

**COST 350 / WG3**  
**May 2006**  
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**COST350**  
**Integrated Assessment of**  
**Environmental Impact of Traffic**  
**and Transport Infrastructure**  
**- A Strategic Approach**

**Part C**  
**Chapter 4**  
**WG 3 - Environmental Indicators**

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## 1. Introduction

Today's Modern European society is undergoing an increase in welfare and in consequence an increase in mobility and infrastructure, but this increase cannot and must not be on the expense of the environment.

These two opposing forces, Environmental protection in one hand and infrastructure growth on the other, can lead to tension between various spatial functions like living, transportation, recreation and others. To optimise the combination of spatial functions and to come to an environmentally sustainable transport system, a multi-disciplinary approach is required.

According to the Brundland Commission (1987), "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". Social, economic and environmental factors are important to achieve this sustainable development.

In the following Chapter, as in all the COST 350 Action, the main focus will be on the environmental aspects and the need to provide decision makers with the useful tools in order to achieve the demanded economic growth in the logic and philosophy of "sustainable development". One such tool can be the input and analysis of a set of environmental "impacts" and indicators as it is presented in this chapter.

It is said that:

*"The overall grade of evolution of a society can be measured in the efficiency and progression of its tools"*

Indicators are of course such tools; they measure developments in selected issues, including progress towards agreed targets (EEA). In today's literature much can be found and thus can be put to use, about environmental indicators, they reflect trends in the state of the environment and can give us an idea of how much progress is been done in order to accomplish the objectives and targets our society has committed it self to.

These last years Environmental Indicators have evolved to powerful tools, but there is a draw back in such an evolution, and that is the complexity and by consequence the ultra specialisation that is needed by users (policy-makers, and why not NGOs, Public), in order to grasp the importance and meaning of these tools and what they represent (Athens Workshop COST 350 Action 9-11 March).

The purpose of this chapter is to evaluate & provide the reader with EEA type of indicators based on DPSIR (Driving forces, Pressure, State, Impact, and Response) and TERM (Transport and Environment Reporting Mechanism) but in the same time explore the further possibilities of having for every impact analysed, a shell like structure, of three corresponding indicators, in function with the level of information available. All this will be described in detail further on.

## 2. Structuring information with DPSIR

### 2.1 DPSIR-Scheme

The work of the European Environmental Agency (EEA) is built around a conceptual framework known as the DPSIR assessment framework [1]:

- D - Driving Force
- P - Pressure
- S - State
- I - Impact
- R - Response.

The scheme offers a basis for analysing the inter-related factors that impact on the environment and is useful for any environmental assessment within EIA or SEA.

Fig. 1: DPSIR in Transport Sector

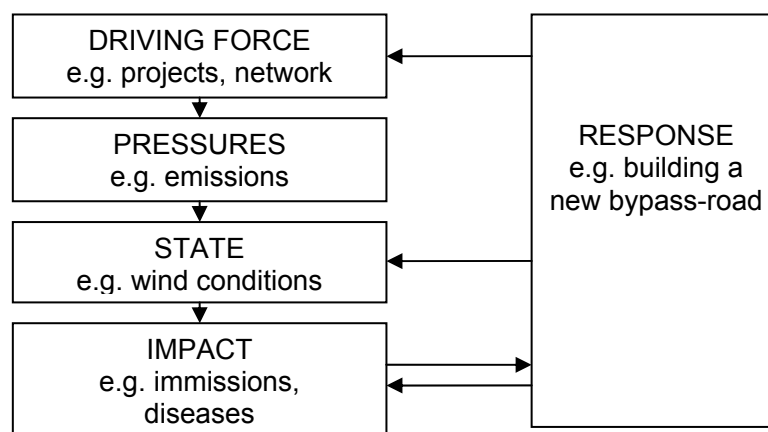


Fig. 1 clarifies the application of this approach in transport planning. Driving force means here the entire traffic network of the regarded region and the new network with all projects becoming part of the plan or program. This force causes effects (pressures, for example emissions), which have consequences on the environment (impacts, for example emissions and/or diseases) depending on the environmental situation concerned (state, for example wind conditions). Part of the answers (of the society, of the administration, of the policy) to these changes of the environment (response) is for example the building of a new bypass-road respectively the whole transport plan/program. The regarded effect on the environment can be also positive, for example noise reduction in town due to the new bypass-road.

### 2.2 Applying DPSIR in SEA

Each of the five DPSIR-elements is described by own indicators. The requirements for the selection of the indicators are described in chapter 4 In SEA it can be also meaningful to aggregate several indicators to new indicators of a higher abstraction level (see part C chapter 5).

In the following chapters some D-, P-, S-, I- and R-indicators for SEA on transport planning are introduced.

## 2.3 Driving force

As driving force usually is not regarded the complete traffic infrastructure within the planning area, but only those modes of transport, which lie in the scope of responsibility of the authority setting up the plan/program. The aim of the transport plan/program is to improve the existing transport infrastructure by taking up certain projects to the plan/program and thus guaranteeing their financing. The projects usually are structural changes of the network, such as building new infrastructure elements, upgrading or retreating them. Also compacting cycles of public transport, measures of traffic management or improvement of the interfaces between two modes of transport, for example park-and-ride-places, would be possible.

Within SEA in transport planning three types of driving force can be differentiated:

1. The traffic network, which functionality should be improved and which environmental negative effects should be decreased. Regarding the network is the main task of SEA, because environmental effects of the whole transport plan/program are to be determined, described and evaluated, which means the changes of the environmental effects from the existing to the future traffic network, with and without realisation of the proposed projects;
2. The projects, because the environmental effects of the transport plan/program proceed mainly from the projects;
3. Several neighbouring projects, in case of which cumulative or synergetic impacts results. This separate view of clusters of projects can be meaningful, if the view of network is not able to illustrate the responded cumulative impacts.

Part of the indicators, which characterise driving force, are for example length and width of the regarded project and/or the regarded network mesh, number of lanes, extent of dams and cuts, traffic volume or truck partition. Usually these data are necessary for the existing network, for the forecasted zero-case (zero-alternative, existing network in the prognosis year) and for the prognosis-case (new network in the prognosis year). Uncertainties in forecasting future traffic flows can be decreased by scenario technology.

## 2.4 Pressure

In the next step the influences of the projects and/or the network on the environment (pressure) are regarded. As known from EIA influences of infrastructure and of transport flows can be differentiated. Influences during the building phase can be neglected within SEA and left to EIA.

The main influences of a transport plan/program are:

Infrastructure influences:

- Land uptake, sealing
- Fragmentation
- Visual influences
- Material and energy consumption

Influences of transport flows:

- Noise
- Pollution
- Accident risk
- Material and energy consumption

If many projects have to be evaluated, it is meaningful to use an aggregated P-Indicator: the influences' magnitude of the project as a function of the type of

project (see table 1). This indicator assumes that high infrastructure influences also always go hand in hand with high influences of transport flows.

Table 1: Effect's magnitude of a project (example from FTIP) [82]

Influences' magnitude	Type of project
Very high:	construction of new federal motorway/four-lane express road with high proportion of cuttings or embankments
High:	construction of new federal motorway/four-lane express road with low proportion of cuttings or embankments or New road with high proportion of cuttings or embankments and daily traffic volume > 25.000 vehicles
Intermediate:	construction of other new roads with low proportion of cuttings or embankments and daily traffic volume < 25.000 vehicles or Improvement of a federal motorway widening by at least 2 lanes with high proportion of cuttings or embankments
Low:	Improvement of a federal motorway widening by at least 2 lanes with low proportion of cuttings or embankments or Improvement of other trunk roads with daily traffic volume > 10.000 vehicles
Very low:	Improvement of roads with daily traffic volume < 10.000 vehicles

## 2.5 State

The environmental impacts of a transport plan/program depend among other things on importance and sensitivity of the affected parts of the environment (state). Therefore SEA has to evaluate the environmental conditions for all environmental factors:

- a) biodiversity, fauna, flora,
- b) population, human health,
- c) soil,
- d) water,
- e) air,
- f) climatic factors,
- g) material assets,
- h) cultural heritage including architectural and archaeological heritage,
- i) landscape,
- j) Interrelationship between the above factors.

The environmental factors might be summarised in groups, for example in "human health and well-being", "nature and landscape" and "water and soil" (FTIP 2003).

In case of transport plans/programs covering a huge area winning the information about the environmental conditions presents a problem to be taken seriously because of the quantity and the availability of the data. All data for the entire planning area have to be presented in comparable quality and topicality. Often data have to be restricted on already existing sources, possibly addited by plausibility checks of an expert.

The indicators for the characterisation of the environmental conditions are importance and sensitivity or environmental resistance, related to areas of the same environmental quality in the planning area. They are in principle the same as in EIA, however adapted to the available data situation. The evaluation can be made for example in four stages (low, intermediate, high, very high). Criteria for the evaluation are for example protection and restriction categories (e.g. protection status, regional

planning goals), condition and importance categories (e.g. land use, uncutted low traffic areas) as well as the preload.

The environmental conditions are usually first judged at the time of the investigation. Subsequently, its development up to the prognosis time of the transport plan/program has to be forecasted.

SEA-directive attaches special importance to the description of ecologically sensitive areas, for example natura-2000-sites. This also benefits the transport plan/program itself, because projects, which are not enforceable because of too large environment conflicts, can be identified promptly.

## 2.6 Impact

In aggregating state and pressure the consequences of the projects' and/or networks' influences on the environment (impact) are detected and assessed on the basis of the agreed system of objectives (chapter 3.2). These consequences could be negative (as the word impact implies) but also positive (for example noise reduction in town due to a new bypass-road). Similar to the abovementioned separation between infrastructure influences and those of transport flows it is meaningful to differentiate the impacts in the same manner (see table 3). The most important effects and impact distances of road traffic are shown in table 2. For each transport plan/program should be decided, which indicators are applied (see chapter 4).

The SEA-directive appendix I demand all indirect and direct impacts to be regarded. Parts of them are secondary, cumulative, synergetic, short- and long-term, constant and temporary, positive and negative impacts. This enumeration represents an enormous methodical challenge, it is however very important, because SEA isn't only lining up environmental assessments of several projects, but regarding the effects of plan/program as a whole. Hence in particular for neighbouring projects own assessment steps for cumulative impacts should be intended. Assistance for the assessment of these cumulative effects provides the British SEA-guideline for transport plans/programs [2].

*The following table gives a schematic description of the effects & typical impact distances of road traffic as the title implies. These impacts (fragmentation, Accidents etc) can be seen in the left side of the table intuitively. Their spatial effects in terms of radius distance from the structure of the road (when it is present or circumstantial) can be seen in right side of the table. Always on the top of the right table next to the highway image we have a scale in meters giving as the length. Right beneath we have the impacts underlined by a red line were the intensity (represented by the thickness of the line) describes the intensity of the impact ranging from heavy, medium and low, and were the length corresponds to the "spread" of the impact away from the road and into the Environment.*



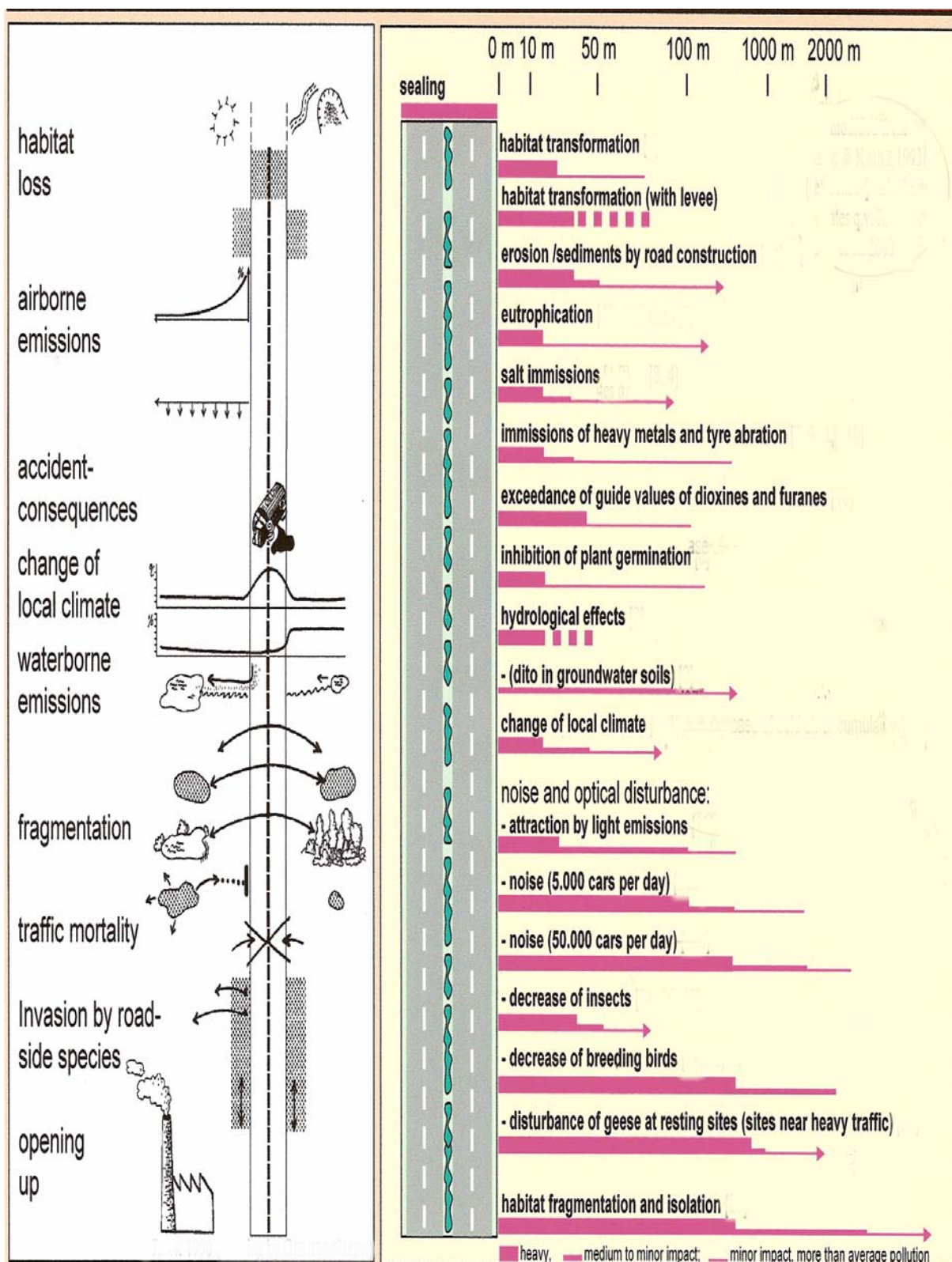


Table 2 Effects & Typical Impact distances of road traffic modified from RECK & KAULE 1993 [see ref. 4, 5, 6].

Table 3 Impacts

State (Environmental factors)		Biodiversity, Fauna and Flora	Population, Human health	Soil	Water	Air	Climate	Material resources	Culture heritage	Landscape
Pressure										
Infrastructure effects	Land uptake	Land uptake	Land uptake	Land uptake	Land uptake	Look to the other environmental factors (Biodiversity, Fauna and Flora, ,Population ...) as the actually affected ones			Land uptake	Land uptake
	Barrier effects	Fragmentation of habitats	Fragmentation of habitats							Fragmentation of habitats
	Visual disturbance	Visual disturbance	Visual disturbance						Visual disturbance	Visual disturbance
	Material consumption and Waste production			Material consumption and Waste production	Material consumption and Waste production			Material consumption and Waste production		Material consumption and Waste production
	Energy consumption							Energy consumption		
	Hydromorphological risks	Hydromorphological risks	Hydromorphological risks	Hydromorphological risks	Hydromorphological risks				Hydromorphological risks	Hydromorphological risks
Vehicles' effects	Energy consumption							Energy consumption		
	Noise (and vibrations)	Disturbance from noise	Disturbance from noise							Disturbance from noise
	Pollutants emissions	Toxicity, Acidification , Photochemical pollution , Eutrophication	Photochemical pollution, Toxicity Sensitive pollution	Acidification, Eutrophication, pollution of soil	Acidification, Eutrophication , pollution of surface water		Climate change		Acidification	Acidification , Sensitive pollution, Eutrophication
	Accidents	Release of dangerous goods due to accidents	Accidents	Release of dangerous goods due to accidents	Release of dangerous goods due to accidents				Release of dangerous goods due to accidents	

## 2.7 Response

After having described and assessed the positive and negative effects on the environment of the projects, networks and alternatives a final entire environmental evaluation is necessary, which flows into a recommendation for the inclusion or refusal of certain projects into the transport plan/program (response). Criteria for this recommendation are mainly the goals set up at the beginning (chapters 3 and 4).

Besides the yes- and no-recommendation there might be a yes-under-condition-category, which recommends the project becoming part of the plan/program in case of certain conditions, for example a further political approval during the following phases of project planning. Beyond that the SEA-recommendation could content priority lists for each of the categories from the environmental point of view as well as further recommendations on the transport plan/program and on transport policy.

## 3. Objectives and targets

### 3.1 Introduction

Problem of environmental protection is being widely discussed for many years but the approach to this subject has been changing in time: from singular actions to the holistic approach that can be realized at strategic level.

Taking it into consideration European Parliament and the Council, on the basis of Commission proposal, established The Sixth Environment Action Programme of the European Community “**Environment 2010: Our future, Our choice**” [24].

The Programme bases upon following presumptions:

- There is scientific consensus that human activity is causing increases in concentrations of greenhouse gases, leading to higher global temperatures and disruption on the climate.
- The implications of climate change for human society and for nature are severe and necessitate mitigation. Measures to reduce emissions of greenhouse gases can be implemented without a reduction in levels of growth and prosperity.
- Healthy and balanced natural systems are essential for supporting life on the planet.
- There is considerable pressure from human activity on nature and biodiversity. Action is necessary to counteract pressures arising notably from pollution and the way in which the land is exploited.
- Soil is a finite resource that is under environmental pressure.
- Despite improvements in environmental standards, there is increased likelihood of a link between environmental degradation and certain human illnesses, therefore the potential risk arising, for example, from emissions and hazardous chemicals, pesticides and from noise should be addressed.
- There is a limited capacity of the planet to meet the increasing demand for resources and to absorb the emissions and waste resulting from their use and there is evidence that the existing demand exceeds the carrying capacity of the environment in several cases.

- Waste volumes in the Community continue to rise, a significant quantity of these hazardous, leading to loss of resources and to increased pollution risk.

According to the 6<sup>th</sup> Programme [24] economic globalisation means that environmental action is increasingly needed at international level, including, among others, transport policies.

There are four main priority areas for action:

### 1. Nature and Bio-diversity – protecting a unique resource

**Objective** – to protect and restore the functioning of natural systems and halt the loss of bio-diversity in the European Union and globally. To protect soils against erosion and pollution.

**Targets** - minimise land uptake by new infrastructure development/transport unit. Move towards less surface consuming means of transport.

### 2. Environment and Health

**Objective** – to achieve a quality of the environment where the levels of man-made contamination, including different types of radiation, do not give rise to significant impacts or risks to human health.

**Targets** – to protect and where necessary restore the structure and functioning of natural systems and halt the loss of bio-diversity both in the European Union and on a global scale. To protect soils against erosion and pollution.

### 3. Tackling climate change

**Objective** – to stabilize the atmospheric concentrations of greenhouse gases at a level that will not cause unnatural variations of the earth's climate.

**Targets** – to achieve above mentioned objective, global emission of greenhouse gases need to be reduced by approximately 70% over 1990 levels in the longer term.

### 4. Sustainable use of natural resources and management of wastes

**Objective** – to ensure the consumption of renewable and non-renewable resources does not exceed the carrying capacity of the environment. To achieve a de-coupling of resources use from economic growth through significantly improved resources efficiency, dematerialization of the economy, and waste prevention.

## 3.2 Nature and bio-diversity – protecting a unique resource

Biological diversity (bio-diversity) is essential to maintain life on Earth and has important social, economic, scientific, educational, cultural, recreational and aesthetic values [14]. In addition to its intrinsic value biodiversity determines our resilience to changing circumstances. Without adequate biodiversity, events such as climate change are more likely to have catastrophic effects.

Healthy and balanced natural systems are essential for supporting life and the functioning of society. Valuable environmental areas should be protected by the Community's Natura 2000 programme and this must be implemented fully. Extending

protection to the wider countryside requires a deeper and effective integration of environment and bio-diversity into agriculture, landscape, forestry and marine policies, coupled with new initiatives, for example to develop a soil strategy for Europe. It requires the coherent reestablishment of habitats and migration corridors for currently threatened species as well as dispersal corridors to enable adaption processes due to environmental changes

Pressures from human activity on nature and bio-diversity can be categorized as follows:

1. Pressure is caused by the changes in the way how people utilize land, and when they exploit natural resources much faster than they can be replenished. The building of new linear infrastructure is fragmenting the countryside into ever-smaller areas, making it harder for species to survive. All the trends suggest that the loss of open countryside to development will continue in the future. Other pollutants are noise and artificial light, which may have negative effects on population of animals (e.g. birds, bats, insects).
2. Pollution from transport, industry and agriculture continues to threaten natural areas and wildlife. Pollution can be caused by direct and dramatic events; the effects can also build up over time, for instance acid rain that wears down soils, forests and lakes, or chemicals that threaten the ability of birds and other animals to breed. 'Eutrophication' or surplus nutrients in water causing algae or other plant growth could become a threat to many biocenoses (including freshwater ones).

At the 1992 Earth Summit in Rio de Janeiro, world leaders agreed on a comprehensive strategy for 'sustainable development' - meeting the needs while ensuring that healthy and viable world for future generations will be left. One of the key agreements adopted in Rio was the **Convention on Biological Diversity**[14]. This pact among the vast majority of the world's governments sets out commitments for maintaining the world's ecological underpinnings. The Convention establishes three main goals:

1. the conservation of biological diversity,
2. the sustainable use of its components,
3. the fair and equitable sharing of the benefits from the use of genetic resources.

During the Conference in Kyiv in 2003 the European Ministers of Environment and Heads of Delegations of the States participating in the process of the Pan-European Biological and Landscape Diversity worked out the **Kyiv Resolution on Biodiversity** [26] stating, among others:

1. By 2006 the Pan-European Ecological Network (core areas, restoration areas, corridors and buffer zones, as appropriate) in all States of the pan European region will be identified and reflected on coherent indicative European maps, as a European contribution towards a global ecological network.
2. By 2008 all core areas of the Pan-European Ecological Network will be adequately conserved and the Pan European Ecological Network will give guidance to all major national, regional and international land use and planning policies as well as to the operations of relevant economic and financial sectors.
3. The Pan-European Ecological Network has the potential to be used as a spatial planning tool for Europe.

As the most important instrument aimed to protect bio-diversity, apart from legislation, the establishment of the Natura 2000 network is considered. It involves the identification of the most representative natural areas and eco-systems, which need to be protected and managed.

Two EU Directives deal with the conservation of European wildlife, focusing on the protection of sites as well as species. The 1979 **Birds Directive** identified 181 endangered species and sub-species for which the Member States are required to designate Special Protection Areas (SPAs). Over 3 000 SPAs have been designated, covering 7% of EU territory. As a result of this action, some severely threatened species are now beginning to recover.

The 1992 **Habitats Directive** aims to protect wildlife species and their habitats. Each Member State is required to identify sites of European importance and to put in place a special management plan to protect them, combining long-term preservation with economic and social activities, as part of a sustainable development strategy. These sites, together with those of the Birds Directive, make up the **Natura 2000 network** - the cornerstone of EU nature protection policy. The Natura 2000 network already comprises more than 18 000 sites, covering over 17% of EU territory, and is to be completed soon.

The risk of negative effects on the nature must be taken into consideration in strategic environmental assessment. In order to make it possible in the following part of the chapter several impacts to assess are being proposed – “Land uptake” (No. 1), “Fragmentation of habitats” (No. 2), “Visual disturbance” (No. 3), “Disturbance from noise” (No. 13), “toxicity” (No. 12) and “Eutrophication” (No. 14).

### 3.3 Environment and Health

#### 3.3.1 *General approach*

There is increasing realization and evidence that human health is strongly affected by environmental problems related to air, water and soil pollution, dangerous chemicals and noise [22]. A holistic and comprehensive approach to environment and health is needed, with precaution and prevention of risk and taking account of particularly vulnerable groups such as children and elderly. Implementation of existing legislation and further actions are needed in the individual policy areas.

#### 3.3.2 *Protection against noise*

Noise still belongs to the most concerned environmental pollutants. This is an essential social problem, and transportation is seen as the primary source. Accepting mobility as a basic human need and as an essential precondition for maintaining economic prosperity and wealth in an enlarging Europe, it is clear that the adverse effects of noise must be reduced while facing a continued increase in freight and passenger transport. It also becomes a problem for biodiversity, because it seems, that noise makes habitats for some kind of species uncomfortable (for example birds) and leads to decreases of populations.

#### **Objective**

According to the Commission proposal for a Directive relating to the assessment and management of Environmental noise, the European Parliament and Council have adopted **Directive 2002/49/EC** of 25 June 2002 whose main aim is to provide a common basis for tackling the noise problem across the EU. The underlying principles of this text, are similar to those for other overarching environment policy directives:

1. Monitoring the environmental problem; by requiring competent authorities in Member States to draw up "strategic noise maps" for major roads, railways, airports and agglomerations, using harmonized noise indicators  $L_{den}$  (day-evening-night equivalent level) and  $L_{night}$  (night equivalent level). These maps will be used to assess the number of people annoyed and sleep-disturbed respectively throughout Europe
2. Informing and consulting the public about noise exposure, its effects, and the measures considered to address noise, in line with the principles of the Aarhus Convention
3. Addressing local noise issues by requiring competent authorities to draw up action plans to reduce noise where necessary and maintain environmental noise quality where it is good. The directive does not set any limit value, nor does it prescribe the measures to be used in the action plans, which remain at the discretion of the competent authorities.
4. Developing a long-term EU strategy, which includes objectives to reduce the number of people affected by noise in the longer term, and provides a framework for developing existing Community policy on noise reduction from source. With this respect, the Commission has made a declaration

concerning the provisions with regard to the preparation of legislation relating to sources of noise.

The risk of disturbance from noise must be taken into consideration in strategic environmental assessment. In order to make it possible in the following part of the chapter one impact to assess is being proposed – “Disturbance from noise” (No. 8).

### **3.3. 3      *Transport safety***

There is no doubt about the objective to decrease deaths and injuries caused by accidents. In concretion there are two targets:

- The goal of the EU-Commission (84) is to halve the number of deaths until 2010 (on the basis of 2000: 40.000 deaths in EU-15, 50.000 in EU-25).
- The Swedish Parliament has approved the “Vision Zero” in 1997 (85) including the long-term road safety goal: there should be no fatalities or serious injuries in road traffic.

The transport safety must be taken into consideration in strategic environmental assessment. In order to make it possible in the following part of the chapter one impact to assess is being proposed – “Accidents on humans” (No. 16).

### **3.3. 4      *Soils protection***

Little attention has so far been given to soils in terms of data collection and research. Yet, the growing concerns on soil erosion and loss to development as well as soil pollution illustrate the need for a systematic approach to soil protection, covering [25]:

1. Erosion and desertification
2. Pollution from landfill waste sites, industry and mining
3. Pollution from air, water, and from some agricultural practices and the application of sewage sludge contaminated by heavy metals, organic pollutants or pathogens
4. Loss of land and therefore soil to development

Soil is essentially a non-renewable resource with potentially rapid degradation rates and extremely slow formation and regeneration processes. The importance of soil protection is recognized both internationally and within the EU. At the Rio summit the participating states adopted a series of declarations of relevance to soil protection. The aim of the 1994 **United Nations Convention to Combat Desertification [19]** is to prevent and reduce land degradation, rehabilitate partly degraded land and reclaim partly desertified land. The 6th Environmental Action Programme established the objective to protect soils against erosion and pollution while the **Sustainable Development Strategy**, [27], noted that soil loss and declining fertility are eroding the viability of agricultural land.



Soil has considerable storage and buffering capacity [25], closely related to its organic matter content. This applies not only to water, minerals, and gases, but also to a multitude of chemical substances. These include both natural and manmade contaminants, which can build up in soil but whose subsequent release can follow very divergent patterns. Certain contaminants can exceed irreversibility thresholds for storage and buffering capacity unnoticed. Anticipatory policies based on monitoring and early warning systems are essential to prevent damage to the environment and risks to public health.

The Community's **6<sup>th</sup> Environment Action Programme** [24] includes a thematic strategy on soil protection with particular attention to preventing erosion, deterioration, contamination and desertification. The purpose of this Communication is to build on this political commitment in order that soil protection be achieved more fully and systematically in coming years by setting out the way towards developing this strategy. However, this Communication is also the first occasion on which the Commission has addressed soil protection for its own sake and therefore it is both broad and descriptive in approach. It addresses inter alia erosion, the decline in soil organic matter and prevention of pollution. It aims in particular to:

1. describe the multiple functions of soils
2. identify its characteristics relevant to policy development
3. identify the main threats to soil
4. present an overview of relevant Community policy
5. present the current situation regarding soil information and monitoring and identify gaps which need to be filled as a basis for soil protection policy
6. establish the policy basis and outline the steps towards the presentation of a thematic strategy on soil protection.

The Commission considers that soil protection at this stage can best be achieved through a strategy based on [25]:

1. initiatives in environmental policies,
2. integration in other policies,
3. soil monitoring, and
4. the future development of new actions based on monitoring results.

Together, these actions form the basis for a thematic strategy on soil which relies in the first instance on current knowledge as the basis for action and, in the future, on developing more fully a knowledge basis for future actions[23].

Land use policy can play an important role in protecting soil resources, by limiting soil sealing and ensuring that soil characteristics (e.g. soil erosion risk) are taken into account in decisions concerning allocation and use of land.

The risk of soil pollution must be taken into consideration in strategic environmental assessment. In order to make it possible in the following part of the chapter two impacts to assess are being proposed – “Concentration of pollutants in soil” (No. 5) and “Acidification” (No. 11).

### 3.3. 5 *Water protection*

The **Water Framework Directive (WFD – Directive establishing a new framework for Community action in the field of water policy (2000/60/EC)** sets a framework for comprehensive management of water resources in the European Community, within a common approach and with common objectives, principles and basic measures. It addresses inland surface waters, estuarine and coastal waters and groundwater. The fundamental objective of the **Water Framework Directive** aims at maintaining 'high status' of waters where it exists, preventing any deterioration in the existing status of waters and achieving at least 'good status' in relation to all waters by 2015. Member States will have to ensure that a coordinated approach is adopted for the achievement of the objectives of the WFD and for the implementation of programmes of measures for this purpose. The objectives of the WFD are:

1. to protect and enhance the status of aquatic ecosystems (and terrestrial ecosystems and wetlands directly dependent on aquatic ecosystems)
2. to promote sustainable water use based on long-term protection of available water resources
3. to provide for sufficient supply of good quality surface water and groundwater as need for sustainable, balanced and equitable water use
4. to provide for enhanced protection and improvement of the aquatic environment by reducing / phasing out of discharges, emissions and losses of priority substances
5. to contribute to mitigating the effects of floods and droughts
6. to protect territorial and marine waters
7. to establish a register of 'protected areas' e.g. areas designated for protection of habitats or species.

The directive rationalizes and updates existing water legislation by setting common EU wide objectives for water. It is very broad in its scope and relates to water quality in rivers, lakes, canals, groundwater, transitional (estuarine) waters and coastal waters out a distance of at least one nautical mile.

There are a number of objectives in respect of which the quality of water is protected. The key ones at European level are general protection of the aquatic ecology, specific protection of unique and valuable habitats, protection of drinking water resources, and protection of bathing water. All these objectives must be integrated for each river basin. It is clear that the last three - special habitats, drinking water areas and bathing water - apply only to specific bodies of water (those supporting special wetlands; those identified for drinking water abstraction; those generally used as bathing areas). In contrast, ecological protection should apply to all waters: the central requirement of the Treaty is that the environment should be protected to a high level in its entirety.

#### ***Surface water***

##### Ecological protection

For this reason, a general requirement for ecological protection, and a general minimum chemical standard, was introduced to cover all surface waters. These are the two elements 'good ecological status' and 'good chemical status'. Good ecological status is defined in Annex V of the **Water Framework Directive**, in terms of the quality of the biological community, the hydrological characteristics and

the chemical characteristics. As no absolute standards for biological quality can be set which apply across the Community, because of ecological variability, the controls are specified as allowing only a slight departure from the biological community which would be expected in conditions of minimal anthropogenic impact. A set of procedures for identifying that point for a given body of water, and establishing particular chemical or hydromorphological standards to achieve it, is provided, together with a system for ensuring that each Member State interprets the procedure in a consistent way (to ensure comparability). The system is somewhat complicated, but this is inevitable given the extent of ecological variability, and the large number of parameters, which must be dealt with.

#### Chemical protection

Good chemical status is defined in terms of compliance with all the quality standards established for chemical substances at European level. The Directive also provides a mechanism for renewing these standards and establishing new ones by means of a prioritisation mechanism for hazardous chemicals. This will ensure at least a minimum chemical quality, particularly in relation to very toxic substances, everywhere in the Community.

The risk of surface water pollution must be taken into consideration in strategic environmental assessment. In order to make it possible in the following part of the chapter two impacts to assess are being proposed – “Concentration of pollutants in surface water” (No. 6) and “Acidification” (No. 11).

### ***Groundwater***

#### Chemical status

The case of groundwater is somewhat different. The presumption in relation to groundwater should broadly be that it should not be polluted at all. For this reason, setting chemical quality standards may not be the best approach, as it gives the impression of an allowed level of pollution to which Member States can fill up. A very few such standards have been established at European level for particular issues (nitrates, pesticides and biocides), and these must always be adhered to. But for general protection, we have taken another approach. It is essentially a precautionary one. It comprises a prohibition on direct discharges to groundwater, and (to cover indirect discharges) a requirement to monitor groundwater bodies so as to detect changes in chemical composition, and to reverse any anthropogenically induced upward pollution trend. Taken together, these should ensure the protection of groundwater from all contamination, according to the principle of minimum anthropogenic impact.

#### Quantitative status

Quantity is also a major issue for groundwater. Briefly, the issue can be put as follows. There is only a certain amount of recharge into a groundwater each year, and of this recharge, some is needed to support connected ecosystems (whether they be surface water bodies, or terrestrial systems such as wetlands). For good management, only that portion of the overall recharge not needed by the ecology can be abstracted - this is the sustainable resource, and the Directive limits abstraction to that quantity.

One of the innovations of the Directive is that it provides a framework for integrated management of groundwater and surface water for the first time at European level.

The risk of negative effects on groundwater quality and quantity must be taken into consideration in strategic environmental assessment. In order to make it possible in the following part of the chapter one impact to assess is being proposed – “Hydraulic risks” (No. 17).

### **3.3. 6     *Air quality***

For more than 25 years the problems of air pollution, especially in the view of its transboundary effects, were taken very seriously. In 1979 the Convention on Long-range Transboundary Air Pollution was adopted in Geneva [8] and . Several protocols followed the Convention: Protocol concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes [9], Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes [10], Protocol on Further Reduction of Sulphur Emissions [11], Protocol on Heavy Metals [12] and Protocol to Abate Acidification Eutrophication and Ground-level Ozone [13]. In 1992 United Nations Framework Convention on Climate Change [17] was adopted, together with connected documents: Kyoto Protocol on Climate Change [18] and “A Guide to the Climate Change Convention Process” [19].

#### Standards

**Directive 80/779/EEC** on air quality limit values and guide values for sulphur dioxide and suspended particulates established binding annual and winter limit values and non-binding guide values for sulphur dioxide and suspended particulates in the atmosphere. Its main purpose was to protect human health and limit values were based on findings of the World Health Organisation.

1. Countries need to assess whether there are operational measuring stations at sites where pollution is expected to be the greatest. Those measuring stations need to use reference methods for sampling and analysis of sulphur dioxide and suspended particulates. Additional measuring stations may be required.
2. Procedures need to be put in place to allow data compilation and analysis at national level and reporting to the Commission.
3. Procedures need to be put in place to ensure that in case the concentrations exceed the limit values in Annex I, the Commission is informed and plans are developed for the progressive improvement of the quality of air in those zones. This requires identification of the main sources of pollution and an assessment of emission reduction possibilities.

Council **Directive 82/884/EEC** prescribed a maximum limit value for lead concentrations in air to protect human health, but insufficient technical and scientific information was available at the time to set limit values for environmental protection.

1. Countries need to assess whether there are operational measuring stations at sites where individuals may be exposed continually for a long period and where there is a likelihood that the threshold limit value for lead is exceeded. Those measuring stations need to use a conforming methods for sampling and analysis.
2. Procedures need to be put in place to allow data compilation and analysis at national level and annual reporting to the Commission.
3. Procedures need to be put in place to ensure that in case the concentrations exceed the limit values, the Commission is informed and plans are developed for

the progressive improvement of the quality of air in those zones. This requires identification of the main sources of pollution and an assessment of emission reduction possibilities.

**Directive 85/203/EEC** laid down binding limit values designed to protect human health and non-binding guide values to improve the protection of human health and contribute to the long-term protection of the environment. The guide values are intended to serve as reference points for the establishment of specific schemes in zones determined by the Member States.

1. Countries need to assess whether there are operational measuring stations at sites where the limit value is likely to be exceeded. Additional measuring stations may be required.
2. Procedures need to be put in place to allow data compilation at national level and reporting to the Commission within six months after each calendar year.
3. Procedures need to be put in place to ensure that in case the concentrations exceed the limit values, the Commission is informed thereof and that plans are developed for the progressive improvement of the quality of air in those zones. This requires identification of the main sources of pollution and an assessment of emission reduction possibilities.

As ground-level ozone levels are increasing, mainly due to the increase in motor vehicle traffic in the EU, **Directive 92/72/EEC** required the Member States to establish an ozone monitoring network. It set health and vegetation protection thresholds for ozone and required each Member State to warn the population when these thresholds were exceeded. Threshold exceedances had to be notified to the Commission on a monthly basis.

During the course of 1998, the Commission intends to come forward with a proposal for a Directive within the context of the **Air Quality Framework Directive**, establishing limit/target values for tropospheric ozone together with very precise monitoring requirements.

1. Countries need to assess whether there are operational measuring stations at sites where the threshold values are likely to be exceeded. The sites need to be selected in accordance with Annex II and need to use a reference method for analysis in accordance with Annex V. Additional measuring stations may be required.
2. Procedures need to be put in place to ensure that in case the concentrations exceed the limit values, the public is informed in accordance with Annex IV, and the Commission is informed by the end of the following month.
3. Procedures need to be put in place to allow data compilation at national level and annual reporting to the Commission.

The risk of negative effects on air quality must be taken into consideration in strategic environmental assessment. In order to make it possible in the following part of the chapter several impacts to assess are being proposed – “Photochemical pollution” (No. 12), “toxicity” (No. 13), Eutrophication (No. 14) and “Sensitive pollution” (No. 9).

### 3.4 Tackling climate change

The scientific consensus is that climate change is happening and the human activity causes the increases in concentrations of greenhouse gases that are the cause of the problem. The key priority for the 6<sup>th</sup> Programme [24] is the ratification and implementation of the Kyoto Protocol to cut greenhouse gas emissions by 8% over 1990 levels by 2008-12. This must be considered as a first step to the long term target of a 70% cut. Given the long-term objective, a global reduction in the order of 20 – 40% (depending on actual rates of economic growth and thus greenhouse emissions as well as the success of measures taken to combat climate change) over 1990 by 2020 will need to be aimed at, by means of an effective international agreement.

The greenhouse gases of concern are carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), as well as so called 'fluorinated gases'. The major driving force behind the increases in emissions of greenhouse gases is burning of fossil fuels in cars, trucks, airplanes, power plants, domestic heaters, etc.

In 1990 transport related CO<sub>2</sub> emissions were measured at 739 Mt, representing 24% of energy related CO<sub>2</sub> emissions. Prognoses show that transport related CO<sub>2</sub> emissions will reach 1000 Mt by 2010 (+260 Mt CO<sub>2</sub>), i.e. almost a 40% increase (this amount would represent 30% of total energy related CO<sub>2</sub> emissions, estimated at 3300 Mt CO<sub>2</sub> in 2010). Transport sector will account for more than 70% of the overall increase in emissions between 1990 and 2010.

The fundamental problem is the current long-term growth of transport demand, exceeding even the overall economic growth rate. The growth of transport demand is mainly canalized into road transport and aviation, thus defeating the efforts to reduce CO<sub>2</sub> emissions by energy efficiency and traffic management measures within these modes. The sustainable mobility concept of the Common Transport Policy has been successful in its 'mobility' aspect but has only marginally contributed to 'sustainability' as far as CO<sub>2</sub> emissions are concerned.

The risk of climate change must be taken into consideration in strategic environmental assessment. In order to make it possible in the following part of the chapter one impact to assess is being proposed – "Climate change" (No. 10). There is also additional one that is strictly connected to climate change (but not only this) – "Use of fossil fuels / renewable energy" (No. 7)

### 3.5 Sustainable use of natural resources and management of wastes

Meeting the challenges of today's environmental problems requires looking beyond a strictly legislative approach and taking a more strategic approach to inducing the necessary changes in the production and consumption patterns [23]. There is need to make the best use of a whole range of instruments and measures to influence decisions made by policy planners.

The Resources Strategy [27] is breaking new ground as the EU has no overall policy at present to address the environmental impacts of resource use and the Commission is not aware of any comprehensive national policies that address this area either. On the other hand, the OECD has done substantial work. The "**Environmental Strategy for the First Decade of the 21<sup>st</sup> Century**" [22], sets, among other things, the goal of decoupling environmental pressures from economic growth. The Resources Strategy [27] will build on this and other work, including

existing strategies and policies that are resource-related, such as the Thematic Strategy for Soil Protection [25], the Biodiversity Strategy [14] and the forthcoming Strategy on the Urban Environment [29].

The Resources Strategy [27] will complement environmental policies which address the status of environmental media. Its point of departure is the beginning of the life-cycle of resources (i.e. mining, harvesting, etc.). From there it tracks resources through the economy, identifies the most serious environmental impacts related to their use and develops solutions. At this point it links in with the other strategies and policies mentioned above. The Resources Strategy [27] may therefore be seen as the base of a pyramid of environmental policies, the top of the pyramid being concern for human health and bio-diversity.

The issues connected with sustainable use of materials must be taken into consideration in strategic environmental assessment. In order to make it possible in the following part of the chapter two impacts to assess are being proposed – “Consumption of non-renewable raw materials and recycling of waste in construction (No. 4) “and “Use of fossil fuels /renewable energy” (No. 7).

### **3.6 Gaps of objectives and targets**

During the last 10 years a lot of strategic document at the different levels were prepared and implemented all over Europe. These documents cover almost all main environmental protection targets and objectives, the main threats and risks. At the same time, although they are presented in strategic document, they demand more project than strategic approach. The whole legal system based on EU Directives indicates the detailed standards for different emission and emission levels in the environment. The strategic targets and objectives are very (maybe even – too) general.

Analysing the SEA Directive it should be noticed that several environmental elements are obligatory taken into account. The above-mentioned documents treat them with different attention but generally cover all of them. However there are two exceptions:

- Still there is gap of regulations concerning transport of dangerous goods although there may be the impression that the rules for transport of dangerous goods and hazardous materials should be established at the high, strategic level.
- In strategic environmental documents the accidents are still out of interest although there are a lot of international programmes aiming to improve the road / railway safety.

#### **4. Selection Criteria for elaboration indicators**

The indicators have been envisaged, in the COST 350 action, as the main tool to carry out a strategic environmental assessment (SEA) of transport plans and programmes. The different typology of pollution and impacts, and the complexity of environmental impact mechanisms are so high that the decision-makers need a support in doing their choice that is based on few, simple, but strict and scientific elements.

In addition, we notice, in WG 2 report, that the quality and the quantity of available information useful to assess environmental impacts of transport policies, plans and programs are very different according the different case studies. Following this remark, we have decided to establish different abstraction levels of available information taking into account quality and quantity of information, and to propose a set of indicators for each level.

Thus, we propose three sets of indicators for SEA of transport plans and programmes, obtained passing through two main steps:

- the definition of a methodological assessment framework;
- the definition of selection criteria and valuation method ;

##### **4.1.1 Definition of a methodological assessment framework**

The approach chosen in the methodology proposed is the “Driving Force – Pressure – State – Impact – Response” (DPSIR) model [Aee, 1999] in order to analyse and structure environmental parameters.

To follow this scheme, the first step has been to identify the major environmental targets which are affected by traffic and transport infrastructures. Nine main environmental targets have been selected regarding those mentioned into the SEA directive (DIR 2001/42/EC) (biodiversity, population, soil, water, air, climate, material resources, culture, and landscape).

The second step has been to show the pressures (due to driving forces) of transport plans and programmes on the aforementioned environmental targets. To this aim, the pressures have been classified according traffic and transport infrastructure. In the field of infrastructure pressures there are land uptake, barrier effects, visual disturbances, material consumption and waste production, and energy consumption. Vehicles contribute to noise, pollutants emissions, accidents, material consumption and waste production, and energy consumption.

The third step has been to describe the major impacts involved by the pressures and menacing the environmental targets. For instance, traffic CO<sub>2</sub> emissions (pressure) involve a global warming (impact) which affects climate (state). The selected impacts are twenty: climate change, toxicity, disturbance from noise, fragmentation of habitats, acidification, etc.

In the context of COST 350, the responses of decision-makers have not been considered.

The definition of a general assessment framework is necessary to structure global information relative to environmental impacts of transport systems. Regarding the results of the analysis the indicators defined for SEA of transport plans and programmes can be based on two axes:



- the driving forces which totally belong to transport parameters and the pressures which constitute the link between transport and environmental parameters;
- the impacts which only belongs to environmental parameters.

#### 4.1.2 Definition of selection criteria

The selection of indicators is a very difficult task due to the many indicators existing in literature. As the choice of indicators must be supported by a scientific and transparent approach, we should provide a set of indicators which is relevant to SEA of transport plans and programmes.

The definition of a set of selection criteria thus appears as a crucial point before proposing indicators, because it makes our choices clear, in terms of the type of indicators we are looking for.

The defined set of criteria has been obtained through a cross-analysis of the work of the WGs 3 and 4, the guidelines released by European Union, and some remarks coming from WG 5.

Firstly, the criteria have been classified in two groups: general criteria and specific criteria. The general criteria refer to global objectives of strategic environmental assessment. Criteria have to show ability of indicators to evaluate environmental performance, as it is recommended by the European Commission. Five general criteria have been proposed:

- significance;
- completeness;
- simplicity and applicability.;
- scientific validity;
- transferability.

In addition to these general criteria, specific criteria may be added. Specific criteria are strictly linked to the goals of COST 350. Criteria have to show that indicators bring specific information regarding:

- European rules-oriented approach
- transport-oriented approach;
- SEA-oriented approach;
- decision-making-oriented approach.

This scheme has allowed to define ten criteria, used to select the indicators presented later (§ 2). These criteria are the same proposed in the WG3 and 4, and here they are described in a detailed way, putting all the question they have to answer. Not all these questions are mentioned in the chapters describing the transport and the environmental indicators as, in each of that case, only some questions are relevant while other are redundant or not significant and vice-versa. Hereafter the ten criteria are described and explained.

##### **1) Significance**

The first criterion wants to verify the relevance for the objective of the plan: a strong relationship (direct or indirect) between the indicator and the objective of the plan, in term of environment, has to be envisaged replying to the following questions:

- how good is the indicator to provide a basis for the evaluation of actions and plans?;
- how important is the indicator for the environment?
- how well the indicator provides an early warning of potential problems?

- how well the indicator demonstrates a move towards or away from sustainability?
- how well the indicator follows cover the targets?
- how well the indicator give a prognosis? Ability to evaluate long term effects of the plan.

## **2) Completeness:**

- how well the indicator covers the different parameter of the DSIPR framework?
- how well the hole set of indicators issues the impact pressures of the project?
- what relation exists between the different indicators (non-redundancy)?

## **3) Simplicity and applicability:**

- how well the indicator can be calculated using easy tools ?
- how well the indicator can be calculated, during the updating in the years, using easy tools ?;
- how is the number of indicators relatives to same topic? (The lower it is, the better it will be)
- how well the indicator can be calculated using simple data that are easily achievable in term of money and time and, above all, that are at a raw level (non elaborated) ?;

## **4) Scientific validity:**

- how well will it describe the impacts effectively?
- how well will it describe the impacts precisely?
- how big is the consensus on the validity of the indicator?
- how well the indicator can be calculated avoiding errors due to the calculation methods. Hence, this means: how much are the methods reliable in avoiding bias ?

## **5) Transferability:**

- in time:
  - how well the indicator can be used in different time periods (past, present, short and long term future) ?;
  - how well the indicator performs to provide a basis for comparison across time ?;
- in space:
  - how well the indicator can be used in different geographical areas maintaining its performance ?
  - how well the indicator can be used in a standardized way at different geographical scales?;

## **6) European rules-oriented:**

- how well the indicator follows the European rules and how well does it cover the targets? (referred to the relevance to the objectives of the plan)

## **7) Transport-oriented:**

- how is the responsibility of the transport sector in the considered impact evaluated by the indicator?
- how well the indicator shows the contribution of the transport sector in the considered impact evaluated by the indicator?

**8) SEA-oriented:**

- how good is the indicator to provide a basis for actions and plans?
- how well the indicator assesses the environment on the strategic level?

**9) Decision-making-oriented:**

- how useful is the indicator for the end-users (decision makers)?
- how well the indicator is comprehensible to the public/decision makers?

**4.1.3 Definition of a valuation method**

A preoccupation always found in a strategic evaluation is to provide results clear, simple and transparent. It is also crucial that all theories, argumentations, methods, etc. respect these conditions. For this reason we have built a method which permits to evaluate indicators, according the list of criteria, following the principal constraints mentioned above.

Thus, each criterion is evaluated considering different questions and a mark is given to the different questions. The magnitude of the response for all the questions is defined such as:

- 1 (negative answer),
- 2 (positive answer),
- 3 (very positive answer).

All responses are given for the indicators selected by the WGs 3 and 4. The aggregation of the different marks, where more questions are considered within a criterion, is based on a simple addition of the different results, giving a final score.

We admit that an indicator should satisfy a minimum of 50% of each criterion (that means 50% of the questions relative to each criteria) to be adopted. If one indicator does not satisfy this minimum of 50% for one criterion (or more), the indicator cannot be selected.

The valuation of the different indicators found in literature is done in part 5.1 Valuation of selected indicators.

As it can be seen in table 3 of chapter 2 “Structuring information with DPSIR” we considered seventeen (17) impacts were every impact corresponds to an indicator which is then divided into three levels according to the availability of information. The three corresponding levels of information are of low, intermediate and high data availability.

In the valuation in chapter 5.1 we display for simplicity only the high level of information (see below table 4) from the 51 different level indicators that have satisfied the selection.

Table 4: List of environmental impact indicators for a strategic valuation of traffic and transport infrastructure

No	Impact	Indicator, depending on availability of information		
		low	intermediate	high
1	Land uptake	Change of surface transport infrastructure	Valuable area lost-sealed area	Natural habitat area lost Domestic and recreation area lost Sealed area
2	Fragmentation of habitats	Risk of impact on valuable areas	Importance of existing habitats and planned ecological networks, length and numbers of cuttings, Fragmentation-Index	Endangerment of populations of (representative) target species
3	Visual disturbance	Risk of impact on valuable areas	Same as high, partly approximated	Claim of valuable areas x effect's magnitude
4	Material consumption and Waste production	None	Consumption of non-renewable raw materials and recycling of waste in construction	Consumption of non-renewable raw materials and recycling of waste in construction
5	Concentration of pollutants in soils	None	Risk of pollution of sensitive soils	Concentration of lead, PAH, pesticides, salt in soil
6	Concentration of pollutants in surface water	Risk of pollution of sensitive water	Same as level 3, partly approximated	Concentration of oil-derivatives, pesticides and salt in water
7	Energy consumption	a) Level of service, b) Transport volume	a) same as level 1, b) same as level 3, partly estimated	a) same as level 1, b) Use of fossil fuels /renewable energy
8	Disturbance from noise	Same as level 2, partly approximated	Risk of affecting highly populated areas or sensitive habitats	Number of people affected by noise level oversteps or proximity of sensitive habitats
9	Sensitive pollution	None	Emissions for	Sensitive Pollution
10	Climate change	Transport volume, weighted by CO <sub>2</sub> -emission-coefficient	Same as level 2, partly approximated	CO <sub>2</sub> -emission

(Continue) Table 4: List of environmental impact indicators for a strategic valuation of traffic and transport infrastructure

No	Impact	Indicator, depending on availability of information		
		low	intermediate	high
11	Acidification	None	Same as high, partly approximated	Emission of pollutants with acidification potential
12	Photochemical pollution	None	Same as high, partly approximated	Emission of photochemical pollutants
13	Toxicity	Emissions of toxic or ecotoxic gases	Risk of affecting a highly populated area (human health) or valuable or sensitive habitats	Number of people or protected area exposed to toxic or ecotoxic pollutant immission standards oversteps of heavy metals (Cu), persistent organic compounds (POC), Particulates, NO <sub>x</sub> (NO <sub>2</sub> ), SO <sub>x</sub> (SO <sub>2</sub> ).
14	Eutrophication	None	Same as level 3, partly approximated	Emission of pollutants with eutrophication potential
15	Release of dangerous goods due to accidents	None	Probability of accidents causing ecological catastrophes	Probability of accidents causing ecological catastrophes within vulnerable areas
16	Accidents	Accident risk	Same as Level 3, partly approximated	Number of killed, seriously or slightly injured persons due to accidents
17	Hydromorphological risks	None	Area affected, species lost, people affected, cost of water supply, partly approximated	Area affected, species lost, people affected, cost of water supply

## **5. Indicators**

### **5.1 Valuation of selected indicators-impacts**

Several criteria have been defined for the valuation and selection of indicators-impacts useful for the strategic evaluation and more particularly to an integrated assessment of environmental impact of traffic and transport infrastructure. The criteria are provided from reflection by guidelines released by European Union.

In order to give the maximum of transparency and comprehensiveness each criterion is defined by different questions and a method has been built; which permits to evaluate the impact-indicators; according to the list of the above criteria, following the principal constraints mentioned in detail in chapter 4. Selection Criteria for elaboration indicators.

All the topics are described in detail within the following Valuation Tables, which present the response to all the specific questions, and the overall score (global evaluation) that can be found in the bottom row of the tables 5-8.

For Simplicity only the high level (level 3) of information which is 17 indicators of the total 51 are presented below).

Valuation Table 5

Impact	No 1	No 2	No 3	No 4
Indicator name	Natural habitat area lost Domestic and recreation area lost Sealed area	Endangerment of populations of (representative) target species	Claim of valuable areas x effect's magnitude	Consumption of non-renewable raw materials and recycling of waste in construction
Significance	Significance	Significance	Significance	Significance
1.1)	3	3	2	2
1.2)	2	3	2	2
1.3)	2	3	2	2
1.4)	2	3	2	2
1.5)	3	3	2	2
1.6)	2	3	2	2
<b>Total</b>	<b>14</b>	<b>18</b>	<b>12</b>	<b>12</b>
Completeness	Completeness	Completeness	Completeness	Completeness
2.1)	3	2	3	2
2.2)	2	3	3	3
2.3)	2	2	2	2
<b>Total</b>	<b>7</b>	<b>7</b>	<b>8</b>	<b>7</b>
Simplicity	Simplicity	Simplicity	Simplicity	Simplicity
3.1)	3	3	3	3
3.2)	2	3	2	3
<b>Total</b>	<b>5</b>	<b>6</b>	<b>5</b>	<b>6</b>
Scientific validity	Scientific validity	Scientific validity	Scientific validity	Scientific validity
4.1)	3	3	3	3
4.2)	3	3	3	3
4.3)	3	3	3	3
4.4)	3	3	3	3
<b>Total</b>	<b>12</b>	<b>12</b>	<b>12</b>	<b>12</b>
Applicability	Applicability	Applicability	Applicability	Applicability
5.1)	3	3	3	2
5.2)	2	2	3	3
<b>Total</b>	<b>5</b>	<b>5</b>	<b>6</b>	<b>5</b>
European Rules-oriented	European Rules-oriented	European Rules-oriented	European Rules-oriented	European Rules-oriented
6.1)	3	3	3	2
<b>Total</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>2</b>
Transport-oriented	Transport-oriented	Transport-oriented	Transport-oriented	Transport-oriented
7.1)	2	3	3	2
7.2)	3	3	3	3
<b>Total</b>	<b>5</b>	<b>6</b>		<b>5</b>
SEA-oriented	SEA-oriented	SEA-oriented	SEA-oriented	SEA-oriented
8.1)	3	3	3	3
8.2)	3	3	3	3
<b>Total</b>	<b>6</b>	<b>6</b>	<b>6</b>	<b>6</b>
Decision-making-oriented	Decision-making-oriented	Decision-making-oriented	Decision-making-oriented	Decision-making-oriented
9.1)	3	3	2	2
9.2)	3	1	2	2
<b>Total</b>	<b>6</b>	<b>4</b>	<b>4</b>	<b>4</b>
<b>Global Results</b>	<b>69</b>	<b>67</b>	<b>56</b>	<b>59</b>

Valuation table 6

Impact number	No 5		No 6	No 7	No 8	No 9
Indicator name	Concentration of lead, PAH, pesticides, salt in soil		Concentration of oil-derivatives, pesticides and salt in water	a) same as level 1, b) Use of fossil fuels /renewable energy	Number of people affected by noise level oversteps or proximity of sensitive habitats	Sensitive Pollution
Significance	Significance	Significance	Significance	Significance	Significance	Significance
1.1)	2		2	2	2	2
1.2)	2		2	2	3	2
1.3)	3		3	1	3	2
1.4)	3		3	2	3	2
1.5)	3		3	2	3	2
1.6)	1		1	1	2	2
Total	14		14	10	16	12
Completeness	Completeness	Completeness	Completeness	Completeness	Completeness	Completeness
2.1)	3		3	1	3	3
2.2)	3		3	1	3	3
2.3)	2		2	1	3	3
Total	8		8	3	9	9
Simplicity	Simplicity	Simplicity	Simplicity	Simplicity	Simplicity	Simplicity
3.1)	3		3	2	3	3
3.2)	2		2	2	3	3
Total	5		5	4	6	6
Scientific validity	Scientific validity	Scientific validity	Scientific validity	Scientific validity	Scientific validity	Scientific validity
4.1)	3		3	3	3	3
4.2)	3		3	3	3	3
4.3)	3		3	3	3	3
4.4)	3		3	3	3	3
Total	12		12	12	12	12
Applicability	Applicability	Applicability	Applicability	Applicability	Applicability	Applicability
5.1)	3		3	3	3	2
5.2)	3		3	3	2	2
Total	6		6	6	5	4
European Rules-oriented	European Rules-oriented	European Rules-oriented	European Rules-oriented	European Rules-oriented	European Rules-oriented	European Rules-oriented
6.1)	3		3	3	3	3
Total	3		3	3	3	3
Transport-oriented	Transport-oriented	Transport-oriented	Transport-oriented	Transport-oriented	Transport-oriented	Transport-oriented
7.1)	1		1	3	2	2
7.2)	3		3	3	3	2
Total	4		4	6	5	4
SEA-oriented	SEA-oriented	SEA-oriented	SEA-oriented	SEA-oriented	SEA-oriented	SEA-oriented
8.1)	3		3	3	3	3
8.2)	3		3	3	3	3
Total	6		6	6	6	6
Decision-making-oriented	Decision-making-oriented	Decision-making-oriented	Decision-making-oriented	Decision-making-oriented	Decision-making-oriented	Decision-making-oriented
9.1)	2		2	2	3	2
9.2)	2		2	2	3	2
Total	4		4	4	6	4
Global Results	62		62	54	68	60



Valuation Table 7

Impact number	No 10	No 11	No 12	No 13
Indicator name	CO2-emission	Emission of pollutants with acidification potential	Emission of photochemical pollutants	Number of people or protected area exposed to toxic or ecotoxic pollutant immission standards oversteps of heavy metals (Cu), persistent organic compounds (POC), Particulates, NOx (NO2), SOx (SO2)
Significance	Significance	Significance	Significance	Significance
1.1)	3	3	2	3
1.2)	3	3	3	3
1.3)	3	3	3	3
1.4)	3	3	3	2
1.5)	3	3	3	2
1.6)	3	3	2	2
Total	18	18	16	15
Completeness	Completeness	Completeness	Completeness	Completeness
2.1)	3	3	3	3
2.2)	3	3	3	2
2.3)	3	3	3	2
Total	9	9	9	7
Simplicity	Simplicity	Simplicity	Simplicity	Simplicity
3.1)	3	3	3	2
3.2)	3	3	3	2
Total	6	6	6	4
Scientific validity	Scientific validity	Scientific validity	Scientific validity	Scientific validity
4.1)	3	3	3	3
4.2)	3	3	3	3
4.3)	3	3	3	3
4.4)	3	3	3	3
Total	12	12	12	12
Applicability	Applicability	Applicability	Applicability	Applicability
5.1)	3	2	3	3
5.2)	3	2	2	3
Total	6	4	5	6
European Rules-oriented	European Rules-oriented	European Rules-oriented	European Rules-oriented	European Rules-oriented
6.1)	3	2	2	3
Total	3	2	2	3
Transport-oriented	Transport-oriented	Transport-oriented	Transport-oriented	Transport-oriented
7.1)	3	2	2	3
7.2)	3	2	2	3
Total	6	4	4	6
SEA-oriented	SEA-oriented	SEA-oriented	SEA-oriented	SEA-oriented
8.1)	3	2	2	3
8.2)	3	2	2	3
Total	6	4	4	6
Decision-making-oriented	Decision-making-oriented	Decision-making-oriented	Decision-making-oriented	Decision-making-oriented
9.1)	3	2	2	3
9.2)	3	2	2	3
Total	6	4	4	6
Global Results	72	63	62	65

Valuation Table 8

Impact number	No 14	No 15	No 16	No 17
Indicator name	Emission of pollutants with eutrophication potential	Probability of accidents causing ecological catastrophes within vulnerable areas	Number of killed, seriously or slightly injured persons due to accidents	Area affected, species lost, people affected, cost of water supply
Significance	Significance	Significance	Significance	Significance
1.1)	3	2	1	2
1.2)	3	2	3	2
1.3)	3	2	3	2
1.4)	2	2	3	3
1.5)	2	2	3	2
1.6)	2	2	3	2
<b>Total</b>	<b>15</b>	<b>12</b>	<b>16</b>	<b>13</b>
Completeness	Completeness	Completeness	Completeness	Completeness
2.1)	3	3	3	3
2.2)	2	2	3	3
2.3)	2	2	3	2
<b>Total</b>	<b>7</b>	<b>7</b>	<b>9</b>	<b>8</b>
Simplicity	Simplicity	Simplicity	Simplicity	Simplicity
3.1)	2	3	3	2
3.2)	2	3	3	3
<b>Total</b>	<b>4</b>	<b>6</b>	<b>6</b>	<b>5</b>
Scientific validity	Scientific validity	Scientific validity	Scientific validity	Scientific validity
4.1)	3	3	3	2
4.2)	3	3	3	2
4.3)	3	3	3	3
4.4)	3	3	3	2
<b>Total</b>	<b>12</b>	<b>12</b>	<b>12</b>	<b>9</b>
Applicability	Applicability	Applicability	Applicability	Applicability
5.1)	3	2	3	2
5.2)	2	2	3	2
<b>Total</b>	<b>5</b>	<b>4</b>	<b>6</b>	<b>4</b>
European Rules-oriented	European Rules-oriented	European Rules-oriented	European Rules-oriented	European Rules-oriented
6.1)	3	3	3	2
<b>Total</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>2</b>
Transport-oriented	Transport-oriented	Transport-oriented	Transport-oriented	Transport-oriented
7.1)	3	3	3	2
7.2)	2	3	3	2
<b>Total</b>	<b>5</b>	<b>6</b>	<b>6</b>	<b>4</b>
SEA-oriented	SEA-oriented	SEA-oriented	SEA-oriented	SEA-oriented
8.1)	3	3	3	3
8.2)	3	3	3	2
<b>Total</b>	<b>6</b>	<b>6</b>	<b>6</b>	<b>5</b>
Decision-making-oriented	Decision-making-oriented	Decision-making-oriented	Decision-making-oriented	Decision-making-oriented
9.1)	2	2	3	3
9.2)	2	2	3	2
<b>Total</b>	<b>4</b>	<b>4</b>	<b>6</b>	<b>5</b>
<b>Global Results</b>	<b>61</b>	<b>60</b>	<b>64</b>	<b>55</b>

## 5.2 Key impacts

In addition six issues were defined (on the base of expert evaluation) as the most relevant ones to be taken into account, if it is possible, as a whole pack\*:

Table 9: COST 350 Action proposed impact three level indicators

No	Impact	Indicator at the Highest information level
1	Land uptake	Natural habitat area lost Domestic and recreation area lost Sealed area
2	Fragmentation of habitat's	Endangerment of populations of (representative) target species
3	Disturbance from noise	Number of people affected by noise level oversteps or proximity of sensitive habitats
4	Climate change	CO2-emission
5	Toxicity	Number of people or protected area exposed to toxic or ecotoxic pollutant immission standards oversteps of heavy metals (Cu), persistent organic compounds (POC), Particulates, NOx (NO2), SOx (SO2).
6	Accidents	Number of killed, seriously or slightly injured persons due to accidents

The following table proposes other key impacts (TERM):

Table 10

No	Impact	Indicator
1	Climate change	Emissions, green house gases
2	Air Pollution	Pot. concentration of particles (PFP)
3	Noise	Annoyance
4	Accidents	Traffic fatalities
5	Protection of biodiversity (terrestrial)	Unfragmented areas
6	Energy resources	Final energy consumption
7	Land as resource	Land take by transport infrastructure

Qualification of TERMS Environmental relevant key indicators for road transport assessment [see bibliography no 29]

The main difference between the COST 350 model and the TERM model is not on the type of impacts proposed (they are actually most similar), but as to relative indicators corresponding with every impact. In our approach we propose a set of three indicators, where every one of them can be selected, according to the level of information available

\* Note

Whenever information will be available, all the six issues should be taken into account by the decision makers. This is the meaning: as a whole pack.

### 5.3 General structure

For all the different impacts the same sheet-form is used. To make clear what information is given on each impact, the general structure of the impact sheets is explained in this section:

After the general details, like the name, the number of the impact and the three levels of data availability which correspond to the indicators, the environmental factors affected are given (which are taken from the EU Directive, Annex 1) according to the following scheme (see table 10).

Table 10: General structure presentation.

Name	<i>Indicator for LOW data availability (Level 1)</i>  <i>Indicator for INTERMEDIATE data availability (Level 2)</i>  <i>Indicator for HIGH data availability (Level 3)</i>	Number
<b>ENVIRONMENTAL FACTORS AFFECTED</b>		
<b>Planning situation:</b> Here is stated on which levels of planning the indicator can be used	<input type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input type="checkbox"/> Corridor	
<b>ENVIRONMENTAL EFFECTS:</b> What are the impacts? Here you find information on which effect(s) on the environment (from infrastructure and traffic/transport) are described by this indicator.		
<b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b> Here you'll find information on in what way the transport system contributes to the general problem/situation.		
<b>INFORMATION LEVELS</b> For plans on different planning situations there will also be different levels of information available for the assessment. For this reason a distinction is made between three abstraction levels for impact assessment, as follows:  LOW data availability IMPACT ASSESSMENT: In this situation there would not be a clear specification of the types and location of transport planning alternatives. Basically, there would only be a notion of dimensions in terms of length and width of possible new alignments and of the approximate location of the regions (in terms of large planning areas) where the network expansions might take place. In addition there are some rough estimates of the extent of transport flows corresponding to the alternatives. This impact assessment level would correspond with a situation whereby preliminary transport planning alternatives would be considered on a large geographical (e.g. the national) level.  INTERMEDIATE data availability IMPACT ASSESSMENT: represents an in-between situation.		

There is no clear specification of planning alternatives but approximate locations of impact areas, and some more selective information on traffic flows is available.

**HIGH data availability IMPACT ASSESSMENT:** maximum data availability: In this situation it is assumed that there is a rather clear specification of the types and locations of planning alternatives. The infrastructure dimensions and alignments are reasonably well known and an assessment of traffic flows associated with the various planning alternatives is available. Given the specification of the locations and dimensions of planning alternatives, site specific information can be obtained on the land use and levels of activities in the impact area of the new alignments of the transport network. This impact assessment level would correspond with a situation whereby concrete transport planning alternatives have been specified on a regional or corridor level.

The following three fields exist for each of the levels 1 to 3:

#### **DESCRIPTION OF THE INDICATOR:**

How can the impacts be assessed? Give a formula and (if needed) a short explanation.

#### **DATA REQUIREMENTS AND AVAILABILITY:**

Which are the data we need for the assessment (and do we have on this information level)? This will be different for every country, but here we give as much information as possible in general. Here will also be stated which of the transport data/indicators from the last chapter are needed for the assessment of this indicator.

#### **MODELLING:**

If there are models needed to do the assessment this models and the input data needs to be available. So here is described if there is a model or are models in Europe (or other data/monitoring), if there are original data available in the member states (or if the EEA provide these) and if a prognoses can be made with this model or data on this indicator.

#### **OBJECTIVES AND TARGETS:**

Which objectives exist on EU level? And which targets exist in EU level?

The targets will be adopted literally and the source will be stated, so there can be no misconceptions on what the basis is for this indicator. Here possible related European conventions are also mentioned.

#### **TIME SCALE**

This information is needed to know from when and for how long monitoring is necessary.

#### **EXPECTANCY**

When can we expect the effect of the indicator? (short or long term)

#### **DURATION**

How long will the effect last? (short or long term).

**MONITORING POSSIBILITIES:**

The significant environmental effects must be monitored (SEA-Directive Art. 10). In this section it is stated how monitoring could work with the help of this indicator. Here it is also mentioned if there any continuous monitoring systems doing this already and if this covers our need.

**RESEARCH NEEDED:**

Which research is needed? Which are the open questions?

**REMARKS**

In this section any remaining remarks are made (for example why an indicator was chosen).

## 5.4 Presentation of the indicators

<b>Name:</b>	<i>Indicator for LOW data availability (Level 1):</i> <b>Change of surface transport infrastructure</b>	<b>No1</b>
<b>Land Uptake</b>	<i>Indicator for INTERMEDIATE data availability (Level 2):</i> <b>Valuable area lost-sealed area.</b>	
	<i>Indicator for HIGH data availability (Level 3):</i> <b>Natural habitat area lost Domestic and recreation area lost Sealed area</b>	
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>		<b>Biodiversity, Fauna, and Flora, Soil, Cultural heritage, Landscape</b>
<b>PLANNING SITUATION:</b>	<input checked="" type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input checked="" type="checkbox"/> Corridor	
<b>ENVIRONMENTAL EFFECTS:</b> Every year in the EU larger portions of land must be sacrificed for the construction of new Transport infrastructure. The negative effects of land uptake towards the Environment consist not only in the privation of free land parcels with negative effects on biodiversity, but also to the Biological deactivation of the affected soil in it self and its ability to Correctly sustain future plant life (sealing-Soil Compaction)[30]. Land uptake includes:  ➤ direct effects (the uptake of land directly for the transport infrastructure) ➤ and indirect effects (junctions, service areas, parking, auxiliary structures)  Negative “spatial“ effects of Transport infrastructure do not stop on the actual soil covered by the infrastructure itself but sometimes can spread up to a 50 meters radius from the structure to the near soil. The effects of land uptake and sealing are greater for highways, motorways and go decreasing for regional roads etc. The least effects are caused by railroads.[31] Land is under continuous pressure from new transport infrastructure. Road is the biggest land consumer, followed by rail. Lack of GIS-based data seriously hinders assessing land ‘consumption’ by transport over time, but it can be estimated that between 1990 and 1999 almost 10 ha each day were consumed by new motorway construction in the EU and about 2 ha each day in the ACs.[33]		



LAND TAKE: ha\km		
Type of infrastructure	Direct	Direct plus indirect
High speed motorway	2,5	7,5
National road	2	6
provincial road	1,5*	4,5
municipal road	0,7	2
Rail road	1	3

Table showing the Direct and indirect (in ha consumed per km of road) land take by transport :  
 This means that a provincial road consumes about 1,5\* ha of surface for every km of its length  
 (Source: EEA-ETC/LC)

Land uptake is directly related to the spatial requirements (the physical dimensions) of the new infrastructure. In this respect, a distinction is made between the direct and indirect spatial requirements of the infrastructure. The direct requirements relate to the land uptake of the new transport network links proper. The indirect land uptake includes the spatial requirements of all other facilities related to the expansion of the transport network, such as crossings and junctions, service and parking areas, auxiliary structures, etc.)

## CONTRIBUTION OF THE TRANSPORT SECTOR:

The average daily land take for motorway construction can be calculated as a proxy for land 'consumption' by transport. Using increases in motorway length and a factor for land used per kilometer of motorway (2.5), it can be estimated that between 1990 and 1998, a total of over 30 000 ha of land, about 10 ha every day, was taken for motorway construction in the EU.[4]

Transport infrastructure consumes 1.2 % of the total available land area in the EU. Road transport is by far the main consumer of land for transport. The road network (motorways, state, provincial and municipal roads) occupies 93 % of the total area of land used for transport in the EU. Rail is responsible for only 4 % of land uptake.(TERM 2000) In The EU during the period 1990-1996 a total of 25000 ha were consumed for motorway construction (10 ha per day)[1]Because of its denser infrastructure networks, land taken by transport in the EU is greater than in the ACs. It is estimated that, in 1998, road and rail infrastructure claimed around 0.82 % of total surface area in the ACs and 1.3 % in the EU. Road is the biggest land consumer in the ACs as well as in the EU.[32]

## INFORMATION LEVEL – Low availability (*Level 1*)

### DESCRIPTION OF THE INDICATOR:

Change of surface transport infrastructure, modification of the existing surface by the new infrastructure in Km<sup>2</sup> or %  
Land surface consumed-occupied for the needs of new transport infrastructure. It includes direct Land uptake for the transport structure itself as well as under the form of remaining “service areas”.

### DATA REQUIREMENTS AND AVAILABILITY:

Need of Analysis of impacts of sealing on local, landscape and global level in relation to sealing degree and quality parameters for sealing and soils; Establishment of socio economic costs of inadequate use (not corresponding with the preferred soil function) of soils by sealing; - Assessment of the benefits and negative impacts of land use planning on sealing.

### MODELLING:

It is possible in most European countries

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

### DESCRIPTION OF THE INDICATOR:

Valuable area lost-sealed area

Natural area lost m<sup>2</sup>

legal protected lost area, m<sup>2</sup>

domestic and recreation area lost, m<sup>2</sup>

### DATA REQUIREMENTS AND AVAILABILITY:

The total direct area of the planning alternative and the approximate spatial location is known as well as areas of impact zones and the areas of domestic and recreational areas, natural areas and legal protected areas within impact zones. The total area needed follows from the total direct area of the planning alternative supplemented with an estimate of the indirect area. This can be expressed in a factor relating the total area to the direct area. On average this factor might amount to about 3.

**MODELLING:**

Geographical information systems (GIS)

## INFORMATION LEVEL – High availability (*Level 3*)

**DESCRIPTION OF THE INDICATOR:**

Natural habitat area lost Domestic and recreation area lost Sealed area

**Formula Units**

Natural habitat area lost m<sup>2</sup>

Domestic and recreation area lost m<sup>2</sup>

Sealed area m<sup>2</sup>

legal protected area lost m<sup>2</sup>

agricultural area lost m<sup>2</sup>

forestry area lost m<sup>2</sup>

other area lost m<sup>2</sup>

Relevant distinctions in the impact assessment are:

- Loss of domestic and recreation area.
- Loss of natural habitat area.
- Sealed area.
- Loss of legal protected Areas (for example Natura 2000 sites)
- Loss of agricultural area
- Loss of forestry area

In order to quantify the impacts, the direct and indirect land uptake should be distinguished by types of land use, as follows:

- domestic area;
- recreational area;
- natural area (possibly by type of habitat);
- Loss of legal protected Areas (for example Natura 2000 sites)
- Loss of agricultural area
- Loss of forestry area
- Other area.

Soil sealing refers to the covering of soil as a result of infrastructure construction; with the result that soil is no longer able to perform the range of functions associated with it.

The sealed area equals the total direct and indirect area of the planning alternative with a possible correction for:

- Non-paved parts of the indirect areas (which might be known from the specification of the indirect areas).

Land taken from paved domestic area (which might be known from location and specific use of domestic area).

- The total (direct and indirect) area of the planning alternative and the spatial locations are known as well as the areas and locations of domestic and recreational areas and natural areas. The domestic and recreation area, natural areas, legal protected areas, agricultural areas, forestry areas and other areas lost can be accurately determined based on a GIS application.

#### **MODELLING:**

Geographical information systems (GIS)

#### **OBJECTIVES AND TARGETS:**

Minimise land uptake by new infrastructure development/transport unit. Move towards less surface consuming means of transport. In Germany for example a land take target of 30 ha per day by 2020 (compared to the actual 100-120 ha per day has been proposed [30]).

#### **TIME SCALE:**

#### **EXPECTANCY**

☒ Short term   ☐ Long term

#### **DURATION**

☒ Short term   ☐ Long term

#### **MONITORING POSSIBILITIES:**

Monitoring is provided by CORINE, TERM

#### **RESEARCH NEEDED:**

Data is available

**REMARKS:**

- Presumably, not all of the indirect land use might be actually paved so that the indirect land use should only be partly included in the sealed area.
- If land is taken from domestic area which is partly paved, the (additional) area sealed might have to be further corrected.
- The loss of domestic and recreational area could be interpreted as social effects. The loss of natural and legal protected areas and the extent of sealing could be interpreted as ecological effects. It could also be considered to associate economic values with the various types of land use in order to express the impact in economic terms.

<b>Name:</b>  <b>Fragmentation of Habitats</b>	<i>Indicator for LOW data availability (Level 1):</i> <b>Risk of impact on valuable areas</b>  <i>Indicator for INTERMEDIATE data availability (Level 2):</i> <b>Importance of existing habitats and planned ecological networks, length and numbers of cuttings, Fragmentation-Index</b>  <i>Indicator for HIGH data availability (Level 3):</i> <b>Endangerment of populations of (representative) target species</b>	<b>N°2</b>	
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>			<b>Biodiversity, Fauna and Flora, Landscape</b>
<b>PLANNING SITUATION:</b>	<input checked="" type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input checked="" type="checkbox"/> Corridor		
<b>ENVIRONMENTAL EFFECTS:</b>  <p>Transport networks divide habitats into small isolated patches and create barriers between populations and on migration paths. This can have four prime effects on species; firstly, it can reduce the size of habitat patches so much that they can no longer support viable populations of important species; secondly it can reduce habitat quality by emissions (negative edge effects), thirdly it can divide essential habitats for species which need separate habitats in their life cycle (like amphibians) and fourthly, it can result in the remaining patches being so isolated from each other that individuals have a low chance of moving between patches. Being unable to move between patches renders species vulnerable to local and regional extinction and it inhibits recolonization as well as sufficient adaption to patch-dynamics or to environmental changes. By these processes, habitat fragmentation by transport networks and consequential secondary developments have become one of the most serious global threats to biological diversity. (luell et al, COST 341 Habitat fragmentation due to Transportation Infrastructure, 2003)</p>			

#### Effects in keywords:

- Habitat loss
- Habitat degradation
- Habitat Fragmentation
- Loss of genetic diversity
- Local and regional extinction
- Loss of biodiversity
- Disturbance
- Invasion by road side species
- Mortality
- Barrier effects on trivial range, migration and dispersal

Fragmentation, as described above, is a collective term, which leads to a serious threat of biodiversity. Habitat loss, habitat fragmentation, disturbance, mortality and barrier effects follow from the alignment of new transport infrastructure. These adverse effects prevent the Connectivity between habitats and processes like migration and dispersal for many species. Loss of genetic diversity, local and regional extinctions and the loss of biodiversity are secondary effects that can cause by fragmentation of infrastructure planning.

Following up on the ideas already developed in the environmental indicator document, the following aspects need to be taken into account in quantifying and qualifying this type of impact:

- The definition of target species which are affected for each planning level (from local to transnational level)
- The magnitude of population of target species (or the proportion of habitat) that will be affected by the new alignment.
- The way in which the habitats of target species will be affected (i.e. distinguishing between core habitats of one population and corridors between habitats of a metapopulation).

#### **CONTRIBUTION OF THE TRANSPORT SECTOR:**

Habitat fragmentation by transport networks and consequential secondary developments have become one of the most serious global threats to biological diversity. ... While habitat fragmentation is increasingly taken into account when new infrastructure is planned, there remain many existing stretches of road and railway where mitigation measures are badly needed. The impact of existing infrastructure can change when new infrastructure is built, further increasing the need for mitigation measures. When designing measures to counteract habitat fragmentation, the focus should, therefore, be on the impact of the infrastructure network as a whole. ... (luell et al, COST 341 Habitat fragmentation due to Transportation Infrastructure, 2003).

## INFORMATION LEVEL – **Low availability** (*Level 1*)

### **DESCRIPTION OF THE INDICATOR:**

Risk of impact on valuable areas (e.g. national parks, natura-2000- or RAMSAR sites) by fragmentation

#### **Formula Units**

Ordinal scale (e.g. low – middle – high)

### **DATA REQUIREMENTS AND AVAILABILITY:**

Area affected see intermediate availability (level 2)

### **MODELLING:**

Geographical information systems (GIS), expert assessment

## INFORMATION LEVEL – **Intermediate availability** (*Level 2*)

### **DESCRIPTION OF THE INDICATOR:**

Summarizing assessment of the criteriae

- Importance (e.g. national, regional or local importance; core areas or corridor zones as shown in figure 1) of existing habitats and planned ecological networks
- Length and numbers of cuttings pursuant to the importance of habitats/ecological networks
- Fragmentation-Index (see below)

The integration of the criteriae could be made for instance by matrices (see example in indicator “Visual impact”) or by an algorithm, which fits to the other methods used in the SEA.



## The purpose and basic elements of ecological networks

Ecological networks try to tackle the underlying causes of the decline of nature: 1) the absolute loss of habitats, 2) the negative impact on vital conditions (e.g. the quality of soil and water, changes in land or water management) and 3) shrinking and isolation of wildlife areas, which negatively affects the long-term survival of populations.

Whatever the scale (from regional to continental), ecological networks consist of the following elements:

- **Core areas:** these contain important species or habitats.
- **Corridor areas:** the functional connections (linear, stepping stones or landscape) enabling dispersal and migration of species that could be subject to local extinction.
- The delineation of **buffer areas** around core areas or corridors to safeguard them from negative influences from surrounding areas.
- The identification of **restoration area:** vital enlargement of existing areas or the creation of new areas to safeguard the sustainable existence of species and ecosystems.

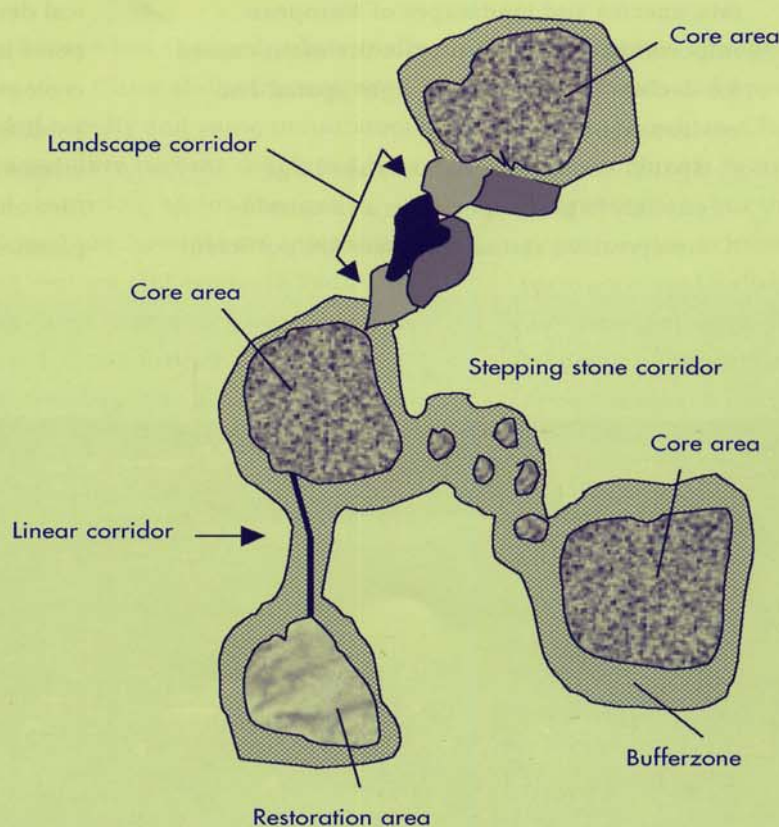


Figure 1: Purpose and basic elements of ecological networks (from 4), for further explanations see (5) also

**Fragmentation-Index** (see figure 2) can be used in areas with a homogeneous structure (= all parts of the area are of equivalent importance for the species regarded).

Impact by fragmentation is the highest in case of the cutting line being in the middle of the area. The sizes of the two remaining areas are identical ( $A1 = A2$ ). The impact is approximately zero if the cutting line is very close to the edge of the area ( $A2 \rightarrow 0$ ).

This relation can be expressed by the term

$$4 * A1 * A2 / (A1 + A2)$$

In this term, A1 and A2 represent the remaining areas after fragmentation, whereby  $A1+A2$  equals the size of the original area. Factor 4 has been chosen in order to get the size of the original area in the worst case of fragmentation in the middle ( $A1 = A2$ ):

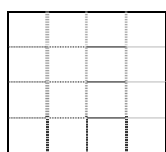
$$4 * A1 * A1 / (A1 + A1) = A1 + A1$$

In order to normalize the result into the range of 0 to 1 (that means to make it independent of the specific area size) the term above is divided by the size of the original area:

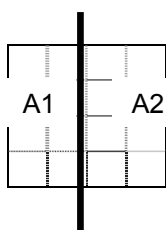
$$\text{Frag} = 4 * A1 * A2 / (A1 + A2)^2$$

with  $\text{Frag} = 1$  in the worst case of fragmentation in the middle and

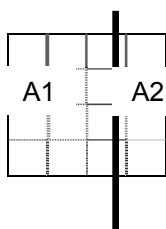
$\text{Frag} \rightarrow 0$  in the best case of fragmentation very close to the edge of the area.



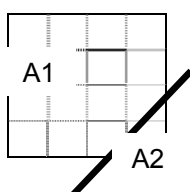
Original area  
Size = 16



Remaining areas  
 $A1 = A2 = 8$   
 $\text{Frag} = 4 * 8 * 8 / (16 * 16) = 1$



Remaining areas  
 $A1 = 12, A2 = 4$   
 $\text{Frag} = 4 * 12 * 4 / (16 * 16) = 0,75$



Remaining areas  
 $A1 = 15, A2 = 1$   
 $\text{Frag} = 4 * 15 * 1 / (16 * 16) = 0,23$

Figure 2: Fragmentation-Index

**Formula Units**

None

**DATA REQUIREMENTS AND AVAILABILITY:**

- Area affected: Maps of ecological networks ((5) – (10)), protected or important areas (e.g. Natura-2000-sites). If there aren't any network-maps available they can easily be created.
- New alignment

**MODELLING:**

Geographical information systems (GIS)

**INFORMATION LEVEL – High availability (*Level 3*)****DESCRIPTION OF THE INDICATOR:**

Endangerment of populations of (representative) target species (e.g. see Annexes II and IV of the Council directive 92/43/EEC) by fragmentation. If possible it could be counted how many important habitats will fall short beneath minimum sizes.

**Formula Units**

Probability

**DATA REQUIREMENTS AND AVAILABILITY:**

- Target species concept (incl. incident of (threatened) target species, size of the affected populations (or habitat if habitat suitability is known), size of the affected metapopulations (or sizes and arrangement of their habitats), arrangement of habitat types (for species which require more than one habitat), home range, migration range and dispersal range of the target species, size and quality of the source habitat, corridors for migration and dispersal, threaten state of the target species).
- Probability of impacts (estimation by experts)
- New alignment

**MODELLING:**

Geographical information systems (GIS), habitat suitability models (Population models like e. g. RAMAS (11) for Population vulnerability analysis)

## OBJECTIVES AND TARGETS:

Preserve a high rate of Biodiversity in Europe. Safeguard the capacity to sustain a large number of species inside protected areas (SPA, RAMSAR). Minimise annoyance close to designated areas and most of all diminish as far as possible the "Fragmentation Island effect-edge effect" [2]

Fulfil the "prospective" of Birds (CEC, 1979) and Habitats (CEC, 1992) Directives that aim at protecting more than 10 % of the territory of the EU.

Preservation and restoration of Migrating Corridors in EU (Bern Convention)

Convention on Biological Diversity (1992)

Pan-European Biological and Landscape Diversity Strategy (1995 –signed by 54 countries) and in preparation: Indicative map and Assessment Report for the Ministerial Conference "Environment for Europe (Belgrade, 2007).

Article 6 of DECISION No 1600/2002/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 July 2002 laying down the Sixth Community Environment Action Programme Stating the following [4]:

- halting biodiversity decline with the aim to reach this objective by 2010, including prevention and mitigation of impacts of invasive alien species and genotypes;
- protection and appropriate restoration of nature and biodiversity from damaging pollution;
- conservation, appropriate restoration and sustainable use of marine environment, coasts and wetlands;
- conservation and appropriate restoration of areas of significant landscape values including cultivated as well as sensitive areas;
- conservation of species and habitats, with special concern to preventing habitat fragmentation;

On biodiversity:

- ensuring the implementation and promoting the monitoring and assessment of the Community's biodiversity strategy and the relevant action plans, including through a programme for gathering data and information, developing the appropriate indicators, and promoting the use of best available techniques and of best environmental practices;
- establishing the Natura 2000 network and implementing the necessary technical and financial instruments and measures required for its full implementation and for the protection, outside the Natura 2000 areas, of species protected under the Habitats and Birds Directives;
- promoting the extension of the Natura 2000 network to the Candidate Countries;

### TIME SCALE:

### EXPECTANCY

☒ Short term   ☒ Long term

### DURATION

☒ Short term   ☒ Long term

## MONITORING POSSIBILITIES:

Fragmentation of habitats is one of the most important threats of biodiversity. Possible evidences about the influence of transport networks on the decrease of biodiversity will be shown in combination with target species, the population vulnerability and the growing transport network.

**RESEARCH NEEDED:**

Test applications of the assessment procedures mentioned above and creating an manual by the analysis of the results. Identifying valuable habitats by automatic classification of satellite images.

Identifying representative target species for the assessment of fragmentation or respectively for interlinking habitats pursuant to ecological regions of the EU. Improvement of habitat models, population models, mobility models and barrier and mortality models for those species.

Assessment and prediction of long-term fragmentation consequences on community level, population level and genetic level for valuable habitats and target species (long-term viability, long-term distribution)

**REMARKS:**

In addition the costs of fauna passages (e.g. ecoducts) necessary to avoid fragmentation effects, estimated by experts, could be taken into account. Estimation of these costs already on SEA-level could have advantages for the further steps of planning on project level: These costs are already implemented in the project's budget.

There are also fragmentation effects on recreation areas, which could be dealt with in the same manner.



**Formula Units**

Ordinal scale (e.g. low – middle – high)

**DATA REQUIREMENTS AND AVAILABILITY:**

Area affected see high availability (level 1)

**MODELLING:**

Geographical information systems (GIS), expert assessment

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

**DESCRIPTION OF THE INDICATOR:**

same as level 3

**DATA REQUIREMENTS AND AVAILABILITY:**

same as level 3, partly approximated

**MODELLING:**

Overlay by GIS

## INFORMATION LEVEL – High availability (*Level 3*)

**DESCRIPTION OF THE INDICATOR:**

(Claim of valuable areas) x (effect's magnitude)

Valuable areas (nature-orientated, e.g. conservation areas, national parks or recreational areas) may be established by regional planning, given by natural shape of landscape or defined by coherent near-natural areas not being divided by transport infrastructure.

Effect's magnitude of transport infrastructure depends on the number of lanes, the height and number of cuttings/embankments or bridges, probably on the daily traffic volume.

Visual disturbance has to be assessed according the specific circumstances of each plan or program. The more valuable the affected area and the higher the effect's magnitude the greater the visual disturbance will be. The assessment could work like the following example for roads (rail analogical):



Value of area:

Low	Areas < 100 km <sup>2</sup> without roads with daily traffic volume > 1000
Middle	Areas > 100 km <sup>2</sup> without roads with daily traffic volume > 1000
High	Recreation or conservation areas established by regional planning

Effect's magnitude:

Low	Two lane road, low proportion of embankments/cuttings
Middle	Two lane road, low proportion of embankments/cuttings or Four lane express road, low proportion of embankments/cuttings
High	Four lane express road, high proportion of embankments/cuttings

Visual disturbance:

Visual disturbance		Value of area		
		Low	Middle	High
Effects' magnitude	Low	low	low	middle
	Middle	low	middle	high
	High	middle	high	high

#### FORMULA UNITS:

Ordinal scale (e.g. low – middle – high)

#### DATA REQUIREMENTS AND AVAILABILITY:

- Valuable areas available (e.g. regional planning) or creatable (GIS-interpretation of land-use)
- Effect's magnitude: estimation for each traffic unit possible

#### MODELLING:

Overlay by GIS

#### OBJECTIVES AND TARGETS:

Visual disturbance and impacting valuable areas should be avoided as much as possible. Sustainable development includes conservation of near-natural and undisturbed landscapes. Landscape protection is "a key element of individual and social well-being, has an important public interest role in the cultural, ecological, environmental and social fields, and constitutes a resource favourable to economic activity and whose protection, management and planning can contribute to job creation"(European Landscape Convention).

#### TIME SCALE:

#### EXPECTANCY

☒ Short term ☐ Long

#### DURATION

☐ Short ☒ Long



**MONITORING POSSIBILITIES:**

Monitoring should describe status and development of near-natural landscapes in each Country/State/Region, year after year, and allow comparing the situation with other Countries/States/Regions.

**RESEARCH NEEDED:**

Relations between transport infrastructure network and social well-being and tourism.

**REMARKS:**

Visual disturbance in towns is not regarded in this context because these effects are better to handle on EIA-level.

Fauna and biodiversity may also be affected by visual disturbance, e.g. endangered species are being trapped by the light of the vehicles or harassed with consequences for the local population's fertility. These effects can be reduced by planting or by walls which leads to a more detailed reflection on EIA-level. On SEA-level these effects are covered by the indicator "land-uptake" (see indicator nr. 9) of valuable biotopes.

The number of people affected may be an important variable, too. But because of reasons of data availability the proposed indicator doesn't include it.

<b>Name:</b>  <b>Consumption of non-renewable raw materials and recycling of waste in construction</b>	<b>Indicator for LOW data availability (Level 1): -</b> <b>Indicator for INTERMEDIATE data availability (Level 2):</b> Consumption of non-renewable raw materials and recycling of waste in construction  <b>Indicator for HIGH data availability (Level 3):</b> Consumption of non-renewable raw materials and recycling of waste in construction	<b>N°4</b>
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>		<b>Material resources, Soil, Water, Landscape</b>
<b>Planning situation:</b>	<input checked="" type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input checked="" type="checkbox"/> Corridor	
<b>ENVIRONMENTAL EFFECTS:</b>  <p>Materials are consumed both during the construction phase of the infrastructure (especially construction materials like aggregates, cement and bitumen), as well as during the use phase of the infrastructure (this then relates to the materials like steel, plastics and rubber for the vehicles driving on this infrastructure).</p> <p>The consumption of these materials effects the environment in the following ways: aggregates and the raw materials for cement production are extracted from earth's surface in quarries and mines which change the shape of the landscape; bitumen for asphalt is extracted from non-renewable mineral oil reserves with consequent environmental impacts; the very large amounts of materials consumed implies many transport activities for the hauling of these materials from a non-local source to the place where the infrastructure is build, with consequent consumption of fuel energy and related emissions.</p> <p>The use of alternative materials, like artificial aggregates from waste materials and recycled aggregates from former construction and demolition activities, compensates for the negative impacts of consuming virgin non-renewable natural materials in road construction, as well as being a solution for the waste management. Also, these alternative materials are more locally available and therefore need less transport for hauling.</p> <p>This is valid for the construction materials as well as for the vehicle materials.</p> <p>The use of waste materials in construction must comply with relevant environmental and technical criteria, to guarantee technical feasibility and protect environment (soil, water).</p>		
<b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b>  <p>The road construction sector consumes large amounts of mineral building materials like crushed stone and sand and binders (cement and bitumen). More than 90 % of all bitumen produced in the oil refineries is used for the construction of asphalt road pavements, for Europe this is yearly</p>		

around 15 million tons of bitumen. Almost all of the stony waste materials like construction and demolition debris, slags (from iron- and steel industry) and ashes (fly-ashes from coal burning thermal electricity making plants and bottom-ashes from waste incineration installations) that are recyclable, are recycled as aggregate in road construction or as constituent in cement production (giving the cement binder for concrete road construction).

[50] To build a road pavement in asphalt, one needs aggregates (stones, sand and filler) and a binder (bitumen). The proportions (in mass) are on average: 5,5 % bitumen + 7,5 % mineral filler + 30 % sand + 57 % stones. Refined bitumen is produced from crude petroleum. The European bitumen industry produces some 16 million tons each year for consumption in the manufacture of road materials and a wide variety of specialist building and industrial products. [51] In 2003 in Europe (numbers for 21 countries: EU-25 without Luxemburg, Lithuania, Cyprus and Malta) approximately 273 million tons of asphalt were produced. With an average bitumen content of around 5,5 %-m, this means that 15 million tons of bitumen were consumed for production of asphalt pavements in those 21 European countries.

The amount of gravel (or other aggregate like crushed stone, natural or crushed sand and mineral filler) can be estimated based on these numbers at around 275 million tons per year for the EU-25.

Of course these are the calculations only for bituminous pavements (asphalt), but also road pavements made of concrete exists and are build.

Also for the construction of a road, more materials are needed than only those here for the pavement layer, which is the top layer with a dimension of 0,1 to 0,25 meter in depth; in plus there is need for materials (crushed stone, gravel, sand) to build the foundation layer and subbase layer (in total these layers will consume around the double of the materials consumed in the pavement layer).

## INFORMATION LEVEL – Low availability (*Level 1*)

As this indicator needs very precise information about the local siting (dimensions of the road, local geography, composition of the pavement and its materials) – which is not available at this low level of information availability – no indicator is used here.

**DESCRIPTION OF THE INDICATOR: -**

**DATA REQUIREMENTS AND AVAILABILITY: -**

**MODELLING: -**

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

**DESCRIPTION OF THE INDICATOR: Same as level 3 partly approximated**

**DATA REQUIREMENTS AND AVAILABILITY: Same as level 3 partly approximated**

**MODELLING: Same as level 3**

## INFORMATION LEVEL – High availability (*Level 3*)

### DESCRIPTION OF THE INDICATOR:

It has been proved that wastes from other industry sectors, such as wastes from power stations and other combustion plants, slag from iron and steelmaking industry, wastes from manufacture of cement, lime and plaster and articles and products made from them, construction and demolition debris, excavated soil, ... can be used as secondary raw material for road construction, from the technological point of view. Usage of these wastes as construction material is a solution for waste management as it results in minimizing the total waste amount to be land filled in the environment.

#### Formula Units:

Ton (Mg) of construction material and % of recycled materials in it.

### DATA REQUIREMENTS AND AVAILABILITY

This indicator needs very precise information about the local siting (dimensions of the road, local geography, composition of the pavement and the materials it is made of. This information is available from the project level.

To assess the possibility to use recycled materials (wastes) for road or railway construction there is need to know:

- the technical and environmental characteristics of the materials and compliance with the technical and environmental criteria
- the cost of waste material in comparison with the cost of raw materials (including costs of production, costs of transport, avoided costs of waste management)
- availability of materials (distance from the nearest factory producing usable wastes; distance from the nearest quarry or mining area of raw materials).

The decision can be based on the cost-benefit analysis.

### MODELLING:

There do not seem to exist any models to be used for the assessment of the recycling possibility. Decisions must be based on engineering judgement about the technical and environmental quality of the materials and for the economic aspects on a cost-benefit analysis.

### OBJECTIVES AND TARGETS:

The increasing pressures of population growth and the rapid rise in consumerism since the 1940s have begun to put the capacity of the earth to assimilate waste under considerable stress. The initial solution was disposal of waste through landfill which soon gave rise to its own problems, as badly located sites have led to contamination of groundwater, infestation by vermin and a proliferation of wind-blown litter.

In the European Union as a whole over two billion tones of waste are produced each year of which approximately 30 million tones can be classified as hazardous. Some 50-60% of the overall solid waste stream is land filled, though the proportion of land filled waste varies substantially in individual Member States and ranges from under 30% in Holland and Luxembourg to virtually 100% in Ireland, Portugal and Greece. EU Directives on waste have for the large part been determined by its various Environmental Action Programmes. In 1989 the EU drew up a policy document entitled "Waste Management Strategy" which set long-term aspirations with regard to the European Union's waste management legislation and activities. Its main principles were:

- prevention of waste by technologies and products;
- recycling and reuse;
- optimization of final disposal;
- regulation of transport;
- remedial action.

On 24 February 1997, Council adopted a Resolution on a Community strategy for waste management which is a review of the 1989 strategy. This Resolution underpins the principles of waste prevention first, then recovery and finally, minimization of final disposal and confirms the current EU policy on the movements of waste. The Resolution gives precedence to the recovery of materials over energy generation and the strongly promotes the principle of producer responsibility.

**TIME SCALE:**
**EXPECTANCY**
☒ Short term    ☐ Long term

**DURATION**
☒ Short term    ☐ Long term

**MONITORING POSSIBILITIES:**

Some monitoring about waste management is done by TERM

**RESEARCH NEEDED:**

More research is needed concerning the environmental effects (perhaps only negative?) of the wastes taken into consideration. The research is in progress.

**REMARKS:**

This indicator has been chosen because it is a good tool to realize the targets of European policy in the wastes management aspect.

<b>Name:</b>  <b>Concentration of pollutants in soils</b>	<b>Indicator for INTERMEDIATE data availability (Level 2):</b> Risk of pollution of sensitive soils  <b>Indicator for HIGH data availability (Level 3):</b> Concentration of lead, PAH, pesticides, salt in soil	<b>Nº5</b>
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>		<b>Material resources, Soil, Water, Landscape</b>
<b>PLANNING SITUATION:</b>	<input type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input checked="" type="checkbox"/> Corridor	
<b>ENVIRONMENTAL EFFECTS:</b>  <p>Soil is the most complicated element of the environment but at the same time the least sensitive one. The soil cannot be analyzed without other elements of the environment and that is why when talking about soil protection, not the soils chemical content is taken into consideration but its fertility. The soil is considered as polluted one when does not manage to provide plants with good life conditions. The soil is protected in order to protect the vegetation on it and the groundwater.</p> <p>The soils' ability to absorb pollutant is a kind of trap when thinking about long period of the time. The pollutants are absorbed and de-mobilized in the soil but they still are in the soil. The ability to absorb pollutants depends on several external factors, e.g. acidity or oxygenizing-potency. The change of external factors (for example by sulphur emission) can mobilize pollutants absorbed in the soil and cause secondary pollution.</p> <p>The concentration of pollutants in the soil given in weight values indicates the effect on the vegetation. For all the species of plants the highest possible level of pollutants' concentration is known – if the concentration is too high this species cannot survive on such soil. On the other hand some species cumulates or magnifies some pollutants and then the consumption of them is dangerous for people.</p>		

[illegible]

The indicator aims, using the table above, to check if in the distance shorter than the pollution range, there are sensitive soils. By “sensitive soils” one ought to understand the protected types / classes of soils that can differ in different countries.

The assessment should be based on the distance of sensitive soils from the transport infrastructure:

- direct collision – high risk,
- distance less than 250 m – low risk,
- distance more than 250 m – no risk.

#### **FORMULA UNITS:**

The indicator answers the question: high risk / low risk / no risk.

#### **DATA REQUIREMENTS AND AVAILABILITY:**

- Approximated distance of the sensitive soils from the transport infrastructure
- Average range of pollution of soils

#### **MODELLING:**

All prognosis are made by comparisons – with the roads/railways of similar parameters and traffic on them. To prognose the emission of pollutants the only needed information is traffic volume and the average concentration of pollutants in the combustion gases (for lead and PAH) or the average amount of pesticides or salt used for winter maintenance annually.

## **INFORMATION LEVEL – High availability (*Level 3*)**

### **Concentration of lead, PAH, pesticides, salt in soil**

#### **DESCRIPTION OF THE INDICATOR:**

Pollutants production and levels of pollution are assessed based on vehicle intensities and vehicle emission characteristics (for lead and PAH) as well as the meteorological conditions that determines the length and intensity of winter maintenance (for pesticides and salt). In this assessment the following parameters should be taken into account:

- the mix of vehicle types (in particular passenger cars and trucks);
- the maximum vehicle velocity;
- the presence of protection facilities;
- elevation of road relative to its surroundings.

More or less sophisticated modelling approaches are available and operational which are capable of computing pollution levels (for lead and PAH) as a function of distance to the road / railway centreline, given a specification of the above parameters. These computations provide the basis for a flexible specification of pollution contours. Given an inventory of the



number of rural or protected areas as a function of distance to the road / railway centreline, assessments in terms of threatened territory within critical pollution contours can be rather easily made. Such computations are primarily driven by traffic volume in terms of vehicle intensities by vehicle type, as achieved during a certain time period.

In case of pesticides and salt the modelling can be based only on the average meteorological conditions from long period determining the amount of these substances used annually for winter maintenance.

For the assessment also the soils' type is needed to be known. For all the main soils' types (that can be also divided according to morphological characteristics or agricultural usefulness) the following tables can be worked out, on the basis of long term measurements combined with long term prognosis.

**Table 2 Example results of .....(type) soil pollution range**

Distance to road centre-line (m)	Car intensity (vehicles per hour) summed over two directions										
	100	500	1.000	2.000	5.000	10.000	20.000	30.000	40.000	50.000	> 50.000
	Pollution level [formula unit – ppm or g/kg of dry mass]										
0											
25											
50											
75											
100											
150											
200											
250											

#### FORMULA UNITS:

- lead & PAH – ppm
- pesticides & salt – g/kg of dry mass

#### DATA REQUIREMENTS AND AVAILABILITY:

- Types of soils in the infrastructure surrounding
- Average range of pollution of different types of soils
- Prognosed traffic intensity

#### MODELLING:

There is no model for imision of pollutants in the soil. All prognosis are made by comparisons – with the roads/railways of similar parameters and traffic on them.

To prognose the emission of pollutants the only needed information is traffic volume and the average concentration of pollutants in the combustion gases (for lead and PAH) or the average amount of pesticides or salt used for winter maintenance annually.

**OBJECTIVES AND TARGETS:**

Within its 6<sup>th</sup> Environmental Action Programme, the European Commission has established the objective of protecting soils against a number of major threats - erosion, pollution, decline of organic matter content, loss of biodiversity, sealing by infrastructure, salinization and desertification.

In order to achieve this objective it has proposed the introduction of a specific thematic strategy for soil protection. The way forward towards this proposed strategy has been outlined in the Communication COM 179 (EC, 2002) 'Towards a Thematic Strategy for Soil Protection'.

The Communication recognizes several distinctive features of soils that make the development of a soil protection policy somewhat different from the protection of air and water. One of these features is the very high degree of spatial variability of soils across Europe. The great diversity of European soils reflects the differences in climate, geology, vegetation, land use and historical development that are characteristic of Europe.

In the national legislation there are some standards concerning the concentration of pollutants in the soils – they usually differ dependently on the type of soil (heavy – light).

**TIME SCALE:****EXPECTANCY**
☐ Short term    ☒ Long term
**DURATION**
☐ Short term    ☒ Long term
**MONITORING POSSIBILITIES:**

Monitoring should be provided constantly – with the measurement every year. It can be begun after few years of infrastructure's exploitation.

**RESEARCH NEEDED:**

There is need to organise the continuous monitoring along the transport corridors. Concerning the pollution by lead it is also important to proceed monitoring of acidification (that can influence the mobility of lead in the soil).

**REMARKS:**

This indicator has been chosen because it is a good tool to decide about the route. Although the emission (and emission) is dependent only on the traffic volume, the real threat for environment differs dependently on the type of soil. When the decision-maker has these two: information – emission and soil's type, he can easily evaluate the threat.

<b>Name:</b>  <b>Concentration of pollutants in surface water</b>	<b>Indicator for LOW data availability (Level 1):</b> Risk of pollution of sensitive water  <b>Indicator for INTERMEDIATE data availability (Level 2):</b> Same as level 3, partly approximated  <b>Indicator for HIGH data availability (Level 3):</b> Concentration of oil-derivatives, pesticides and salt in water	<b>N°6</b>
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>		<b>Material resources, Soil, Water, Landscape</b>
<b>PLANNING SITUATION:</b>	<input checked="" type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input checked="" type="checkbox"/> Corridor	
<b>ENVIRONMENTAL EFFECTS:</b> <p>A huge amount of wastes is produced in Europe. At the same time, because of the high density of population, in many countries we can observe problems with potable water. There underground water is not enough to provide everybody with potable water – also the surface water must be used for such purpose. Water, especially running one - like all the elements of the environment has the ability of self-protection. Last time this ability is being destroyed by to high volumes of pollutants. There is need to protect surface water against pollution.</p> <p>When talking about transport sector several pollutants ought to be taken into consideration, such as:</p> <ul style="list-style-type: none"> <li>➤ oil – derivatives – generated by engine installations and serious accidents with dangerous goods' transport.</li> <li>➤ pesticides – generated by railways' maintenance,</li> <li>➤ salt (e.g. sodium chloride NaCl) – generated by roads' maintenance.</li> </ul>		
<b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b> The contribution of transport is not very high.		
<div style="text-align: center; padding: 10px;"> <b>INFORMATION LEVEL – Low availability (Level 1)</b> </div> <div style="border: 1px solid black; padding: 10px; margin-top: 10px;"> <b>Risk of pollution of sensitive water</b>   <b>DESCRIPTION OF THE INDICATOR:</b>          The indicator aims to assess the risk of pollution of sensitive water.          By “sensitive water” one ought to understand the protected types / classes of water that can       </div>		

differ in different countries. That can mean: high quality surface water as well as potable water reservoirs.

The risk of pollution is assessed in two-grade scale: high or low. The assessment should be based on the distance of sensitive water reservoirs from the transport infrastructure:

- direct collision – high risk,
- distance less than 250 m – low risk,
- distance more than 250 m – no risk.

#### **DATA REQUIREMENTS AND AVAILABILITY:**

The distance between transport infrastructure and the sensitive water reservoirs.

#### **MODELLING:**

No modeling required.

## **INFORMATION LEVEL – Intermediate availability (*Level 2*)**

### **Concentration of oil-derivatives, pesticides and salt in water, partly approximated**

#### **DESCRIPTION OF THE INDICATOR:**

This indicator aims to evaluate the emission of pollutants in the run-off water. The concentration of pollutants in the water run-off depends mainly on the vehicles number and their technical conditions.

Pollutants production and levels of pollution are assessed based on vehicle intensities and vehicle emission characteristics (for oil-derivatives) as well as the meteorological conditions that determines the length and intensity of winter maintenance (for pesticides and salt). In this assessment the maximum vehicle velocity should be taken into account.

More or less sophisticated modelling approaches are available and operational which are capable of computing emission levels (for oil-derivatives) as a function of traffic velocity, given a specification of the above parameters. These computations provide the basis for a flexible specification of emission. Given an inventory of the protected areas as a function of distance to the road centreline, assessments in terms of threatened basins can be rather easily made. Such computations are primarily driven by traffic volume in terms of vehicle intensities, as achieved during a certain time period.

In case of pesticides and salt the modelling can be based only on the average meteorological conditions from long period determining the amount of these substances used annually for winter maintenance.

For the assessment all types of water basins are taken as equal – independently on the destination.

**FORMULA UNITS:**

- oil-derivatives –  $\text{mg/dm}^3$
- pesticides & salt – g/kg of dry mass

**DATA REQUIREMENTS AND AVAILABILITY:**

- Concentration of each pollutant in the water run-off (known from the long term measurements),
- Natural recipient's distance from the road / railway centerline.

**MODELLING:**

All prognosis are made by comparisons – with the roads/railways of similar parameters and traffic on them. To prognose the emission of pollutants the only needed information is traffic volume and the average concentration of pollutants in the combustion gases (for lead and PAH) or the average amount of pesticides or salt used for winter maintenance annually.

## INFORMATION LEVEL – High availability (*Level 3*)

### Concentration of oil-derivatives, pesticides and salt in water

**DESCRIPTION OF THE INDICATOR:**

Indicator is the same as for intermediate availability (see level 2) but all the data is more detailed and so the prognosis can be more detailed.

**FORMULA UNITS:**

- oil-derivatives –  $\text{mg/dm}^3$
- pesticides & salt – g/kg of dry mass

**DATA REQUIREMENTS AND AVAILABILITY:**

- Concentration of each pollutant in the water run-off (known from the long term measurements),
- Natural recipient's distance from the road / railway centerline.

**MODELLING:**

All prognosis are made by comparisons – with the roads/railways of similar parameters and traffic on them. To prognose the emission of pollutants the only needed information is traffic volume and the average concentration of pollutants in the combustion gases (for lead and PAH) or the average amount of pesticides or salt used for winter maintenance annually.

## OBJECTIVES AND TARGETS:

As part of a substantial restructuring of EU water policy and legislation, a Directive establishing a new framework for Community action in the field of water policy (2000/60/EC) was agreed by the European Parliament and Council in September 2000 and came into force on 22<sup>nd</sup> December 2000. The Directive, generally known as the Water Framework Directive (WFD) rationalizes and updates existing water legislations and provides for water management on the basis of River Basin Districts (RBD's).

The main activities for the implementation of the WFD will take place in the context of River Basin Management Projects led by local authorities.

The overall objective of river basin projects is to establish an integrated monitoring and management system for all waters within a RBD, to develop a dynamic programme of management measures and to produce a River Basin Management Plan, which will be continually updated.

Central to the Water Framework Directive is a requirement for Member States to encourage the active involvement of all interested parties in its implementation.

The WFD sets a framework for comprehensive management of water resources in the European Community, within a common approach and with common objectives, principles and basic measures. It addresses inland surface waters, estuarine and coastal waters and groundwater. The fundamental objective of the Water Framework Directive aims at maintaining "high status" of waters where it exists, preventing any deterioration in the existing status of waters and achieving at least "good status" in relation to all waters by 2015. Member States will have to ensure that a co-ordinated approach is adopted for the achievement of the objectives of the WFD and for the implementation of programmes of measures for this purpose. The objectives of the WFD are:

- to protect and enhance the status of aquatic ecosystems (and terrestrial ecosystems and wetlands directly dependent on aquatic ecosystems)
- to promote sustainable water use based on long-term protection of available water resources
- to provide for sufficient supply of good quality surface water and groundwater as need for sustainable, balanced and equitable water use
- to provide for enhanced protection and improvement of the aquatic environment by reducing / phasing out of discharges, emissions and losses of priority substances
- to contribute to mitigating the effects of floods and droughts
- to protect territorial and marine waters
- to establish a register of 'protected areas' e.g. areas designated for protection of habitats or species.

The directive rationalizes and updates existing water legislation by setting common EU wide objectives for water. It is very broad in its scope and relates to water quality in rivers, lakes, canals, groundwater, transitional (estuarine) waters and coastal waters out a distance of at least one nautical mile.

At the national level all the member states establish emission standards for all kinds of wastes, including run-offs from the road pavement and railway embankments. There are also standards concerning the quality of the water in rivers and lakes.

For example: in Poland only standards concerning:

- suspension ( $100 \text{ mg/dm}^3$ )
  - oil-derivatives ( $15 \text{ mg/dm}^3$ )
- are established.

<b>TIME SCALE:</b>	<b>EXPECTANCY</b> <input checked="" type="checkbox"/> Short term <input type="checkbox"/> Long term	<b>DURATION</b> <input type="checkbox"/> Short term <input checked="" type="checkbox"/> Long term
<b>MONITORING POSSIBILITIES:</b> Monitoring should be provided constantly, with the measurement every year in spring or summer period. It should be begun immediately after infrastructure's exploitation starts.		
<b>RESEARCH NEEDED:</b> There is need to organize the continuous monitoring along the transport corridors in order to improve the prognosis models. It is also needed in the scope of indicating the changes trends in the water environment.		
<b>REMARKS:</b> This indicator has been chosen because it is a good tool to decide about the route. Although the emission (and emission) is dependent only on the traffic volume, the real threat for environment differs dependently on the type of natural recipient and its water quality. When the decision-maker has these two; information – emission and recipient can easily evaluate the threat.		

<b>Name:</b>  <b>Use of fossil fuels /renewable energy</b>	<p><b>Indicator for LOW data availability (Level 1):</b> a) Level of service, b) Transport volume</p> <p><b>Indicator for INTERMEDIATE data availability (Level 2):</b> a) same as level 1, b) same as level 3, partly estimated</p> <p><b>Indicator for HIGH data availability (Level 3):</b> a) same as level 1, b) Use of fossil fuels /renewable energy</p>	<b>N°7</b>	
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>			<b>Material resources, Soil, Water, Landscape</b>
<b>PLANNING SITUATION:</b>	<input checked="" type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input type="checkbox"/> Local <input checked="" type="checkbox"/> Corridor		
<p><b>ENVIRONMENTAL EFFECTS:</b>          Evaluating the total fuel (energy) consumption a distinction has to be made between fuel consumed for building the infrastructure (type a) and for operating the vehicles on this infrastructure (type b).          a) The amount of fuels (energy) needed for the construction of new roads or railways is in close correlation to the kind and amount of material consumption. An indicator for this type of energy consumption is the level of service.          b) Concerning the second type of fuel (energy) consumption the role of the transport sector (especially the road transport) is significant recently in the use of fossil fuels. The energy source of the today's engines of road vehicles is almost exclusively fuel (petrol, diesel) made from crude oil. The reserves of crude oil of our Earth are very limited: according to the SHELL's estimation (for the year 2000) the length of time until exhaustion of traditional reserves of crude oil is about 65 years (in case of natural gas this duration is about 164 years). The significant role of the road transport in the fossil fuel consumption is accelerated by rapidly rising demand for mobility especially in India and China. Based on the before mentioned reasons the use/savings of fossil fuels can be considered as a global scale and long term indicator. The use of renewable energy (bio-fuels, solar, wind etc.) instead of the fossil fuels is also an indicator for fossil fuel savings.</p>			
<p><b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b> The share of road transport in use of fossil fuels is between 10-30% changing from a developing country to a well motorized one. The fossil fuels as source of tractive energy can be substituted in transport subsectors in various ways, the most simple in case of the railway. Increase of the share of biofuels for road vehicles give a potential for use of renewable energy.</p>			



## INFORMATION LEVEL – Low availability (*Level 1*)

### DESCRIPTION OF THE INDICATOR:

#### a) Level of service

The amount of fuels (energy) needed for the construction of a new road or railway depends on the geometrical dimensions of the new infrastructure and the design of the construction. Level of service gives good information in this relation.

#### Formula Units:

None

#### b)Transport volume

Because the composition and traffic circumstances of the vehicle fleet is unknown on this information level the transport volume can be used instead of them.

#### Formula Units:

Passengerkm, tonskm

### DATA REQUIREMENTS AND AVAILABILITY:

The values of both indicators are available in forecasted form on this information level.

### MODELLING:

None

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

### DESCRIPTION OF THE INDICATOR:

#### a) same as level 1.

#### b) same as level 3. partly estimated

### DATA REQUIREMENTS AND AVAILABILITY:

The values of both indicators usually are forecasted.

### MODELLING:

None

## INFORMATION LEVEL – High availability (Level 3)

### DESCRIPTION OF THE INDICATOR:

#### **a) same as level 1.**

#### **b) Use of fossil fuels/renewable energy**

The amount of fossil fuel as consumption or savings given in metric ton equivalent due to the transport infrastructure investment (or transport policy, plan, program version) indicates the effect on decrease of the fossil fuel stock.

The amount of renewable fuel consumption substituting traditional fuels given also in metric ton crude oil equivalent can be the other indicator for evaluation of saving fossil fuels. The fossil fuel consumption can be used for decision making because it makes possible to compare different alternatives. Its important characteristic is the potential for communicating to the public quantifying the advantage of the whole system of the investment being in question.

The dominant part has the road transport itself in the use of fossil fuels, the energy consumption of construction and operations of the infrastructure have less importance.

**Formula Units** specific fuel consumption: l/100 km, kg/100 km; total fuel consumption: ton/year

### DATA REQUIREMENTS AND AVAILABILITY:

The total fossil fuel consumption can be calculated on the basis of the specific fuel consumption (l/100 km, kg/100 km) of the vehicles (vehicle categories) and their operation circumstances (average speed, distances). Then it can be converted into crude oil equivalent taking into consideration their heating values. The substitution of fossil fuels by renewable ones can be evaluated on the same way.

Data sources:

Fuel Consumption and Emissions Type Approval Figures for Motor Vehicles.

Kraftfahrt Bundessamt yearly handbook from 1990. every year

MEET Methodology for Calculating Transport Emissions and Energy Consumption.

### MODELLING:

On the basis of transport volume data of different subsectors and specific fuel consumption.

Road Transport: Fossil fuel use can be calculated based on composition of vehicle fleet and traffic volume as well as average speed.

Rail Transport: Using composition of locomotive fleets and transport volume as well as specific fuel consumption fossil fuel use can be calculated.

Model: ARTEMIS 2005.

**OBJECTIVES AND TARGETS:**

There are directives, standards and good engineering practice for specific fuel consumption data of road vehicles and railway transport considering different operation circumstances. As long term consumption target the so called zero fossil fuel consumption vehicle (e.g. hydrogen fuelling) can be considered. In case of city transport the share of not fossil fuel depending vehicles has to be considered. According to the Directive 2003/30/EC on the promotion of renewable fuels for transport a minimum proportion of biofuels 5,75% shall be achieved by 31.12.2010. The target of the Green Book of EC is 20 % of fuels placed on the market for transport purposes by 2020.

**TIME SCALE:****EXPECTANCY**
☒ Short term    ☐ Long term
**DURATION**
☐ Short term    ☒ Long term
**MONITORING POSSIBILITIES:**

Monitoring should describe the progress time to time and compare the situation with other similar cases. Database of specific fuel consumption is usually available. A special interest has to be given to the increase of the share of renewable fuels.

**RESEARCH NEEDED:**

There is a need for fossil fuel consumption data on future vehicles (hybrid, hydrogen fuelled, fuel cells powered etc.).

The share of fossil fuels as energy sources in case of city public transport and railway is usually not exactly known.

**REMARKS:**

The separate evaluation of use of fossil fuels with other words the share of renewable fuels beside the climate change is justified by the decreasing reserves and increasing price of crude oil.

<b>Name:</b>  <b>Disturbance from noise</b>	<p><b>Indicator for LOW data availability (Level 1):</b> Same as level 2, partly approximated</p> <p><b>Indicator for INTERMEDIATE data availability (Level 2):</b> Risk of affecting highly populated areas or sensitive habitats</p> <p><b>Indicator for HIGH data availability (Level 3):</b> Number of people affected by noise level oversteps or proximity of sensitive habitats</p>	<b>N°8</b>
<b>ENVIRONMENTAL FACTORS AFFECTED:</b> <div style="float: right;"> <b>Biodiversity, Fauna, Flora, Population (health, annoyance)</b> </div>		
<b>PLANNING SITUATION:</b>	<input checked="" type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input checked="" type="checkbox"/> Corridor	
<b>ENVIRONMENTAL EFFECTS:</b>  <p>Noise is one the biggest problems in today's reality. It causes annoyance for people and animals. The impact of noise on life-condition is very important although not the direct one. It influences the nervous system as well as the immunological system making the natural immunity from the diseases.</p> <p>The investigation undertaken during the last years show apparently that the noise level higher than 65 dB causes the serious health risks for human beings.</p>		
<b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b>  <p>Transport is the main source of noise in the majority of urban areas.</p>		
<div style="text-align: center; border: 1px solid black; padding: 10px;"> <p><b>INFORMATION LEVEL – Low availability (Level 1)</b></p> <div style="border: 1px solid black; padding: 10px; margin-top: 10px;"> <p><b>Risk of affecting highly populated areas or sensitive habitats, partly approximated</b></p> <p><b>DESCRIPTION OF THE INDICATOR:</b></p> <p>The indicator aims to estimate the risk of affect the sensitive areas – that means highly (densely) populated areas (cities, town, villages – depends on regional characteristics) or</p> </div> </div>		

sensitive habitats (nests of birds, especially predators, or other animals enlisted in the Red Books).

The distance of high / low risk of affection can be taken from the Table elaborated on the basis of measurements:

**Table 1 Example results of noise range**

Distance to road / railway centre-line (m)	Car / train intensity (vehicles per hour) summed over two directions										
	100	500	1.000	2.000	5.000	10.000	20.000	30.000	40.000	50.000	> 50.000
	Noise level dB(A)										
0											
100											
200											
500											
1000											
2000											

**FORMULA UNITS:**

The indicator answers the question: yes / no.

**DATA REQUIREMENTS AND AVAILABILITY:**

Distance between transport infrastructure and sensitive areas.

**MODELLING:**

No modeling needed.

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

### Risk of affecting highly populated areas or sensitive habitats

**DESCRIPTION OF THE INDICATOR:**

The indicator aims to estimate the distance to the sensitive areas (described for low availability – level 1) and compare it with the range of noise levels oversteps. The noise levels oversteps are assessed on the basis of noise emission.

The assessment should be based on the distance of sensitive areas from the transport infrastructure:

- direct collision or distance less than 250 m – high risk,
- distance more than 250 m but less than 500 m – low risk,
- distance more than 500 m – no risk.

**FORMULA UNITS:**

The indicator answers the question: high risk / low risk / no risk.

**DATA REQUIREMENTS AND AVAILABILITY:**

- Noise levels oversteps' range (based on noise emission)
- Distance to sensitive areas (highly populated areas or sensitive habitats)

**MODELLING:**

The data needed is the noise emission level. To prognose the emission of noise the only needed information is traffic volume and the average noise emitted by a single vehicle (dependent on its type, age – these are statistic information, individual for every member state).

To prognose the range of noise level oversteps the emission is necessary.

## INFORMATION LEVEL – High availability (*Level 3*)

### Number of people affected by noise level oversteps or proximity of sensitive habitats

**DESCRIPTION OF THE INDICATOR:**

The information about noise can be presented in two ways:

- The equivalent noise levels oversteps during:
  - $L_{den}$  (day-evening-night noise indicator) – that means the noise indicator for overall annoyance;
  - $L_{night}$  (night-time noise indicator) – that means the noise indicator for sleep disturbance;

**1. Definition of the day-evening-night level  $L_{den}$** 

The day-evening-night level  $L_{den}$  in decibels (dB) is defined by the following formula:

$$L_{den} = 10 \lg \frac{1}{24} \left( 12 * 10^{\frac{L_{day}}{10}} + 4 * 10^{\frac{L_{evening} + 5}{10}} + 8 * 10^{\frac{L_{night} + 10}{10}} \right)$$

in which:

- $L_{day}$  is the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the day periods of a year,
- $L_{evening}$  is the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the evening periods of a year,
- $L_{night}$  is the A-weighted long-term average sound level as defined in ISO 1996-

2: 1987, determined over all the night periods of a year;

in which:

- the day is 12 hours, the evening four hours and the night eight hours.
- for the start of the day (and consequently the start of the evening and the start of the night) the default values are 07.00 to 19.00, 19.00 to 23.00 and 23.00 to 07.00 local time,
- a year is a relevant year as regards the emission of sound and an average year as regards the meteorological circumstances;

and in which:

- the incident sound is considered, which means that no account is taken of the sound that is reflected at the façade of the dwelling under consideration (as a general rule, this implies a 3 dB correction in case of measurement). The height of the  $L_{den}$  assessment point depends on the application:
- in the case of computation for the purpose of strategic noise mapping in relation to noise exposure in and near buildings, the assessment points must be  $4,0 \pm 0,2$  m (3,8 to 4,2 m) above the ground and at the most exposed façade; for this purpose, the most exposed façade will be the external wall facing onto and nearest to the specific noise source; for other purposes other choices may be made,
- in the case of measurement for the purpose of strategic noise mapping in relation to noise exposure in and near buildings, other heights may be chosen, but they must never be less than 1,5 m above the ground, and results should be corrected in accordance with an equivalent height of 4 m,
- for other purposes such as acoustical planning and noise zoning other heights may be chosen, but they must never be less than 1,5 m above the ground, for example for:
  - rural areas with one-storey houses,
  - the design of local measures meant to reduce the noise impact on specific dwellings,
  - the detailed noise mapping of a limited area, showing the noise exposure of individual dwellings.

## 2. Definition of the night-time noise indicator

The night-time noise indicator  $L_{night}$  is the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the night periods of a year;

in which:

- the night is eight hours as defined in paragraph 1,
- a year is a relevant year as regards the emission of sound and an average year as regards the meteorological circumstances, as defined in paragraph 1,
- the incident sound is considered, as laid down in paragraph 1,
- the assessment point is the same as for  $L_{den}$ .

## 3. Supplementary noise indicators

In some cases, in addition to  $L_{den}$  and  $L_{night}$ , and where appropriate  $L_{day}$  and  $L_{evening}$ , it may be advantageous to use special noise indicators and related limit values. Some examples are given below:

- the noise source under consideration operates only for a small proportion of the time (for example, less than 20 % of the time over the total of the day periods in a year, the total of the evening periods in a year, or the total of the night periods in a year),

- the average number of noise events in one or more of the periods is very low (for example, less than one noise event an hour; a noise event could be defined as a noise that lasts less than five minutes; examples are the noise from a passing train or a passing aircraft),
- the low-frequency content of the noise is strong,
- $L_{Amax}$ , or SEL (sound exposure level) for night period protection in the case of noise peaks,
- extra protection at the weekend or a specific part of the year,
- extra protection of the day period,
- extra protection of the evening period,
- a combination of noises from different sources,
- quiet areas in open country,
- the noise contains strong tonal components,
- the noise has an impulsive character.

➤ Number of affected people

At all of the levels of planning number of affected people can be used as an indicator. At the national level it will answer the question – how many (and how big) town we are able to bypass, at the lower levels the question will be more detailed (how many villages, how many house will not have annoyance observed).

At the corridor level it is also prognoses the levels of noise at the facades.

➤ Proximity of sensitive habitats

Using the table described for intermediate data availability (see level 2) and knowing the distance to the sensitive habitats it is possible to assess the real annoyance for wildlife.

**FORMULA UNITS:**

- The equivalent noise levels oversteps – dB, the number of affected people.
- Distance to sensitive habitats – m.

**DATA REQUIREMENTS AND AVAILABILITY:**

To assess the indicator it is necessary to measure / prognosis / count / estimate the noise emission levels. The basic information must be spatial planning data:

- the density of population,
- the distance to settlements (for national, regional and local levels)

or

- the distance to the first (sometimes also the second) line of buildings (for corridor level),
- the building structures organization.

For calculation of this indicator the state indicator “Percentage of people living in the areas along the infrastructures”, described in Chapter 3 should be used.



**MODELLING:**

To prognose the noise emission the emission known is necessary.

For emission models (e.g. Soundplan, CadnA) the topographical data is also needed.

**OBJECTIVES AND TARGETS:**

Further to its 1996 Green Paper (COM(96)540), the European Commission developed a new framework for noise policy, based on shared responsibility between the EU, national and local level, and including measures to improve the accuracy and standardisation of data to help improve the coherency of different actions.

This document lead to a comprehensive set of measures, including:

- The creation of a Noise Expert Network, whose mission is to assist the Commission in the development of its noise policy.
- The Directive on Environmental Noise aimed at requiring competent authorities in Member States to produce strategic noise maps on the basis of harmonized indicators, to inform the public about noise exposure and its effects, and to draw up action plans to address noise issues.
- The Directive on Equipment Used Outdoors that simplifies the legislation about many noisy equipments.
- The follow-up and development of existing EU legislation relating to sources of noise, such as motor vehicles, aircraft, railway rolling stock and the provision of financial support to different noise related studies and research projects.

Further to the Commission proposal for a Directive relating to the assessment and management of Environmental noise (COM(2000)468), the European Parliament and Council have adopted Directive 2002/49/EC of 25 June 2002 whose main aim is to provide a common basis for tackling the noise problem across the EU. The underlying principles of this text, are similar to those for other overarching environment policy directives:

- Monitoring the environmental problem; by requiring competent authorities in Member States to draw up "strategic noise maps" for major roads, railways, airports and agglomerations, using harmonised noise indicators  $L_{den}$  (day-evening-night equivalent level) and  $L_{night}$  (night equivalent level). These maps will be used to assess the number of people annoyed and sleep-disturbed respectively throughout Europe
- Informing and consulting the public about noise exposure, its effects, and the measures considered to address noise, in line with the principles of the Aarhus Convention
- Addressing local noise issues by requiring competent authorities to draw up action plans to reduce noise where necessary and maintain environmental noise quality where it is good. The directive does not set any limit value, nor does it prescribe the measures to be used in the action plans, which remain at the discretion of the competent authorities.
- Developing a long-term EU strategy, which includes objectives to reduce the number of people affected by noise in the longer term, and provides a framework for developing existing Community policy on noise reduction from source. With this respect, the Commission has made a declaration concerning the provisions laid down in article 1.2 with regard to the preparation of legislation relating to sources of noise.

At the national level all the member states establish emission standards for all kinds of vehicles and emission standards for noise level in the environment.

<b>TIME SCALE:</b>	<b>EXPECTANCY</b> <input checked="" type="checkbox"/> Short term <input type="checkbox"/> Long term	<b>DURATION</b> <input type="checkbox"/> Short term <input checked="" type="checkbox"/> Long term
<b>MONITORING POSSIBILITIES:</b>  <p>No later than 30 June 2012, and thereafter every five years, strategic noise maps showing the situation in the preceding calendar year have to be made and, where relevant, approved by the competent authorities for all agglomerations and for all major roads and major railways within their territories.</p> <p>No later than 30 June 2007 strategic noise maps showing the situation in the preceding calendar year have to be made and, where relevant, approved by the competent authorities, for all agglomerations with more than 250 000 inhabitants and for all major roads which have more than six million vehicle passages a year, major railways which have more than 60 000 train passages per year and major airports within their territories.</p>		
<b>RESEARCH NEEDED:</b>  <p>There is need to organise the continuous monitoring along the transport corridors but only for protected (urban) areas.</p>		
<b>REMARKS:</b>  <p>This indicator has been chosen because it is a good tool to decide about the route. Although the emission (and immission) is dependent only on the traffic volume, the real threat for environment differs dependently on the type of surrounding. When the decision-maker has these two information – emission and number of people living in the surrounding of the planned route – he can easily evaluate the threat.</p>		

<b>Name:</b>  <b>Sensitive Pollution</b>	<p><i>Indicator for LOW data availability (Level 1):</i> No evaluation on this level</p> <p><i>Indicator for INTERMEDIATE data availability (Level 2):</i> Emissions for sensitive pollution</p> <p><i>Indicator for HIGH data availability (Level 3):</i> Sensitive Pollution</p>	<b>Nº9</b>
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>		Population, Air
<b>PLANNING SITUATION:</b>	<input type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input type="checkbox"/> Corridor	
<p><b>ENVIRONMENTAL EFFECTS:</b></p> <p>Exhaust emissions of road vehicles have a great share in the air pollution caused by anthropogenic activity. Different pollutant groups are responsible for the human health, climate change, ozone layer depletion and photochemical effects. Some exhaust gas components effect the human well being irritating the respiratory system, the eyes and skins. This is the background for their bad odour and smell effects. Their annoyance is usually short term and has local character. The quantity of their emissions is usually regulated by emission standards and their pollution level is controlled by air quality norms. As indicators two characteristic compounds aldehydes and ammonia were chosen. According to the air quality measurements there is a serious annoyance (unpleasant smell first of all) and in addition health risk (exceeding limit values) nearby main roads with heavy traffic.</p>		
<p><b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b></p> <p>On local level especially in the neighborhood of main streets and roads exhaust gases of the vehicles are the main polluting sources. The number of affected people is very high in urban areas, where the road vehicles are the determinant sources of the emissions for these kind air pollutants. The importance of railway and inland shipping is much less compared to the road vehicles.</p>		

## INFORMATION LEVEL – Low availability (*Level 1*)

### DESCRIPTION OF THE INDICATOR:

No evaluation from this point of view on this level of information

### Formula Units:

Nothing for this information level

### DATA REQUIREMENTS AND AVAILABILITY:

Nothing for this information level

### MODELLING:

None

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

### DESCRIPTION OF THE INDICATOR:

It is the same as in case of information level 3. but only the emissions of the pollutants are estimated on the basis of forecasted traffic volume and composition,

### Formula Units:

kg/day or ton/year.

### DATA REQUIREMENTS AND AVAILABILITY:

It is the same as in case of information level 3.

### MODELLING:

Estimation of emissions is possible on the basis of the forecasted total average traffic volume and composition as well as emission factors.

## INFORMATION LEVEL – High availability (*Level 3*)

### DESCRIPTION OF THE INDICATOR:

**Aldehydes** are part of the hydrocarbons emitted fundamentally by the exhaust gases. Aldehydes are irritants and it is due to the double bonds of their structure, their toxicity increases with lower molecular weight. The substances resulting from automotive pollution are mainly formaldehyde (HCHO), acetaldehyde (CH<sub>3</sub>CHO) and acrolein (CH<sub>2</sub>=CHCHO). The aldehyde emission usually is given as formaldehyde equivalent. Formaldehyde is also reproached for genotoxic and carcinogenic properties. The aldehyde emissions can very effectively reduced by the today's catalyst technology.

Diesel fuelled engine usually emit more aldehydes than that of the petrol fuelled. They are on the list of "Priority Air Toxics" defined by US EPA as mobile air toxics. Their exhaust emissions are regulated worldwide.

**Ammonia (NH<sub>3</sub>)** emission usually is a by-product of the catalytic process in the catalyst and in case of the Euro4/Euro5 technology at heavy duty diesel engines, its origin is the chemistry of the additive used for the SCR (Selective Catalytic Reduction) technology. It has a very strong and characteristic smell effect. The emission of these air pollutants can be calculated on the basis of their specific emission factors.

The impacts of these air pollutants can be evaluated first of all on the basis of the concentrations compared to the limit values, secondly comparing emissions of different versions.

### Formula Units:

Emission of the pollutants gases in g/km or kg/day, ton/years.

Concentration of the pollutants in the ambient air in ppm or mg/m<sup>3</sup>.

### DATA REQUIREMENTS AND AVAILABILITY:

The limit values for aldehydes (as formaldehyde equivalent) are given in emission standards with decreasing tendency as g/km for passenger cars. On the basis for the yearly mileage (vehicle km/a) and traffic prognosis their emissions can be calculated. The same process can be used for ammonia, but because it is an unregulated exhaust component its specific emission (g/km or g/kWh) value is given in handbooks. The total quantity of these substances is usually expressed in kg/day or metric ton/day.

HBEFA Handbook Emission Factors for Road Transport UBA/Berlin

### MODELLING:

The calculation of emission of sensitive pollutants is possible on the basis of road traffic data (traffic volume, share of the main vehicle categories, traffic circumstances described by average speed) and emission factors.

For the calculation of concentrations of sensitive pollutants in the ambient air there are well-known and worldwide accepted (standardised) dispersion models.

**OBJECTIVES AND TARGETS:**

The goal is to fulfil the limit values and the air quality targets (maximum immission concentration) given in the recent European Directives. As long term goal for limit value in the ambient air the threshold for smell effect can be considered.

**TIME SCALE:****EXPECTANCY**
☒ Short term    ☐ Long term
**DURATION**
☒ Short term    ☐ Long term
**MONITORING POSSIBILITIES:**

Both air polluting materials can be monitored by appropriate analyses methods. The importance of their decrease can be evaluated by ambient air quality measurements before and after the construction of the infrastructure and thereafter every five years evaluating the change of the situation.

**RESEARCH NEEDED:**

There is a need for unified national emission factors on the basis of large scale measurements characterising the average emissions of existing and future road vehicle fleets.

**REMARKS:**

To take into consideration these air pollutants can be justified by the annoyance of smell and health risk evaluated by frequency of excess of limit values.

<b>Name:</b>  <b>Climate Change</b>	<p><i>Indicator for LOW data availability (Level 1):</i> Transport volume, weighted by CO<sub>2</sub>-emission-coefficient</p> <p><i>Indicator for INTERMEDIATE data availability (Level 2):</i> Same as level 2, partly approximated</p> <p><i>Indicator for HIGH data availability (Level 3):</i> CO<sub>2</sub>-emission</p>	<b>N°10</b>
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>		Climate, biodiversity, population, cultural heritage
<b>APPLICATION LEVEL:</b>	<input checked="" type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input type="checkbox"/> Local <input type="checkbox"/> Corridor	
<p><b>ENVIRONMENTAL EFFECTS:</b></p> <p>Climate change is characterised by the global warming [Giec, 2001]. This type of pollution involves contribution of many green gasses. Most of them have got a positive and direct contribution, which means that emissions involve directly a global warming. These gazes are CO<sub>2</sub>, CH<sub>4</sub>, SF<sub>6</sub>, N<sub>2</sub>O, O<sub>3</sub>, and Hydrocarbons which contains Cl, F, Br (like PFC and HFC). Few of them have got a positive but indirect contribution. These gazes are CO, NO<sub>x</sub>, NMVOC, CH<sub>4</sub>. Few gasses, as halogens, SO<sub>2</sub> and aerosols, have got a negative and indirect contribution to the global warming, which means that they contribute to a global cooling. Only six gazes which contribute directly to the global warming are taken into account into the Kyoto protocol. These gasses are CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, SF<sub>6</sub>, PFC and HFC. The climate change may induce several changes: increase of global meaning precipitations and steam concentration, decrease of the snow cover and see ice, increase of the climate variability. All these changes affect natural environment (increase of the see level), biodiversity (disappearance of certain species), and population (apparition of news diseases, migrations, disappearance of cultural areas). The irradiative forcing, causing a increase of the temperature at the earth' surface, is considered by scientific community as the best characteristic impact of the climate change [Giec, 2001].</p>		
<p><b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b></p> <p>Contribution of transport to the climate change differs between different countries. In France, the contribution of transport is evaluated at 22% in 2000 [Citepa]. Most of the contribution is due to CO<sub>2</sub> emissions. For this reason, only CO<sub>2</sub> emissions are taken into account in our methodology.</p>		

## INFORMATION LEVEL – Low availability (*Level 1*)

### DESCRIPTION OF THE INDICATOR:

#### Transport volume, weighted by CO<sub>2</sub>-emission-coefficient

Transport volume (mode) \* CO<sub>2</sub>-emission-coefficient (mode)

#### Formula Unit:

passengers\*km or t\*km, weighted

### DATA REQUIREMENTS AND AVAILABILITY:

Transport volume (passengers\*km or t\*km) for each mode

CO<sub>2</sub>-emission-coefficient (0 ... 1) of each transport mode (road, rail). These coefficients can be found in literature [Hugrel & all.]. They are calculated according different methodologies. They are different from the impact factor corresponding to the global warming of each pollutant that means the capacity of each pollutant to involve a global warming, even if they are expressed in term of CO<sub>2</sub> emission, as in the global warming of each pollutant (see indicator of level 3).

### MODELLING:

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

### DESCRIPTION OF THE INDICATOR:

Same as level 3, partly approximated

### DATA REQUIREMENTS AND AVAILABILITY:

Same as level 2, partly approximated

### MODELLING:

Same as level 2, partly approximated



## INFORMATION LEVEL – High availability (Level 3)

### DESCRIPTION OF THE INDICATOR:

#### CO<sub>2</sub>-emission

This indicator expresses the global warming potential of greenhouse gases emitted by transport system in term of the quantity of CO<sub>2</sub> emissions equivalent (kt CO<sub>2</sub> equivalent /year). Considering that CO<sub>2</sub> is the most relevant green gas emitted by transport systems, the indicator corresponds finally to CO<sub>2</sub> emissions resulting from calculations with Artemis model.

#### Formula Unit:

kt CO<sub>2</sub> equivalent /year

### DATA REQUIREMENTS AND AVAILABILITY:

The calculation of the indicator is only based on the quantity of CO<sub>2</sub> emissions (kt/year) resulting from calculations with Artemis model

### MODELLING:

*Transport data:*

Road transport: repartition of vehicles in different types of vehicles, number of km done by type of vehicles, repartition of km done by each type of vehicles on urban roads, regional road, and highways, and finally the average speed on the different types of roads.

Rail transport: repartition of trains in different types of trains, number of km done by type of vehicles, repartition of km done by each type of trains, the average speed, and the number of stops.

*Model*: Artemis (2006) or more qualitative models (as FTIP-model) [Germany]

### OBJECTIVES AND TARGETS:

Considering the climate change convention, Europe has engaged itself to reduce green gasses' emissions, taken into account in the Kyoto protocol, over 8% from 2008 to 2012, comparing to emissions mean level of 1990.

No concrete objectives and targets, at national or European level, have been identified for the transport sector.

#### TIME SCALE:

#### EXPECTANCY

☒ Short term    ☐ Long term

#### DURATION

☐ Short term    ☒ Long term

**MONITORING POSSIBILITIES:**

The importance of the contribution to the climate change can be evaluated by calculation of emissions before and after the construction of the infrastructure. At a national or European level, calculations of CO<sub>2</sub> emissions are done by EEA (TERM provides an indicator of CO<sub>2</sub> emissions per year).

**RESEARCH NEEDED:**

There is a consensus on the indicator. The research need is focus on the emissions model which demands a lot of data, and produces a result with a high uncertainty.

**REMARKS:**

As soon as a molecule of a green house gas is emitted in the atmosphere, we can consider that this molecule has got an effect on the global warming. That is the reason why the expectancy may be qualified as “short term”, because, as soon as a plan modifies the emissions of green house gazes, there may be a consequence on the global warming.

<b>Name:</b>  <b>Acidification</b>	<p><i>Indicator for LOW data availability (Level 1):</i> --</p> <p><i>Indicator for INTERMEDIATE data availability (Level 2):</i> Same as level 2, partly approximated</p> <p><i>Indicator for HIGH data availability (Level 3):</i> Emission of pollutants with acidification potential</p>	<b>N°11</b>
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>		Soil, Water, Air, Fauna and Flora, cultural heritage, Biodiversity
<b>PLANNING SITUATION:</b>	<input checked="" type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input checked="" type="checkbox"/> Corridor	
<b>ENVIRONMENTAL EFFECTS:</b>  Acidification is characterised by the acidification potential. This type of pollution mainly involves the contribution of tree gases: SO <sub>2</sub> , NO <sub>x</sub> , NH <sub>y</sub> . These gases induce the creation of nitric acids (H <sub>2</sub> SO <sub>4</sub> ) and sulphuric acids (HNO <sub>3</sub> ) which release ions H <sup>+</sup> . The concentrations of these acids are obviously high in areas where precursors are emitted. Nevertheless acid rains are observed in septentrional areas of Europe where there are so few emissions, which supposes a transport at a regional scale of acid deposits. Acidification affects; natural environment (acidification of soil and water), flora (decrease of the primary productivity, increase of the vulnerability of vegetal species, influence in the forest withering, disappearance of certain species), fauna and population (disappearance of certain species of fauna due to the decrease or the disappearance of food resources, deleterious effects on eyes and lungs), and man-made environment (destruction of cultural areas).		
<b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b>  Contribution of transport to acidification differs from one country to another. In France, the contribution of transport is evaluated at 18% in 2000 [Citepa].		

## INFORMATION LEVEL – Low availability (*Level 1*)

### DESCRIPTION OF THE INDICATOR:

At this information level, no indicator is used because the indicator of level 2 needs a precise information about the local sitting (dimensions of the road, local geography, composition of the pavement and its materials) which is not available at this low level of information availability.

### DATA REQUIREMENTS AND AVAILABILITY:

### MODELLING:

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

### DESCRIPTION OF THE INDICATOR:

Same as level 3, partly approximated

### DATA REQUIREMENTS AND AVAILABILITY:

Same as level 3, partly approximated

### MODELLING:

Same as level 3, partly approximated

## INFORMATION LEVEL – High availability (*Level 3*)

### DESCRIPTION OF THE INDICATOR:

#### Emission of pollutants with acidification potential

The indicator establishes firstly the acidification potential of each substance mentioned above. The result is expressed in term of (kt) H<sup>+</sup> equivalent (per kt pollutant i) emissions. The AP<sub>i</sub> is then multiplied by the quantity of the substance i emitted (m<sub>i</sub>). Acidification (A) corresponds thus to the quantity of H<sup>+</sup> equivalent emissions:

$$A = \sum_i AP_i \times m_i \text{ [Citepa, , Hauschild, 1998a, b]}$$

Pollutant	AP <sub>i</sub>
SO <sub>2</sub>	0,0313
NO <sub>x</sub>	0,0217
NH <sub>y</sub>	0,0588

**Formula Units**kt H<sup>+</sup> equivalent**DATA REQUIREMENTS AND AVAILABILITY:**

The calculation of the indicator is only based on the emissions of NO<sub>x</sub> and SO<sub>2</sub> emitted (m<sub>i</sub>).

**MODELLING:**

*Transport data:*

Road transport: repartition of vehicles in different types of vehicles, number of km done by type of vehicles, repartition of km done by each type of vehicles on urban roads, regional road, and highways, and finally the average speed on the different types of roads.

Rail transport: repartition of trains in different types of trains, number of km done by type of vehicles, repartition of km done by each type of trains, the average speed, and the number of stops.

*Model*: Artemis [Inrets, 1999] or more qualitative models (FTIP-model) [Germany]

**OBJECTIVES AND TARGETS:**

Taking in consideration the fact that this indicator is not yet a reference, the European Commission does not take this indicator into account in the NEC directive 2001/81/CE. This directive establishes limits of national emissions of four pollutants contributing to acidification, eutrophication and ozone formation. European countries have thus engaged themselves to reduce these “multi-effects” gazes’ emissions, to the level of 1990, in term of quantity of emissions and non in term of percentage. Remind that objective values concern all emissions sources, and none specifically transport sector.

Regarding France contribution, we can notice that France is also still over the limits of the NEC directive for NO<sub>x</sub> and SO<sub>2</sub>, but should be easily achieved for NMVOC (table 1).

Table 1 : Emissions objective values relative to the NEC directive and situation in 2001 (France)

Pollutant	Emissions in 2001(kt)	Share of transport sector	Objective value (kt)	Dead line
NO <sub>x</sub>	1411	54%	810	2010
SO <sub>x</sub> *	610	6%	1050	2010

\*Non considering biotic emissions (forests, agricultural fields...)

**TIME SCALE:****EXPECTANCY**

☐ Short term    ☒ Long term

**DURATION**

☐ Short term    ☒ Long term

**MONITORING POSSIBILITIES:**

The importance of the contribution to the acidification can be evaluated by calculation of emissions before and after the construction of the infrastructure.

**RESEARCH NEEDED:**

There is a medium consensus on the indicator. The research need is also focus on the emissions model which demands a lot of data, and produces a result with a high uncertainty.

**REMARKS:**

The expectancy is qualified of “long term”, because the effect claims the transformation from primary pollutants into secondary pollutants, and this transformation is done in some days or some months.

<b>Name:</b>  <b>Photochemical pollution</b>	<i>Indicator for LOW data availability (Level 1):</i> --  <i>Indicator for INTERMEDIATE data availability (Level 2):</i> Same as level 3, partly approximated  <i>Indicator for HIGH data availability (Level 3):</i> Emission of photochemical pollutants	<b>N°12</b>	
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>			Biodiversity, Fauna, and Flora, Population (health, annoyance), Biodiversity
<b>APPLICATION LEVEL:</b>	<input checked="" type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input checked="" type="checkbox"/> Corridor		
<b>ENVIRONMENTAL EFFECTS:</b>  <p>Photochemical pollution is characterised by the creation of photochemical oxidants, and particularly tropospheric ozone, which is used to represent all photochemical oxidants [As, 1993]. The photochemical oxidants are a secondary pollutant, which means that they are not directly emitted by transport infrastructures for example, but result of photochemical reactions from primary pollutants directly emitted in the atmosphere. This type of pollution involves contribution of three main gases: CO, NO<sub>x</sub> and NMVOC. NMVOC and CO deteriorate under the action of hydroxyl radical (OH<sup>•</sup>), and lead in the presence of NO<sub>x</sub> to photochemical oxidants, and especially to ozone synthesis. Tropospheric ozone production results from a non linear mechanism. It depends in fact of the ratio between NMVOC (or CO) concentration and NO<sub>x</sub> concentration in the air. Photochemical pollutants essentially affect population and fauna (deleterious effects on eyes and lungs), and flora (necrosis, acceleration of senescence, and influence in the forest withering).</p>			
<b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b>  <p>Contribution of transport to the photochemical pollution differs between different countries. In France, the contribution of transport is evaluated at 36% in 2000 [Citepa].</p>			

## INFORMATION LEVEL – Low availability (*Level 1*)

### DESCRIPTION OF THE INDICATOR:

At this information level, no indicator is used because the indicator of level 2 needs a precise information about the local sitting (dimensions of the road, local geography, composition of the pavement and its materials) which is not available at this low level of information availability.

### DATA REQUIREMENTS AND AVAILABILITY:

### MODELLING:

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

### DESCRIPTION OF THE INDICATOR:

Same as level 3, partly approximated

### DATA REQUIREMENTS AND AVAILABILITY:

Same as level 3, partly approximated

### MODELLING:

Same as level 3, partly approximated

## INFORMATION LEVEL – High availability (*Level 3*)

### DESCRIPTION OF THE INDICATOR:

#### Emission of photochemical pollutants

[Citepa, , Hauschild, 1998a, b]

This indicator establishes firstly the photochemical ozone creation potential of each substance mentioned above (POCP<sub>i</sub>) (table 8). The result is expressed in term of (kt) ethylene equivalent per kt pollutant i emissions. The POCP<sub>i</sub> is then multiplied by the quantity of the substance i emitted (m<sub>i</sub>). Ozone formation (OF) corresponds thus to the quantity of ethylene (C<sub>2</sub>H<sub>4</sub>) equivalent emissions:  $OF = \sum_i POCP_i \times m_i$ .



Pollutant	POCP <sub>i</sub>
C <sub>2</sub> H <sub>4</sub>	1
CO	0,027
NM VOC	0 to 1,12
NO	-0,427
NO <sub>2</sub>	0,028

**Formula Units**

kt ethylene equivalent

**DATA REQUIREMENTS AND AVAILABILITY:**

The calculation of the indicator is only based on the emissions of CO, NMVOC, NO and NO<sub>2</sub> emitted.

**MODELLING:**

*Transport data:*

Road transport: repartition of vehicles in different types of vehicles, number of km done by type of vehicles, repartition of km done by each type of vehicles on urban roads, regional road, and highways, and finally the average speed on the different types of roads.

Rail transport: repartition of trains in different types of trains, number of km done by type of vehicles, repartition of km done by each type of trains, the average speed, and the number of stops.

*Model*: Artemis [Inrets, 1999] or more qualitative models (FTIP-model) [Germany]

**OBJECTIVES AND TARGETS:**

Taking in consideration the fact that this indicator is not yet a reference, the European Commission does not take this indicator into account in the NEC directive 2001/81/CE. This directive establishes limits of national emissions of four pollutants contributing to acidification, eutrophication and ozone formation. European countries have thus engaged themselves to reduce these “multi-effects” gazes’ emissions, to the level of 1990, in term of quantity of emissions and non in term of percentage. Remind that objective values concern all emissions sources, and none specifically transport sector.

Regarding France contribution, we can notice that France is also still over the limits of the NEC directive for NO<sub>x</sub> and SO<sub>2</sub>, but should be easily achieved for NMVOC (table 1).

Table 1 : Emissions objective values relative to the NEC directive and situation in 2001 (France)

Pollutant	Emissions in 2001(kt)	Share of transport sector	Objective value (kt)	Dead line
NO <sub>x</sub>	1411	54%	810	2010
NM VOC*	1537	29%	1050	2010

\*Non considering biotic emissions (forests, agricultural fields...)

<b>TIME SCALE:</b>	<b>EXPECTANCY</b> <input checked="" type="checkbox"/> Short term <input type="checkbox"/> Long term	<b>DURATION</b> <input checked="" type="checkbox"/> Short term <input type="checkbox"/> Long term
<b>MONITORING POSSIBILITIES:</b>  The importance of the contribution to the photochemical pollution can be evaluated by calculation of emissions before and after the construction of the infrastructure.		
<b>RESEARCH NEEDED:</b>  There is a medium consensus on the indicator. The research need is also focus on the emissions model which demands a lot of data, and produces a result with a high uncertainty.		
<b>REMARKS:</b>		

<b>Name:</b>  <b>Toxicity</b>	<p><b>Indicator for LOW data availability (Level 1):</b> Emissions of toxic or ecotoxic gases</p> <p><b>Indicator for INTERMEDIATE data availability (Level 2):</b> Risk of affecting a highly populated area (human health) or valuable or sensitive habitats</p> <p><b>Indicator for HIGH data availability (Level 3):</b> Number of people or protected area exposed to toxic or ecotoxic pollutant immission standards oversteps of heavy metals (Cu), persistent organic compounds (POC), Particulates, NO<sub>x</sub> (NO<sub>2</sub>), SO<sub>x</sub> (SO<sub>2</sub>).</p>	<b>N°13</b>
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>	Population, fauna and flora, biodiversity	
<b>PLANNING SITUATION:</b>	<input type="checkbox"/> National <input type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input checked="" type="checkbox"/> Corridor	
<p><b>ENVIRONMENTAL EFFECTS:</b></p> <p>Toxicity is characterised by its effects on human health by mortality or morbidity [Chiron, 1996, Oms, 1999, 2000, Seethaler, 1999].</p> <p>Ecotoxicity is characterised by effects on fauna and flora (mortality, diseases...).</p> <p>Only effects induced by primary pollutants are taken into account in the toxicity and ecotoxicity field. That means that toxically and ecotoxically effects mentioned in acidification and photochemical are not taken into account into the toxicity and ecotoxicity concept, in order to avoid redundancy. This type of pollution involves thus contribution of many primary gazes, emitted most of the time at a local or regional scale, and which exposition varies from short term (pollution peaks) to long term (few years). Three main pollutants groups have a contribution to toxicity and ecotoxicity. Heavy metals constitute the first groups. Heavy metals provoke chronic effects. The second group gather persistent organic compounds which accumulate in body fat and cause chronic effects. Main persistent organic compounds emitted are polycyclic aromatic hydrocarbons (PAH), dioxins and furans, hexachlorobenzene (HCB), and polychlorobiphenyls (PCB). The last group is essentially represented by particulates, and also by NO<sub>x</sub> and SO<sub>x</sub>, which may cause acute effects.</p>		
<p><b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b></p> <p>Contribution of transport to the toxicity and ecotoxicity differs from one country to another, and also from the different pollutant considered.</p>		

## INFORMATION LEVEL – Low availability (*Level 1*)

### DESCRIPTION OF THE INDICATOR:

#### Emissions of toxic or ecotoxic gases

Transport volume of different modes \* emission coefficient of heavy metals (Cu), persistent organic compounds (POC), Particulates, NO<sub>x</sub> (NO<sub>2</sub>), SO<sub>x</sub> (SO<sub>2</sub>) for each transport mode.

#### Formula Units:

passengers or tons \* g (of each pollutant)

### DATA REQUIREMENTS AND AVAILABILITY:

Transport volume for each transport mode (in tons \* km; vehicles \* km; passengers \* Km)

Emission coefficient of each transport mode (in g/km)

### MODELLING:

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

### DESCRIPTION OF THE INDICATOR:

Risk of affecting a highly populated area (human health) or valuable or sensitive habitats

#### Formula Units

High ... low

### DATA REQUIREMENTS AND AVAILABILITY:

Expert judgment made on the basis of crossing toxic or ecotoxic pollutants emission with proximity of highly populated area (human health) or valuable or sensitive areas

### MODELLING:

## INFORMATION LEVEL – High availability (*Level 3*)

### DESCRIPTION OF THE INDICATOR:

Number of people exposed to toxic pollutant immission standards oversteps of heavy

metals (Cu), persistent organic compounds (POC), Particulates, NO<sub>x</sub> (NO<sub>2</sub>), SO<sub>x</sub> (SO<sub>2</sub>), or valuable or sensitive area affected by ecotoxic pollutant immission of heavy metals (Cu), persistent organic compounds (POC), Particulates, NO<sub>x</sub> (NO<sub>2</sub>), SO<sub>x</sub> (SO<sub>2</sub>).

The indicator gives the number of people or the surface of spacial area exposed to one or more of the pollutants mentioned previously.

**Formula Units**

None

**DATA REQUIREMENTS AND AVAILABILITY:**

The calculation of the indicators of toxicity is based on the one hand on the measurement of toxic pollutants immission and the identification of those which are over the standards, and on the other and the number of people living living in a highly populated area near the transport infrastructure.

The calculation of the indictor of ecotoxicity is based on the one hand on the measurement of ecotoxic pollutants immission, and on the other and the number of surface of sensitive or valuable areas near the transport infrastructure

**MODELLING:**

For toxicity, the idea is to estimate the number of people living (in a highly populated area) near the transport infrastructure with a GIS.

For ecotoxicity, the same approach is provided in term of surface.

**OBJECTIVES AND TARGETS:**

Air Quality Framework Directive 96/62/EC, and the daughter directives.

**TIME SCALE:**

**EXPECTANCY**

☒ Short term ☒ Long term

**DURATION**

☒ Short term ☒ Long term

**MONITORING POSSIBILITIES:**

The importance of the contribution to the toxicity or ecotoxicity can be evaluated before and after the construction of the infrastructure, and the number of people living in the proximal areas of the transport plan.

**RESEARCH NEEDED:**

There is a medium consensus on the indicator. The research need is also focus on the emissions model which demands a lot of data, and produces a result with a high uncertainty.

**REMARKS:**

<b>Name:</b>  <b>Eutrophication</b>	<b>Indicator for LOW data availability (Level 1):</b> --  <b>Indicator for INTERMEDIATE data availability (Level 2):</b> Same as level 3, partly approximated  <b>Indicator for HIGH data availability (Level 3):</b> Emission of pollutants with eutrophication potential	<b>N°14</b>
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>		
<b>APPLICATION LEVEL:</b> <input type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input checked="" type="checkbox"/> Corridor		
<b>ENVIRONMENTAL EFFECTS:</b>  <p>Eutrophication is characterised by the eutrophication potential. Eutrophication potential traduces the capacity of a substance to release ions <math>\text{PO}_4^{3-}</math>, which is also a nutriment for plant. This type of pollution mainly involves the contribution of <math>\text{NO}_x</math>. This gas induces the creation of nitrates (<math>\text{NO}_3</math>). The concentrations of nitrates in the water constitute an enrichment of nutritive substances which involves the aquatic primary production. Eutrophication is obviously high in areas where precursors are emitted. Nevertheless eutrophication could be observed far from the emissions source areas, which supposes a transport at a regional scale of <math>\text{NO}_x</math> and nitrates as well. Eutrophication affect natural environment (anoxia of the medium: water and soil), biodiversity (morbidity and mortality of fauna, and finally of flora) and population (degradation of cultural areas).</p>		
<b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b>  <p>Contribution of transport to the eutrophication differs from one country to another. In France, the contribution of transport to eutrophication (through air pollutants) is evaluated at 54% in 2000 [Citepa]. All the contribution is due to <math>\text{NO}_x</math>.</p>		

## INFORMATION LEVEL – Low availability (*Level 1*)

### DESCRIPTION OF THE INDICATOR:

At this information level, no indicator is used because the indicator of level 2 needs a precise information about the local sitting (dimensions of the road, local geography, composition of the pavement and its materials) which is not available at this low level of information availability.

### DATA REQUIREMENTS AND AVAILABILITY:

### MODELLING:

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

### DESCRIPTION OF THE INDICATOR:

Same as level 3, partly approximated

### DATA REQUIREMENTS AND AVAILABILITY:

Same as level 3, partly approximated

### MODELLING:

Same as level 3, partly approximated

## INFORMATION LEVEL – High availability (*Level 3*)

### DESCRIPTION OF THE INDICATOR:

#### Emission of pollutants with eutrophication potential

The indicator corresponds to the quantity of NO<sub>x</sub> emissions

#### Formula Unit:

t/year

**DATA REQUIREMENTS AND AVAILABILITY:**

The calculation of the indicators is only based on the emissions of NO<sub>x</sub> (t/year).

**MODELLING:**

*Transport data:*

Road transport: repartition of vehicles in different types of vehicles, number of km done by type of vehicles, repartition of km done by each type of vehicles on urban roads, regional road, and highways, and finally the average speed on the different types of roads.

Rail transport: repartition of trains in different types of trains, number of km done by type of vehicles, repartition of km done by each type of trains, the average speed, and the number of stops.

*Model*: Artemis [Inrets, 1999] or more qualitative models (FTIP-model) [Germany]

**OBJECTIVES AND TARGETS:**

Considering that this indicator is not yet a reference, the European Commission does not take this indicator into account in the NEC directive 2001/81/CE. This directive establishes limits of national emissions of four pollutants contributing to acidification, eutrophication and ozone formation. European countries have thus engaged themselves to reduce these “multi-effects” gasses’ emissions, to the level of 1990, in term of quantity of emissions and non in term of percentage. Remind that objective values concern all emissions sources, and none specifically transport sector. Regarding France contribution, we can notice that France is also still over the limits of the NEC directive. The objective value should normally be easily achieved for NMVOC emissions, whereas efforts seem to be necessary to achieve NO<sub>x</sub> objective value (table 1).

Table 1 : Emissions objective values relative to the NEC directive and situation in 2001 (France)

Pollutant	Emissions in 2001(kt)	Share of transport sector	Objective value (kt)	Dead line
NO <sub>x</sub>	1411	54%	810	2010

**TIME SCALE:****EXPECTANCY**

☒ Short term    ☐ Long term

**DURATION**

☐ Short term    ☒ Long term

**MONITORING POSSIBILITIES:**

The importance of the contribution to the eutrophication can be evaluated by calculation of emissions before and after the construction of the infrastructure.



**RESEARCH NEEDED:**

There is a medium consensus on the indicator. The research need is also focus on the emissions model which demands a lot of data, and produces a result with a high uncertainty.

**REMARKS:**

<b>Name:</b>  <b>Release of dangerous goods due to accidents</b>	<b>Indicator for INTERMEDIATE data availability (Level 2):</b> Probability of accidents causing ecological catastrophes  <b>Indicator for HIGH data availability (Level 3):</b> Probability of accidents causing ecological catastrophes within vulnerable areas	<b>N°15</b>
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>		
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>		Soil, Water, Culture
<b>PLANNING SITUATION:</b>	<input checked="" type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input type="checkbox"/> Corridor	
<b>ENVIRONMENTAL EFFECTS:</b>  On the European road network huge amounts of dangerous goods are transported. Although there are a lot of prevention measures used on roads, such as: <ul style="list-style-type: none"> <li>➤ tight drainage systems,</li> <li>➤ retention ponds,</li> <li>➤ phone net,</li> <li>➤ others.</li> </ul> The road administration must be prepared for the situation of accidents connected with ecological catastrophes when the hazardous substances are released into the environment.		
<b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b>  Transport is the only source of such threats.		
<div style="text-align: center; border: 1px solid black; padding: 10px;"> <b>INFORMATION LEVEL – Low availability (Level 1)</b> </div> <div style="border: 1px solid black; padding: 10px; margin-top: 10px;">         The indicator does not apply.       </div>		

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

### DESCRIPTION OF THE INDICATOR:

The indicator aims to estimate the probability of serious environmental catastrophe caused of vehicles/train transporting dangerous goods. The probability of accident differs dependently on the parameters of road or railway, traffic volume and, generally speaking – transport safety.

#### Formula Units:

% (count using the weights of different environmental elements' sensitivity)

### DATA REQUIREMENTS AND AVAILABILITY:

The basic data needed is the information concerning the routes of dangerous goods transport. On this basis there is need to assess the sensitivity of the environment in every route surrounding.

According to the ADR Agreement (for roads) and RID Agreement (for railroads), the correct administrative organs (e.g. road administration, fire rescue services) must be informed about such a transport.

In every country some roads are indicated to be used for dangerous goods transport. In practice this data is not always available – all the countries know about the fact of boarder crossing but do not know the exact route of the transport.

### MODELLING:

No modelling methods.

All the comparisons should based on the observations made on the probability of accidents.

## INFORMATION LEVEL – High availability (*Level 3*)

### DESCRIPTION OF THE INDICATOR:

The indicator aims to estimate the probability of serious environmental catastrophe caused of vehicles/train transporting dangerous goods. The probability of accident differs dependently on the parameters of road or railway, traffic volume and, generally speaking – transport safety, as well as the sensitivity of the environment in the surrounding.

**Formula Units:** % (count using the weights of different environmental elements' sensitivity)

## DATA REQUIREMENTS AND AVAILABILITY:

The basic data needed is the information concerning the routes of dangerous goods transport. On this basis there is need to assess the sensitivity of the environment in every route surrounding.

According to the ADR Agreement (for roads) and RID Agreement (for railroads), the correct administrative organs (e.g. road administration, fire rescue services) must be informed about such a transport.

In every country some roads are indicated to be used for dangerous goods transport. In practice this data is not always available – all the countries know about the fact of boarder crossing but do not know the exact route of the transport.

## MODELLING:

There are no modelling methods but when the sensitivity of the environment is known it is easy to compare alternatives taking into consideration the sensitivity of the environmental' elements.

The sensitivity of the environmental elements can be evaluate using 5-grades scale of threat's force:

- 1 – very low
- 2 – low
- 3 – medium
- 4 – high
- 5 – very high.

Because water and air are the most threatened environmental element different weights (1 to 5 degree of threat) can be given to certain situation, for example:

- water intakes areas (5) or the areas of non-insulated deep ground-water basins (4) are more sensitive than the areas of the basins of non-potable shallow ground-water (2) or well-insulated deep ground-water basins (1);
- infrastructure (road or railway) constructed along the deep and narrow valley (4) is more sensitive than flat area (1) or densely urbanized settlement area (5) is more sensitive than the industrial zone (1), etc.

## OBJECTIVES AND TARGETS:

The European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR was done at Geneva on September 1957 under the auspices of the United Nations Economic Commission for Europe, ant it entered into force on 29<sup>th</sup> January 1968.

The Agreement itself was amended by the protocol amending article 14 (3) done at New York on 21st August 1975, witch entered into force on April 1985.

The Agreement itself is short and simple. The key article is the second, which quotes that apart from some excessively dangerous goods, other dangerous goods may be carried internationally in road vehicles subject to compliance with:

- the conditions laid down in Annex A for the goods in question, in particular as regards their packaging and labelling; and
- the conditions laid down in Annex B, in particular as regards the construction, equipment and operation of the vehicle carrying the goods in question.

Annexes A and B have been regularly amended and updated since the entry into force of ADR. These annexes were entirely revised and restructured between 1992 and 2000, and a first version of the restructured annexes entered into force on the 1<sup>st</sup> of July 2001. It was published as document ECE/TRANS/140, Vol. 1.1 And II. New amendments entered into force on the 1<sup>st</sup> of January 2003, and consequently, a second consolidated “restructured” version was published as document ECE/TRANS/175, Vol. I and II (“ADR 2005”). The new structure is consistent with that of the United Nations Recommendations on the Transport of Dangerous Goods, Model Regulations, the International Maritime Dangerous Goods Code (of the International Maritime Organization), the Technical Instructions for the Safe Transport of Dangerous Goods by Air (of the International Civil Aviation Organization) and the Regulations concerning the International Carriage of Dangerous Goods by Rail (of the Intergovernmental Organization for International Carriage by Rail). The lay-out is as follows:

*Annex A: General provisions and provisions concerning dangerous articles and substance*

- General provisions
- Classification
- Dangerous goods list, special provisions and exemptions related to dangerous goods packed in limited quantities
- Packing and tank provisions
- Consignment procedures
- Requirements for the construction and testing of packagings, intermediate bulk containers (IBCs), large packagings and tanks
- Provisions concerning the conditions of carriage, loading, unloading and handling

*Annex B: Provisions concerning transport equipment and transport operations*

- Requirements for vehicle crews, equipment, operation and documentation
- Requirements concerning the construction and approval of vehicles.

**TIME SCALE:**

**EXPECTANCY**

☒ Short term    ☐ Long term

**DURATION**

☐ Short term    ☒ Long term

**MONITORING POSSIBILITIES:**

This kind of monitoring is a part of all the monitoring networks concerning different elements of the environment (soil, water, air, etc.).

**RESEARCH NEEDED:**

**REMARKS:**

This indicator has been chosen because it is a good tool to decide about the route of dangerous goods' transport. Although the probability of accident (with the presumption that all the alternatives are of the same parameters) depends only on the traffic volume, the real threat for environment differs dependently on the sensitivity of the environmental elements. When the decision-maker has the information about environmental sensitivity, he can easily evaluate the threat.

<b>Name:</b>  <b>Accidents</b>	<p><i>Indicator for LOW data availability (Level 1):</i> Accident risk</p> <p><i>Indicator for INTERMEDIATE data availability (Level 2):</i> Same as Level 3, partly approximated</p> <p><i>Indicator for HIGH data availability (Level 3):</i> Number of killed, seriously or slightly injured persons due to accidents</p>	<b>N°16</b>
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>		<b>Population</b>
<b>PLANNING SITUATION:</b>	<input checked="" type="checkbox"/> National <input checked="" type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input checked="" type="checkbox"/> Corridor	
<p><b>ENVIRONMENTAL EFFECTS:</b></p> <p>Road traffic accidents in the European Union (EUR-15) annually claim more than 40 000 lives and leave more than 1.7 million people injured, representing estimated costs, both direct and indirect, of 160 billion euro (81). A large number of measures to reduce road accidents have been taken successfully and the number of dead and injured people decreases, but still on a high level. The number of accidents remains relatively stable in EU. Property damage can be neglected on SEA-level.</p> <p>Road accidents represent the main cause of death for persons under 45. Railway and waterway accidents can be neglected in this context.</p>		
<p><b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b> Transport is the only source of such threats.</p>		
<p style="text-align: center;"><b>INFORMATION LEVEL – Low availability (Level 1)</b></p> <div style="border: 1px solid black; padding: 10px; margin-top: 10px;"> <p><b>DESCRIPTION OF THE INDICATOR:</b> accident risk, as in level 3, approximated by comparing similar existing traffic units</p> <p><b>FORMULA UNITS:</b> Same as level 3</p> </div>		

**DATA REQUIREMENTS AND AVAILABILITY:**

Traffic volume by mode, factor accident probability derived from accidents rates of existing traffic units

**MODELLING:**

Analogue level 3, estimated by assumptions derived from the existing network. Important are lengths of traffic units with high respectively low accident risk, estimated by criteria shown in level 3.

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

**DESCRIPTION OF THE INDICATOR:**

same as level 3, partly estimated by assumptions

**FORMULA UNITS:**

Same as level 3

**DATA REQUIREMENTS AND AVAILABILITY:**

analogue level 3, partly estimated by assumptions

**MODELLING:**

analogue level 3

## INFORMATION LEVEL – High availability (*Level 3*)

**DESCRIPTION OF THE INDICATOR:**

Number of killed, seriously or slightly injured persons due to accidents.

**FORMULA UNITS:**

Number of persons

**DATA REQUIREMENTS AND AVAILABILITY:**

- accident risk depending on
- the location of the road (urban or interurban);
- 
- the type of the road (e.g. highways as the safest roads, rural roads with the heaviest accidents, urban roads with the most accidents);
- the surroundings which represent the use of the roads (e.g. residential areas causing pedestrian and bicycle crossing;
- the type of junctions (e.g. crossings on two levels are safer as signalized junctions or roundabouts, which are safer as non-signalized junctions)
- the maximum vehicle velocity.
- Driving performance (vehicles \* km/a)

In addition the proportion of trucks can be added by applying a factor (larger than 1) that takes into account the capacity effect of trucks relative to passenger cars. It could be that an increase in maximum velocity of 10 km/hour increases risk levels for both passenger cars and trucks by 5%. Contribution of truck to risk level can be larger than contribution of passenger cars by a factor of 2.

estimation for each traffic unit possible

**MODELLING:**

If there isn't any existing standardization available it can be derived by the existing accident situation in the planning area. Reference number of killed or injured persons could be derived from generally available statistical information related to the driving performance of representative existing road networks. More specific characteristics or developments related to the alternative planning option can then be taken into account to assess the relevant changes of accident risk and related number of killed or injured persons.

For the German Federal Transport Infrastructure Plan (82) a model has been developed to estimate the accident rate, depending on driving performance and type of road (83, see fig. 1), which may be an example for estimating accident risk. Accident risk also depends on the type of junctions (see fig. 2).

Fig. 1: Average accident cost rate for accidents with personal damage for several types of roads (83)



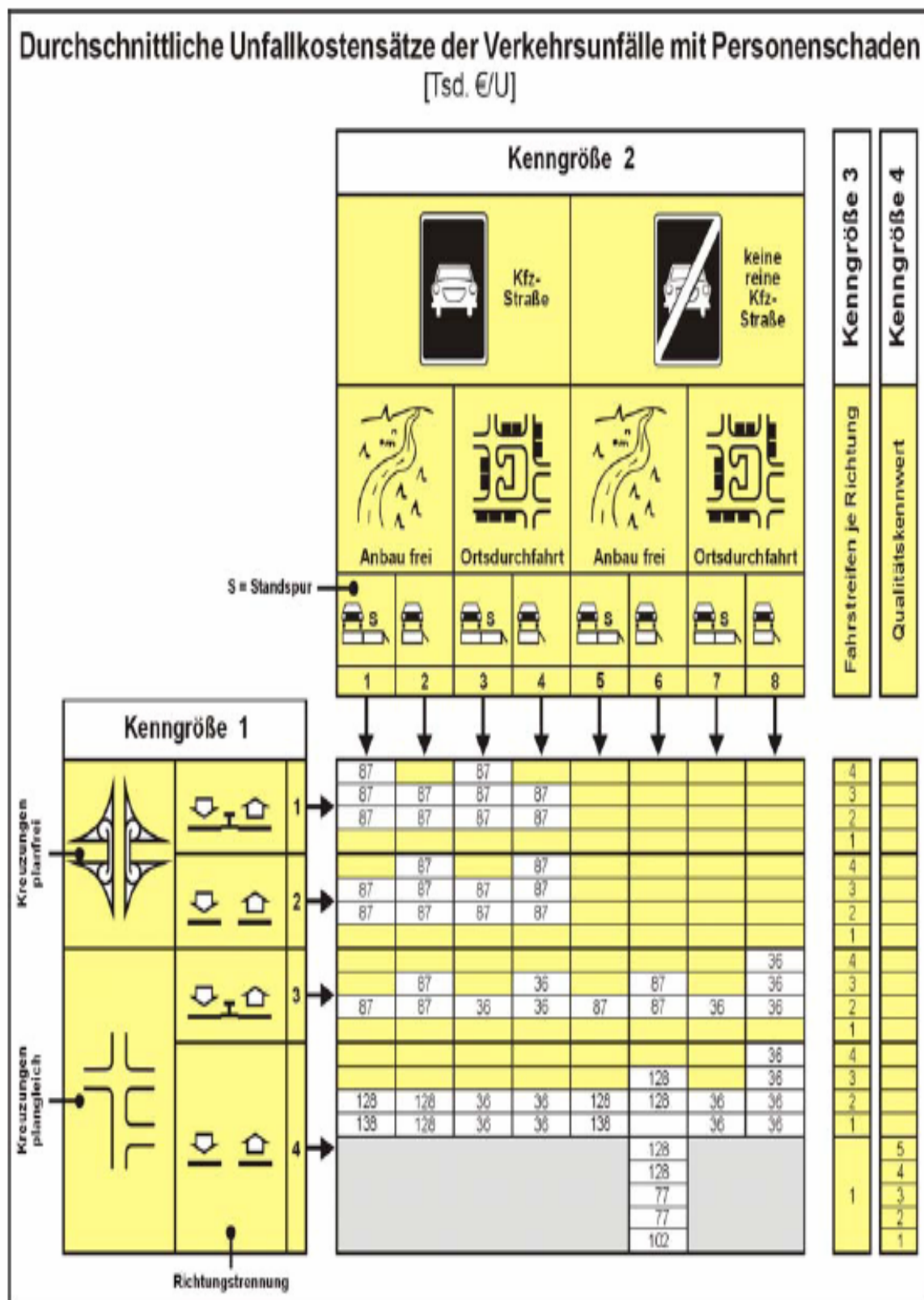
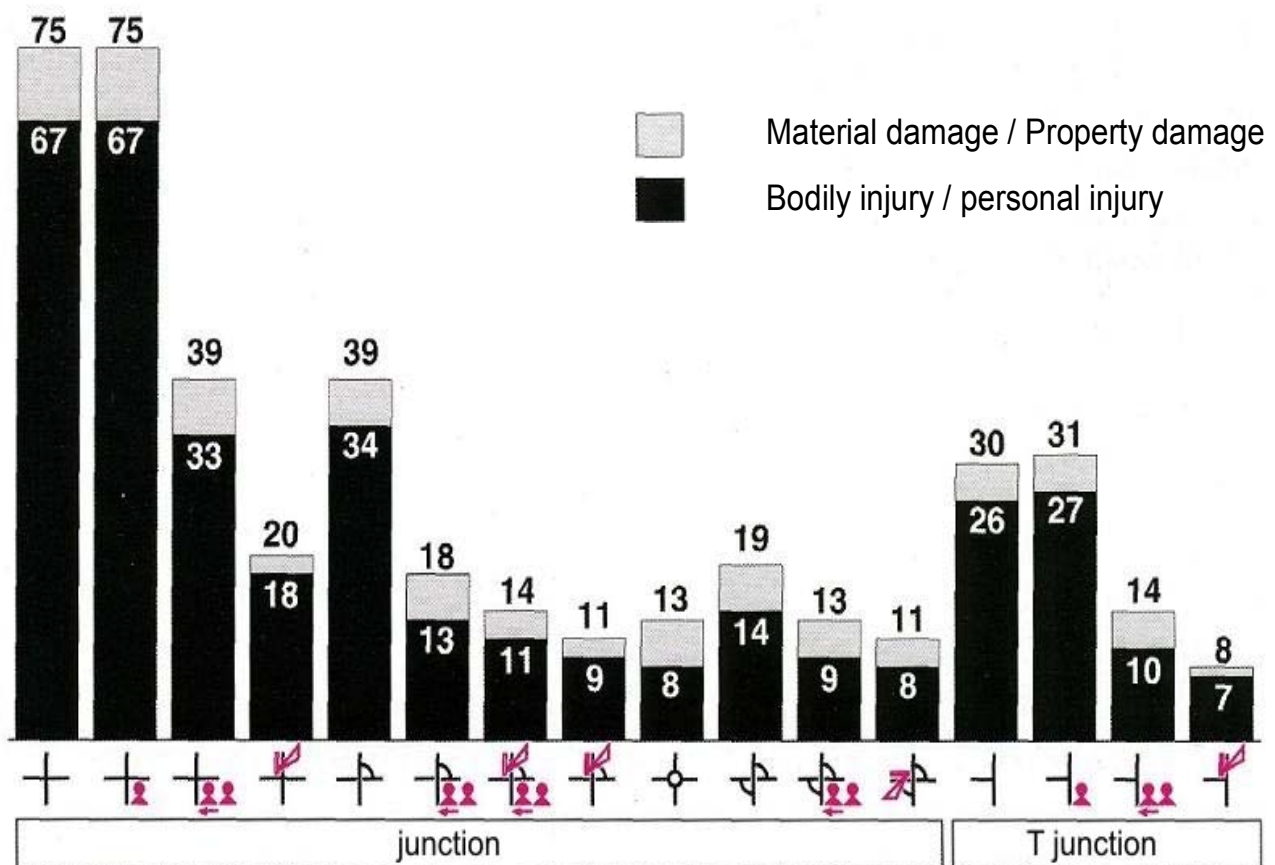


Fig. 2 : accident risk, depending on type of junction (89)



pic.8: rates of accident costs at junctions - middle year of calculation 1992 (costs from 2000)

- |  |  |  |   |
|--|--|--|---|
|  | junction   |  | roundabout traffic  |
|  | junction with traffic lights   |  | junction with two own accesses for turning traffic  |
|  | junction with traffic lights especially for left turn  |  | junction with traffic lights especially for left turn and with two own accesses for turning traffic |
|  | junction with local overspeed protection   |  | junction with local overspeed protection and two own accesses for turning traffic                   |
|  | junction with own access for turning traffic   |  | T junction  |
|  | junction with traffic lights especially for left turn and with own access for turning traffic                                  |  | T junction with traffic lights  |
|  | junction with traffic lights especially for left turn, with own access for turning traffic and with local overspeed protection |  | T junction with traffic lights especially for left turn   |
|  | junction with local overspeed protection and own access for turning traffic  |  | T junction with local overspeed protection  |

**OBJECTIVES AND TARGETS:**

There is no doubt about the objective to decrease deaths and injuries caused by accidents. In concretion there are two targets:

- The goal of the EU-Commission (84) is to halve the number of deaths until 2010 (on the basis of 2000: 40.000 deaths in EU-15, 50.000 in EU-25).
- The Swedish Parliament has approved the “Vision Zero” in 1997 (85) including the long-term road safety goal: there should be no fatalities or serious injuries in road traffic.

**TIME SCALE:****EXPECTANCY**

☒ Short term ☐ Long

**DURATION**

☐ Short ☒ Long

**MONITORING POSSIBILITIES:**

Monitoring should describe the progress to more safety in each Country/State/Region, year after year, and allow to compare the situation with other Countries/States/Regions. EU-Commission (86) provides a Community database on road accidents (CARE (87)) in order to achieve this aim. For example number of accidents, number of victims (killed/injured), accident severity are available. Hence a database for monitoring accident rate exists in each Member State, it has to be related to the road units.

**RESEARCH NEEDED:**

There is a need to know whether a new by-pass-road will increase or decrease the total number of accidents, together with those on the town-cross link. Also the models for estimating future accidents and the number of killed or severely injured people should be evaluated.

**REMARKS:**

On national level it could be wise only to use number of killed persons in order to reduce expenditure. Objectives mentioned above only stress on killed persons.

Accident cost rates or similar economic indicators could be an alternative, but they are recommended only in addition. The number of killed or injured persons should remain in order to assess the objectives and targets mentioned above.

The number of killed or severely injured people (88) or fatality rates (persons killed per passenger kilometers) depend on the local/regional/national circumstances concerning ambulance service, medical provision etc. and the national definitions of road deaths, e.g. in the 30 days following the accident. So they aren't comparable directly in an EU-wide monitoring-system.

Fauna and biodiversity may also be affected by accidents, particularly in habitats of endangered species or species with low abundance. In worst cases there might be consequences for the local population. These effects can be reduced by planting, by fences or by walls, but these measures let the barrier-effect increase. Hence a more detailed reflection on EIA-level is necessary. On SEA-level the indicator “habitat fragmentation” (see indicator no. 2) covers this topic adequately.

<b>Name:</b>  <b>Hydromorphological risks</b>	<i>Indicator for INTERMEDIATE data availability (Level 2):</i> Area affected, species lost, people affected, cost of water supply, partly approximated  <i>Indicator for HIGH data availability (Level 3):</i> Area affected, species lost, people affected, cost of water supply	<b>N°17</b>
<b>ENVIRONMENTAL FACTORS AFFECTED:</b>		<b>Biodiversity, Fauna, Flora, Population</b>
<b>PLANNING SITUATION:</b>	<input type="checkbox"/> National <input type="checkbox"/> Regional <input checked="" type="checkbox"/> Local <input checked="" type="checkbox"/> Corridor	
<b>ENVIRONMENTAL EFFECTS:</b>  <p>The water regime of a freshwater ecosystem is the prevailing pattern of water flow over a given time.</p> <p>More specifically, it refers to the duration and timing of flooding resulting from surface water (overland flow), precipitation and ground water inflow.</p> <p>Water in the soil is an important component of the ecosystem. In one hand it represents an essential resource for plant growth and it plays a crucial role in transporting dissolved elements for the plant nutrition. On the other hand water is one of the main factors in pedogenesis that determines most of the processes in soil formation. The soil water regime depends on the physical characteristics of the soil (e.g. hydraulic conductivity) and on the hydrology of the drainage basin.</p> <p>Freshwater ecosystems are the ecosystem type most rapidly being lost and degraded worldwide. Causes include excessive abstraction of water upstream, disruption of natural flooding cycles through flood control works. If freshwater ecosystems are to be maintained, it is critical that environmental flows be defined and guaranteed.</p>		
<b>CONTRIBUTION OF THE TRANSPORT SECTOR:</b>  <p>The construction of new transport infrastructure causes serious changes in the ground water regime – the need of the certain capacity of ground on which the infrastructure can be settled cause the need of the exchange of weak grounds connected with wetland ecosystems. The direct result of ground exchange is the serious change of groundwater conductivity and, following – the change of soil humidity.</p> <p>It causes damage of wetland ecosystems. The range of the changes differs for different soil types and the land uptake.</p>		

## INFORMATION LEVEL – Low availability (*Level 1*)

The indicator does not apply.

## INFORMATION LEVEL – Intermediate availability (*Level 2*)

### DESCRIPTION OF THE INDICATOR:

The indicator aims to calculate the territory to be affected by the construction of transport infrastructure.

Taking into account the value of the ecosystem (protected?) that is to be destroyed it is possible to analyze the effect on the biodiversity.

Taking into consideration the number of people living at the endangered territory and using groundwater as the potable one it is possible to assess the harmful effect on human population. The presumption that the lowering of groundwater level causes need of organising potable water supplies from other sources can lead to the calculation of economic costs of constructing of water pipe-lines.

The indicator answers following questions:

1. How big area is going to be affected?

**Formula Units:** km<sup>2</sup>, ha

2. How many species (plants and animals) is going to loose their habitats?

**Formula Units:** total numbers

3. How many protected species (plants and animals) is going to loose their habitats?

**Formula Units:** total numbers

4. How many of endangered species are able to move / to be removed?

**Formula Units:** total numbers / % (of species able to remove / be removed)

5. How many people is going to be affected by the lowering of groundwater level (in terms of loosing the source of potable water)?

**Formula Units:** total numbers

6. How big will the cost of water supplies be?

**Formula Units:** total numbers

**DATA REQUIREMENTS AND AVAILABILITY:**

To calculate the real risk for the environment and human population the following data is needed:

- type of land usage at the threatened territory,
- number of people living at this territory and using the groundwater for their daily life (as potable water),

number of protected species living at the threatened territory.

**MODELLING:**

There are no analytical models. The prognosis ought to base on practical observations.

## INFORMATION LEVEL – High availability (*Level 3*)

**DESCRIPTION OF THE INDICATOR:**

The same as for level 2 – more detailed.

**DATA REQUIREMENTS AND AVAILABILITY:**

The same as for level 2 – more detailed.

**MODELLING:**

There are no analytical models. The prognosis ought to base on practical observations.

**OBJECTIVES AND TARGETS:**

According to the Water Framework Directive the quantity is also (apart from quality) a major issue for groundwater. Briefly, the issue can be put as follows. There is only a certain amount of recharge into a groundwater each year, and of this recharge, some is needed to support connected ecosystems (whether they be surface water bodies or terrestrial systems such as wetlands). For good management, only that portion of the overall recharge not needed by the ecology can be abstracted - this is the sustainable resource, and the Directive limits abstraction to that quantity.

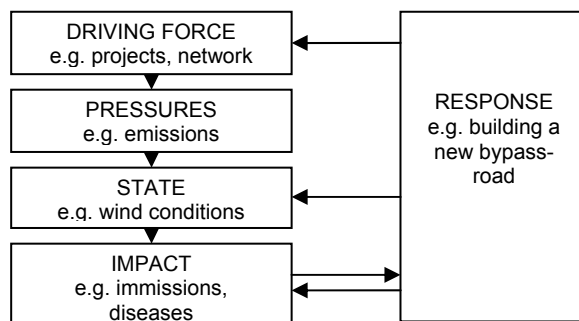
<b>TIME SCALE:</b>	<b>EXPECTANCY</b> <input checked="" type="checkbox"/> Short term <input type="checkbox"/> Long term	<b>DURATION</b> <input type="checkbox"/> Short term <input checked="" type="checkbox"/> Long term
<b>MONITORING POSSIBILITIES:</b>  Monitoring of the groundwater level should be provided constantly during the construction stage. During the operational phase the monitoring of the ecosystems' condition should be proceeded.		
<b>RESEARCH NEEDED:</b>  There is a need for analytical and methodological approaches to explicitly link scenarios developed at different geographic scales. Such approaches would provide decision-makers with detailed information that directly links the local, national, regional, and global scales of the future of ecosystem services. Significant advances are needed in models that link ecological and social processes. Models do not yet exist for many cultural, and supporting ecosystem services. There is also a lack of theories and models that anticipate thresholds at which an ecosystem suffers fundamental changes or even a collapse.		
<b>REMARKS:</b>  This indicator has been chosen because it is a good tool to decide about the route. Although the real effects is dependent on many factors, the general conclusions can be elaborated. When the decision-maker has information concerning the area to be threatened together with number of endangered people and ecosystems / species, he can easily evaluate the threat.		

## 6. Summary

The main objective of WG3 was to propose the most relevant environmental indicators to be used as a tool for decision makers in the development of sustainable transport infrastructure. In order to achieve this, the first effort was dedicated into the approach and analysis of the DPSIR-Scheme, where the concepts of the application of DPSIR in SEA and a more thorough approach of all the single aspects are described:

- Driving Force,
- Pressure,
- State,
- Impact,
- Response.

DPSIR in Transport Sector



Secondly, all the aims and targets that must be taken into account as far as the environmental protection is concerned, were elaborated. They include the following:

- Tackling climate change,
- Protecting nature and bio-diversity,
- Environment and Health (water protection, Soils protection, quality, Protection
- Sustainable use of natural resources and management of wastes.

After the above two phases, WG3 proceeded in the formulation of general and specific criteria to be used in order to evaluate and select the most relevant environmental indicators.

The criteria were the following:

### General criteria:

- Significance
- Completeness
- Simplicity
- Scientific validity
- Applicability

### Specific criteria:

- European rules-oriented approach
- Transport-oriented approach
- SEA-oriented approach
- Decision-making-oriented approach



Based on the above criteria, seventeen impacts were selected as follows:

No	Impact	Indicator, depending on availability of information		
		low	intermediate	high
1	Land uptake	Change of surface transport infrastructure	Valuable area lost-sealed area	Natural habitat area lost Domestic and recreation area lost Sealed area
2	Fragmentation of habitats	Risk of impact on valuable areas	Importance of existing habitats and planned ecological networks, length and numbers of cuttings, Fragmentation-Index	Endangerment of populations of (representative) target species
3	Visual disturbance	Risk of impact on valuable areas	Same as high, partly approximated	Claim of valuable areas x effect's magnitude
4	Material consumption and Waste production	None	Consumption of non-renewable raw materials and recycling of waste in construction	Consumption of non-renewable raw materials and recycling of waste in construction
5	Concentration of pollutants in soils	None	Risk of pollution of sensitive soils	Concentration of lead, PAH, pesticides, salt in soil
6	Concentration of pollutants in surface water	Risk of pollution of sensitive water	Same as level 3, partly approximated	Concentration of oil-derivatives, pesticides and salt in water
7	Energy consumption	a) Level of service, b) Transport volume	a) same as level 1, b) same as level 3, partly estimated	a) same as level 1, b) Use of fossil fuels /renewable energy
8	Disturbance from noise	Same as level 2, partly approximated	Risk of affecting highly populated areas or sensitive habitats	Number of people affected by noise level oversteps or proximity of sensitive habitats
9	Sensitive pollution	None	Emissions for	Sensitive Pollution
10	Climate change	Transport volume, weighted by CO2-emission-coefficient	Same as level 2, partly approximated	CO2-emission

(Continue)

No	Impact	Indicator, depending on availability of information		
		low	intermediate	high
11	Acidification	None	Same as high, partly approximated	Emission of pollutants with acidification potential
12	Photochemical pollution	None	Same as high, partly approximated	Emission of photochemical pollutants
13	Toxicity	Emissions of toxic or ecotoxic gases	Risk of affecting a highly populated area (human health) or valuable or sensitive habitats	Number of people or protected area exposed to toxic or ecotoxic pollutant immission standards oversteps of heavy metals (Cu), persistent organic compounds (POC), Particulates, NO <sub>x</sub> (NO <sub>2</sub> ), SO <sub>x</sub> (SO <sub>2</sub> ).
14	Eutrophication	None	Same as level 3, partly approximated	Emission of pollutants with eutrophication potential
15	Release of dangerous goods due to accidents	None	Probability of accidents causing ecological catastrophes	Probability of accidents causing ecological catastrophes within vulnerable areas
16	Accidents	Accident risk	Same as Level 3, partly approximated	Number of killed, seriously or slightly injured persons due to accidents
17	Hydromorphological risks	None	Area affected, species lost, people affected, cost of water supply, partly approximated	Area affected, species lost, people affected, cost of water supply

For each of the above seventeen impacts we recommend three corresponding indicators that represent three different levels of available information, moving from the lower level of information, to the intermediate level, and finally to the higher information level available.

## Level 1

### **LOW data availability IMPACT ASSESSMENT:**

In this situation there would not be a clear specification of the types and location of transport planning alternatives. Basically, there would only be a notion of dimensions in terms of length and width of possible new alignments and of the approximate location of the regions (in terms of large planning areas) where the network expansions might take place. In addition there are some rough estimates of the extent of transport flows corresponding to the alternatives. This impact assessment level would correspond with a situation whereby preliminary transport planning alternatives would be considered on a large geographical (e.g. the national) level.

## Level 2

### **INTERMEDIATE data availability IMPACT ASSESSMENT:**

Represents an intermediate situation, There is no clear specification of planning alternatives but approximate locations of impact areas, and some more selective information on traffic flows is available.

## Level3

### **HIGH data availability IMPACT ASSESSMENT:**

Maximum data availability: In this situation it is assumed that there is a rather clear specification of the types and locations of planning alternatives. The infrastructure dimensions and alignments are reasonably well known and an assessment of traffic flows associated with the various planning alternatives is available. Given the specification of the locations and dimensions of planning alternatives, site specific information can be obtained on the land use and levels of activities in the impact area of the new alignments of the transport network. This impact assessment level would correspond with a situation whereby concrete transport planning alternatives have been specified on a regional or corridor level.

Finally from the total seventeen "impacts" mentioned above, six "key impacts" are selected since they are considered to be the most important, they should be dealt with in every SEA for transport plans and programmes. The remaining eleven can be used if they are found to be relevant during the scoping procedure. And they depend on the type of SEA (national, regional, and local or corridor level) and the quality of data.

No	Key Impacts
1	Land uptake
2	Fragmentation of habitat's
3	Disturbance from noise
4	Climate change
5	Toxicity
6	Accidents

*The above table shows the six Key impacts always to be considered in a SEA, for transport plans and programmes since they are of the most important.*

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## **7. Legal basis**

- I. Council Directive 70/156/EEC of 6 February 1970 on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers
- II. Council Directive 70/220/EEC of 20 March 1970 on the approximation of the laws of the Member States relating to measures to be taken against air pollution by gases from positive-ignition engines of motor vehicles
- III. Council Directive 74/290/EEC of 28 May 1974 adapting to technical progress Council Directive No 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by gases from positive-ignition engines of motor vehicles
- IV. Commission Directive 77/102/EEC of 30 November 1976 adapting to technical progress Council Directive 70/220/EEC of 20 March 1970 on the approximation of the laws of the Member States relating to measures to be taken against air pollution by gases from positive- ignition engines of motor vehicles
- V. Commission Directive 78/665/EEC of 14 July 1978 adapting to technical progress Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against pollution of the air by gases from positive ignition engines installed in motor vehicles
- VI. Council Directive 77/143/EEC of 29 December 1977 on the approximation of the laws of the Member States relating to roadworthiness tests for motor vehicles and their trailers
- VII. Council Directive 77/537/EEC of 28 June 1977 on the approximation of the laws of the Member States relating to the measures to be taken against the emission of pollutants from diesel engines for use in wheeled agricultural or forestry tractors
- VIII. Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds
- IX. Council Directive 80/779/EEC of 15 July 1980 on air quality limit values and guide values for sulphur dioxide and suspended particulates
- X. Council Directive 81/854/EEC of 19 October 1981 adapting, consequent upon the accession of Greece, Directive 79/409/EEC on the conservation of wild birds
- XI. Council Directive 82/884/EEC of 3 December 1982 on a limit value for lead in the air
- XII. Council Directive 83/351/EEC of 16 June 1983 amending Council Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by gases from positive- ignition engines of motor vehicles
- XIII. Council Directive 85/203/EEC of 7 March 1985 on air quality standards for nitrogen dioxide
- XIV. Council Directive 85/210/EEC of 20 March 1985 on the approximation of the laws of the Member States concerning the lead content of petrol
- XV. Council Directive 88/76/EEC of 3 December 1987 amending Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by gases from the engines of motor vehicles
- XVI. Council Directive 88/77/EEC of 3 December 1987 on the approximation of the laws of the Member States relating to the measures to be taken against the emission of gaseous pollutants from diesel engines for use in vehicles
- XVII. Council Directive 88/436/EEC of 16 June 1988 amending Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to



- be taken against air pollution by gases from engines of motor vehicles (Restriction of particulate pollutant emissions from diesel engines)
- XVIII. Council Directive 89/458/EEC of 18 July 1989 amending with regard to European emission standards for cars below 1,4 litres, Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by emissions from motor vehicles
  - XIX. Commission Directive 91/244/EEC of 6 March 1991 amending Council Directive 79/409/EEC on the conservation of wild birds
  - XX. Council Directive 91/441/EEC of 26 June 1991 amending Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by emissions from motor vehicles
  - XXI. Council Directive 94/24/EC of 8 June 1994 amending Annex II to Directive 79/409/EEC on the conservation of wild birds
  - XXII. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora
  - XXIII. Council Directive 92/72/EEC of 21 September 1992 on air pollution by ozone
  - XXIV. Council Directive 93/12/EEC of 23 March 1993 relating to the sulphur content of certain liquid fuels
  - XXV. Council Directive 93/59/EEC of 28 June 1993 amending Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by emissions from motor vehicles
  - XXVI. Directive 94/12/EC of the European Parliament and the Council of 23 March 1994 relating to measures to be taken against air pollution by emissions from motor vehicles and amending Directive 70/220/EEC
  - XXVII. European Parliament and Council Directive 94/63/EC of 20 December 1994 on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations
  - XXVIII. Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control
  - XXIX. Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management
  - XXX. Directive 96/69/EC of the European Parliament and of the Council of 8 October 1996 amending Directive 70/220/EEC on the approximation of the laws of the Member States relating to measures to be taken against air pollution by emissions from motor vehicles
  - XXXI. Commission Directive 97/49/EC of 29 July 1997 amending Council Directive 79/409/EEC on the conservation of wild birds
  - XXXII. Council Directive 97/62/EC of 27 October 1997 adapting to technical and scientific progress Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora
  - XXXIII. Council Decision of 27 January 1997 establishing a reciprocal exchange of information and data from networks and individual stations measuring ambient air pollution within the Member States (97/101/EC)
  - XXXIV. Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption
  - XXXV. Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air
  - XXXVI. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy
  - XXXVII. Directive 2000/69/EC of the European Parliament and of the Council of 16 November 2000 relating to limit values for benzene and carbon monoxide in ambient air

- XXXVIII. Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment
- XXXIX. Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants
- XL. Directive 2002/3/EC of the European Parliament and of the Council of 12 February 2002 relating to ozone in ambient air
- XLI. 2002/11/EC: Commission Decision of 28 December 2001 adopting the list of sites of Community importance for the Macaronesian biogeographical region, pursuant to Council Directive 92/43/EEC (notified under document number C(2001) 3998)
- XLII. Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise
- XLIII. 2004/69/EC: Commission Decision of 22 December 2003 adopting, pursuant to Council Directive 92/43/EEC, the list of sites of Community importance for the Alpine biogeographical region (notified under document number C(2003) 4957)
- XLIV. Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air