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SEA and Sustainable Development In the Baltic Sea Region

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SEA AND SUSTAINABLE DEVELOPMENT

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1 Introduction

Strategic Environmental Assessment (SEA) is emerging as a procedure which has the objective of incorporating environmental concerns into decision-making at the level of policies, plans and programmes. The formulation of a policy, plan or programme is motivated by economic, social and environmental objectives, united under the notion of sustainability. The concept of sustainable development has been widely acknowledged since 1987, when the World Commission on Environment and Development (the Brundtland Commission) published their report 'Our Common Future'.[1] In this report, sustainable development is defined as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*." For the Brundtland Commission, the main aspects of sustainability were issues of social and economic equity, but the report also stimulated further discussions on the environmental aspects of economic development.[2] At the United Nations Conference on Environment and Development (the Earth Sumnit), held in Rio de Janeiro in June 1992, an action programme titled Agenda 21 has been approved by more than 170 countries, which addresses all major policy areas relevant for sustainable development. Following the requirements of Agenda 21, environmental issues have to be integrated into all policy areas including transport policy.

A prerequisite for the integration of environmental concerns is to assess the impacts of transport policies on the environment. In contrast to the compulsory Environmental Impact Assessment (EIA) of projects, the goal of SEA is to integrate environmental aspects into the planning process as early as possible, that means, at the level of strategic decision-making where the planning framework for future projects is outlined. Therefore, SEA is an important instrument in transportation planning aiming at achieving sustainable development. Two questions arise: how do the results of the discussion process on environmentally sustainable development relate to SEA, and secondly, how can the results of SEA be integrated into a common assessment framework that also considers the economic and social impacts of proposed planning initiatives?

Answering the first question is rather simple: the environmental objectives that have been fixed in national and international agreements in the Agenda 21 process have to be the terms of reference for carrying out SEA. In the second chapter of this paper, the transfer of environmental goals, indicators and quality standards into SEA application will be demonstrated for the example of Baltic 21, an Agenda 21 for the Baltic Sea region. Finding solutions for the integration of SEA into a common assessment framework is a more complex issue. Standardised techniques like cost-benefit and multi-criteria analysis exist in order to value the impacts of transport infrastructure projects. At the strategic planning level, however, long-term and large-scale impacts are of high relevancy, for which these techniques are less suitable as shown in the third chapter. Therefore, a methodology for an integrated assessment at the strategic level has been

[1] *Brundtland, 1987*
[2] *OECD, 1996*

developed based on a backcasting approach. The procedure and its application to a case study in Germany are presented in the fourth chapter of this paper. Finally, conclusions are drawn in order to give recommendations for future transport policy.

2 Environmental Goals and Indicators for Sustainable Development

2.1 Development of an Indicator and Standards System

The basic concept of sustainable development can be regarded as a central guideline in future policy-making. However, this concept has to be specified in order to have an influence on policy decisions. This process is described below for the example of Baltic 21, which is an initiative taken in 1996 by the Prime Ministers of the Baltic Sea states in order to achieve sustainable development and adopted by the Foreign Ministers in June 1998. The Agenda includes goals and action programmes for sustainable development for the seven sectors agriculture, energy, fisheries, forests, industry, tourism, transport, and spatial planning. In the Baltic 21 Transport Sector Report,[3] the environmental, social, and economic goals, which have to be satisfied in order to reach sustainable transportation, are described as follows:

- ***environmental****: the rate of use of non-renewable resources should not exceed the rate at which renewable substitutes are developed, the rate of pollution emission should not exceed the assimilative capacity of the environment (see Daly, 1990 and Kågeson, 1994), biodiversity should be protected,*
- ***social****: access to all activities necessary to participate in social life has to be guaranteed as far as possible, air quality and noise should not exceed the health standards suggested by the WHO (World Health Organisation), accident risks should be minimised,*
- ***economic****: mobility of persons and of goods necessary to achieve a prosperous economic development has to be provided, without overdrawing the financial possibilities of the public and private budgets*."

For use in SEA, quantitative values to measure the achievement of sustainability goals are needed. Therefore, indicators have to be developed that describe present and desired states of the system. The design of an indicator system has to consider environmental objectives given by policy as well as quality criteria obtained through scientific research, which express the ability of the environment to cope with certain burdens. The aim is to determine target values to limit anthropogenic environmental effects. These targets can relate to different stages of human intervention into the environment, but a framework has to be set up that is consistent, complete, based on available data, and can easily be understood. A well-known approach is the Pressure-State-Response framework (PSR) applied by the OECD.[4] The basic assumption of this approach is a concept of causality: *"human activities exert pressures on the environment and change its quality and the quantity of natural resources (the 'state' box). Society responds to these changes through environmental, general economic and sectoral policies (the 'societal response'). The latter form a feedback loop to pressures through human activities."* The PSR-approach is designed for application in environmental policy review and in order to gain information for future policy making aiming at sustainability. This approach can be adapted to the requirements of SEA, within which future environmental conditions are assessed depending on present policy decisions.

In a SEA indicator system, different procedural levels can be distinguished.[5] **Measure** indicators are applied for the operationalisation of proposed policy measures as input for the forecast of sectoral activities. These are characterised by **activity** indicators that are needed as a basis for the prediction of environmental impacts. For the assessment of environmental impacts it is possible to apply pressure indicators as well as indicators of environmental state. The magnitude of **pressure** indicators depends only on the amount of human activities (e.g. pollutant emissions) while **state** indicators describe the reaction of

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[3] *Wuppertal Institut, Ökopol, 1998 p. 3*
[4] *OECD, 1993*
[5] *Gühnemann, 1999*

the environment to these pressures, which is also influenced by the characteristics of the environment (*sensitivity* indicators). State indicators can refer to transfer media, concentrations or damages. Environmental quality *standards* can be defined at both levels – pressure and state indicators – in order to evaluate environmental impacts. The framework for this SEA indicator system and its relation to the PSR approach of the OECD and possible levels for environmental quality standard setting is illustrated in the following figure.

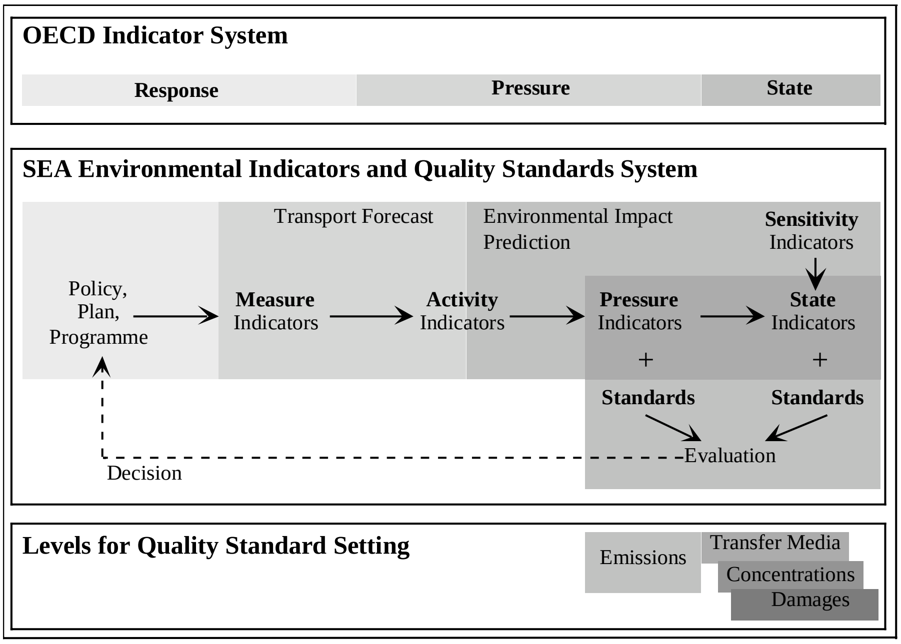

Figure 1: SEA environmental indicators and quality standards system (Gühnemann, 1999, p. 52)

2.2 Application to Baltic 21

In the Baltic 21 process, provisional lists of common and sectoral indicators have been set up. Motivated by the sustainability goals, six areas of common indicators are defined: health, economy, co-operation, ecosystems, efficiency in the use and maintenance of renewable resources, and material flow of non-renewable resources. In order to monitor the process towards sustainable transportation, the proposed indicator set listed in the transport sector report is based on outcome oriented pressure and state indicators, which are linked to goals. However, the environmental objectives are not characterised by concrete target values but by the description of pathways. Therefore, a linkage to SEA can be established by forecasting the defined indicators and checking whether the results of SEA application indicate that policy measures are on the right track.

Thus, SEA can benefit from the Agenda 21 process by adopting pressure and state indicators defined for monitoring sustainable development and the corresponding environmental objectives. In the best case, these objectives are defined by concrete target values in order to enable the evaluation of a specific environmental state. Sources for environmental indicators and quality standards in the transport sector are e.g. the Fifth EC Environmental Action Programme titled "Towards Sustainability", the OECD Project on Environmentally Sustainable Transport (EST), the WHO Air Quality Guidelines for Europe, and the catalogue of measures on transport and the environment by the German Environmental Agency. [6] In table 1, the OECD criteria for environmentally sustainable transport are listed.

In order to evaluate the effects of transport policy, plans and programmes, the task of SEA development is then to determine measure and activity indicators as well as sensitivity indicators of the environment, which are needed to forecast values for the environmental indicators. The choice of SEA models depends on several factors like the context of region, availability of data or the policy level. However, a wide range of transport forecast and environmental impact prediction models already exists that can be used as a guideline for the determination of the necessary indicators.[7]

Table 1: OECD criteria for environmentally sustainable transport[8]

Theme / **Indicator**	Type **P**	**S**	**Quality Standard/Objective**
Climate Change			
CO_2 emissions	x		-80% total transport emissions 2030 compared to 1990
Air Pollution and Acidification			
NO_x emissions	x		-90% total transport emissions 2030 compared to 1990
VOC emissions	x		-90% total transport emissions 2030 compared to 1990
Particulate emissions	x		-55% to -99% total transport emissions of fine particulate (PM_{10}) in 2030 compared to 1990, depending on local and regional conditions
Noise			
noise levels (outdoor)	x		55 – 70 dB(A) during the day, depending on local and regional conditions, must not be exceeded in 2030
noise levels (indoor)		x	45 dB(A) at night maximum level in 2030
Land-Use			
share of land used	x		local and regional objectives for ecosystem protection are met, share of land devoted to transport likely to be reduced

P = Pressure Indicator, S= State Indicator

For example, the noise disturbance calculated by a model for road transport noise in Europe is shown in the following figure. In this case, the achievement of a target value of 55 dB(A) for outdoor noise has been checked. As activity indicators, traffic data for the links of the road network is needed, sensitivity indicator is the number of inhabitants in a defined grid square of 25x25 km^2.

[6] *EC, 1993, COM, 1995; OECD, 1996, 1997; WHO, 1996; Umweltbundesamt 1997*
[7] *see e.g. COM, 1999, ECMT, 1998, Gühnemann, 1999, TÜV Rheinland et al., 1997*
[8] *OECD, 1996*

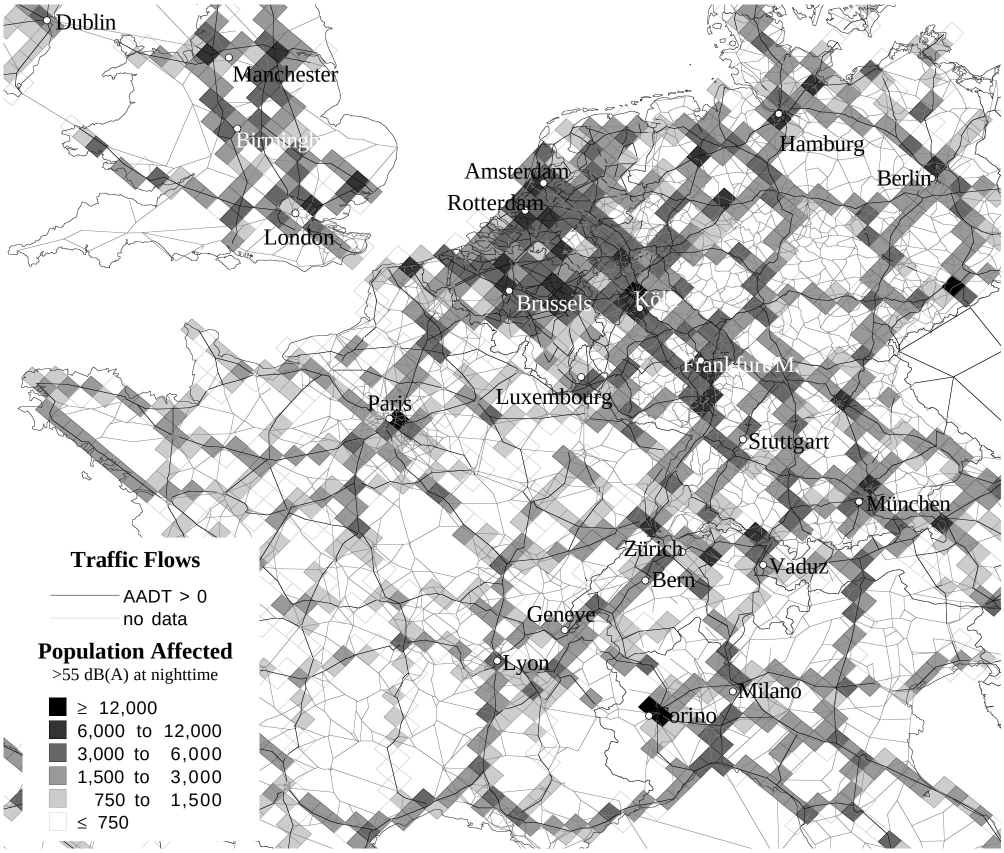

Figure 2: Population affected by road transport noise in the Europe 1993[9]

Strategic Environmental Assessment is thus linked to the design of sustainable transport policy by producing results which enable decision-makers to evaluate the environmental consequence of policy measures at an early planning stage. On top of that, all types of impacts should be integrated into a general assessment framework in order to build up a consistent basis for decision-making. The impact assessment consists of three steps: data collection, impact prediction and impact evaluation. A compatible assessment of environmental as well as economic and social impacts has to be established by the use of joint baseline date and scenarios for the impact prediction. For the overall evaluation of impacts, different techniques are available to support decision-makers. In the following chapter, options for integrating environmental impacts into conventional direct evaluation techniques are demonstrated.

3 Integrating Environmental Impacts into Direct Evaluation Techniques

In transport planning, evaluations are carried out with the objective to weigh the advantages and disadvantages of transport policy measures one against the other in relation to a given set of policy goals. The basic decision problem is characterised by the dilemma in choosing one out of at least two comparable alternative actions which best satisfies the objectives of a decision-maker. The problem is that mostly multiple objectives have to be achieved. For the evaluation of transport infrastructure, usually two different techniques are applied: Multi-Criteria Analysis (MCA) and Cost-Benefit Analysis (CBA). Both are

[9] *Gühnemann, 1999*

comparable in that they apply a metric to every measured impact to transform the multidimensional impact values to a one-dimensional scale such that the results can be compared and summarised by a utility function. However, in MCA the impact criteria are either weighted by values supplied by the decision-maker or left in an unweighted disaggregate format. On the contrary, CBA claims to derive a decision not from the individual preferences of a decision-maker but founded on a socially accepted valuation system. Therefore, the impacts of proposed actions are usually transformed into a monetary unit expressing social welfare. The objective is then to maximise this welfare. Since CBA is a common method for the evaluation of transport infrastructure projects, methods for integrating environmental issues into CBA are described in the following.

In Cost-Benefit Analysis, the impacts of investments are commonly evaluated by means of the market price. However, many impacts, in particular environmental effects, do not have a market price. Hence, it is necessary to derive alternative measurements that express the economic value of these effects in monetary terms. For many socio-economic effects, standardised evaluation approaches exist. To derive monetary values for environmental effects, different methods are applied, e.g. damage cost approach, stated preference methods, revealed preference methods and avoidance cost approach. In a research project on behalf of the German Federal Environmental Agency,[10] monetary evaluation approaches have been developed for environmental impacts which are not yet included in the economic assessment for the federal transport infrastructure plan (Bundesverkehrswegeplan, BVWP). These comprise the following effects:

Tropospheric Ozone: Impacts by photo-oxidants were examined in a two-step process: firstly, damages to human health and vegetation were estimated based on a simplified ozone formation model and by means of dose-response functions. Secondly, these damages were valued with specific cost rates and assigned to the precursors. Thus, annual cost values of 320 DM per ton of pollutant emissions have been calculated for NO_x and VOC based on the year 1990, and cost values of 406 DM/ton NO_x and 526 DM/ton VOC in 2010.

Carcinogenic Pollutants: The mortality due to transport emissions of benzene and particles was determined by means of a unit-risk approach. The total mortality in Germany then valued with a cost rate of 1.4 Mio. DM per death. This results in cost rates of 100 DM/(ton urban emission * Mio. inhabitants) for benzene and 1.750 DM/(ton urban emission * Mio. inhabitants) for particles.

Anthropogenic Greenhouse Effect: Because of high uncertainties in expected damages, we recommend to apply a cost rate of 400 DM per ton anthropogenic CO_2-emissions. This cost rate was calculated based on an avoidance strategy aiming at a long-term reduction of climate gases by 80%.

Outdoor Noise: It is proposed to classify the elements of a standard grid into spatial noise types according to the utilisation categories: residential area, functional utilisation and close-to-nature recreation. Noise sensitivity values and target noise levels are assigned to these spatial noise types. By application of average cost values to sensitivities and transport flows in a grid element, outdoor noise costs for each grid element per year are determined.

Nature and Landscape: The evaluation of specific aspects of nature and landscape should be based on social conventions on the desired state of the natural environment. Three complementary approaches are derived from this central requirement:

1. Avoidance cost approach: Monetary values for avoiding impairments on designated areas can be based on the costs of project alternatives, variants, or costs for abatement measures.

2. Compensation cost approach: If compensation is possible for environmental functions that are lost due to transport projects, costs arise for the acquisition and reconditioning of areas, cultivation measures, and due to the loss of ecological functions over a limited time period.

3. Unsealing cost approach: No additional ground should be sealed for transport infrastructure construction. Cost values for removing pavement were specified for infrastructure types.

[10] *carried out by IWW et al., 1999*

One possibility to incorporate environmental aspects into a common assessment framework is by using an approach where CBA is encompassed by additional assessments such as SEA. The role of SEA would be, on the one hand, to supply the resulting values for those environmental impacts that can be transformed to monetary units and integrated into CBA, and on the other hand, to provide additional information to support decision-making.

However, monetary values for environmental effects are often generally criticised because they suggest that there is a trade-off between environmental quality and material goods. Further problems with the application of CBA arise from the problems with the consideration of environmental risks, irreversible damages, and the interests of future generations. Techniques like sensitivity analysis are available to reduce the deficiencies of CBA in relation to these topics. However, uncertainties remain on the monetary values for these impacts and on the choice of the social rate of discounting. It is therefore necessary to supplement the direct valuation method by an approach that – in the case of established quality standards for environmental impacts and when translated into prices – is capable of influencing traffic behaviour in such a way that environmental targets are achieved. Such a methodology has also been developed in the aforementioned research project by IWW et al. (1999) and is presented in the following chapter.

4 Integrated Strategic Assessment with the Backcasting Approach

In contrast to the conventional forecasting and evaluation process, in the backcasting approach alternative transport planning scenarios are the outcome, not the input of the assessment procedure. This is described in the following section. Subsequently, the application of the backcasting approach is presented for the case study of Baden-Württemberg, a federal state in the south-west of Germany.

4.1 Procedure

In the forecasting approach the path of impacts from the source of emissions to the valuation of the expected damage is directly followed. The backcasting approach takes a converse approach to analysis (see figure 3). In the first step, levels of environmental impacts that guarantee, based on present knowledge, sustainable development ('safe minimum standards') are defined. For this task the SEA indicator and quality standards systems presented in the previous chapter can be applied. The second step is to determine sets of political instruments, including infrastructure expansion, which achieve the safe minimum standards. This is checked by an impact prediction for the defined action plans. Different network configurations are finally assessed with respect to the material welfare losses which their realisation would induce (remember that costly resources have to be invested and transport demand might have to be restricted) to meet the safe minimum standards. In this manner an environmentally sustainable transport plan can be developed that outlines, along with the infrastructure projects, those complementary measures necessary to comply with environmental goals.

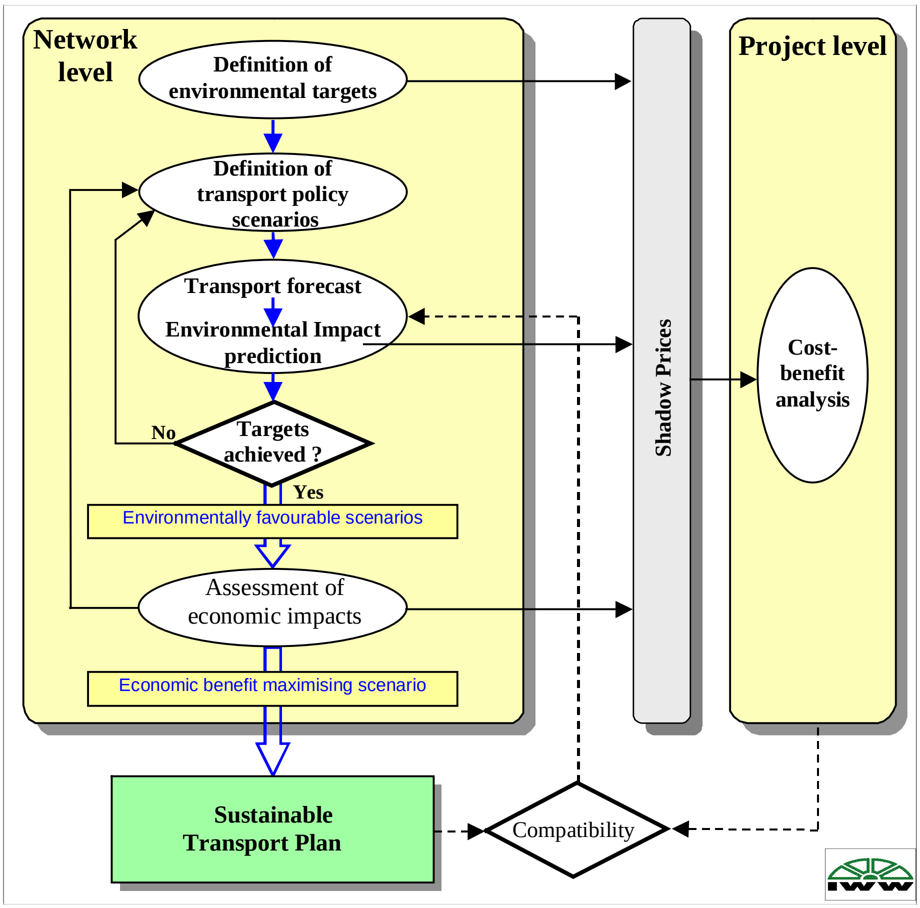

Figure 3: Methodology for the design of environmentally sustainable transport plans[11]

A major application field for the backcasting approach is transport infrastructure planning at the strategic level. Theoretically it is conceivable to assess each possible combination of alternative infrastructure projects separately in order to find the environmentally and economically most beneficial scenario. Due to the immense number of possible combinations this will practically be impossible. On the other hand, the assessment of single projects is necessary in order to take investment decisions. This assessment should be compatible with the assessment of the transport plans. At this point, the application of shadow prices for externalities offers a solution to the problem. Shadow prices can be described in simple words as follows: if a transport infrastructure project leads to a violation of an environmental target by one unit, new policy measures have to be taken. These measures will lower the economic benefit of the whole transport plan by a certain amount. This amount is termed the shadow price of the target. It is possible to derive shadow prices for the fulfilment of environmental targets using the results of the environmental and the economic assessment if a transport policy scenario of maximum economic benefit which achieves the environmental targets was found.[12] By adding the opportunity costs to the avoidance costs for technical measures necessary in order to reach the environmental targets, the costs of capital for environmental targets are received, here as marginal costs at the point of maximum welfare. These can be applied in CBA at the project level, thus linking strategic level and project-level assessment.

[11] *IWW et al., 1999, Schade et al., 1998*

[12] *for further information see IWW et al., 1999, Gühnemann, 1999*

The backcasting approach has recently been applied in some research studies, for instance in the POSSUM project of the 4th Framework Programme of the European Commission[13] and in the EST (Environmental Sustainable Transportation) project of the OECD.[14] A backcasting approach is appropriate if the time horizon of impacts is very long. As argued above, it is, in this case, very difficult to apply direct monetary valuation approaches for the impacts and the risks which are produced for future generations. Therefore, the indirect approach, based on clear specifications as to how the present generation is willing to manage the environmental risks for future generations, appears to be superior. This approach corresponds to the fundamental principles of ecological economics,[15] which requires an analysis of the relationship between economy and ecology based on:

- the acceptance of limits to ecosystem resilience capacity,
- the rejection of the hypothesis of infinite substitutability,
- the consideration of environmental risks, and
- the necessity to regard intergenerational equity in the allocation of goods.

Based on these axioms, a sustainability requirement has to be integrated into the evaluation of environmental impacts. This is achieved by the introduction of the safe minimum standards reflecting the limits of economic activities. There are, however, two caveats to be considered:

1. The safe minimum standards have to be defined on the basis of expert knowledge and value judgements. This presupposes an interaction between experts and political decision-makers. The introduction of safe minimum standards and the sustainability requirement is sometimes feared to lead to an eco-dictatorship of environmental experts. However, the alternative is to adjust the discount rates in CBA, which is likely to be inefficient and therefore less desirable.[16]
2. The economic assessment is based on the assumed transport policy scenario and the cost estimates for the single measures. A rich combinatorial range of possible measures can be the result of the definition and assessment of scenario impacts. Double counting may occur in the sense that avoidance measures for one impact can also contribute to the reduction of others. Therefore, methods have been developed to assign the costs of measures to the impacts.[17]

The backcasting methodology represents an integrative framework for SEA and conventional economic assessment. The feasibility of the backcasting approach has then been demonstrated at the regional level in a case study for the German federal state of Baden-Württemberg.

4.2 Case Study Baden-Württemberg

For the application of the backcasting approach, it has been necessary to develop a SEA methodology for a network-wide and multi-modal assessment of environmental impacts as well as basic methods for socio-economic assessment of transport infrastructure plans. Since the environmental impacts are assessed in relation to safe minimum standards, the economic assessment can be restricted to socio-economic impacts that in general can be better valued by market prices or direct cost approaches. For these impacts, standardised valuation methods exist that can be applied in economic assessment. From the research for the transport master plan for Baden-Württemberg (IVT, IWW, 1995), environmental and transport data were available. Additionally, newly developed prediction models for environmental impacts have been linked to conventional transport models that provide detailed data on traffic flows for all transport modes. In the following sections, the modelling steps are briefly explained, and some results of impact assessment are presented.

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[13] *University College London et al., 1997*
[14] *OECD, 1997*
[15] *e.g. Pearce et al., 1989*
[16] *Pearce, Turner, 1990, p. 225*
[17] *IWW et al., 1999, Gühnemann, 1999*

Definition of environmental targets

The environmental targets applied in the backcasting approach represent safe minimum standards to prevent irreversible environmental damage. The following table summarises indicators and environmental targets applied in our project. These were derived from lists of environmental criteria for sustainable transport by the German environmental agency (Umweltbundesamt 1997).

Table 2: Indicators and target values for environmental impacts

Environmental Impact	Indicator	Environmental Target 1992 - 2010
Global warming	CO_2 emissions in transport	-30%
Tropospheric ozone	transport emissions of NO_x VOC	-80% -70%
Atmospheric pollution	ambient concentration of benzene particles	2.5 µg/m^3 1.5 µg/m^3
Noise	daytime level of noise exposure of inhabitants	≤ 65 dB(A)
Nature protection	further fragmentation of restricted areas further sealing of ground surface	not allowed not allowed

Definition of transport policy scenarios

The selection and combination of transport policy measures is a crucial point in the development of environmentally sustainable transport plans. Not only environmental, but also economic and social requirements for an efficient transport system have to be taken into consideration. Efficient, consistent and operational catalogues of measures, termed ”framework scenarios” in this project, have to be assembled, which can consist of all types of transport related measures such as infrastructure investments, regulatory or financial instruments. Based on the results of the impact assessment, the framework scenarios might have to be modified in order to achieve environmental targets or to improve economic efficiency.

In this case study, three different transport policy scenarios were defined for 2010: a trend scenario based assumptions of the last German transport master plan (BVWP '92), framework scenario 1 with a focus on regulatory and fiscal policy instruments such as infrastructure prising, strict emission limits and raised fuel taxes, and framework scenario 2 assuming less restrictive measures but organisational improvements in the transport sector. A strict technical assumption that has been used in both scenarios is a fleet average for fuel consumption of 5 l/100km for cars. The transport networks for the trend scenario and for framework scenario 1 is composed of the present German infrastructure network plus approved projects of the BVWP '92. Based on the results from the transport forecast for these scenarios, new projects with only small transport flows have deleted from the networks in framework scenario 2.

Transport forecasts

Based on the scenario assumptions, forecasts of passenger and freight traffic were performed by means of a multi-modal transport model covering generation, distribution, modal split, and traffic assignment. The forecast was based on transport demand matrices set up for the BVWP'92 using a refined regional differentiation (121 districts corresponding to NUTS-IV regions in Baden-Württemberg). Induced traffic was explicitly taken into account and the traffic data was directly linked to the environmental data via a grid model (5x5 km^2 squares). Detailed network models for the modes road, rail, air and inland waterway transport were available.

On this basis, the impact of external factors on key transport variables was predicted in a multi-stage process. As a result of the assumed policy measures, for example the rail share of total freight volume will increase from 28% in the trend scenario to 40% in both framework scenarios, of long-distance passenger transport volume from 5% in the trend scenario to more than 8% in the framework scenarios. Moreover, the increase in traffic flow (measured in vehicle-km) on roads in the framework scenarios is considerably lower than in the trend scenario (outside urban areas: +19% cars/+37% lorries in the trend scenario, +8%/+21% in framework scenario 1, +2%/+3% in framework scenario 2).

The basic data for the prediction of environmental impacts are the characteristics of the traffic flow on the transport networks. The applied transport models are capable of providing data in the necessary accuracy and differentiation.

Prediction of environmental impacts

In order to predict environmental impacts, models for forecasting emissions, ambient concentrations, noise exposure, and effects on nature and landscape have been developed. The results of the impact prediction have to be compatible with the environmental targets defined in advance. For the modelling of local and regional environmental impacts, the environmental burdens due to other sources and the characteristics of affected regions play an important. In the case study, the observed region of Baden-Württemberg has been overlaid with a grid using a resolution of 5x5 km^2, whose elements were assigned specific region types based on the analysis of individual indicators. Spatial characteristics, which have been used in the case study, are protected areas, wind velocities, and population densities.

Transport emission forecast

For the prediction of emissions due to road transport activities, data on traffic flows as well as emission factors in the following differentiation were applied: 6 air pollutants (CO_2, NO_x, CO, VOC, benzene, diesel soot particles), 2 types of fuels (gasoline, diesel), 4 vehicle categories (cars/two-wheelers, light duty vehicles ≤ 3.5t, heavy duty vehicles > 3.5 t, buses), 4 road categories (motorways, other rural, main urban, other urban), 3 congestion classes (not congested, congested 5% of time, congested 10% of time), and 3 gradient classes (≤ -6%, -5% to +5%, ≥ 6%). Additionally, average factors for cold start emissions in Germany were estimated. Evaporative VOC emissions were calculated for Germany and assigned to the grid squares proportional to population densities. The basis for the calculation of rail transport emissions were average energy consumption rates specified for three different train categories (inter-city passenger, regional and metro passenger, freight trains). Emission factors were determined for direct emissions from diesel engines and for the emissions from power generation related to rail transport. For inland waterway shipping, average emission rates per ship type were applied. The case study results for transport emissions are presented in figure 4.

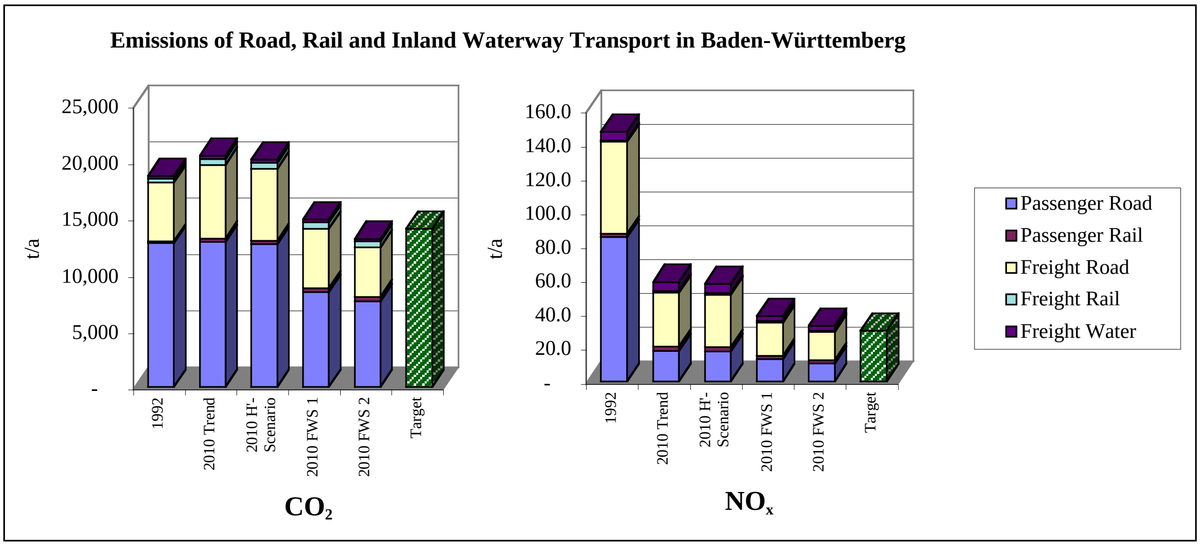

Figure 4: Emissions of road, rail and inland waterway transport in Baden-Württemberg

It can be concluded that the modal shifts and technical measures assumed in the framework scenarios contribute significantly to the reduction of gaseous emissions, mainly by reductions achieved in road transport. This includes the savings in fuel production which also leads to a decrease in emissions from fuel production. The target level for VOCs is already achieved in the trend scenario. However, the target for NO_x is slightly exceeded. CO_2 emissions increase by 8% in the trend scenario compared to 1992, but can be reduced to the target level of -30% in framework scenario 2. Thus, a level of emissions is reached in framework scenario 2 such that a transport plan has been found that largely achieves the pre-set target levels for transport emissions.

Transport Related Concentrations of Air Pollutants

A prediction model for the dispersion of air pollutants had to be developed since the targets for benzene and diesel particles are provided as maximum concentration values. Air quality at a given location depends on the background concentration and on the additional concentration due to emissions from transport. Standard values for present background concentrations for different types of regions could be derived from literature. To forecast future values, the background concentration was decreased proportionally to the change of emissions between the base year 1992 and 2010 differentiated by region types. For the prediction of the additional concentration from road transport, several models with different aggregation levels are described in the literature. At the level of national transport planning, screening models can be applied that require an acceptable number of input parameters and limited computing power. In the case study, separate models have been applied for ambient concentrations along rural roads and for roads in urban areas. Input variables of the urban model[18] are standardised concentration values for different road classes, average values for wind velocities and emission densities per road that are calculated in the emission prediction model.

As a state indicator for air pollution in a specific area, the maximum of all calculated concentration levels was determined for each grid square. The target value for the concentration of diesel soot particles (see figure 5) is exceeded by these peak values in the base year 1992 in 100%, in framework scenario 2 in 3% of the grid squares. In the case of benzene, these values are 98% for 1992 and 0.2% for framework scenario 2. It can be concluded that air quality will increase significantly under the assumed measures.

[18] *based on an approach developed by Lohmeyer, 1996*

Additional action is necessary to achieve the environmental targets also in the town centres of Stuttgart, Karlsruhe and Freiburg.

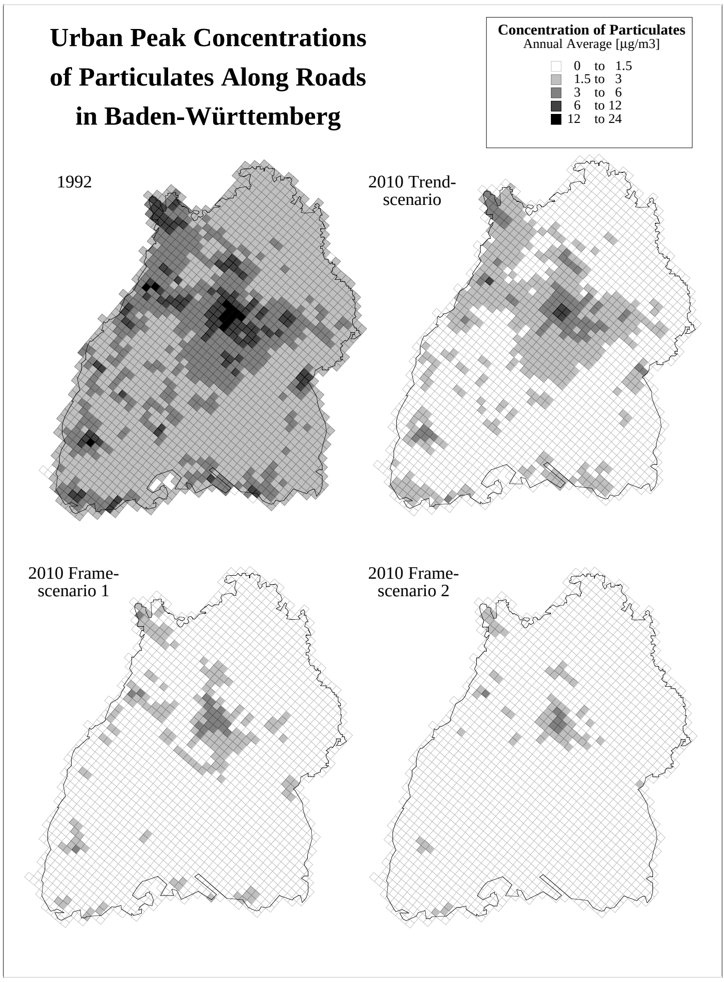

Figure 5: Urban peak concentrations of diesel soot particles along roads in Baden-Württemberg

Noise

Models for the prediction of noise disturbance at the network have been established in the case study for road and rail transport noise. The reference noise level along roads is calculated based to the noise protection manual for roads in Germany.[19] This model has been enhanced by the incorporation of the actual traffic mix from the transport models and by the inclusion of reflections via typical housing structures, which are also applied to calculate the number of inhabitants that are exposed to noise above the defined threshold level 65 dB(A) at daytime.[20] In total, about 10% of the population are exposed to road noise above the target level. The prediction of rail transport noise is based on a model provided by German noise legislation. Noise levels along tracks are calculated based on the number of trains and parameters describing train characteristics such as train length, speed, type of breaks, and share of trains operating during night-time differentiated by train categories. A corridor is determined for each network section, in which a the

[19] *BMV, 1992*
[20] *Heusch-Boesefeldt, 1997*

target noise level is exceeded. Based on the population density of the affected region, the number of inhabitants in this corridor is estimated. The case study shows that about 2% of the population in Baden-Württemberg are exposed to daytime noise levels above 65 dB(A) due to rail transport. The increase of rail traffic in the framework scenarios leads to higher noise exposure along certain railway links. In framework scenario 2, these noise impacts are partly compensated by an improved equipment of the trains.

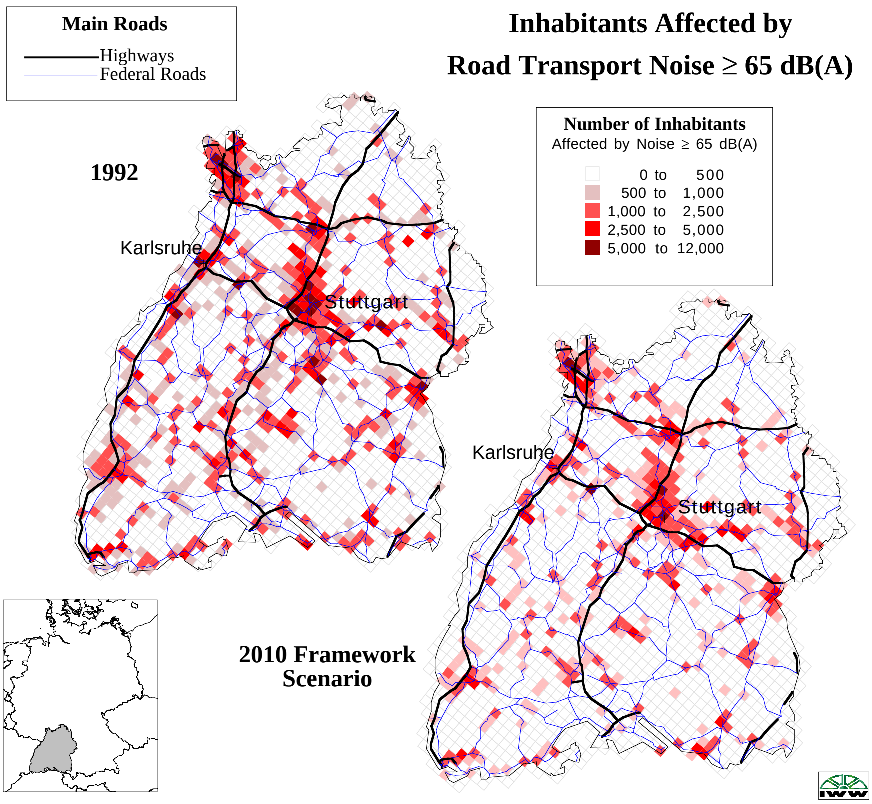

Figure 6: Inhabitants affected by road transport noise in Baden-Württemberg

Impacts on Nature and Landscape

To assess impacts of transport infrastructure on nature and landscape at the network level, the following impact indicators have been used: lengths and land take by networks, the division of conservation areas and impacts of infrastructure construction on exclusion areas. The division of conservation areas is determined by overlaying transport networks and spatial data. Areas where further infrastructure construction is not allowed in order to achieve environmental targets are referred to as ”exclusion areas”. These are, for example, nature protection areas, national parks, the core areas of nature parks, and protection areas of European significance (e.g. Important Bird Areas). To demonstrate the feasibility of the approach, data on nature protection areas is used in the case study. For all grid squares, the percentage of nature protection areas of the total area is calculated and those squares with a share above 25% are defined as exclusion areas (see figure 7). If a new infrastructure alignment would fall into one of these areas when following a direct route then an alternative variant has to be chosen which bypasses the exclusion area. If upgrading existing infrastructure within an exclusion areas is planned, supplementary mitigation measures will be necessary. This leads to additional infrastructure investment and operation costs, which amount to a total of 80 Mio. DM/year in framework scenario 1, respectively 40 Mio. DM / year in framework scenario 2.

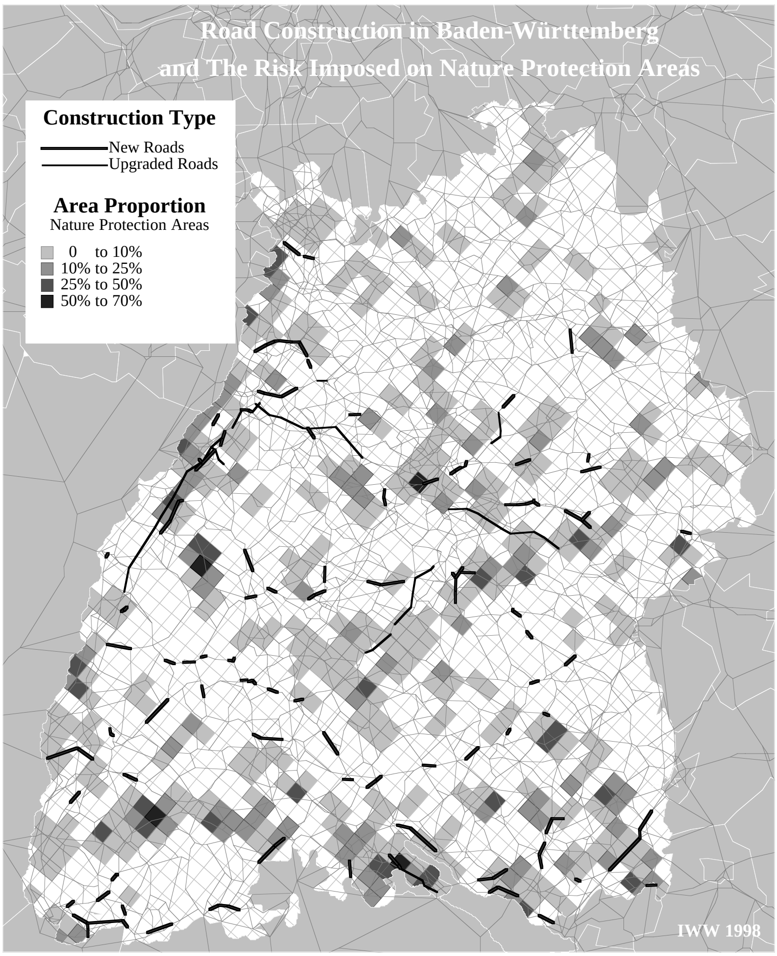

Figure 7: Road construction and the risk for nature reserves in Baden-Württemberg

Economic evaluation and calculation of shadow prices

The economic assessment of the transport policy scenarios includes construction costs, maintenance costs, operating costs, revenues, generalised costs, and traffic safety (see figure 8). These can be quantified by means of standardised techniques, which have been taken from transport infrastructure planning in Germany.[21] Additionally, costs of technological prevention measures have been included.[22] For each scenario, the aggregated sum of economic costs has then been calculated. The cost increase in framework scenario 2 compared to framework scenario 1 turns out to be quite moderate, because the definition of framework scenario 2 aimed at reducing the economical shortcomings by the assumed measures.

[21] *BMV, 1993*
[22] *e.g. based on a study by ECN et al. (1996)*

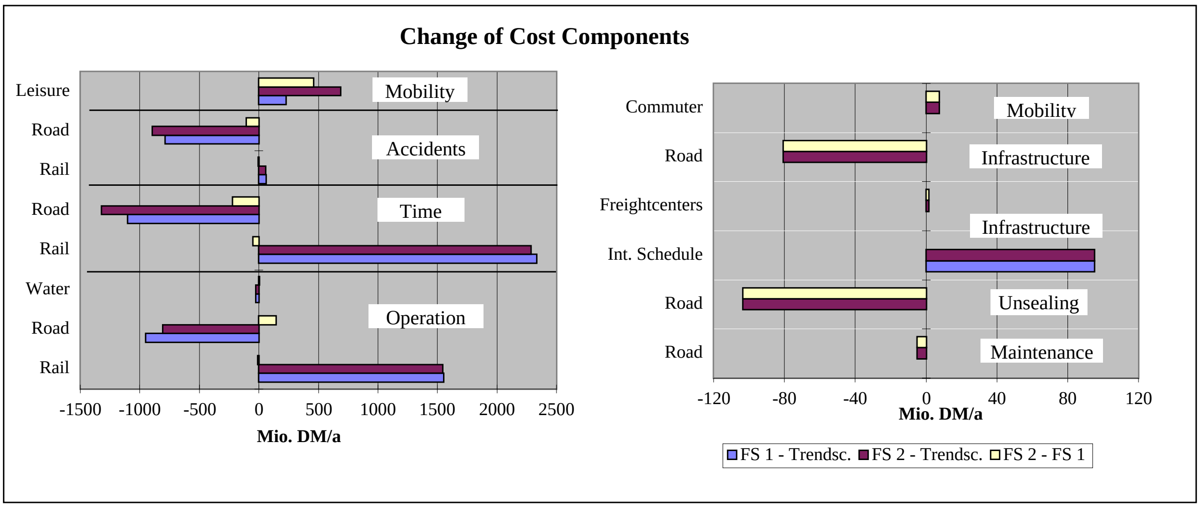

Figure 8: Change of costs between scenarios

These scenario costs are the basis for the calculation of shadow prices and have been attached to the environmental impacts. First, these impacts are weighted according to the difference between the indicator values of the trend scenario and their targets. The costs of framework scenario 2 are then assigned to the impacts in the ranking order and according to their weights. If the target value for an impact is not achieved in framework scenario 2, additional measures are assumed following a least-cost principle until the targets are achieved. In order to consider risks of damage that remain below environmental targets, direct and indirect approaches are linked. While the shadow-price approach is applied for target breaches, impacts below the fixed standards are valued by means of damage cost or willingness-to-pay approaches. Here, the results from the enhancement of the monetary evaluation of environmental effects in the cost-benefit analysis for single projects, are applicableThe resulting cost values for environmental impacts (see table 3) can be applied in cost-benefit analysis for the assessment of transport infrastructure projects. However, these cost values are only valid for the study region and for the defined environmental targets.

Table 3: Cost values for the evaluation of individual projects

Environmental Impact	Differentiation			Cost Values	Unit
CO_2	global			400	DM/tonne
NO_x	global			17,850	DM/tonne
VOC	global			525	DM/tonne
Diesel Soot Particles	projects in grid squares, within which the target values of 1.5 $\mu g/m_3$ is achieved in the trend scenario			1,750	DM/(tonne inner-urban* Mio. inhabitants)
	projects in grid squares, within which the target values of 1.5 $\mu g/m_3$ is achieved in framework scenario 2 first			2,550	
	projects in grid squares, within which the target values of 1.5 $\mu g/m_3$ is exceeded in framework scenario 2			4,050	
Benzene	projects in grid squares, within which the target values of 2.5 $\mu g/m_3$ is achieved in the trend scenario			100	DM/(tonne inner-urban* Mio. inhabitants)
	projects in grid squares, within which the target values of 2.5 $\mu g/m_3$ is achieved in framework scenario 2 first			2,000	
Noise	Road	> 65 to 67 dB(A)		41	DM per inhabitant exposed to noise above 65 dB(A)
		> 67 to 70 dB(A)		109	
		> 70 dB(A)	motorways	2,321	
			rural roads	3,656	
			urban roads	5,324	
	Rail	> 65 to 67 dB(A)		4,420	
		> 67 to 70 dB(A)		9,665	
		> 70 dB(A)		20,680	

5 Conclusions

Strategic environmental assessment is closely related to the concept of sustainable development. The integration of environmental issues into decision-making at all policy levels is a key requirement to achieve sustainability. The application of SEA in the transport sector offers the opportunity to design transport policies and plans from start on in such a way that environmental objectives are achieved. Thus, possible conflicts can be avoided, which contributes to efficient transport planning.

SEA is an objective-driven procedure. The definition of environmental standards and the selection of adequate indicators determine the results of the impact evaluation. SEA can benefit from the Agenda 21 process by incorporating defined environmental objectives into the assessment. A framework for a consistent indicator and quality system has been presented that guides the translation of general objectives into variables that can be applied in SEA. The approach takes account of the different levels of impacts and quality standards, which provide a basis for the impact evaluation.

Besides environmental objectives, transport policy aims at achieving economic efficiency and social balance of the transport system. Different methods can be applied that support decision-makers in comparing policy options with regard to multiple and partly conflicting objectives. In this paper, the backcasting approach is presented that incorporates the assessment of environmental impacts into transport infrastructure planning at an early stage and in a multi-modal manner, based on defined safe minimum standards. At least one scenario has to be explicitly designed which is in accordance with established environmental policy goals. By the application of shadow prices, which are derived from the optimal transport policy scenario, an integration of network-wide assessment and cost values used in project appraisal is achieved.

In the case study for Baden-Württemberg, methods for the analysis of environmental impacts have been expanded, at a high level of specificity, to large areas, several modes and a range of environmental impacts. The backcasting approach has been applied in order to take into account global and long-term impacts as well as the uncertainty related to network-wide assessment at the European or regional level. The development of a flexible methodology for SEA at different planning levels improves the potential for integrating environmental, social and economic issues in the decision-making process at European, national and regional transport infrastructure planning.

An essential part of the backcasting methodology is the application of socially acceptable targets for environmental impacts. This presupposes an interaction between experts and political decision-makers as started in the BALTIC 21 process. In this way a transport policies, plans and programmes can be designed that correspond to the requirements of environmental sustainability and at the same time improve the economic and spatial functionality of the transport system.

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