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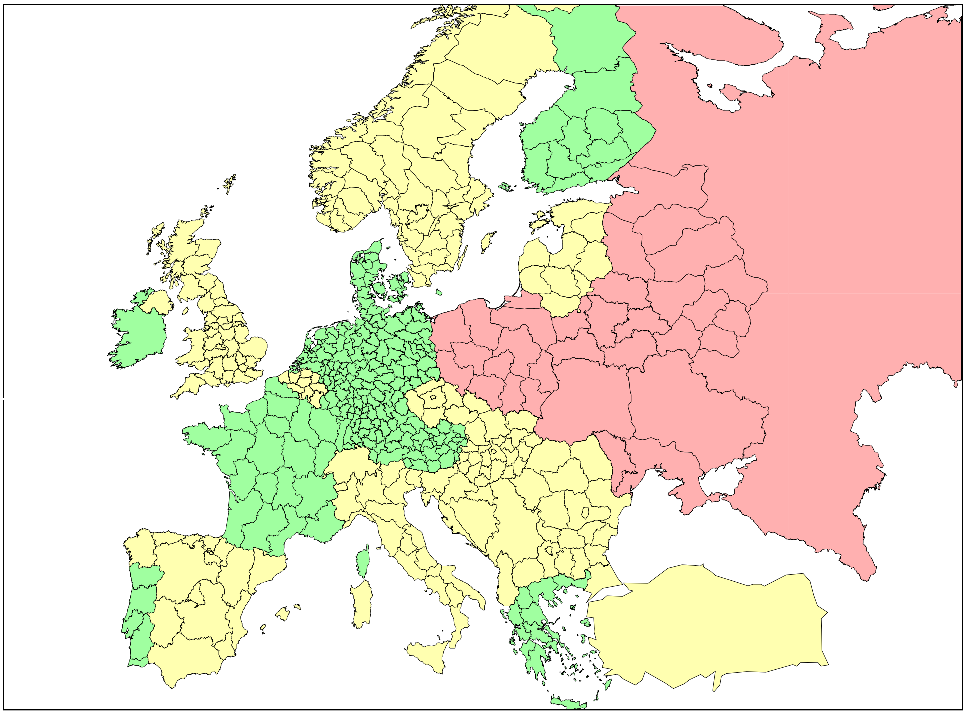
SEA in CODE-TEN



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Abstract

Pan-European integration has brought the environmental evaluation of transport into a new scope due to the size of development schemes. For instance, developing and extending the Trans-European Networks (TENs) is likely to impact the environment on a very large scale. The Common Transport Policy (CTP) - the main European strategic policy document to date - identifies environmental issues among the objectives of sustainable mobility (Commission of the European Communities 1992 and 1999). Therefore, a strategic assessment process should reflect how transport policies either promote or act counter to environmental sustainability. Strategic environmental assessment (SEA) is a framework for evaluating the environmental performance of strategic plans, policies and programmes, and judging on an implementation scheme, which best meets the relevant quality criteria.

The framework itself is meaningless, unless it supports strategic decision-making. In CODE-TEN - a research project funded by the European Commission – a methodology for assessing the socio-economic impacts of strategic transport actions was developed. As an application, a set of alternative infrastructure policies was examined. Experience shows that assessing the environmental impacts of strategic transport actions with sufficient coverage requires modelling the European network and traffic flows as an entity. The transport model must be linked with economic scenarios for projecting future transport development. Infrastructure policies or other strategic actions must be specified as well as linked with the projection tools. Modeling is needed for quantifying the impacts for a set of environmental indicators. Finally, the impact information must be weighted against sustainability criteria. The results are then passed on to overall policy assessment, which weights all socio-economic impacts against each other.

In order to develop more systematics into SEA, an agreement should be reached upon which impacts should be included in strategic analysis. As too many impacts cannot be assessed due to capacity constraints, some impacts may be assigned to represent a group of related impacts as proxies, according to the conduct of CODE-TEN. It should be debated whether site-specific impact information should be included in the assessment, or whether these issues should be automatically considered in the planning and implementation phases of infrastructure projects. The environmental objectives should be debated to clarify their relative importance between each other.

The results of the assessment experiment demonstrate that alternative transport infrastructure development policies have an impact on the environmental impacts of

transport. Road-based policies will intensify environmental detriments, whereas rail and intermodality-based network policies may curb unfavourable development trends. In eastern parts of Europe, where existing networks are insufficient in capacity and quality, the importance of infrastructure policies is relatively stronger than in the EU. Therefore, the analyst must carefully interpret these findings and the potentials of alternative policies in the light of regional premises. As an important generalisation, even the network-based infrastructure policies alone will not lead to the achievement of environmental objectives. Statutory and economic control measures need to be included in sustainable policy packages.

Preface

The aim of this report is to describe an evaluation method for environmental impact assessment of different transport policies (implemented as large scale transport projects). The implementation of the method together with practical tests were undertaken in CODE-TEN project (Strategic Assessment of corridor developments, TEN improvements and extensions to the CEEC/CIS) funded by the European Commission under the 4th Framework Programme. The national financing for VTT was provided by the Finnish Ministry of Transport and Communications.

The authors wish to thank Dr. Liana Giorgi of ICCR for her feedback during the project, as well as Mr. Gunnar Platz of PLANCO for the transport forecasts behind the evaluations. CODE-TEN reports may be achieved via ICCR homepage (http://www.iccr-international.org/projects/).

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Contents

1. Introduction

Pan-European integration has brought the environmental evaluation of transport into a new scope due to the size of development schemes. For instance, developing and extending the Trans-European Networks (TENs) is likely to impact the environment on a very large scale. The Common Transport Policy (CTP) - the main European strategic policy document to date - identifies environmental issues among the objectives of sustainable mobility (Commission of the European Communities 1992 and 1999). Therefore, a strategic assessment process should reflect how transport policies either promote or act counter to environmental sustainability.

Strategic environmental assessment (SEA) is a framework for evaluating the environmental performance of strategic plans, policies and programmes, and judging on an implementation scheme, which best meets the relevant quality criteria. The framework itself is meaningless, unless it supports strategic decision-making. According to Lee & Walsh (1992), SEA a) describes actions for identifying and assessing impacts, b) identifies the areas likely to be affected, c) predicts the significance of the impacts, and d) integrates the findings into overall evaluation.[1] SEA needs to be tested against a framework of international objectives, ideally permitting comparisons across frontiers and jurisdictions in order to draw conclusions on the quality of the results of impact assessment. Ultimately, SEA should state whether or not strategic actions meet the objectives of environmental sustainability.

The issues of strategic assessment and decision-making have been debated in the European context in projects such as COMMUTE, POSSUM, TENASSESS and SAMI. Project-level tools do not have the capacity of producing impact information for strategic decision-making unless they are developed further. The environmental impacts, which should be assessed at the strategic level, have not been defined unambiguously[2]. The weights that the impacts need within decision-making are not clear. No commonly affirmed guidelines exist for making definite judgements on the environmental sustainability of strategic transport actions. Developing further from this premise, this article highlights the experience of performing SEA at the pan-European level based on the findings of CODE-TEN.

CODE-TEN - a research project funded by the European Commission - has developed methodology for assessing the socio-economic impacts of strategic transport actions. As an application, a set of alternative infrastructure policies was examined. Experience shows that assessing the environmental impacts of strategic transport actions with sufficient coverage requires modelling the European network and traffic flows as an entity (CODE-TEN 1999b). The transport model must be linked with economic scenarios for projecting future transport development. Infrastructure policies or other strategic actions must be specified as well as linked with the projection tools. Statistical estimation is needed for

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[1] See e.g. Wood & Djeddour (1992), Therivel & Partidario (1996) and Banister (1998).
[2] Dom (1995) is one of the few existing applications of SEA.

quantifying the impacts for a set of environmental indicators. Finally, the impact information must be weighted against sustainability criteria. The results are then passed on to overall policy assessment, which weights all socio-economic impacts against each other.

In CODE-TEN, the weighting is based on *sustainability appraisal* adopted from COMMUTE (1998), which compares impact information with strategic environmental objectives and targets. The 5th Environmental Action Program (5EAP) and its later reviews provide a minimum set of strategic environmental indicators and objectives for the analysis (European Commission, 1993). Table 1 presents the impacts chosen for analysis in CODE-TEN along with the definitions of objectives and targets.

Table 1. European environmental objectives and targets, modified from 5EAP and other related policy documents and fitted for the use of CODE-TEN.

Impact	Indicator	Objective	Target
Climatic change	The volume of CO_2 emissions	No exceeding of the earth's natural absorption capacity.	Stabilization at the level of 1990 by 2005 and 2010.
Acidification	The volume of NO_X emissions	No exceeding of critical loads and thresholds.	Until 2000 reduction of 30 % from 1990 level.
Air quality	CO exposure area as a representative proxy indicator	All people should be effectively protected against acknowledged health risks of air pollution.	Apply WHO guidelines on ambient concentrations of CO.
Nature and biodiversity	Land-take as a representative proxy indicator	Maintenance of nature and biodiversity through sustainable development and management in and around natural habitats of Europe.	Maintenance and restoration of natural habitats and species. Creation of a network of protected sites by 2004.
Noise	Noise exposure area	No person should be exposed to noise levels, which endanger health and quality of life.	No exposure to levels higher than 65 dB(A) during night time and never a level of 85 dB(A).
			Exposure to levels below 55 dB(A), and between 55 and 65 dB(A) should not increase.

2. Assessment of environmental impacts of large-scale transport actions

Strategic actions impact the environment and communities at all levels of geographic resolution (local, regional, international, global). Impacts may be brought out to a larger domain than single projects ever would. Stocktaking of the impacts is required for ensuring good coverage and equity of the assessment. This sets high requirements for data collection and the assessment tools. The results also become less comparable as the diversity of information increases. For practical reasons, choices have to be made upon the number of impacts and scope to be covered.

CODE-TEN categorised four dimensions, which impact assessment should aim to cover:

- Total volume of impacts
- Total space likely to be impacted
- Characteristics of incidence areas (population/area)
- Temporal distribution (when and for how long the impacts are likely to be perceived).

In CODE-TEN, environmental impacts are classified into three broad categories: *global*, *local* and *natural resource* impacts. This classification describes the regional scope and incidence of impacts. *Global impacts* are those least bound to space and *local impacts* primarily target communities in the proximity of a corridor. *Natural resource impacts* primarily target nature, which is mainly a local impact by character. However, based on the presentation of the spatial distribution of impacts in Table 2, the distribution is never definitive. Wherever possible, the spatial and temporal impact distributions were taken into consideration in the formulation of assessment models.

Table 2. Spatial distribution and severity of impacts.

Impact	**Spatial distribution**			**Temporal distribution**
	Local/ Community	**Regional/ National**	**Cross-border/ Global**	
Climate	X	XX	XXX	Long (cumulative)
Acidification	X	XX	XXX	Long (cumulative)
Air quality	XXX	X	X	Short/Intermediate (cumulative)
Land-take (Nature and biodiversity)	XXX	XX	O/X	Short/long-term/everlasting
Noise	XXX	X	O	Short (continuous/ fluctuating)

O - No Impact X - low; XX - medium; XXX – high

In CODE-TEN, the capacity of statistical impact assessment tools determined the precision of impact assessment. Geographical or demographic data was not included in the analysis. The analysis of *local impacts* focused on a predefined buffer zone along a corridor. *Regional, cross-regional and global impacts* were quantified as total masses without specifying incidences on people and natural areas. Impact information was produced in both absolute and relative terms.

Estimating *air quality* (local impact) optimally comprises four tasks: a) estimating emissions generated by a development project, b) estimating the resulting concentrations of pollution, c) comparing the pollution to ambient air quality standards, and d) considering incidence populations. However, in CODE-TEN, data limitations restrict descriptions of incidences to generalisations on the area of exposure. The changes in the size of the exposure area of a principal local air pollutant CO, is estimated and it is expected to represent other local pollutants as a proxy. The exposure area is defined by estimating the total volume of CO emissions on each link, and calculating the width of the buffer zone in which the predefined threshold level is exceeded.[3]

Noise impacts (local impact) were also estimated statistically as changes in the size of the exposure area exceeding the threshold volume of 55 dBA[4]. *Land-take* represented natural resource impacts as a proxy indicator. It was assumed that protected habitats or species are definitively respected when planning infrastructure projects. In CODE-TEN, inventories on such areas were not made. *Global impacts* were assessed as changes in the volume of CO_2 and NO_x emissions. The emissions are estimated by simply multiplying total vehicle-kilometres by mode-specific emission factors and aggregating the total emissions.

[3] Ambient threshold concentrations have been adopted from WHO guidelines (EURO, 1998).
[4] See Table 1 in Section 1.

3. The assessment process in CODE-TEN

CODE-TEN examined Europe as an entity with respect to economic scenarios and transport policy options, network description, transport statistics, traffic forecasts and network assignments. Figure 1 presents how environmental assessment is integrated into the overall assessment process. Combinations of economic scenarios and transport policy options (Table 3) were applied to the transport and network data to generate datasets, named here as *transport development alternatives* (Table 4).[5]

A *transport development alternative* synthesizes, e.g. high economic growth and quick integration (*Renaissance*), with emphasis on intermodality and interoperability in developing the transport system (TPS [B]). The premise is that alternative economic scenarios yield different rates of growth in transport demand and environmental strain, which in turn can be influenced by different infrastructure policies. *Renaissance* comprises both high growth and quick integration, whereas *Fragmentation* represents contrary development. *Dilution* is slow in integration, but high in economic growth. *Solidarity* involves co-operation despite low economic growth. Each economic scenario involves different flow volumes and modal and route splits with transport cost and travel time as main determinants in the forecasts.

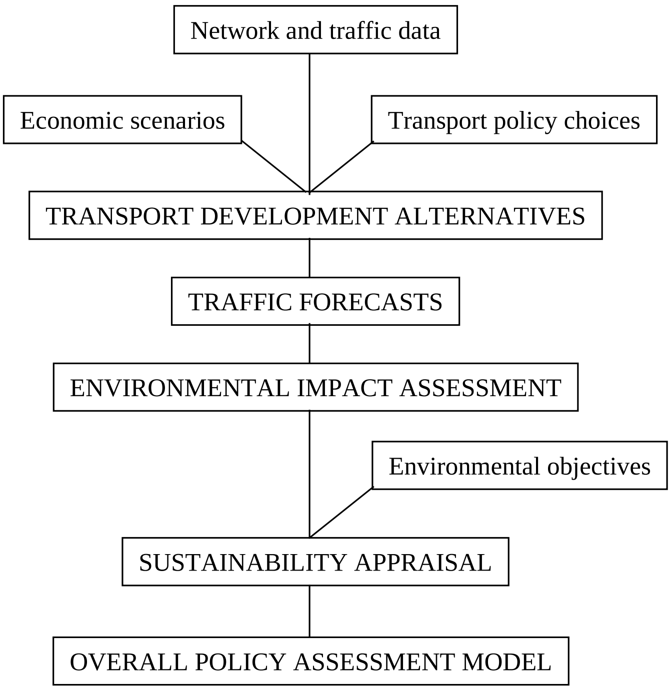

Figure 1. Impact assessment flow chart.

[5] See CODE-TEN (1999c).

The selected set of environmental impacts is calculated using suitable models and the transport forecasts derived from each transport development alternative. The environmental impact information is compared with corresponding strategic environmental objectives in the sustainability appraisal. The positive, negative or neutral impacts induced on environmental indicators are interpreted and transferred later on to an overall policy assessment model, which is not discussed here. (CODE-TEN, 1999a and CODE-TEN, 2000)

Table 3. Economic and transport policy scenarios in CODE-TEN.

Pan-European economic scenarios	Transport policy scenarios (TPS)
• Renaissance = high economic growth, quick European integration • Dilution = high economic growth, slow European integration • Solidarity = low economic growth, quick European integration • Fragmentation = low economic growth, slow European integration	• TPS Do-Nothing = no deliberate regulatory actions or investment priorities • TPS [A] = liberalized and deregulated markets, road investment emphasis • TPS [B] = regulated markets, development of intermodality and interoperability (network-approach) • TPS [C] = liberalized and deregulated markets, determined decoupling • TPS [D] = regulated markets, determined decoupling

Table 4. Transport development alternatives assessed in CODE-TEN.

Growth/ Integration	**Transport development alternative**	
	Quick integration (2005/2010)	**Slow integration (2010/2015)**
High growth (up to 7 %)	• Renaissance, TPS [C/D], Do-Nothing • Renaissance, TPS [A], All-Road • Renaissance, TPS [B], All-Rail • Renaissance, TPS [B], Network-Approach • Renaissance, TPS [A], Road-Priority	• Dilution, TPS [C], Do-Nothing • Dilution, TPS [B], Network-Approach • Dilution, TPS [A], Road-Priority
Low growth (up to 2.5 %)	• Solidarity, TPS [C], Do-Nothing • Solidarity, TPS [B], Network-Approach • Solidarity, TPS [A], Road-Priority	• Fragmentation, TPS [B/C], Do-Nothing • Fragmentation, TPS [B], Network-Approach • Fragmentation, TPS [A], Road-Priority

The assessment process tests scenario-specific infrastructure investments in the following corridors:

(a) Moscow-St.Petersburg-Helsinki-Stockholm-Copenhagen

(b) Warsaw-Riga-Tallinn-Helsinki 'Via Baltica'

(c) Berlin-Warsaw-Minsk-Moscow-Nizhny Novgorod

(d) Danube waterway

(e) Berlin-Praque-Vienna-Budapest-Sofia-Constanta/Thessaloniki

(f) Salzburg-Ljubljana-Zagreb-Beograd-Thessaloniki

(g) Venice-Triest/Koper-Budapest-Kiev

(h) Lisbon-Madrid-Paris-Berlin/Bruxelles.

The corridors are located in both the CEEC and the western parts of the CIS[6]. Investments include upgrading parts of the road and rail network and inland waterways with different emphasis in different policy alternatives.[7] The results of impact assessment cannot be assigned to any particular corridor case, as they were all included in each assessment. In a large network, the impacts are spread and mixed, i.e. a change in one link affects all competing links. Changes in one part of the network impact the whole length of journeys or freight flows using that particular part of the network.

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[6] Non-member Central and Eastern European Countries (CEEC) with the Baltic States and Community of Independent States (CIS; Russia).

[7] Inland waterway infrastructure was neglected in the assessment due to the lack of sufficient input data. Their role is marginal in the current package of investments.

4. Results of impacts assessment

The premise

CODE-TEN analysed the environmental impacts for the set of economic scenarios both with do-nothing transport policy and with different infrastructure investment packages. The do-nothing policy represents capacity problems and bottlenecks occurring on the network. The infrastructure policies improve the efficiency of the network and relieve bottlenecks with emphasis on either roads, or rail and interoperability.

The impacts are estimated for a forecast of inter-regional and international freight and passenger flows, not local transport. Freight flows are based on trade statistics, and as a crude assumption, passenger flows are assumed to fluctuate accordingly. The accuracy and density of network description varies between the CEEC/CIS area and the EU, which produces some imbalance in the results. The baselines for the volume of traffic and vehicle technology are also different in these areas. Differences in the quality of existing infrastructure also lead to significantly different impacts in the EU and the CEEC/CIS area.

The results represent a cross-sectional target year of 2015. They are now presented as aggregates for the EU (including Norway and Switzerland) and the CEEC/CIS area. CO_2 and NO_x are presented as changes in total emissions volumes, CO and noise as changes in exposure area exceeding predefined threshold values, and land-take as land consumption due to construction.

Due to constraints faced in the data collection and modelling phase, the link to reality may have been lost considering the exact numbers at the level of the target year. The numbers presented here do not represent a future forecast, which could be used for decision-making as such.

Scenario comparisons under do-nothing policies

First, the baseline model runs were produced before manipulating development trends. There are four alternative European futures with regard to economic growth and integration. *Renaissance* is the desired scenario, with quick integration and intensive economic growth in all areas. With the highest growth in transport demand, it is fixed as the reference case. *Renaissance* will yield the highest intensification of environmental impacts on the current level, in both the EU and the CEEC/CIS area.

Table 5 illustrates the environmental outcome of *Dilution*, *Solidarity* and *Fragmentation* compared to *Renaissance* under the *do-nothing* policy. In all the scenarios, transport increases, generally increasing environmental impacts on the current level. *Fragmentation* is almost as harmful as *Renaissance* in environmental respects. All the results are dominantly dependent on economic growth in the particular scenario. Interestingly, prosperity and recession would both produce the least favourable outcome, although for different reasons. As a generalisation, growth increases mobility, whereas recession constrains transport to poor technology and infrastructure.

The EU area seems to be less sensitive to the alternative scenarios, unlike the CEEC/CIS area. Especially *Fragmentation* treats the CEES/CIS area poorly. For the EU, *Solidarity* produces a less intensive increase in impacts on the environment, and *Dilution* the least increases compared to *Renaissance*. The CEEC/CIS area typically behaves differently compared to the EU in different scenarios. In *Dilution*, economic development is based more on internal markets, not on European co-operation. Thus, in the CEEC/CIS area, environmental impacts do not grow as intensively as in *Renaissance*. In the EU, local impacts are intensified due to higher emphasis on local activities. In *Solidarity*, both economic growth and European co-operation contribute to the less intensive increases in environmental impacts.

Table 5. Impact outcome in the different scenarios compared to Renaissance scenario under do-nothing policies (% change as weighted average).

Do-nothing policy	**Local impacts**				**Natural resources**		**Regional/Global impacts**			
Scenario	CO* [km2]	%	noise [km2]	%	land-take** [km2]	%	CO_2 [1000 t/year]	%	NO_x [1000 t/year]	%
Renaissance										
EU + NOR&SCH	593	-	19 247	-	12 801	-	351 879	-	1 282	-
CEEC/CIS	302	-	12 547	-	5 034	-	176 192	-	1 433	-
Total	895	-	31 794	-	17 835	-	528 071	-	2 715	-
Dilution										
EU + NOR&SCH	+7	+1	+635	+3	0	0	-269	0	0	0
CEEC/CIS	-49	-16	-189	-2	0	0	-37 164	-21	-291	-20
Total	-42	-5	+446	+1	0	0	-37 434	-7	-292	-11
Solidarity										
EU + NOR&SCH	-1	0	0	0	0	0	-12 651	-4	-40	-3
CEEC/CIS	-15	-5	+140	+1	0	0	-21 178	-12	-159	-11
Total	-17	-2	+140	+0,4	0	0	-33 829	-6	-199	-7
Fragmentation										
EU + NOR&SCH	-61	-10	+93	1	0	0	-42 315	-12	-142	-11
CEEC/CIS	+16	+5	-676	-5	0	0	+30 840	+18	+260	+18
Total	-45	-5	-582	-2	0	0	-11 341	-2	+118	+4

*Note that this figure represents the area with violation of CO threshold levels. The area is relatively small, because only long-distance transport is examined, not urban traffic.

**There are no land-take impacts because infrastructure policies are not applied in the *do-nothing* alternative.

Policy comparisons under Renaissance and Fragmentation

In the second phase, a set of infrastructure policies is applied for demonstrating how they alter the development in environmental respects. The most informative scenarios, *Renaissance* and *Fragmentation*, are analysed under *do-nothing, network-approach* and *road-priority* policies. *Network-approach* has a strong emphasis on railways and intermodality, and *road-priority* on road investments.

The clearest demonstration of the impacts of infrastructure policies is gained when *Renaissance* is assessed by prioritising either rail or road. According to Table 6, the growth rates of CO_2 and NO_x emissions and the size of CO exposure area exceeding threshold concentrations can be effectively mitigated by the *network-approach*, whereas *road-priority* would clearly intensify detrimental impacts. However, the gains of the *network-approach* are achieved at the cost of increases in excess noise exposure and land-take, mainly due to the construction of new rail infrastructure and increase in rail transport.

Table 6. Network-approach and road-priority policies compared to do-nothing policy under Renaissance scenario (% change as weighted average).

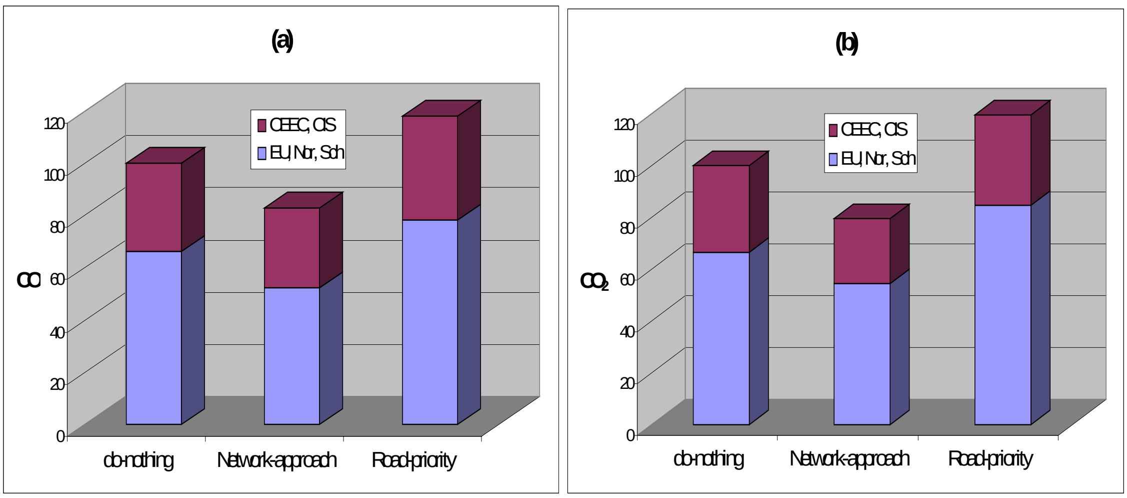
Renaissance scenario	**Local impacts**				**Natural resources**		**Regional/Global impacts**			
Policy	CO [km2]	%	noise [km2]	%	land-take [km2]	%	CO_2 [1000 t/year]	%	NO_x [1000 t/year]	%
Do-nothing										
EU + NOR&SCH	593	-	19 247	-	12 801	-	351 879	-	1 282	-
CEEC/CIS	302	-	12 547	-	5 034	-	176 192	-	1 433	-
Total	895	-	31 794	-	17 835	-	528 071	-	2 715	-
Network-approach										
EU + NOR&SCH	-123	-21	+537	+3	+5	0	-63 842	-18	-274	-21
CEEC/CIS	-28	-9	+523	+4	+141	+3	-44 653	-25	-368	-26
Total	-151	-17	+1 059	+3	+146	+1	-108 495	-21	-641	-24
Road-priority										
EU + NOR&SCH	+109	+18	-261	-1	+5	0	+95 448	+27	+320	+25
CEEC/CIS	+52	+17	+26	0	+141	+3	+7 193	+4	+43	+3
Total	+162	+18	-236	-1	+146	+1	+102 641	+19	+363	+13

Under the regimes of low economic growth and slow integration in *Fragmentation* (Table 7), the environmental impacts of transport will increase almost as intensively under *do-nothing* policy as in *Renaissance*. The *network-approach* cannot curb the growth in emissions in the EU, although it seems to be effective in the CEEC/CIS area. Again, *road-priority* will intensify the growth in emissions in the EU, but improvements in the poor road infrastructure in the CEEC/CIS area will slightly mitigate the growth in CO_2 and NO_x. The results described here are visualised on national level in Appendix A using GIS presentations.

Table 7. Network-approach and road-priority policies compared to do-nothing under Fragmentation scenario (% change as weighted average).

Fragmentation scenario	**Local impacts**				**Natural resources**		**Regional/Global impacts**			
Policy	CO [km2]	%	noise [km2]	%	land-take [km2]	%	CO_2 [1000 t/year]	%	NO_x [1000 t/year]	%
Do-nothing										
EU + NOR&SCH	523	-	19 340	-	12 801	-	309 564	-	1 140	-
CEEC/CIS	318	-	11 872	-	5 034	-	207 184	-	1 693	-
Total	850	-	31 212	-	17 835	-	516 748	-	2 833	-
Network-approach										
EU + NOR&SCH	+15	+3	+112	+1	+5	+0	+6 695	+2	+21	+2
CEEC/CIS	0	-0	+605	+5	+141	+3	-37 822	-18	-331	-20
Total	+15	+2	+717	+2	+146	+1	-31 127	-6	-310	-11
Road-priority										
EU + NOR&SCH	+161	+30	-278	-1	+4,9	+0	+135 989	+44	+454	+40
CEEC/CIS	+12	+4	-52	-0,4	+141	+3	-10 982	-5	-136	-8
Total	+173	+20	-330	-1	+146	+1	+125 007	+24	+318	+11

Highlighting two key indicators further, Figures 2a and 2b illustrate how two competing rail and road-based transport policies affect CO and CO_2 emissions in the EU and the CEEC/CIS area under the *Renaissance* scenario. The figures clearly indicate that, if infrastructure policies emphasise only road development, new routes will attract transport from rail to road resulting in an even worse environmental outcome than the *do-nothing* policy, although the function of the networks is improved. In the *network-approach*, emissions grow less intensively in both areas, indicating that it is the favourable policy in environmental respects.



Figures 2a and 2b. Relative increases in the area of excess CO exposure (left) and volume of CO_2 emissions (right) with different transport policy alternatives under Renaissance scenario (do-nothing = 100).

Figures 3 and 4 provide further evidence of the effectiveness of the *network-approach* and the harmful development induced by the *road-priority* policy in a comparison between the four scenarios. The potentials of the *network-approach* are especially clear when *Renaissance* and *Dilution* developments are compared using the excess exposure area of CO and the volume of CO_2 emissions are key indicators. Although transport demand increases intensively due to high economic growth, the policy is effective in limiting the growth rate of both CO (local) and CO_2 (global) emissions. Again, it is evident, that *road-priority* policy yields the highest intensification in emissions.

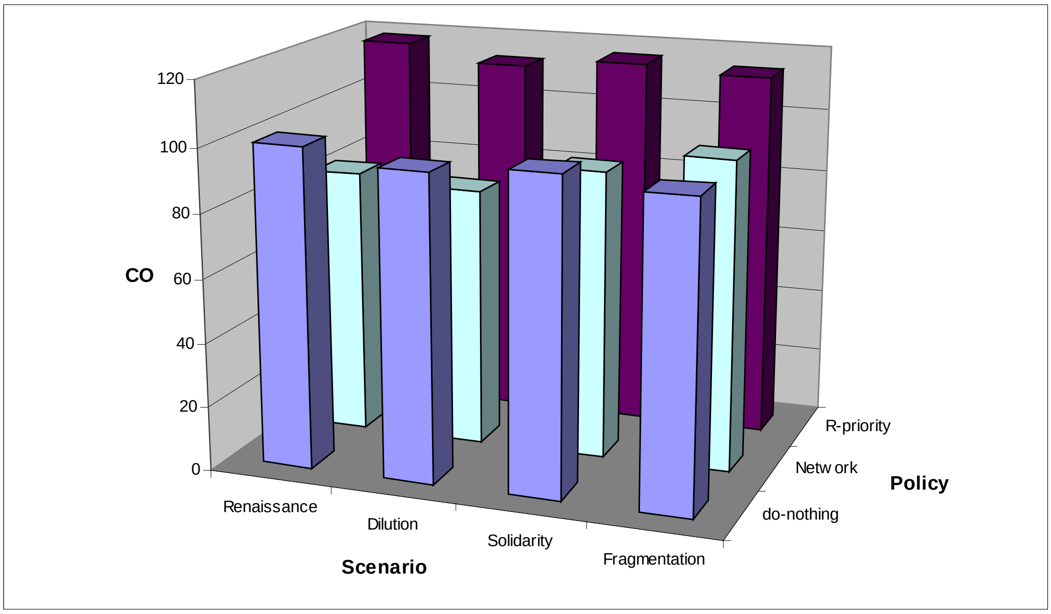


Figure 3. Relative size of the excess CO exposure area with alternative transport policies aggregated for Europe (Renaissance scenario under do-nothing policy = 100).

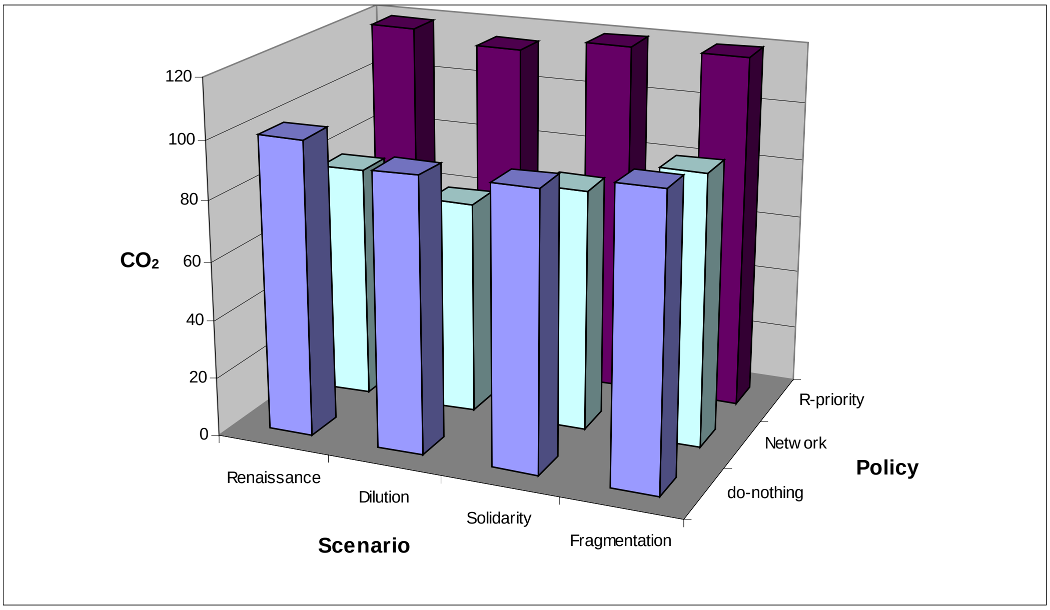


Figure 4. Relative intensity of CO_2 emission volumes with alternative transport policies aggregated for Europe (Renaissance scenario do-nothing policy = 100).

5. Threshold analysis and environmental sustainability

The ultimate goal of SEA is to judge the environmental sustainability of a strategic action. The indicators of CODE-TEN are weighted by *sustainability appraisal*, which recognises the environmental policy objectives as thresholds and compares them with impact information. The process resembles multi-criteria analysis as each indicator is examined separately within a set of distinctive attributes. The suitable set of attributes in this case is adopted and developed from the definitions of the CTP and 5EAP.

In Table 8, the principal attribute reflecting the general objective, *sustainable mobility,* is split further into sub-attributes expanding the considerations to the sectors of society. Now the main interest is in *environmental sustainability*. The attributes at the third level correspond to the spatial impact classification of CODE-TEN. The fourth level names the indicators of CODE-TEN.

Table 8. Hierarchy of Attributes for SEA in CODE-TEN.

Socio-economic sustainability criteria in CTP		**Environmental sustainability criteria developed in CODE-TEN**	
		Impact categories	Indicators
Sustainable mobility	• Reinforcement of the internal market • Efficiency of the transport sector • Social and economic cohesion • **Environmental sustainability** ⇒ • Actions to promote safety • Measures in the social field • Relationships with third countries	Global impacts Natural resource impacts Community impacts	CO_2, NO_x Land-take Ecosystems Air quality Noise

The basic assumption of *sustainability appraisal* is that all impact-types can be associated with an environmental objective comparable with the information produced by the assessment tools. Thus, if an impact results in:

- an overrun of the corresponding threshold level, sustainability is violated.
- environmental quality corresponding very close to a threshold level, the situation is critical.
- a negligible change in environmental quality, or at least the corresponding threshold level is not threatened, sustainability is not violated.
- a decrease in environmental strain, sustainability is promoted.

The number and severity of violations, critical calls and environmental improvements will indicate how a particular action would affect the quality of the environment. However, threshold comparisons encounter problems. Environmental objectives often declare no more than a need to minimise environmental impacts. The spatial assignments of the objectives are unclear and they apply to all sectors of the economy, not only transport. Trade-off situations between overruns, critical calls and positive developments will occur. Eventually, the evaluator has to interpret the criticality of impacts both individually and as a set for providing an indication of the trends induced by the *transport development alternatives* with regard to the environment.

Carbon monoxide (CO). Road-based policies are likely to increase the size of area with excessive ambient concentrations of CO in the proximity of corridors, whereas network-based policies may curb the increase in exposure. Even with network-based policies, the thresholds are often violated. However, the results are mixed between different transport development alternatives. Generally, either the thresholds are violated or the situation is critical.

Noise. The network-approach with the development of rail connections would produce more intensive increases in excess noise exposure, than do-nothing or road-priority policies. No infrastructure policy seems to be particularly effective with regard to noise reduction targets, unless mitigation measures are used. Noise exposure will increase or the situation remains critical with regard to thresholds levels.

Land-take. There are no absolute constraints given on land use, except for certain natural areas that are protected by legislation and where fragmentation of both natural habitats and communities is considered unfavourable. The total change in land-take implies that both the network-approach and the road-priority policy would produce similar, but relatively small additional environmental impacts, because existing corridor locations and alignments are utilised in the development projects. No threshold violations are induced.

Carbon dioxide (CO_2) and nitrogen oxide (NO_X). It seems very unlikely that the transport sector will be able to contribute to the reduction targets of global pollutants, carbon dioxide particularly, unless strong steering policies are applied. The road-priority policy would only intensify the growth rate of emissions, and even the network-policy can only curb growth. Should some reductions in emissions occur nevertheless, these could be attributed to the improvement in fuel efficiency and vehicle technology, not infrastructure policies. Therefore, infrastructure policies violate thresholds for both emission-types.

As there exists no ranking for the relative significance of environmental impacts, it is impossible to assign a definite sustainability score to the above results. Nevertheless, some interpretations can be made based on the existing definitions of environmental sustainability.

According to the World Commission on Environment and Development (1987), sustainable development meets the needs of the present generation without compromising the ability of future generations to meet their own needs. Another, more accurate definition is Daly's presentation of sustainability (1991): 1) The use of renewable resources should not exceed the rate of regeneration. 2) The rate of use of non-renewable resources should not exceed the rate at which sustainable substitutes are developed. 3) The rates of emissions should not exceed the rates of assimilative capacity of the environment.

Judging infrastructure development according to the above criteria would be unfavourable towards further network expansions. As a generalisation, the development trends are negative in environmental respects due to the overall growth in mobility under all economic scenarios. Even the most favourable network policies only limit growth rates of emissions.[8]

The definition of sustainable mobility in the Common Transport Policy (1992) lists a broader set of expansive and defensive goals. Accordingly, sustainable mobility can be achieved by keeping the objectives of environmental sustainability, safety, free movement of goods and people, economic development, as well as social cohesion within the same framework. Problems arise when failure in achieving environmental objectives should be balanced against other socio-economic objectives. Once again, the evaluator faces the problem of trade-offs and relative significance between the positive and negative indicators.[9] It is evident that the environmental objectives of CTP are not met by infrastructure policies as such.

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[8] A very typical result of road project appraisal is that more than due to the project itself, environmental detriments on a particular link will be reduced due to improvements in vehicle technology and the quality of fuels.

[9] For debate on the problematics of the definition and measurement of sustainability, see e.g. Button & Nijkamp (1997), Greene & Wegener (1997) and Fricker (1998).

6. Conclusions

According to the experience of CODE-TEN, it is possible to link scenario techniques, transport modelling and assessment tools for producing information on the environmental impacts of large-scale transport actions. Still, the link between the different tools must be strengthened. Examining Europe as an entity in economic scenarios, network modelling, traffic forecasts and impact estimation, is methodologically very demanding but necessary. Looking at separate parts of the network would ignore the relationships between flow changes within the system, and only covering the main transport network as an entity prevents loss of information. Extending data coverage and assessment to local transport is required.

The most significant environmental impacts of transport can be estimated based on statistical models if the quality of input data is sufficient. Including population statistics in the estimation models will correct the missing information on exposure. However, quantifying the impacts on natural entities remains problematic. Such information can only be obtained at the site. The proxy indicator land-take may not capture these impacts sufficiently. Geographical information systems (GIS) will enable the inclusion of more features of the environment and communities into the assessment process.

In order to develop more systematics into SEA, an agreement should be reached upon which impacts should be included in strategic analysis. As too many impacts cannot be assessed due to capacity constraints, some impacts may be assigned to represent a group of related impacts as proxies, according to the conduct of CODE-TEN. It should be debated whether site-specific impact information should be included in the assessment, or whether these issues should be automatically considered in the planning and implementation phases of infrastructure projects. The environmental objectives should be debated to clarify their relative importance between each other.

Debate on the non-exclusivity and coherency of the objectives of sustainable mobility is needed for ranking the importance of environmental information with other socio-economic impacts. This is also a concern of equity in spatial respects. The geographical and sector allocations of responsibilities with respect to meeting environmental objectives need to be further defined. Strategic assessment has to be iteratively integrated into the decision-making and planning process to effectively utilise the potentials of preventive and mitigating measures.[10]

The results of the assessment experiment demonstrate that alternative transport infrastructure development policies have an impact on the environmental impacts of transport. Road-based policies will intensify environmental detriments, whereas rail and intermodality-based network policies may curb unfavourable development trends. In

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[10] At the moment of writing this article, several on-going research activities funded by the European Commission aim at filling the gaps in assessment methodology and tools of decision-making.

eastern parts of Europe, where existing networks are insufficient in capacity and quality, the importance of infrastructure policies is relatively stronger than in the EU. Therefore, the analyst must carefully interpret these findings and the potentials of alternative policies in the light of regional premises. As an important generalisation, even the network-based infrastructure policies alone will not lead to the achievement of environmental objectives. Statutory and economic control measures need to be included in sustainable policy packages.

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Appendix A:

GIS Presentations of SEA

This appendix contains a set of transport policy comparisons presented as thematic maps. The assessment has been done in CODE-TEN project, and the background scenarios and transport policy options are described in CODE-TEN deliverable 4.

Following maps include three comparisons of **global** impacts (change in CO_2 as an indicator) and three comparisons of **local** impacts (change in CO emissions as an indicator). The presented changes are defined as relative changes **compared to do-nothing** scenario.

Compared pairs are

- *Road priority* vs. *Network* approach under **Solidarity** assumptions
- *Road priority* vs. *Network* approach under **Dilution** assumptions
- *All road* vs. *Rail priority* approach under **Renaissance** assumptions.

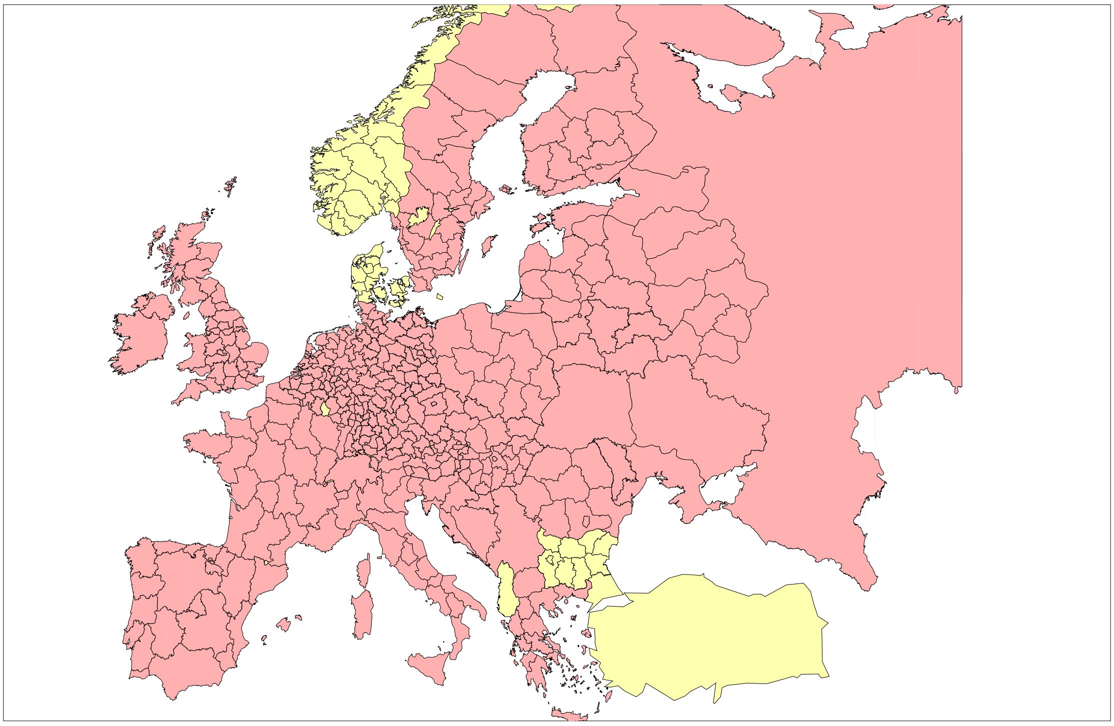
Colour scheme:

green = improvement

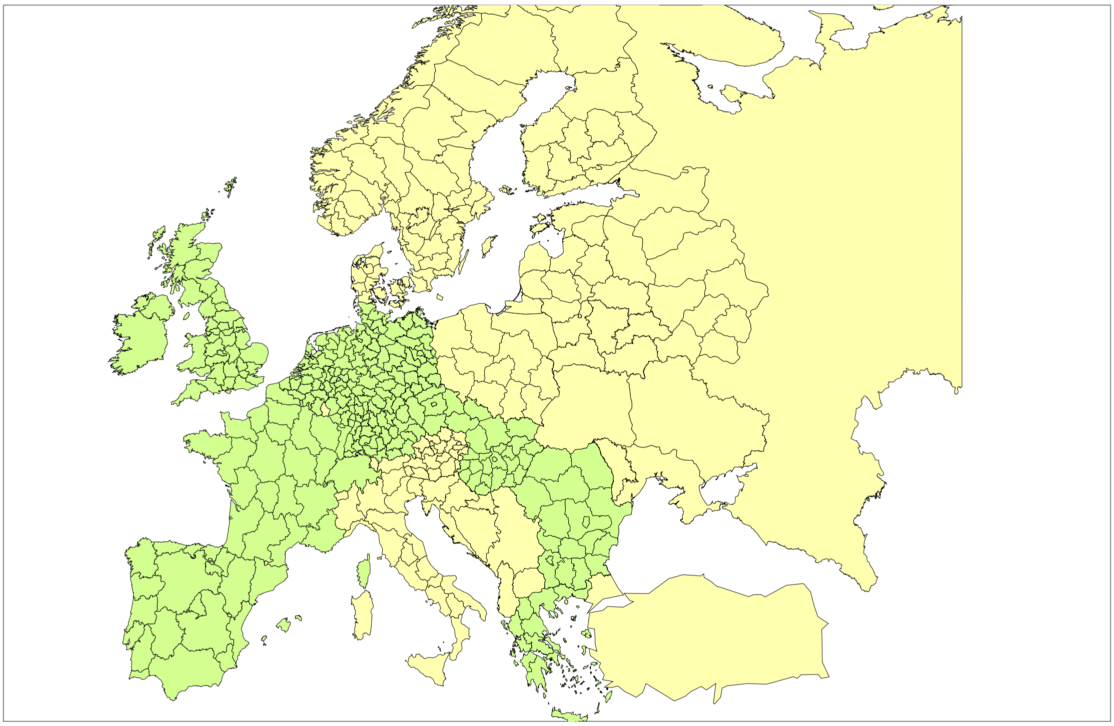
yellow = no accountable change

red = worsening

Global Environmental Impacts Under Solidarity Assumptions

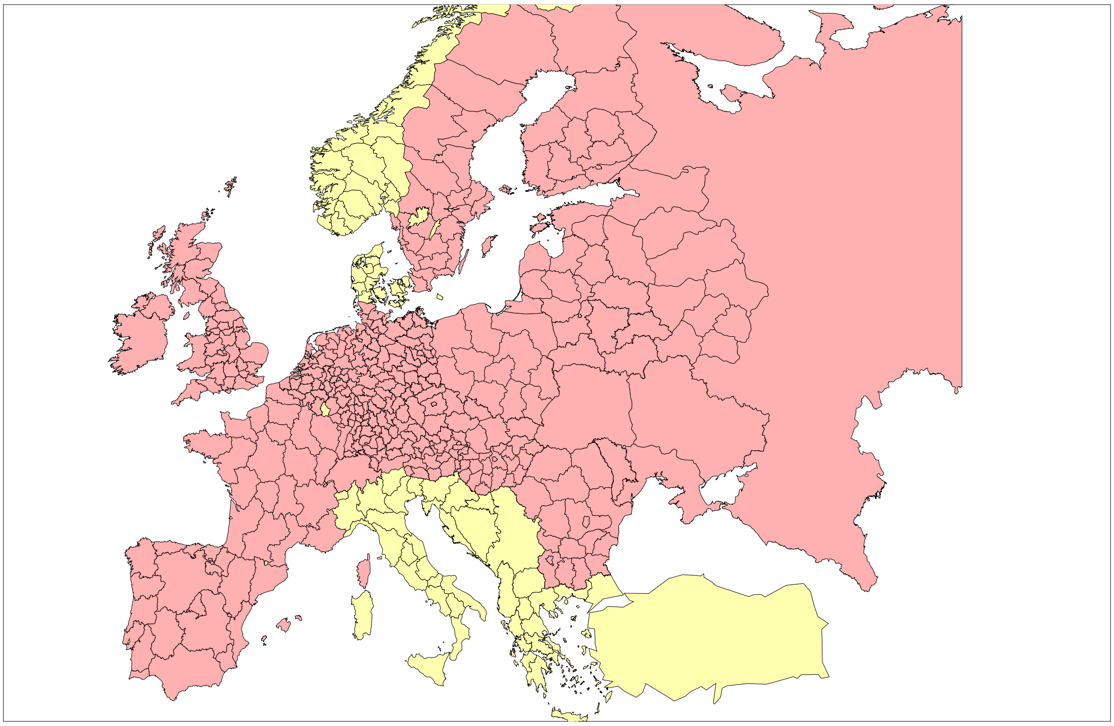


Road Priority

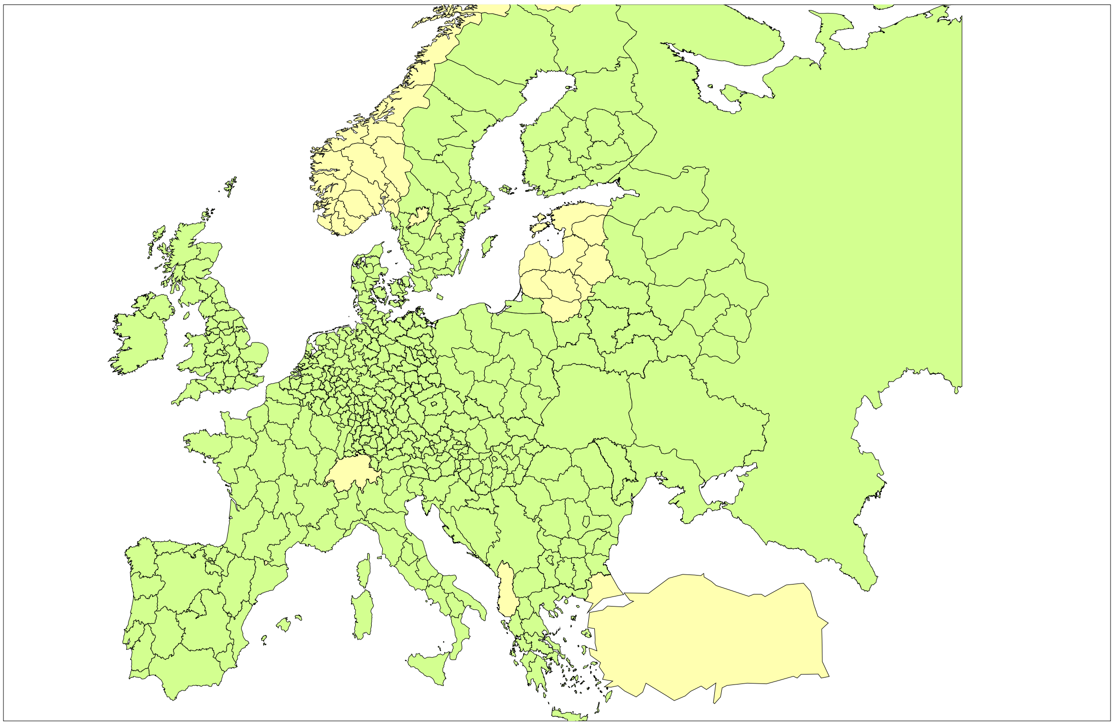


Network Approach

Global Environmental Impacts Under Dilution Assumptions

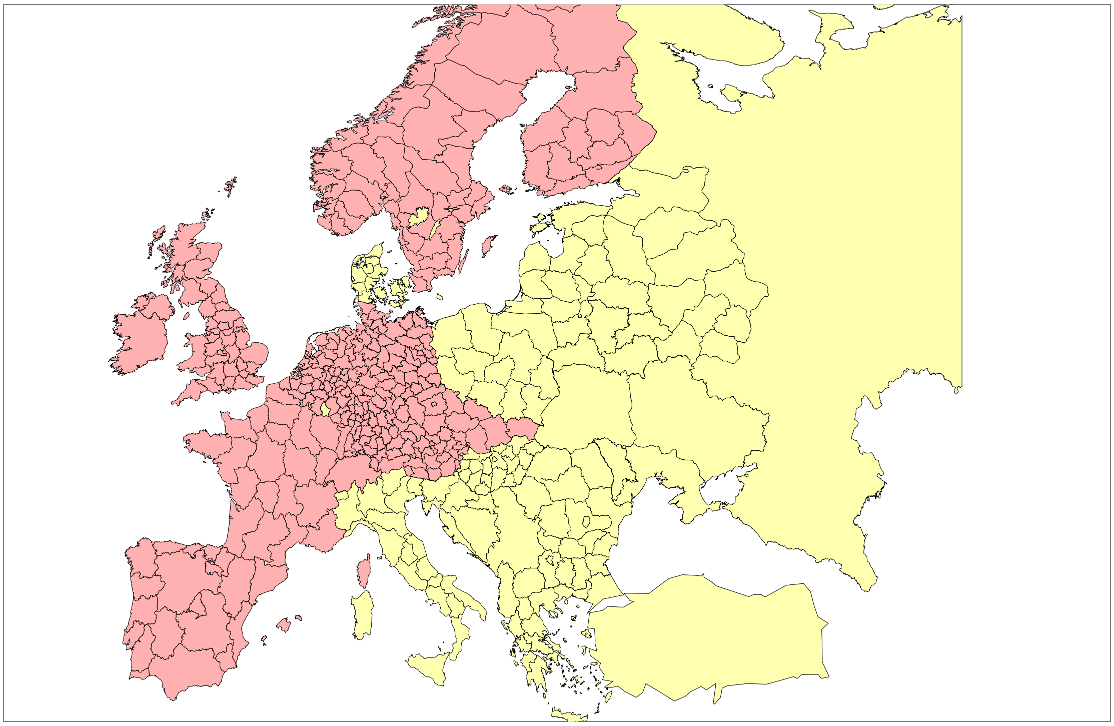


Road Priority

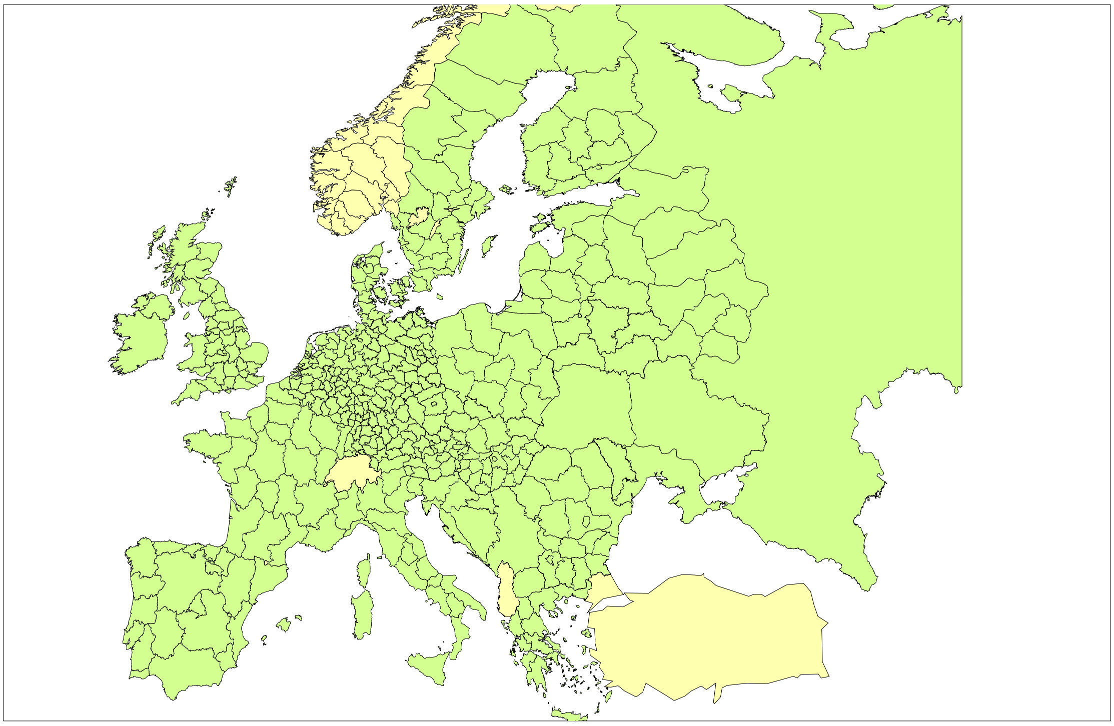


Network Approach

Global Environmental Impacts Under Renaissance Assumptions

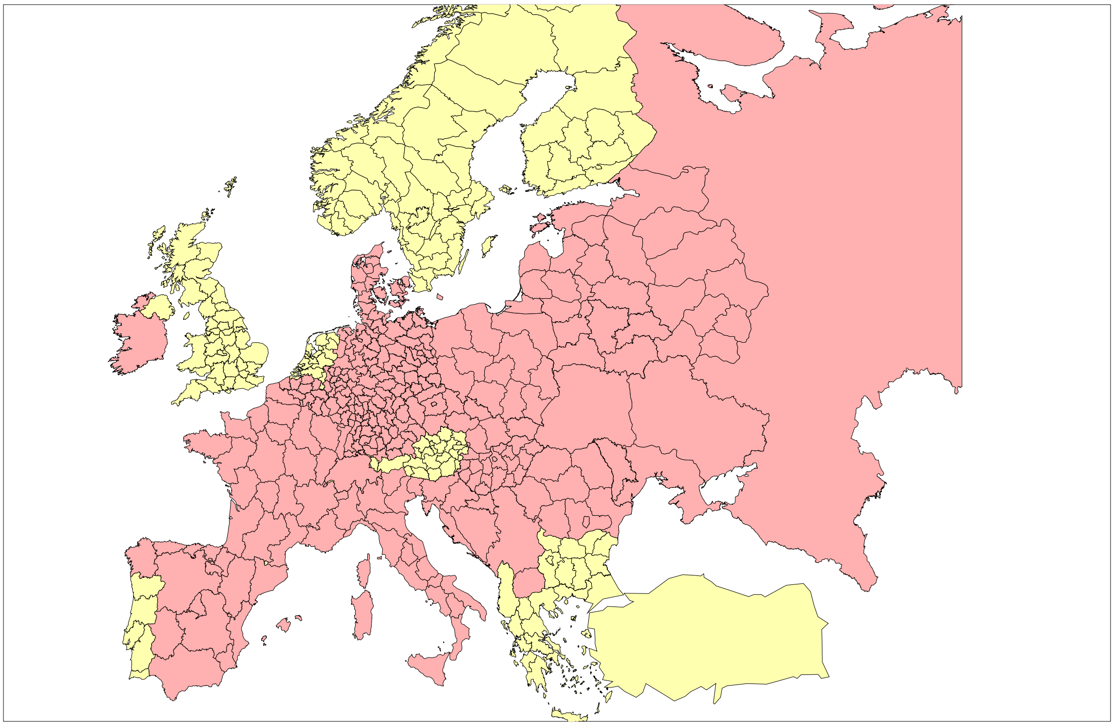


All Road Approach

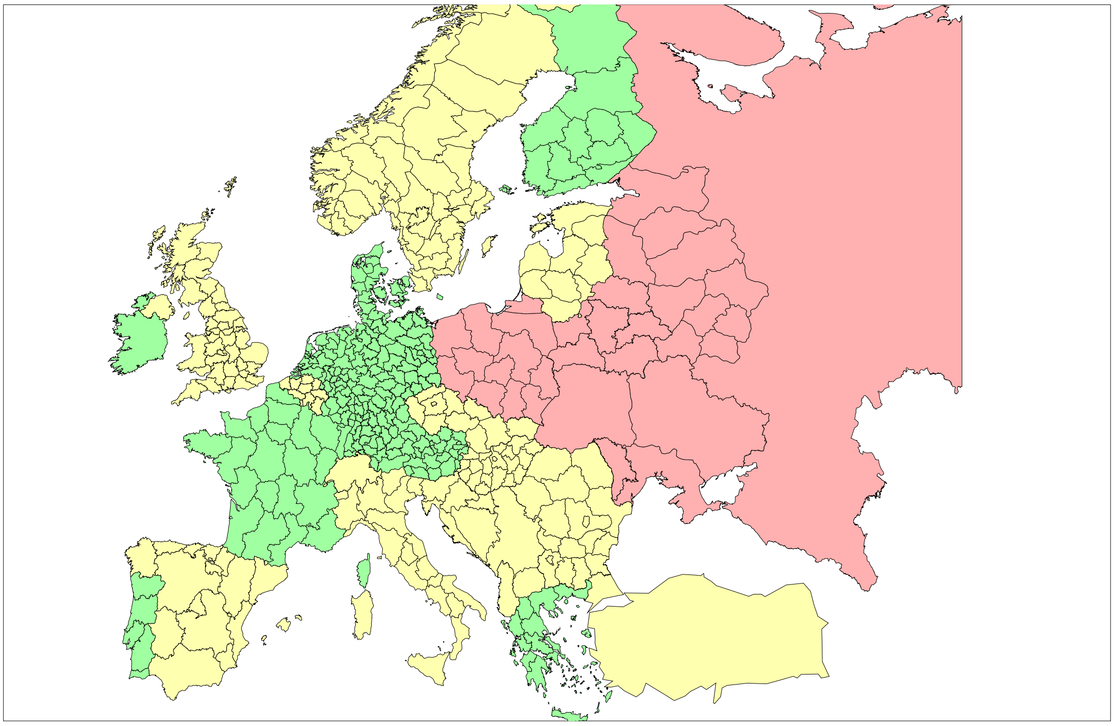


Rail Priority

Local Environmental Impacts Under Solidarity Assumptions

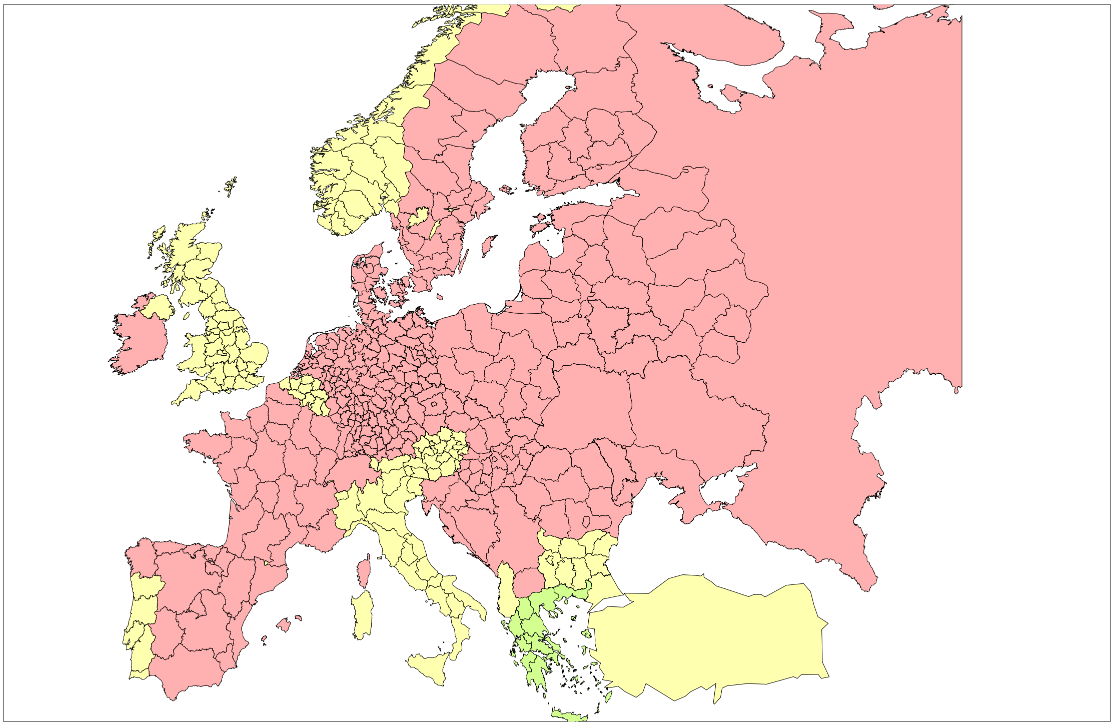


Road Priority

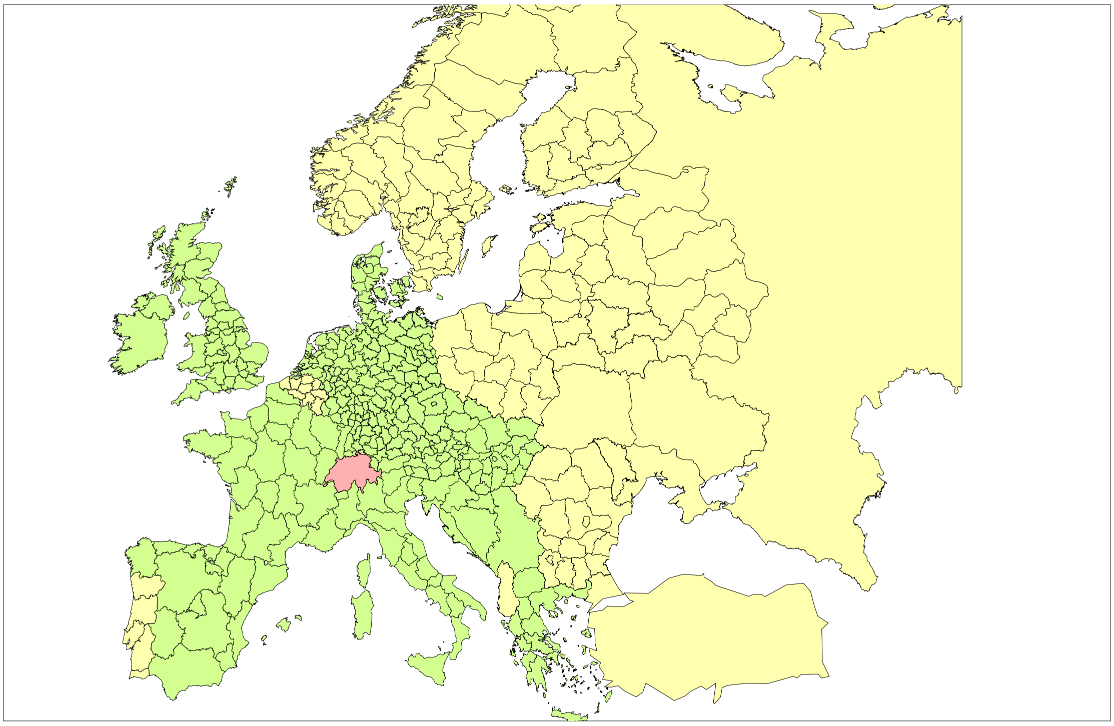


Network Approach

Local Environmental Impacts Under Dilution Assumptions

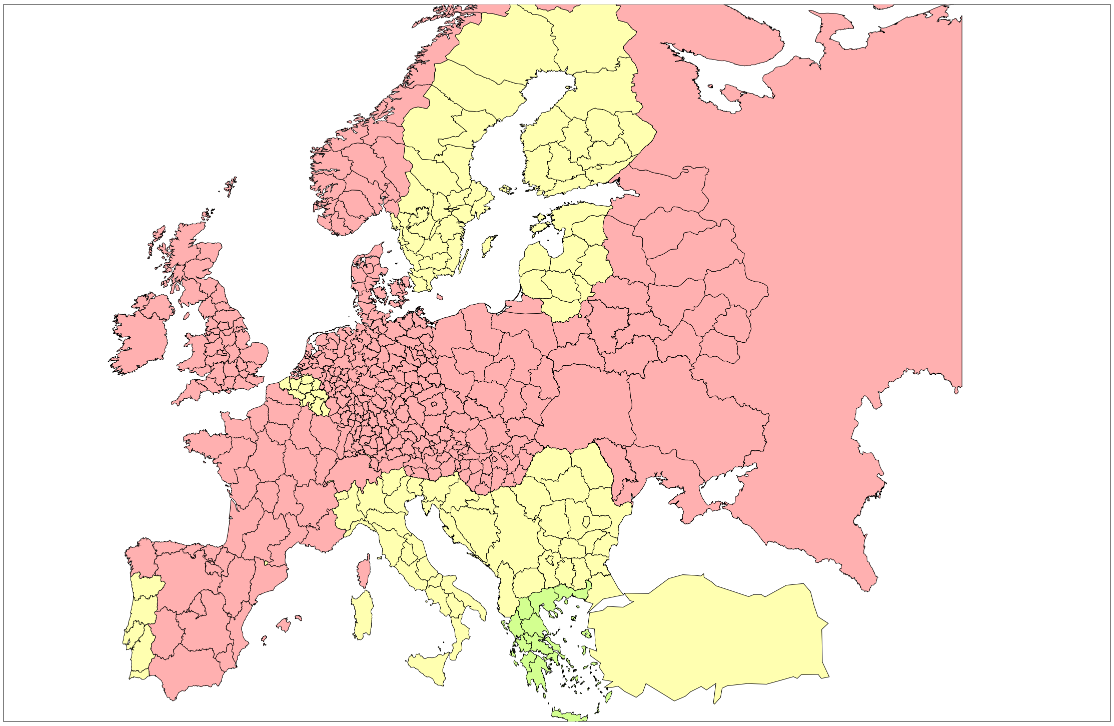


Road Priority

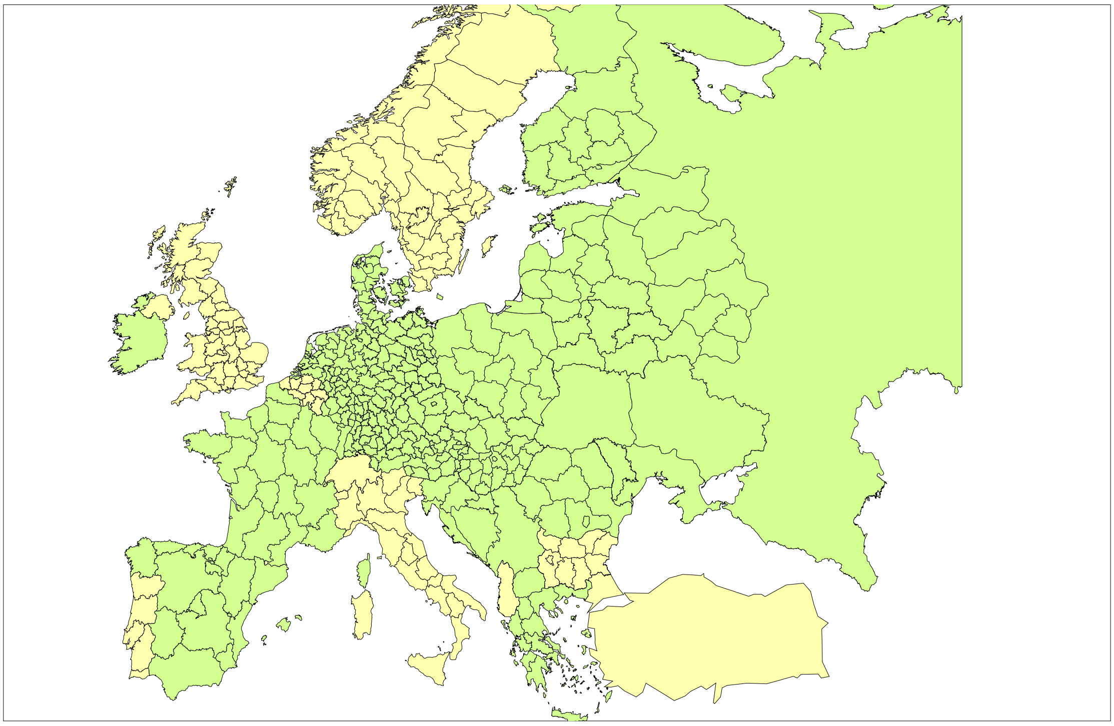


Network Approach

Local Environmental Impacts Under Renaissance Assumptions



All Road Approach



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Environmental assessment of strategic transport actions SEA in CODE-TEN

Abstract

Pan-European integration has brought the environmental evaluation of transport into a new scope due to the size of development schemes. For instance, developing and extending the Trans-European Networks (TENs) is likely to impact the environment on a very large scale. The Common Transport Policy (CTP) - the main European strategic policy document to date - identifies environmental issues among the objectives of sustainable mobility (Commission of the European Communities 1992 and 1999). Therefore, a strategic assessment process should reflect how transport policies either promote or act counter to environmental sustainability. Strategic environmental assessment (SEA) is a framework for evaluating the environmental performance of strategic plans, policies and programmes, and judging on an implementation scheme, which best meets the relevant quality criteria.

The framework itself is meaningless, unless it supports strategic decision-making. In CODE-TEN - a research project funded by the European Commission – a methodology for assessing the socio-economic impacts of strategic transport actions was developed. As an application, a set of alternative infrastructure policies was examined. Experience shows that assessing the environmental impacts of strategic transport actions with sufficient coverage requires modelling the European network and traffic flows as an entity. The transport model must be linked with economic scenarios for projecting future transport development. Infrastructure policies or other strategic actions must be specified as well as linked with the projection tools. Modeling is needed for quantifying the impacts for a set of environmental indicators. Finally, the impact information must be weighted against sustainability criteria. The results are then passed on to overall policy assessment, which weights all socio-economic impacts against each other.

In order to develop more systematics into SEA, an agreement should be reached upon which impacts should be included in strategic analysis. As too many impacts cannot be assessed due to capacity constraints, some impacts may be assigned to represent a group of related impacts as proxies, according to the conduct of CODE-TEN. It should be debated whether site-specific impact information should be included in the assessment, or whether these issues should be automatically considered in the planning and implementation phases of infrastructure projects. The environmental objectives should be debated to clarify their relative importance between each other.

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Keywords
transportation, environmental impacts, assessment, emissions, CODE-TEN, sustainability, air quality, biodiversity, noise control, climatic change

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