ASSESSMENT OF THE ECONOMIC VALUE OF ENVIRONMENTAL DEGRADATION IN SERBIA

Final report

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TABLE OF CONTENTS

SUMMARY

In the period February – July 2004 a project has been undertaken to assess the "Economic Value of Environmental Degradation in Serbia". Main objective of the study is to quantify as much as possible the economic damage of environmental degradation in Serbia. Other than in most Central & Eastern European Countries, during the 90-ties no attempt has been made to improve the environment in Serbia, leading to high levels of pollution around the country.

Methodologies applied

To assess damages a survey was made for earlier "damage" studies, for example the study on "The Benefits of Compliance with the Environmental Acquis for the Candidate Countries" carried out for the EU. Finally in most cases the so-called benefit transfer method has been applied, making use of results of earlier studies, and transferring these results to Serbia, making use of data on emissions to air, waste water discharges and waste in Serbia. Most damages relate to health (mortality and morbidity) but also to damages to environment, and the in-efficient use of resources.
A spreadsheet model has been developed to assess in a structured and consistent way the damages to environment. The core of the model is formed by so called unit damage estimates (for example the economic damage of the emission of 1 tonne of Sulphur dioxide) which were adapted to Serbia, by applying international Purchase Power Parity standards.

Results

The table gives an overview of the "low" and "high" estimate of the damages in the different areas investigated.

Table A
Assessment of total annual damages to the Serbian environment, in million €.

area	minimum estimate	% of total damage	maximal estimate	% of total damage
air	€ 447	52%	€ 1,370	54%
water	€ 179	21%	€ 576	22%
waste	€ 98	11%	€ 276	11%
noise	€ 57	7%	€ 181	7%
soil erosion	€ 79	9%	€ 158	6%
Total	**€ 861**	**100%**	**€ 2,561**	**100%**
Share in GDP	**4.7%**		**14%**	

Total damages to environment range from € 860 million to about € 2.5 billion per year. This is equivalent to 4.7% to more than 14% of Serbian GDP (assumed to be € 18.3 billion per year). As expected from other studies, largest damages are to be experienced due to air pollution, pollution of water, loss of valuable water resources and a lack of proper waste management practices. The damages relate to health costs, damage to crops/buildings and loss of income, due to for example mortality (leaving families without income) or damaged nerve system as a result of lead inhalation.

A scenario analysis on the development of economy and environmental policy shows that only in case moderate economic growth is combined with approximation to EU environmental law, the economic damages of environmental degradation will decrease in the coming ten years.

1 INTRODUCTION

This is the final report of the project "Assessment of The Economic Value of Environmental Degradation in Serbia". This study is undertaken within the framework of the Environmental Capacity Building Programme financed by the European Agency for Reconstruction.

The study is developed in response to an urgent need to raise the environmental agenda within the Serbian government and across the country. This is done by (amongst other) indicating how the key environmental degradation issues affect economic growth in Serbia, and what are their cost implication to the state, municipal and household budgets.

Environmental degradation in Serbia affects quality of life and imposes significant costs on society. Some of the costs arise through, for example, ill health associated with poor environmental quality (loss of income, costs of medical treatment and even loss of life). Other costs arise directly, for example, erosion of soils leading to loss of agricultural productivity.

The impacts of these problems on the economy of Serbia have been examined, and are presented in this report in terms of the total monetary cost. The estimates provide the basis for effective policy decisions to ensure that resources for environmental investment and improvement are efficiently allocated.

This report covers the first comprehensive study that puts a total economic value on environmental degradation in Serbia.

1.1 Objectives of the study

The wider objective of the project is to demonstrate the real cost of environmental degradation, poor quality of environmental media and unsustainable exploitation of some natural resources in Serbia. The costs are to be presented for the most recent data available. If found useful a projection is to be made to show the future level of costs if no actions are taken to address the present level of pollution and unsustainable development patterns.

The project includes the following specific objectives:

- Raising institutional capacity in Serbia by providing training on economic valuation of environmental damage, dissemination of the study results, and provision of the Ministry of Protection of Natural Resources and Environment employee to work alongside the project consultants;
- Development of the economic assessment methodology tailor made for the Serbian conditions (reflecting the range of environmental issues and the data coverage);
- Collection and interpretation of a whole range of environmental, economic and health related data addressing the analytical needs of the economic assessment methodologies;
- Identification and description of the key environmental issues selected for economic valuation;
- Identification and analysis of the dose-response-functions linking the amount of pollution/environmental degradation with their physical effects (such as deterioration of health conditions, loss of production or loss of amenity values);
- Demonstration of total economic values of the identified effects of environmental pollution/degradation using a number of methods including: the Effect on Production, Preventive Expenditure, Replacement Costs, Human Capital, Contingent Valuation and other;
- Presentation of the estimated damage costs as percentage of GDP, annual state budget and average annual budget of a household.

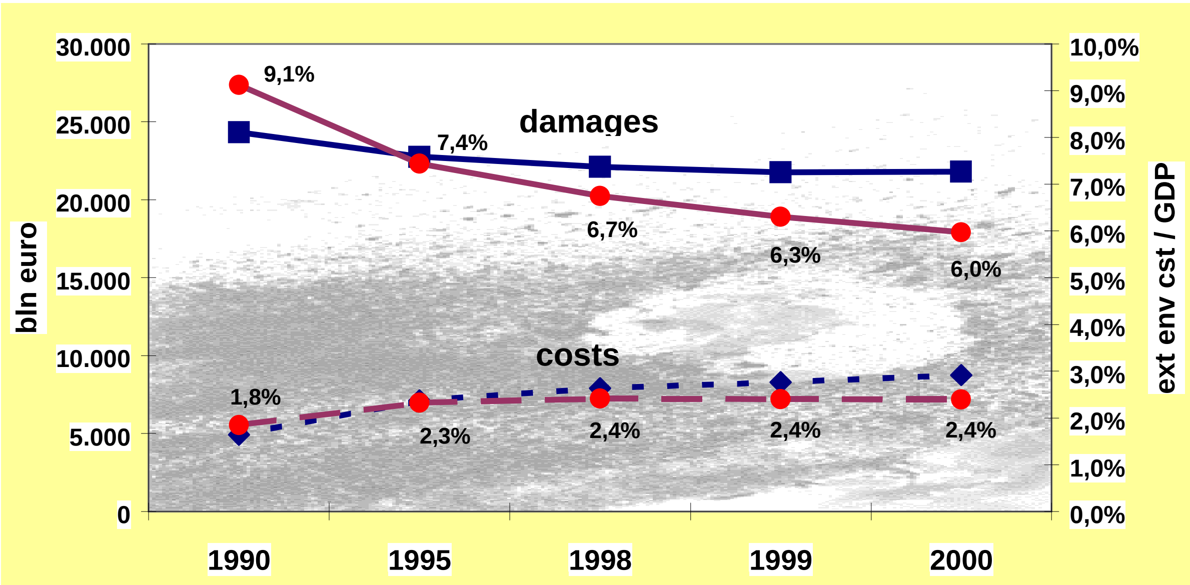
1.2 Environmental costs and damages

The link between economic development and environment is at least twofold:

- on the one hand the economy is negatively influenced by environmental stresses (emissions of various substances, leading to for example negative health impacts). These are the so called environmental damages;
- on the other hand investments are needed in environmental infrastructure, to comply with regulations. These are the so called environmental costs (and investments);

To give just an example of this relation ship the following figure may be illustrative.

Figure 1.1
Development of Environmental Costs and Damages in the Netherlands, 1990 -2000
source: TME, 2001



In this graph, total environmental costs and damages in the Netherlands are presented and compared. Costs are calculated by the Central Bureau of Statistics (CBS), whereas the environmental damages have been assessed by TME (TME, 2001). The results have been presented in both absolute terms (billion euros) as in relative terms (compare to GDP).

It can be seen that in the period 1990 – 2000 the environmental costs (what the Dutch society actually spends on environment) have doubled (from 5 -> 10 billion). But in relative terms the costs have not increased drastically and remain more or less stable at a percentage of about 2.4% of GDP from 1995 onwards.
In the same period, as a result of environmental policy (and the related actions and investments), the damages to environment have decreased, in both absolute and relative terms. In absolute terms, the decrease is relatively small: from € 24.3 billion to € 21.8 billion, or about 10%. As GDP has grown rapidly in the same period, the relative decrease of environmental damage is much larger: from 9% of GDP in 1990 to 6% in 2000.

The graph also reveals that sustainable development in the Netherlands is still in its initial phase, damages are much larger than costs. In absolute terms damages are more than € 10 billion larger than costs, in relative sense, damages are 6% compared to costs of 2.4% of GDP.

From an environmental economic point of view, sustainability would be achieved if overall costs would match damages. It is clear that this situation is still not achieved in the Netherlands, although in some areas of environmental policy certainly large progress has been achieved.

1.3 Organisation of the Report

The areas covered by this study are discussed in the following parts of this report[1]:

- chapter 2: methodology;
- chapter 3: air pollution including climate change;
- chapter 4: water management;
- chapter 5: waste management;
- chapter 6: noise;
- chapter 7: soil erosion;
- chapter 8: development of economic damage of environmental degradation in Serbia in the coming 10 years;
- chapter 9: overview of results.

Moreover 4 annexes cover the following subjects:

- annex 1: emission data (estimates);
- annex 2: deriving unit costs;
- annex 3: corrections Benefit Transfer: purchase power parity, impact of air pollution;
- annex 4: environmental related health damage;
- annex 5: costs and benefits of Accession
- annex 6: energy efficiency trends

[1] damage to the environment due to the NATO campaign is not covered by the report.

2 VALUING ENVIRONMENT: METHODOLOGY AND APPROACH

2.1 Introduction

Economists are aware that not only markets “make” the economy. Although the central idea in the economic theory is that produced quantities and prices, depend largely of demand for and supply of goods and services, markets are not perfect. It is known that for some goods and services no markets exist and thus no prices. These are called the so-called externalities of the economic behaviour. These are unpriced, positive or negative effects. An example of a positive externality is the existence of a shopping street with similar shops. Although one might argue that this would lead to more competition, it actually may lead to free access to customers of the competitor.
In case of environment, externalities are normally negative. A product or service that is supplied along with large negative externalities to the environment is actually sold to cheap on the market, as the externalities are not incorporated in the price.
As no direct market for environmental goods and services exist, environmental economist have looked for ways to put a value on these externalities.

This chapter deals with the following issues:

- first the most common methods used to “price” the environment are discussed and explained in brief;
- secondly, the way in which this knowledge is used in this current study is further elaborated;
- thirdly the damages that have been investigated and for which a monetary value could be estimated are briefly discussed;
- finally, some issues that should be borne in mind when valuing environmental damages in Serbia are discussed.

2.2 Environmental resource valuation techniques

Attaching monetary values to all stocks and flows of environmental resources is a complex task. When environmental resources are subject of market transactions, and when the markets operate perfectly and transparent, the observed prices contain information about the social value of environment. However, for most of the environmental resources there is no apparent market, or the markets operate in an imperfect way sending wrong price signals. Environmental resources often have the characteristics of public goods, which give a rationale for using various indirect monetary valuation techniques for most of the environmental services. The underlying principle for economic valuation is that consumers’ *willingness to pay* (WTP) for an environmental benefit, or their *willingness to accept compensation* (WTA) for environmental degradation, gives the appropriate basis for valuation.

2.2.1 Total Economic Value

The term total economic value (TEV) is used to refer to the whole class of values that have an origin in human behaviour and are amenable to economic analysis (Perman et.al. 1997). It can also be defined as the monetary measure of the change in society’s well-being due to a change in the quantity and/or quality of environmental assets (Pearce 2002). To consider the effects of various changes on all aspects of human well-being, TEV can be desegregated into use value and non-use value.
Use value include:

a) Direct use value, where a resource is actually used for market purposes, either commercial harvesting or recreation (e.g. logging timber, fishery, swimming, hiking etc).

b) Indirect use value, where there is a social benefit from ecosystem functioning (e.g. water purification, erosion protection or carbon sequestration).

c) Option value, where individuals are willing to pay for the future use of the resource (e.g. future visits to national parks).

Non-use values include:

a) Existence value, which reflects the "moral", or better say philosophical reasons for environmental protection, unrelated to any current or future use.

b) Bequest values, which reflect public willingness to pay to ensure future generations to enjoy the same environmental benefit in the years to come.

The total economic value is the sum of use and non-use values (Table 1).

TEV = direct use + indirect use + option + existence + bequest values

The first task in identifying any of these values is to determine how environmental changes affect social well-being. The second task is to estimate the monetary value of changes using one of the following techniques. All the techniques can be divided into two groups:

A) *Revealed preference techniques*, which derive preferences from actual market based information. In this case preferences are reviled indirectly from the market operations in which environmental goods and resources play a significant role;

B) *Stated preference techniques*, which determine preferences directly from consumers, by using various types of questionnaires.

In the revealed preference group of the techniques are:

1. Averting behaviour;
2. Hedonic pricing;
3. Travel cost method;
4. Random utility or discrete choice models.

Table 2.1
Economic taxonomy for environmental resource valuation

Total Economic Value				
Use Values			Non-use Values	
Direct Use	Indirect Use	Option Value	Bequest Value	Existence Value
Outputs directly consumable	functional benefits	Future direct and indirect values	use and non-use value of environmental legacy	value from knowledge of continued existence
• food • biomass • recreation • health	• flood control • storm protection • nutrient cycles	• biodiversity • conserved habitats	• habitats • prevention of irreversible change	• habitats • species • genetic • ecosystem

source: EFTEC/RIVM, 2000

Stated preference techniques consist mainly of two approaches:
1. Contingent valuation techniques
2. Hypothetic choice modelling

2.2.2 Revealed Preference Techniques

Averting Behaviour Technique is based on the assumption that market goods can, to some extent, act as substitutes for environmental goods and services. Expenditures made on certain market goods, like noise insulation, water filters, or air refreshers, reveal the public preference for a certain quality of environment, e.g. quietness, clean air, and unpolluted water. The described technique is broadly applicable, wherever the data about household expenditures on protective and preventive facilities exist. However, sometimes it can provide incorrect estimates if other aspects of consumers' behaviour are ignored, like potential external benefits, rent seeking, "free rider" behaviour etc. In the averting behaviour analysis time dimension is sometimes also neglected, because protective expenditures are in most cases linked to discrete, not continuous activities, but the benefits obtained are mostly continuing through some period of time. That is the reason why such technique tends to underestimate the value of the environmental goods and services.

Hedonic Pricing is based on analysis of the environmentally influenced market operations. It consists of a method of estimating the implicit prices of characteristics, which differentiate closely related products For example real-estate markets are heavily influenced by the environmental performances of the goods traded. Prices of the residential area, in the similar type of buildings, vary from one part of town to another owing, beside other circumstances, to the environmental quality of the area. By analysing price variations in environmentally different surroundings, WTP for environmental goods and services is revealed. The main disadvantage of the technique is in very high data requirements, high real-estate market transparency, and in the assumption of perfect property rights functioning.

Travel Cost approach is based on the actually observed transportation costs aimed to travel to the environmentally sound areas. Visitors to recreational parks and nature reserves usually incur costs in time and money aiming to reach such sites. Analysing these expenditures can be used to infer the values placed by visitors on environmental resources. Although it measures only use-value of the resources, the method is now a day broadly used for valuing the non-market benefits of the outdoor recreational resources. However, it is very data sensitive and demanding.

Random Utility or Discrete Choice Models are developed for a partial valuation of composite environmental goods. The essence of random utility or discrete choice models lays in explanation of the choice between two or more goods with varying environmental attributes as a function of their characteristics. For example, it can be used in situations where polluting activity creates damage to some features of a recreational site but not to all other.

2.2.3 Stated Preference Techniques

The main advantage of Stated Preference Techniques is that they enable economic value estimations for a) non-traded goods; b) non-use value of environmental resources.

Contingent Valuation Method is one of the most advanced and the most used techniques for environmental valuation. In contingent valuation researches precise questionnaires are developed, aiming to obtain a direct answer from the individuals questioned. The essential part of the questionnaire is information about the willingness to pay for a certain environmental benefit, or willingness to accept compensation for a forgone benefit, or an incurred cost. The contingent valuation questionnaire should define environmental good itself, the institutional context of its consumption, and the way of paying for it. Although the questions are related to a hypothetical situation, the respondents are expected to behave as though they were in a real market. Respondents state the preferences in a form o bidding game. Econometric techniques are used to analyse the obtained results. Accuracy of conclusions is closely related to the construction of the questionnaire. That is the reason why a precise procedure should be applied (Arrow et. al. 1993). A very instructive example can be found in the Hungarian attempt to estimate the economic value of clean air (Kaderjak and Powel 1997).

Hypothetic choice modelling is a name of a group of techniques created to obtain individual responses on multicriteria-choice questions, ranking the offered alternatives of specific environmental resource use. The main disadvantage of the choice modelling is that it is very dependable on questionnaire structure, it gives more ordinal preference information than a precise cardinal figure, and the data requirements are often very high.

2.2.4 Dose-response and Exposure-response functions

Unlike the previously described techniques Dose-response valuation procedure does not attempt to measure preferences. It measures the relationship between a unit concentration of a pollutant and its impact on the relevant receptor. Exposure–response functions are based on the same principle, but measure the response with the respect to the exposure. Exposure is a measure of the levels of a pollutant in the environment surrounding the receptor in question.

The initial estimates are not in monetary units but are in the natural physical units for the medium being affected. The second stage involves calculating a monetary value for the each unit of damage. How this will actually be done depends on type of physical damage. Where the impacts are primarily felt upon marketed commodities, the observed prices are often used as value indicators. Where no markets exist using one of the previously mentioned techniques reviles WTP measures. In spite of the opinions that the approach is theoretically sound, and can be used whenever the physical and ecological relationship between a pollutant and its output is known (EFTEC/RIVM 2000), other, more cautious approaches state that the technique has a number of drawbacks (Perman et al 1997). Firstly, errors that are made in the first step are multiplied in the second stage. Secondly, if impacts are sufficiently large to alter relative prices, the valuation procedures tend to break down. Furthermore, by falling to take account of substitution effects that arise, estimates may be upward biased. Difficulties and uncertainties may also arise in identifying the pollutant responsible to the damage, and in isolating the synergetic effects of multi-causal and long-term impacts. Additionally, the further complications arise when the evidence of a physical response may not be economically relevant. For these reasons large quantities of data may be required and the approach may be costly to undertake (EFTEC/RIVM 2000).

2.2.5 Life Risk Valuations

Monetary valuation of environmental impact on human life and health is probably the most complex and the most controversial issue in environmental valuation theory and practice. In this kind of analysis, an individual estimation of personal value of life and health is basic. Valuation of the individual's life made by the other members of society should be added in the next stage, and finally the aggregate social costs incurred by the environmentally caused health problems should be taken into consideration. According to that, life risk valuation include three kinds of estimates:

VOR_{ii} refers to the individual **i's** valuation of risk to themselves, i.e. "own risk"
VOR_{ij} refers to the individual **j's** valuation of risks to individual **i**
SCI_i refers to the social cost of illness suffered by individuals and by the rest of society, i.e. social cost of morbidity, invalidity and mortality.

Statistical value of life is calculated by adding all individuals' WTP aimed for environmental improvements. For example, it is assumed the annual death risk caused by a certain

environmental change is 0.005 and that the exposed population is 10,000. This means that in the analysed group there will be 50 death cases in the year to come. If specific measures and policies were implemented, the risk rate would be 0.003, and twenty lives would be saved. If all of the targeted group members are questioned to reveal personal WTP for risk minimisation, and the average WTP is 5000 US$ it means that 10,000 men together are willing to pay 50 million US$ for the environmental improvement. Assuming that the improvements will cause 20 saved lives annually, it can be stated that the average statistical value of life is 2,5 million US$.
It is absolutely clear that the mentioned technique does not give a real value of life. It is just a way to obtain economic information how much the targeted population is willing to pay for the improvements. Because of possible misleadings this method is not very popular.

Certain improvements in practice can be made with “value of a life year” (VOLY) calculations. Instead of mortality estimation, a valuation is made for an additional year of life saved by the environmental improvements. For example, if an implementation of the specific environmental improvement measure has effect in 0.4 years longer life, and the average WTP for cost coverage is 10.000 US$, it can be concluded that an additional year of life has value of 25.000 US$ for the targeted group of people.

Similar approach can be used in WTA analysis. However, the results obtained using WTP and WTA may differ in a range 2-5 times (Gregory 1986). The reason for such drastic deviation can be found in a fact that there is no substitutes for the majority of environmental goods, and men are much more willing to claim for a compensation for the lost benefit, than to pay for environmental resource protection (Hanemann 1991).

In applying the mentioned techniques, another drawback may appear, related to the individual wealth of respondents. The fact is that WTP and WTA will largely depend on wealth of people analysed. So, the rich will always attach higher values to the environmental goods and services than the poor, irrespective of the real risks.

Total social cost technique (TSC) is not based on the stated preferences but on the real costs of the human capital losses incurred by environmental changes. Social costs are consisted of mortality costs DC, invalidity costs IC, and morbidity costs MC.

$$TSC = DC + IC + MC$$

Mortality costs can be desegregated in the direct (dDC) and opportunity (oDC) costs

$$DC = dDC + oDC$$

Direct social costs of mortality are in fact costs of alimony for dependant members of the harmed family. Opportunity costs are related to the GDP losses of premature death caused by environmental changes.

$$oDC = (GDPpc - \text{pers. consumpt.}) \bullet \text{number of death cases, environmentally related}$$

If invalidity cases are caused by environmental degradation the costs incurred consist of direct costs (dIC) and opportunity costs (oIC), i.e.

$$IC = dIC + oIC$$

The direct costs are related to social security expenditures for the environmentally related invalidity and the opportunity costs are consequence of the forgone amount of GDP.

oIC = GDPpc • number of environmentally related disability cases

Finally, the medical expenses for the treatment of environmentally related diseases determine direct morbidity costs (dMC). Opportunity costs (oMC) are related to the forgone income of the economic activity due to environmentally caused illnesses.

MC = dCV + oMC

Although it seems theoretically sound, this method may also create problems because of unclear definition of environmentally caused health problems. It is nearly impossible to have mortality, invalidity, and morbidity data strictly linked with certain environmental changes. In this sense, any attempt of using proxy figures may lead to unreliable conclusions.

2.2.6 Benefit transfer

Benefits transfer is a frequently applied method aimed for economic valuation of environmental changes. The essence of benefits transfer is that use is made of previous valuations studies of similar environmental performances in other countries or regions, and then, with necessary adjustments, is applied in a present study. It relies on methodology and data from previous studies, and it transfers it to the current case, producing estimates for a specific environmental damage.

Relying on the results from previous studies may create a set of problems. It is not always methodologically correct to transfer and to apply data on physical impacts, geographical aspects and local population preferences form a previous study to the current one. The mentioned procedure is more accurate if the local influences are less. For global impacts, such as climate change, or ozone layer depletion, the methodology is fully justified. However, when local characteristics are present, previous results should be adjusted and applied with care. Necessary adjustments should be made for: income, population size and characteristics, background conditions and other determinants for which current data are accessible.

Boyle and Bergstrom (1992) proposed the following three criteria for a successful benefits transfer application:

1. Similarity of the environmental good or service to be valued;
2. Similar demographic, geographic, economic and social characteristics, or the ability to adjust for these kinds of parameters statistically (King & Mazzotta, 2004). EFTEC/RIVM mention the following potential adjustments (p. 127):
   - average income;
   - population size and characteristics;
   - background conditions;
   - level of impacts, and
   - other determinants;
3. Evidence of sound economic and statistical methodology applied in the preliminary study.

A fourth, practical criterion is:

4. Use if possible more than one reference study to have an idea of credibility and reliability.

The benefit transfer methodology is especially useful in cases where an assessment of a wide range of environmental damages needs to be made at country or regional level. In such case the assessment of different damages require various different approaches/methodologies. It then will be very costly and time consuming to perform various original valuation techniques like Contingent Valuation (“Willingness to Pay”), Hedonic pricing, Time costs, etc.

Examples of studies in which the benefit transfer methodology has been used successfully are:

- The European Commission DG Environment study "European Environmental Priorities: an Environmental and Economic Assessment" (RIVM et al 2001a). This study estimates at EU level the economic costs to prevent and benefits to environment for various scenarios and over ten policy priorities. The methodology is based on a logical stepwise progression through emission, change in exposure, quantification of impacts using exposure-response functions, to valuation based on willingness-to-pay. For acidification and ozone the benefits are calculated by using monetary unit damage estimates for four pollutants (expressed as € per tonne SO_x, NO_x NH_3 and VOC), which were derived from a EAE Technology study (RIVM, 2001b, p. 63, 73). Benefits of reducing particle matter (PM10) in air are based on mortality and morbidity costs and dose (emissions and concentrations) – response functions (RIVM et al, 2000a, p. 68-71). For climate change unit damage values (in € per tonne CO_2, CH_4 and N_2O) are used to asses benefits (RIVM, 2000b, p. 62). For water quality unit benefits were estimated based on Willingness to Pay studies for improved water quality and unit damage costs (expressed in € per tonne N and P) were derived from various Baltic Sea studies on nutrient reduction (RIVM et al., 2000c, p.34). Waste related benefits were also estimated using unit damage values for various disposal routes (expressed as € per tonne waste incinerated, landfilled, recycled and composted) (RIVM, 2000d).
- The European Commission DG Environment study "The Benefits of Compliance with the Environmental Acquis for the Candidate Countries" (Ecotec et al. 2001). In this study, air quality benefits are estimated making use of the Ecosense model which was developed for the EU ExternE project. In Ecosense emissions and concentrations, dose-response functions for health damages, crops and monuments are modelled and linked by monetary unit values (for human life, etc.) to assess damages. For water damages were assessed by using Willingness to Pay studies from UK and USA for improved water quality (using € per inhabitant per year estimates). Waste damages are mostly assessed indirectly through impact-pathway analyses combined with Life Cycle Analyses of waste, estimating emissions of air pollutants (CO_2, CH_4, NO_x, etc.) and applying unit values (expressed as € per tonne CO_2, CH_4, NO_x, etc.).
- The study for the Netherlands Ministry of Economic Affairs "Valuing the Benefits of Environmental Policy: The Netherlands" (EFTEC/RIVM 2000), London, 30 June 2000. This study largely follows the European Commission DG Environment study "European Environmental Priorities: an Environmental and Economic Assessment" (RIVM et al 2001a). Additionally damages for noise and soil have been estimated. For noise benefit transfer (% decrease in value of property related to increase in noise levels) has been applied to assess benefits of the policy.

The conclusion of this overview may be that in case benefits or damages have to be assessed at country level (or at EU level) the benefit transfer methodology is used successfully. The examples show that the type of benefit transfer applied differs from case to case:

- for acidification the Ecotec study uses the Ecosense model which follows the logical stepwise progression through emission, change in exposure, quantification of impacts using exposure-response functions, to valuation based on willingness-to-pay. In the study for the EU Pearce applies unit damage values per kg Pollutant emitted, thus implicitly covering the steps "change in exposure" and "impacts due to exposure-response function" in these numbers;
- Whereas Ecotec analyses waste disposal chains by means of LCA, indicating changes in emissions and using unit values for emissions to assess the damages of each waste disposal route, in the in EU study Pearce makes use of earlier conducted studies to directly arrive at monetary unit costs per tonne of waste.

2.3 Approach followed in the study on "Assessment of the Economic Value of Environmental Degradation in Serbia"

2.3.1 Potential approaches and selection of methodology

As shown in the last paragraph, many methods to assess environmental damages exist. Most methods require in-depth analyses of data, setting up experiments, statistical analyses of vast amounts of data, etc.

As time and budget for this study are limited, and in line with earlier (multi-)country studies, the Benefit Transfer methodology has been applied to evaluate economic value of environmental damages. This brings the following advantages:

- many different issues of environmental policy can be covered by the study (as many reference studies are available for many topics)
- it saves time and budget.

In the benefit transfer methodology results from earlier studies in mostly other countries and economic circumstances are "transferred" by applying for example "purchase power parity" and adaptations to population, geographical circumstances, levels of impact, etc.

The benefit transfer method in general and the way in which it was implemented in this study is explained in the following paragraphs.

2.3.2 Benefits transfer: methodological issues

In this project, methodology and results of environmental valuation used for the benefit transfer origin from studies carried out for European countries: as well for Western Europe (RIVM/EFTEC) as for Central and Eastern Europe (Ecotec). These studies have been executed by experts in this field in Europe, and have applied internationally accepted methods. These studies can therefore be regarded as the best available at the moment. All three studies intensively cover and analyse data sources of original, reference studies in various environmental policy fields.

In cases the benefit transfer methodology has been applied, the similar environmental goods have been valued in both the original study and this study (for example air quality effects on health, etc.).

Economic, demographic and social factors are not (very) similar in the current study and the original studies used for the benefit transfer. Adjustments are possible for (EFTEC/RIVM):

- average income;
- population size and characteristics;
- background conditions;
- level of impacts, and
- other determinants.

Thus it is necessary to adjust the results of the original study to the national circumstances. As sufficient information is available on income, population, area, urbanisation, it is possible to correct for these factors up to a satisfactory level in the current study.

It thus can be assumed that the benefits transfer methodology can be applied successfully in the current study.

2.3.3 Correction of economic parameters: Purchasing Power Parity

When applying the benefit transfer approach in most cases data from other countries will be used. This is clearly the case in this study, as in Serbia no earlier studies are available.

When considering economic parameters, it is important to stress the influence of price level differences between the original and the current study. These differences have a significant impact on WTP calculations. This means that simply applying exchange rates to compare different countries is not the soundest way to use data from original studies in the current study.

Next to exchange rates, the so-called purchasing power parity (PPP) is used in exchange rate calculations (Ready et. al. 1999). This is done by defining a basket of products and services, then calculate the total local/national costs for that basket, and then compare these costs for different countries[2].

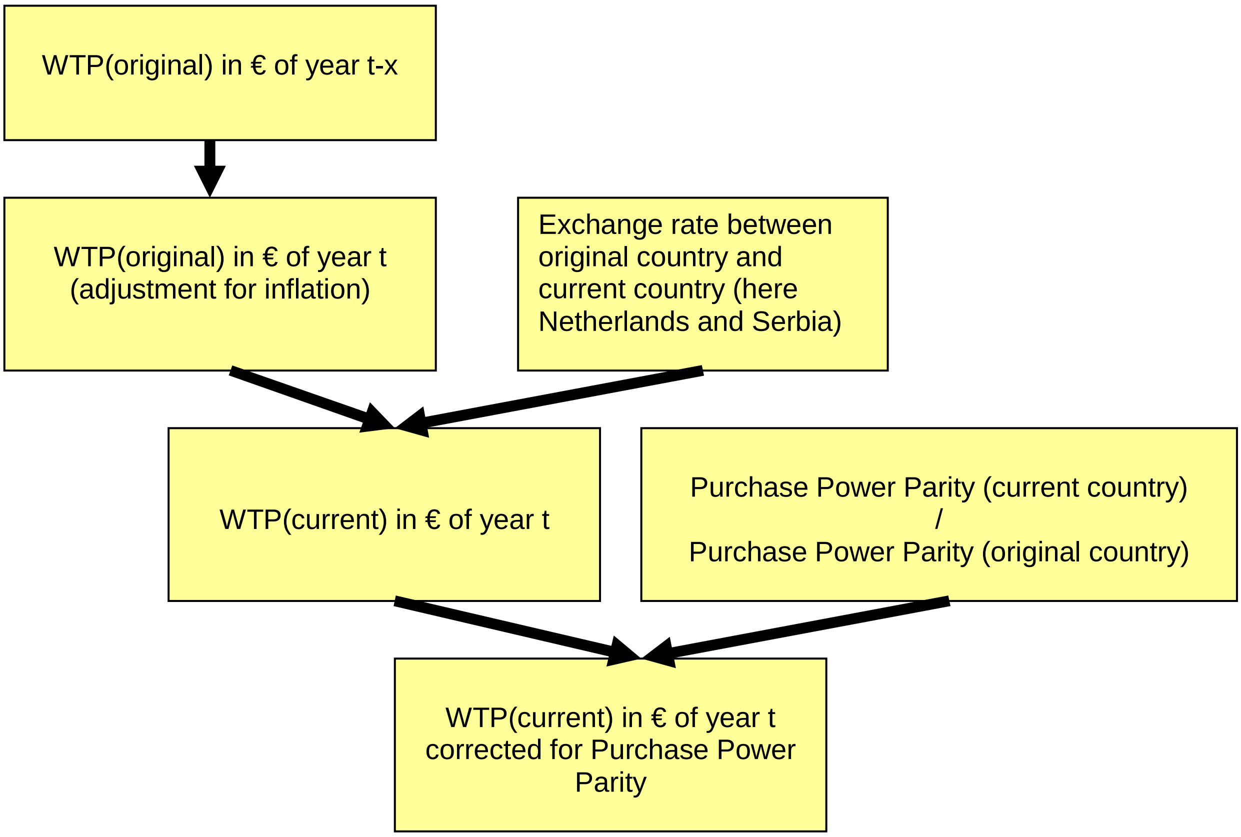
For most of the countries PPP rates of exchange are documented by the OECD (www.oecd.org/statsportal) but also the CIA World Factbook (CIA, 2004) gives an overview of these values. Actually we have used the PPP's as stated in the CIA Factbook (which also gives a lot of other valuable and standardised information on almost all nations of the world).

Although PPP rates are very convenient for use in the benefits transfer, they do not solve all the problems. If certain environmental goods are equally distributed over the whole geographical area of the current study, a unique PPP standard can be applied. However, if the analysed environmental goods are unequally distributed (as in the most cases are) additional adjustments have to be made. For example, if cost of the environmental good is 20 % higher in urban areas than in the rest of the country, a correct WTP calculation is obtained not only by PPP use, but also by multiplying it with a 1.2 coefficient.

To take inflation on board, intertemporal adjustment also has to be made. For example, if the original study was conducted in 1994, the obtained WTP should be adjusted by a consumer price index (CPI) in order to avoid inflation impact.

A detailed adjustment procedure is as follows (see next page):

[2] Other "popular" approaches to compare wealth between nations are the "MacDonalds-standard" (by comparing the price of a Big Mac in different countries) or the "Levis jeans standard" (by comparing the price of Levis jeans). But of course these popular approaches have not been used in this study but they can serve of simple examples of the PPP concept.

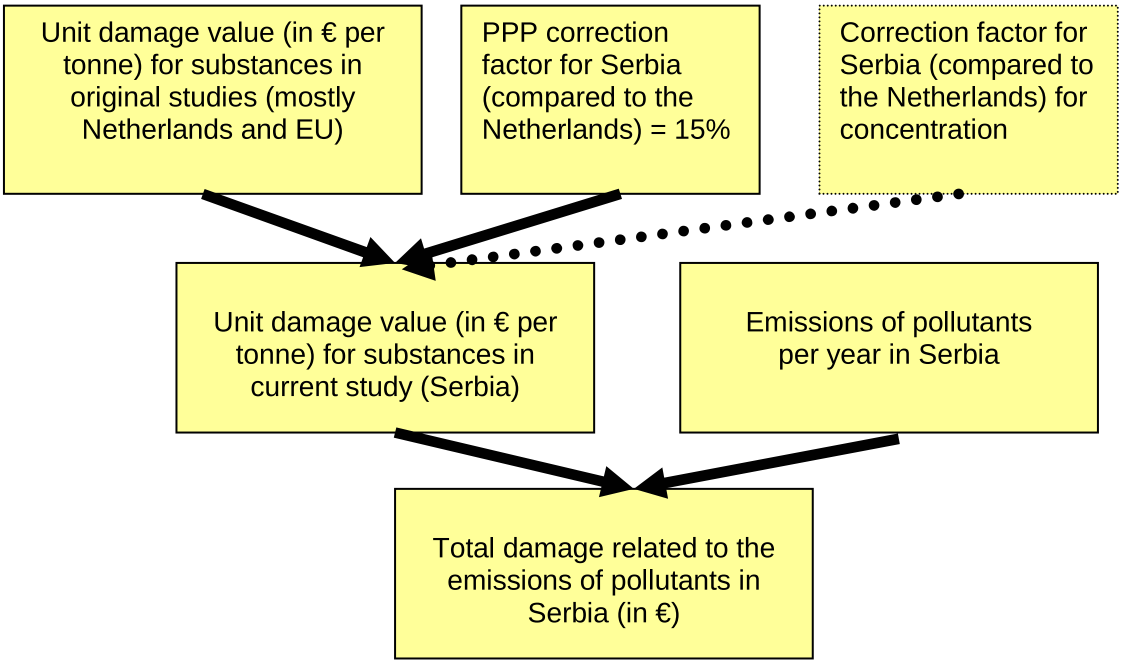


However, the problem of a cultural diversity remains. Different populations may hold very different attitudes towards environmental issues, because of cultural, educational, religious and other reasons. Thus significant differences in WTP of different groups for similar environmental impacts may remain even after all the necessary adjustments.

2.3.4 Benefit transfer approach applied in this study

As a conclusion it can be stated that benefits transfer technique is far from ideal, but compared to the other methods it has great advantages related to a high efficiency, low data requirements, low financial costs and high reliability if correctly applied.

In the context of this study we have used the benefit-transfer approach in a simplified way. Due to the lack of models, detailed data on for example health effects in relation to the concentrations of polluting substances in the environment, we have mainly applied benefit transfer in the following way:



This actually means that in most cases no attempt has been made to (i) first estimate physical damage (mortality, morbidity, other physical damages) and (ii) calculate costs related to the physical effects. In stead, we have directly use estimates of unit damage values related to emissions or discharges. This has both advantages and disadvantages:

- the advantage is clear: it is not necessary to investigate the impact pathway and make estimates of the physical effects. From emissions one can directly "jump" to damages by multiplying them with unit damage costs (adapted though to the Serbian context);
- the disadvantage is that no indication is given of the physical effects, which sometimes might give a stronger message (for example: the message that due to environmental degradation each year almost 4,000 people die in Serbia has for many people a more concrete, thus stronger meaning, than saying that due to environmental degradation the damage in economic terms is for example € 2.5 billion).

The approach (partly) followed in this study is far from unique, many other studies also (partly) rely on benefit transfer in monetary units per emission:

- in the study carried out by RIVM/EFTEC for the Netherlands the benefits related to less air pollution (SO_2, NO_x, NH_3) have been valued by applying unit damage values for SO_2, NO_x and NH_3. Also benefits related to the reduction of water pollution are assessed by applying unit values for nutrients (N, P);
- in the Ecotec study, benefit-estimates of waste management are (partly) based on unit damage values (estimated by quantifying landfill gas emissions and applying unit values for CO_2 and methane).

In most cases a low and high estimate have been made. This to express the uncertainty of the damage assessments reviewed. Also, in most case, two approaches have been used to assess unit damage values:

- "demand-side approaches", of which most have been discussed in paragraph 2.2. "Demand orientated", because all of these ways to estimate damages are somehow based on the demand for a cleaner environment;

- “supply-side approach”, which are based on the marginal costs to reduce pollution to targeted levels.

2.4 Type of damages valued

During the period in which the project was carried out we have investigated all kinds of methods to assess damages. This includes the valuation of more “traditional” environmental problems like:

- air pollution related damages, focussing on health related problems, acidification and damage to crops. These include air pollutants like CO_2, SO_2, NO_x, NH_3, fine particles (PM10) and VOC
- water pollution, focussing on eutrophication;
- waste: damages due to uncontrolled landfilling of waste (leading to the emissions of methane and CO_2, both greenhouse gasses).

In addition to these more traditional approaches we have applied several additional approaches, by combining results from various studies (both on emission assessment and the economic valuation of certain pollutants). This includes:

- air pollution as a result of leaded gasoline;
- water pollution as a result of the lack of manure management;
- depletion of groundwater resources in Vojvodina;
- “import” of vast amounts of heavy metals from mining operations in Kosovo;
- hazardous waste;
- uncontrolled tipping / burning of waste outside landfills (and the linked emissions of dioxins, PAC’s and PAH’s);
- depletion of resources (storage of ashes from power plants)
- noise related damages;
- damage due to soil erosion in Vojvodina.

In this final report all these damage-categories have been covered and monetarised.

3 ECONOMIC DAMAGES LINKED WITH AIR POLLUTION

3.1 Introduction

Damages related to air pollution are mostly health related, but also damages are related to (loss of) crop, materials and buildings.

The following damages linked with air pollution have been assessed:

- climate change, focusing on CO_2 (carbon dioxide);
- acidification: SO_2 (sulphur dioxide), NO_x (nitrogen dioxides), NH_3 (ammonia);
- air quality ozone formation: VOC (volatile organic compounds);
- air quality: lead and PM10 (fine particles).

3.2 Methodology

Most – but not all – studies reviewed include a step in the analyses where the physical impacts (mainly mortality and morbidity) are first assessed. Afterwards these physical effects are quantified in monetary terms by applying the value of life.

The damages due to air-pollution in Serbia can also be partly described in terms of health effects (for example mortality, for which annex 4 gives a rough estimate), and then be translated in monetary terms. However, in such an approach no estimate can be made for non-health damages (like climate change) and no distinction can be made between different air pollutants. Therefore, damages due to air-pollution in Serbia have been evaluated using (annual) emissions and unit damage costs (€ per kg emission).

First, for the mentioned substances data on annual emissions in Serbia have been collected. In addition for some substances also import and export of pollutants has been taken into account.

From various sources either direct estimates of unit damage costs (expressed in € damage per tonne emissions) or estimated unit damage costs for substances (for example by dividing total annual damage by annual emissions) have been derived. As economic, demographic and geographical aspects are not similar in the originating countries (Netherlands, other EU countries) and Serbia, corrections had to be made for:

- purchase power parity;
- population;
- deposition (or if not available: emissions) of substances per square kilometre in Serbia compared to (mainly) the Netherlands. This gives a proxy of concentrations of air pollutants in Serbia compared to the Netherlands (see for further details on these calculations annex 3) and thus for exposure [3].

Combining emissions with unit damage values leads to an estimate of total damages per substance.

3.3 Climate change

3.3.1 Carbon dioxide (CO_2)

CO_2 is not believed to cause direct damages to the environment or health. However, through global warming the following effects can be anticipated (EFTEC/RIVM, 2000, p. 33):

- sea level rise;

[3] This spatial correction has not been applied for lead, as lead concentrations near roads (where most people are exposed directly) are decisive.

- change in agriculture, forests and fisheries;
- change in energy, water, construction, transport and tourism sectors;
- increased risk of disaster: changes in the frequency and severity of storms, floods, droughts, hurricanes and precipitation levels;
- change in biodiversity;
- increased human morbidity and premature mortality, and human migration.

Various studies have tried to assess the damages related to climate change. In many cases the assumption was made that CO_2 emissions will double and the resulting effects were then valued in monetary terms. Estimates of damages range from a few euros per tonne CO_2 to over € 100 per tonne (see EFTEC/RIVM, p. 37, Ecotec, p. 123).

Another approach is followed by TME, calculating the marginal costs to reduce CO_2 emissions to the targeted levels for 2010 in the Netherlands (see annex 2). The original estimate was a marginal cost of around 150 guilders per tonne CO_2 avoided, which is € 68 per tonne CO_2.

Total CO_2-emissions in Serbia are estimated at about 45,000,000 tonnes per year (based on WRI, 2004, 90% of CO_2 emissions of Serbia & Montenegro taken for Serbia).

The following table gives a low and high estimate of the total annual damage due to CO_2-emissions in Serbia. To apply unit damage costs to Serbia we have corrected these for purchase power parity: 15%. No adjustment for local circumstances other than PPP is necessary, as climate change is a global problem (EFTEC/ RIVM, p. 127).

Table 3.1
Total annual damages of carbon dioxide emissions in Serbia, low and high estimate

	total	low estimate	high estimate
emissions per year (tonnes)	45,592,200		
unit damage value (after correction), € per tonne		€ 1.31	€ 10.0
total damage per year		€ 59,672,144	€ 455,922,000

source: own estimate

The table clearly shows that even with a low estimate the monetary damage of carbon dioxide emissions are considerable: € 60 mln per year. If the “marginal costs” approach is followed the damage is estimated to be considerably higher: almost € 0,5 billion per year.

3.4 Acidification

3.4.1 Introduction

The primary pollutants causing acidification are sulphur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (NH_3). Together with their reaction products, after their deposition, lead to changes in the chemical composition of the soil and surface water. This process interferes with ecosystems leading to what has become known as 'acidification'. Their concentration in the air can also cause impacts to human health.

3.4.2 Sulphur dioxide (SO_2)

There are five major receptors of air pollution: human health, crops, materials damage, ecosystem damage and visibility impairment (EFTEC/RIVM, 2000).

For the Netherlands (and other EU countries) the damages have been assessed in the ExternE project (ExternE, 1997). These values have been used also in the EFTEC study.

Unit values for the Netherlands range from € 3,693 per tonne (TME) to € 9,150 (EFTEC/ RIVM). The high estimate is based on the impact pathway analyses performed in the framework of the ExternE project of the EU.

As circumstances in Serbia differ from the Netherlands, the following corrections have been made:
- for purchase power parity: 15%;
- for population 46% (which means that the Serbian population is almost half of the Dutch population);
- for deposition per square kilometre 215% (which means that deposition of SO_2 in Serbia is more than twice as high as in the Netherlands).

Together with the estimated annual emission this results in the following minimum and maximum damages.

Table 3.2
Total annual damages of sulphur dioxide (SO_2) emissions in Serbia, low and high estimate

	total	low estimate	high estimate
emissions per year (tonnes)	525,000		
unit damage value (after correction), € per tonne		€ 541	€ 1,341
total damage per year		€ 284,093,694	€ 703,853,053

source: own estimate

A factor that should be taken into account is that the effects of acidification are continental, so part of the damages from the emissions from Serbia will occur in other countries, and vice versa. According to the EMEP modelling work on transboundary movements of air pollution, it was estimated that in 2001 Serbia imported 195 thousand tonnes of sulphur and exported 109 thousand tonnes of it. With regard to import of SO_2, the biggest depositions have been imported from sources in Bosnia and Herzegovina (20-30 %), Romania and Bulgaria (10 %). Serbia's export of SO_2 was mostly to Romania, Bulgaria and Ukraine.
It thus can be concluded that Serbia is a net importer of SO_2, making the above estimate of damages a minimum one.

3.4.3 Nitrogen Oxides (NO_x)

The (damage) effects of nitrogen oxides (NO_x) are complex: directly through health, but also indirectly due to the formation of ozone (in relation to VOC emissions). In hot summers in Western Europe, many elderly people get hospitalised with respiratory diseases, caused by summer smog.

The unit damage values for the Netherlands range from € 2,138 (EFTEC, low estimate taken from ExternE) to € 3,545 per tonne (TME).

To apply these figures for the Netherlands to Serbia, the following corrections have been made:
- purchase power parity: 15%;
- population 46%;
- for deposition per square kilometre 60% (see annex 3 for details).

Together with the estimated annual emission of 161,000 (WRI) this results in the following minimum and maximum damages.

Table 3.3
Total annual damages of nitrogen oxides (NO_x) emissions in Serbia, low and high estimate

	total	low estimate	high estimate
emissions per year (tonnes)	161,000		
unit damage value (after correction), € per tonne		€ 87	€ 145
total damage per year		€ 14,033,533	€ 23,271,867

source: own estimate

According to the EMEP modelling work on transboundary movements of air pollution, it was estimated that in 2001 Serbia exported about 15.8 thousand tonnes and imported about 40.1 thousand tonnes of nitrogen oxides. Serbia is thus a net importer of nitrogen oxides. Most of the nitrogen enters Serbia from Italy and Croatia and it is exported to Romania.

3.4.4 Ammonia (NH_3)

Ammonia has about the same effects on human health and environment as nitrogen oxides. It also may cause eutrophication of the environment (surplus of nutrients) (EFTEC, p. 49).

Unit damage values for the Netherlands range from € 1,454 (EFTEC, low estimate) to € 12,409 per tonne (TME).

To apply these figures to Serbia we have corrected these for:
- purchase power parity: 15%
- population 46%;
- for deposition per square kilometre 39%.

Together with the estimated annual emission of 90,000 tonnes annually (IIASA) this results in the following minimum and maximum damages.

Table 3.4
Total annual damages of ammonia (NH_3) emissions in Serbia, low and high estimate

	total	low estimate	high estimate
emissions per year (tonnes)	90,000		
unit damage value (after correction), € per tonne		€ 39	€ 332
total damage per year		€ 3,497,177	€ 29,846,482

source: own estimate

3.4.5 Total damage associated with acidification in Serbia

From the estimates in the last paragraphs the following overview can be made on damages of acidification in Serbia.

Table 3.5
Total annual damages of acidification in Serbia, low and high estimate

substance	emissions (t/y)	total damage, million € low	high
sulphur dioxide (SO_2)	525,000	€ 284.1	€ 703.9
nitrogen oxides (NO_x)	161,000	€ 14.0	€ 23.3
ammonia (NH_3)	90,000	€ 3.5	€ 29.8
total		€ 301.6	€ 757.0

source: own estimate

Total annual economic damage linked with acidification in Serbia is estimated between € 301 million and € 757 million. As noted in previous paragraphs, Serbia is a net importer of acidification, making the actual damage in Serbia larger by between 10 % and 20%.

3.5 Tropospheric Ozone

3.5.1 Volatile Organic Compounds (VOC's)

Together with NO_x and (sun)light VOC's are responsible for the formation of tropospheric ozone. This causes summer smog which may cause respiratory diseases and other health problems. Certain VOC's also may have carcinogenic effects (for example benzene).

Cars and other vehicles are the largest source of ozone precursors (NO_x and VOC); hence ozone levels are usually highest in cities at the peak of summer. Due to the complex chemistry of ozone production in the atmosphere ozone pollution is usually a problem in the Southern cities of Europe.

Most of the health effects of ozone are immediately felt and short lived, although scientists are concerned that repeated short-term damage from ozone exposure may cause permanent injury. Ozone impacts on human health by:

- Reducing lung function, (symptoms include coughing, irritation in the airways, rapid or shallow breathing, and discomfort when breathing or general discomfort in the chest);
- Aggravating asthma by making asthmatics more sensitive to allergens and through the reduced lung function and irritation;
- Inflaming and damaging the lining of the lung (similar to a sunburn repeated damage could have long-term health effects); and
- Other effects on people's health may include aggravating chronic lung diseases and reducing the immune system's ability to fight off bacterial infections in the respiratory system.

Ozone presents a particular problem to children, asthmatics, outdoor workers, competitive athletes, and other people who exercise outdoors. People can reduce their exposure to ozone if they are aware of areas and times of the year when ozone levels are high. They can avoid going out in high risk periods with their children, avoid living in certain areas and avoid exercising when ozone levels are high (Ecotec, 2000, p. 90).

Unit values for the Netherlands range from € 863 per tonne (TME) to € 1,572 (EFTEC, low estimate, calculated through NO_x estimate and the Equivalence factors for Ozone for NO_x and VOC, which is 1/1.22).

To apply these figures to Serbia we have corrected these for:

- purchase power parity: 15%

- population 46%;
- for emissions of VOC's per square kilometre 13%.

Together with the estimated annual emission of VOC of 97,000 (WRI) this results in the following minimum and maximum damages.

Table 3.6
Total annual damages of volatile organic compounds (VOC) emissions in Serbia, low and high estimate

	total	low estimate	high estimate
emissions per year (tonnes)	97,000		
unit damage value (after correction), € per tonne		€ 7.6	€ 15.5
total damage per year		€ 738,087	€ 1,499,277

source: own estimate

3.6 Air quality

3.6.1 Fine particle matter (PM10)

Suspended particulate matter (PM) is made up of a variety of materials and discrete objects and may be liquid or solid, organic or inorganic. PM makes up most of the visible and obvious form of air pollution and is a contributor to summer and winter smog's characteristic of urban areas. Pollutant particles vary in size, from 0.001µm to 10 µm.

Air pollution can affect human health by damaging the respiratory tract directly or by entering the blood or lymph systems. Soluble particulate matter can also be transported to organs some distance from the lungs. A strong correlation has been found between increases in the daily mortality rate and acute episodes of air pollution. Damage may also occur to buildings, historic monuments and vegetation near or within cities. (EFTEC/RIVM, 2000, p. 81).

Unit values for the Netherlands range from € 28,364 per tonne (TME) to € 51,358 (EFTEC/RIVM, low estimate, calculated by dividing total annual damages in the Netherlands in 1990 by the total annual emissions, see annex 2).

To apply these figures to Serbia we have corrected these for:
- purchase power parity: 15%
- population: 46%;
- for emissions of PM10 per square kilometre: 61%.

Together with the estimated annual emission of PM10 of 60,000 (IIASA, 2004 based on the assumption that the emissions in Serbia are about 75% of the Former Yugoslavian emissions) this results in the following minimum and maximum damages.

Table 3.7
Total annual damages of fine particle matter emissions in Serbia, low and high estimate

	total	low estimate	high estimate
emissions per year (tonnes)	60,000		
unit damage value (after correction), € per tonne		€ 1,174	€ 2,126
total damage per year		€ 70,433,559	€ 127,533,356

source: own estimate

3.6.2 Lead (Pb)

Lead is used in gasoline as an additive for motor performance. Most emissions of lead and occurrence of lead in ambient air are caused by leaded gasoline. Infants and young children are especially sensitive to even lower levels of lead. Effects on health include (US EPA, 2004):

- damage of organs (kidneys, liver , brain, etc.);
- affects brains and nerves: seizures, mental retardation, behavioural disorder, memory problems and mood changes. Low lead levels already damages the brain of children and foetuses, resulting in learning deficits and lowered IQ;
- affects heart and blood: high blood pressure, increased heart disease;
- affects animals and plants;
- affects fish.

Recent measurements of lead contents in the air in Belgrade (January 2003) show that the concentrations of lead in the air were 5.6 times higher than allowed (5.6 microgram compared to 1 microgram). On the other hand it is reported by the Municipal Health Institute of Belgrade that no elevated lead contents in blood was measured. This is somewhat strange, as for example in Latvia the concentration of lead in hair of people living in cities has found to be around ten times higher than for people living in rural areas. This is an indication of the scale of the reality of the problem. Thus a reduction in lead emissions is likely to produce major health benefits (Ecotec, 2000, p. 93).

No official estimate is available for the lead emissions in Serbia. We have made our own estimate using the following assumptions:

- each year about 589,000 ton = about 780,132 m3 leaded gasoline is produced and sold on the Serbian fuel market;
- the average lead contents in leaded gasoline is about 0.45 gr/litre;
- this results in an annual emission of lead of 351 ton/year.

Unit values range from € 273,000 to € 546,000 per tonne (assessment based on US EPA, Lovei, see annex 2).

To apply these figures to Serbia we have corrected these for purchase power parity: 15%. More corrections for local circumstances (for example deposition/emission per square kilometre) have not been made, as lead exposure near roads is the highest and most hazardous (so it does not make sense to calculate an average for the whole country).

Together with the estimated annual emission of lead (Pb) from gasoline in Serbia this results in the following minimum and maximum damages.

Table 3.8
Total annual damages due to lead (Pb) emissions in Serbia, low and high estimate

	total	low estimate	high estimate
emissions per year (tonnes)	351		
unit damage value (after correction), € per tonne		€ 40,147	€ 80,294
total damage per year		€ 14,094,011	€ 28,188,021

source: own estimate

Total annual damages of leaded petrol are estimated at between € 14 million and € 28 million in Serbia.

3.6.3 Health effects of air pollution

Mortality and morbidity play a large role in the total damage due to air pollution. In the previous sections no attempt is made to assess the physical damages (to health), as models to assess these for Serbia (like Ecosense) are not available to the researchers.

A way to indicate air pollution related mortality is to divide total damage due to acidification and air quality by the value of life (as applied in this study: € 431,000 per capita after PPP correction). This results in a minimum estimate of 900 annual cases of mortality and a maximum of 2,100 cases.

Although no specific research is available on air pollution related mortality (and morbidity), a rough estimate is available from the Public Health Institute in Belgrade: about 4,000 cases of air pollution related mortality cases per year. Details on this estimate are given in Annex 4.

Damages of air pollution in terms of mortality can also be assessed by applying a formula that relates reduction of exposure (concentrations) of PM10 to decrease in mortality (see Ostro, 1994 and Dixons, 1996):

Mortality = $6.72 * 10^{-6}$ * **<u>(change in concentration of PM10)</u>** * 7.479 mln (population)

In most Serbian cities the annual mean concentration of particle matter is well over 100 microgrammes per m^3 . Assuming that 75% of ambient concentrations directly relates to Serbian emissions, maximal reduction of particles concentrations in ambient air can be estimated in the range of 75 micorgrammes (and higher). Applied in the above formula this would result in a reduction of 3770 premature death annually due to air pollution.

Although the approaches to assess health effects are rough, the results show in some cases a remarkable resemblance. So it appears that annually at least thousand to several thousands premature death cases can be linked to air pollution in Serbia.

3.7 Air pollution: summary and discussion

The damage assessment for air pollution in this study is based on the emissions of 7 different substance to air. The economic valuation of the damages is based of the application of “unit damage costs” (expressed as € per kilogramme). This valuation implicitly includes valuation of the damages to (especially) health, but a physical estimate of these effects is not given by applying this method. Indirectly, indicative calculations reveal that annually between 1,000 and 4,000 air pollution related cases of mortality are suffered in Serbia.

The following table gives an overview of the estimated damages due to air pollution stemming from Serbia, subdivided in the main categories and substances.

Table 3.9
Total annual damages due to air pollution in Serbia, low and high estimate, in mln €

	emissions	total damage, million €			
	tonne/year	low estimate		high estimate	
carbon dioxide (CO_2)	45,592,200	€ 60.3		€ 455.9	
climate change			**€ 60.3**		**€ 455.9**
sulphur dioxide (SO_2)	525,000	€ 284.1		€ 703.9	
nitrogen oxides (NO_x)	161,000	€ 14.0		€ 23.3	
ammonia (NH_3)	90,000	€ 3.5		€ 29.8	
Acidification			**€ 301.6**		**€ 757.0**
fine particles (PM10)	60,000	€ 70.4		€ 127.5	
volatile organic compounds (VOC)	97,000	€ 0.7		€ 1.5	
lead (Pb)	351	€ 14.1		€ 28.2	
air quality			**€ 85.3**		**€ 157.2**
Total			**€ 447.2**		**€ 1,370.1**

source: own estimate

The (maximal) per capita damage of air pollution in Serbia is € 183 per year. This is relatively low compared to the average estimated benefits of reducing air pollution in 10 Central and Eastern European Countries (€ 325 per capita, see Annex 5), but higher than the benefits in for example Bulgaria (€ 136 per capita).

Compared to a GDP of € 18.3 billion, damage is estimated between 2.4% and 7.5% thereof. Acidification (mainly SO_2) and climate change dominate the economic damages. Damages linked to air quality (lead and fine particles) are less dominating.

4 ECONOMIC DAMAGES LINKED WITH WATER

4.1 Introduction

Water is essential for life and therefore it can be expected that the protection of water resources may result in large economic benefits. In this chapter an assessment of these potential benefits is made, by estimating the current damage to water resources in Serbia.

Given the data available the analyses is limited to:
- discharges of waste water from households (sewers) and industries;
- discharges of nutrient from pig farming (as an example of the potential pollution from the livestock sector in (mainly) Vojvodina;
- groundwater resources in Vojvodina.

Damages due to waste water discharges and (pig)manure may be:
- health tread (through the lack of sewers and contamination of drinking water);
- diminishing ecological value;
- diminishing recreational and productive function (fishery, water) of water.

Pollution of groundwater leads to depletion of potential drinking water resources, which causes direct economic damage (due to higher production costs from alternative resources).

Additionally information has been gathered on the water quality of the Ibar river, which is heavily polluted with heavy metals from metallurgical industries in Kosovo (lead and zinc smelters, using water for the process).

Benefit studies on water quality and related economic benefits are rare and do not cover all issues related to water pollution. It is for example not easy to assess the damage of lack of sewers, as most studies relate to nutrients (EFTEC&RIVM), or apply a more general “willingness to pay” approach (Ecotec) is applied.

The water related damages are therefore probably underestimated. For example information lacks on industrial discharges, and only part of the water-resources problems in Serbia could be addressed in the framework of this study.

4.2 Waste water discharges from households and industries

4.2.1 Introduction

In Serbia there is a lack of wastewater treatment facilities, most wastewater that is collected is discharged without any treatments. For the largest part these discharges contribute to the pollution of the Danube water shed. The total amount of wastewater discharged is equal to about 12 million inhabitant equivalents (Water-management foundations of Republic of Serbia, 2001).

4.2.2 Methodology

To assess the economic damage linked with the discharges of waste water we have used (i) information of discharges of organic pollution (COD[4]) and nutrients (Nitrogenous compounds and

[4] COD = Chemical Oxygen Demand, which is a measure for the pollution of water with organic compounds. High levels of COD in water lead to low oxygen levels in water, which changes to water ecosystem (as all organisms that need oxygen will die)

phosphorous compounds[5]) in sewage and industrial waste water and (ii) unit damage values for the emissions of these substances. This methodology has been applied by Pearce in (RIVM, 2001a) and EFTEC.

It is an alternative to the approach followed by Ecotect in "Benefits of compliance with the environmental acquis for the candidate countries". This approach and application to Serbia will be explained and presented in end of this chapter.

4.2.3 Discharges of waste water

The following table gives an overview of the estimated discharges of wastewater in Serbia, subdivided in municipal sewage and industrial wastewater.

Table 4.1
Discharges of waste water in Serbia, 1998[6]

Type of waste water	Wastewater Discharge (000 m^3/y)	BOD 5 (t/y)	inhabitant equivalents	Total Nitrogen (t/y)	Total Phosphor (t/y)
Municipal sewage	405,187	116,592	5,323,858	19,404	5,830
Industrial (BOD dominated)	386,916	159,007	7,263,792	6,454	1,972
Industrial (Inorg. Dominated)	436,432	13,409	612,285	16,714	6,130
TOTAL	1,228,535	289,079	13,199,935	42,572	13,932

source: Federal Ministry for Development Science and Environment, 1998

It can be seen that about 45% of the pollution originates from municipal sewage and about 55% from industries.

4.2.4 Unit damage values applied

The unit values applied are summarised in the following table.

Table 4.2
Unit damage values for water pollutants in sewage and industrial waste water

substance	low estimate	high estimate	source
COD	€ 36	€ 1,477	TME (EFTEC); TME (control cost)
P-tot	€ 5,909	€ 74,000	TME; EFTEC
N-tot	€ 11,818	€ 15,000	TME; EFTEC

For COD the unit damage values are derived from (low estimate) the assumption that COD is about 4x more hazardous as CO_2, taking the low estimate for CO_2 (EFTEC). The high estimate is based in the marginal control costs estimated by TME (see annex 2).

[5] measured as N-total and P-total. High nutrients concentrations in water lead to the growth of certain organisms suffocating all other live. This phenomenon is also known as euthrophication.
[6] also data for 2001 are known, but these exclude BOD, which is an essential element in the damage analyses. Therefore, 1998-data have been used, which include BOD. The differences between 1998 and 2001 are small (13.1 against 12.3 million inhabitant equivalents).

For both nitrogenous and phosphorous compounds the low estimates are based on marginal control costs (TME), whereas the high estimates are based on a willingness to pay study for the Baltic region (cited in EFTEC and RIVM, 2000).

It should be noted that the above values are the original values, to apply these to Serbia a correction for purchase power parity has been used of 15%.

4.2.5 Total damages due to discharges of waste water

By combining annual discharges of COD (estimated by multiplying BOD discharge by a factor 2.5, which is common for sewage), N-total and P-total with the unit damage values, a low and high estimate of the economic damages due to discharges of waste water is made. The results are shown in the next table.

Table 4.3
Estimated economic damages due to the discharges of waste water in Serbia, in € million

substance	emissions in tonne per year	low estimate	high estimate
Chemical Oxygen Demand (COD)	722,698	€ 3.8	€ 157.0
Phosphorous compounds (P-tot)	13,932	€ 12.1	€ 151.6
Nitrogen compounds (N-tot)	42,572	€ 74.0	€ 93.9
Total		€ 89.9	€ 402.5

source: own estimate

The calculation reveals that the annual damage linked with the discharges of waste water are estimated at € 90 million to about € 400 million per year. It should be noted that it is likely that these estimates would even be higher if information about (industrial) discharges of toxic substances (like heavy metal, PAC's) would have been known.

4.3 Water pollution of pigs (and other livestock)

4.3.1 Introduction

In the Serbian part of the Danube basin there are over 3.6 million pigs, but also other livestock (which has not been investigated). Currently there is hardly any manure management taking place (using it for example on arable land), most manure of larger pig farms is dumped in pits, the sludge is used as fertiliser.

It is clear that in such way large amounts of nutrients will leak to surface and groundwater, degrading the possibilities of economical use thereof.

4.3.2 Methodology

To assess the economic damage linked with the discharges of waste water we have estimated (i) the discharges of nutrients (Nitrogenous compounds and phosphorous compounds) due to manure of pigs and (ii) unit damage values for the emissions of these substances.

4.3.3 Discharges of nutrients from pigs

In the State of the Environment 2000 report for Serbia (Republic of Serbia, Ministry for Protection of Natural Resources and Environment, 2002) it is mentioned that the total livestock in Serbia produces as much pollution as the whole population, without further quantification.

The estimate made here may serve as a first attempt to quantify these discharges, although it overestimates the nutrients discharge of the pig sector (as not all nutrient will be discharged), on the other hand it does not take into account nutrient pollution from other animals (cows, etc.).

The potential emissions of livestock in Serbia can be estimated by information on the number of pigs in Serbia and emissions factors (per type of pig).

The following table gives a summary of this estimation:

Table 4.4
Estimation of P and N-tot emissions from pigs in Serbia, 200

Types of pigs	Number of pigs	emission factor N-tot	N-prod	emission factor P-tot	P-prod
		kg N-tot per pig	kg/y	kg P-tot per pig	kg/y
Suckling pigs under 2 month	992 000	4.9	4 860 800	1.04	1 030 154
Pigs from 2 to 6 month	1 445 000	9.9	14 305 500	1.04	1 500 577
Sows and sows of first farrow	818 000	9.9	8 098 200	1.04	849 462
Boars for service	49 000	9.9	485 100	1.04	50 885
Other pigs	304 000	9.9	3 009 600	1.04	315 692
Total	3 608 000		30 759 200		3 746 769

Source: own estimation based on Statistical yearbook Serbia (pigs) and CBS 2004 (emission factors).

This estimate shows that the potential nutrient discharges from pig farms are about 25% of P-tot discharges through wastewater and about 70% of N-tot wastewater discharges.

4.3.4 Unit damage values applied

The unit values applied are summarised in the following table.

Table 4.5
Unit damage values for water pollutants in sewage and industrial waste water

substance	low estimate	high estimate	source
P-tot	€ 5,909	€ 74,000	TME; EFTEC
N-tot	€ 11,818	€ 15,000	TME; EFTEC

For both nitrogenous and phosphorous compounds the low estimates are based on marginal control costs (TME), whereas the high estimates are based on a willingness to pay study for the Baltic region (cited in EFTEC/RIVM, 2000).

It should be noted that the above values are the original values, to apply these to Serbia a correction for purchase power parity has been used of 15%.

4.3.5 Total damages due to discharges of nutrients by pig farms

By combining annual discharges of N-total and P-total with the unit damage values, a low and high estimate of the economic damages due to discharges of nutrients by pig farms is made. The results are shown in the next table.

Table 4.6
Estimated economic damages due to the discharges of waste water in Serbia, in € million

substance	emissions in tonne per year	low estimate	high estimate
Phosphorous compounds (P-tot)	3,747	€ 3.3	€ 40.8
Nitrogen compounds (N-tot)	30,759	€ 53.5	€ 67.9
Total		€ 56.7	€ 108.6

source: own estimate

The calculation reveals that the annual damage linked with the discharges of nutrients from pig farms are estimated at € 57 million to about € 109 million per year.

It should be noted that for pig farms alone, this is probably an overestimation, as some of the nutrients will be used economically. On the other hand, as we have only assessed discharges from pig farms and have not made an attempt to quantify nutrient discharges from other livestock, additional damages may be anticipated.

4.4 Groundwater resources

4.4.1 Introduction

Especially in Vojvodina groundwater resources are depleted due to overexploitation and pollution. Therefore, in many cases groundwater cannot anymore be withdrawn from the first aquifer, but need to be withdrawn from deeper aquifers.

This is not only a loss of resources, but also poses a (drinking)water quality problem, as the concentrations of Arsenic are elevated (in 22% of samples). Also Mercury (47% of samples) and Cadmium (25% of samples) show concentrations above standards. So the second aquifer is not always well suited to produce drinking water (but also using it for irrigation will lead in the long term to accumulation of heavy metals in soils and the food chain).

4.4.2 Methodology

To value this damage to the groundwater resources an estimate has been made of the amount of water that cannot anymore be withdrawn from the first aquifer, and the price of production of drinking water has been applied to this.

4.4.3 Estimated damage to groundwater resources in Vojvodina

The total amount of groundwater that is affected is estimated as follows:

- the total annual groundwater extraction in Vojvodina (6 m3/second), which results in an annual production of 189 million cubic meters;
- 57% of groundwater needs to withdrawn from the second aquifer;
- this results in a total annual loss of groundwater resources from the first aquifer of 107 million cubic meter water annually.

The cost of production of (high quality) drinking water is not precisely known. Therefore, we have taken the price of water in Belgrade for consumers[7] as an indication of the minimum damage value, being € 0.30 per cubic meter (20 dinars). The high estimate is estimated to be 2 times higher, € 0.60 per cubic meter (which is still less than 50% of the unit costs as estimated by TME for the Netherlands (see annex 2)).

This results in an annual estimated damage due to the depletion of groundwater resources in Vojvodina of at least € 32.4 million annually, and a maximal damage of € 64.7 million.

As we were only able to assess damages in Vojvodina, it can be anticipated that the total damage to groundwater resources in Serbia will be larger[8].

4.5 Import of pollution through rivers

Although no complete picture of the import of pollution through rivers exist, we have been able to partly quantify the influx of heavy metals from Kosovo. Through the river Ibar large amounts of heavy metals, originating from the tributary to the Ibar, river Sitnica are imported.

The pollution originates from the mining complex and lead smelters in Obilic, where surface water is used in the industrial process (washing metal ores) and discharged afterwards (without sufficient treatment).

The following table gives an overview of the minimum and maximum concentrations of 4 heavy metals monitored in the Ibar near the city of Kraljevo

Table 4.7
Minimum and maximum concentrations of heavy metals in river Ibar at Kraljevo

substance	min	max
	mg/l	mg/l
Zn (zinc)	10	510
Cd (cadmium)	0.1	0.35
As (arsenic)	5	17.5
Pb (lead)	10	15

source: Gavric.

Combining these concentrations with a flow of 63 m3 per second (which is the average flow of the Ibar river near Kraljevo) this results in the following estimate of emissions (we have taken lower concentrations for this estimate) and damage costs.

[7] The actual full costs of water production and distribution are not known, as investments in the past have been financed through the public budget. It is stated by the water company in Belgrade that the price per cubic meter at least covers the current operational costs in Belgrade.
[8] Although it is indicated that the largest problems with groundwater exist in Vojvodina, so additional damages in other parts of Serbia will not be that large.

Table 4.8
Estimated import of heavy metals through the Ibar river in Serbia, low and high unit damage values and total economic damage (low and high estimate)

	emissions	unit damage/tonne		total damage, million €	
substance	t/y	low	high	low	high
Pb (Lead)[9]	19,868	€ 832	€ 43,449	€ 16.5	€ 863.2
Cd (Cadmium)	199	€ 43,449	€ 103,491	€ 8.6	€ 20.6
As (Arsenic)	9,934	€ 43,449	€ 51,246	€ 431.6	€ 509.1
Zn (Zinc)	19,868	€ 166	€ 43,449	€ 3.3	€ 863.2
Total				€ 460.1	€ 2,256.1

source: own estimate

Total “imported” damages from Kosovo are higher than the other damages to water resources as quantified in this chapter. As these damages cannot be influenced directly by the Serbian government, we have not included them in the total estimate of damages for water resources. However, the magnitude of these damages shows that it is a serious problem in Serbia that should be solved in co-ordination with the authorities in Kosovo.

In this case the annual “damage” in the field of water is estimated at between 3.5% and 15.5% of GDP.

4.6 Alternative approach to assess the damages of water pollution in Serbia

As we have applied a different methodology than in the study on the “Benefits of the environmental acquis for Accession countries” (Ecotec, 2000), it is interesting to see how our estimate would compare to an estimate using the Ëcotec” methodology (see for detailed description of the Ecotec methodology, Ecotec, 2000, p. 173 - 193). This method tries to link results of Willingness to Pay studies in various countries to the Central and Eastern European Countries. As it assesses the Willingness to Pay for improvements (but no total abolishment of pollution) results do not necessarily reflect the total damage of depleted water quality.

In the Ecotec approach three types of benefits of water management have to be assessed:

- to drinking water;
- to recreational use of water;
- to non user value of rivers and lakes.

The Willingness to Pay for improved (high quality) water supply is estimated by taking average UK and US WTP-figures (per household € 25 - € 650 per year), apply a PPP correction (resulting in € 3,38 - € 60 per household per year for Serbia), and estimate the share of the affected households (25% in Serbia, 623,000). This results in total annual benefits of € 2.1 mln to € 71.4 mln.

The Willingness to Pay for improved water quality for recreational use is estimated to be € 20 per adult per year in Poland (or corrected for PPP € 8,62 in Serbia), with an adult population of 5.2 million this results in annual benefits to recreation of € 50 million.

The Willingness to Pay for non user value of rivers is estimated by multiplying the length of rivers (in km) that have “poor” quality and for which it is assumed that they will have “fair” quality after

[9] The original document mentions copper (Cu) in stead of lead (Pb). Additional information shows that this is a mistake, which we have corrected.

implementation of policy, with the WTP of households to achieve this improvement. In Serbia 2113 km (out of 4071 km) has “poor” quality, 1799 km is classified as “fair” and only 159 km as “good”. Total benefits are estimated at € 7.3 mln per year in Serbia. The result of this part of the estimate is depending largely on length of rivers in a country (and the way in which this has been defined and classified).

The following table gives an overview of the benefits if the Ecotec approach had been followed.

Table 4.9
Total annual willingness to pay for clean drinking water, recreational use of water and the non user value of water in Serbia, low and high estimate, in mln €

	Minimum estimate	Maximum estimate
WTP clean drinking water	€ 2.1	€ 37.4
WTP recreational use water	€ 36.5	€ 44.9
WTP non user value water	€ 7.3	€ 7.3
Total damages	**€ 45.9**	**€ 89.6**

source: own calculations applying the Ecotec approach

The total annual benefits of improved water quality in Serbia are estimated to be between € 45 mln and € 90 mln, This is quite lower than the estimated total damage as calculated in the previous section wastewater (€ 90 - € 400 mln). Several reasons can be mentioned which may explain – at least part of – the difference:

- when measuring Willingness to Pay in the way applied in the Ecotec approach one does not cover total damage but only part of it;
- the Ecotec approach is sensitive to bias in statistical data on river length and quality;
- it does not specifically measure the Willingness to pay for improved water quality.

4.7 Water pollution: summary and discussion

In this chapter an attempt was made to value the damages to water resources in Serbia. The following table gives an overview of the results.

Table 4.9
Total annual damages due to water pollution in Serbia, low and high estimate, in mln €

substance	discharges tonne/year	total damage, million € low	low (subtotal)	high	high (subtotal)
Chemical Oxygen Demand (COD)	722 698	€ 3.8		€ 157.0	
Phosphorous compounds (P-tot)	13 932	€ 12.1		€ 151.6	
Nitrogen compounds (N-tot)	42 572	€ 74.0		€ 93.9	
Wastewater			**€ 89.9**		**€ 402.5**
P-tot	3 747	€ 3.3		€ 40.8	
N-tot	30 759	€ 53.5		€ 67.9	
Pigs			**€ 56.7**		**€ 108.6**
Water	189 216 000	€ 32.4		€ 64.7	
Groundwater			**€ 32.4**		**€ 64.7**
Total			**€ 179.0**		**€ 575.9**
Import heavy metals Ibar			**€ 460.1**		**€ 2,256.1**

source: own estimates

The results show that the discharges of wastewater, nutrients form pig farms and the depletion of groundwater resources in Vojvodina already count for an annual damage of between € 180 million to over € 0.5 billion. The (maximal) damage is € 77 per inhabitant per year. This is a little lower than the average benefits in Central and Eastern European countries of water policy (€ 96 per capita per year), but higher than estimated benefits for for example Bulgaria (€ 52 per capita per year) and Romania (€ 56 per capita per year) (Ecotec, 2001).

Applying an alternative approach – based on Willingness to Pay studies – comes to a considerably lower estimate: € 45 - € 90 mln per year. But in this case only benefits of policy are measured and not the total damages.

The results also show that the import of "damages" through the Ibar river (heavy metals) would count for an annual damage of between € 460 million and over € 2 billion.

In relation to the GDP of Serbia (at € 18.3 billion per year), the damages through water pollution are between 1% and 3.2% of GDP. If the imported damage is also taken into account damages would range from minimally 3.5% to over 15.5% of GDP.

5 ECONOMIC DAMAGES LINKED WITH WASTE MANAGEMENT

5.1 Introduction

As the Waste management Strategy for Serbia points out, the lack of proper waste management in Serbia causes large damages. For example, there are no sanitary landfills yet in Serbia, most waste is dumped on dumpsites without any precaution (not covered, not weighted, no collection of leachate and no landfill gas collection). Due to climatologic circumstances, many landfills are on fire during the dry season. Also, large amounts of waste in rural areas are simply not collected and either dumped at illegal dumpsites (often near rivers, causing additional environmental hazards) or burned. Large amounts of fly ash and mining waste are dumped each year, without any measures for recycling.

In this chapter, the economic damage linked with the poor management of waste in Serbia are investigated. As data on waste in Serbia are poor, the assessment only covers municipal waste, hazardous industrial waste and fly ash. For soil contamination some quantitative data have been collected, but these are not sufficient to make an assessment of the potential damage linked with soil contamination.

5.2 Methodology

For waste an estimate of the amounts of waste disposed at landfills (and in what condition) has been made. The estimate is limited to the landfill of municipal waste, including “back yard burning”, hazardous waste and fly-ash.

For municipal waste the methodology used is largely the same as for Accession countries (Ecotec, 2000) and for landfills (COWI, 2000). This implies that first the emissions to air and to water (leachate) have been estimated, and unit values for these air and water pollutants have been applied to assess the economic damage. As additional data were available in comparison with the studies of Ecotec and COWI, some additional estimates could be made, mainly including more pollutants.

For hazardous waste it was not possible to rely on a methodology that already had been applied in other (Accession) countries. Therefore, a relative simple methodology has been developed and applied.
First an estimate was made (based on the assessment for municipal waste) of the damages per tonne municipal waste. Next this figure has been “inflated” by a factor 7.95. This factor is based on the marginal control costs approach (see annex) for both hazardous and non hazardous waste.

For fly ash it has been assumed that fly ash could (as is the case in many EU countries) be used partly to substitute primary construction materials like cement and sand. For example, in the Netherlands, 100% of fly ash from power plants is used in cement, saving considerable amounts of primary construction materials. It has been assumed that the economic damage of not recycling fly ash can be assessed by the costs of production of primary materials.

5.3 Municipal waste

The total amount of municipal waste generated in Serbia is about 2.2 million tonnes per year. As (hardly) any recycling is in place in Serbia, this waste either ends up at landfills or is dumped illegally or burned. It can be assumed that the current waste management practice will lead to high levels of pollution of groundwater and air (through emissions of for example methane (landfill gas), but also dioxins and fine particles when burned).

The economic damages linked with municipal waste is divided in three parts:
- emissions from landfills to air;
- emissions from “back yard” burning to air;
- discharges of substances with leachate.

This is only a partial analysis, as for example the potential contamination of soils due to bad waste management is only partly covered (by the assessment of leachate from landfills, but not form illegal dumpsites, dumpsites on industrial sites, etc.).

5.3.1 Emissions to air from landfills

By estimating the emissions to air form landfills the damages of waste management can be (partly) assessed in an indirect manner. In annex 1 these emissions have been estimated, in annex 2 the unit values applied to these substances are presented. As the unit values in annex 2 are derived from EU studies (mostly the Netherlands) a correction for the economic circumstances in Serbia needs to be made. This is explained in detail in annex 3, where it is concluded that a correction of 15% of the EU (Netherlands) unit values would be a good estimate for Serbia.

The following table gives an overview of the economic damage linked with the current landfill practices in Serbia.

Table 5.1
Estimated emissions to air from landfill in Serbia, low and high unit damage values and total economic damage (low and high estimate)

substance	emissions t/y	unit damage/tonne low	unit damage/tonne high	total damage, million € low	total damage, million € high
CH_4 (methane)	94 916	€ 28	€ 210	€ 2.6	€ 19.9
CO_2 (carbon dioxide)	916 436	€ 1.32	€ 10	€ 1.2	€ 9.2
PM10 (fine particles)	5 363	€ 1,174	€ 2,126	€ 6.3	€ 11.4
dioxins	0.000282	€ 11 858 mln	€ 23 560 mln	€ 3.3	€ 6.7
PAC	0.16	€ 25,051	€ 49,774	€ 0.004	€ 0.01
PAH	16	€ 60	€ 119	€ 0.001	€ 0.002
Total				€ 13.5	€ 47.2

source: own estimate

It can be seen that largest damages are linked with emissions of methane and fine particles. Emissions of the highly toxic dioxins count for about 15-20% of total damages. Proper management of landfills could drastically reduce these emissions and thus the damages connected.

5.3.2 “Back yard burning” of municipal waste

About 1/3 of total municipal waste is not collected, mostly in rural areas. This waste is partly used as fodder for animals (if organic), dumped illegally or burned. It is assumed that about 50% of the amount is burned, or about 385,000 tonnes annually. The analysis of damages is limited to this backyard burning. This means that in reality the damages may be larger as the damage to landscape, surface of groundwater and soil contamination is not valued.

The related emissions to air have been estimated making use of a study of the US EPA (1997) (see annex 1).

Table 5.2
Estimated emissions to air from “back yard burning” in Serbia, low and high unit damage values and total economic damage (low and high estimate)

substance	emissions	unit damage/tonne		total damage, million €	
	t/y	low	high	low	high
PM10 (fine particles)	5 775	€ 1,174	€ 2,26	€ 6.	€ 12.3
dioxins	0.000304	€ 11 858 mln	€ 23 560 mln	€ 3.6	€ 7.2
PAC	173	€ 25 051	€ 49 774	€ 4.3	€ 8.6
PAH	17 325	€ 60	€ 119	€ 1.0	€ 2.1
Total				€ 15.8	€ 30.1

source: own estimate

Emissions of fine particles account for the largest part of the economic damages.

5.3.3 Leachate from landfill

About 80% of landfills are located close to rivers (Danube, Sava). This poses a potential environmental hazard for these rivers, as leachate of landfills is not collected nor treated. Landfills cover an area of about 1000 ha in Serbia, causing each year the generation and discharge to surface water, soil and groundwater of about 850,000 m3 of contaminated leachate (see annex 1).

Damages linked with leachate are not very well understood. In a report for the European Union only 3 studies were identified that somehow tried to assess the damage costs related to leachate. Two of these studies assess the damage as a total per tonne of waste, trying to quantify either the clean up costs (ranging between € 0 – € 1.54 per tonne of waste) or the damage to health (mortality and morbidity, ranging between € 0 – € 1.09 per tonne) (COWI, 2000, p. 46). A third study identifies damage costs related to different pollutants, focussing on heavy metals and dioxins (ECON, 1995).

To estimate damages linked with leachate, the estimated discharges of COD (Chemical Oxygen Demand) and nutrients have been used. In addition, an estimate has been made of the discharges of heavy metals in leachate (based on emission factors for a mature landfill, see annex 1).

In combination with unit damage values for the substances discharged with leachate an estimate has been made of the associated economic damages of the lack of leachate control/treatment.

Table 5.3
Estimated discharges from leachate of landfills in Serbia, low and high unit damage values and total economic damage (low and high estimate)

substance	emissions	unit damage/tonne		total damage, million €	
	t/y	low	high	low	high
COD (Chemical Oxygen demand)	41 590	€ 5	€ 217	€ 0.2	€ 9.0
N tot (Nitrogen compounds)	389	€ 1,738	€ 2,206	€ 0.7	€ 0.9
P tot (Phosphorous compounds)	426	€ 869	€ 10,882	€ 0.4	€ 4.6
Cu (Copper)	0,068	€ 832	€ 43,449	€ 0.0001	€ 0.003
Ni (Nickel)	0,238	€ 1,997	€ 43,449	€ 0.0005	€ 0.01
Cr (Chromium)	0,639	€ 43,449	€ 2,911,712	€ 0.03	€ 1.86
Zn (Zinc)	0,170	€ 166	€ 43,449	€ 0.00003	€ 0.01
Total				€ 1.3	€ 16.4

source: own estimate

It can be seen that the total estimated economic damage connected with leachate varies from € 1.3 million to more than € 16 million per year. This points at a large uncertainty in the estimate (which is understandable, as little work has so far been done on assessing the damage on leachate).

Compared to an assessment where use is made of unit damage values for leachate per tonne waste landfilled ((COWI, 2000) maximal € 1.54 per tonne, assuming about 1.3 million tonnes landfilled per year, arriving at damage costs for leachate of about € 2 million) our low estimate comes near to such an assessment.

It is remarkable that damages associated with the discharges of heavy metals are relatively small. One reason may be that the (low estimates of) unit damage values for heavy metals are relatively low, but it is also due to the relative small amounts of heavy metals released in leachate (which was also confirmed by a study on Dutch landfills a few years ago).

5.3.4 Unit damages

The results in the previous paragraphs enable a simple calculation of the unit costs per tonne of municipal waste. Total damages are estimated at between € 48 million and € 125 million annually. Related to 2.2 million tonnes of waste, the unit damage for municipal waste can be estimated at between € 22 and € 57 per tonne.

5.4 Hazardous waste

As indicated earlier, the assessment of damages linked with hazardous waste is rough. The main reasons for this are:

- uncertainty about the annual amount of hazardous waste in Serbia;
- the characteristics of hazardous waste in Serbia;
- the disposal routes for hazardous waste.

Moreover, the unit damages linked with hazardous waste are not very well documented in literature. For example, the benefits linked with hazardous waste management have only been assessed qualitatively in the Ecotec study (Ecotec, p. 198).

The amount of hazardous waste in Serbia is not documented by statistics. There are several estimates of the quantities produced. We have used an estimate of 225,000 tons hazardous waste that is dumped on landfills (as there are no other final disposal routes available in Serbia: there is no hazardous waste incinerator).

The characteristics of hazardous waste may largely influence the outcomes of any damage assessment. The more toxic the wastes, the larger the potential damages to the ecosystem (leaking to (ground)water, soil) and human health. Since no information is available on the characteristics of these wastes in Serbia, we are forced to use the assumption that the toxicity of the waste is "average" (like in other countries).

The way hazardous waste is managed also largely may influence the damages. It makes a large difference if the hazardous waste is dumped on landfills together with municipal waste without specific precautions ("co-disposal"), or if the hazardous waste is first immobilised and afterwards stored in specific sections of landfill, well isolated from the surrounding environment. In Serbia, the situation is not clear, but it is stated that in many cases hazardous waste is co-disposed with municipal landfills, creating an additional environmental risk (and potentially high future clean up costs of contaminated sites).

The quantification of the economic damages related to (the lack of) hazardous waste management in Serbia is based on the following assumptions:

- the amount of hazardous waste dumped is an indication of the damages;
- the unit damage for hazardous waste can be assessed by comparing hazardous waste with municipal waste.

Estimates of unit marginal control costs for hazardous waste are 7.95 times higher than for municipal waste (see annex 2). In the previous paragraph the unit damages related to municipal waste are estimated at between € 22 and € 57 per tonne. The unit damage for hazardous waste can thus be estimated at between € 173 and € 452 per tonne.

Total annual damages related to hazardous waste are thus estimated at:

225,000 tonnes x unit costs = between € 39 and € 102 million per year.

5.5 Uneconomical use of resources – fly ash from power stations

As an example of uneconomical use of resources the example of fly ash from coal/brown coal fired power plants can be used. In the current situation all fly ash (a by-product of the incineration of coal) is dumped at depots near to the power plants. According to the Report on the State of the Environment (Republic of Serbia, 2002, p. 104) in total the depots occupy a space of 1,461 ha.

The exact amount of fly ash produced annually is not documented very well by the authorities. However, from other sources it is clear that annually about 4.8 million ton of (fly) ash is produced at the Obrenovac power plant (HP Institut, 2002) and additionally 1.7 million tonnes is produced at Drmno Kostolac power plant. So, annually about 6.5 million ton of fly ash is currently generated and dumped in Serbia.

The damages related to this (uncontrolled) dumpsites can be assessed making use of the assumption that fly ash could replace primary construction materials like cement and sand. For example, in most EU countries fly ash (but also "mining waste" and other large relatively homogenous relatively non hazardous waste streams) are used in the construction sector.

The local price of raw materials (sand) is € 15 per m3 (information from sand producing industry in Serbia). The extraction costs (which are roughly the same as dredging costs) are € 3.50 per m3. Assuming a specific weight of sand of 2 tonnes per m3, the unit costs per tonne can be estimated between € 1.75 and € 7.5 per tonne.

Together with the estimated amount of 6.5 million tonnes of fly ash generated each year, the damage linked with dumping of fly ash can be assessed at between € 11.4 and € 48.7 million per year.

Of course it would not be possible to shift the current practice immediately to the desired, ideal situation in which all fly ash can be used [10]. It is certain that the use of economic instruments could give an incentive to the power sector to reduce the landfill, as reuse would reduce costs.

5.6 Soil contamination

Since the industrial revolution in the 19th century (and even earlier) many sites have been contaminated with hazardous substances, released to the soil. Only in the 80-ties of the last century, authorities became aware of the potential magnitude of the problems connected to the uncontrolled dump of hazardous waste and releases of for example oil and other organic substances to the soil.

For the first National Environmental Policy Plan in the Netherlands, it was estimated that the clean up costs of the soil contamination would be € 5 billion for municipalities (mainly due to old gas factories) and about € 10 billion for industrial sites (Jantzen, 1989).
Part of the clean up costs were linked with gasoline station (where in the past gasoline and diesel was spilled and not collected as currently is the case), and clean up costs were estimated at about € 100,000 - € 200,000 per gasoline station. With a number of 6,000 stations total costs for gasoline stations is about € 900 million (or 7% of total clean up costs).

In a study by EFTEC/RIVM (2000) it has been estimated that the total benefit of cleaning up all contaminated sites in the Netherlands in the coming 30 years would be around € 50 billion[11]. This benefit is calculated as 10% of the value of residential and industrial land.
The benefits (or damages) would thus be about 3 times higher than the costs to clean the contaminated land.

For Serbia we are not able to make such an assessment, as too little reliable data is available. No information on contaminated sites is present, and it is also hard to find reliable data on land use (for industrial purposes) in Serbia. A rough estimate indicates that about 2-3% of total area in Serbia is industrial, this would be about 175,000 – 265,000 ha.
With a total number of about 600 gasoline stations (information from Beopetrol, NIS Jugopetrol and the Directorate Ministry of Capital Investments) potential clean up costs in Serbia in this sector would be € 100 million (without adapting prices).

From the data examined it is clear that soil contamination in Serbia can be a real problem, of which however the magnitude is difficult to assess. It is reasonable to assume that many industrial sites will be contaminated, just as is the case in EU countries. In addition to that the lack of proper waste management in industry may indicate that the problem in Serbia even may be worse than in EU countries, where at least since the 80-ties waste management at industrial sites became part of the good management practices of industries.

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[10] the National Waste Strategy assumes that annually about 2 million ton of fly ash could be used as secondary material (p. 61)).
[11] the quantitative assessment by EFTEC & RIVM is however disputable, it says that 631,000 ha of land is contaminated in the Netherlands. This is 15% of total area in the Netherlands, which must be an overestimation with a factor 10 or more. Also the 10% value and the values use in the report are disputable!

Overlooking the scarce information, it may be concluded that economic damages linked with soil contamination will be of significant magnitude in Serbia. However, data does not allow making an estimate of these damages.

5.7 Waste management: summary and discussion

In this chapter an attempt was made to value the damages linked with (the lack of) waste management in Serbia. The following table gives an overview of the results.

Table 5.4
Total annual damages linked with waste management in Serbia, low and high estimate, in mln €

type of waste	amount of waste	total damage, million €	
	t/y	low	high
landfill: air emissions	1 430 000	€ 13.5	€ 47.2
landfill: leachate		€ 1.3	€ 16.4
backyard burning	385 000	€ 33.1	€ 61.5
municipal waste total		**€ 47.9**	**€ 125.0**
hazardous waste	225 000	€ 38.9	€ 101.7
hazardous waste		**€ 38.9**	**€ 101.7**
fly ash	6 500 000	€ 11.4	€ 48.8
depletion of resources		**€ 11.4**	**€ 48.8**
Total		**€ 98.2**	**€ 275.5**

source: own estimates

The results show that the damages linked with waste management are for about 50% related to municipal waste (air pollution, leachate) and for about 40% to hazardous waste. Due to the lack of use of fly ash as a secondary material in construction annually between € 11 – 49 million is lost in natural resources.

Total damages due to waste management are estimated to between 0.5% and 1.5% of GDP. Per capita damages are estimated to be maximal € 37 per year. This is low in comparison with estimates of per capita damages in Central and Eastern European Countries where the average is € 99 per capita (Ecotec, 2001). Also per capita benefits in Bulgaria (€ 82 per year) and Romania (€ 118 per year) are considerably higher than in Serbia. One of the main reasons that damage-estimates in Serbia are relatively low compared with other Central and Eastern European Countries is the low Purchasing Power Parity in Serbia (15% compared to for example 24% for Bulgaria).

As mentioned in the introduction of this chapter, damages related to waste management are not very well documented. The analysis in this chapter thus only covers part of the overall damages[12]. This is for example illustrated by our semi-quantitative analysis on soil contamination, which could add considerable damages to the total presented here.

[12] Although we believe that we have identified more damage categories than many other studies focussing on waste.

6 NOISE

6.1 Introduction

Although noise is currently not a priority issue in environmental policy in Serbia, it is clear from studies in Western Europe and the United States, that with growing wealth it becomes one of the most difficult environmental problems to solve.

6.2 Approach

As little structural information is available about noise in Serbia, a general approach has been followed making use of data from the Netherlands (EFTEC/RIVM, 2000).

Two approaches are generally used to assess the damage due to high noise levels:
- an approach based on differentiation in house-prices (the so-called hedonic approach);
- an approach based on willingness to pay (by applying contingency valuation).

In the Dutch study on the damages linked with high noise levels the second approach has been followed. It has been estimated that the willingness to pay for avoiding 1 dB(A) of noise above the level of 50 dB(A) is € 20 per year.

6.3 Estimated noise levels

As no information on the division of the population over the various noise bands is available for Serbia, it has been assumed that for Serbia the same characteristics apply as for the Netherlands, but with the following adaptations:
- only road noise has been taken into account (no air plane and railway noise);
- as the Netherlands is more urbanised than Serbia a correction has been made for that.

This results in the following division of the population over noise bands.

Table 6.1
Percent of Dutch population exposed to various noise bands from road transport, and estimated exposure of Serbian population

Noise band dB(A)	% of Netherlands population exposed	% of Serbian population exposed
51-55	28.45%	18.03%
56-60	21.96%	13.92%
61-65	8.70%	5.51%
66-70	1.71%	1.08%
71-75	0.17%	0.11%
76-80	0.02%	0.01%
Total	61.01%	38.66%
share of urban population	89%	56%

source: for the Netherlands: RIVM/EFTEC, 2000, for Serbia: own estimate

The table shows that currently more than half of the Dutch population suffers somehow elevated noise levels. For Serbia it is estimated that due to the lower urbanisation, less people are exposed to elevated noise levels: about 38%. This has been estimated by simply taking the Dutch percentages in each noise band and multiply this with the correction factor for urbanisation: 56% (Serbian urbanisation) / 89% (Dutch urbanisation) = 0.63.

6.4 Unit values

For noise EFTEC/RIVM estimate that each decibel (dB(A)) of noise above 50 dB(A) is valued by people at € 20 per year. In other words, people are willing to pay € 20 per year to live in a surrounding with 1 dB(A) less noise.

Applying the purchase power parity correction factor used throughout this study of 15%, this would be € 2.94 per dB(A) in Serbia. This will be regarded as the "low" estimate.

However, as already mentioned, noise can also be value by taking a certain percentage of the value of property. Having reviewed various studies on that, the value of property decreases by an average of about 0.4% per additional dB(A) (IVAM & TME, 2002).
As no information on the total number of dwellings is available, the following approach is used to arrive at a "high" estimate of unit costs:

- the average price of a square meter dwelling in Serbia is estimated at € 1,000 in Belgrade and € 600 in other towns. Let's assume that for whole Serbia the price is about € 700;
- in the Netherlands the average price per square meter can be roughly estimated at € 1,500;
- this would suggest that the average Dutch unit damage cost per decibel should be corrected by a factor of 47%;
- the willingness to pay would than be € 9.33 per decibel in Serbia.

6.5 Damage assessment

Using the data derived in the last sections leads to the following estimate of economic damage as a result of noise levels above 50 dB(A).

Table 6.2
Total damage due to elevated noise levels in Serbia, low estimate (based on PPP) and high estimate (based on relative property prices)

Noise exceedance > 50 dB(A)	low estimate	high estimate
3 dB(A)	€ 11,897,203	€ 37,753,792
8 dB(A)	€ 24,488,584	€ 77,710,441
13 dB(A)	€ 15,765,363	€ 50,028,751
18 dB(A)	€ 4,290,520	€ 13,615,251
23 dB(A)	€ 545,027	€ 1,729,553
28 dB(A)	€ 78,060	€ 247,711
Total	**€ 57,064,758**	**€ 181,085,499**

source: own estimate

6.6 Discussion

Although no structural data is available on elevated noise levels, it is clear that also in Serbia noise levels at certain areas (especially in larger town) are above 50 dB(A). It may even be that the noise of road traffic is underestimated, as the car fleet in Serbia is relatively old in comparison with the Netherlands (and other EU countries). This is supported by the measurement in the "29 novembra street" in Belgrade (Republic of Serbia (2002), page 51), where noise levels during the day are 80 dB(A) and during the night 73 dB(A), exceeding the “noise standard” of 50 dB(A) by respectively 30 and 23 dB(A). Also from Novi Sad information on high noise levels were reported (above 100 dB(A)).

The total damage related to noise varies largely depending on the correction factors used for purchase power parity. If the standard correction factor is applied (15%), damages are estimated at € 57 million annually.
However if a correction factor is used that compares prices of property between Serbia and the Netherlands, the correction factor is 47%, thus leading to an annual damage of € 181 million per year.

It is remarkable that there is such a large difference between these two correction factors. One would expect that the market for property in Serbia would at least reflect the current economical circumstances in the country. This would lead to far lower prices than the actual ones. An explanation may be that the property market has adapted already for a large extend to the European levels (adapting more quickly than the economy). But also certain monopolistic features of the property market (e.g. there is only one city centre in Belgrade, property can only be developed when having a permit, which depends for a large part on spatial policy) may have an influence. A third explanation for the unexpected high property prices is that the grey economy in Serbia is very large, leading to more demand than would be expected if only looking at the official figures. A fourth explanation may be that investments in real estate are more popular than in a “regular/developed” economy as it is one way to avoid the risks (capital market is not functioning very well, putting savings on the bank also is negatively influenced by the “trauma” of the Milosovic era).

7 SOIL EROSION IN VOJVODINA

7.1 Introduction

As early as in 1985 concerns were expressed about the soil erosion (due to wind) taking place in Vojvodina. As agriculture is an important source of income, erosion can be seen as a long-term thread to economic sustainable development.

In this chapter an attempt is made to quantify roughly the potential economic loss due to soil erosion in Vojvodina.

Soil erosion (due to water) is also present in the central part of Serbia (see for example: Kostadinov, 1998). However, due to lack of data we have not included this in the assessment although these damages should not be neglected.

7.2 Soil erosion

In Vojvodina about 85% of agricultural land suffers from soil erosion. In this case the erosion takes place as a result of the winds.

The following table gives an overview of the magnitude of the problem in Vojvodina.

Table 7.1
Soil erosion in Vojvodina

intensity t/ha	area affected (in ha x 1000)	%
0,3	137.1	6.37%
0.8	37.8	1.76%
0.9	117.0	5.44%
1	257.4	11.96%
1.1	244.8	11.38%
1.2	356.6	16.57%
1.3	476.3	22.14%
1.4	424.8	19.74%
1.5-2	54.9	2.55%
>2	44.8	2.08%
Total	**2151.5**	**100.00%**

source: Letic, Ljubomir et al. 2001. p. 51

This table shows that about 85% of agricultural soils in Vojvodina have an annual loss of over 0,9 ton material per ha (which falls in the category “disturbed soils” or “very disturbed soils”).

The causes for soil erosion are (Letic, 2001, p. 17):

- decrease of area covered with forests;
- bad organisation of land management;
- irregular feeding of cattle;
- agricultural mismanagement;
- deep ploughing.

7.3 Economic valuation of soil erosion

Due to the wind erosion the yields of agricultural crops may drop by as much as 20 – 30%, compared to well managed soils. However, in Vojvodina the situation is not that bad: it is estimated that the maximal reduction in crop yield is about 5% (Letic, 2001, p. 130 – 131).

As detailed data on crops and yield reductions in Vojvodina are not known, the assessment is performed in a more gradual way. The assumption made is that the yield reduction of 5% applies to the total agricultural output in Vojvodina. A more conservative estimate would be a 2.5% reduction in agricultural yield.

Table 7.2
GDP and share of agriculture in GDP, Serbia, central Serbia and Vojvodina, 2001

	million dinar	million euro*	share of agriculture in GDP
GDP Serbia	553,303	8,512[13]	
agriculture	138,138	2,125	25%
GDP central Serbia	370,935	5,707	
agriculture	81,674	1,257	22%
GDP Vojvodina	182,367	2,806	
agriculture	58,488	900	32%

source: Statistical Institute Republic of Serbia, 2003
*: applying an exchange rate of 65 dinar per euro for 2001.

This table clearly shows the importance of agriculture in Serbia (25% of GDP is generated in this sector) and the even greater importance of agriculture in Vojvodina, where it comprises 32% of regional GDP.

Based on the data presented it can thus be estimate that the annual damage of soil erosion in Vojvodina is 5% of € 900 million = € 45 million annually (or € 22 million applying 2.5% yield reduction).

As with the other calculations made in this report, not the official exchange rate should be used to arrive at a “euro-figure”, consideration should be given to the purchase power parity. In this case the correction is “upwards” starting from a Serbian number to arrive at a comparable “euro-number”.

According to the above table, and a population of 7.479 million inhabitants the GDP per capita in 2001 in Serbia was € 1,138. However, in our other calculations we have assumed a GDP per capita of about US$ 4,000. Assuming simply an exchange rate of 1 between US$ and € (which is more or less correct for 2001 – 2002). We thus should apply a correction factor for purchase power parity of 4000/1138 = 3.51.

The total annual loss of yield due to soil erosion in Vojvodina can therefore be estimated at between € 79 million (2.5% yield reduction) and € 158 million (5% yield reduction).

[13] This GDP figure is calculated with the exchange rate not taking into account purchase power parity (see annex 3 for more details)

As stated in the introduction, water erosion in Central Serbia also is a serious problem. Without further monetary quantification it should be noted that the economic damage due to water erosion in Central Serbia may be as high as the damage due to wind erosion in Vojvodina. Total area affected by water erosion is about 3 times the area affected in Vojvodina, leading to comparable or even larger losses of humus and nutrients in the soil than in Vojvodina (Kostadinov, 1998, table 3).

8 ASSESSMENT OF FUTURE ECONOMIC VALUE OF ENVIRONMENTAL DEGRADATION

8.1 Introduction

In this report a first attempt has been made to assess the economic damage linked with environmental degradation in Serbia. The damage assessment is limited to the current state of the environment in Serbia (by using the most recent data on emissions to air, wastewater discharges and waste generation, completed with information on noise and soil (wind) erosion.

The question may arise how these damages may develop over – say – the coming ten years. Such an assessment only would be possible if already exactly is known how the economy in Serbia will develop over the coming ten years, and how environmental policy will be implemented.

As such information is not readily available, and amongst others, may be influenced by the outcomes of this study (as it might trigger environmental action in the near future) we have applied a scenario analysis to illustrate possible development of environmental degradation in Serbia.

8.2 Approach

We have followed the following approach concerning economic growth:

- 3 growth scenarios for the Serbian economy:
    - low growth scenario: 1.8% (slightly above population growth). This growth rate can also bee seen as a minimal "survival" scenario for the Serbian economy;
    - middle growth scenario: 4,73%, based on the current growth rates in Poland, Hungary and the Czech Republic (Economist, 2004, p. 102);
    - high growth scenario: 8%. In this scenario it is assumed that Serbia achieves the same growth rate as for example the Russian federation (Economist, 2004, p. 102).

For the development of damages also three approaches are have been applied:

- a "ceteris paribus" scenario, which implies that damages would grow at the same rate as economy, assuming no technological changes (this scenario would be a simple extrapolation of the total damage with the growth rate of the economy);
- a scenario in which it is assumed that autonomous technological progress and a shift in the sectoral structure of the economy, leads to less pollution per € earned in the future. This effect is estimated at 2% (which is about the rate of energy efficiency gains in Hungary and Czech Republic over the last decade);
- a policy scenario, assuming implementation approximation to EU legislation in Serbia. We have assumed that such a scenario will lead to about 5% reduction of environmental stress per € earned per year.

8.3 Results

The following table gives an impression of the total future damage to environment in the various scenarios. It should be noticed that for reasons of simplicity we have taken the low estimate of total environmental damage (€ 860 million per year).

Table 8.1
Estimated development of economic damages of environmental degradation in Serbia, 3 economic growth scenarios and 3 environmental policy scenarios

		environmental policy scenarios		
economic growth scenarios		one-on-one 0%	techn. progress -2%	EU env. policy -5%
low	1,80%	€ 1.028.598.525	€ 840.439.884	€ 615.859.933
middle	4,73%	€ 1.366.524.357	€ 1.116.549.892	€ 818.188.611
high	8%	€ 1.857.828.719	€ 1.517.981.326	€ 1.112.350.681

source: own estimate

The table shows that in only three of the nine possible combinations, the damage after 10 years would be lower than the current damage. In all other cases the damage will increase.

It is hard to forecast the economical developments in Serbia in the coming next ten years, as the political situation is not yet very stable, making it difficult to attract foreign investments.

In the most pessimistic view (low economic growth), the damage will only slightly decrease, in combination with "autonomous progress". In such an economic scenario, there seems little space for an accelerated environmental policy, as the availability of funds for investments (especially in the public sector) will be very limited. But it is questionable if the low economic growth rate would be enough to introduce the needed innovations and shifts in sectoral structure (to achieve 2% relative reduction of environmental stress).

In a moderate economic development scenario, comparable with for example Poland, Hungary or the Czech republic, the environmental damage may decrease only if environmental policy is taken seriously, leading to a reduction of environmental stress of on average 5%.

The scenario analysis shows that in the high growth scenario even a reduction of 5% of relative environmental stress would not be sufficient to reduce total damages. But such a high growth scenario seems unlikely for at least the coming years.

9 OVERVIEW OF RESULTS AND CONCLUSIONS

In the period February – July 2004 this project to assess the "Economic Value of Environmental Degradation in Serbia" has been performed. Main objective of the study is to quantify as much as possible the economic damage of environmental degradation in Serbia. Other than in most Central & Eastern European Countries, during the 90-ties no attempt has been made to improve the environment in Serbia, leading to high levels of pollution around the country.

9.1 Methodologies applied

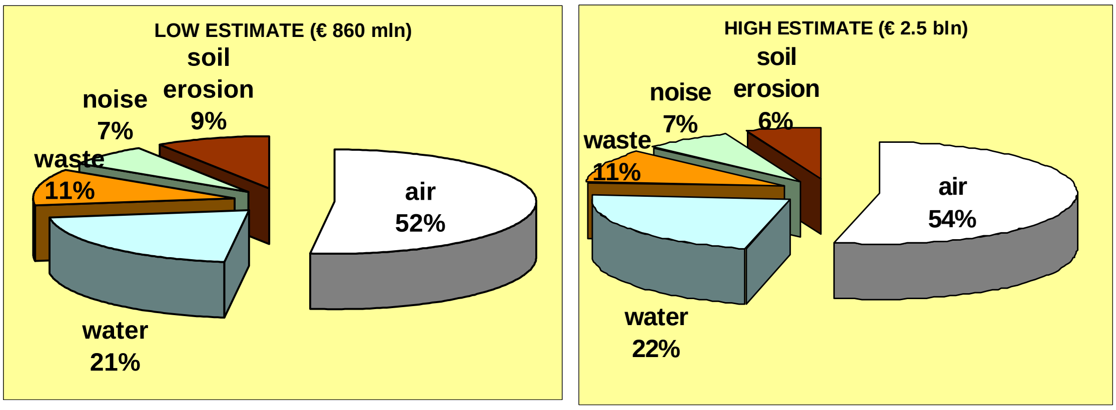
To assess damages a survey was made for earlier "damage" studies, for example the study on "The Benefits of Compliance with the Environmental Acquis for the Candidate Countries" carried out for the EU. Finally in most cases the so-called benefit transfer method has been applied, making use of results of earlier studies, and transferring these results to Serbia, making use of data on emissions to air, waste water discharges and waste in Serbia. Most damages relate to health (mortality and morbidity) but also to damages to environment, and the in-efficient use of resources.

A spreadsheet model has been developed to assess in a structured and consistent way the damages to environment. The core of the model is formed by so-called unit damage estimates (for example the economic damage of the emission of 1 tonne of Sulphur dioxide) which were adapted to Serbia, by applying international Purchase Power Parity standards.

9.2 Results

Figure 9.1 gives an overview of the "low" and "high" estimate of the damages in the different areas investigated.

Figure 9.1
Assessment of total annual damages to the Serbian environment, low and high estimate



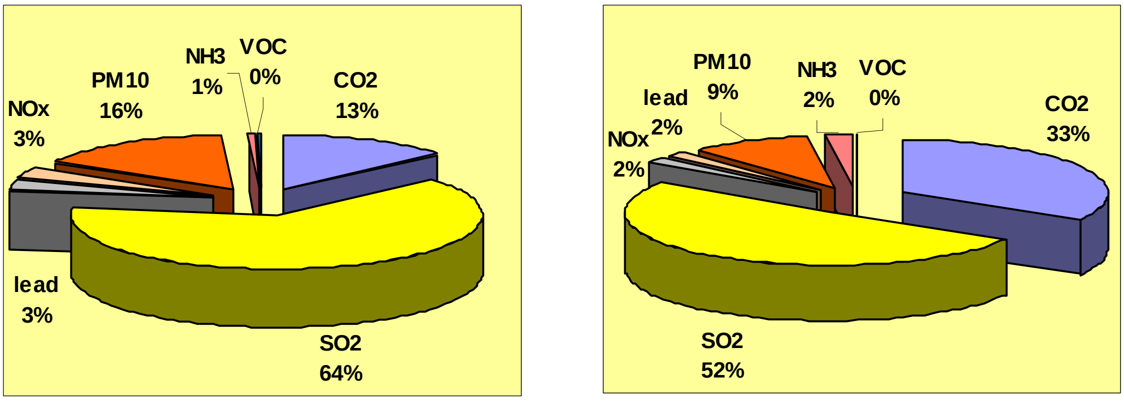
Total damages to environment range from € 861 million to about € 2.5 billion per year. This is equivalent to 4.7% to 14% of Serbian GDP (assumed to be € 18.3 billion per year).
Annual per capita damages can be assessed at € 115 in the low estimate and € 342 in the high estimate. This is in line with results of the EU study on benefits (Ecotec) where average per capita benefits of accession to EU (environmental legislation) is estimated at between € 100 (low) and € 520 per year (high) (see annex 5).

Although the results of the EU study on benefits (Ecotec) can only partly serve as a base of comparison for the current study[14], the results are quite well in line. For example, air-pollution related benefits count for between 52% - 63% of total benefits in the Ecotec study, for Serbia this is between 52% - 54%. Water counts for between 18% and 42% in the Ecotec study, for Serbia this is 21% - 22% of total damage. Waste benefits count for 5% - 19% of total benefits estimated for Accession Countries, in Serbia waste causes 11% of damages.

9.2.1 Air pollution related economic damages

Total air pollution related damages are estimated between € 447 and € 1,370 million per year. Damages related to air pollution are dominated by damages due to climate change and to health (mortality, morbidity), but also relate to crops and damage to buildings. In figure 9.2 the division of these damages over the different substances is presented.

Figure 9.2
Division of air related damages over substances, low (€ 447 mln) and high (€ 1,370 mln) estimate



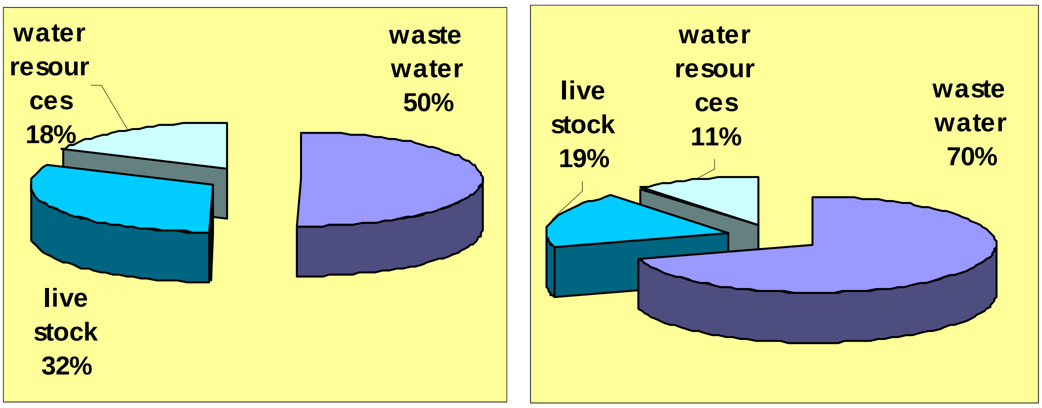
In both the low estimate (left graph) as the high estimate, the damages are dominated by acidification (mainly SO_2 which already counts for more than 50% of total air-pollution related damages).

9.2.2 Water pollution related economic damages

Damages related to water pollution are linked with the (untreated) discharges of sewage and industrial wastewater, nutrients discharges due to livestock (pig farms) and the contamination of groundwater (limited analysis to Vojvodina). Damages have been assessed making use of “Willingness to pay” figures for the reduction of discharges of nutrients, and for groundwater are based on the production costs of drinking water of high quality.

[14] Other Central and Eastern European Countries have other purchase power parity figures, and in the Ecotec study benefits relate to emission reduction due to EU environmental policy, whereas the damages assessed in the current study relate to total emissions. Also in the current study we covered more environmental domains (noise, soil erosion).

Figure 9.3
Division of water related damages over categories, low and high estimate



In figure 9.3 the division of the damages over the three mentioned categories is presented. In the low estimate (€ 179 million) the damages are dominated by discharges of wastewater, in the high estimate (€ 576 million) this domination is even larger.

Not shown in the figure is the assessment of damages due to the import of pollution (heavy metals) through the Ibar river. These damages, which cannot directly be influenced by the Serbian government, are estimated to be between € 460 million (low estimate) to € 2.2 billion (high estimate), indicating that these imports are devastating for the quality of the Ibar river.

9.2.3 Waste management related economic damages

Waste management related damages in Serbia are linked with uncontrolled landfill (air pollution by fires, amongst other with fine particles, methane and dioxins, leachate), illegal tipping (fires), hazardous waste and the uneconomical use of resources (as fly ash is dumped in stead of used as construction material). Total damages are estimated at between € 98 million (low estimate) and € 276 million (high estimate).

Figure 9.4
Division of water related damages over categories, low and high estimate

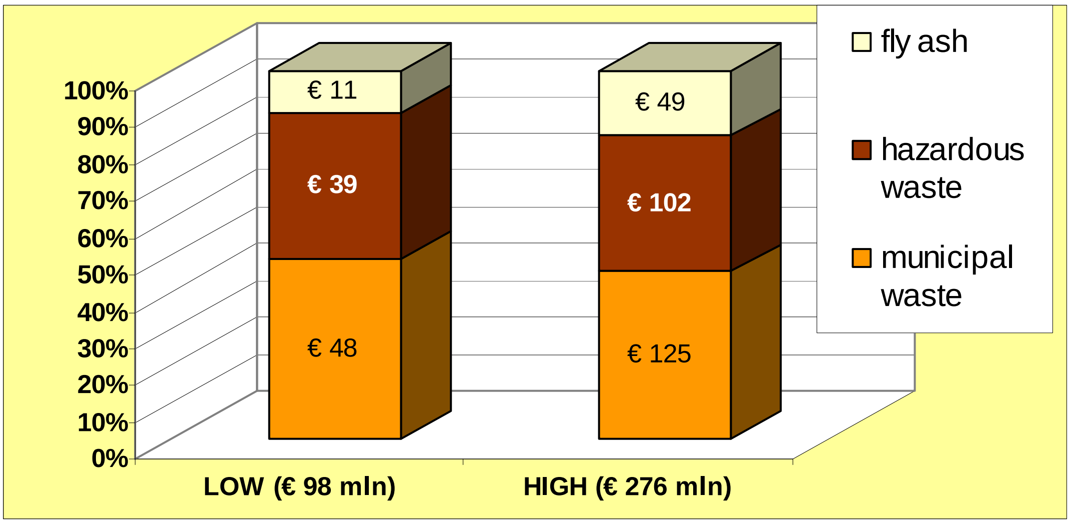


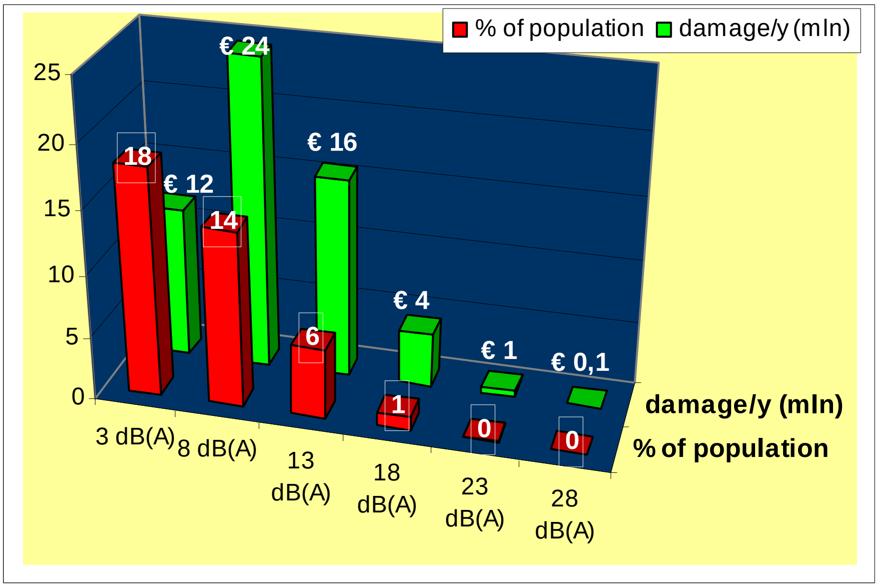
Figure 9.4 shows that the largest damages are linked with the (lack of) management of municipal waste (about 50% of total damages in the low and high estimate). Damages linked to hazardous waste are almost as large, whereas the inefficient management of resources (fly-ash) can count for up to 20% of damages.

As the assessment of damages linked with waste management is only partial (due to both a lack of quantitative information but also the lack of methodological framework), it can be anticipated that in reality these damages are higher.

9.2.4 Noise related economic damages

Although structural measurements or estimates of noise levels in Serbia are not available, it can be assumed (from other experience and some typical measurements in cities in Serbia) that noise levels are often above 50 dB(A) (which is internationally a sort of threshold value for damages due to noise). Based on data for the Netherlands and the level of urbanisation in Serbia an estimate has been made of elevated noise levels and the division thereof over noise classes. This is shown in the following graph.

Figure 9.5
Estimated % of Serbian population exposed to noise levels > 50 dB(A) and related economic damages (low estimate)



It is estimated that about 38% of the Serbian population is exposed to noise levels above 50 dB(A). Total damage is estimated at between € 57 million and € 181 million per year. Damages are also related to health, but mainly to decreased value of property.

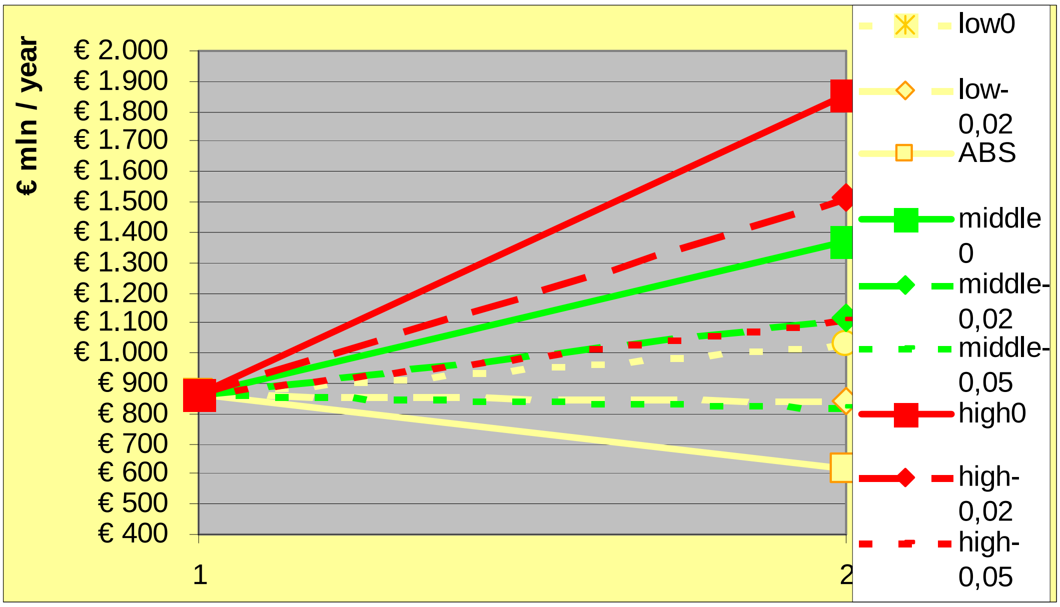
9.2.5 Soil erosion related economic damages

In Vojvodina, more than 85% of agricultural soil is sensitive to wind erosion. Annually on average 2.5 million ton of (fertile) soils is lost, more than 1 tonne per ha per year! It is estimated that the annual damage is some 5% of the total turn over in agriculture in Vojvodina, which is about € 160 million per year (high estimate, low estimate 50% of this).

9.3 Assessment of potential economic damage of environmental degradation in the future

A scenario analysis on the development of economy (3 annual growth rates of respectively 1.8%, 4.7% and 8%) and environmental policy (3 reduction rates of relative environmental stress: 0%, 2% and 5%) shows that in only three of the nine possible combinations, the damage after 10 years would be lower than the current damage. In all other cases the damage will increase. This is shown in the figure 9.6.

Figure 9.6
Estimated damages after 10 years in different scenarios



The most "desired" economic development scenario would be a moderate economic growth scenario (like in Poland, Czech Republic or Hungary). This growth scenario (green lines) will only lead to a reduction of damages if the environmental policy achieves a relative reduction of environmental stress of on average 5% per year.
With a low growth rate (yellow lines), it will be very hard to reduce damages as such growth rates will not lead to necessary innovations and will not generate enough funds for advanced environmental policy.

It can therefore be concluded that it will be an extremely difficult task for Serbia in the coming ten years to reduce environmental damages.

9.4 Concluding remarks

The study has shown that the economic damages of environmental degradation in Serbia are not to be ignored. In the low estimate these damages are already 4.7% of GDP, the high estimate shows that damages may be over 14% of GDP. This is an argument for an enforced environmental policy, because such policy will bring benefits (less damages) to the Serbian society as a whole.

The outcomes of this study are in line with earlier work done for Accession countries and show an evenly distribution of damages (and thus potential benefits) over the traditional environmental themes air, water and waste, which count for more than 75% of total damages.

Although damages in the traditional areas of environmental policy may be large, also attention should be given to the depletion of natural resources, as is shown by the partial analysis of soil erosion.

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ANNEX 1: EMISSION DATA

Air pollution

For air pollution the data used are shown in the following table.

Table 1
Emissions of air pollutants in Serbia in tonnes per year

substance	emissions	Source *
CO_2	45,592,200	WRI. 2004
SO_2	525,000	WRI. 2004
NO_x	161,000	WRI. 2004
NH_3	90,000	IIASA. 2003
VOC	97,000	WRI. 2004
PM10	60,000	IIASA/TME. 2004 **
lead	351	TME. 2004 ***

*:
** estimated at 75% of emissions in Former Yugoslavia
***: estimated by Gasoline production in tonnes: 589,000 ton = about 780,132 m3, with 0.45 grams of lead per litre. Only lead emissions from gasoline have been estimated.

Data on emissions are of various years (around 2000) as they were picked from different sources (as indicated). In some cases (lead, PM10), emissions have been estimated on basis of other available data.

Water pollution

For the assessment of damage related to water pollution, data on water pollution by industries and municipal sewage have been used. In addition, data on nutrients discharges by cattle (pigs) have been estimated. Also the import of emissions through the river Ibar have been assessed.

Table 2
Discharges of water pollutants to surface water in Serbia

Type of waste water	Wastewater Discharge (000 m^3/y)	BOD 5 (t/y)	inhabitant equivalents	Total Nitrogen (t/y)	Total Phosphor (t/y)
Municipal sewage	405,187	116,592	5,323,858	19,404	5,830
Industrial (BOD dominated)	386,916	159,007	7,263,792	6,454	1,972
Industrial (Inorg. Dominated)	436,432	13,409	612,285	16,714	6,130
TOTAL	1,228,535	289,079	13,199,935	42,572	13,932

source: Federal Ministry for Development Science and Environment, 1998 (and Water-management foundations of Republic of Serbia, 2001)

In addition it has been estimated how much nutrients are discharged annually by pig farms.

Table 3
Estimate of nutrient discharges of pig farms in Serbia

pigs in Serbia	number of pigs	emission factor N-tot kg N-tot per pig	N-prod kg/y	emission factor P-tot kg P-tot per pig	P-prod kg/y
Suckling pigs under 2 month	992 000	4,9	4 860 800	1,04	1 030 154
Pigs from 2 to 6 month	1 445 000	9,9	14 305 500	1,04	1 500 577
Sows and sows of first farrow	818 000	9,9	8 098 200	1,04	849 462
Boars for service	49 000	9,9	485 100	1,04	50 885
Other pigs	304 000	9,9	3 009 600	1,04	315 692
Total	3 608 000		30 759 200		3 746 769

source: Federal Statistical Office, 2002; CBS (2004)

The following table gives an overview of concentrations of Heavy Metals in the Ibar river, measured near Kraljevo

Table 4
Concentrations of heavy metals in the Ibar river near Kraljevo

substance	minimal concentration	maximal concentration
	mg/l	mg/l
Zn (zinc)	10	510
Cd (cadmium)	0.1	0.35
As (arsenic)	5	17.5
Pb (lead)	10	15

source: Gavric (2004)

Together with an average flow of 63 m3 per second, the total annual influx of heavy metal can be estimated. For this assessment the minimal concentrations are used.

Table 5
Estimated (minimal) annual import of heavy metal through the Ibar river

substance	annual import (in tonnes / year)
Pb (lead)	19 868
Cd (cadmium)	199
As (arsenic)	9 934
Zn (zinc)	19 868

source: own estimate

Waste generation

Precise data on waste generation, recycling and processing are lacking in Serbia. Most figures on waste have therefore to be based on expert estimates (as in the “National Waste Management Strategy”).

The following table gives an overview of the estimated amounts of waste included in the analysis.

Table 6

Waste in Serbia

Type of waste	amount (tonnes per year)	
municipal waste	2 200 000	
of which:		
- to landfills		1 430 000
- waste on landfills on fire		357 500
- not collected		770 000
- waste not collected burnt		385 000
hazardous (industrial) waste	225 000	
fly-ash	6 500 000	

source: Waste management strategy and own estimates.
It is estimated by waste experts in the Ministry that about 1/3 of total municipal waste is burnt somehow (either on landfill or in backyard or as fuel).

For the total amount of municipal waste a subdivision is made by means of collection and disposal for further analyses. This subdivision is necessary to assess emissions to air.

Table 7
Estimated emissions to air per tonne waste dumped at landfills

Substance	landfills on fire	landfills not on fire
CH_4	0	88.5 kg/tonne
CO_2	1,833	243.375 kg/tonne
PM10	15	- kg/tonne
dioxins	0.00000079	- kg/tonne
PAC	0.00045	- kg/tonne
PAH	0.045	- kg/tonne

source: CH_4 and CO_2 based on 100 m3 landfill gas per tonne waste (Ecotec), PM10, dioxins, PAC and PAH based on (US EPA, 1997)

For waste burned in the backyard the same emission factors as for landfills on fire have been used (last 4 rows of table).

For part of the waste landfilled in Serbia, estimates of the amount of leachate and the discharges of substances are available. These are presented in the following table.

Table 8
Generation and discharge of leachate (to surface and groundwater/soil) at landfills in Serbia

River basin	Quantity of leachate water (m3/year)	Number of landfills	Landfill area (ha)	BOD (t/year)	COD (t/year)	Suspended matter (t/year)	N (t/year)	P (t/year)
Danube	536745	181	667	14943	26151	80	245	267
Sava	98020	43	123	2830	4953	15	46	51
V. Morava	41079	28	62	1150	2013	6	19	21
Z. Morava	134260	37	139	3677	6435	20	60	66
J. Morava	41582	44	53	1164	2038	6	19	21
TOTAL	851686	333	1044	23764	41590	127	389	426

source: Gavric

Based on the amount of leachate generated and concentrations of heavy metal in leachate an additional estimate has been made of the discharge of heavy metals in leachate. The following emission factors have been used.

Table 9
Concentrations of heavy metals in leachate at a mature landfill

substance	Emissions factors in g/m3	Estimate annual emissions (tonnes per year)
Cu 2+	0.08	0.681
Ni 2+	0.28	2.385
Cr 3+	0.75	6.388
Zn 2+	0.2	1.703

source: Trièys (2002), data from Lithuania; Gavric (quantity of leachate)

ANNEX 2: DERIVING UNIT COSTS

Introduction

This annex gives a description of how unit costs have been derived from various studies. In some cases the unit costs have been derived by own calculations which will be described in this annex.

Two sets of unit costs have been used, as described in the methodological chapter (2):

- unit costs based on a "demand" approach;
- unit costs based on a "supply" approach.

"SUPPLY APPROACH"

As describe in the methodology chapter the supply approach for the estimation of unit costs is based on the principle that for each pollutant it is (in principle) possible to derive a marginal abatement function. This was for example done for the first Environmental Outlook ("Concern for Tomorrow", RIVM, 1988) and the consequent first National Environmental Policy Plan of the Netherlands (VROM, 1989). These cost function were based on the underlying calculations of environmental costs (or better said abatement costs) to arrive at the targeted reduction of emissions (Jantzen, 1989).

The unit costs derived from this study are presented in the following table.

Table 1
Unit costs for various main pollutants based on the marginal cost approach to achieve (National) environmental targets (2010)

full name	abbreviation	unit costs
		€ per tonne
Carbon dioxide	CO_2	68
Sulphur dioxide	SO_2	3,693
Nitrogen oxides	NO_x	3,545
Volatile organic compounds	VOC	863
Ammonia	NH_3	12,409
Fine particles	PM10	28,364
Heavy metals		295,455
Water use		1.35
Chemical oxygen demand	COD	1,477
Phosphorous compounds	P-TOT	5,909
Nitrogen compounds	N-TOT	11,818
Heavy metals		295,455
Oil/organ comp		1,477
Non hazardous waste		52
Hazardous waste		414

source: Jantzen (1989) and TME (2001).

“DEMAND APPROACH”

In this case the unit values are derived from studies in which both emissions (or emission reductions) and total damages (or reduction or total damage) have been assessed. The total damage can be assessed by an “impact pathway” analyses, “willingness to pay/to accept”, etc.

“Value of Life”

In many of the studies reviewed the “value of life” plays an important role in the assessment of damages. For example, in the study on benefits of environmental policy in the Netherlands (EFTEC/RIVM, 2000), damages related to air pollution have been assessed by:

- assessing emissions;
- assessing concentrations of pollutants in the air;
- assessing the relation between concentration of pollutants in the air and the resulting health damages (mortality and morbidity);
- assessing the value of life (for persons under and above 65).

The central value of life used in the assessment (for the Netherlands) is € 3.47 million per premature dead. For people aged over 65 a value of 70% has been taken: € 2.4 million.

Dioxins and PAC’s

Koehler et al (2004) made an assessment of health related damages (cancers) due to substances defined in the Toxic Releases Inventory (TRI) of the US EPA.

The emissions were divided in:

- dioxins;
- PAC’s (polycyclic aromatic compounds);
- other PAH’s.

The total annual damage in the US, based on cancers, is estimated at US$ 1.1 billion or US$ 702 million if a latency period is assumed of 10 years, at a 5% discount rate. This is base on a value of life (VOL) of US $ 4.4 million per human being and 260 fatal cases per year due to dioxin, PAC’s and other releases of substances in the TRI. Making a correction for both exchange rate, inflation (= 1) the total damage would be assessed at between € 1.1 billion and € 702 million.
As noted before, the unit damage value (VOL) in the Netherlands has been estimated at € 3.47 million, which is 79% of € 4.4 mln. Making a correction for this lower VOL the total (lower estimate of) damage can be assessed at € 554 million per year.

About 76% of this damage is related to dioxins and 20% to PAC’s, whereas other substances in the TRI’s count for 4% of total damage.

Combining this figure with annual emissions of dioxins and PAC’s an assessment can be made of the damage caused by the emissions of one unit of dioxins or PAC’s.

Total annual emissions in the United States are estimated at:

- dioxins: 5.218 kg;
- PAC’s: 650,000 kg;
- total Toxic Releases studied: 54,456,471 kg.

Combining annual damages and emissions results in the following unit damage values (US 1998 values):

- dioxin: between US$ 81,000,000 and US$ 160,000,000 per kilogram;
- PAC’s: between US$ 170 and US$ 338 per kilogram;
- other PAH’s: between US$ 0.41 and US$ 0.81 per kilogram.

PM10 fine particles

EFTEC&RIVM have carried out a study on the Benefits of environmental policy in the Netherlands. Part of this study has addressed air quality problems related to PM10.

The unit damage value has been derived fm the 1990 emissions and the estimated economic damage (mainly mortality and morbidity).

The emissions of PM10 in 1990 were 27,400 tonnes. The total economic damage is estimated at € 2.383 billion in 1990 (related to a mortality of 931 persons).

Unit damage per tonne PM10 emitted can then be estimated at € 51,358 per tonne.

Heavy metals

Little knowledge exists on the damage caused by heavy metals. Only a few studies have addressed this problem and the outcomes are sometime at least "strange". The following table gives an overview of some figures found in literature.

Table 1
Unit damage values for heavy metals discharged to water or soil

substance	unit damage costs
Cu (copper)	€ 5,657 per tonne
Ni (nickel)	€ 13,577 per tonne
Cr (chromium)	€ 19,799,644 per tonne
Zn (Zinc)	€ 1,131 per tonne
Cd (Cadmium)	€ 703,736 per tonne
As (Arsenic)	€ 348,474 per tonne
Hg (Mercury)	€ 1,022,000 per tonne

source: ECON

The ECON study based the damages on control costs (for only one heavy metal) and adapted values for other heavy metals by applying toxicity factors.

Lead (Pb)

For lead (Pb) unit costs have been derived as follows:

- the costs to reduce lead emissions are estimated at between 1 and 2 US$ cent per litre gasoline (price-level 1985) (Lovei, 1999);
- adapted for inflation this is (2,5 % per year, 20 years) 1.64 and 3.28 US$ cents per litre;
- assuming an exchange rate of 1 € per 1 US$;
- lead contents in leaded gasoline is about 0.4 gram per litre;
- costs to reduce 1 kg of lead emissions are then estimated at € 27.3 to € 54.6 per kilogram;
- the actual benefits of reducing lead are estimated to be 10 times higher than the costs (US EPA, cited in Lovei (1999));
- so the unit damage costs for lead are estimated at between € 273,000 and € 546,000 per tonne.

ANNEX 3: CORRECTIONS BENEFIT TRANSFER: GDP AND PURCHASE POWER PARITY (PPP), IMPACT OF AIR POLLUTION

Introduction

This annex gives some more details on the way the benefit transfer has been applied in this study. Two issues are covered:

- adaptation to economic circumstances, making use of purchase power parity comparison
- adaptation for air pollutants to (a proxy for) concentrations of air-polluting substances and population.

Purchase Power Parity

A common way to make international economic comparisons between countries is to use so called purchase power parity (PPP) figures instead of using the official exchange rate. By using PPP attention is given to lower prices in some countries than others.

The following table gives a few comparisons of GDP and GDP per capita expressed in PPP (2002)

Table 1
GDP and GDP per capita in selected countries. purchase power parity in US$ 2002

	GDP mln US$ (ppp'02)	GDP/cap US$ (ppp'02	GDP as % of GDP Netherlands
Serbia	23,150	2,200	8%
Netherlands	437,800	27,200	100%
Czech Republic	157,100	15,300	56%
Bulgaria	49,230	6,500	24%

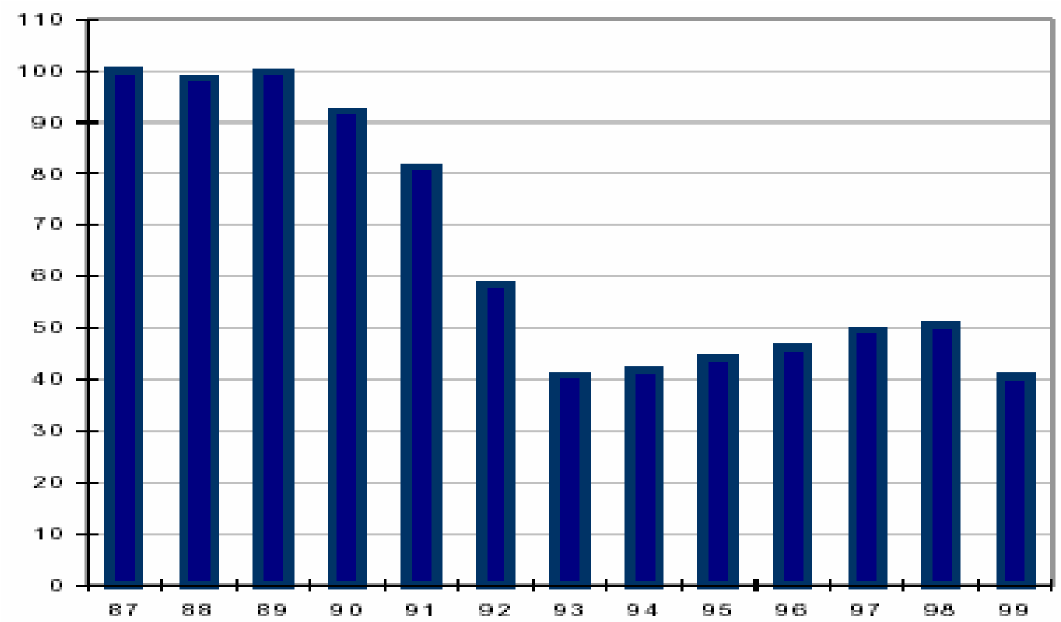
CIA. 2003

Compared to Bulgaria, one of the poorest Accession Countries, GDP per capita in Serbia in 2002 was almost 3 times lower. Compared to the Netherlands, Serbian GDP per capita was only slightly more than 8% in 2002.

The following graph gives an overview of the development of the GDP in Serbia between 1987 and 1999:

Figure 1

GDP of Serbia 1987-1999 (index 1987=100)



(Source: G17, 2000)

Unofficial estimates for 2003 GDP per capita is about US$ 4,000 per capita, which is substantially higher than the CIA estimate. Using a Euro-Dollar Exchange rate of 1.2, the value in Euro would be € 3,300 per capita.

Using the official 2002 estimate of the GDP would result in a correction factor of 8% (taking for Serbia 8% of the unit damage values calculated for the Netherlands).

Taking this very low number would underestimate the damage in the longer term in Serbia assuming that economic growth will be achieved in the coming 10 years.

Considering this a conversion rate of 15% is used in the calculations.

Impact of air pollution

Introduction

The financial damage caused by air pollution in a country depends – according to theory – on the concentration of air-pollutants (and hence damage to health, buildings, crops), total population exposed (and purchase power which already is explained in the previous section).

Health damages are related to concentrations of pollutants in ambient air: the higher the concentrations, the more individuals suffer health problems. In general it is assumed that health damages are linearly correlated to concentrations (EFTEC, "Table 4.2.12, Exposure response coefficients for health impacts", p. 57). This implies that a two times higher concentration of pollutants in air will lead to a two times higher damage.

So if a benefit transfer is made from the Netherlands to Serbia, concentrations and population exposed have to be taken into account.

The total population exposed is for all pollutants the same: Serbian population is 7,479,437 (or 46.3% of Dutch population:16,150,511).

However, concentrations depend – amongst others – on:

- emissions, import and export of pollutants;
- area.

As a firm database to compare concentrations between Serbia and the Netherlands fails, a second best option has been used, by assessing the deposition of air-pollutants per square kilometre. This gives in most cases (for "continental pollutants" like SO_2, NO_x, VOC) a good proxy of concentrations.
As we have not sufficient information on ambient concentrations for the 6 pollutants in question to make a comparison between the Netherlands and Serbia, we need to define a proxy for concentrations.

Most practical, is to estimate average annual deposition per square kilometre as a proxy for concentrations in ambient air. Of course this approach does not take into account differences between concentrations in ambient air (for example, close to a road concentrations of various air pollutants tend to be (much) higher than at a distance), and therefore does not completely represent exposure of population to air pollution (it may well be that population lives in areas where concentrations tend to be higher than the average concentrations in a country). But as more precise data are lacking, the proposed assessment is the best available proxy. The following table gives the estimated correction factor derived.

Table 2
Population, area and deposition of air pollutants in Serbia and the Netherlands, correction factors applied in the benefit transfer for each air-pollutant

	population	area	SO_2		NO_x		NH_3		VOC		PM10	
		km2	t/y	t/km2	t/y	t/km2	t/y	t/km2	t/y	t/km2	t/y	t/km2
Netherlands	16150511	41526	133467	3,21	145471	3,50	107787	2,60	352000	8,48	46400	1,12
Serbia	7479437	88361	611000	6,91	185300	2,10	90000	1,02	97000	1,10	60000	0,68
	correction factors:											
concentration				**215%**		**60%**		**39%**		**13%**		**61%**
population	**46,3%**			**46%**		**46%**		**46%**		**46%**		**46%**
total				**100%**		**28%**		**18%**		**6%**		**28%**

Source: TME calculations based on various statistical data

ANNEX 4: MORTALITY IN SERBIA DUE TO ENVIRONMENTAL DEGRADATION

According to the medical experts from the Public Health Institute in Belgrade during last fifteen years there were no diseases caused by water pollution problems, however there is increasing problem of air pollution diseases.

Table 1 shows mortality data for Serbia (without Kosovo) and also gives details on certain diseases leading to mortality.

Table 1
Mortality in Serbia (excluding Kosovo)

	1991	1998	1999	2000	2001
Total mortality	89117	99376	101444	104042	99008
male	47764	51738	52432	53751	51060
female	41353	47638	49012	50291	47948
Malignant diseases	14761	17393	17508	18077	18112
Respiratory non malignant	4344	3920	3839	4752	3526
Poisonings and injuries	5590	4299	4541	4122	4306

source: : Serbian Statistical Yearbooks 2001, 2002, 2003

It is estimated by an expert of the Public Health Institute, Belgrade (Dr Snezana Matic-Besarabic, Public Health Institute, Belgrade) that up to 15% of the death cases from the three mentioned groups of diseases can be linked to the environmental pollution or caused by the pollution. The environmentally caused mortality figures for Serbia without Kosovo can then be estimated as following:

Table 2
Environmental related mortality in Serbia (excluding Kosovo)

	1991	1998	1999	2000	2001
Malignant diseases	2214	2609	2626	2712	2717
Respiratory non malignant	652	588	576	713	529
Poisonings and injuries	839	645	681	618	646
TOTAL	3705	3842	3883	4043	3892

(source: Matic-Besarabic)

It is hard to compare these estimates with other estimates for surrounding countries. For example, Ecotec (p.111) estimates that in Bulgaria *maximal avoided* mortality due *to reduction of air-pollution* is 1,163 cases of mortality, but in Hungary 2,704. These numbers however, do not represent *total* mortality in these countries and thus cannot be directly compared with the figures in table 2.

ANNEX 5: COSTS AND BENEFITS OF ACCESSION

Introduction

This annex serves to give some quantitative background information on studies performed on Accession countries on both economic costs and benefits of EU environmental policy.
In the period 1994 -2000 many studies have been performed to assess the costs of accession. The study "Compliance Costing for Approximation of EU Environmental Legislation in the CEEC " (EDC et al, 1997) gave a first comprehensive estimate of the investments that are needed in the 10 central eastern European countries. Later many specific country studies have been performed to assess investments to comply with EU environmental legislation.
To complete the picture, a study was commissioned by EU to calculate the financial benefits of EU accession (Ecotec) related to environmental improvements.

In this annex a brief overview will be given of the results of these studies. This serves as a base of comparison for the current study, although the comparison is restricted:

- for most Accession countries higher incomes lead to higher PPP and thus higher benefits/avoided damages
- the Ecotec study assesses benefits (= avoided damages, mostly related to avoided emissions) whereas in this study for Serbia *total damages* are assessed (linked with total emissions);
- the current study on Serbia covers more environmental domains (noise, soil erosion);
- the approach to assess monetary damages in the current study differs considerably from the Ecotec approach in certain areas. But as the current study makes use of results from earlier scientific work for EU and the Dutch government that is partly based on the same models (ExternE for air pollution), this should in general not cause much "rumble" and "flutter" in the results.

As a "value added" also an attempt has been made to calculate the benefit/cost ratio in the field of environment of EU accession for the ten countries studied.

Costs of Accession

Table 1 gives an overview of the needed investments for accession.

Table 1
Investments needed for approximation to EU environmental legislation in Accession countries (excl. drinking water) (in € million), TME-estimate 1999

Country	Air	Water	Waste	IPPC	Total
Bulgaria	3607	2056	2477	3261	11401
Czech Republic	3393	1164	1152	3725	9434
Estonia	640	168	698	489	1995
Hungary	2479	1678	454	1761	6371
Latvia	511	776	343	90	1720
Lithuania	967	435	364	44	1810
Poland	7772	6524	3695	6927	24918
Romania	2031	1385	2568	806	6789
Slovakia	1735	499	892	1596	4722
Slovenia	540	1149	1073	50	2812
TOTAL	23674	15833	13716	18748	71972

source: compilation of estimates by TME based on POL-101, EST-101, BUL-111, ROM-101, SLO-, SR-, CR-, Worldbank, TME estimates.

The following table gives an estimate of the annual per capita expenditure on environment in accession countries.
Total annual expenditures are estimated at 15% of total investment outlays (based on Jantzen, 1989).
Per capita expenditures are the calculated by dividing total annual expenditures by population.

Table 2
Estimated per capita annual expenditures in accession countries to comply with EU environmental legislation

Country	Air	Water	Waste	IPPC	Total
Bulgaria	€ 65	€ 37	€ 45	€ 59	€ 206
Czech Republic	€ 49	€ 17	€ 17	€ 54	€ 137
Estonia	€ 64	€ 17	€ 70	€ 49	€ 199
Hungary	€ 37	€ 25	€ 7	€ 26	€ 95
Latvia	€ 31	€ 47	€ 21	€ 5	€ 103
Lithuania	€ 39	€ 18	€ 15	€ 2	€ 73
Poland	€ 30	€ 25	€ 14	€ 27	€ 97
Romania	€ 14	€ 9	€ 17	€ 5	€ 45
Slovakia	€ 48	€ 14	€ 25	€ 44	€ 131
Slovenia	€ 40	€ 86	€ 80	€ 4	€ 211
TOTAL	€ 34	€ 23	€ 20	€ 27	€ 103

Source: compilation of estimates by TME based on POL-101, EST-101, BUL-111, ROM-101, SLO-, SR-, CR-, Worldbank, TME estimates.

Estimated *additional costs* to comply with EU environmental legislation will costs the inhabitants of the accession countries (and now mostly new member states of the EU) between € 45 and € 211, with an average of € 103 per capita per year.

Benefits of Accession

Cleaning up the environment will not only cost a lot of euros, it also will bring benefits to accession countries and new member states. The results of the study carried out for the EU (Ecotec) can serve for this purpose. These are shown in table 3a and 3b, representing the low and the high estimate.

Table 3a
Estimated annual monetary benefits for accession countries due to implementation of EU environmental legislation, low estimate, € mln

Country	Air	Water	Waste	Total
Bulgaria	110	160	20	290
Czech Republic	730	1 560	95	2 390
Estonia	40	27	10	75
Hungary	590	280	115	985
Latvia	50	40	5	95
Lithuania	160	125	6	290
Poland	2 650	1 400	165	4 210
Romania	780	405	85	1 270
Slovakia	350	305	30	690
Slovenia	70	150	25	240
All Countries	5 530	4 452	556	10 535
	52%	42%	5%	100%

Table 3b
Estimated annual monetary benefits for accession countries due to implementation of EU environmental legislation, high estimate, € mln

Country	Air	Water	Waste	Total
Bulgaria	1 130	435	680	2 240
Czech Republic	3 600	2 475	1 150	7 220
Estonia	210	100	180	490
Hungary	4 100	1 080	1 900	7 080
Latvia	320	140	110	570
Lithuania	820	280	205	1 300
Poland	15 400	3 280	2 750	21 400
Romania	5 850	1 250	2 650	9 800
Slovakia	2 250	680	440	3 370
Slovenia	475	350	290	1 120
All Countries	34 155	10 070	10 355	54 590
	63%	18%	19%	100%

Source: Ecotec, 2000

There is a considerable difference between the low and high estimate (on average about a factor 5, but for some countries almost 10). As in the “high estimate” the assumed reductions for air are more in line with actual EU policy, and these estimates dominate the results, the high estimate is taken as a base for comparison with the cost results.

The per capita benefits of EU environmental policy can then be calculated as follows.

Table 4
Per capita estimated annual monetary benefits for accession countries due to implementation of EU environmental legislation, high estimate, €

Country	Air	Water	Waste	Total
Bulgaria	€ 136	€ 52	€ 82	€ 270
Czech Republic	€ 350	€ 240	€ 112	€ 701
Estonia	€ 140	€ 67	€ 120	€ 327
Hungary	€ 406	€ 107	€ 188	€ 701

Country	Air	Water	Waste	Total
Latvia	€ 128	€ 56	€ 44	€ 228
Lithuania	€ 222	€ 76	€ 55	€ 351
Poland	€ 398	€ 85	€ 71	€ 553
Romania	€ 260	€ 56	€ 118	€ 436
Slovakia	€ 417	€ 126	€ 81	€ 624
Slovenia	€ 238	€ 175	€ 145	€ 560
All Countries	€ 325	€ 96	€ 99	€ 520

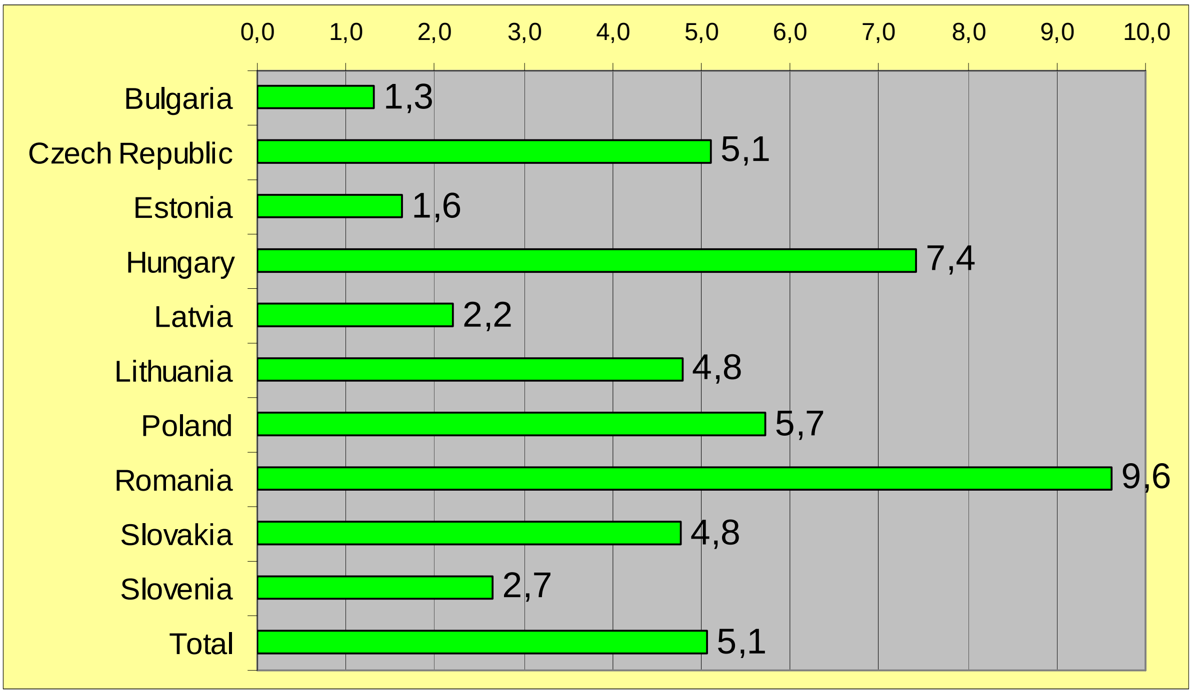
Source: Ecotec, 2000

Annual per capita benefits of EU environmental policy are estimated at on average € 520 (which is about 5x higher than the costs), they range from € 270 in Bulgaria to €701 in both Czech Republic and Hungary.

Cost/Benefits ratio of Accession

Having both estimates of costs and benefits of accession in the environmental domain, it now is possible to calculate the benefit-cost ratio for (former) accession countries. The results of these calculations are shown in the following graph.

Figure 1



source: TME estimations

The results show that on average benefits are 5x higher than costs. For some countries the benefit cost ratio is low, for example Bulgaria with 1.3. Several explanations can be given for such deviations from the average: high costs per capita (for example many old power station needing refurbishment, lack and bad maintenance of waste water and waste management infrastructure), low benefits due to low PPP income relative to other accession countries.

ANNEX 6: ENERGY EFFICIENCY

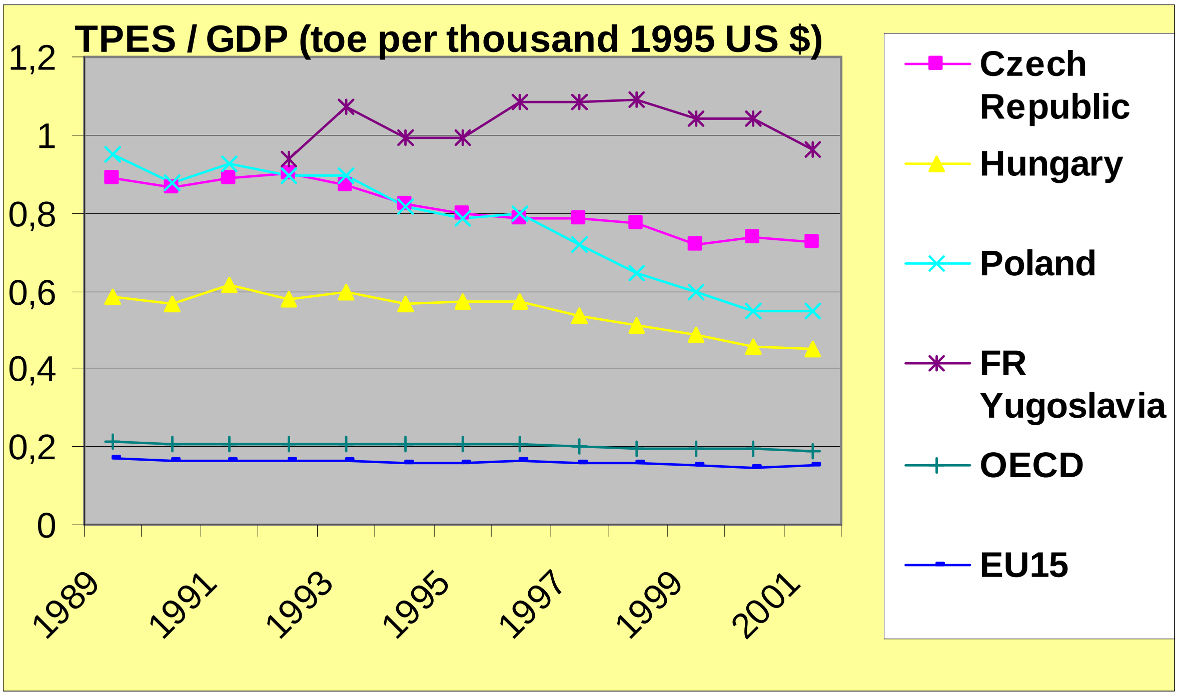
It is possible to distinguish between at least two periods in Serbia:
- Situation before 1990;
- Period 1990-2000.

The period before 1990 can be described as "comparable with other CEE countries" (some attention for environmental issues, environmental legislation in place, some investments in pollution control).

The period between 1990 and 2000 can be described as a period in which little to no attention was given to environmental concerns. Existing environmental infrastructure was badly or not at all maintained, industry did not consider issues like efficient resource use, etc.

This is illustrated by the following figure, in which the energy inputs per $ 1,000 GDP is compared for former Yugoslavia, with EU and 3 Accession countries. Whereas in the Accession countries energy inputs dropped considerably in 10 years time, GDP in Yugoslavia was even more energy intensive per US$ earned at the end of the decade than at the beginning.

Figure 1
Energy Intensity in some of the transitional countries and FR Yugoslavia



source: IEA, 2003