as well as the grief and sorrow of his family and friends. The risk value can also be said to reflect how much an individual is willing to pay to reduce his own risk to be injured or killed. This value is normally considered to include the value of a person’s future consumption. That is why consumption should be deducted from the production loss in the indirect costs if a risk value is used. There is no market price on risk value, so normally this value must be estimated from experiments or constructed market models.

There are different methods to estimate the value of risk reduction, direct and indirect ones. A direct estimate is to use a stated preference study, that is, to ask individuals about their willingness to pay for a risk reduction.

An indirect estimate is to use revealed preferences, which means that you study how people actually behave and then transform this behaviour to an estimated value. The revealed preference approach is to value trade-offs, for example, how people accept wage compensation for risky jobs or how much a company is prepared to pay for improved safety for its workers. The argument against this technique is that risky jobs attract a certain type of people who like to take risks, or that some people may have limited work opportunities and have no other choice than to accept a risky job, without getting fully compensated. Similarly you can look at how people insure their lives, but this, however, does not only indicate how people value their lives, but more how much they can afford to insure themselves and how much other people are depending on their income.

Another indirect estimate is to use implicit values. For example, when a Government takes a decision to reduce a risk it will implicitly value the effects. Hopefully the Government is aware of the cost this decision implies. This method, however, is normally considered to be imprecise.

Some of the mostly used methods are:

- Court decisions
  Compensation ruled by a court could be used as a value for pain and grief. This value, however, is depending on the expected future incomes and the skill of the lawyer.
- Health index approach
  This method is based on the relation of health to quality of life. Non-fatal injury accidents are valued as weights/fractions of fatal accidents. The “value of life” is set using the relations between different degrees of injury.
- Human capital approach
  This method is purely based on future income losses and costs of health care for accidents’ victims. To value the potential reduction in health care costs as a result of safety measures, an approach called cost-of-illness is used. This approach should be combined with willingness-to-pay, since no values of the benefits are included in the human capital calculations.
- Willingness-to-pay (WTP)
  The value of increased safety is determined by how much individuals are prepared to pay for small improvements of their safety, or demands in compensation, to increase the risks. WTP-studies are based on observations of individual trade-offs between income and risk, or by questioning individuals about their willingness to pay for improvements. Also collective, for example political, decisions can be used.

WTP is the most used method and also considered the most relevant among experts.

The following table, 3.1, is a summary of the WTP approach:

	Direct estimates	**Indirect estimates**
Collective decisions	-	Implicit values
Individual decisions	Stated preference	Revealed preference

Table 3.1 Different methods for studying risk values

3.2 Present accident values

Today, KGM calculates IRR, NPV and BCR for traffic safety projects using values for property damage, injuries and fatalities. The value for property damage is based upon estimates of repair costs from the policeman making the accident report. The estimated cost is TL 409,740,514 per average accident, based on police reports from 1999. Probably, value-added tax is included, since this is an estimate of the cost to repair something. The cost of property damage is an average for all police-reported accidents, and does not differentiate between accidents with injuries or fatalities. Here, it could be argued from experiences in other countries, that the property damage costs are higher for accidents with fatalities and injuries than for accidents with property damage only. This is also supported by the values in the police reports analyzed by severity. Therefore, it would be better to calculate the costs using different property damage costs for accidents with property damage only, accidents with injuries and accidents with fatalities.

The costs of injuries are based on the costs of fatalities. The cost of a fatality is based on the expected income that the victim loses, which corresponds to loss of production, calculated as the average labor cost for 35 years. The average victim is statistically supposed to earn TL 1,764 million per year for another 35 years, which corresponds to TL 61,753 million. GNP per capita 1998 in US$ is used to substitute the average income used in the calculation, but the exchange rate used was from 1999. In this calculation, the present value of future earnings are not considered. From an economic point of view it would be better to do so. Otherwise it could be said that the present calculation is correct only if the economic growth is equal to the discount rate, which is highly unlikely. If a risk value shall be used, the consumption is normally considered to be included in this risk value. Therefore, most economists argue that consumption should be deducted from the value of production, to gain the net loss. If a study of willingness-to-pay is performed to obtain a risk value, the consumption should be deducted from the production. This value does not include value-added tax, which would be correct to add.

The cost of injuries is calculated as loss of production assuming that different percentages of the injured are not able to work for different time periods. The formula used assumes that 40 % is out of production for 1 month, 30 % for 3 months, 20 % for 6 months and 10 % for 35 years. The last statement corresponds to lifetime disability. This part of the expression means that 10 % will have injuries leading to full disability and that this is valued to the same amount as for one person who dies. Of course, this could be argued against, as life itself does not have any specific monetary value. Therefore, in the following, it is suggested that some kind of risk value (or value of statistical life) should be introduced.

When calculating the value of production loss for injuries, the same error is made as when calculating the loss of production after a fatal accident, that is the present value is not considered. In this case it only influences 10 % of the value. The source for the percentages for how long victims are out of production is not known. But since no other data is available and these percentages seem to be reasonable (although somewhat high compared with other countries), we suggest that they should be used for the present. The production is calculated as GNP per capita as used above.

3.3 Accident data

An important source to accident and casualty valuation is the available accident statistics. But, as in most statistics there are uncertainties. Some of the major question marks are:

- To which extent are accidents reported to the police?
- How well can the damages and injuries be estimated by the reporting policeman?
- How will the statistics be corrected for injured that later die in hospital?
- How do statistics account for those who die while being transported to hospital?

The police (EGM) register accidents in a database. Since the last quarter of 1997 the Gendarme reports accidents on a road network decided by each province, mostly non-government rural roads. The police database contains most accidents, though the Gendarme part, after the change in 1997, cannot be neglected. In 1998, the Gendarme reported about 4 % of the total accidents. These 4 % contained about 20 % of the fatal accidents and almost 20 % of the fatalities. Since Gendarme reported accidents are most similar to the police reported accidents for rural areas, it could be mentioned that the corresponding figures for these in 1998 were 15 % of the total, 45 % of the fatal accidents and 51 % of the fatalities.

The accident report situation is somewhat complex. Gendarme have officially only reported accidents since the last quarter of 1997, as mentioned above, and entered the data in an accident database (in a similar way as the police do) only since the beginning of 1999. The area from which the police respectively the Gendarme reports accidents varies between provinces and may not always be completely known by all.

The percentage of fatal accidents in the police reports has decreased during the last ten years (1990-1999), see table 3.2. This can indicate either that the degree of reporting for non-fatal accidents has increased or that improved road infrastructure and vehicles etc. have really improved the safety situation concerning fatal accidents.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fatal accidents	4.4%	3.4%	2.7%	2.4%	2.0%	1.6%	1.2%	1.0%	0.8%	0.8%

Table 3.2 The percentage of fatal accidents in police reports.

The development of the different severity of accidents, using 1990 as index=100, is as follows, table 3.3:

Index	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
No. of accidents	100	123	149	181	203	243	299	336	382	380
Fatal accidents	100	96	93	97	90	88	82	76	73	65
Injury accidents	100	102	106	115	114	121	115	117	121	119
Prop. damage accidents	100	144	191	244	288	359	474	545	630	630

Table 3.3 Index showing the development of accidents and severity in police reported accidents Gendarme reported accidents not included.

If only rural roads are considered and the traffic increase is considered (index accidents (1990=100)/index traffic growth (1990 =100)) the trends are as follows, table 3.4:

Index acc. /index veh.km.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
No. of accidents	100	121	121	136	137	124	119	152	149	141
Fatal accidents	100	101	84	83	79	66	61	56	48	43
Injury accidents	100	110	104	110	109	105	108	108	93	86
Prop. Damage accidents	100	140	155	184	190	164	150	236	250	240

Table 3.4 Index showing the development of accidents and severity in police reported accidents on rural roads, corrected for traffic increase. Gendarme reported accidents not included.

These figures seem to be somewhat strange and the reason for these peculiar development trends need to be analyzed more in detail. It should be observed that from 1997 the Gendarme are also reporting accidents, partly from areas previously reported by the police.

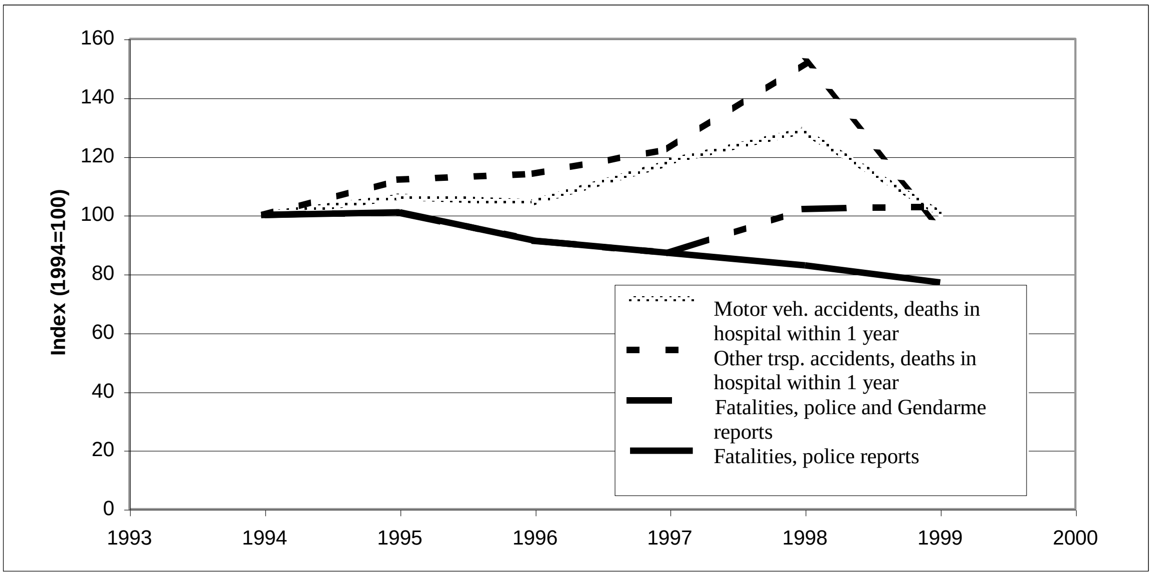

Figure 3.1 Development from 1994 of traffic fatalities statistics from different sources

In figure 3.1 above the development of fatalities in the police reports between 1994 and 1999 are compared with statistics from the Ministry of Health regarding the number of persons who died in hospital after motor vehicle accidents and other transport accidents. As can be seen, the data do not have the same development, which is somewhat strange.

The development can partly be explained by:

- An improved first aid and hospital care
- An increased use of seat belts and better-equipped cars
- An increase in use of full coverage insurance may contribute to an increase in property damage reports.

The reporting policeman estimates the property damage cost of the accident in the police report. The estimates for 1998 imply that rural accidents have about 3 times the cost of the average, while urban accidents have only 0.7 times.

Likewise, accidents in rural areas in 1998 in 3.2 % were fatal and in 32.1 % led to injuries. For urban areas these figures were 0.4 % and 10.9 %. For accidents reported by Gendarme 5.1 % were fatal and 27.1 % led to injuries.

The number of fatalities per fatal accident is for urban areas 1.17 persons and for rural areas 1.50.

The two last paragraphs above imply that it may be wise to distinguish between rural and urban accidents, since rural accidents have higher values.

The most correct data to use and set values for, should probably be “property damage only accidents”, “accidents with injuries” and “accidents with fatalities”. From a statistical point of view it would be better to apply an average number of fatalities or injured per fatal and injury accident respectively from the police reports. The data needed for this is not available at present. It would be necessary to know how many injured persons there are per average fatal accident. To find this information is somewhat complicated because fatalities are only noted in the report if a person is killed at the site of the accident.

The average age of fatalities seems to be somewhere between 30 and 35 years according to accident statistics for 1998, which seems to coincide with the 35 years average loss of production for fatalities used by KGM.

In many cases the accident data is statistically uncertain, and it would be preferable to use standard values for a certain type of road environment, for example, motorways or signalized intersections. The actual accident situation can be considered, but would then have to be adjusted towards the standard value. In Sweden, this adjustment is made like this: **(formula 3.3)**

N(*) = N(N) + Cn * (N(O) – N(N))

where:

Cn = 0.25 * N(N) / (1 + 0.25 * N(N))
N(*) = Corrected number of accidents
N(O) = Observed number of accidents (police reported accidents)
N(N) = Normal number of accidents in this environment per million vehicles and year * number of million vehicles per year on which the N(O) is based.

For number of injuries (or injuries and fatalities) the similar procedure is done like:
(formula 3.4)

I(*) = I(N) + Ci * (I(O) – I(N))

where:

Ci = 0.10 * I(N) / (1 + 0.10 * I(N))
I(*) = Corrected number of injuries
I(O) = Observed number of injuries (police reported injuries)
I(N) = Normal number of injuries in this environment per million vehicles and year * number of million vehicles per year on which the I(O) is based.

At present this type of correction cannot be used in Turkey since there are no standard values for different road environments etc. If such values will be available in the future, a similar correction should be used in Turkey.

3.4 Suggested improvements of accident values

3.4.1 Short-term perspective

In the short-term perspective it is only feasible to use already available data. Therefore, in the following section, we have looked at what is available and how this material could be better used.

Since the number of fatalities and injuries for a selected black spot may have a large statistical uncertainty, it would be preferable to use some kind of average number of fatalities and injuries per fatal and injury accident as a basis. It has been possible to estimate figures of the number of injuries in fatal accidents by using the accident statistics from the Pilot Project region of the Traffic Safety Project.

In rural areas, the number of injured persons per fatal accident has been estimated to be 2.8 and per injury accident to be 2.2 persons. These estimates are based on the more detailed police reports from the Pilot region.

If the value of property damage for the average accident is calculated to TL 409,740,514, the value for rural road accidents should be around 3 times this, that is around TL 1,200,000,000. However, for Gendarme reported accidents it is estimated at about TL 800,000,000. By not using the Gendarme values in the calculation of property damage, the value becomes somewhat overestimated. However, the Gendarme have not been reporting accidents for as long as the police and it is probably better to avoid mixing the estimates of the different organisations.

If a certain safety measure is reducing accidents with property damage only, using the average cost for urban or rural accidents, the costs will be overestimated since the property damage cost is higher for accidents with casualties. And, for a safety measure which mainly lessens the risk of getting killed or injured, the benefit is underestimated.

The costs of the property damage for different categories of accidents, using the police cost estimates, have for rural areas been approximated to:

- Property damage only accident TL 690 million
- Injury accident TL 1,550 million
- Fatal accident TL 2,850 million

An estimate has been made for urban areas and later in the text we will account for this. KGM is planning to install a database program in order to be able to make this type of analysis in an easier way in the future.

Professor Dr. Rıdvan Ege claims, using statistics from the Ministry of Health and other sources, that out of about 10,000 traffic fatalities in 1997, about 5,200 are killed instantly and in the police report noted as fatalities. Of the remaining fatalities it is assumed that 1,150 die during transport to hospital and about 3,500 die in hospital. Since the analysis at KGM is based on the police reports, the fatalities should be multiplied by a factor of 1.9 using these figures. On the other hand, this implies that the number of injuries should be decreased with the corresponding number of injured (about to 0.96).

The statistical source for the number of people who die during transport to medical care has not been found, and the other values used by Professor Dr. Ege have been changed since 1997. For correcting the police and Gendarme reported fatalities and injuries an average of 1998 and 1999 is used, which gives the following correction factors:

- Fatalities 1.51
- Injuries 0.97

These correction factors are based on the sum of police and Gendarme statistics in relation to the total, including the ones who die in hospital according to Ministry of Health statistics, see table 3.5 below. It should be observed that the number of victims that die during transport to medical care is not known and therefore not included.

Fatalities	1998	1999
Police	4935	4596
Gendarme	1148	1534
In hospital (MoH)	3478	2694
Total	**9561**	**8824**

Table 3.5 Number of reported fatalities in 1998 and 1999

Usually one can suspect that accident reporting, at least for injuries and property damage is not 100 %. In most countries this is the case. In Sweden, for example, almost 100 % of the fatal accidents, 42 % of the injury accidents, and 7 % of only property damage accidents are reported. For those injured in motor vehicle accidents, only 60 % are reported, for bicycle accidents 20 % and pedestrian accidents 45 %. Many of the non-reported accidents in Sweden are with bicyclists and pedestrians.

The reason for not reporting an accident could be, for example, use of alcohol, the police is not nearby and the waiting time would be substantial, there is no possibility to contact the police or that the damage cost is less than the excess of the insurance. The excess is the part of the damage cost one must pay before the insurance pays anything. A large part of the accidents, at least in most countries, often includes only one vehicle. This may give the driver the feeling that he can only blame himself. Accordingly, there is often no one but the driver, who has any interest in reporting the accident for insurance claims (if he finds it worth while).

In Sweden, an accident is considered fatal if the person dies within 30 days. Severe injury is defined as an injury that requires hospitalisation, slight injury means an injury that needs treatment but not hospitalisation.

The following procedure is suggested to be used to calculate the monetary values:

1. Corrections to make it possible to use both fatal/injury accidents as well as fatalities/injuries. From police statistics (1995-1999) and statistics from the Pilot Project region (1998-1999) where more detailed data are available, the following number of injured and killed persons per accident could be estimated for <u>rural</u> accidents:

   → 1.5 fatalities per fatal accident
   → 2.8 injuries per fatal accident
   → 2.2 injuries per injury accident

   Assuming that the relations between injuries in fatal accidents and injuries in injury accidents are the same as for rural areas, the following values are obtained for <u>urban</u> accidents:

   → 1.2 fatalities per fatal accident
   → 1.9 injuries per fatal accident
   → 1.5 injuries per injury accident

2. These figures are now corrected by using the statistics from the Ministry of Health (1998-1999) that show how many of the persons who probably are reported as injured that will die in hospital within one year. The normally used and recommended period is 30 days. At present, however, this is the only available data. To ignore this and consider these victims as injuries is certainly a much larger error than to include them as fatalities. It should be noted that there might be a risk that some accidents are recorded twice. In the calculation of the values below, it has been assumed that those who die in hospital after an accident twice as often have been involved in a fatal accident as in a severe injury accident. So the numbers from (1) above will be changed to:

for <u>rural</u> accidents:

→ 2.1 fatalities per fatal accident
→ 2.2 injuries per fatal accident
→ 2.1 injuries per injury accident

for <u>urban</u> accidents:

→ 1.5 fatalities per fatal accident
→ 1.6 injuries per fatal accident
→ 1.4 injuries per injury accident

There are also a few fatalities per injury accident, but these are approximated to zero per injury accident.

The fatalities above are corrected with the factor of 1.51 and the injuries with 0.97 mentioned earlier. These correction factors are based on the following data from 1998/1999, see also table 3.5:

→ Number of police reported fatalities: 4,935/4596
→ Number of Gendarme reported fatalities: 1,148/1,534
→ Number of police reported injuries: 114,552/109,899
→ Number of Gendarme reported injuries: 11,241/15,687
→ Number of persons who die of motor vehicle accidents in hospital: 3,478/2,694

All of the accidents related to motor vehicles are not necessarily road traffic accidents, but as the majority of them probably are, that is, there will only be a small overestimation.

3. The value of property damage is then corrected by using the estimate in the police reports and divide them into rural and urban:

→ Property damage per vehicle (used today by KGM): TL 410 million
→ Property damage per vehicle in rural areas: TL 860 million
→ Property damage per vehicle in urban areas: TL 280 million

4. With data from the Pilot region, the **cost of property damage** for different types of accident severity can be estimated:

→ Rural property damage only accident: TL 690 million
→ Rural injury accident: TL 1,550 million
→ Rural fatal accident: TL 2,850 million
→ Rural injury: TL 710 million
→ Rural fatality: TL 660 million
→ Urban property damage only accident: TL 240 million
→ Urban injury accident: TL 550 million
→ Urban fatal accident: TL 1,000 million
→ Urban injury: TL 370 million
→ Urban fatality: TL 320 million

The values for killed and injured persons above are corrected for persons who die in hospital after an accident from (2).

For urban accidents, the costs for the different types were not possible to obtain from the Pilot region (which is assumed to be purely rural). Therefore, the relative differences between the costs of property damage accidents for different severe accidents in urban areas were assumed to be the same as for property damage costs in rural areas. The relations used were 1:2.25:4.14, from property damage only to fatal accidents property damage costs.

This assumption was built on the fact that the property damage costs for different accident severities vary in the same way for urban and rural areas. This may not be accurate, but it is the best approximation that can be made at present with available data.

5. The net present value of production loss is then calculated, the net value calculated as production minus consumption because a risk value is going to be added, in which the value of consumption is included. The net present value is at present calculated for fatal accidents as the income during 35 years (expected remaining working years for a fatality) which is estimated as TL 1,216 million per year. The present value is calculated using an average annual economic growth of 5 % and a discount rate of 15 %.

   The annual income is estimated as GNP per capita in 1999, and the public and personal consumption is estimated from the statistics to be 75 % of this.

   This gives the following present values for net production loss, including VAT:

   → TL 3,430 million for a fatality
   → TL 1,325 million for an injury

   The reason for the rather small difference depends on the high discount rate.
   The values per reported accident will be:

   → TL 10,224 million for a rural fatal accident
   → TL 2,882 million for a rural injury accident
   → TL 7,153 million for an urban fatal accident
   → TL 1,952 million for an urban injury accident

6. The material costs are, beside the indirect costs of net production loss, the direct costs such as hospital costs, administration costs and property damage costs. The latter has been calculated above, but for the two first ones no data are available. In Sweden, these values have been studied and estimated, and as no data are available for Turkey, these costs are assumed to be equally large parts of the material costs as in Sweden. Some very preliminary data from Gazi University hospital indicates that this assumption is reasonable. This gives the following factors by which the sum of property damage and production loss obtained in 4 and 5 above should be multiplied:

→ for property damage accidents 1.15
→ for injuries/injury accidents 1.34
→ for fatalities/fatal accident 1.06

7. The risk value is then calculated using the Swedish values. These are corrected in relation to the difference in GNP of Sweden and Turkey in 1997, which gives a factor of 8.6 higher GNP per capita in Sweden. Using this relation in calculating a risk value for Turkey, the following values are obtained at a price level of 1999:

→ TL 3,700 million for an injury
→ TL 107,000 million for a fatality

These corrections (1 to 7) above give the following values, see tables 3.6, 3.7 and 3.8, assuming tax factor 1 equals 1.17 (VAT = 17 %):

Accidents		Material cost	Risk value	Total
RURAL AREAS	Fatal accident	13,973	235,959	249,931
	Injury accident	6,741	9,432	16,173
	Prop. damage	813	0	813
URBAN AREAS	Fatal accident	8,716	161,889	170,605
	Injury accident	3,796	6,865	10,661
	Prop. damage	286	0	286

Table 3.6 Costs per police and Gendarme reported accident in TL million, price level 1999, incl. 17 % VAT.

Values per person in actual case		Material cost	Risk value	Total
RURAL AREAS	Fatality	4,368	107,252	111,620
	Injury	3,103	3,693	6,797
URBAN AREAS	Fatality	4,013	107,252	111,265
	Injury	2,587	3,693	6,281

Table 3.7 Costs per killed/injured in TL million, price level 1999, incl. 17 % VAT.

Values per police reported person		Material cost	Risk value	Total
RURAL AREAS	Fatality	6,117	161,950	168,068
	Injury	3,065	3,583	6,648
URBAN AREAS	Fatality	5,762	161,950	167,713
	Injury	2,545	3,583	6,127

Table 3.8 Costs per killed/injured police and Gendarme reported person

in TL million, price level 1999 incl. 17 % VAT.

Starting in 2000, the police will no longer enter the “property damage only” reports into the accident database. A safety measure will in most cases also affect the total number of accidents. Sometimes it will decrease all severity types. In other cases, it will decrease the number of fatalities and injuries but increase the number of property damage only accidents. The present KGM black spot program requires the number of accidents, and since the material should be available, KGM might find it necessary to enter these data into an accident database. When analyzing what kind of measures that are effective at a black spot, it may also be useful to consider the information from property damage only accidents.

If the property damage only accidents are not available, it is still possible to include them in the cost-benefit analysis using average number of property damage accidents in relation to accidents with injuries and fatalities. In the long-term perspective this relation may be expected to change and should then be updated. There will then be a problem to estimate a new relation factor, but it is recommended to include the property damage only accidents at this time.
One could argue that the cost of an injury should be different in rural accidents than in urban since the degree of severity can be different. The speeds are higher in rural areas but on the other hand there are more accidents involving pedestrians in urban areas. As no data is available, they are assumed to be equal.

The relations for property damage costs for accidents with property damage only, with injuries or fatalities are in Sweden 1:3.5: 21. These figures are much higher than the ones estimated by the police in Turkey, which give the relation 1:2.25:4.14. This is estimated from one year of accidents in the Pilot region. When more data is available, this figure should be updated.

In most countries there is considerable underreporting for injury accidents and property damage only accidents. Awaiting a Turkish survey of the degree of reporting, it could be possible to assume that the proportions are equal to those in Sweden. These correction factors, however, may be a bit too high for Turkish conditions, since bicycle and pedestrian accidents have the lowest degree of reporting and since bicycling is not so frequent in Turkey as in Sweden. Instead, by way of precaution, the factor should be calculated on the degree of reporting for motor vehicle accidents. The following factors to calculate accident costs from police reported accidents could be used to consider non-reported accidents:

- Fatalities 1.0
- Injuries 1.7
- Property damage 7

However, at present we do not recommend the use of these, since there is no source available that indicates how many injury and property damage only accidents that are not reported. KGM must consider if such corrections should be used, and then if the Swedish values could be used as estimates, meanwhile Turkish values are obtained.

The numbers of accidents in the KGM analyses are considered to increase in proportion to traffic growth. This can be questioned since better cars with more safety equipment and better, more informed drivers will be a part of the normal development. In Turkey, there has not been any correlation between traffic growth and accident growth during the last years. Instead fatal accidents, according to police reports, have decreased by 3.6 % per year for the last 9 years, while the traffic on state highways and provincial roads have increased by 8 % per year for the last 8 years. It has not been possible to find a full explanation for these seemingly illogical figures. At present we recommend that no increase/decrease of traffic accidents is made over time in the analyses.

The factor describing the decrease in accidents not related to improvements in the road environment is very difficult to isolate. In Sweden, the factor is considered to be a few percent per year providing zero traffic increase. In Turkey, this figure could be higher as the potential for improvements is larger. The improvements undertaken the last years in Turkey are, however, not likely to be the only explanation for the large decrease in fatal accidents.

The calculation methods and values used above in steps 1-7 have been included in an Excel sheet that can be used by KGM for black spot analysis, Appendix 1. From this it is possible to follow how different values are calculated and there is also the possibility to change some factors and data to calculate new values. A short manual has been written for this Excel sheet.

3.4.2 Long-term perspective

In a long-term perspective, it is suggested that surveys are made and that new material is collected in order to describe the costs of accidents better, and also to make a better estimate of the risk value for fatal and injury accidents. All data and costs should be improved and updated.

The accident data should preferably be based on three- or five-year periods and more data will later be available for the Pilot region. All costs should be checked and fixed at a given price level when, for example, the national statistics for the year 2000 are available.

The effects and costs of safety measures, as well as other road investments, should continuously be updated, for example, by using the follow up program recently started by the Traffic Division at KGM. This program was initiated in 1998, and at the end of 2000 there should be 3 years of accident statistics for the first projects.

The estimates of property damage costs probably need to be improved. The policeman making the accident report today bases property damage costs on a rough estimate. This value is dependent on the skill of the individual policeman and his knowledge of repair costs and also on his possibility to make an adequate judgement of the size of the damage on the spot.

One way to improve the quality of the property damage costs would be to request insurance companies for information, though it must be remembered that all vehicles do not have an insurance that covers repair costs of the own vehicle.

An improvement which could be made without any major effort or cost, would be to ask the police/Gendarme to account for property damage costs divided into the categories of "property damage only accidents", "injury accidents" and "fatal accidents". If the number of injuries per fatal accident can be accounted for as well, this would mean a major improvement.

How well the police and Gendarme estimates correlate to the real cost from insurance claims and repair shops could also be studied.

According to international recommendations it would be better to use the following definitions for traffic accidents:

- Fatality: A person who dies within 30 days after the accident
- Severe injury: A person who is hospitalised
- Slight injury: An injury that does not lead to hospitalisation

Generally the knowledge of to what extent different accidents (property damage only, injury, fatal) are reported to police needs to be investigated.

The costs of hospital and medical treatment can preferably be obtained by following up a number of traffic accident victims of different degrees of severity during a longer period. Within the emergency aid pilot project at Gazi University hospital, that is a part of this project, these values should be possible to estimate.

The severity of an injury accident and for how long an injured person is unable to work fully needs further investigation. Hopefully, the studies at Gazi University hospital can give some input.

The degree of severity reported as injured varies largely. Therefore, it would be better if the police reports could split this category into slight and severe injury. This would improve the estimates of an accident with injuries during safety analyses. On the other hand, experiences from other countries show that it is difficult for the police to determine the degree of injury.

Administrative costs related to traffic accidents of the insurance companies and costs over the state budget for police and courts can be difficult to obtain. These costs should preferably be estimated per accident category, that is property damage only, injury (slight and severe) and fatal.

For the calculations of net production loss, either the GNP per capita approach could be used or an attempt to estimate the average income of traffic victims could be tried.

The discount rate should be further discussed. To find the correct discount rate for infrastructure investments is probably a task for the concerned Ministries.

The tax factors needs further investigations. To determine tax factor 1, set equal to the average VAT for private and public consumption, should merely be a question of gathering the correct data. Then, it is more difficult to decide whether to use tax factor 2 or not, and in the former case what value to use. There are arguments both for and against using a marginal cost of public funds. The decision to use this is a question not only for KGM, but for all public investments in Turkey.

To determine actual Turkish risk values, a willingness-to-pay study is recommended. This needs expertise specialised in the field. A short description of a Swedish study is made under 3.5.

3.5 Willingness-to-pay study, example from Sweden

To estimate the value of risk reduction, a willingness-to-pay (WTP) approach is recommended, using a contingent valuation (CV) study. The CV-study made by Ulf Persson et al. for the Swedish National Road Administration used hypothetical questions of WTP in a survey. The data was collected using a postal questionnaire sent to a random sample of 5,650 individuals, age 18 to 74. Two sets of questionnaires were used in the study. One had the purpose to estimate the value of a statistical life (VOSL) in the road traffic sector and the other had the purpose to estimate the value of risk reduction for non-fatal injuries.

The VOSL-study included 3,050 questionnaires divided into 6 groups:

1. Questioned about how much they were prepared to pay for a 10 % risk reduction.
2. Questioned about how much they were prepared to pay for a 30 % risk reduction, with sub-groups (“scope embedding”): a) for the risk of getting killed in traffic, b) for the risk of getting injured in traffic, c) for the risk of getting injured or killed in traffic.
3. Questioned about how much they were prepared to pay for a 30 % risk reduction, with sub-groups that had to consider if they were prepared to accept to pay a given amount for this (“starting point bias”). The amounts for the 6 sub-groups were SEK (Swedish kronor) 20, 50, 100, 500, 1000 and 2000.
4. Questioned about how much they were prepared to pay for a 30 % risk reduction, with 2 sub-groups that had to consider the time perspective (“temporal embedding”), a) if the amount was to be paid yearly for 5 years, b) the whole amount was to be paid at one time but for a risk reduction period of 5 years.
5. Questioned about how much they were prepared to pay for a 50 % risk reduction.
6. Questioned about how much they were prepared to pay for a 99 % risk reduction.

The study for non-fatal injuries:

1. Questioned about how much they were prepared to pay for a 30 % risk reduction, with sub-groups with questions that test how the size of the risk reduction is considered (“scale embedding”): a) valuing a 20 % risk reduction by installing an airbag in the steering wheel of an old inherited car which lacked this equipment, b) valuing a 20 % risk reduction by installing a side-airbag in a car that already had an airbag in the steering wheel, c) valuing a 40 % risk reduction by installing both an airbag in the steering wheel and a side-airbag. All these sub-groups were further divided into 4 groups all with one injury that led to disability (or fatal in one case), one severe but

healing injury and one slight injury. The groups were given different combinations of detailed descriptions, one for each of the three injury groups.
2. Questioned about how much they were prepared to pay for a 50 % risk reduction, divided into 4 sub-groups with different combinations of description, one for each of the three injury groups as described above.

In the text below there are some examples of questions used in the questionnaire besides general information like sex, age, household income, means of transport, car ownership, experience of accidents, health status and such:

- Questions about how aware the person is of his own risk, e.g. “An average risk to get killed in traffic an average year is about 5 to 100,000 for a person in his fifties. How large do you think your own risk is of getting killed in an accident an average year? Your risk can be both higher and lower than the average. Consider how much you expose yourself in a traffic environment, which means of transport you use, and how you behave, e.g. how safe is your driving behaviour. Answer: I believe the risk is …….. to 100,000.”
- Questions about WTP, e.g. “How much would you consider to pay at the most per year to reduce your own risk of getting killed in a traffic accident with one third? Answer: ……….. SEK per year.”

There was quite thorough information in the questionnaire such as:

“In the question to follow we want you to answer the question about how much you yourself would be willing to pay for safety equipment that reduces your own risk of getting killed in a traffic accident with one third. Before you decide how much you at most would be willing to pay, we like you to consider the following:

- The reduction of risk only applies to getting killed in a traffic accident. The risk of getting injured is not influenced.
- The safety equipment is not uncomfortable, ugly or unpleasant to use. It is not noticeable. You yourself can only use the equipment. It does not influence the risk of other persons.
- The safety equipment will only work for one year. Thereafter you must pay again if you want to continue to use the risk reduction.
- An accident will not influence the economy of your family, as we assume that the insurance company fully will cover the loss of income to your family and any cost for medical care and medicine.
- The amount of money you pay to reduce this risk leads to less money to consume other goods and services.”

The injuries used in the injury groups, as described in the non-fatal accident methodology above, were all described in detail.

One of often mentioned critics of the WTP-method is that it is very hypothetical, that the interviewed person never has to pay what he claims he is willing to, and that some persons may have a problem to understand the questions or relate to them.

The method is very complex and it is advisable to use personnel with deep insights in economics and statistics. Still WTP is considered to be the best method for estimating risk values.

3.6 Conclusions

Even if there are problems to obtain relevant reliable statistics and data, it is possible - by using estimates and experiences from other countries and by analyzing existing data more in detail - to define values of reasonable quality to use in cost-benefit analysis for traffic safety measures.

The statistics can be further evaluated and updated as new values and knowledge becomes available. Studies can be made, such as the ones suggested above in this chapter, to further improve the basic data.

The suggested method in this chapter should not be seen as a final approach for valuing the effects of a safety measure. It is merely a suggestion how to use some of the available data and knowledge better. One purpose is to stimulate KGM and others to constantly improve the use of available data and to increase the awareness of where the major fields of improvements are within accident statistics and values of safety effects.

Combining the present analyzing methods at KGM with the suggestions made in this chapter will provide KGM with more accuracy and reasonable quality to value the effects of safety measures.

4 Other values

4.1 Road maintenance costs

For maintenance costs KGM uses actual costs of road maintenance. This is normally also the best way. There is no reason to question the quality of these costs at present, and normally these values will be updated on an annual basis.

4.2 Vehicle operating costs

At present vehicle operating costs (VOC) are derived from HDM-III, which has been calibrated for Turkish conditions. The quality of this value depends on how well this calibration is made. KGM is at present starting to use the new version, HDM-IV, which requires some additional data and calibration. At the same time, maybe the data used for VOC should also be updated and improved.

4.3 Time values

Time costs constitute one of the larger components (normally benefit) of road improvements. Therefore, it may be worthwhile to put some effort in acquiring the time value.

The average time value is normally supposed to be related mainly to income, choice of mode and purpose of travel. You usually distinguish between at least two kinds of purposes for traveling, business trips and other trips. Sometimes other trips are further divided into trips to/from work, shopping trips, leisure and visiting trips and so on. But since no such data is available for Turkey, we suggest that two different values is enough to start with.

The value per time unit should be set equal for short trips as for long trips if available data is not sufficient to differentiate. Small gains of time are normally supposed to have the same value per time unit as large time gains. Reasons for considering even small gains of time can be that people are driving against red light, over-takings are made in improper situations and at dangerous locations etc. One assumption is that there often are dependence between several road projects and that small time gains therefore are accumulated into large gains of time.

Gains of travel time possible to be transformed into working time are valued to the price of the market. The value of time is supposed to be proportionate to income; the income is normally not supposed to vary between different regions. On the other hand, income is supposed to vary between means of transport and purpose of travel.

One reason for using income as a source for time value is the consequences for future time values, which may be of significant importance with regard to the lifetime of infrastructure investments.

In the following, reference is made to the way time values were estimated in Sweden.

Time savings made in connection with business trips do not always mean that working time increase with the same amount. Instead, a part of the time saving will lead to, for example, that the road user will get more leisure time. In Sweden it is assumed that two thirds of the time saving will be spent on working and one third will be spent on leisure time. The cost of salary might be used as a base for valuation of the timesaving made during working time. The salary cost shows the value of what the employee produces. The reduction of travel time makes it possible for the employee to produce goods instead of using the time for traveling. This time should be valued. The third spent on leisure is estimated as for trips between workplace and home as mentioned below, but has been given a somewhat higher value than the one based on the salary of an industrial worker. For Turkey, since no such data is available, we suggest that the whole time saving is considered to be used for work.

The alternative cost for business trips should then be estimated to the lost production in trade and industry. The trade and industry estimate this loss in production at the total salary cost, including additional employers' costs. The goods produced by the industrial worker will be sold at the market with a price corresponding to the salary cost that the company would have paid the industrial worker and all additional costs such as insurances and pensions for the employee and other state charges based on the employee's salary.

At the market, this merchandise or service will be sold at the production cost with added taxes (and the state yields taxes). When buying these goods the price would correspond to the consumer’s willingness to pay for what they would have been able to produce instead of traveling. For that reason, the salary per hour including overhead costs and tax factor one is used. This tax factor is used due to the fact that the state yields taxes if the consumer uses his money buying goods.

The total gain of travel time for truck drivers is supposed to be transformed into work. The value of gained travel time is assumed to correspond to the salary per hour, that is the average salary for truck drivers, including the employer’s additional costs and tax factor one.

The value of travel time for the three different types of travels during leisure time[1] are in Sweden based on an estimation of the willingness to pay corresponding to salary. The estimated values are compilations of different investigations mostly based on revealed preferences.

The valuations of trips between workplace and home in Sweden are supposed (based on econometric valuations and interviews) to be 30 % of the salary per hour (not including the employer’s costs for salaries), for shopping trips 25 % of the salary per hour and for other kinds of trips during leisure time, 20 % of the salary per hour. The average salary for industrial workers (men) is used as a base for valuation of time spent on trips during leisure time (employer’s additional costs excluded).

In Sweden, as well as in other countries, many studies have been carried out to show how timesaving during leisure time can be estimated. Mainly, real choice behaviour (revealed preferences) has been studied. For example, studies have been carried out investigating when road users choose to drive a faster but more expensive road, instead of a slower and less expensive one. This can illustrate the road user’s valuation of time savings. Many studies are also based on the road user's choice between different means of transport.

These studies have shown that the valuation of the time saved during leisure time is somewhere between 15 and 35 % of the road users’ average salary per hour. Based on such observations and average salary, per hour values can been estimated for time saving during leisure trips. For Turkey we suggest 25 % of the average salary per hour for non-business trips until other values can be obtained from studies.

The table below could be used to calculate a preliminary value, awaiting studies to obtain Turkish values.

The values in table 4.1 are very rough estimates and given in thousand Turkish Lira. Before these values are used, they should be validated.

Salary for business trips = average salary of a businessman * the employer’s additional costs * VAT
Salary for other trips = average salary for an industrial worker including vacation payment
Salary for truck driver = average salary of a truck driver * employer’s additional costs * VAT

[1] Trips to and from work, shopping trips and other trips during leisure time

Salary for a business man	850 thousand TL/hour
Salary for an industrial worker	360 thousand TL/hour
Salary for a truck driver	360 thousand TL/hour
Addition for employer's total salary costs (including employer's additional costs)	1.20
Tax factor	1.17

Trip purpose for cars	Distribution of trip purposes (%)	Number of persons/veh.	Cost per vehicle hour (thousand TL)	Time value as % of salary
Business trips	30	2.0	2,417	100
Other trips	70	3.0	277	25
All car trips	**100**	**2.8**	**919**	
Trucks		1.8	910	
	Percentage trucks	32		
	Total traffic	**916**	**cost per vehicle hour (thousand TL)**	

Table 4.1 Principle to estimate travel time costs

The values in the table above show a simplified approach for Turkey. All values need to be obtained by using reliable sources or relevant surveys. The distribution of trip purposes and number of persons per vehicle are Swedish values increased with 50 % since we have seen from accidents that the number of fatalities and injuries per accident are at least 50 % higher in Turkey than in Sweden. The percentage of trucks comes from KGM statistics for KGM roads.

4.4 Other missing values

The are several other effects that could be of interest to value in monetary terms. However, the task to do so is not simple and it may be difficult to gain support for such an undertaking. One example is environmental costs, such as for exhaust emissions. A value obtained by using willingness to pay, however, will not reflect the global interest to lessen such emissions. The same kind of problems are valid for company market profits. For this, a multi-criteria analysis can be helpful, although not the only solution, but maybe the best at hand.

There is one emission value that is easier to obtain and that is the value for noise pollution. This can be estimated by revealed preferences by studying property values and rents for different noise environments. Noise can of course also be considered using multi-criteria analysis.

Barrier effects can be of two kinds. One is the natural barrier a road makes in the landscape, disturbing the view, the possibilities of recreational use and affecting the wild life. The other kind is when the road and its traffic are disturbing the local population's pattern of movement and the fact that they may experience a greater risk than what is actually the case. Both these types of effects can be valued by using stated preference studies or considered by using multi-criteria analysis.

In most countries, where the environmental effects partly have been valued, the values are rather small. This does not reflect the importance to consider the environmental effects of road investment. Therefore, emissions and other environmental effects are probably best considered in a multi-criteria analysis.

5 Conclusions

The present method used by KGM calculating BCR is recommended to be used with some modifications. We suggest using the values in tables 3.6 – 3.8 together with the Excel sheet ("Black-spot CB-analysis.xls") prepared by SweRoad for valuing effects of safety projects.

The program that is used to find black spots should, as the Traffic Division at KGM suggested, be based on three years accident statistics. Then cost-benefit analyses should be made for about twice the amount available in the budget. It would then be easier to prioritise the projects so the traffic safety effects are maximized for the available funds. It should be observed that low-cost alternatives tend to yield higher BCRs than high-cost alternatives.

If there are any reasons not to follow the order of the prioritised list, KGM should inform the decision makers what the consequences of this would be and how this would influence the possibilities to improve the safety situation in the most efficient way.

There are several fields covered by this report for which improvements could be an important future task. The most important ones are:

- Improvement of accident statistics to cover the total number from Police, Gendarme and the Ministry of Health.
- Knowledge of the total number of non-reported accidents, injuries and fatalities.
- Improvement of the risk value; updating the approach used in this report when new data becomes available and in the longer perspective undertake a willingness-to-pay study.
- Validate the discount rate and economic growth forecast.
- If a road data bank will be set up (together with an accident data bank), it will be possible to obtain accident and injury rates for different road environments. These can be used both for calculating corrected accident data and determine effects of new investments.
- Implemented road safety measures should be followed up to increase the knowledge of which effects have been reached.

To be able to include all major effects in a CBA a Turkish value of time are needed. Estimating time values using Turkish data about vehicle composition and earnings is therefore an important future task.

In the methods used in this report we correct the number of fatalities using the Ministry of Health statistics. The number of injured is only corrected downwards because we assume that the ones who die in hospital are reported as injured in the police reports. From international experience we know that all injuries and accidents are not reported. It is, therefore, an important task to estimate this underreporting.

The report is to a large extent about which are the most important effects to value. Even if the environmental effects are difficult to value, they are important to consider in a full cost-benefit analysis. If not valued they must be considered besides the CBA, for example, by using multi-criteria analysis.

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Excel calculation sheet used by the Planning Division, Karayolları Genel Müdürlüğü

7 Appendices

Appendix A - Excel sheet for cost benefit analysis of black spots, “Black-spot CB-analysis.xls”

Appendix B - Manual for using the Excel sheet, “Black-spot CB-analysis.xls”

Appendix C - Persson Ulf, Nilsson Katarina, Norinder Anna, Hjalte Krister, The value of Statistical Life in Transport: Some evidence on scale embedding from a New Contingent Valuation Study in Sweden.

Appendix D - Trawén Anna, Marasta Pia, Persson Ulf, Costs per Fatal Casualty in Traffic Accidents, Paper to 3rd KFB Research Conference, June 13-14, 2000.