# EUROPEAN COMMISSION

# DG TREN

**SIXTH FRAMEWORK PROGRAMME, THEMATIC PRIORITY 8**
**POLICY-ORIENTATED RESEARCH**
**SPECIFIC TARGETED RESEARCH PROJECT – CONTRACT N. 044274**

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ASsessing SEnsitiveness to Transport

# Assessing Sensitiveness to Transport

## D.6: Cross-Site Analysis and Conclusions Report

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|---|---|
| Deliverable no. | D.6. |
| Dissemination level | |
| Work Package | WP6: Cross-Site Evaluation and Conclusion |
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| Quality review | ISIS |
| Status (F: final, D: draft) | D |
| Project Start Date and Duration | 01 May 2007 – 30 October 2009 |
| Date of report | December 2009 |

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*List of Acronyms*

| | |
|---|---|
| ACE | Alpine crossing exchange |
| APT | Areas with (potentially) higher Pressures from Transport |
| AQMA | Air Quality Management Area |
| Base | Base scenario |
| BAU | Business as usual scenario |
| CBA | Cost/benefit analysis |
| CDA | Continuous Descent Approach |
| CI | Connectivity index |
| COPERT | |
| CS | Case Study |
| DEM | Digital elevation model |
| e.g. | exempli gratia – for example |
| EIA | Environmental Impact Assessment |
| Etc. | Et cetera – and so forth |
| EU | European Union |
| EVA | Swedish Road Administration Planning tool for socio-economic analyses of road projects |
| GIS | Geographic Information Systems |
| GRACE | EU project meaning Generalisation of Research on Accounts and Cost Estimation |
| HEATCO | EU project meaning Developing Harmonised European Approaches for Transport Costing and Project Assessment |
| HGV | Heavy Goods Vehicle |

| | |
|---|---|
| i.e. | id est – that is |
| IMO | International Maritime Organisation |
| IUCN | International Union for Conservation of Nature |
| JRC | Joint Research Centre |
| Km | Kilometre |
| $Km^2$ | Square kilometre |
| LEZ | Low emission zone |
| M | Meter |
| MARPOL | International Convention for the Prevention of Pollution From Ships |
| MedPAN | The network of managers of marine protected areas in the Mediterranean |
| NGO | Non-governmental organization |
| OA | Output Area |
| ONS | Office for National Statistics (UK) |
| PSSA | Particularly Sensitive Sea Areas |
| POU | Planungsgruppe Ökologie + Umwelt GmbH |
| PP | Policy Package |
| RAC/SPA | Regional Activity Centre for Specially Protected Areas |
| SA | Sensitive areas |
| SEA | Strategic Environmental Assessment |
| TAA | Transport affected areas |
| TSA | Transport Sensitive Areas |
| UK | United Kingdom |
| UNEP | United Nations environment programme |

| | |
|---|---|
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| VA | Vulnerable areas |
| WP | Work Package |
| WTP | Willingness to pay |
| WWF | World Wide Fund for Nature |
| µg/m3: | Micrograms per cubic meter |

# 0 Executive Summary

## Objectives

ASSET has the following main objectives:

- To develop a robust methodology for the identification and analysis of TSA - Transport Sensitive Areas (WP1 and WP2)
- To identify the range of policy instruments that can reduce the negative impacts of transport in TSA (WP4)
- To test and apply the TSA methodology for the identification of hot spots at EU level (WP3)
- To test and apply the TSA methodology on a series of diversified case studies, for the assessment of the potential impact of targeted policy instruments and policy packages (WP5)
- To draw conclusions on the applicability and on the limits of the methodology and tools developed (WP6)

This report (D6 – Cross-site analysis and conclusions report) accordingly builds upon the findings of all previous ASSET work and Deliverables, also taking into account the discussion and the presentations made during the ASSET Final Conference, held in Brussels, on 30th November 2009. Based on the comparative review of the 10 case studies, D6 addresses three main issues:

(i) Is the proposed definition (and classification) of TSA acceptable and practicable (in the light of the experience of applying the TSA methodology developed by ASSET to concrete examples)?

(ii) Which policy measures and packages are more suitable to deal with the various types of TSA?

(iii) Is additional knowledge required to mainstream the concept of TSA, and which issues should be addressed by future research?

## Definition and classification of TSA

The cross-site analysis in D6 reviewed the concept of Transport Sensitive Areas (TSA): case studies have allowed to test the applicability of concepts, tools and methodological recommendations developed in the previous project phases, and their findings have been scrutinized to ascertain whether the outcomes of WPs 1 through 4 (e.g. definitions, choice of criteria, assessment of policy instruments) should be revised or amended for final validation. D6 accordingly proposes a final definition of TSA and a set of criteria for identifying sensitive areas, which largely confirm the definition proposed in the earlier project stages (D2):

Transport related pressures and impacts considered in view of the identification of TSAs are

- Air pollution
- Noise
- Infrastructure
- Accidents.

On the other hand, the endpoints considered as relevant for transport sensitiveness are:

- Exposed population
- Ecosystems

- Landscape with recreational/touristic functions
- Cultural heritage

Causal relationships between pressures and endpoints are thus the following

| ASSET approach to TSA | | | | | |
|---|---|---|---|---|---|
| **Transport Related Pressures** | **Higher Vulnerability of Endpoints** | | | | |
| | Population exposure (density) | Sensitive ecosystems | Landscape with recreational (touristic) function | Unique natural resources and cultural heritage | Areas with extraordinary preload levels |
| Noise | ✓ | ✓ | ✓ | ✓ | |
| Air Pollution | ✓ | ✓ | ✓ | ✓ | ✓ |
| Infrastructure | ✓ | ✓ | ✓ | ✓ | ✓ |
| Accidents | | ✓ | | ✓ | |

For each pressure/impact and for each endpoint, the level of sensitiveness of a given area will depend on (i) the actual level of pressure and, for a given level of pressure on (ii) the level of impacts induced by such pressure.
Accordingly, to determine whether a given area is a TSA, pressures and impacts are assessed in two steps (respectively called "check1" and "check2")

- Check 1 aims at identifying whether, in the area at hand, the vulnerability of endpoints is intrinsically higher (than average). This amounts to determining if and why, in that area, impacts and costs arising from a given level of pressure are higher
- Check 2 aims at determining whether, in the area at hand, a given level of transport activity will generate higher pressure (than average). This amounts to determining if and under which conditions emissions and concentrations per vehicle km or infrastructure km are higher.

The two checks rely on a series of indicators and on sensitivity thresholds associated to each of those and for each transport related pressure and impact, as shown in the following table.

| Indicator number | name | description | Threshold | Noise | Air pollution | Infra-structure | Acci-dents |
|---|---|---|---|---|---|---|---|
| **Check 1 for the definition of SA** | | | | | | | |
| 11 | Population density | | 90-percentile | X | X | X | X |
| 12 | Sensitive ecosystems | Natura 2000, UNESCO biosphere reserve | yes / no | X | X | X | X |
| | | European Coastal Erosion Layer | yes / no | | | X | |
| 13 | Cultural heritage | UNESCO world heritage site | yes / no | X | X | X | X |
| 14 | Tourisitc and recreational value | number of overnight stays / km2 | 90-percentile | X | X | X | |
| 15 | Connectivitiy index | Measure of ease of movements | Average of Natura 2000 sites | | | X | |
| 16 | Tunnels | | 500m length | | | | X |
| 17 | Pollution of ground water | ground water protection zone | yes / no | | | | X |
| **Check 2 for the definition of TAA** | | | | | | | |
| 21 | Topography | Altitude differences | 400m in 1km | X | X | X | |
| 22a | Wind speed | Possibly frequency of wind above certain velocity | to be determined in WP3 | X | | | |
| 22b | Wind speed | Low wind speeds | 10-percentile | | X | | |
| 23 | Temperature | Possibly average yearly temperature | to be determined in WP3 | X | | | |

The ASSET case studies have allowed to test the relevance and the usability of the selected indicators:

| № | Case Study | Check 1 | | | | | | Check 2 |
|---|---|---|---|---|---|---|---|---|
| | | Population Density | Sensitive Ecosystem s | Cultural Heritage | Touristic and recreational value | Connectivity index | Tunnels | Topograph y (*) |
| 1 | Pyrenees | ✓ | ✓ | ✓ | | | ✓ | ✓ |
| 2 | Alpine crossing | ✓ | ✓ | | ✓ | ✓ | | ✓ |
| 3 | Omberg | ✓ | ✓ | ✓ | ✓ | | ✓ | |
| 4 | Cuenca Del Manzanares | | ✓ | | | | | ✓ |
| 5 | Lipno | | | | | | | |
| 6 | Mediterranean Sea | | ✓ | | | | | |
| 7 | Trans-Pennine Corridor | ✓ | ✓ | ✓ | | | | |
| 8 | Frankfurt Airport | ✓ | ✓ | ✓ | ✓ | | | |
| 9 | Copenhagen | ✓ | | | | | | |
| 10 | Budapest | ✓ | | | | | | |

*ASSET threshold used*

(*) The topography indicator developed in ASSET was intended to be a proxy for many different effects, notably including: a) Probability of inversions; b) Actual or potential transport route gradients, c) Amphitheatre effect; d) Reflections (echo); e) Decrease of effectiveness in noise barriers; f) Curvy roads (braking and accelerating results in higher emissions or even accident risk)

The experimental application of the above framework in the case studies has led to the formulation of the following caveats and recommendations:

- **Thresholds of sensitiveness**. The use of the same percentile, i.e. the 90-percentile, to define thresholds for identifying the sensitiveness of transport areas to population density, was finally not recommended due to the different scales of analysis. The Trans-Pennine case study shows in fact that using the same 90-percentile threshold when the scale of analysis shifts from local (Census for output areas (OAs) to regional scale (counties) implies an extreme variability in the resulting absolute value of the thresholds, respectively 8,970 residents per km2 against 2,230, making the assessment of sensitivity arbitrary and uncertain. Similar caveats have also been stressed in the Copenhagen and Budapest case studies. A viable alternative could be to use absolute values or a fixed 90 percentile, i.e. of the EU population density, or to use local/national standards. A similar argumentation holds true for the overnight stays and for wind speeds, where alternative thresholds based on national average and standards were proposed (Frankfurt Airport, Copenhagen and Budapest case study).

- **Enhancing and refining evaluation methods**. As far as the assessment of transport sensitiveness to the presence of vulnerable ecosystems and social and cultural heritage are concerned, Natura 2000 sites and UNESCO biosphere reserves have proved to be important sources for the identification of sensitiveness, namely in the Pyrenees, Alpine and Cuenca del Manzanares case studies. However, as shown in the Omberg case study, other effects arising from transport infrastructure development as land take, barrier effects and visual intrusion, i.e. the so called encroachment effect, need to be appropriately considered, implying the development of contingent valuation methods for the monetary evaluation, further developing the HEATCO methodology assumed as common basis for the evaluation (http://heatco.ier.uni-stuttgart.de/) .

- **Adapting to scale and space**. In extremely large scale case studies, as in the Mediterranean Sea, the ASSET methodology for the identification of sensitiveness has been implicitly considered as applied, taking stock of the international conventions, i.e. the MARPOL convention, which defines the Mediterranean Sea as a Special Area that deserves to be protected due to its ecological conditions and the significant sea traffic. In such a case, the focus of the case study has been the evaluation of policy packages to address environmental protection; in particular to test market-based instruments to mitigate transport impacts

- **Data availability.** In general, some indicators for assessing sensitiveness, i.e. "temperature", "connectivity", and "ground water pollution", despite their importance, have been scarcely used in the case studies due to poor data availability.

Ultimately, taking account of the above caveats, a possible classification of TSA is therefore proposed:

- all areas for which Check1 is "positive" are automatically considered TSAs
- additionally, areas for which Check 2 is "positive", and check 1 is also "positive" if applying a lower threshold for the indicators defined (see table).

| An area is a TSA if: | Type of TSA | Type of Check |
|---|---|---|
| Population density is above the fixed threshold | Noise, Air pollution, Infrastructure, accidents TSA | Check 1 |
| Population density is above the 75% of the fixed threshold value and it is a sensitive area defined by check 2 topography indicator | Noise, Air pollution, Infrastructure TSA | Check 1 and Check 2 |
| Sensitive land-use functions are present | Noise, Air pollution TSA | Check 1 |
| Number of elderly (65+) or children (-14) is above the fixed threshold | Noise, Air pollution TSA | Check 1 |
| Number of elderly (65+) or children (-14) is above the 75% of the fixed threshold value and it is a sensitive area defined by check 2 topography indicator | Noise, Air pollution TSA | Check 1 and Check 2 |
| Catalogued as Natura 2000 site, a UNESCO biosphere reserve or UNESCO world heritage site | Noise, Air pollution, Infrastructure, accidents TSA | Check 1 |
| Catalogued as national/regional natural or cultural site and it is a sensitive area defined by check 2 topography indicator | Noise, Air pollution, Infrastructure, accidents TSA | Check 1 and Check 2 |
| Included in the European Coastal erosion layer. | Infrastructure TSA | Check 1 |
| Number of overnight stays/Km2 or the number of visits to attraction sites is above the fixed threshold | Noise, Air pollution, Infrastructure TSA | Check 1 |
| Number of overnight stays/Km2 or the number of visits to attraction sites is above the 75% of the fixed threshold value and it is a sensitive area defined by check 2 topography indicator | Noise, Air pollution, Infrastructure TSA | Check 1 and Check 2 |
| Connectivity Index is above the average value calculated within Natura 2000 sites | Infrastructure TSA | Check 1 |
| The road tunnel is longer than 500m (≥ 500m). | Accidents TSA | Check 1 |
| The area is a ground water protection zone. | Accidents TSA | Check 1 |

**Policy instruments for TSA**

Based on the four main types of sensitivity to transport pressures (Noise, Air Pollution, Infrastructure and Accidents), ASSET identified potential extraordinary measures to be adopted when dealing with transport sensitiveness. In particular, Deliverable D4 classified policy instruments in four categories, reflecting differences in both their potential effectiveness and their “modus operandi”, i.e. whether they address transport pressures directly or by means of indirect drivers, e.g. the reduction of traffic flows:

1. Extraordinary measures, suitable to be adopted in situations in which local conditions heavily affect TSAs;

2. Complementary measures, i.e. accompanying and supporting measures

3. Measures that reduce transport pressures indirectly, by pursuing other, primary objectives such as e.g. raising revenues, reducing traffic flows, improving accessibility, etc.

4. Measures with no significant impact

The table below classifies the policy instruments by type of TSAs.

| | Type of transport sensitive area | | | |
|---|---|---|---|---|
| **Policy Instrument** | **Noise Pollution** | **Air Pollution** | **Accident** | **Infrastructure** |
| ***Pricing*** | | | | |
| Cordon / Access Pricing | E possible | E possible | E possible | - |
| Congestion Charging | I | I | I | - |
| Infrastructure tolls and charges | E possible | E possible | E possible | - |
| Area Licensing | E possible | E possible | I | - |
| ***Taxation*** | | | | |
| All forms | I | I | I | - |
| ***Infrastructure and Planning*** | | | | |
| Improved Infrastructure | I | I | E possible | E possible |
| SEA + EIA | C | C | C | E (mandatory) |
| Priority Lanes | C | C | - | - |
| Traffic Management Systems | C | C | - | - |
| ***Regulation*** | | | | |
| Low Emission / Environmental Zone | E possible | E possible | E possible | - |
| Other zone access controls (Table 2) | E possible | E possible | E possible | - |
| EU Directives and International Regulations | C, I | C, I | C, I | C |
| Permits and Quotas | E possible | E possible | E possible | - |
| ***Information and Public Awareness*** | | | | |
| All forms | I, C | I, C | I, C | - |

E: extraordinary measure; I: indirect impact; C: complementary measure; -: no significant impact

This table demonstrates the wide range of instruments that have been tested in the case studies under varying circumstances. Due to this variety, the aim of the cross site analysis cannot be to generalise the suitability of any policy instrument for a specific type of sensitive area or to optimise its application. Taking into account the difficulty to derive robust policy recommendations from the implementation of a limited set of case studies addressing a wide range of policy instruments under heterogeneous conditions, the following conclusions can be drawn:

- In Mountainous Areas different policy packages yield consistently high reductions for most environmental costs: in the Pyrenees a policy package with toll for heavy goods vehicles and decreased speed limits leads to a reduction of noise by 30%. Regarding the Alpine crossing it figures out that Alpine crossing exchange permits in Switzerland, unlimited supply of rolling motorway and a ban to certain lorry categories can reduce noise up to 51%, accidents up to 24% and air pollution up to 17%.

- Non-mountainous natural areas: while infrastructure measures play an important role in the Omberg case study in Sweden, which exhibits a reduction in air pollution up to 70%, accidents up to 49% and noise up to 30% if two national roads in this area are upgraded and a toll or a km tax on one of these national roads will be introduced, the Cuenca del Manzanares case study shows a possible reduction up to 63% for noise and up to 5% for air pollution solely based on a reduction of speed limits. In the Trans-Pennine Corridor in United Kingdom cordon pricing will help to reduce noise up to 9 %, air pollution up to 2% and accidents by 1%.
- In marine areas, regulative and legislative measures (low emissions fuels, security enforcements, etc) are likely to be effective, with a complementary role assigned to market-based instruments, e.g. differentiated fairways and Port dues
- Urban areas, not surprisingly, appear as those TSA where curbing negative environmental effects of transport remains a major challenge In Copenhagen each of the three measures road pricing, toll ring system or environmental zone regulation can lead to a reduction of air pollution by more than 6% and in Budapest an access fee can reduce noise by 6% and accidents and air pollution by 1%. A case in point is the area around Frankfurt Airport where a kerosene tax is the main driver to reduce air pollution by 15 % and noise by 14%.

In the case studies where noise has been assessed, ASSET policy packages have revealed a great potential for noise exposure mitigation. This is particularly true for mountain areas, as inferred from Pyrenees and Alpine Crossing results. Also as regards noise, results from Pyrenees and Manzanares case studies revealed a great success of regulatory measures like the reduction of speed limits.

Several case studies have revealed either small increases in air pollution emissions or significant differences in air pollution results between policy packages. This is usually the case when tolling or taxation measures are applied, which result in rerouting of traffic flows and increased mileage that compensates the potential reductions in the areas of application. Regulatory measures play an important role as complementary measures in reducing the overall level of emissions or as localised, extraordinary measures, e.g. through heavy vehicle bans.

As for accidents, improvements are greater in those cases where infrastructure improvement has taken place (e.g. Omberg). Nevertheless, traffic decrease is the main driver for achievements as regards this impact, which also accounts for significant improvements due to tolling and regulatory measures aimed at traffic reduction.

The importance of traffic reduction as a driver of environmental improvement holds true for all transport related effects. But this should not lead to misleading conclusions e.g. identifying the more restrictive measures as the more effective. Case studies like the Pyrenees have revealed better results in a priori “softer” policy packages.

Overall, the conclusions derived from the ASSET case studies concerning the most appropriate application of policy packages in TSAs are in some way mixed and not amenable to be summarised with straight messages. This depends on the complexity of TSAs, involving different geographical scales and socio-economic contexts, owing to the limited number of case studies that can be implemented along the lifetime of a research project.

On the one hand, the ASSET case studies show that simple and focused regulatory measures can be as effective in tackling the main transport related impacts as less socially accepted measures like pricing. This is also confirmed by more qualitative oriented assessments like in the Mediterranean case study.

On the other hand, , the case studies have also shown that great care has to be taken in the implementation of instruments in order to prevent undesired effects. These are in particular:

- The focus on one TSA or single corridor inevitably fails to provide a full picture of impacts, as measures adopted at a single area/corridor level can lead to redistribution of traffic between the different corridors that would be minimised if a larger area is considered. Hence, the choice of the application area of a policy should take into account transport interdependencies as well as implementation costs and the legislative powers of implementing institutions.
- Coordinated implementation is required, in particular in cross-border applications, in order to reduce overall transport volumes and avoid traffic diversion and relocation of environmental impacts. This also holds true for smaller scale applications if more than one authority is involved.
- Accompanying measures are necessary for fiscal as well as regulatory instruments in order to improve acceptability and to reduce undesired impacts e.g. through use of revenues for extending capacities for alternative modes: Extraordinary measures on mountainous case studies lead to a large shift of transport volumes from road to rail. The capacities for Alpine and Pyrenean crossing rail freight traffic have to be large enough to cope with the shifted transport volumes from road. It is also necessary to properly consider special measures for short haul transport, such as a price reduction for short transport distances, in order to limit the negative impact on regional commerce.
- A clear, harmonised definition of Transport Sensitive Areas is required to avoid arbitrary application of the concept by countries as a form of 'tax-exporting' behaviour. The concepts and web-tool developed in ASSET can be used for scoping and strategic planning purposes. Further development as mentioned above is required

**Additional knowledge and further research needs**

The extensive debate that took place within ASSET, also with the involvement of stakeholders, led to concluding that the definition of sensitive areas and Transport Sensitive Areas should be independent of the scale of representation, as "everything is sensitive to a certain extent".

- Notably, sensitiveness thresholds adopted for a given indicator (or a combination of indicators) to define TSAs should not change with the scale of the analysis. On the other hand, a higher level of disaggregation of the data and indicators used for sensitiveness appraisal will allow to be more accurate and reliable in identifying local phenomena that trigger area sensitiveness. While the GIS tool developed by ASSET (D3) already allows to usefully combine several indicators at varying scales of representation, additional and more detailed data at the local scale are needed in order to make a better use of the indicators themselves

- The case studies have provided valuable evidence on the topics to be addressed by future research, i.e. the policy research (trading off) on the (positive or negative) interactions between policy instruments developed in a given area and those adopted in neighbouring areas. There have been examples where the application of measures in a TSA results on undesired effects on neighbouring and other TSAs. This is a key issue for future application of the TSA concept, relevant for all types of TSA, and should be further explored. In the light of the heterogeneity of policies tested in the case studies, a first series of indications on the applicability of instruments to different types of TSAs have been reached, but further research into the design of policy packages and implementation issues is required in order to avoid undesired impacts and optimise output.

- Future research should also focus on the identification of suitable thresholds for several of the indicators proposed by ASSET, ideally leading to propose smart combinations of different indicators and thresholds to accurately define TSA using local scale data.

- It has been proved that few but well established indicators work really well in big areas. Topographic conditions, protected areas, and even population density seems to set up the general framework for regional scales in order to look for solutions at that level. Population density also makes sense at this scale, even when no clear guidelines on which area should be taken to calculate percentiles were given. General indicators are easily available, and present the minimum requirements for a TSA analysis and policy package application. A more detailed analysis of specific areas of interest could then be undertaken in order to check the assessment and redefine risks and costs.

- It is worth to highlight the transnational scope of several case studies (Pyrenees, Alpine Crossing and Mediterranean Sea), where two or more countries are involved, which may have implications in the development of the ASSET approach, especially in the economic valuation of environmental and health effects, as well as in the design and choice of policy measures. Also, large case studies with a trans-national scope imply the intervention of administrations at national, regional and sometimes local level. In general institutional and organisational issues associated to the required level of collaboration between administrations and stakeholders groups calls for additional efforts.

# 1 Introduction

## *1.1 Overview*

The EU-project ASSET (ASessing SEnsitiveness to Transport), funded by the 6th European Research Framework Programme aims at developing the scientific and methodological capabilities to implement European policies designing at balancing the environmental protection of sensitive areas with the provision of an efficient transport system, giving a special emphasis on market based instruments. It mainly looks for a common framework of definitions, criteria, methodology, and valuation parameters for Transport Sensitive Areas (TSA), producing a map of TSAs across the EU. A review of policy instruments and packages for the protection of TSA and an analysis of applicability to different TSA categories has also been undertaken, based on 10 case studies in different contexts. Work Package 6 (WP6) is the final piece of work, summarising the methodology and the main lessons learned from case studies performance.

Figure 1 shows the different work packages (WP) of ASSET and their interdependencies.

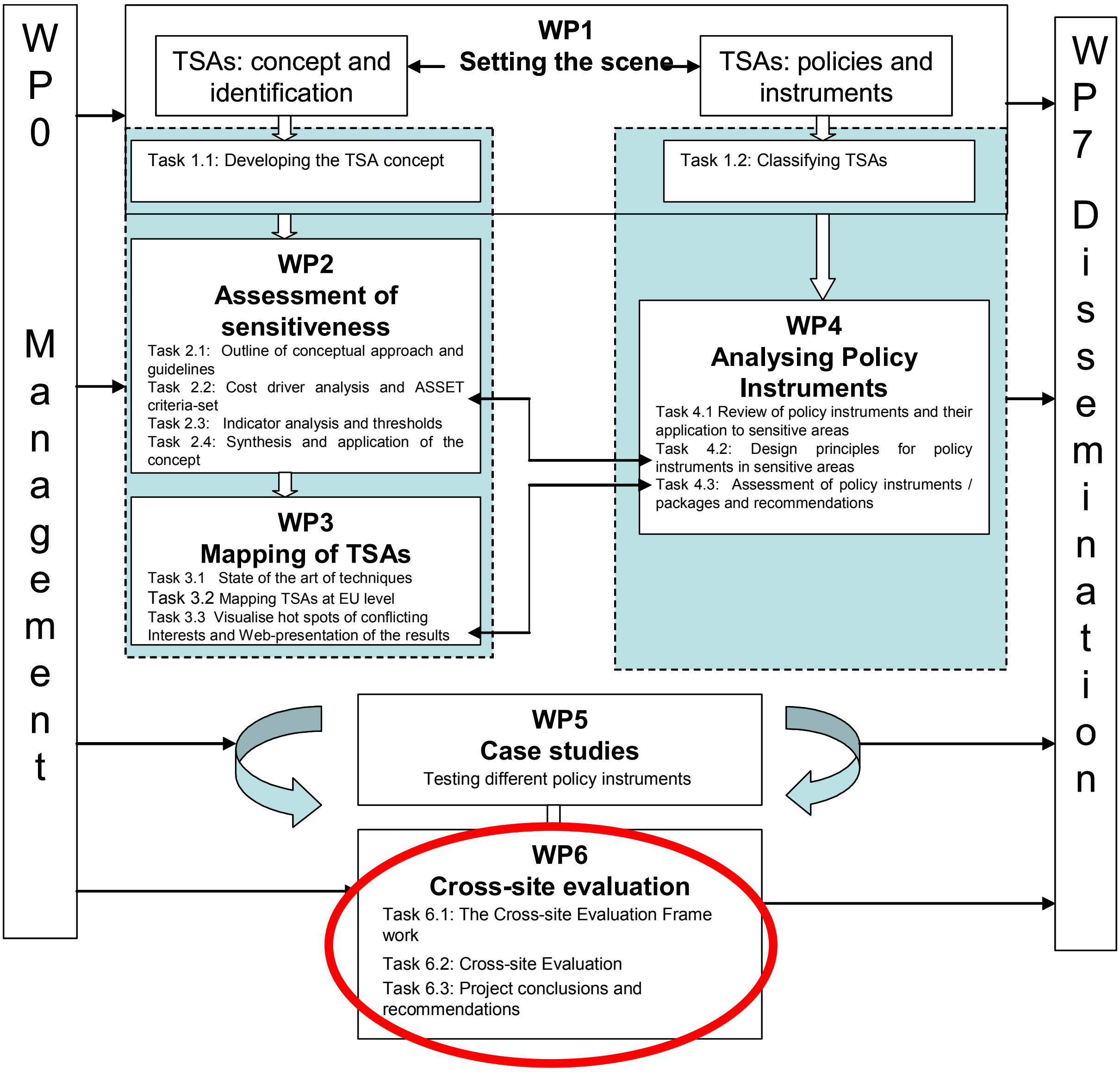



**Figure 1: ASSET Work Package structure and position of WP6.**

This deliverable summarises the results of the Work Package 6 “Cross-site Evaluation and Conclusions” conceived to check how the concepts derived by different work packages throughout the project were adopted and implemented in the case studies developed within Work Package 5. Work Package 6 aimed at the identification of the relevant factors/causes/reasons that contribute to achieve the results, impacts and outcomes of the different case studies. Being complementary to the evaluation exercises of the individual case studies, the work undertaking in this Work Package primarily focus on the main difficulties encountered, the differences between outcomes from case studies within each typology, and on the explanations of these differences.

Based on the case studies results and their experience in terms of ASSET methodology implementation, the notion of transport sensitive area in general terms is reviewed to explore the possibilities of understanding it as an agreed concept with uniform elements. Therefore, final discussion on the definitions behind the general TSA concept, the indicators and thresholds that should be applied and the recommendations for future application of the methodology are presented. Future research needs and recommendations for further conceptual development, as well as policy applications and general conclusions are also included.

## 1.2 Structure and main objectives of the report

The report is structured in line with the chain of knowledge acquired during the project timing, being the performance of case studies the core piece of work from which all relevant concepts are discussed. Therefore, the first chapter of the report forms the introductory part, presenting the positioning of the work package within the whole ASSET projects and the aims of WP6.

The results and performance of case studies are briefly presented in Chapter 2, which analyses and comments how the developed ASSET methodology have performed under the particular circumstances, giving special attention to the most important issues: contour conditions , the identification of Transport Sensitive Areas, the use of indicators and thresholds, issues of scale and space, the assessment of environmental and health burdens and their economic valuation and the design and choice of policy measures that have been applied in the case studies.

Chapter 3 takes into account all the results, comments and suggestions from case studies and analyses how the ASSET methodology contributes to the common approach required to implement European policies with the aim of balancing the environmental protection of valuable and sensitive areas with the provision of an efficient transport system. Based on the inputs and performance of case studies, this chapter finally suggests various amendments to the already solid methodology in order to facilitate and assure future harmonisation in the definition and delimitation of Transport Sensitive Areas regardless the scale of work and presented the most promising policies that have been tested in the different situations, also analysing main concerns and points of attention for future application. A brief description on transferability issues and position of stakeholders is finally included based on the questionnaires filled by the case studies.

At last, the amendment of the Eurovignette Directive and opportunities for the TSA concept is analysed, as well as future research needs, prior to the presentation of the final conclusions.

# 2 Case Studies results – brief description of performance

This section is aimed at fulfilling WP6's objectives of:

- Assessing the suitability of the common methodological approach defined in ASSET
- Analysing and evaluating the context, results and impacts of measures and policy instruments considered in the case studies, to learn from their performance

To do so a review of all case studies will be undertaken, and the main difficulties/uncertainties in the application of the ASSET methodology will be identified. The analysis of the performance achieved in the different case studies will help us know whether these difficulties/uncertainties are case specific issues or a shared barrier that will require an amendment of the ASSET criteria and method. This assessment will cover both the identification and classification of transport sensitive areas, and the design and choice of policy measures.

In addition, the review of case studies will help us identify the relevant factors/causes/reasons that have particularly contributed to case studies' results. In this regard, the main goal is to assess how the different measures have performed under the particular circumstances of each case study.

Outcomes from this chapter will feed into the following sections, where the main issues will be discussed and a revision of the ASSET methodology will be undertaken.

The structure of the assessment is as follows:

- Contour conditions (geographical location, area size, population, etc.)
- Sensitive Areas
- Relevant Transport Activities
- Definition of Indicators and Thresholds
- Scale and Space
- Environmental and Health Burdens
- Economic valuation of effects
- Design and Choice of Policy Measures
- Impact assessment

## *2.1 Contour conditions and geographical features*

The location of Case Study areas can be seen in the following map:

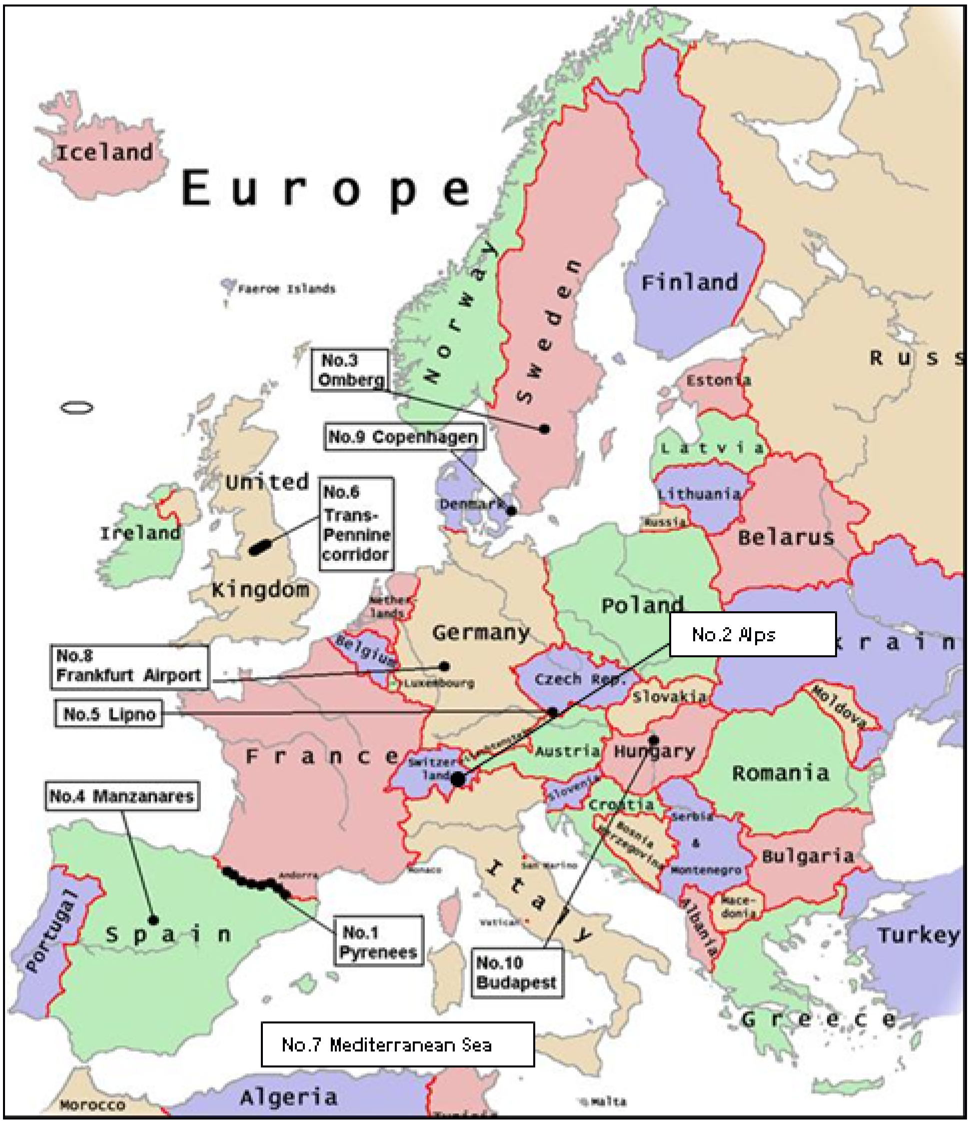



**Figure 2: Case Studies location.**

The blend of involved countries comprises a good representation of all the possible realities within Europe: from Nordic countries like Sweden or Denmark to Mediterranean countries like Spain or Italy; from EU founder states like Germany to new member states like Hungary or Czech Republic, including a non EU member state (Switzerland); from countries with a clear Atlantic orientation like UK to Eastern countries like Hungary. Therefore there is a great diversity of political and socioeconomic contexts affecting the transport system and policies in the corresponding countries.

It is worth to highlight the transnational scope of several case studies (Pyrenees, Alpine Crossing and Mediterranean Sea), where two or more countries are involved, which may have implications in the development of the ASSET approach, especially in the economic valuation of environmental and health effects, as well as in the design and choice of policy measures.

Case studies were selected in the light of the presence of threatened areas suffering from severe transport-related environmental burdens, were the ASSET approach is expected to identify and delimit all threatened areas in the considered zone and define the most effective political measures to protect them. But there is not a common criteria followed for the geographical delimitation of each case. Most of the case studies use administrative and functional criteria for this delimitation, as this leads to obvious advantages: jurisdiction of clearly defined authorities or governments, easiness of data gathering process, better delimitation of stakeholders, etc.

This clear advantage may be darkened by misleading approaches for example if the criteria used for the delimitation of the case study area are the limits of a National/Regional protected area. In that case, it may correlate (if amended according to below suggestion from other case studies) with two of the main indicators for the identification of sensitive areas (Sensitive Ecosystems indicator: Natura 2000 + national/regional protection figures; and Cultural Heritage indicator: UNESCO sites + national/regional protection figures), and the ASSET methodology would be biased by this decision, limiting the "search" for Sensitive Areas to an already designated sensitive zone, and making it difficult to identify additional sensitive areas in the surroundings of the protected zone.

Considering that the ASSET approach points out these indicators as suitable for the identification of Transport Sensitive Areas according to the four considered effects (noise, air pollution, transport infrastructure related impacts and accidents), the impact-driven classification of the area may not lead to any additional result.

These considerations point out at the need to define specific criteria for each area type in order to delimit an influence area around them where the ASSET approach will be applicable.

There are large differences between case studies in terms of area size (from 2.5 million km2 in the Mediterranean Sea case study to 97 km2 in Copenhagen). These differences pose implications on the scale and level of detail required. Also the involvement of the different administrative levels and stakeholders differs according to the area considered (depending on the administrative units comprised, the transport infrastructures considered, the presence/absence of protected areas, etc.).Large case studies with a trans-national scope imply the intervention of administrations at national, regional and sometimes local level. Smaller case studies only account for the implication of regional or local administration levels. So are the case with stakeholders, mostly transport authorities according to the administrative level of the case study and operators.

Population, land uses, and economical functions of the areas considered are also relevant factors in order to define the context in which each case study applied the ASSET approach.

The above issues are summarized in the following table:

| No | Case Study | Area Type | Country | Population (inhab.) | Surface (km²) | Pop. Density (inhab./km²) | Main economic usage | Scope/Scale |
|---|---|---|---|---|---|---|---|---|
| 1 | Pyrenees | Mountain | France, Andorra and Spain | 1.552.995 | 48.645 | 31,93 | Services, tourism | Transnational/Strategic |
| 2 | Alpine crossing | Mountain | Austria, Germany, France, Italy, Slovenia and Switzerland | 13.600.000 | 190.600 | 71,35 | Tourism | Transnational/Strategic |
| 3 | Omberg | Unique natural resources and cultural heritages | Sweden | 63.000 | 700 | 90,00 | Agriculture, tourism, forestry | Regional/Intermediate |
| 4 | Cuenca Del Manzanares | Unique natural resources and cultural heritages | Spain | 497.000 | 529 | 939,51 | Cattle farming | Regional/Intermediate |
| 5 | Lipno | Unique natural resources and cultural heritages | Czech Republic | 12.520 | 618 | 20,26 | Tourism | Regional/Intermediate |
| 6 | Trans-Pennine Corridor | Unique natural resources and cultural heritages | UK | 5.917.310 | 5.397 | 1.096,41 | Industry | Regional/Intermediate |
| 7 | Mediterranean Sea | Marine | Adjacent countries | 81.000.000 | 2.500.000 | 32,40 | Fisheries | Transnational/Strategic |
| 8 | Frankfurt Airport | Agglomeration | Germany | 3.400.440 | 4.900 | 693,97 | Services, Industry | Local/Detailed |
| 9 | Copenhagen | Agglomeration | Denmark | 600.000 | 97 | 6.185,57 | Public and private services, administration, tourism | Local/Detailed |
| 10 | Budapest | Agglomeration | Hungary | 2.513.000 | 3.056 | 822,32 | Residential and ceomerce | Local/Detailed |

**Table 1: Case Studies summary**

The following figure gives an overview on the land use patterns of the case studies.

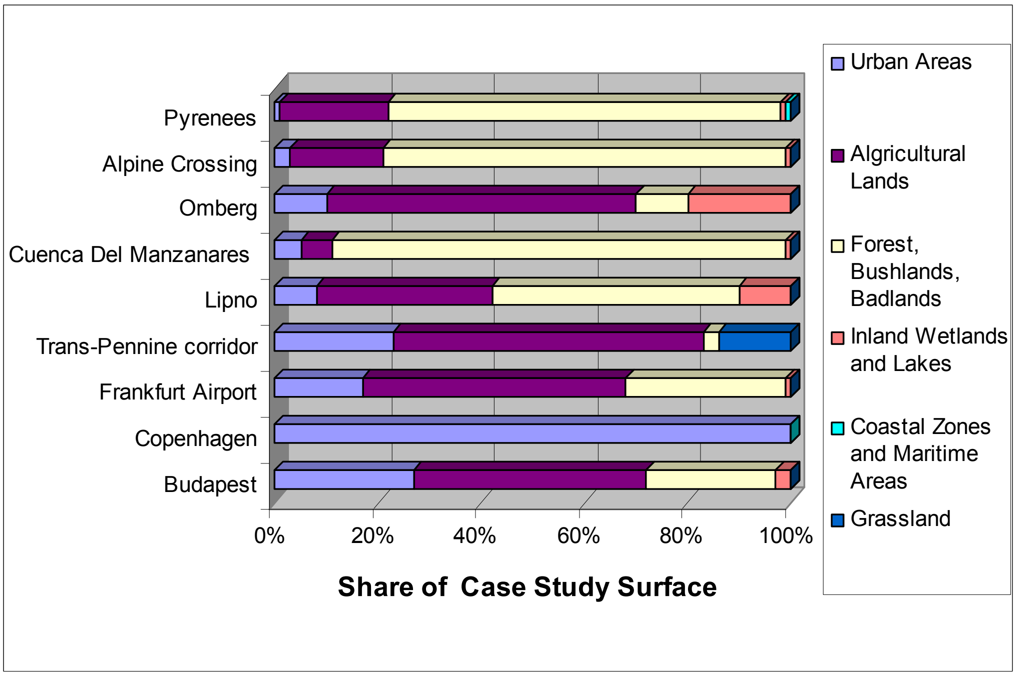



**Figure 3: Share of Case Study surface**

Most case studies show diversified land use patterns, with the exception of Copenhagen, which concentrates on the urban environment. After Copenhagen, the space used by human settlements reaches 27% in Budapest and 17% in Frankfurt. Clearly visible is the dominance of forests, bush and badlands which cover 87% of Manzanares, 78% in the Alps and 76% in the Pyrenees. Agricultural usage is wide spread amongst the studies and reaches up to 60% in Omberg and the Trans-Pennine Corridor. In Omberg, Lipno and Budapest a significant share of the surface is covered by inland wetlands and lakes.

## *2.2 Sensitive Areas*

According to ASSET Deliverable D1 “Definition of transport sensitive areas and their classification” (Sessa et al., 2007), there are five typologies of potentially transport sensitive areas:

1. Mountain areas
2. Coastal zones
3. Marine areas
4. Unique natural resources and cultural heritages
5. Agglomerations

ASSET Case Studies were pre-selected according to this classification. The following table shows the area type that each CS was selected to address:

| No | Case Study | Type of sensitive area |
|---|---|---|
| 1 | Pyrenees | Mountain |
| 2 | Alpine crossing | Mountain |
| 3 | Omberg | Unique natural resources and cultural heritages |
| 4 | Cuenca Del Manzanares | Unique natural resources and cultural heritage |
| 5 | Lipno | Unique natural resources and cultural heritage |
| 6 | Trans-Pennine Corridor | Agglomeration and unique natural resources |
| 7 | Mediterranean Sea | Marine |
| 8 | Frankfurt Airport | Agglomeration |
| 9 | Copenhagen | Agglomeration |
| 10 | Budapest | Agglomeration |

**Table 2: Case Studies’ Area Types**

Although classified like this, several case studies cannot be classified in one particular category, including features of sensitiveness of different area types. This holds true especially for larger case studies, like mountain areas, which in addition to its mountainous character includes areas of outstanding natural richness, cultural heritage and important agglomerations.

This issue may not be significant within the assessment framework developed by ASSET as it is now, where the methodology is roughly the same for all area types at any possible scale. But the eventual amendment of the ASSET methodology (discussed in this Deliverable) will most probably lead to a methodological framework which whilst sharing a common approach, differs in the particular criteria (namely indicators and thresholds) applied at different scales in different area types.

Also according to ASSET's methodology, Policy Relevant Transport Sensitive Areas are identified by cross-checking two categories of elements:

- transport related impacts
- features of sensitivity against transport related impacts

The next table shows the way in which transport related higher pressures and the higher vulnerability of endpoints may be combined in order to identify TSA:

| Transport Related Pressures | Higher Vulnerability of Endpoints | | | | |
|---|---|---|---|---|---|
| | Population exposure (density) | Sensitive ecosystems | Landscape with recreational (touristic) function | Unique natural resources and cultural heritage | Areas with extraordinary preload levels |
| Noise | ✓ | ✓ | ✓ | ✓ | |
| Air Pollution | ✓ | ✓ | ✓ | ✓ | ✓ |
| Infrastructure | ✓ | ✓ | ✓ | ✓ | ✓ |
| Accidents | | ✓ | | ✓ | |

**Table 3: ASSET approach to TSA**

As explained in ASSET Deliverable D2 "Identification and Assessment of Sensitiveness" (Lieb et al., 2008), this approach distinguishes between two "checks" that have to be carried out:

- Check 1: Higher vulnerability of endpoints
  This first step is aimed at knowing why are the endpoints more vulnerable to a given pressure, i.e. why are impacts and costs higher?
- Check 2: Higher transport related pressures
  With this check we analyse under what conditions pressures caused by transport are higher, i.e. we analyse under what conditions emissions and concentrations per vehicle km or infrastructure / route km are higher.

The following indicators are applied to the study area in order to undertake this double check:

| Indicator number | name | description | Threshold | Noise | Air pollution | Infra-structure | Acci-dents |
|---|---|---|---|---|---|---|---|
| **Check 1 for the definition of SA** | | | | | | | |
| 11 | **Population density** | | 90-percentile | X | X | X | X |
| 12 | **Sensitive ecosystems** | Natura 2000, UNESCO biosphere reserve | yes / no | X | X | X | X |
| | | European Coastal Erosion Layer | yes / no | | | X | |
| 13 | Cultural heritage | UNESCO world heritage site | yes / no | X | X | X | X |
| 14 | Tourisitc and recreational value | number of overnight stays / km2 | 90-percentile | X | X | X | |
| 15 | Connectivitiy index | Measure of ease of movements | Average of Natura 2000 sites | | | X | |
| 16 | **Tunnels** | | 500m length | | | | X |
| 17 | Pollution of ground water | ground water protection zone | yes / no | | | | X |
| **Check 2 for the definition of TAA** | | | | | | | |
| 21 | **Topography** | Altitude differences | 400m in 1km | X | X | X | |
| 22a | Wind speed | Possibly frequency of wind above certain velocity | to be determined in WP3 | X | | | |
| 22b | Wind speed | Low wind speeds | 10-percentile | | X | | |
| 23 | Temperature | Possibly average yearly temperature | to be determined in WP3 | X | | | |

**Table 4: ASSET indicators set (as developed in WP2)**

This indicator based process comprises the first two steps of the ASSET approach, where the double check is used for the identification of Sensitive Areas (SA) and Transport Affected Areas (TAA), respectively. The combination of these two makes it possible to delimit Transport Sensitive Areas (TSA) within a particular study area.

The analysis of case studies reveals a higher and more accurate application of Check 1 (8 out of 10 case studies applied any Check 1 indicator, with an average below 3 indicators used, which represents around 40% of the proposed set of indicators), while Check 2 criteria has been applied to a lower extent and not always according to the intended scope (only 3 case studies applied any Check 2 indicator, with a lower average in the number of indicators: 0.4, which represents a 5% of the proposed set of indicators). Insight on these issues will be provided below. The following are two graphs summarizing the level of usage in each case study of the proposed set of indicators for both Check 1 and 2:

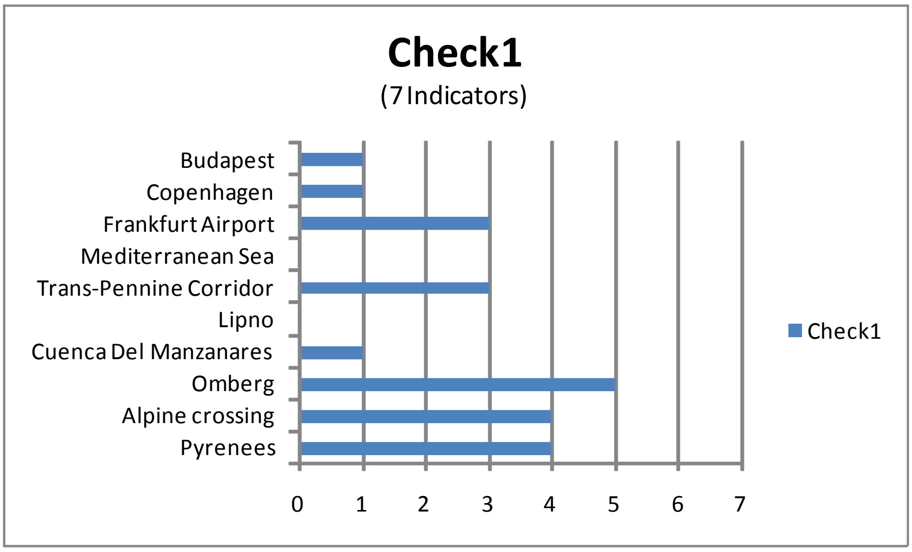



**Figure 4: Check 1 indicators usage**

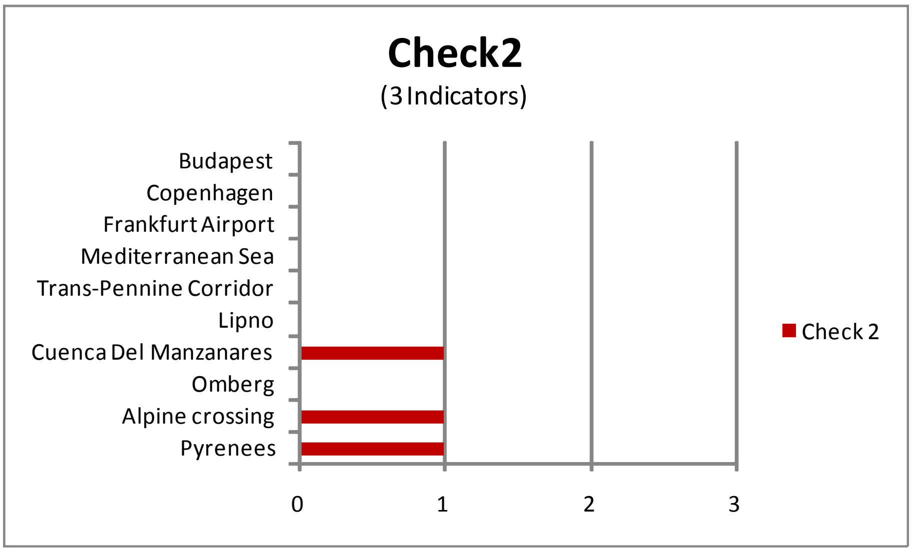



**Figure 5: Check 2 indicators usage**

It is worth mentioning that the indicator set allows for a classification of the sensitivity of case study areas according to the different transport related pressures considered, i.e. Noise TSA, Air Pollution TSA, Transport Infrastructure TSA and Accident TSA (like is made in the case of the Alpine Crossing case study, where specific maps have been developed identifying TSA according to the results of the application of the combination of indicators corresponding to each transport impact that is shown in the table above), being this an objective of the ASSET methodological approach.

This is not the case for the classification according to the reason for the higher vulnerability of endpoint. While it is possible to identify areas whose higher vulnerability is due to a high population exposure (Population Density indicator), the presence of a sensitive ecosystem (Sensitive Ecosystem indicator), the high touristic and recreational value (Touristic and recreational value indicator) or the presence o unique natural resources or cultural heritage (Sensitive Ecosystems + Cultural Heritage indicators), it fails in the assessment of areas with high preload levels (will be further explained below). This issue may be of relevance since the presence of high preload levels indicated that the damage is already being produced, while the higher vulnerability of endpoints, being very important, is limited to the identification of areas where the damage would be more severe, in case it occurs. Therefore, areas with high preload levels may sometimes be an indication for prioritizing action, i.e., for the identification of Policy Relevant TSA, where extraordinary policy action is required.

## 2.3 Relevant Transport Activities

A complete description of case study areas requires the consideration of the relevant transport activities that take place within the areas considered in each of them.

According to D1 the ASSET approach considers the following modes:

- Road
- Rail
- Water (marine and inland)
- Air

The analysis of Case Studies reveal that most of them focus on road transport, which is considered in 8 of the 10 case studies, while railway transport activity is only considered in 3 of them. Sea transport is considered in the Mediterranean Sea case study and Air transport is only considered in the Frankfurt Airport case study.

| Nº | Case Study | Transport Activity | | | |
|---|---|---|---|---|---|
| | | Road | Rail | Air | Sea |
| 1 | Pyrenees | ✓ | ✓ | | |
| 2 | Alpine crossing | ✓ | ✓ | | |
| 3 | Omberg | ✓ | | | |
| 4 | Cuenca Del Manzanares | ✓ | | | |
| 5 | Lipno | ✓ | | | |
| 6 | Trans-Pennine Corridor | ✓ | | | |
| 7 | Mediterranean Sea | | | | ✓ |
| 8 | Frankfurt Airport | | | ✓ | |
| 9 | Copenhagen | ✓ | | | |
| 10 | Budapest | ✓ | ✓ | | |

**Table 5: Main transport activity in Case Studies area**

It can be concluded that ASSET Case Studies mostly follow a mono-modal approach. This is especially true if we consider that, among the three (out of ten) case studies that consider two modes (road and rail), only one of them estimate environmental and health burdens derived from railway transport (Alpine Crossing). A main reason for this restriction are the availability of data and models. As model development was not part of the research aims of ASSET, the case studies made use of existing resources.

This issue has several implications in the development and assessment of Case Studies:

- The most obvious implication is that impacts derived from other modes are not accounted in the evaluation, and modal shift results are not always analysed.
- One the other hand, a multi-modal approach allows testing combinations of push and pull measures, where restrictive measures to the main mode are accompanied by incentive measures for alternative modes, although there are also good examples in the case studies..

Both mountain area case studies (Pyrenees and Alpine Crossing) focus mainly on freight transport, due to the high transit volumes. The Mediterranean Sea case study also focuses on freight. On the contrary, Manzanares, Frankfurt and Budapest case studies only deal with passenger traffic. The rest of case studies consider both passenger and freight transport. As we will see below, in these cases, policy action relies on overall traffic volumes, affecting both transport sectors at the time.

| Nº | Case Study | Transport Sector | |
|---|---|---|---|
| | | Passenger | Freight |
| 1 | Pyrenees | | ✓ |
| 2 | Alpine crossing | | ✓ |
| 3 | Omberg | ✓ | ✓ |
| 4 | Cuenca Del Manzanares | ✓ | |
| 5 | Lipno | ✓ | ✓ |
| 6 | Trans-Pennine Corridor | ✓ | ✓ |
| 7 | Mediterranean Sea | | ✓ |
| 8 | Frankfurt Airport | ✓ | |
| 9 | Copenhagen | ✓ | ✓ |
| 10 | Budapest | ✓ | |

**Table 6: Transport sector considered in Case Studies**

Differences in area size, together with the different scopes in terms of transport modes and sector, are the reason behind the different consideration of relevant transport activities between case studies:

- Larger case studies like the Pyrenees and the Alpine Crossing consider traffic volumes on the main trunk routes (motorways, highways and main rail corridors). Opposite is the case of the urban case studies (Copenhagen and Budapest), which include traffic volumes at street level. In between both poles, the rest of the case studies include traffic volumes in both large interurban corridors and rural/local roads.
- Freight oriented case studies focus on tonnage which is later on converted into vehicle throughput by means of load factors in order to proceed with the environmental and economic assessment.
- While most of the case studies deal with daily average traffic, The Trans-Pennine Corridor case studies only focuses on peak hour traffic.

Overall there is no differential treatment for long and short distance traffic, even though this may be a relevant issue for the further application of the ASSET methodology, especially at the EU level, where TSA may be affected by long distance traffic volumes whose origin and destination is outside the borders of the corresponding country. This is especially true for mountain areas (where an implicit distinction is made by limiting the study to traffic flows on main roads), whose relevance is somehow associated to it frequent character as natural borders between countries, as it can be inferred from the transnational scope of the Pyrenees and Alps case studies. This may also be the case for other area types within countries or regions, where the distinction should be made between national or regional/local traffic volumes.

## 2.4 Definition of Indicators

The ASSET methodological approach is a four step process in which the above referred double check is used for the identification of Transport Sensitive Areas (TSA). In a final step, the presence of actual or planned damaging traffic volumes in a TSA is used as the criteria for the identification of those TSAs, that are policy relevant. These require the application of extraordinary policy measures should be applied. In this regard, there are not defined thresholds for damaging traffic volumes, which are very context dependent. Nevertheless, the use of the Air Quality Management Areas (AQMAs) concept by the Trans-Pennine case study (defining areas where policy action is conditioned to the observance of certain concentration thresholds for air pollution) points out at the possibility of using a similar approach in order to identify damaging traffic volumes. This would require the solely accounting of traffic related impacts (e.g. isolation transport related emission form pollutant emissions from other sources)

The backbone of this methodological approach is the indicator set and their corresponding thresholds developed within ASSET's Work Package 2 (see table 4).

It was said that the aim of the Case Studies was to test the suitability of these indicators and thresholds on different scales and under different context conditions. What follows is a specific analysis of the usage of Check 1 and Check 2 indicators in the case studies.

### 2.4.1 Check 1: Higher vulnerability of endpoints

In this section the use of Check 1 indicators is assessed. The following table summarizes the ASSET indicators used in each case study:

| Nº | Case Study | Check 1 Indicators | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Population Density | Sensitive Ecosystems | Cultural Heritage | Touristic and recreational value | Connectivity index | Tunnels | Pollution of ground water |
| 1 | Pyrenees | ✓ | ✓ | ✓ | | | ✓ | |
| 2 | Alpine crossing | ✓ | ✓ | | ✓ | ✓ | | |
| 3 | Omberg | ✓ | ✓ | ✓ | ✓ | | ✓ | |
| 4 | Cuenca Del Manzanares | | ✓ | | | | | |
| 6 | Trans-Pennine Corridor | ✓ | ✓ | ✓ | | | | |
| 7 | Mediterranean Sea | | ✓ | | | | | |
| 8 | Frankfurt Airport | ✓ | ✓ | ✓ | ✓ | | | |
| 9 | Copenhagen | ✓ | | | | | | |
| 10 | Budapest | ✓ | | | | | | |

**Table 7: Check 1 indicators usage**

Considering only the indicators not used in each case study, the following table summarises the reasons for it:

| Nº | Case Study | Check 1 Indicators | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Population Density | Sensitive Ecosystems | Cultural Heritage | Touristic and recreational value | Connectivity index | Tunnels | Pollution of ground water |
| 1 | Pyrenees | | | | Lack of data | Lack of data | | Lack of data |
| 2 | Alpine crossing | | | Lack of data | | | | Lack of data |
| 3 | Omberg | | | | | Lack of data | | Lack of data |
| 4 | Cuenca Del Manzanares | Not relevant | | Not relevant | Not relevant | Not relevant | Not relevant | Not relevant |
| 6 | Trans-Pennine Corridor | | | | Lack of data | Lack of data | Lack of data | Lack of data |
| 9 | Copenhagen | | Unsuitable | Unsuitable | Unsuitable | Unsuitable | Unsuitable | Unsuitable |

**Table 8: Reasons for not using Check 1 indicators**

Several case studies proposed amendments to the definition of some of these indicators. the following is a list of the amendments proposed, that will be further discussed in the next chapter:

- Sensitive ecosystems: inclusion of national/regional protection figures. This was discussed in ASSET D2, but it was also proposed by several case studies (Omberg, Trans-Pennine) based on the presence in the corresponding case study areas of areas of outstanding natural value which are protected under national/regional protection figures but are not part of Natura 2000 network.
- Cultural heritage: inclusion of national/regional protection figures. Like the above one, this amendment was made by several case studies (Omberg, Trans-Pennine) based on the presence in the corresponding case study areas of areas of outstanding cultural and heritage value which are protected under national/regional protection figures but are not part of UNESCO network
- Touristic and recreational value: proposal ranges from the use of national/regional designated areas (Trans-Pennine) to the use of other indicators related to the number of tourists, like the number of day visits to controlled Nature Parks, the number of vehicles entering a certain zone, etc. (Pyrenees, Omberg, Trans-Pennine). The main reasons for this amendment are the lack of data on overnight stays and the importance of day visits in many of the analyzed areas.

Also the use of complementary indicators for the identification of Sensitive Areas was proposed (see Table 9):

- Degree of Naturalness: this indicator is proposed by Manzanares case study in order to assess the relative value of the species present in an area in terms of rarity-biodiversity, the degree of conservation of the habitat, etc. That is to say, an assessment of all the benefits that the ecosystem is actually and potentially providing to the local community and the society as a whole
- Number of species of fauna in the area of study: this indicator was proposed by Manzanares case study in order to complement the Sensitive Ecosystem indicator. They were already discussed in ASSET D2 when assessing Barrier Effect (Infrastructure related impact). In particular, the need to measure the number of species with extensive land need in each area was pointed out to properly assess the potential impacts caused by a new infrastructure. But data needs were found far beyond the study scope and therefore the degree of protection was appointed as a proxy in this regard

- Distribution of Land (Lipno): proportion of different kinds of land and their use reflect natural conditions, number and occurrence of certain animal and plant species, as well as in the general ecological and economical situation of an area. High proportion of agricultural farm land may influence the quality of waters and it may induce threatening of soils by erosion (ploughing); on the other hand, proportion of forests and water surfaces may increase the attractiveness of an area for recreation, implicating all the related aspects of tourism, positive as well as negative. The structure of land utilization also indicates the social and economical characteristics of an area and the potential of its utilization in future.
- Hydrological conditions (Lipno): hydrological conditions co-determine some features of a given area. They are reflected in its natural conditions, influencing e.g. the occurrence and quantity of certain biocenosis[1] and the potential of an area to be used by water-demanding industries. The difference between the inflow and outflow after floods is a very significant predicative indicator of an area retention capacity (capacity to retain water in the country).
- Number of settlement units (Lipno): the number of settlement units in an area, or their size, is connected with many other elements pertaining to the given areas, whether it is a certain level of human impacts on nature, forming of landscape, ensuring of other needs such as construction of roads, or the agricultural or industrial activities. Relationships can be found also with population density, employment rate and other socio-economic factors.
- Tourist paths (Lipno): generally, the presence of tourist paths and cycle paths is a positive phenomenon. In part, it is expected, that they will – in a way – preserve entering places, where some damage to the nature could be evoked, however they also offer people a chance to spend their free time in a "sustainable" manner. Less importantly, cycle and tourist paths also open alternative ways of transport from one place to another. This can be used as a proxy for the touristic and recreational value of an area.
- Bed capacity of accommodation facilities (Lipno): the number of beds represents the number of all beds that serve guests to retire during the night. It is also possible to regard the number of spaces available in the open space, which equals to the number of places for tents and caravans multiplied by four. The net use of beds reflects the number of beds that are actually available to guests. This can also be used as a proxy for the touristic and recreational value of an area.
- Number of temporary residents (Lipno): the number of temporary residents indicates the volume of tourists, but also that of potential seasonal labor force. Proportion of temporary residents to total population should not be liable to great seasonal fluctuations. These fluctuations might result in overloading of the environment or in economic and social instability of an area.
- Ecological footprint of an area (Lipno): this indicator enables to assess, whether the demans of an area with respect to natural resources exceeds its biological potential. A simple result expressed in the form of an area can be easily seized and understood and can be communicated also to the general public.
- Number of residents/employees, age, and gender along roads: Copenhagen case study revealed that, at a high level of detail, more than the population density is relevant, the interest is in the number of residents/employees, age, and gender along roads. In addition to a residential population database, this would require a dataset including the location of workplaces and the number of employees in each of them

[1] Biocenosis could be defined as a group of interacting organisms that live in a particular habitat and form a self-regulating ecological community.

- Number of elderly (65+) and children (-14) along roads (Copenhagen): this indicator is used to identify more vulnerable individual that may be affected by air pollution to a greater extent. In addition to the analysis of the residential database, this indicator also requires a workplace database which allows for the localization of sensitive land-use functions (nurseries, kindergartens, hospitals, etc.) and the number of visitors in each of them.
- Concentrations levels ($NO_2$, $PM_{10}$ and $PM_{2.5}$) (Copenhagen): high concentration levels of air pollution indicate that streets may be close to exceed a EU Air Quality limit values and hence increased traffic or otherwise increase in emissions poses a risk for exceedances of the limit values. As there are potential problem with exceedances of $NO_2$ and $PM_{10}$ limit values the street concentrations of these pollutants have been chosen as indicators. The EU air quality limit for $NO_2$is 40 µg/$m^3$ in 2010. The EU air quality limit value for $PM_{10}$ is also 40 µg/ $m^3$ but has to be met in 2005. The new EU Air Quality directive required to reduce exposure to $PM_{2.5}$ in urban areas by an average of 20% by 2020 based on 2010 levels. It obliges them to bring exposure levels below 20 micrograms/ $m^3$ by 2015 in these areas.
- Street Canyons (Copenhagen): this indicator is intended to assess the urban topography and it correlates building height/street width and concentrations/exceedances. The idea is to identify urban areas and in particularly busy streets that are street canyons with high population density and/or especially high density of vulnerable populations group based on the indicators listed above.
- Health Risk: statistical loss of life expectancy for 1x1 km2 grid (Copenhagen): this is a relevant indicator which was already discussed in WP2. It is a health risk indicator that may be calculated based on $PM_{2.5}$ levels and dose-response relationships

Being this a mere description of the proposals made by Case Studies, the suitability of these indicators will be further discussed in the following section of this report. It is worth mentioning that several of the indicators mentioned above were already discussed in ASSET D2.

As for the transport related effects that can be assessed with each of them, it is as follows:

| | Noise | Air pollution | Infrastructure | Accidents |
|---|---|---|---|---|
| Degree of Naturalness | ✓ | ✓ | ✓ | ✓ |
| Number of species of fauna in the area of study | | | ✓ | |
| Distribution of Land | ✓ | ✓ | ✓ | |
| Hydrological conditions | | | | ✓ |
| Number of settlement units | ✓ | ✓ | ✓ | ✓ |
| Tourists paths | ✓ | ✓ | ✓ | |
| Bed capacity of accommodation facilities | ✓ | ✓ | ✓ | |
| Number of temporary residents | ✓ | ✓ | ✓ | ✓ |
| Ecological footprint of an area | ✓ | ✓ | ✓ | |
| Number of residents/employees, age, and gender along roads | ✓ | ✓ | | |
| Number of elderly (65+) and children (-14) along roads | ✓ | ✓ | | |
| Concentrations levels (NO2, PM10 and | | ✓ | | |

| | Noise | Air pollution | Infrastructure | Accidents |
|---|---|---|---|---|
| **PM2.5** | | | | |
| **Street Canyons** | | ✓ | | |
| **Health Risk** | ✓ | ✓ | | |

**Table 9: Transport effects assessed by new proposed indicators**

To highlight the indicators proposed by Copenhagen which revealed a promising way to approach the identification of Air Pollution TSA.

Population density and Sensitive Ecosystems are the most frequently used indicators, followed by Touristic and Recreational Value and Cultural Heritage. Tunnels and Connectivity Index are vaguely used. Even though there are references to it in some case studies (Omberg), there is no evidence of the use of the Pollution of Ground Water indicator.

## Analysis of Check 1 according to transport related effects

If we analyze the application of the Check 1 indicators for each transport effect considered separately, the following results emerge:

### *Noise*

| Nº | Case Study | Check 1 – Noise Indicators and Relevance | | | |
|---|---|---|---|---|---|
| | | **Population Density** | **Sensitive Ecosystems** | **Cultural Heritage** | **Touristic and recreational value** |
| | | High Relevance | Medium Relevance | High Relevance | High Relevance |
| | | 90-percentile | Yes/No | Yes/No | 90-percentile of overnight stays |
| 1 | Pyrenees | ✓ | ✓ | ✓ | |
| 2 | Alpine crossing | ✓ | ✓ | | ✓ |
| 3 | Omberg | ✓ | ✓ | ✓ | ✓ |
| 4 | Cuenca Del Manzanares | | ✓ | | |
| 5 | Lipno | | | | |
| 6 | Trans-Pennine Corridor | ✓ | ✓ | ✓ | |
| 7 | Mediterranean Sea | | | | |
| 8 | Frankfurt Airport | ✓ | ✓ | ✓ | |
| 9 | Copenhagen | ✓ | | | |
| 10 | Budapest | ✓ | | | |

**Table 10: Check 1 noise indicators usage**

The indicators population density and sensitive ecosystems were applied in the majority of the case studies where noise is a relevant issue. Fewer than half of the case studies applied cultural heritage and only two touristic and recreational value, mainly due to a lack of data.

There are case studies that only account for one relevant indicator for the assessment of noise impacts (Copenhagen and Budapest) while others like the Manzanares case study only used a medium relevance indicator for this transport related pressure.

From the above table it can be inferred that the proposed indicators set is more adequate for strategic scale case studies (Pyrenees, Alps, Omberg…). In line with this, it is especially significant that urban case studies do not seem to find the indicator set proposed suitable for the assessment of sensitiveness to noise.

## *Air Pollution*

| Nº | Case Study | Check 1 – Air Pollution Indicators and Relevance | | | |
|---|---|---|---|---|---|
| | | Population Density | Sensitive Ecosystems | Cultural Heritage | Touristic and recreational value |
| | | Very High Relevance | Medium Relevance | Medium Relevance | Low Relevance |
| | | 90-percentile | Yes/No | Yes/No | 90-percentile of overnight stays |
| 1 | Pyrenees | ✓ | ✓ | ✓ | |
| 2 | Alpine crossing | ✓ | ✓ | | ✓ |
| 3 | Omberg | ✓ | ✓ | ✓ | ✓ |
| 4 | Cuenca Del Manzanares | | ✓ | | |
| 5 | Lipno | | | | |
| 6 | Trans-Pennine Corridor | ✓ | ✓ | ✓ | |
| 7 | Mediterranean Sea | | ✓ | | |
| 8 | Frankfurt Airport | ✓ | ✓ | ✓ | |
| 9 | Copenhagen | ✓ | | | |
| 10 | Budapest | ✓ | | | |

**Table 11: Check 1 air pollution indicators usage**

Similar to the case of noise, population density and sensitive ecosystems are the most used indicators for air pollution, whereas cultural heritage was used on several case studies and touristic and recreational value was scarcely used.

The use of the Population Density indicator for the assessment of air pollution is dominant, being of a very high relevance. Accordingly, almost every case study makes use of it, with the only exception of Manzanares case study.

The assessment of air pollution also reveals the lower suitability of the indicator set for large scale case studies, in particular in urban areas. Nevertheless, the importance of this is low if we consider that the most relevant indicator is used in most case studies. Also the problems encountered in many case studies for the application of the Touristic and Recreational Value indicator are limited by the low relevance of this indicator in assessing the air pollution effect.

## *Transport Infrastructure*

| Nº | Case Study | Check 1 – Transport Infrastructure Indicators and Relevance | | | | |
|---|---|---|---|---|---|---|
| | | Population Density | Sensitive Ecosystems | Cultural Heritage | Touristic and recreational value | Connectivity Index |
| | | Medium-Low Relevance | Very High Relevance | Very High Relevance | Medium Relevance | High Relevance |
| | | 90-percentile | Yes/No | Yes/No | 90-percentile of overnight stays | Average within Natura 2000 sites |
| 1 | Pyrenees | ✓ | ✓ | ✓ | | |
| 2 | Alpine crossing | ✓ | ✓ | | ✓ | ✓ |
| 3 | Omberg | ✓ | ✓ | ✓ | ✓ | |
| 4 | Cuenca Del Manzanares | | ✓ | | | |
| 5 | Lipno | | | | | |
| 6 | Trans-Pennine Corridor | ✓ | ✓ | ✓ | | |
| 7 | Mediterranean Sea | | | | | |
| 8 | Frankfurt Airport | ✓ | ✓ | ✓ | | |
| 9 | Copenhagen | ✓ | | | | |
| 10 | Budapest | ✓ | | | | |

**Table 12: Check 1 infrastructure indicators usage**

Again, population density and sensitive ecosystems were widespread used, followed by cultural heritage indicator. The connectivity indicator was just taken into account by one case study, due to its complexity calculation. Data availability for the usage of touristic and recreational value was found to be scarce.

In addition to the already mentioned finding concerning the higher suitability of the proposed set of indicators to low scale study areas, to highlight that in the assessment of transport infrastructure related pressures there is a high relevance of indicators poorly (Cultural Heritage) or even scarcely (Connectivity Index) used indicators

### *Accidents*

| Nº | Case Study | Check 1 – Accidents Indicators and Relevance | | | | |
|---|---|---|---|---|---|---|
| | | Population Density | Sensitive Ecosystems | Cultural Heritage | Road Tunnels | Pollution of Ground Water |
| | | Low Relevance | High Relevance | Low Relevance | Low Relevance | High Relevance |
| | | 90-percentile | Yes/No | Yes/No | **500m length** | Yes/No |
| 1 | Pyrenees | ✓ | ✓ | ✓ | ✓ | |
| 2 | Alpine crossing | ✓ | ✓ | | | |
| 3 | Omberg | ✓ | ✓ | ✓ | ✓ | |
| 4 | Cuenca Del Manzanares | | ✓ | | | |
| 5 | Lipno | | | | | |
| 6 | Trans-Pennine Corridor | ✓ | ✓ | ✓ | | |
| 7 | Mediterranean Sea | | ✓ | | | |
| 8 | Frankfurt Airport | ✓ | ✓ | ✓ | | |
| 9 | Copenhagen | ✓ | | | | |
| 10 | Budapest | ✓ | | | | |

**Table 13: Check 1 accidents indicators usage**

Similar indicators usage patterns than described above are found here. Associated to this transport related pressure there is a high relevance indicator that is not used by any case study (Pollution of Ground Water) due to data availability..

## Analysis of Check 1 according to area type

Following is an analysis of Check 1 in each of the four area types considered within ASSET:

### *Mountain areas*

| Nº | Case Study | Check 1 Indicators | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Population Density | Sensitive Ecosystems | Cultural Heritage | Touristic and recreational value | Connectivity index | Tunnels | Pollution of ground water |
| 1 | Pyrenees | ✓ | ✓ | ✓ | | | ✓ | |
| 2 | Alpine crossing | ✓ | ✓ | | ✓ | ✓ | | |

**Table 14: Check 1 indicators usage in mountain areas**

Pollution of ground water is the only indicator that has not been found suitable by any of the mountainous case studies due to data problems. Connectivity index presented also problems due to its complexity, as it is difficult to calculate individually for each case study.

### *Unique natural resources and cultural heritages*

| Nº | Case Study | Check 1 Indicators | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Population Density | Sensitive Ecosystems | Cultural Heritage | Touristic and recreational value | Connectivity index | Tunnels | Pollution of ground water |
| 3 | Omberg | ✓ | ✓ | ✓ | ✓ | | ✓ | |
| 4 | Cuenca Del Manzanares | | ✓ | | | | | |

**Table 15: Check 1 indicators usage in unique natural areas**

The fact that the Manzanares case study only assessed the most suitable indicator (even though all of them were reviewed) makes the analysis difficult. While average numbers may indicate a low suitability of Check 1 indicators in unique natural resources and cultural heritage areas, the Omberg case study reveal a high suitability of these indicators (5 indicators used of the 7 proposed).

### *Marine*

The Mediterranean sea is already considered a sensitive area by the MARPOL convention, therefore this case study considered the Mediterranean Sea as a sensitive area as a whole.

The ecosystem of the Mediterranean Sea is considered sensitive to air pollution and marine pollution due to accidents.

### *Agglomeration*

| Nº | Case Study | Check 1 Indicators | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Population Density | Sensitive Ecosystems | Cultural Heritage | Touristic and recreational value | Connectivity index | Tunnels | Pollution of ground water |
| 6 | Trans-Pennine Corridor | ✓ | ✓ | ✓ | | | | |
| 8 | Frankfurt Airport | ✓ | ✓ | ✓ | | | | |
| 9 | Copenhagen | ✓ | | | | | | |
| 10 | Budapest | ✓ | | | | | | |

**Table 16: Check 1 indicators usage in agglomeration areas**

Urban case studies reveal a lower level of suitability of Check 1 indicators: 2 out of 5 possible indicators used, which represents less than half of the proposed set of indicators. There are 4 indicators that have not been found suitable by any of the urban case studies.

### 2.4.2 Check 2: Higher transport related pressures

According to ASSET D2 (Lieb et al. 2008), Transport Affected Areas are defined as these areas where the actual or potential presence of a transport route leads to particularly high pressures.

The following table summarizes the ASSET indicators used in Check 2 for the identification of TAA in each case study:

| Nº | Case Study | Check 2 Indicators | | |
|---|---|---|---|---|
| | | Topography | Wind Speed | Temperature |
| 1 | Pyrenees | ✓ | | |
| 2 | Alpine crossing | ✓ | | |
| 3 | Omberg | | | |
| 4 | Cuenca Del Manzanares | ✓ | | |
| 5 | Lipno | | | |
| 6 | Trans-Pennine Corridor | | | |
| 7 | Mediterranean Sea | | | |
| 8 | Frankfurt Airport | | | |
| 9 | Copenhagen | | | |
| 10 | Budapest | | | |

**Table 17: Check 2 indicators usage**

Compared to Check 1, ASSET indicators in Check 2 are scarcely used. As a consequence there are several Case Studies that were unable to carry out the identification of TAA. The main reasons provided for not using the proposed indicators are:

- Unsuitability of the proposed indicator or thresholds
- Lack of data

Unlike Check 1, there were no new indicators proposed for Check 2. Amendments to the proposed indicators were not made either.

According to its usage it seems that the Topography indicator is the only suitable indicator of Check 2, which mostly fits in mountain areas where this indicator is useful to identify areas where the inversion effect may occur. The Copenhagen CS proposed a new indicator in line with the Topography indicator, but adapted to the urban context. The Urban Topography indicator is aimed at identifying Street Canyons where dispersion is restricted, leading to higher concentrations of pollutants. Streets can be characterized as street canyons depending on building height divided by street width (H/W).

## *2.5 Definition of Thresholds*

In this section the application and suitability of the thresholds associated to the above indicators will be assessed.

Taking into consideration only those indicators that were actually used in any of the two Checks, the following table highlights those case studies where the ASSET proposed thresholds were found suitable:

| № | Case Study | Check 1 | | | | | | Check 2 |
|---|---|---|---|---|---|---|---|---|
| | | Population Density | Sensitive Ecosystems | Cultural Heritage | Touristic and recreational value | Connectivity index | Tunnels | Topography (*) |
| 1 | Pyrenees | ✓ | ✓ | ✓ | | | ✓ | ✓ |
| 2 | Alpine crossing | ✓ | ✓ | | ✓ | ✓ | | ✓ |
| 3 | Omberg | ✓ | ✓ | ✓ | ✓ | | ✓ | |
| 4 | Cuenca Del Manzanares | | ✓ | | | | | ✓ |
| 5 | Lipno | | | | | | | |
| 6 | Mediterranean Sea | | ✓ | | | | | |
| 7 | Trans-Pennine Corridor | ✓ | ✓ | ✓ | | | | |
| 8 | Frankfurt Airport | ✓ | ✓ | ✓ | ✓ | | | |
| 9 | Copenhagen | ✓ | | | | | | |
| 10 | Budapest | ✓ | | | | | | |

*ASSET threshold used*

**Table 18: Thresholds usage**

The application of Check 1 and Check 2 totals 26 applications of 7 of the 10 indicators proposed by ASSET. But only in4 of these indicators the ASSET proposed threshold have been found suitable (accounting for 6 applications in total). To highlight that 5 case studies didn't find any of the proposed thresholds suitable at all. Again, this holds true especially for high scale case studies.

The following table summarizes the reasons for unsuitability and the amendments made for those indicators were the proposed thresholds were found unsuitable:

| № | Case Study | ASSET thresholds – reasons for unsuitability and amendments | | | |
|---|---|---|---|---|---|
| | | Indicator | Proposed Threshold | Reason for Unsuitability | Amendment |
| 1 | Pyrenees | Population Density | 90-percentile (Europe) | The indicator would not be relevant, since the population density in the Pyrenean region is low compared to the main conurbations in Europe | 90-percentile of the case study area |
| | | Topography | 400m altitude difference in 1 km | Amphitheater effect has been acknowledge in valleys within the case study area where differences in altitude are below 400m | |
| 2 | Alpine crossing | Population Density | 90-percentile (Europe) | No maps for thresholds developed in WP3 | - |
| | | Sensitive Ecosystems | Yes/No (Natura 2000) | | |
| | | Touristic and recreational value | 90-percentile (overnight stays/km$^2$) | | |
| | | Connectivity index | Average within Natura 200 sites | | |
| 3 | Omberg | Population Density | 90-percentile (Europe) | Little relevance | - |
| | | Sensitive Ecosystems | Yes/No (Natura 2000) | The area comprises several nature reserves pointed out by the Swedish Government | Expanded to national figures of protections as well |
| | | Cultural Heritage | Yes/No (UNESCO) | | |

| Nº | Case Study | ASSET thresholds – reasons for unsuitability and amendments | | | |
|---|---|---|---|---|---|
| | | **Indicator** | **Proposed Threshold** | **Reason for Unsuitability** | **Amendment** |
| | | | | as being of national interest for the purposes of nature conservation, conservation of the cultural environment and outdoor recreation | |
| | | Touristic and recreational value | 90-percentile (overnight stays/km²) | Little relevance due to the high number of day visits | - |
| 6 | Trans-Pennine Corridor | Population Density | 90-percentile (Europe) | Too arbitrary varies with region size | Air Quality Management Areas (Yes/No) |
| | | Sensitive Ecosystems | Yes/No (Natura 2000) | There are sites under environmental protection in the UK which are not listed by Natura 2000 | Expanded to national figures of protections as well |
| | | Cultural Heritage | Yes/No (UNESCO) | There are sites under cultural/heritage protection in the UK which are not listed by UNESCO | Expanded to national figures of protections as well |
| 8 | Frankfurt Airport | Population Density | 90-percentile (Europe) | Too arbitrary | - |
| | | Sensitive Ecosystems | Yes/No (Natura 2000) | There are sites under environmental protection in Germany which are not listed by Natura 2000 | Expanded to national figures of protections as well |
| | | Cultural Heritage | Yes/No (UNESCO) | There are sites under cultural/heritage protection in Germany which are not listed by UNESCO | Expanded to national figures of protections as well |
| | | Touristic and recreational value | 90-percentile (overnight stays/km²) | Overlaps with the population density. Also this phenomenon can be covered by the indicators already applied for sensitive ecosystems and cultural heritage sites which usually also attract a high number of visitors, in particular the National Parks. | - |
| 9 | Copenhagen | Population Density | 90-percentile (Europe) | Too crude | Focus on distribution of data instead of "cutoff" values. E.g. an exposure distribution (population times concentrations) |
| 10 | Budapest | Population Density | 90-percentile (Europe) | Too low threshold for a city like Budapest | 65-percentile of the case study area |

**Table 19: Reasons for unsuitability of thresholds and amendments**

As for the above referred proposals for new indicators, there are no suggestions on the thresholds to be used for with each of them. This will be discussed in the following sections of this report, along with the suitability of the indicators proposed.

## 2.6 Scale and Space

The relevance of the indicators is conditioned to a high extent by the geographical scale used for the analysis. A good example illustrating this issue is related to the application of the Population Density indicator in the Trans-Pennine Corridor case study: in this case the population densities were calculated based on data of the 2001 Census for output areas (OAs), the smallest statistical unit in England with at least 100 residents and 40 households (ONS, 2007). On OA level, population densities vary between 2 and 90,000 residents/km2 with a median value of 4,560. The 90-percentile value is 8,970. However, when applying the 90-percentile rule to higher levels of administrative regions, the threshold drops to 4,625 for wards and 2,230 for counties. It was concluded that the 90-percentile population density indicator was too arbitrary and its use dismissed for the identification of SA in favor of the UK definition of AQMAs instead.

As regards of the geographical scale, the spatial resolution of case studies varies from 10x10km grid to the street and address level in towns as given in the following table:

| Nº | Case Study | Spatial Resolution | | |
|---|---|---|---|---|
| | | Grid Pattern | | Administrative Units |
| | | Max. | Min. | |
| 1 | Pyrenees | 1 x 1 km | 1 x 1 km | Municipalities and Communes |
| 2 | Alpine crossing | | | |
| 3 | Omberg | | | |
| 4 | Cuenca Del Manzanares | 0,1 x 0,1 km | 0,1 x 0,1 km | Municipalities |
| 5 | Lipno | 1 x 1 km | 1 x 1 m | Town area |
| 6 | Trans-Pennine Corridor | | | Output areas |
| 7 | Mediterranean Sea | | | |
| 8 | Frankfurt Airport | 10 x 10 km | 10 x 10 km | |
| 9 | Copenhagen | | | Street |
| 10 | Budapest | 1 x 1 km | 1 x 1 km | Town area |

**Table 20: Spatial Resolution used in Case Studies**

Indicators and thresholds need to be adapted to the required spatial resolution. For example, large mountain areas require a low scale for the analysis. Adequate indicators and thresholds are needed in order to identify significant ‘quasi homogenous areas’ where the design and application of extraordinary policy measures is much easier to conceive. Otherwise the result would be a patchwork of sensitive and non-sensitive areas unsuitable for the kind of assessment that ASSET proposes. The use of adequate indicators and thresholds means that local features such as small natural monuments, ponds or villages may not be taken into account when low scale/big areas analysis is undertaken. This rough assessment is not suitable for high scale case studies, where a higher level of accuracy is required.

Another issue related to geographical scale, are so called buffer zones, which have been used in several case studies. The width of the defined buffer zones is correlated to the area zone being assessed and the scale used in each case, and differs according to the different indicators. For example, while the Manzanares case study defines a 3 km buffer around the park as influence area in order to take into account the impact of transport activities around the park, in Copenhagen a buffer zone of 100m along streets (50m on each side) was used to select addresses in buildings along roads to link population data to the respective road. Several case studies pointed out the convenience of defining buffer zones around heritage sites, which use to be very small for inclusion at the scale used. The Pyrenees case study lay out a buffer zone of 1000m around the UNESCO world heritage site present in the case study area. For other point sites such as listed buildings, they suggest that a high concentration of them in a particular region could indicate a relevance as TSA. The Frankfurt case study agrees on the need to establish buffer zones around heritage sites but finds it difficult to define a fix parameter for its extent, which is found dependent on the particular context of each area.

## 2.7 Environmental and Health Burdens

As part of the analysis of policy instruments, the reduction of environmental and health burdens have been quantified in the case studies to a varying degree, driven mainly by the availability of models and tools. The following table summarizes the environmental and heath burdens calculated in each case study for the four main types of pressures used to identify TSAs:

| № | Case Study | Transport Effect | | | |
|---|---|---|---|---|---|
| | | Noise | Air Pollution | Infrastructure | Accidents |
| 1 | Pyrenees | ✓ | ✓ | | |
| 2 | Alpine crossing | ✓ | ✓ | | ✓ |
| 3 | Omberg | ✓ | ✓ | | ✓ |
| 4 | Cuenca Del Manzanares | ✓ | ✓ | | |
| 5 | Lipno | | ✓ | | |
| 6 | Trans-Pennine Corridor | ✓ | ✓ | | ✓ |
| 7 | Mediterranean Sea | | ✓ | | |
| 8 | Frankfurt Airport | ✓ | ✓ | | |
| 9 | Copenhagen | | ✓ | | |
| 10 | Budapest | ✓ | ✓ | | ✓ |

**Table 21: Transport Effects assessed in Case Studies**

All case studies measure air pollution (although not always the same pollutants), even in those cases such as Omberg where air pollution is not considered the major problem in the area. In this regard, all case studies approach this burden by estimating pollutant emissions (serving as basis for the economic valuation), but Copenhagen also focuses on air quality levels in terms of pollutant concentration levels and violation of the EU limit values (only for $NO_2$ and $PM_{10}$).

Noise impact is also considered to a great extent (7 out of 10 case studies measure noise), but the approach followed for the estimation of this burden is not homogeneous among case studies.

The environmental and health burdens associated to transport in the different scenarios have been considered by four case studies, which included this effect in their estimations. Three of them (Alpine Crossing, Omberg and Trans-Peninne Corridor) conducted this assessment by means of the social costs of accidents (i.e. costs associated to deaths and severe injuries), while the Mediterranean case study also included the environmental impact of accidents (risk of accidents for hazardous goods transport as a driver for soil and water pollution.

In addition to these effects, several case studies (Pyrenees, Alpine Crossing, Omberg, Trans-Pennine Corridor, Mediterranean Sea, Copenhagen and Budapest) found it relevant to include an assessment on climate change. $CO_2$ emissions are assessed comparing aggregate national or European levels.

To highlight the Omberg case study, where the low population density and moderate traffic volumes limit the importance of health and environmental impacts. In this case the assessment focuses on the encroachment effect, which is partly captured under the Infrastructure-TSA concept, defined by land take, barrier effect and visual intrusion. There is no generally accepted explicit definition of encroachment, although the purpose is to capture the impact of infrastructure and traffic on the natural and cultural values as well as the landscape as an entirety. The economic valuation of the encroachment effect is difficult due to the heterogeneity, uniqueness and the importance of substitutes in each case. Nevertheless, the monetary valuation of this impact may be approached by the decreased value of an area where the encroachment will or might occur. This valuation is determined by summing up all the demands for compensation for all individuals affected by the change of e.g. a new road. This can be done by a method to elicit the willingness to pay (WTP) for non market goods. This is the approach followed in the Omberg case study to assess encroachment costs.

## 2.8 Economic valuation of effects

For the economic valuation of environmental and health burdens, the ASSET approach suggests the use of the HEATCO project cost factors, while the HEATCO project actually recommends using country specific values if available . Nevertheless, most case studies used HEATCO values for the cost assessment of environmental and health impacts:

| Nº | Case Study | Cost Factors | |
|---|---|---|---|
| | | HEATCO | Country Specific or Local |
| 1 | Pyrenees | ✓ | |
| 2 | Alpine crossing | | ✓ |
| 3 | Omberg | ✓ | |
| 4 | Cuenca Del Manzanares | ✓ | |
| 5 | Lipno | ✓ | |
| 6 | Trans-Pennine Corridor | ✓ | |
| 7 | Mediterranean Sea | ✓ | |
| 8 | Frankfurt Airport | ✓ | |
| 9 | Copenhagen | | ✓ |
| 10 | Budapest | ✓ | |

**Table 22: Cost factors use in Case Studies**

The application of HEATCO cost factor arouses several issues related to the use of geographically homogeneous factors:

- Pyrenees case study used average cost factors based on Spanish and French HEATCO values due to the cross-border character of the study area.
- In the Alpine Crossing case study average Swiss cost factors were increased according to the GRACE project findings which revealed how environmental costs are higher in the Alps than in the flat areas. This may apply to other mountain areas, but the Pyrenees case study was unable to consider this effect due to the lack of an specific study that could provide the corresponding increase factors for this specific study area
- Not all damage factor provided by HEATCO are sensitive to the changes in population density and in distance to the source of emission
- The Omberg case study shows that other effects arising from transport infrastructure development as land take, barrier effects and visual intrusion, i.e. the so called encroachment effect, need to be appropriately considered, implying the development of contingent valuation methods for monetary evaluation, further developing the HEATCO methodology.

It was also highlighted the anthropocentric focus of the HEATCO approach, where the damage seems to happen only if human life and health are affected, and the loss of biodiversity and damages to the natural environment are poorly considered.

As already mentioned for transport activity a comparison between case studies in terms of environmental and health impacts doesn't make sense due to the large contextual differences between them, plus the different effects considered in each case. Nevertheless, like it was made for the case of traffic volumes, expected growths in environmental and health burdens are showed in the following figure:

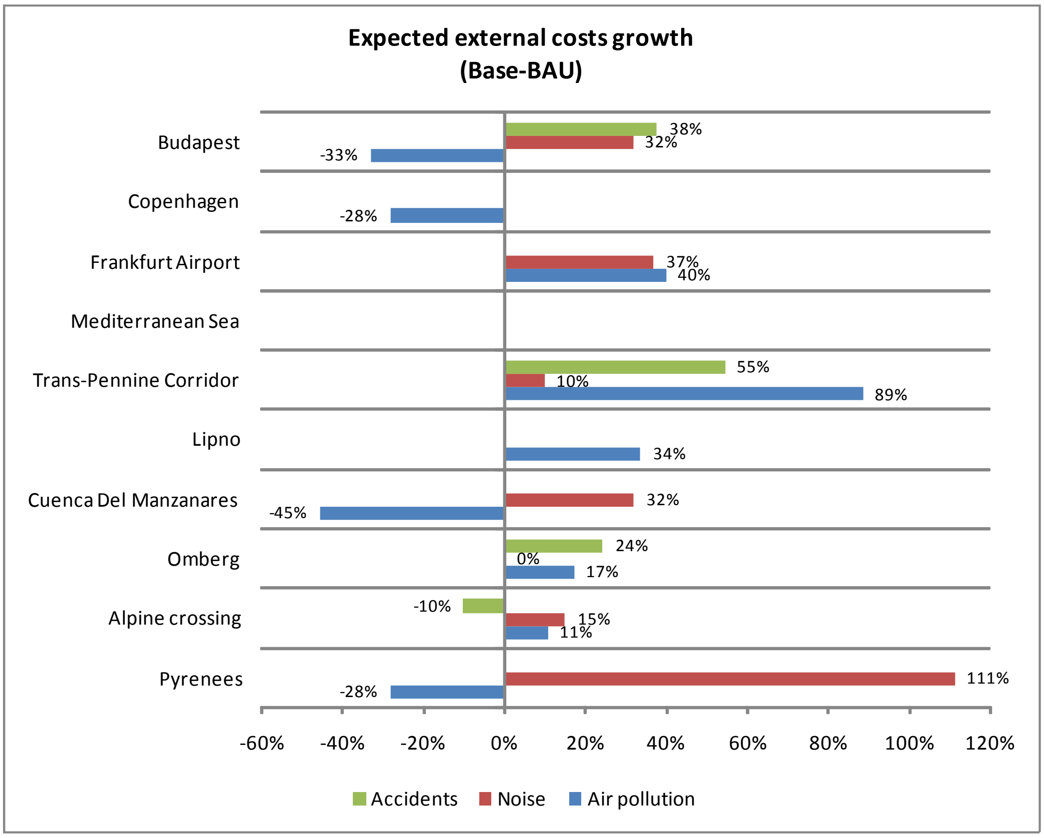



**Figure 6: Expected external costs growth (Base-BAU)**

Reductions in air pollution emissions in the BAU scenario of several case studies are due to the technological improvement of the corresponding vehicle fleets which compensates the increase in traffic volumes.

Overall, the methodology used by all case studies during the assessment of environmental and health burdens process is similar. The process encompasses the use of a modelling tool to determine traffic volumes, mileage and vehicle classes. Traffic volumes and fleet composition evolution is forecasted:

- Air pollution: emission factors for the pollutants assessed are applied to the mileage corresponding to the different vehicle classes considered. Cost factors (HEATCO or national/local equivalents) are then used in order to determine the monetary value of the air pollution impact.
- Noise: noise emissions are calculated according to the different vehicle classes and noise levels maps derived from formulae/models that calculate noise levels taking into account traffic composition and distance to the source (among other factors like speed, possible barriers,…). The population exposed to different noise levels is estimated

based on noise maps and population density. Cost factors (HEATCO or national/local equivalents) are then used in order to determine the monetary value of the noise impact.

- Accidents: accident rates and fatalities/injuries are derived from actual statistics and forecasted to the future scenario. Cost factors (HEATCO or national/local equivalents) are then used in order to determine the monetary value of the accidents impact.

The use of analogous methodological approaches allows the comparison of traffic and impacts reduction/increase trends once that the policy measures are applied. Still, within the common methodological approach, there are differences between cases which require that any comparison of results should be taken with caution. Main differences are:

- Modeling approach and components (which are out of the scope of this report)
- Linked to the above but on a more strategic level, the inclusion of different transport modes and the possibility of modal shift may result in significant differences
- The use of different emission factors (according to e.g. national standards) which place differences in the results obtained for environmental and health factors
- The set of air pollutants assessed may distorts the comparison of aggregated emission values or monetary equivalents

| Nº | Case Study | Air Pollutants Assessed | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | NOx | PM | $CO_2$ | $SO_2$ | NMVOC | CO | Others |
| 1 | Pyrenees | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| 2 | Alpine crossing | ✓ | ✓ | | | | | ✓ |
| 3 | Omberg | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| 4 | Cuenca Del Manzanares | ✓ | ✓ | | | ✓ | | |
| 5 | Lipno | ✓ | | | ✓ | ✓ | | |
| 6 | Trans-Pennine Corridor | ✓ | ✓ | | ✓ | ✓ | | |
| 7 | Mediterranean Sea | ✓ | ✓ | | ✓ | ✓ | | |
| 8 | Frankfurt Airport | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| 9 | Copenhagen | ✓ | ✓ | ✓ | | | ✓ | |
| 10 | Budapest | ✓ | ✓ | ✓ | | | | |

**Table 23: Air pollutants assessed in Case Studies**

- When assessed the people exposure to noise levels, some case studies used a population density distribution over built area while others used average population density. These two different approaches may result in significant differences
- Differences in the definition, accounting and classification of accidents (e.g. the time frame within which a death after an accident account as a fatality)

## 2.9 Design and Choice of Policy Measures

A major aim for ASSET was to test 'extraordinary' policy measures in the case studies. These have been defined in Deliverable 1 as policy measures that "require additional instruments or more stringent implementation of existing measures in situations in which local conditions heavily affect Transport Sensitive Areas."

| Policy Instrument | Type of transport sensitive area | | | |
|---|---|---|---|---|
| | Noise Pollution | Air Pollution | Accident | Infrastructure |
| ***Pricing*** | | | | |
| Cordon / Access Pricing | E possible | E possible | E possible | - |
| Congestion Charging | I | I | I | - |
| Infrastructure tolls and charges | E possible | E possible | E possible | - |
| Area Licensing | E possible | E possible | I | - |
| ***Taxation*** | | | | |
| All forms | I | I | I | - |
| ***Infrastructure and Planning*** | | | | |
| Improved Infrastructure | I | I | E possible | E possible |
| SEA + EIA | C | C | C | E (mandatory) |
| Priority Lanes | C | C | - | - |
| Traffic Management Systems | C | C | - | - |
| ***Regulation*** | | | | |
| Low Emission / Environmental Zone | E possible | E possible | E possible | - |
| Other zone access controls (Table 2) | E possible | E possible | E possible | - |
| EU Directives and International Regulations | C, I | C, I | C, I | C |
| Permits and Quotas | E possible | E possible | E possible | - |
| ***Information and Public Awareness*** | | | | |
| All forms | I, C | I, C | I, C | - |

E: extraordinary measure; I: indirect impact; C: complementary measure; -: no significant impact

**Table 24: Policy instruments**

The following table summarizes the policy measures that were implemented in each case study, taking into account the above classification of measures used in ASSET D1 and D4. Additionally, other categories have been included in order to represent the whole range of measures applied:

| Nº | Case Study | Policy Measures | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Pricing | Taxation | Infrastructure and Planning | Regulation | Information and Public Awareness | Subsidies | Technical |
| 1 | Pyrenees | □ HGV road toll | | | □ Total restriction of HGV traffic on road segments<br>□ Reduction of speed limits | | | |
| 2 | Alpine crossing | □ Alpine Crossing Exchange<br>□ Charge for crossing the Alps | | □ Unlimited supply of rail traffic | □ Low emission zone | | □ Stop rail subsidies in CH | |
| 3 | Omberg | □ Road toll | □ Differentiated kilometer tax | □ Road improvements | □ | | | |
| 4 | Cuenca Del Manzanares | □ Distance based charge | | | □ Reduction of speed limits | | | |
| 5 | Lipno | □ Road toll | | □ Cycling infrastructure<br>□ Road infrastructure<br>□ Rail infrastructure | □ Traffic restrictions | | □ Subsidies to purchase less emitting and quitier buses | |
| 6 | Trans-Pennine Corridor | □ Cordon charging | | | | | | |
| 7 | Mediterranean Sea | □ Swedish port and fairway dues differentiation scheme | | | □ Third maritime safety package | | | □ Technical measures to reduce emissions (5)<br>□ Technical measures to reduce the risk of oil spill (2) |
| 8 | Frankfurt Airport | | □ Kerosene Tax<br>□ ETS-EU | □ Continuous Descent Approach | | | | |
| 9 | Copenhagen | □ Toll ring<br>□ Road pricing | | □ Traffic management | □ Environmental zone regulation<br>□ Ban on petrol-powered passenger cars without catalytic converters<br>□ Accelerated introduction of new emission standards | | | □ NOx reduction equipment on HDV<br>□ Introduction of low emission vehicles |
| 10 | Budapest | □ Access fee | | | | | | |

**Table 25: Policy measures used in Case Studies**

The most frequently used type of measure are Pricing measures, which accounts for 12 different measures and is used in 9 of the 10 case studies. Among them, the most frequent measure is the implementation of a distance based toll in road infrastructures (tested in the Pyrenees, Omberg, Manzanares, Lipno and Copenhagen).

Following Pricing, Infrastructure and Planning, and Regulation measures account for 8 applications which are tested in 5 case studies. Regulatory measures are mostly traffic restriction to certain areas to petrol-powered vehicles based on environmental criteria. Within this category a newly proposed measure has revealed promising results in its application in both Pyrenees and Manzanares case studies: the reduction of speed limits. Infrastructure and Planning measures are most commonly supply oriented measures ranging from the construction or improvement of transport infrastructure (road, rail and cycling) to the improvement of the supply in transport services.

Few case studies tested Taxation measures (Omberg and Frankfurt), while Information and Public Awareness measures were not considered at all.

Besides, a wide range of technical measures to reduce pollutant emissions (Copenhagen and Mediterranean Sea) and oil spills (Mediterranean Sea) have been tested.

Some considerations about transport subsidies have also been considered in the Alps and Lipno case studies, but with a very different sign: while the former tested the adoption of subsidies for the purchase of environmental friendly vehicles, the later considered the discontinuation of rail subsidies.

The average number of measures tested is 4.2 measures per case study, ranging from 1 (Trans-Pennine Corridor and Budapest) to 16 (Alpine crossing). Figures for Policy Packages are similar: average number of Policy Packages tested of 3.3, ranging from 1 (Budapest) to 8 (Copenhagen). The average number of measures per policy package is 1.7.

| Nº | Case Study | Policy Packages (and number of measures) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | PP1 | PP2 | PP3 | PP4 | PP5 | PP6 | PP7 | PP8 |
| 1 | Pyrenees | (2) | (3) | | | | | | |
| 2 | Alpine crossing | (4) | (6) | (6) | | | | | |
| 3 | Omberg | (1) | (1) | (2) | (2) | | | | |
| 4 | Cuenca Del Manzanares | (1) | (1) | | | | | | |
| 5 | Lipno | (2) | (2) | (2) | | | | | |
| 6 | Trans-Pennine Corridor | (1) | (1) | (1) | (1) | | | | |
| 7 | Mediterranean Sea | (1) | (5) | (4) | | | | | |
| 8 | Frankfurt Airport | (1) | (1) | (1) | | | | | |
| 9 | Copenhagen | (1) | (1) | (1) | (1) | (1) | (1) | (1) | (1) |
| 10 | Budapest | (1) | | | | | | | |

**Table 26: Policy Packages**

Policy measures are not always packaged in policy packages and often they are tested as isolated measures which doesn't allow for a synergy analysis. Also there are cases where one single measure with variations in its parameters (e.g. pricing fee) is tested (Trans-Pennine Corridor). In Budapest case study policy action is limited to a single measure.

There are two issues that require special attention, especially for pricing measures. The first of them has to be with the delimitation of the area in which the selected policy measures will be applicable. It is the purpose of ASSET that the defined methodological approach will help in defining this application area. Nevertheless, this is not the case in several case studies, where the area is defined exclusively by administrative and/or functional parameters.

The second one is the rationale behind the pricing fee. Different methods have been applied in order to determine the charges offering the opportunity to test the various approaches adopted by case studies.

| Nº | Case Study | Rationale for pricing |
|---|---|---|
| | | Approach |
| 1 | Pyrenees | According to traffic reduction objective |
| 2 | Alpine crossing | Result of market forces after a political decision on ACE's cap |
| 3 | Omberg | Political decision |
| 4 | Cuenca Del Manzanares | Recommendation from literature |
| 5 | Lipno | - |
| 6 | Trans-Pennine Corridor | Maximization of objective function |
| 7 | Mediterranean Sea | Fixed looking at the corresponding costs of technical measures |
| 8 | Frankfurt Airport | Based on recommendations by different international and national bodies |
| 9 | Copenhagen | According to emissions reduction objective |
| 10 | Budapest | Part of the Transport Charging Strategy |

**Table 27: Rationale behind pricing fees**

## *2.10 Impact Assessment*

In order to discuss the potential of the different policy measures tested in the case studies, an impact assessment is undertaken in this section.

Following is a summary of the Policy Packages evaluated:

| Nº | Case Study | Policy Packages | |
|---|---|---|---|
| | | PP | Measures |
| 1 | Pyrenees | PP1 | Toll for HGV<br>Decrease speed limits |
| | | PP2 | Toll for HGV<br>Decrease speed limits<br>Ban to HGV in central Pyrenees |
| 2 | Alpine crossing | PP1 | ACE in CH<br>Unlimited supply of rolling motorway<br>Stop rail subsidy in CH<br>LEZ (ban up to EURO III lorries) |
| | | PP2 | ACE in CH, A and F<br>Unlimited supply of rolling motorway<br>Stop rail subsidy in CH<br>LEZ (ban up to EURO III lorries) |
| | | PP3 | ACE in CH<br>Transit charge in A and F<br>Unlimited supply of rolling motorway<br>Stop rail subsidy in CH<br>LEZ (ban up to EURO III lorries) |
| 3 | Omberg | PP1 | Improvement of national road 50 |
| | | PP2 | Improvement of national road 32 |
| | | PP3 | Improvement of national road 32<br>Toll in national road 50 |

| Nº | Case Study | Policy Packages | |
|---|---|---|---|
| | | PP | Measures |
| | | PP4 | □ Improvement of national road 32<br>□ Km tax in national road 50 |
| 4 | Cuenca Del Manzanares | PP1 | □ Distance based charge |
| | | PP2 | □ Reduction of speed limits |
| 5 | Lipno | PP1 | □ Subsidies to purchase environmental friendly buses<br>□ Cycling infrastructure |
| | | PP2 | □ Traffic restrictions in natural areas |
| | | PP3 | □ New road infrastructure<br>□ Road toll<br>□ New rail infrastructure |
| 6 | Trans-Pennine Corridor | PP1 | □ Cordon pricing (global benefit for the whole region)) |
| | | PP2 | □ Cordon pricing (local benefit for 2 TSA together) |
| | | PP3 | □ Cordon pricing (Nash equilibrium with pollution costs) |
| | | PP4 | □ Cordon pricing (Nash equilibrium without pollution costs) |
| 7 | Mediterranean Sea | PP1 | □ Swedish port and fairway dues differentiated scheme |
| | | PP2 | □ Internal Engine Modifications (IEM)<br>□ Direct Water Injection (DWI)<br>□ Humid Air Motors (HAM)<br>□ Exhaust Gas Recirculation (EGR)<br>□ Selective Catalytic Reduction (SCR). |
| | | PP3 | □ Double hull tankers<br>□ Implementation of AIS<br>□ Third maritime safety package (ERIKA III)<br>□ Civil liability and Fund conventions |
| 8 | Frankfurt Airport | PP1 | □ Kerosene Tax |
| | | PP2 | □ ETS-EU |
| | | PP3 | □ Continuous Descent Approach |
| 9 | Copenhagen | PP1 | □ NOx reduction equipment on HDV |
| | | PP2 | □ German environmental zone regulation |
| | | PP3 | □ Ban on petrol-powered passenger cars without catalytic converters |
| | | PP4 | □ Accelerated introduction of new emission standards |
| | | PP5 | □ Introduction of low emission vehicles |
| | | PP6 | □ Traffic management |
| | | PP7 | □ Toll ring |
| | | PP8 | □ Road pricing |
| 10 | Budapest | PP1 | □ Access fee |

**Table 28: Policy packages and measures**

The following figures show main results of the impact assessment of each policy package compared to the BAU scenario (only Case Studies where a quantitative analysis has been conducted are included). Percentage values represent the variation in terms of external costs evolution of Policy Packages scenario compared to BAU scenario:

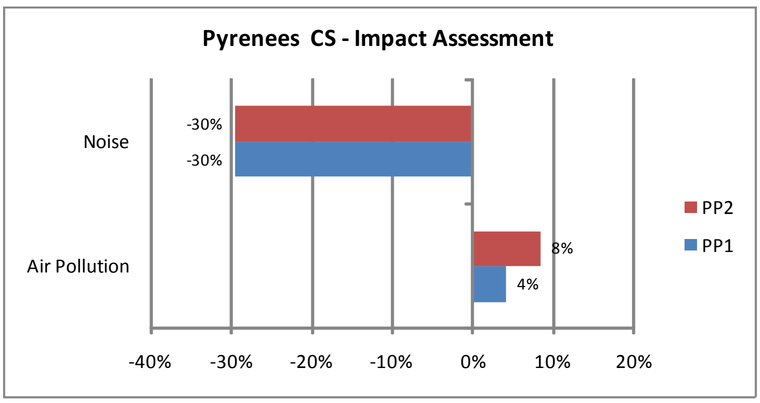



**Figure 7: Pyrenees Case Study – Impact Assessment**

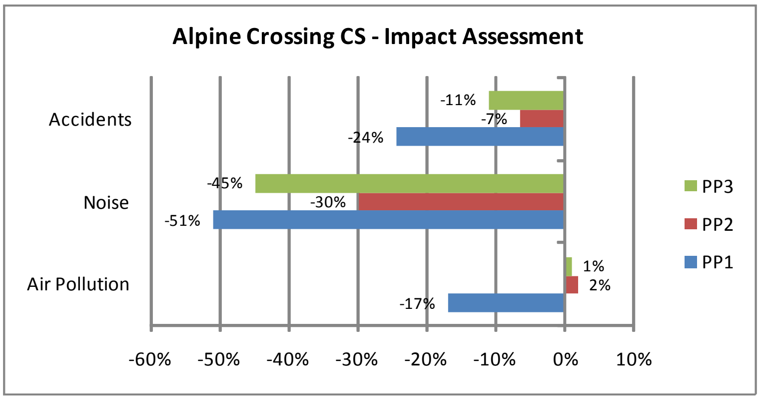



**Figure 8: Alpine Crossing Case Study – Impact Assessment**

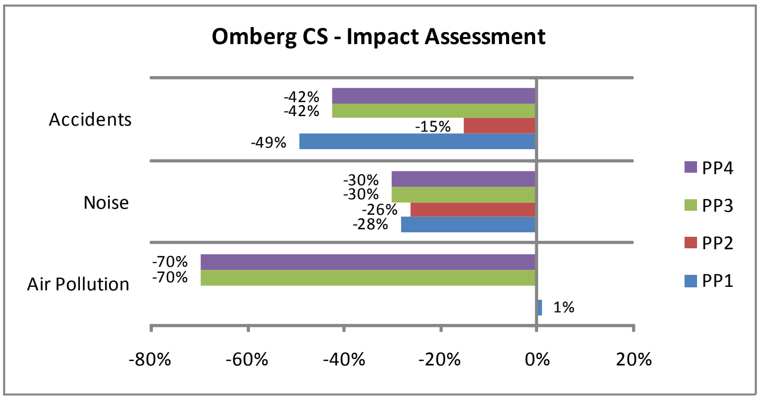



**Figure 9: Omberg Case Study – Impact Assessment**

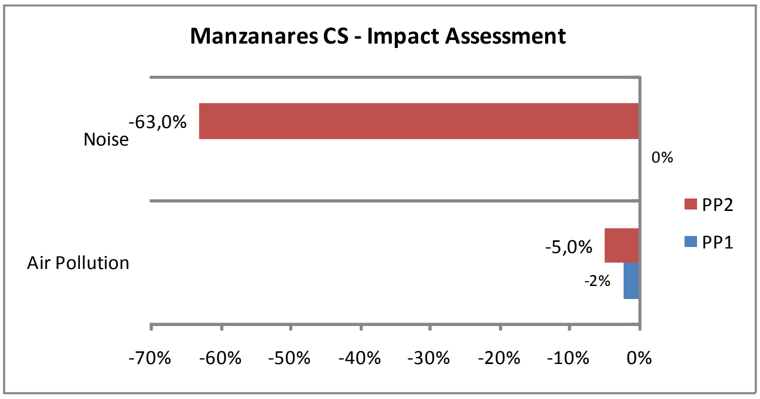



**Figure 10: Manzanares Case Study – Impact Assessment**

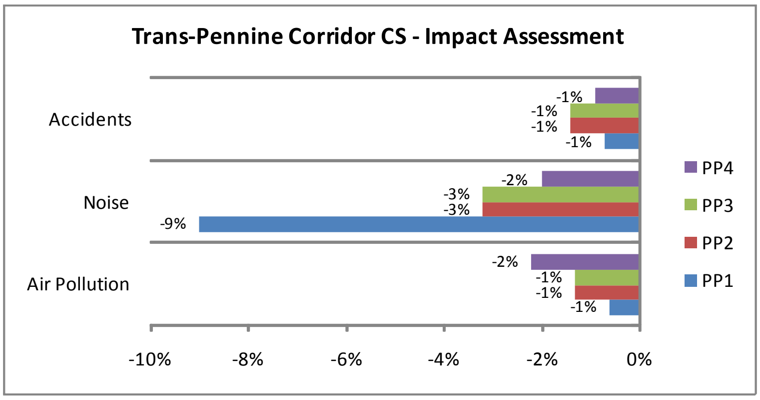



**Figure 11: Trans-Pennine Corridor Case Study – Impact Assessment**

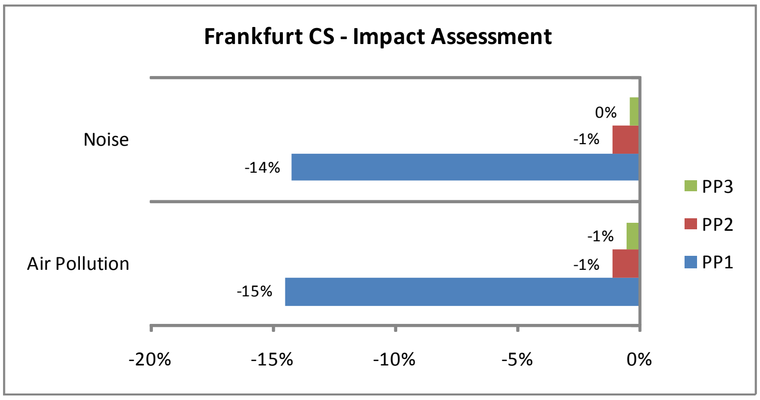



**Figure 12: Frankfurt Airport Case Study – Impact Assessment**

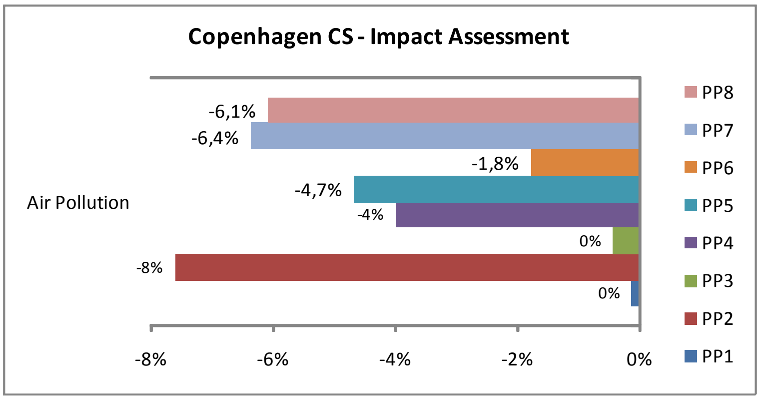



**Figure 13: Copenhagen Case Study – Impact Assessment**

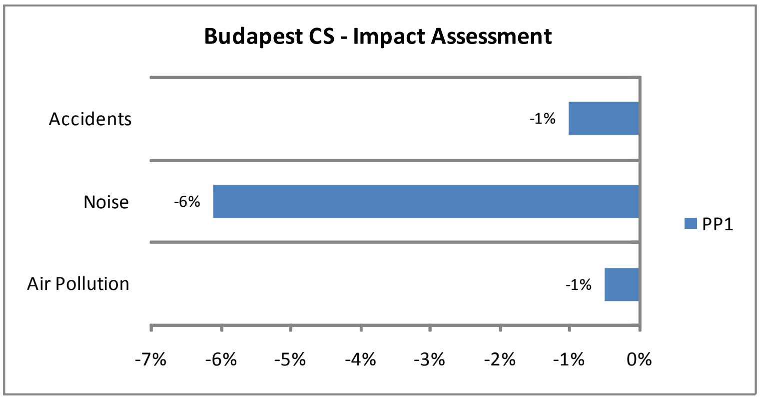



**Figure 14: Budapest Case Study – Impact Assessment**

In those Case Studies where noise has been assessed, ASSET policy packages have revealed a great potential for noise exposure mitigation. This holds particularly true for mountain areas, as inferred from Pyrenees and Alpine Crossing results. Also as regards noise, results from Pyrenees and Manzanares case studies revealed a great success of regulatory measures like the reduction of speed limits.

Several Case Studies have revealed either small increases in air pollution emissions or significant differences in air pollution results between policy packages (the expected traffic volume increase in the Pyrenees made the results different, as emissions increase significantly). This is usually the case when tolling/taxation measures are applied, which result in rerouting of traffic flows and increased mileage that compensates the potential reductions in the areas of application. This issue points out at the definition of the case study area as a key issue highly influencing the assessment results. This question will be further discussed in the next section of this report.

As for accidents, improvements are greater in those cases where infrastructure improvement has taken place (Omberg). Nevertheless, traffic decrease is the main driver for achievements as regards of this impact, which also accounts for significant improvements due to tolling and regulatory measures aimed at traffic reduction.

The latter issue (i.e. the importance of traffic reduction as driver for environmental improvement) holds true for all transport related effect. But this may not lead to misleading conclusions like identifying the more restrictive measures as the more effective. Case studies like the Pyrenees have revealed better result in a priori "softer" policy packages.

Overall conclusion of the policy packages application is that simple and focused regulatory measures can be as effective in tackling the main transport related impacts as less socially accepted measures like pricing. This is also concluded by more qualitative oriented assessments like the Mediterranean case study. However, because the case studies' objective has not been to optimise the policy packages applied but rather test the feasibility of the concept, improvements to the results of pricing as well as regulatory instruments could be achieved through careful bundling with complementary measures. For example, use of revenues for investment into alternative modes can greatly improve acceptability as well as efficiency of charging policies.

As already highlighted above, one final relevant issue that is worth assessing is the management of the undesired effects derived from the application of the referred policy instruments in case studies:

| Nº | Case Study | Undesired Effects |
|---|---|---|
| 1 | Pyrenees | - Diversion from traffic flows across the central part of the Pyrenees to the motorways in the maritime façades<br>- Migration effect: usage of alternative routes not suitable for heavy goods vehicles, specially narrow and bending mountain roads (less likely due to geographical constrains) |
| 2 | Alpine crossing | - The implementation of an ACE will strongly increase the price of Alpine crossing local and short haul traffic. Additionally, it is just the local and short haul traffic for which the possibilities of a compensation of the rise in price through rail freight traffic are limited, as rail freight traffic is less competitive on short distances. |
| 3 | Omberg | - Increased emissions of air pollutants due to higher traffic speeds |
| 4 | Cuenca Del Manzanares | - Potential adverse effects due to the diverted traffic |
| 5 | Lipno | - |
| 6 | Trans-Pennine Corridor | - If restraint measures are developed in isolation, rerouting effects can add substantial environmental burdens to other regions as well. |
| 7 | Mediterranean Sea | - |
| 8 | Frankfurt Airport | - |
| 9 | Copenhagen | - |
| 10 | Budapest | - Overall time losses due to rerouting |

**Table 29: Undesired effects**

As can be seen from the table above, a recurring issue in the application of extraordinary policy instruments for the protection of TSAs is to how deal with the negative impacts of redirected traffic. This shows that policies should not be developed for TSAs in isolation from surrounding areas but need to be integrated in a strategy for the whole region affected.

# 3 Discussion and redefinition of issues from case studies performances

By developing case study applications in WP5, the ASSET partners have tested all different concepts, tools and recommendations delivered in the previous ASSET work packages in different circumstances, according to the typologies of TSA identified. This is a significant amount of work that cannot be overlooked. All case studies have faced similar difficulties in applying a common methodology to a unique context. This gives a clear picture of the degree of suitability of the definitions and issues that have been studied in ASSET and, even more importantly, the extent to which a number of elements need to be discussed and redefined in order to improve future application in different areas. Most of them have also been identified in ASSET D5, announcing the appropriateness of a further discussion in WP6.

This chapter discusses the main issues that the ASSET project has developed and reviewed, highlighting the evolution throughout the project, including the success, shortcomings and amendments that have been identified or proposed during the execution of the case studies, in order to be able to deliver a final outlook of the methodology.

## *3.1 Definition of transport sensitive areas*

This is a key element of ASSET, as one of its main objectives is to set up a common framework of definition to deal with transport sensitive area across the EU. Previous ASSET documents have set up the pursued comprehensive framework, as a result of the revision of earlier definitions, research results, and improvements from the analysis.

However, ASSET Deliverable 5 "Description of the Results of the Case Studies" have stated that generally, the distinction between SA, TAA and TSA are considered as feasible, although some concerns were expressed related to (i) 'actual' and 'potential' presence of transport effects, (ii) geographical scale, and (iii) uncertainties when several indicators produced contradicting results. It is concluded that even though the responses of the research partners were generally positive, the definition of SA, TAA and TSA is not always clear and needs more practice oriented guidance. This does not necessitate a redefinition of sensitive areas, but a clearer presentation and nomenclature. One of the objectives of Deliverable 6 is therefore to discuss these issues from the starting point of ASSET, throughout its evolution, and the problems encountered by the Case Studies. The work will be finalised by undertaking the task of presenting a clearer picture of the TSA definition, in order to avoid possible points of confusion in future applications, thanks to the performance of ASSET case studies.

### 3.1.1 Setting the scene, dealing with the TSA concept

The ASSET Deliverable D1, "Definition of transport sensitive areas and their classification" reported the outcome of the ASSET Work Package 1: "Setting the scene", providing the conceptual background for developing the concept of transport sensitive area (TSA) and for reviewing the policy instruments designed to mitigate the negative transport impacts in that areas. Regarding the first item - developing the concept of TSA- this initial work showed that although the concept of sensitive areas as well as of transport related sensitive areas has been researched in Europe since the last decade, a general agreed definition of sensitive areas as well as of transport related sensitive areas is missing on an international and national level. An outlook on the approach to this concept in international treaties and EU legislation, research works, studies and regional protocols as well as national legislation was carried out, confirming the need of general agreed definition of sensitive areas.

Following the arguments on the first ASSET deliverable, it is said that, in order to be classified as "transport sensitive", the following conditions have to be clearly present in a given area:

- Particularly high sensitivity against potential transport-related impacts, and
- High or very high transport-related impacts – supposing that a major transport route is crossing the area.

By considering this conditions crucial for an area to become "transport sensitive", one can note that the exposure to high volumes of traffic in itself is not a peculiar characteristic of TSA (although obviously more severe impacts would come if traffic is intense), nor the mode of transport considered or even the existence of a transport route. Therefore, what is relevant in the TSA context is whether a certain traffic volume leads to more severe impacts in TSA than elsewhere.

Finally, a **transport sensitive area (TSA)** was defined as **"an area where the presence of a transport route deteriorates the quality of the area clearly more than the presence of the same transport route in another area because the impacts caused are particularly high".**

It is worth noting that this TSA concept is relative. It needs a "reference" of what is considered to be "acceptable impacts" in that particular area. But the acceptability of "local impacts" greatly varies according to the particular local conditions, and to the priorities of local actors. The successful application of such a relative definition in the wide and divers European context will need a channelled development.

Actually, one should take account of the European-wide definition that is pursued here. The TSA definition should be clear on what is to be considered as a TSA under EU procedures and legislation, giving as concise and detailed indicators and thresholds as possible. If TSA concept is to be applied on EU regulation, a comprehensive TSA EU-wide definition will avoid misinterpretations, setting agreed criteria based on solid principles and consensus.

The definition should also include the principle of subsidiarity. Indicators and thresholds will identify TSAs relevant at EU level, that would eventually be used to apply EU agreed policies and measures, regardless of the development that this concept could potentially achieve in national or regional contexts.

In fact, there will be situations where new indicators could define new TSAs derived from the availability of local scale data. However, it is considered that as far as the European-wide TSA concept is concerned, these new TSAs defined at the local scale should not be identified by a lax interpretation of existing indicators (i.e. adding local interest areas to the "sensitive ecosystem" indicator) but identified by the use of new data that become available at a different scale of work for already proposed (i.e. wind speed) or eventually agreed indicators. Otherwise, the definition of TSA areas would be very much dependent on national/regional political decision, leaving EU-wide TSA concept vulnerable to misinterpretations that may create unfavourable competitive conditions. Following the above example, the potential enlargement of existing indicators to other national or regional interests would define TSA at national or regional level, out of the implications that a TSA at European level may eventually generate.

Therefore, indicators and thresholds should not be relative, context dependent or policy dependent if they will define TSA at EU level. In that case everything could be a EU-TSA. This is obvious when a radical example is analysed: If it is said that “sensitive ecosystems” Check 1 indicator is not strictly defined by the presence of internationally protected areas[2], and other national/regional could be added on a more local scale, a given region in EU-countries border area could potentially define its whole region as protected under regional legislation, and then has the basis of being qualified as EU-TSA. The latter could potentially lead to the application of special charges for transport flows according to EU law, and that, eventually, could divert traffic to other areas (sensitive or not) or even pose conflicts on competitiveness between EU countries. The latter is especially controversial for peripheral areas. In order to avoid such episodes, we propose to use only international designated areas, as are multilaterally defined and controlled, being national/regional protected areas a potential indicator for defining TSA at national/regional level.

The proposed approach is actually in line with other legislation developments concerning the protection of the environment. Regulations as mature as EIA or the latter SEA set up a common EU-framework, leaving space to the member states to develop it when transposing the Directive. In fact, a common list of projects at EU-level are indicated as minimum requirements to nations where transposing both mentioned Directives to the internal framework, and more stringent interpretation could be made by countries and regions, facilitating the adaptation of the mechanism to national context.

### 3.1.2 Questions about the dependency of TSA concept on the presence of a transport route.

As stated above, ASSET Deliverable 5 “Description of the Results of the Case Studies”, according to the case studies experience, has found the distinction between SA, TAA and TSA feasible, but with some concerns. Probably the most important one, regarding the impact on the ASSET TSA definition, was related to the ‘actual’ and ‘potential’ presence of transport effects in order to define a TSA as such.

In fact, after the definition of TSA given in ASSET D1 -*an area where the presence of a transport route deteriorates the quality of the area clearly more than the presence of the same transport route in another area because the impacts caused are particularly high*-, ASSET Deliverable 2 stresses the importance of the definition of being independent of transport volumes or route. It states that “If the transport volume were relevant, transport sensitive areas would only consist of narrow corridors along transport routes (e.g. Brenner, Gotthard etc.). Therefore, and quoting ASSET D2, definitions of TSA should ensure that whole areas are defined as transport sensitive (indicating where plans for new infrastructures might be problematic).

Therefore, the definition does not say that the transport route must be present, it only says that if a transport route is present, then the quality of the area is clearly reduced. This idea, included in Deliverable 2, is coherent with observations made after the completion of the IWW and POU study on transport-related impacts and instruments for sensitive areas. By defining TSA as a combination of both elements of high sensitivity and high transport-related

[2] However, national/regional protected areas are classified as TSA when Check 2 indicators are present.

impacts, areas not experiencing high transport levels (i.e. transport-related impacts) today, but probably affected in the future would be left outside the definition.

Therefore, as stated in ASSET D2, TSAs include areas without transport activity but where that transport activity would be more detrimental, in case it actually develops (cases where we “only” have a potential affection, e.g. plans for a new rail line through an ecologically precious wetland). The traffic volume (actual or predicted) would become relevant only afterwards, while discussing policy measures to implement in the area.

ASSET WP5 included ten case studies designed to test the feasibility of the ASSET methodology. Although it was considered apparent enough in the definition, several case studies stated the need to further clarify the independency of the TSA concept to the existence of a transport route. The following discussion fulfils this task, in order to avoid misunderstandings in future applications.

The confusion was probably derived from the use of the name “Transport Affected Areas” to define areas where the **actual or potential** presence of a transport route leads to particularly high pressures due to environmental conditions (Check 2 analysis), an additional argument to qualify an area as TSA. Although ASSET D2 clearly stated “the actual or potential presence of a transport route”, this can be overlooked, and the name of TAA will be therefore changed to avoid this type of confusion.

In addition, it is believed that the TSA definition given above could also be slightly changed to make its meaning clearer. The following definition is therefore proposed:

"An area where the **actual or potential** presence of a transport route deteriorates the quality of the area clearly more than in another area, because the local impacts caused are particularly high.”

**In conclusion, and according to the definition given in ASSET D1 and D2, a TSA is independent of the existence of a transport route and high transport-related impacts, and independent of the actual exposure to high volumes of traffic. As ASSET D2 stated, if the TSA was dependent on the existence of a transport route, we would only have narrow corridors along the transport routes, and the latter was not the intention of ASSET.**

In addition, the term **Policy Relevant** TSA was also defined in ASSET D2 and applied in different case studies as those TSAs where damaging traffic volumes are actually present or planned, and policy measures should be taken. Of course, the political process will not lead to policy measures everywhere, but it should be identified where the effects of such measures are most beneficial to the TSAs as a whole, limiting undesired effects and/or possible conflicts between policy objectives. On the other hand, TSAs where existing traffic is actually producing unacceptable effects should be the priority, compared to other TSA with more moderate traffic.

However, it is believed that TSA definition will need to be applied with a certain level of flexibility, at least regarding two different dimensions:

- Geographical: The exact delimitation of TSA relies on the geographical scale and the availability of data. Whereas the TSA concept is independent of the scale of work, new TSAs could be defined when dealing with local scale as more precise data are available to feed the agreed indicators.

- Temporal: According to the precautionary approach strongly supported by the EU policies, we should also apply political measures in areas where expected traffic flows in sensitive areas would lead to detrimental impacts according to evidence from predictive tools and models. Most case studies used scenarios to assess the most likely evolution of the transport system to evaluate where should policies should be applied with maximum chance of success.

Another issue related to the definition of TSAs is the distinction according to the type of transport pressure (air pollution, noise, etc) and the vulnerability of an area. As Deliverable 2 states, the area has to be considered transport sensitive only for the corresponding pressure, while the same area might be considered ordinary for all the other pressures. Policy measures will eventually be defined according to the type of pressures. The application of this distinction did not appear to have caused difficulties in the case studies and is well accepted, although most of the indicators were shared for different effects.

Summary of definitions (Derived from ASSET D1 and D2:

• **Transport sensitive areas (TSA):** An area where the **actual or potential** presence of a transport route deteriorates the quality of the area clearly more than in another area, because the local impacts caused are particularly high.

• **Policy Relevant TSA:** Only those TSA, where damaging traffic volumes are actually present or planned, are relevant for policy makers. In these areas policy measures should be taken to protect the TSA from the negative impacts from transport.

• **Vulnerable areas (VA)**: These areas are environmentally, socially, culturally or economically sensitive because the local impacts due to a given or potential pressure are clearly higher than in other areas. Previously named Sensitive Areas (SA)

• **Areas with (potentially) higher Pressures from Transport (APT)**: These are areas where the actual or potential presence of a transport route leads to particularly high pressures. Previously named Transport Affected Areas (TAA)

### 3.1.3 Transport Sensitive areas as a twofold concept.

Having defined TSA as an EU wide concept, we can then focus on the notion of sensitivity, i.e., when an area should be defined as sensitive to transport. ASSET Deliverable 2 made a deeper analysis on this matter, based on the idea that local circumstances leading to varying environmental costs of transport are identified and can thus be reflected in cost estimations and policy advice for solutions.

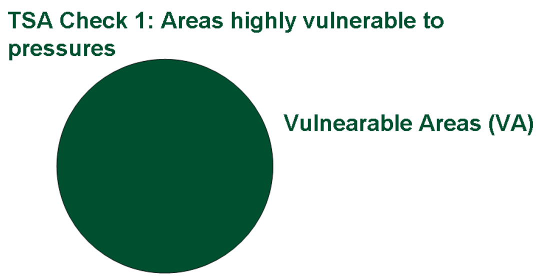
The first step in the analysis is to define areas vulnerable to transport pressure as TSA. Thus TSA include areas that are environmentally, socially, culturally or economically sensitive because the local impacts due to a given or potential transport pressure are clearly higher than in other areas. **Higher vulnerability to transport pressures** is the key characteristic of these areas. The idea is to identify areas where impacts are higher (e.g. due to high population density) or where the costs are higher (e.g. due to damages to unique natural resources, habitats or cultural heritages) than in other areas affected by similar effects. These areas are named “Vulnerable Areas” (VA). They were named Sensitive Areas (SA) in the previous ASSET deliverables, but the term “sensitive” is repeated when defining TSA and “Vulnerable Areas” was considered a clearer name for these areas.

Therefore, TSA will be defined by the presence of key elements, i.e, areas protected by EU environmental legislation (Natura 2000 Network), highly populated areas, international cultural heritage sites, etc. To identify such areas, indicators were grouped in the so-called Check 1, which were satisfactorily applied by most case studies, and will be reviewed in the following sections of this report. Thresholds defined for Check 1 indicators will identify **vulnerable areas**, directly qualifying as TSA.

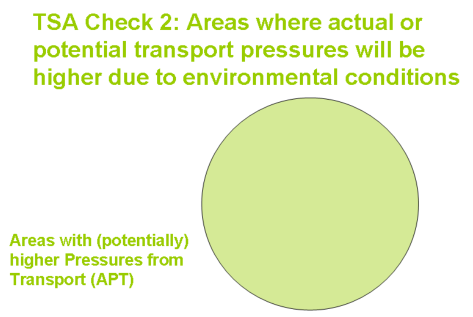
But the concept of transport sensitive areas should also take account of those **areas where transport pressures would be significantly higher** than in other areas due to environmental conditions (gradients, narrow valleys, frequency of inversions, etc). Therefore, Deliverable 2 designed a second check, which analyses under what conditions pressures caused by transport are higher, i.e. under what conditions emissions and concentrations per vehicle km or infrastructure / route km are higher. In these areas where pressure is particularly high, a lower threshold for the indicators of Check 1 should be applied in order to qualify an area as TSA. But Check 2 does not identify TSAs by itself, as higher pressures not always mean high impacts. These areas are subordinated to the outcome of Check 1.

Deliverable 2 named the results of Check 2 as Transport Affected Areas (TAA), but Case Studies performance have revealed that “transport affected” has generally been confused with the actual presence of high traffic volumes, and this is not the aim of this Check 2. It is therefore proposed to avoid the term TAA, and name Check 2 result **Areas with (potentially) higher Pressures from Transport (APT)**, and just define TSA as a twofold concept, compound by a combination of check1 and Check 2 analyses.

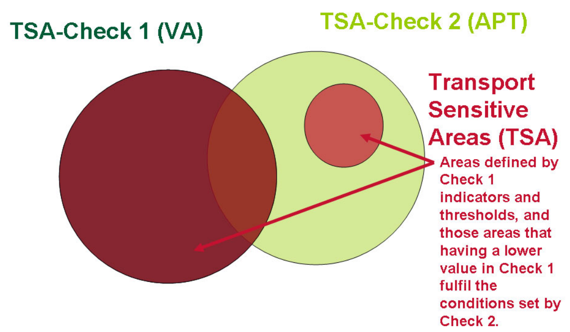
Transport Sensitive Areas are then those areas defined by Check 1 indicators and thresholds, and those areas that having a lower value in Check 1 fulfil the conditions set by Check 2.



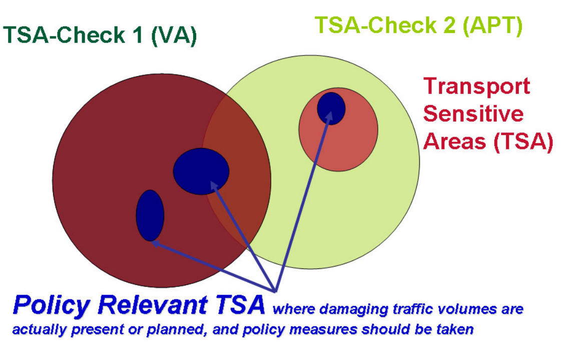

Step 1: Identification of areas that are environmentally, socially, culturally or economically sensitive because the local impacts due to a given or potential transport pressure are clearly higher than in other areas.




Step 2: Identification of areas where transport pressures would be significantly higher than in other areas due to environmental conditions (gradients, narrow valleys, frequency of inversions, etc).




Step 3: Transport Sensitive Areas are qualified by Check 1 indicators and thresholds, and are also those areas that having a lower value in Check 1 fulfil the conditions set by Check 2




Step 4: Identification of those TSA where damaging traffic volumes are actually present or planned.[3]

***Figure 16. Proposed method for the identification of TSAs:***

## *3.2 Geographical scale and space*

### 3.2.1 Implications on the TSA definition

Previous sections of the present document have highlighted the significant variability of case studies scale, comprising large areas such as the Mediterranean Sea or the Alps as well as the

[3] Note that particularly affected areas could also be APT but not TSA, i.e, an area with high transport flows where transport-related pressures are significantly higher than in other areas due to environmental conditions (topography), but the area is not particularly vulnerable (and therefore not qualify as TSA).

city of Budapest or the natural area of Omberg/Tåkern. As WP5 has pointed out, the variety of geographical extensions analysed makes a comparison of the cases very difficult but, on the other hand, enables us to reflect on the difficulties and practical applicability of the developed methodology. The aim of the present section is to consider how the proposed methodology deals with the scale variable and discuss about the optimal approach that we should apply from the scientific point of view.

A number of shared principles are needed to clarify the relationship between the definition of transport sensitive areas and the geographical scale of work. One of them is that the definition of transport sensitive areas should be **independent of the scale of work**, avoiding misinterpretation of the concept, as discussed above. The level of detail should allow defining TSA more precisely, identifying areas where damage is higher under similar effects. The detailed identification at large scale (local areas) will be made using more accurate data for EU-wide indicators (i.e. accurate limits of Natura 2000, data on population density at census areas), or by using specific local indicators agreed at EU level (i.e. wind speed). However, the actual threshold of a given indicator to define TSAs should not change according to the scale of the analysis and should be defined at EU level.

When dealing with TSA definition and geographical scale, the first conclusion is that poor availability of precise data could make the TSA concept difficult to handle in practice. Basically, there have not been sufficient examples of measurements and data collections in –for instance- mountain valleys to assure that above a certain number of inversion events per year, a valley should be catalogued as sensitive for air quality reasons (also depending on a certain wind speed). And, should the transport-related emissions in that valley reach a certain level, this valley will need extraordinary policy measures to overcome the harm that subsequent concentration of pollutants will produce in the human health and the natural surroundings. This is just an example using mountain valleys, but the situation is similar in agglomerations, coastal/maritime areas or natural surroundings.

In the best case scenario, where we would have precise meteorological data at convenient scale (frequency of inversion events, wind speeds or precipitations) the task of applying specific indicators and thresholds to define TSA would be just slightly easier. And just slightly easier because we would need to build thresholds based on different –and probably complex- combinations of indicators. There is no doubt that the impact caused in a given valley depends on the number of inversions, but also on wind speed and on how stable is the meteorological situation in that specific area. **Future research should focus on the identification of suitable thresholds for several of the indicators proposed by ASSET, and ideally could propose an intelligent combination of different indicators and thresholds to accurately define TSA using local scale data.** Experience from ASSET case studies give light to some important points of interest, but more efforts are required to reach a comprehensive proposal, including the less straightforward Check 1 indicators, were absolute thresholds above which an area should be qualified as TSA could not be provided at this point.

What is clear at this point is what we mean by TSA. It is an area more vulnerable or worth of protection, where limit values set up by EU environment policy (air pollution, noise legislation) designed to be applied uniformly across the EU may not be adequate because the local impacts caused are particularly high. Obviously, the more precise data available, the more accurate analysis could be done, but as far as the EU scale is concerned, there is a need to stick to simple data and indicators for practical reasons.

In the context of the ASSET project, WP3 was designed to fulfil an important gap in the development of the TSA concept at EU level. Once defined what we should understand by TSA, it was considered fundamental to undertake the task of mapping these areas EU-wide. The result is an interactive, web-based map of the criteria and indicators proposed in ASSET WP2 regarding transport sensitive areas (TSAs) and impacts from transport activities at pan European level, utilising existing maps and statistical data. By using this tool, policy relevant TSAs can be highlighted and zoomed at any place within the EU, showing the different features that define their sensitiveness and understanding the interdependencies with other areas and networks. It is therefore an optimal basis for more comprehensive assessments.

### 3.2.2 The concept of case study area

Once that a key ASSET objective - to fulfil the requirement for mapping transport and related sensitive areas in the EU- is complete, future application of the TSA concept would require a more specific analysis of different zones in Europe, dealing with specific areas of interest that have been identified in the EU wide mapping exercise. But the next question is; what should be the area that would need to be included in this more specific study, capable of taking all relevant issues on board? WP5 case studies have dealt with this element, defining case study areas for their specific assessment. It is worth to take on board the lessons learnt.

As it has been said in the chapter 2 of the present document, there was not a common criteria used in order to obtain a geographical delimitation of the area for each case study undertaken in ASSET D5. Case study limits were selected in the light of the experience of each partner, taking account of a known area where its sensibility character, the type of impacts, data and transport flows are already familiar. Given project resources and objectives this was regarded as the best possible approach to study different areas and typologies. And it is probably the approach that will be followed in future applications of the methodology. Each nation/region will make an assessment of the opportunities that the methodology offers to a well-known geographical context that contains areas defined as TSA by following the ASSET approach.

Reasonably, the geographical limits of the studied area have mostly been practical. Lessons learnt from case studies indicate that future applications should use the following criteria for the delimitation of the studied area, in order to include all possible zones of interest:

- Criteria of transport sensitivity: First analysis of topological context, population density, presence of natural and cultural areas of concern, etc.
- Presence of severe transport-related environmental burdens, i.e, infrastructure driven delimitation.
- Transport system interdependencies (origin/destination flows), traffic characteristics, network topology.
- Administrative boundaries, political delimitation.

These four criteria affecting the area of interest should be combined and none of them precluded. While the first set of criteria is used for the identification of TSAs themselves, the other three criteria are necessary in order to ensure the policy relevance and optimal application of policies for TSAs. At this first stage, where mostly practical geographical delimitation is pursued, the analysis should be rather general, although sufficient for gathering relevant information on the contour conditions. The ASSET methodology is expected to identify and delimit within the case study area all threatened areas, and define the most effective political measures to protect them. Each of the four criteria would give relevant information to understand at first stage why the specific area could be under threat, what are the main driving forces involved and what could be the best policy options to tackle potential undesired situations within the case study area. An early identification of stakeholders is also desired.

But it is also important to include in the analysis the area that could be affected by unintended or undesired effects due to the application of the policy measures considered in the analysis. It would have little sense to implement a policy package that, whereas improving the situation of a given TSA, it is worsening other areas or even global conditions to an unacceptable level. The latter was clearly stressed by several case studies (see table 29).

### 3.2.3 The need to define different scales of work

Deliverable 5 states that, "when analysing the Case Studies, the geographical scale is of major importance for the definition of sensitive areas. E.g., due to its large extent the Mediterranean and the Alps are regarded as one TSA each. If the large scale of Omberg was applied here, thousands of TSA would have to be identified."

As it has been said earlier, the concept of transport sensitive areas should remain constant regardless the geographical scale considered[4]. At the same time, it is clear that scale differences pose implications on the level of detail required, the precision needed in the analysis and data management skills. Not to mention political issues when trying to effectively implement the selected measures. The geographical scale will determine which indicators are used and the level of precision in the definition of TSAs. When dealing with large areas (European, strategic, transnational level), generalizations on the outcomes of the indicators test are needed, while at local scale (town or street level) sophisticated indicators should be applied to precisely assess the sensitive characteristics of the area and the potential evolution when implementing measures.

[4] It is worth to highlight here that geographical scale does not mean resolution or data accuracy. While working at European scale it is possible to deal with very detailed data on, for instance, the location of cultural heritage sites at a high precision (although they could not be visible)

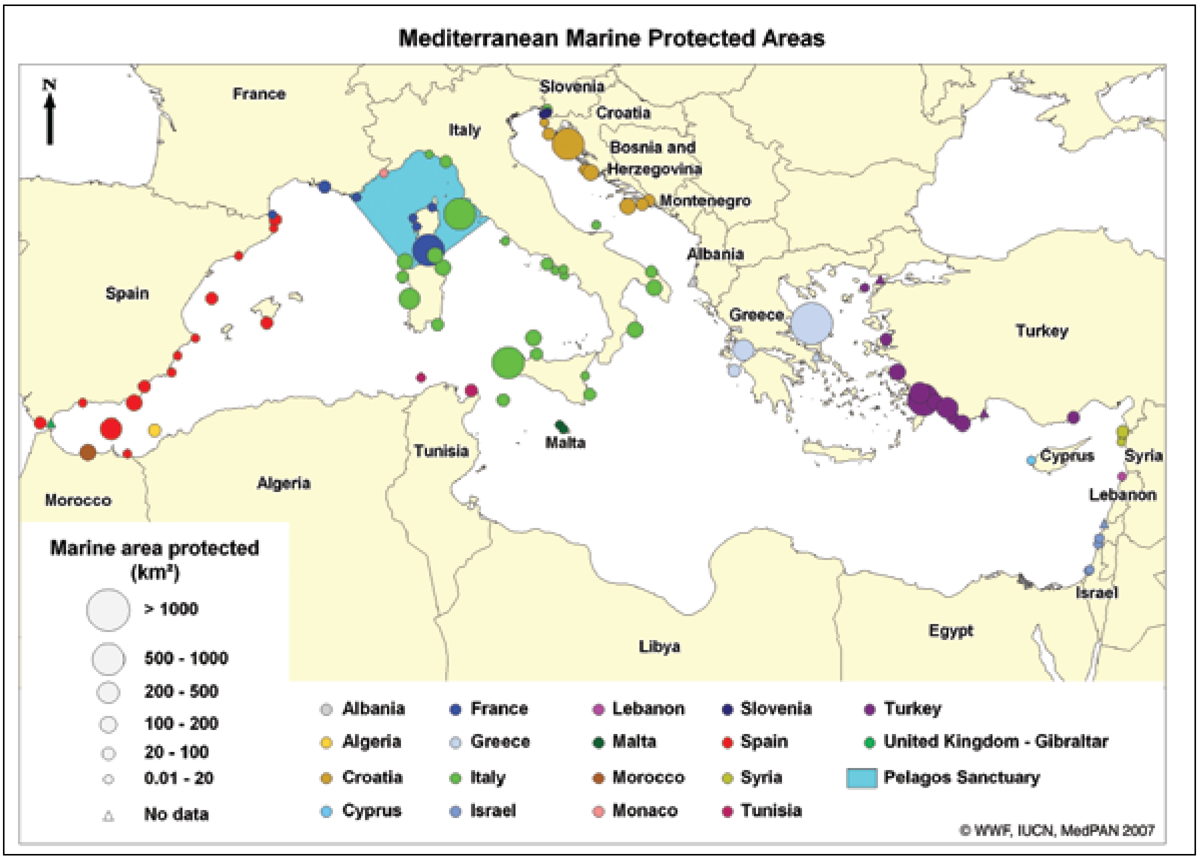



**Figure 15: Mediterranean Marine Protected Areas.**

Source: "Status of Marine Protected Areas in the Mediterranean Sea" by IUCN, WWF and MedPAN supported by UNEP Regional Activity Centre for Specially Protected Areas (UNEP RAC/SPA). From the Mediterranean Case Study (ASSET D5).

Keeping the focus on the analysis, the use of transport models and Geographical Information Systems are regarded as essential to handle most of these implications and also to facilitate the analysis at different scales, which is crucial to obtain an optimal result. They give the opportunity to work at different levels, using aggregated or detailed information where needed, testing different solutions and thoughtfully evaluating results. Three scales of an iterative work are proposed for any TSA analysis.

*Small scale – broader area*

The territory selected as case study area under the four criteria proposed above would ideally include all the TSAs that were actually the initial motivation of the study, as well as other areas and networks that interact or have a reasonable relation with them. The objective of undertaking the analysis at small scale (EU-strategic scale) is to ensure that these features are fully included and appropriately addressed before the outcome of the analysis is made, limiting the probability and intensity of undesired effects.

When the analysis is focused on a natural surrounding that is crossed by an international transport route, broader area analysis should take on board route alternatives for the transport mode at stake and their surroundings, as well as potential ways of modal shift and their implications in terms of environmental impacts. In the case of agglomerations or relatively small protected areas, the wider analysis will include adjacent areas -the metropolitan area- or even other agglomerations in a relation of interdependency, as well as the transport network and nodes that are somehow influencing the performance of the particular transport route affecting the selected individual or grouped TSA.

When the focus of the analysis is the assessment of the sensitiveness of large areas (extended mountain ranges, Mediterranean Sea) the small scale analysis is the obvious approach, concentrating on the main transport routes, wider areas of interest and regional interactions. Clearly, this rough assessment is not able to take into account local features, such as small natural monuments, single trees, ponds or villages, but will produce knowledge on the key elements needed to forecast the likely situation once policies are implemented.

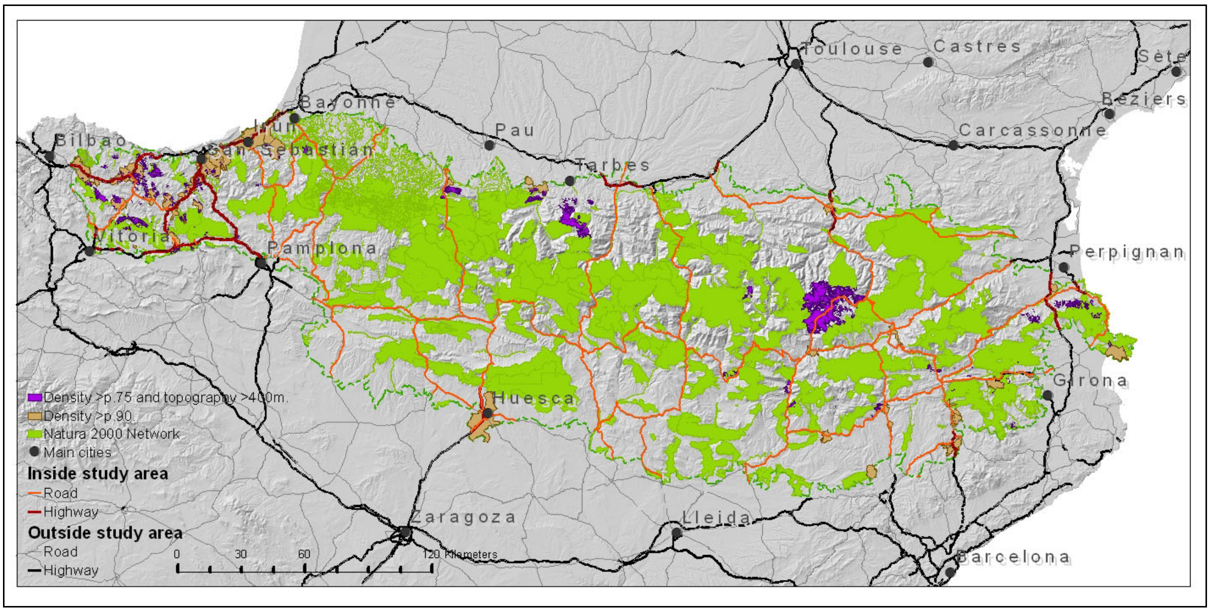



**Figure 16: Sensitive areas identified in the Pyrenees case study using limited indicators**

When undertaking the small scale analysis, relatively few and simple indicators built with aggregated data and usually available at EU level have shown a variety of areas of interest, which generally meet the expectations of those with first hand knowledge of the area. In other words, a limited number of indicators set a minimum definition on where should we focus when a more local application of ASSET concepts is undertaken. In addition, it makes possible the analysis of a wide area under the perspective of a regional transport planning, i.e., assessing the need of transport activities and the best way to manage the conflict between this need and the existence of places of great interest and relative untouched environments, in order to select preferable corridors for existing and forecasted flows.

The outcome would be, however, a great number of areas that probably comply with the thresholds defined for the different indicators in order to be catalogued as TSAs. This situation could be difficult to handle if the geographical flexibility of the TSA concept is not applied at this scale. A classification of relatively homogenous spaces or units within the area should be pursued for a first assessment of the likely implications of the already sketched policy measures and packages.

As Deliverable 5 points out, there is still the question on whether delimitation on a large geographical scale remains necessary or desirable after the general assessment at small scale. In this regard, as it has been already mentioned, far from being incompatible or counterproductive, both analyses are highly recommended, as each of them would produce different and valuable results for a better understanding of the options in a given area. Even when the focus of the analysis is the assessment of the sensitiveness of large areas, the subsequent analysis at detailed scale will give valuable data to assured that a given policy set up to improve the performance at regional scale is not generating adverse unacceptable impacts in specific local areas of interest. And, on the other hand, the detailed analysis will demonstrate that implemented policies are, as envisage, positively influencing the ex-ante situation in the selected sensitive and transport sensitive areas. Finally, it will produce feedback on the feasibility of the indicators and thresholds, evaluating its suitability and, if that is the case, improving the assessment for future applications.

*Large scale-local areas*

General indicators are easily available, and present the minimum requirements for a TSA definition, analysis and policy package application in large areas. Most of the indicators proposed in ASSET D2 where proposed for an European-strategic scale, where the focus of the methodology was placed. Local scale indicators were more difficult to design at this stage, and it was agreed that successive work-packages (specially WP3 and 5) would then test the appropriateness of proposed indicators and thresholds as well as making propositions for new or redesigned indicators at local scale. The outcome of this effort is the definition of a set of proposed new indicators that could assist for a more detailed analysis of specific areas of interest, reinforcing the feasibility of applying the ASSET methodology to the local scale. Some of the proposed local scale indicators would be added to those already defined in ASSET D2 in order to establish a comprehensive battery of indicators at both small and large scale.

Once broader scale analysis have been mostly done, a local analysis should then be undertaken in order to know the specific characteristics of sensitivity of the area, check the practicability of the previous assessment, model the policy measures, forecast the likely evolution of the area and the transport-related effects and redefine risks and costs. At this scale, more accurate data is available allowing a better measurement of indicators, or giving unique measure for those not available on a European scale.

As an example, the Copenhagen case study stated that "Urban background concentrations are modelled with the Urban Background Model to estimate concentrations on a 1x1 km2 grid resolution to input the modelling of street concentrations which are modelled with the Operational Street Pollution Model." Thanks to a further availability of accurate data, an analysis of the concentration of air pollutants at street level is possible, which is a valuable input for the whole assessment of TSAs and potential application of policy measures.

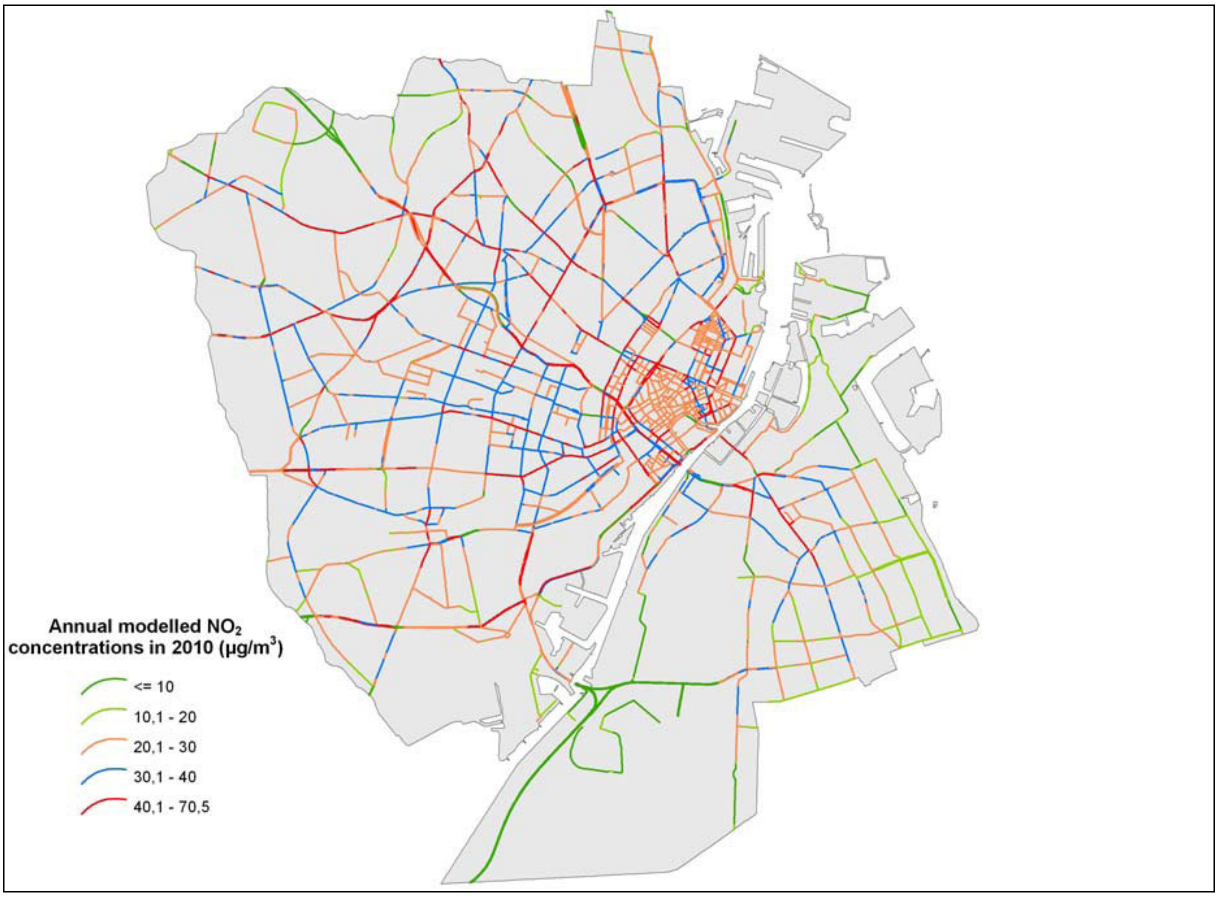



**Figure 17: Mode result for air pollution at street level. Copenhagen case study.**

In addition, there are a number of issues that could have been studied in a general scale but where more precision is needed to become relevant. For example, when assessing air pollution and noise in the selected areas at broader scale (in the Pyrenean or alps area), resulting values should be taken as an approximation, as these are local impacts affecting a very limited area, and influenced by very local variables. The characteristics that impose an area as more vulnerable due to a poor circulation of air, or the actual assessment of the number of people affected by noise in a given area, are variables that require local scale analysis. Gathering accuracy in the impact analysis and its monetization or its conversion to economic effects is a crucial issue to improve practical acceptability of the concept and local support once the measures are ready to be implemented. Sophisticated methods and specific indicators according to concrete points of interest would give light to some of these impacts, but the lack of measurements and data collections on the already known EU- sensitive areas is a major point of interest, as we still do not have relevant references to build from.

However, local analysis could most of the times be better defined by local administrations, making use of specific data and sometimes without employing complex methods. Once the broader analysis is done, local stakeholders could receive the outcome and investigate the different impacts that would be derived by the implementation of policies, and then report back. Different administrations should cooperate accordingly to reach an optimal alternative, if needed, to the original situation of TSAs.

*Global scale*

Several case studies undertaken in WP5 reveal that the implementation of a policy or policy package in one area could strongly affect another sensitive area. Local environment may be improved but traffic simply reroutes and diverts itself on to non-managed areas and the problem is merely shifted away but not solved. Therefore, it is vital for a regulator to be at the upper level to take into account both local and more general impacts The analysis at the broader scale (national/EU wide) should identify these situations and solve them, opting for the best balanced solution at all scales and different locations.

In addition, global scale needs to be fully considered as well. The initial argument was that global warming would not be analysed, as TSAs and policy measures to be applied will depend very much on local conditions and impacts. However, case studies have demonstrated that this approach could often be counterproductive and not easily understood. The idea is to ensure that the positive effects in one specific area do not produce negative overall effects as a result of rerouting, an increase in the number of vehicles-kilometre. This can actually be detrimental to the overall welfare.

It is therefore fundamental that there is a global regulator monitoring the performance of the measures rather than focusing exclusively on the local improvement. Once global effects are also identified, they can be taken into account in a CBA. Otherwise, the best solution could not always be achieved, as not all effects are effectively managed.

### 3.2.4 The impact on the ASSET methodology

It is been already mentioned that ASSET is concentrated on the European scale, as its aim is "to develop the scientific and methodological capabilities required to implement European policies…". Therefore, we kept the focus on the TSAs that are relevant from a European perspective (European / international significance), developing the methodology and concepts under this perspective throughout all work-packages. However, as several case studies have demonstrated, the conceptual and methodological approach can also be applied to other scales, and new indicators have been proposed to enhance such application. Moreover, even when applying the concept to an European scale, a minimum assessment of results taking account of the local and global scale is also required to fulfil the task of providing the best possible result.

Therefore, the ASSET methodology should take account of the need to assess the results derived from the application of measures at different scales of work, as it has been argued. Figure 20 shows the process once TSA and Policy Relevant Areas have been identified. Once the policy measures at the small scale (large areas) are defined and modelled, the analysis of results at that scale will determine whether the proposed measures are beneficial to the identified TSAs and the surrounding areas. If that is not the case, i.e. results obtained are not as beneficial as expected, a redefinition of the measures proposed or their geographical application should be followed. On the other hand, when the assessment of results at small scale is satisfactory, a similar analysis at the local and global scale is needed in order to assure its feasibility while eliminating or minimizing undesired effects.

The objective is to reach an optimal result from the three points of view. The subsequent analysis could be done by the same body or by different administrations in cooperation.

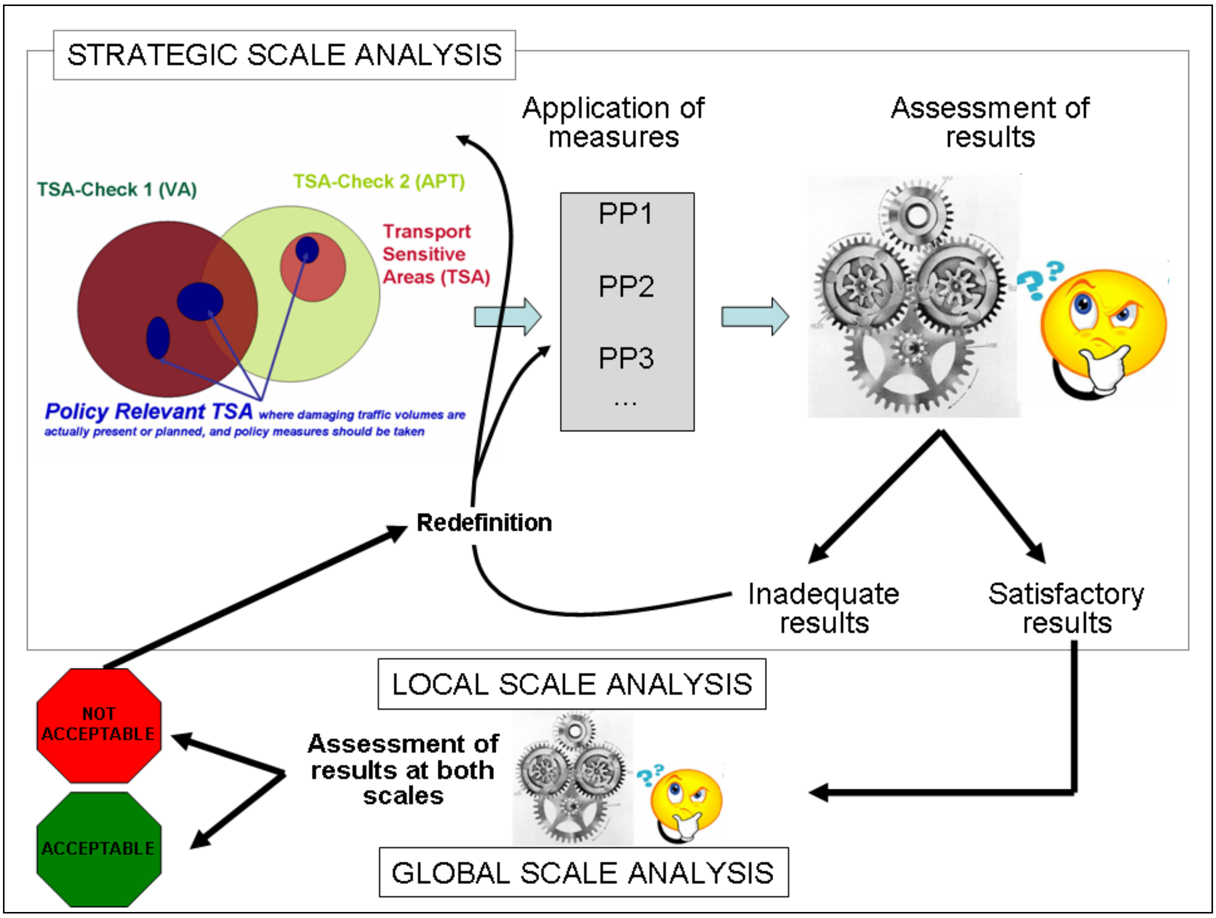



**Figure 18: ASSET Methodology and scales of work.**

## *3.3 Definition of Indicators and thresholds*

Most of the indicators defined in deliverable 2 as the drivers of sensitivity to transport have been applied with success in the case studies. Section 2.4 of the present report reveals how case studies have dealt with indicators, stating the general assessment on their use, weak and strong points, and even proposing new indicators where relevant. It has been reported that both the scale of the area under study and data availability have limited the suitability of a number of indicators according to the case studies performance. This section will therefore revise the use of indicators under the proposed ASSET methodology in order to be further implemented in future applications.

| Indicator | | | | Noise | Air pollution | Infrastruc-ture | Accidents |
|---|---|---|---|---|---|---|---|
| **Number** | **Name** | **Description** | **Threshold** | | | | |
| **Check 1** | | | | | | | |
| 11 | Population density | - | 90-percentile | X | X | X | X |
| 12 | Sensitive ecosystems | Natura 2000, UNESCO biosphere reserve | Yes / No | X | X | X | X |
| | | European Coastal Erosion Layer | Yes / No | - | - | X | - |
| 13 | Cultural Heritage | UNESCO World heritage site | Yes / No | X | X | X | X |

| Indicator | | | | Noise | Air pollution | Infrastruc-ture | Accidents |
|---|---|---|---|---|---|---|---|
| **Number** | **Name** | **Description** | **Threshold** | | | | |
| **Check 1** | | | | | | | |
| 14 | Touristic and recreational value | Number of overnight stays/Km2 | 90-percentile | X | X | X | - |
| 15 | Connectivity Index | Measure of ease of movements | Average within Natura 2000 sites | - | - | X | - |
| 16 | Tunnels | | 500m. lengh | - | - | - | X |
| 17 | Pollution of groundwater | Ground water protection zone | Yes /No | - | - | - | X |
| **Check 2** | | | | | | | |
| 21 | Topography | Altitude differences | 400m. in 1 km | X | X | X | X |
| 22a | Wind Speed | Possibly frequency of wind above certain velocity | to be determined in WP3 | X | - | - | - |
| 22b | Wind Speed | Low wind speeds | 10-percentile | - | X | - | - |
| 23 | Temperature | Possibly average yearly temperature | to be determined in WP3 | X | - | - | - |

**Table 30. Indicators and thresholds defined in ASSET D2, pg 132**

The present section is included in the report with the aim of clarifying, in the light of case studies performance, what should be the role of the indicators and thresholds, their suitability at different scales, and their implications for mapping.

The suitability of the indicators was assessed by the Case Study Partners, and their views were summarized in WP5 and section 2.4 of the present report. Basically, previous work has revealed that the proposed indicators are more adequate for transnational/strategic case studies (Pyrenees, Alps…) and regional/intermediate, but more research is needed to identify suitable indicators to be applied at large scale (specially agglomerations). Case studies performance and the ideas and proposals that came across are relevant basis to proceed and motivate further research.

Population density and sensitive ecosystems are the most frequently used indicators during the case studies analysis, whereas topography was applied just in three examples and wind speed was not used at all. This leads to the idea that sometimes it was not the concept that it failed, but the lack of data or the scale of work. There are also situations where the indicator was defined in a proper manner, but there is no evidence on the threshold to be used, and generalizations led to confusion and rejection.

The present report has discussed the difficulties in understanding the concept of Transport Affected Area (TAA) as it was firstly proposed. In fact, Check 2 indicators were scarcely used, and several case studies were unable to carry out the identification of areas where the presence of a transport route leads to particularly higher pressures. Only the topography indicator was used in this Check 2, and it was felt that the TAA concept was substantially more mature for its application to mountain areas. The experience gathered over time in dealing with mountainous areas, their particular sensitivity, and transport flow related problems have facilitated the definition and availability of data to successfully proceed with the analysis at a large geographical level, usually involving more than one European country.

However, it is believed that Check 2 concept is needed and could be also feasible at other levels.

It has also been noted that several indicators obtained little attention when undertaking case studies: “temperature”, “connectivity”, “road tunnels”, “cultural heritage” and “ground water pollution” where very scarcely used. On the other hand, the indicator “Pollution of Ground Water” was considered as a high relevance indicator, but was not used by any case study mostly because of the lack of data.

As a result, the present document should review why these indicators were rejected, poorly used, or definitely appreciated, and which circumstances made change this assessment. The scale of work is regarded as a key issue, as one size does not fit all, and some indicators can only be applied at a given scale. Previous sections of the present report have shown how a detailed methodology of assessment based on the analysis at three geographical scales should help to reach the pursued objectives. Indicators for each scale of work should therefore be used, and the present section is design to deal with the latter. Other point of interest for the classification of indicators is the different typologies of transport sensitive areas.

### 3.3.1 The use of indicators & thresholds vs the scale of work. Old and new proposals

Section 2.4 of the present report dealt with how case studies have made use of the indicators proposed by ASSET D2, the reasons for not using some of them and the amendments proposed, while section 2.6 review the issue of scale and space highlighted also by case studies performance. On the other hand, section 3.2.3 proposed defining three different scales of work when undertaking TSA projects at EU level, as a suitable approach to deal with the mentioned problems in a feasible way.

During the discussion about definition of TSA and the scale of work, it has been said that the definition of sensitive areas and Transport Sensitive Areas should be independent of the scale of work, as everything is sensitive to a certain extent. Therefore, the level of detail should allow to define TSA more precisely, to use more accurate data and therefore a refinement of already used indicators, and to gather new data at local scale and then use indicators define for that scale, but the actual threshold of a given indicator or a combination of indicators to define TSAs should not change according to the scale of the analysis.

This is why it has been decided to join the discussion on indicators with that on thresholds. It is believe that both concepts should be considered together as the same “cut-off” value should be applied for a given indicator regardless the geographical area concerned in order to be qualify as a pan European concept without misinterpretations. Similar requirements lead to similar possibilities.

On the other hand, the experience gathered in the case studies reveals the need to apply fixed thresholds for each indicator instead of the use of percentiles, as the latter is context-dependent (see discussion on the population density indicator).

### 3.3.2 Check 1 indicators and thresholds at EU-strategic scale

POPULATION DENSITY

It is clear that high population densities are a feature of sensitivity against potential transport related impacts. In fact, it has been highlighted as a relevant indicator for the four types of effects considered: air pollution, noise, infrastructure and accidents. This indicator should select areas where the high population density would lead to more severe impacts. According to the search undertaken (see ASSET D2), reliable data is available even at 100m x 100m-grid. This is a suitable indicator for working on all scales, giving such detail of data available.

Once assuring availability of data and usefulness of the indicator, the main difficulty lies in the definition of a threshold. Here is where case studies have stated disconformities with the proposed threshold of the 90-percentile chose to select the highest 10% of Europe with the highest population density.

As ASSET D2 already pointed out, it must be clearly stated that there is no scientifically correct threshold, being a political decision more or less arbitrary. The higher the threshold, the smaller the area qualified as vulnerable. However, as the work on the EU-wide mapping exercise has revealed, the vast majority of the EU population is living in agglomerations which only take up a few percent of the EU's territory. As a consequence, a 90-percentile threshold includes areas down to 75 inhabitants/square-kilometre, according to the population density map modelled by JRC. Therefore, relative indicators (and percentile thresholds) mean that everything is sensitive to a certain extent, as depending on the reference (EU population, region population, municipalities…) the threshold varies. Of course, the use of percentiles results in an absolute threshold when the calculation method and the reference are constant - 90 percentile of EU population density is an absolute threshold- but case studies reveal that such a constant reference is not well acceptable. If that is the case, and is not assured the actual use of a fixed reference, then we should not use percentiles. On the contrary, it will be better just to give the value (90 percentile of EU population density) as absolute threshold. We may not know a good threshold, but percentiles are misleading.

The example of how Trans-Pennine Corridor case Study dealt with this indicator strengthens the idea: *"Doubts on which area should be taken into account when calculating this indicator have risen in the present study, as results would be different when considering only the area under study or Europe-wide population values"..."The population densities in our case study have been calculated based on data of the 2001 Census for output areas (OAs), the smallest statistical unit used in England with at least 100 residents and 40 households (ONS, 2007). On OA level, population densities in the case study area vary between 2 and 90,000 residents per km2 with a median value of 4,560. The 90-Percentile value is 8,970. However, when applying the 90-percentile rule to higher levels of administrative regions, the threshold drops to 4,625 for wards and 2,230 for counties. In conclusion, we found the 90-percentile population density indicator too arbitrary and decided to apply the UK definition of AQMAs instead."*

We have reached the point where one of the most interesting issues of ASSET lies. Whether the definition of Transport Sensitive Areas as a European concept potentially used in regulatory frameworks should be independent of the scale of work (as mentioned above) and therefore could not be a political decision beyond the EU itself. An important problem would be faced if indicators and thresholds defining TSA at EU-level are relative, context dependent or policy dependent. In that case everything could be a EU-TSA, and potentially a TSA at

EU-level could be anywhere if thresholds are varied, with the implications that such qualification could eventually mean on EU legislation. The best approach should be setting a threshold valid for this indicator, capable of identifying the most densely populated areas at any scale of work for qualifying TSA at EU level, regardless of other approaches at national or regional level (on national or regional legislation). However, case studies have found this indicator highly relevant, as it is clear that some dense areas are affected by major EU transport routes. But how dense is too dense?

Absolute values on standardised grid sizes would be helpful. In addition, assigning thresholds based on the area covered is neither feasible nor advisable. However, it is hard to find scientific evidence for selecting a threshold or a cut-off value. Eventually, we have found cases where thresholds are to a certain degree a question of political decisions. Is the administration in charge of the legislative measure that should set up a suitable threshold, valid within its territory, where policies are to be implemented and experienced. This is common in EU legislation, as the Environmental Impact Assessment Directive, where a number of projects as minimum requirements for nations are set up, whereas nations have also the possibility of enlarging the list in their own transpositions.

For example, Article 2 of Directive 2008/50/EC on ambient air quality and cleaner air for Europe, deals with the definition of agglomeration, relevant for designing action plans an mapping purposes, but fails to propose a fixed threshold of population density to assist on its exact delimitation. Instead, the Directive opts to leave the responsibility to member countries: "'agglomeration' shall mean a zone that is a conurbation with a population in excess of 250000 inhabitants or, where the population is 250000 inhabitants or less, with a given population density per km2 to be established by the Member States".

In the Spanish legislation we can finally find a fixed threshold for the delimitation of agglomerations. The Real Decree 1513/2005 that develops The Law of Noise 37/2003 deals with this issue in its Annex VII, establishing a threshold of 3000 residents per km2 to be applied to census sections (the smallest statistical unit used in Spain). The agglomeration is defined by sections in isolation or grouped if the horizontal distance between them is less than 500 metres. When the total population of group sections is higher than 100.000 inhabitants, the total area is considered an agglomeration, having several legal effects.

Noise Directive leaves the responsibility of setting a threshold to member countries, but the implications are "protective", i.e. mapping the area and designing an action plan will be required. However, there are no further implications on setting charging schemes or influencing transnational transport flows, as it is the case, eventually, of TSAs. This is why it seems better to set up a threshold at EU level for EU TSAs, regardless of further developments at national or regional level.

So one question that is still open is therefore what threshold should be used for population density indicator. For example, 3000 residents per $km^2$ could be a good threshold. It will of course select vulnerable areas, automatically qualified as TSAs at EU level, where political measures would be applied. By using this threshold, few areas within the EU would be selected, just dense agglomerations, but this is actually the purpose of the indicator. Other indicators would select different zones by alternative attributes.

A second question is the threshold to be chosen for qualifying APT areas (defined by Check 2) as TSAs. It has been said that a lower threshold should be established, as APT are areas where transport pressures would be significantly higher than in other areas due to environmental conditions. ASSET D2 proposed a 75 percentile instead of 90 percentile in these areas. This would mean that a threshold of 2500 residents per km2 should be applied

SENSITIVE ECOSYSTEMS

Sensitive ecosystem is the second most used indicator in the case studies undertaken. There is no doubt that nature protection areas should be considered as a relevant indicator at all scales, as there is reliable data available. When working at European-strategic scale, this indicator is crucial for understanding the potential of the TSA concept in the EU.

In particular we take into account Natura 2000 areas and UNESCO biosphere reserves. Those two figures of protection will pose a sound basis for the identification of TSAs in a given area, and both are supported by a clear legal international background. There are 553 UNESCO's Man and the Biosphere Programme sites worldwide in 107 countries, whereas Natura 2000 has built up a vast network of over 26,000 protected areas covering all the Member States and a total area of around 850.000 km2, representing more than 20% of total EU territory, constituting the backbone of the EU's internal policy on biodiversity protection. For marine areas the transport sensitive areas have already been defined by the International Maritime Organisation (IMO), namely the Particularly Sensitive Sea Areas (PSSA).

The main concern arisen during case studies was the feasibility of including national/regional protection figures to enrich the indicator. This amendment was made by several case studies (Omberg, Trans-Pennine) based on the presence in the corresponding case study areas of areas of outstanding natural value which are protected under national/regional protection figures but are not or only partly included in the Natura 2000 network.

Again, the question here is also the implications derived from leaving TSAs classification on political decision beyond the EU itself. The main advantage of using Nature 2000 and UNESCO Biosphere sites as an indicator of sensitive ecosystems is data availability and political consensus over a given area in order to reach the qualification. On the other hand, Natura 2000 sites are selected on the basis of national lists proposed by the Member States. They submit a list of the best wildlife areas containing the habitats and species listed in the Habitats Directive and the Birds Directive. This list must then be submitted to the European Commission, and an evaluation and selection process on European level will take place in order to become a Natura 2000 site.

Therefore, the process is controlled by the EU, whereas all countries (and regions) could freely send their areas of interest to them, assuring that a precious ecological area will be part of the network. The fact that the EU is controlling the process help in avoiding misinterpretations between countries or regions, and is an optimal basis for implementing the TSA concept as an EU figure for policy implementations.

The importance of this point is obvious when a radical example is analysed: In ASSET D2 we said that Sensitive ecosystems indicator (threshold yes/no) is defined by the presence of internationally protected areas, and other national/regional protected areas could be added on a more local scale. Therefore, any EU region (i.e., a border region) could potentially define its whole region (or an area crossed by an existing transport route) as protected under regional legislation, and then has the basis of being qualified as EU-TSA. The latter means that the area is potentially elected for applying special charges for transport flows that, eventually, could divert traffic to other areas (i.e. TSA qualified by the population indicator) or even make conflicts on competitiveness between EU countries.

Therefore, we propose to use only international designated areas as Check 1 “sensitive ecosystem” indicator, as they are multilaterally defined and controlled. However, national and regional natural protected areas would act as a lower threshold for Check 1 “sensitive ecosystem” indicator, i.e., if an area is classified as APT by Check 2 and is also protected by the national or regional legislation, that area is a TSA.

At the same time, nations and regions could also define TSAs at national or regional level that will be defined by natural areas nationally or regionally protected, although those TSAs should not have EU-wide implications unless a sort of verifying process is established. On the other hand, it is worth to remind that most of the national and regional protected areas are already Natura 2000 or could also be included within the definition of TSA by other indicators, namely connectivity index or recreational and touristic value. Regarding its inclusion in Natura 2000 network, and as stated in ASSET D2 page 86, there is a high percentage of regional and nationally protected areas that overlap with Natura 2000.

On the other hand, the European Coastal Erosion Layer, which was proposed as a subindicator for defining sensitive ecosystems (and TSAs) has not been mentioned during the CS process. Whereas the Mediterranean case study clearly dealt with maritime areas, there was no other case study on coastal areas. As a consequence, there are not arguments against or in favour of dropping this indicator, so it should be maintained for the time being.

Several case studies proposed to use a buffer around figures of protection. Although it makes sense to consider that not only those sites are important for ecological protection, but the surrounding areas in order to assure connectivity and support a range of vital ecosystem functions, more scientific evidence should be found to support the idea and it will depend very much of the rest of indicator values. ASSET Deliverable D3 and the web EU mapping tool has set up a buffer of 1 km around Natura 2000 areas. According to the Habitats Directive any plan or project not directly connected with the management of the site but likely to have a significant effect thereon is to be subject to appropriate impact assessment of its implications for the site in view of the site’s conservation objectives. However, the precise distance from which adverse effects is likely to disturb the site it is still not clear.

CULTURAL HERITAGE SITES

The aim of this indicator is to enrich the definition of TSAs considering also additional aspects that contribute to what could be named socially / culturally sensitive area. It was proposed that the best way to consider this issue is to add those sites catalogued as areas of special cultural heritage by UNESCO, as a feasible proxy. Similar to what has been said above on sensitive ecosystems, sites catalogued by this figure of protection guarantee its quality and international relevance. They are also available in GIS format, facilitating its use at any scale of work, whereas it is more relevant at local/project scale and not visible at EU scale.

The vast majority of these sites are small roman ruins, churches, abbeys or carvings. This size makes its inclusion dependent on the level of analysis and potential of mitigation measures. In a European analysis, small sites are irrelevant, but on project level, they will play a role in route planning / infrastructure design and protection matters. Being the latter true, its inclusion in a GIS system facilitates its management even on a EU scale, they are simply not relevant when undertaking such analysis, but its location is monitored, which could be useful in some cases.

In addition, case studies have also proposed the inclusion of areas of outstanding cultural and heritage value which are protected under national/regional protection figures but are not part of UNESCO network. The reflection made above, regarding sensitive ecosystems and how to consider national/regional protection sites is relevant also here. We propose to use national and regional cultural areas as a lower threshold for Check 1 “cultural heritage sites” indicator, i.e., if an area is classified as APT by Check 2 and is also identified as of cultural importance by the national or regional legislation, that area is a TSA.

In terms of thresholds, it is clear that the presence/absence of the protected figure is what identifies the site as vulnerable, but case studies have also proposed to use a buffer zone around the site. It was proposed to use a buffer of 1000 metres but, although some distance from the transport route must be kept in order to enjoy the site, more scientific evidence would be needed to support the idea.

TOURISTIC AND RECREATIONAL VALUE

One reason why an area can be transport sensitive is its high touristic value as a recreational area. Deliverable 2 made a comprehensive discussion on the importance of using this indicator in the assessment of sensitiveness, showing different alternatives for measuring this aspect and the disadvantages or main concerns involved. Finally, it was chose to use the number of nights per km2 as our indicator.

Again, case studies have dealt with this indicator, and they give some comments for its improvement. The main reasons for the proposed amendments are the lack of data on overnight stays, the unsuitability of the threshold proposed and the importance of day visits in many of the analyzed areas. Other proposals include the number of vehicles entering a certain zone. In fact, none of the case studies has actually used this indicator, also stating that could be overlapped with mainly the population density and sensitive ecosystem indicators, and therefore is indirectly considered. As a consequence, no thresholds were proposed.

The discussion on the use of different indicators at different scales could be extended to areas of local importance for recreational purposes, i.e., green near recreation areas in densely populated areas, highly relevant at local scale where open spaces are scarce. The difficulty lies In how to measure the relative importance of these areas and how to manage them under a EU-wide perspective. In fact, decisions on the transport system at that scale are placed at the local administration level, and usually they are areas with no major through EU-transport flows. Therefore, its relevance as an European-wide concept is unsure. Subsidiarity is a significant concept here, as it is probably the nearest administration (local or regional) the most suitable to take on board decisions on the local recreational area, being aimed at transport related-impacts protection or mitigation. Nevertheless, if these areas are included in the ASSET methodology, then a unique threshold should be established. Should green urban areas be considered relevant as EU-wide concept, then the number of visits to these green near recreation areas of interest for agglomerations is proposed to be included as a check1 indicator at local scale, applying the same threshold used at strategic scale, so almost any green urban space will be classify as TSA.

Beyond green areas with a strong local character, recreational and touristic value indicator is relevant at all scales, depending on the size of the area that is being visited and the administration that is actually obtaining the data. However, it happens to be really difficult to get data at strategic level, as no standardised procedures for data gathering are introduced among national or EU administrations. At local level, data on the number of visits to significant sites or the number of overnight stays per municipality could be easier to get, although case studies experience have shown no success. It is worth to include the number of visits as an indicator of touristic and recreational value, since it could complement the analysis by adding areas that are mostly day visited.

Data on visits to protected natural areas are often obtained in a more stable basis. This could be useful for both areas that are not classified as Natura 2000 but are of ecological importance as well as areas visited for other purposes (cultural areas, among others). Being its relevance as indicator high at all scales, the difficulty now is placed on setting a threshold. The discussion on the use of percentiles is also relevant here, and the problem is also whether to set a single threshold for all type of sites (national or regional protected areas, urban recreational sites, cultural sites, etc) or differentiate it among typologies (natural, cultural, etc). As an example, the average number of visits per year in Spanish natural protected areas (out of those compiling data) in 2004 was 31400 visits/year. Moreover, once an absolute threshold is proposed, a second problem will be how to delimit the area that has been visited, in order to qualify it as TSA. In that sense, there must be a previous reference to properly delimit that area (Regional Park, site of scientific interest, historic city centre….)

Again, thresholds set for both the number of overnight stays and day visits indicators should be lower when the area is classified as APT.

CONNECTIVITY INDEX

This is an indicator that has been scarcely used in the case studies. Case studies stated that the main reason is the lack of data to build the indicator. As ASSET D2 detailed, the connectivity index is designed to give information about the easiness of movement for a given animal population to reach similar areas and therefore can express how previously damaged it is in terms of wildlife conditions. Its calculation will need of a geographical database about habitats at European level, as well as a build map of the main barriers and obstacles for wildlife movements. Therefore, the calculation EU-wide is relatively complex. The proposed threshold was the average of the indicator value calculated within Natura 2000 sites, assuming that connectivity index in Natura 2000 areas would be good enough to guarantee easiness of movement.

The mapping exercise done in WP3 has now resulted in a EU-wide map of connectivity index (CI). This map depicts habitat connectivity in Europe, being useful to identify Vulnerable Areas. Habitat connectivity is mapped using an approach on shortest distance to neighbouring habitats of same type. As this map was not available for case studies, we could not assess how the calculated values could represent study areas natural features. On the other hand, the proposed threshold (average value within Natura 2000 sites) has not been assessed either, and therefore further research should discuss its result. However, it is believed that the indicator could be a good proxy of biological potential, joint with field information on rare habitats or areas with high biodiversity. Therefore, this indicator would be valid at all scales, although taking advance of more precise data when working at local environments.

TUNNELS

This is an indicator that is defined as relevant for accidents as a transport-related pressure. Accidents in tunnels entail a high risk of causing large numbers of casualties if hazardous goods are involve, to which the ASSET approach is restricted as it is assumed that general accidents would be dealt with by other policy. As a threshold, tunnels longer than 500m are considered as sensitive for hazardous goods transport, and should be mapped and taken into consideration. Of course, it only applies to existing or planned transport routes, as it is not possible to anticipate potential tunnels placement and length. Again the EU-wide map tool developed in WP3 assists to the task of including tunnels in the analysis proposed in ASSET as tunnels longer than 500m compound a layer to be added to other GIS features.

Regarding the scale of work, it is obvious that there are tunnels longer than 500m that still are not visible at certain scales. However, its location can give valuable inputs for the policy measures to be applied at this scale, as one objective could be to redirect traffic flows to other parts of the transport network or, on the other hand, risk assessment would be needed if traffic is to be lead to existing tunnels as an undesired effect. At local scale, more specific assessment of the risks on tunnels when modelling the new expected situation could be done.

| Check 1 Indicators at EU-Strategic level | | | | Noise | Air pollution | Infrastrc-ture | Accidents |
|---|---|---|---|---|---|---|---|
| **Number** | **Name** | **Description** | **Threshold** | | | | |
| **Check 1** | | | | | | | |
| 11 | Population density | - | ? | X | X | X | X |
| 12 | Sensitive ecosystems | Natura 2000, UNESCO biosphere reserve | Yes / No | X | X | X | X |
| | | European Coastal Erosion Layer | Yes / No | - | - | X | - |
| 13 | Cultural Heritage | UNESCO World heritage site | Yes / No | X | X | X | X |
| 14a | Touristic and recreational value | Number of overnight stays/Km2 within a municipality | ? | X | X | X | - |
| 14b | Touristic and recreational value | Number of visits to attraction sites | ? | X | X | X | - |
| 15 | Connectivity Index | Measure of ease of movements | Average within Natura 2000 sites | - | - | X | - |
| 16 | Tunnels | | 500m. lengh | - | - | - | X |

**Table 31. Check 1 indicators and thresholds at EU-strategic scale proposed after CS performance**

## OTHER INDICATORS RELEVANT AT EU SCALE PROPOSED BY CASE STUDIES

Case studies have also identified different potential approaches to define an area as TSA based on its vulnerability (Check 1). Although they are mainly relevant at local scale, there are several proposals that could be used as complementary indicators for those previously defined. The so-called “degree of naturalness” and “number of species of fauna in the area” both proposed by the Manzanares case study are aimed to complement the sensitive ecosystem indicator, adding valuable information on the specific characteristics of the area under study. Should data be available, these two indicators could produce a more comprehensive map of sensitiveness based on the biodiversity and ecosystem functions. Deliverable 2 also mentioned different approaches to complement the sensitive ecosystem indicator, namely “fragmentation index” and “species-area relationship”.

However, as far as EU-wide TSA concept is concerned, it seems optimal to concentrate on the degree of protection (Nature 2000 sites) as a good proxy in this regard, complemented with the connectivity index map developed by WP3 and available in the Web tool. Both data requirements to build the indicators proposed above and its management to obtain a comprehensive indicator remain as relevant shortcomings to include them in the ASSET proposal to identify TSAs. On the other hand, available information at more local scale could give useful and very interesting details to better understand the area where measures are to be applied and assist to modulate their design.

### 3.3.3 Check 1 indicators and thresholds at large-local scale

Most of the Check 1 indicators relevant at the EU-strategic scale will be also relevant for the local scale. More accurate data will help in the identification and delimitation of the areas, and could also assist to the best design and assessment of policy measures. The methodological approached proposed in section 3.2.4 of this report is actually highlighting the importance of working on three different scales to achieve an optimal result. The indicators that are explained below would play that function, while also giving extra information on issues that could not be optimally analysed at strategic scale but are very much relevant for the aim of ASSET. Below there is an explanation of those proposed indicators that where not addressed at strategic scale.

POLLUTION OF GROUNDWATER

The aim of this indicator was to highlight areas where potential intrusion of vehicle fuels and hazardous goods into the ground water used to produce drinking water would pose an unacceptable risk. Deliverable 2 pointed out the relevance of this indicator, proposing its assessment when undertaking cases studies. However case studies have found it difficult to apply, mainly due to lack of data. Information derived from the recent legislation on water management across Europe, the EU Water Framework Directive (2000 / 60 / EC) and the new Groundwater Directive (2006 / 118 /EC) requiring member states to define and report groundwater bodies, will assist in obtaining a comprehensive map at EU-level. Unfortunately, this is not ready yet, but once member states report to the EU relevant data, a map could be built and these areas will be classified as TSA.

For the time being, the scale of the available maps is far too coarse, and more detailed maps will be needed to allow for a reasonable analysis of transport related sensitivities. Therefore, this is an indicator that could be useful when working at larger scales (local area), where data from the Water Management Administration could be easily added to the analysis.

SENSITIVE AREAS BECAUSE OF HEALTH- SENSITIVE PEOPLE

This is an indicator that has been proposed by Copenhagen case study, and has been included in chapter 2 of the present report. The mentioned case study used this indicator as a valuable input for air pollution impacts. However, it is believed that it will serve for all impacts analysed in ASSET (as well as most of the indicators at more strategic scale) namely noise, transport infrastructure and accidents.

The proposal aims at identifying sensitive areas to transport-related pressures based on the higher sensitivity of the persons that live, work, learn, etc. in a given area. And it is conceived as a twofold indicator. On the one side it will locate relevant public areas that are sensitive because the characteristics of the people that can be found there: workplace database which allows for the localization of sensitive land-use functions (nurseries, kindergartens, hospitals, etc.) and the number of visitors in each of them. On the other side, the indicator will also identify more vulnerable individuals that may be affected by transport pressured to a greater extent, i.e., a residential database with the number of elderly (65+) and children (-14) along transport routes. The age group of children (0-14 yr) and elderly (66 yr +) may be considered to be particularly sensitive in relation to health risk of air pollution.

The main concern is again data availability and what thresholds should be suitable for incorporating this indicator to the assessment undertaken at strategic scale under similar grounds. As far as the first part of the indicator is concerned, an analogy with the EU-scale indicator would mean that the presence of sensitive land-use functions will automatically classify an area as TSA. On the other hand, an indicator based on the number of elderly (65+) and children (-14) along transport routes will pose further difficulties in terms of finding a suitable threshold. No comprehensive proposals have been made in this regard, and should be subject for further research. If we are to propose an absolute value, this will be in relation to the threshold proposed for the indicator of "population density" at EU-strategic scale. That is to say, if 3.000 residents per km2 is proposed as the threshold for "population density", we should derive a suitable threshold for the density of more vulnerable people by applying the EU-average percentage in the population pyramid to the mentioned value.

| **Check 1 Indicators at local level** | | | | **Noise** | **Air pollution** | **Infrastruc-ture** | **Accidents** |
|---|---|---|---|---|---|---|---|
| **Number** | **Name** | **Description** | **Threshold** | | | | |
| **Check 1** | | | | | | | |
| 11 | Population density | | ¿? – same than that at EU scale | X | X | X | X |
| | Sensitive people | Presence of sensitive land-use functions | Yes / No | X | X | X | X |
| | Sensitive people | Number of elderly (65+) and children (-14) | Related to population density threshold | X | X | X | X |
| 13 | Cultural Heritage | UNESCO World heritage site | Yes / No | X | X | X | X |
| 14a | Touristic and recreational value | Number of overnight stays/Km2 | ¿? – same than that at EU scale | X | X | X | - |
| 14b | Touristic and recreational value | Number of visits to attraction sites | ¿? – same than that at EU scale | X | X | X | - |
| 15 | Connectivity Index | Measure of ease of movements | Average within Natura 2000 sites | - | - | X | - |
| 16 | Tunnels | | 500m. length | - | - | - | X |
| 17 | Pollution of groundwater | Ground water protection zone | Yes /No | - | - | - | X |

**Table 32. Check 1 indicators and thresholds at large-local scale proposed after CS performance**

### 3.3.4 Check 2 indicators and thresholds at EU-strategic scale

Proposed ASSET indicators in relation to Check 2 were scarcely used when carrying out case studies during WP5. While it is true that the term Transport Affected Area (TAA) was somehow confused with the actual existence of a transport route, the fact is that most of case studies were unable to carry out the identification of those areas where transport pressures would be significantly higher than in other areas due to environmental conditions (gradients, narrow valleys, frequency of inversions, etc). Changing the name of the Check 2 battery of indicators to APT (Areas with (potentially) higher Pressures from Transport), as it has been argued in previous sections of this report, will probably help in future application. However, as reported from CS, the main reasons provided for not using the proposed indicators are basically their unsuitability or the lack of data. In spite of this, case studies barely proposed new indicators for Check 2 or significant amendments to the existing indicators.

ASSET D2 proposed fewer indicators for Check 2 than for Check 1. There was just the topography indicator for infrastructure related effects that, on the other hand, is a good proxy for several effects (probability of inversions, gradients, amphitheatre effect) as includes the identification of valleys that are also relevant when considering higher noise and air pollution pressures. Moreover, there are three indicators proposed, although they are difficult to assess at strategic scale: two indicators proposed for wind speed, as wind has different effects on noise and air pollution, and the temperature indicator having influence on noise.

As case studies performance reveals, the amount and detail of data required to use temperature and wind speed indicators were not suitable for application at the more strategic scale, and case studies dealing with the local scale encountered difficulties applying wind speed or temperature indicators.

TOPOGRAPHY

The only Check 2 indicator proposed by ASSET that was actually used by CS was the topography indicator. It is worth mentioning that this indicator was much more used and mature enough due to its inclusion in previous projects somehow dealing with transport sensitive areas. Road freight transport through sensitive and border mountainous areas have been of high interest within discussions.

In the EU-strategic scale, topography indicator is used as a proxy for the definition of areas where transport pressures would be significantly higher than in other areas, assuming that steep topography will exacerbate air pollution, noise, infrastructure an accident effects. Actually the topography indicator developed in ASSET D2 was intended to be a proxy for many different effects, highlighting the following:

- Probability of inversions
- Actual or potential transport route gradients
- Amphitheatre effect
- Reflections (echo)
- Decrease of effectiveness in noise barriers
- Curvy roads (braking and accelerating results in higher emissions or even accident risk)

The topography indicator correlates the altitude between points situated within a certain distance. Thus, altitudinal differences above 400 metres are assessed within a 1 km area around a given spot in the territory. This methodology is intended to identify the presence of areas in which concentration of atmospheric pollutants, and amphitheatre noise effects tend to be higher. Within a mountainous area, this indicator is obviously very relevant. Its assessment on a mountain range and its surroundings identify extensive areas, some of them used by transport infrastructures.

Therefore, it is considered a good indicator for EU strategic scale, successfully applied on at least one case study, that need to be complemented at the local scale when undertaking a comprehensive TSA analysis. The amendment and improvement of this indicator at local scale would reveal the actual characteristics of a given valley to experience amphitheatre effects if a transport route is placed, the level of pollutants dispersion that would be achieved or the likely frequency of inversions, to assess how much higher transport related pressures would be in these areas.

Another critical issue is the estimation of the road gradients considered for the study area, although it should be ideally assessed at project scale. Emission factor functions vary according to different gradient ranges. COPERT 4 pollutants calculation model distinguishes between 0%, ±2%, ±4% and ±6% gradient ranges. Differences in emission results of a heavy duty vehicle running along a flat road or a 6% gradient road (either positive or negative) are significant enough to undertake a simplified calculation of the potential gradient of the actual or potential route. The following graph illustrates the variation in emissions resulting from the consideration of the different available engine technology and gradient ranges for a heavy vehicle operating at 50km/h speed and an average load of 50%.

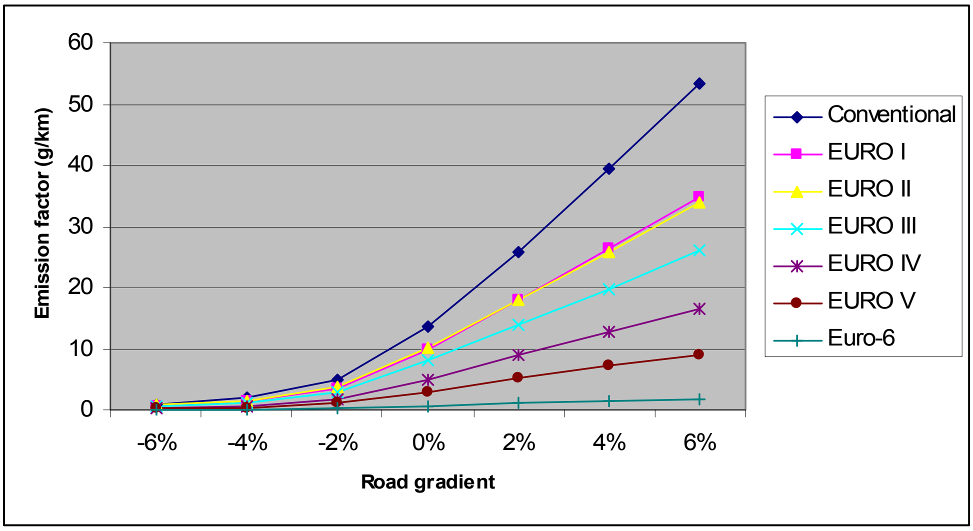



**Figure 19: NOx Emission factors vs engine technology and road gradient for a HGV. Speed: 50 km/h**

The use of geographic information systems and already easily available maps (DEM: Digital Elevation Model 90x90 m.) gives huge possibilities for the assessment of topographical conditions and likely consequences. Also, the EU-wide mapping tool developed by ASSET WP3 actually shows altitude differences, valleys and slopes EU-wide, serving as a valuable help for this first strategic scale analysis in any European area. However, the study should not finish at a broad scale but go deeply into the smaller places. Once the first analysis is done, it is necessary to use more detailed data to refine the assessment.

| Check 2 Indicators at EU-strategic scale | | | | Noise | Air pollution | Infrastruc-ture | Accidents |
|---|---|---|---|---|---|---|---|
| Number | Name | Description | Threshold | | | | |
| Check 1 | | | | | | | |
| 21 | Topography | Altitude differences | 400m in 1 km | X | X | X | - |

**Table 33. Check 2 indicators and thresholds at EU strategic level proposed after CS performance**

### 3.3.5 Check 2 indicators and thresholds at large-local scale

URBAN TOPOGRAPHY INDICATOR

The Copenhagen case study proposed a new indicator in line with the topography indicator, but adapted to the urban context. The Urban Topography indicator is aimed at identifying street canyons in urban areas where dispersion is restricted, leading to higher concentrations of pollutants. Streets can be characterized as street canyons depending on building height divided by street width (H/W).

According to the Copenhagen report:

*"The urban topography plays a major role on concentrations in streets. Street canyons are streets with a narrow street width and tall buildings along the street at both sides. Street canyons restrict dispersion leading to highly elevated concentrations in busy streets. High traffic density in urban areas also leads to high emission density that leads to elevated concentrations in the urban background."*

This interesting approach could add valuable information on how to identify APT in urban areas. It is actually a step forward in the development of the concept, previously restricted to mountainous areas. Similar detrimental conditions to those present in narrow valleys could indeed be found in other environments, such as agglomerations, where the spatial patterns or context configurations could lead to experience significant higher transport pressures than in other areas.

Whereas the proposed urban topography indicator could fulfil the gap for urban areas, there has not been any sound proposal for a Check 2 indicator in other areas, namely maritime or natural non-mountainous areas. Prevailing wind directions leading to pollutants transportation from a main source to natural surroundings in land areas or similar conditions regarding ocean currents and oil spills could be interesting approaches to be further research for these type of areas.

Regarding the proposed urban topography indicator, more research is also needed in terms of finding a suitable threshold for the indicator. Copenhagen case study use this indicator in conjunction with the Average Daily Traffic, but that approach is not in line with what is intended here, the definition of a suitable Check 2 indicator. Therefore, the case study did not propose any threshold to be used in order to classify streets as APT and then use the results to analyse them in the light of other Check 1 indicators outcome to potentially obtain TSAs. As a consequence, more research is actually needed in this regard.

METEOROLOGICAL INDICATORS

The original proposal of indicators for Check 2 included, apart from topography indicator, some indicators related to meteorological conditions, namely wind speeds and temperature, relevant for noise and air pollution effects.

It is clear that meteorological conditions could favour propagation of high local noise and influence the dispersion of air pollution. Wind speed, wind direction, number of inversion events and temperature are meteorological variables of interest for this purpose. Briefly, the temperature influences sound propagation constantly in every direction because the velocity of noise increases with the temperature. Also, noise levels are lower in the direction against the wind, whereas wind speed has mainly an influence for sound propagation at near-ground sources and receivers. On the other hand, inversion events impair the dispersion of pollutants, as well as low wind speed. Inversions also lead to higher noise levels.

However, topography indicator was the unique Check 2 indicators to be used by case studies. At the strategic scale, topography indicator facilitates valuable approximation for these effects, given the difficulty of gathering wind speed or temperature data relevant for the intended analysis. It was said that in local conditions where more data are available the different effects can possibly be captured in more detail than "only" with the altitude difference indicator.

In fact, according to the responses of case studies specific questionnaires, “meteorological data could only be found either for single stations or for whole regions (as an aggregate, but taking the stations’ data as representative). We would need wind speed / temperature on a data scale that would allow identifying which valleys might be prone to higher concentrations / noise.” (Trans-Pennine case study). But case studies working at a more local scale could not use these indicators either.

As ASSET D2 stated “For wind speed and temperature only statistical data or calculated data from a meteorological model, can be taken for the calculation on a European scale.”. WP3 would then analyse available data and the chances to obtain a pan European map data with high spatial resolution. Modelling data exist only at 50x50 km resolution on European scale.

The definition of a suitable threshold was also difficult when analysing meteorological indicators in ASSET D2. It was hard to determine the correct indicator and threshold, and ASSET D2 finally proposed to use 10% lowest wind speeds for the time being, to be reviewed in WP3, whereas no thresholds for the rest of meteorological indicators were defined. However, WP3 found similar difficulties, and, regarding wind speed and temperature indicators, Deliverable 3 shows that no sufficient data could be found to reflect these two proposed indicators at a level of sufficient spatial detail.

However, WP3 dealt with some model simulations to cover this topic, and concluded the analysis by stating that “even though the atmospheric modelling presented here is rather coarse in term of spatial resolution, it should be considered together with the previous indicator on topography, covering the local variations from the overall atmospheric conditions.” Therefore a map renamed “meteorology” is available at the ASSET Web GIS tool showing data on "the influence of meteorological conditions on the dispersion of chemicals by making a simulation with constant emissions of a chemical tracer. Results highlight regions or areas in Europe where air pollution is concentrated due to atmospheric dispersion alone".

As a consequence, Check 2 indicators and thresholds for local scale would need further review, and the identification of APT depends very much on results coming from the topography indicator developed for strategic scale, which serves as a suitable proxy in this regard. The usage of the so-called urban topography indicator in urban areas and the "meteorology" map available at the ASSET Web GIS tool should complement as far as possible the results at local scale, but should not be included to define TSA for the time being.

| Check 2 Indicators at large-local scale | | | | Noise | Air pollution | Infrastruc-ture | Accidents |
|---|---|---|---|---|---|---|---|
| **Number** | **Name** | **Description** | **Threshold** | | | | |
| **Check 1** | | | | | | | |
| 21 | Topography | Altitude differences, complemented with better, more accurate local data | 400m in 1 km | X | X | X | - |
| 21a | Urban Topography | Building height divided by street width (H/W) | ? | X | X | | |
| 22a | Wind Speed | Possible frequency of wind above certain velocity | ? | X | - | - | - |
| 22b | Wind Speed | Low wind speeds | ? | - | X | - | - |
| 23 | Temperature | Possibly average yearly temperature | ? | X | - | - | - |
| 24 | Frequency of inversions | Nº of days/year | ? | X | X | | |

**Table 34. Check 2 indicators and thresholds at large-local scale proposed after CS performance**

### 3.3.6 Summary of indicators

Check 1 is a set of indicators aiming at identifying areas that are environmentally, socially, culturally or economically sensitive because the local impacts due to a given or potential transport pressure are clearly higher than in other areas. The outcome would therefore be named "Vulnerable Areas" (VA).

| Summary of Check 1 Indicators | | | | | Noise | Air pollution | Infrastruc-ture | Accidents |
|---|---|---|---|---|---|---|---|---|
| **Number** | **Name** | **Description** | **Threshold** | **Proposed Scale** | | | | |
| 11 | Population density | - | ? | S/L | X | X | X | X |
| | Sensitive people | Presence of sensitive land-use functions | Yes / No | L | X | X | X | X |
| | Sensitive people | Number of elderly (65+) or children (-14) | Related to population density | L | X | X | X | X |

| Summary of Check 1 Indicators | | | | | Noise | Air pollution | Infrastruc-ture | Accidents |
|---|---|---|---|---|---|---|---|---|
| Number | Name | Description | Threshold | Proposed Scale | | | | |
| | | | threshold | | | | | |
| 12 | Sensitive ecosystems | Natura 2000, UNESCO biosphere reserve | Yes / No | S | X | X | X | X |
| | | European Coastal Erosion Layer | Yes / No | S | - | - | X | - |
| 13 | Cultural Heritage | UNESCO World heritage site | Yes / No | S/L | X | X | X | X |
| 14a | Touristic and recreational value | Number of overnight stays/Km2 | ? | S/L | X | X | X | - |
| 14b | Touristic and recreational value | Number of visits to attraction sites | ? | S/L | X | X | X | - |
| 15 | Connectivity Index | Measure of ease of movements | Average within Natura 2000 sites | S/L | - | - | X | - |
| 16 | Tunnels | | 500m. length | S/L | - | - | - | X |

**Table 35. Summary of Check 1 indicators and proposed scale.**

On the other hand, Check 2 is established to identify **areas where transport pressures would be significantly higher** than in other areas due to environmental conditions. Check 2 results are **Areas with (potentially) higher Pressures from Transport (APT)**

| Summary of Check 2 Indicators | | | | | Noise | Air pollution | Infrastruc-ture | Accidents |
|---|---|---|---|---|---|---|---|---|
| Number | Name | Description | Threshold | Proposed Scale | | | | |
| 21 | Topography | Altitude differences | 400m in 1 km | S/L | X | X | X | - |
| 21a | Urban Topography | Building height divided by street width (H/W) | ? | L | X | X | | |
| 22a | Wind Speed | Possible frequency of wind above certain velocity | ? | L | X | - | - | - |
| 22b | Wind Speed | Low wind speeds | ? | L | - | X | - | - |
| 23 | Temperature | Possibly average yearly temperature | ? | L | X | - | - | - |
| 24 | Frequency of inversions | Nº of days/year | ? | L | X | X | | |

**Table 36. Summary of Check 2 indicators and proposed scale.**

As it was argued, in these areas where pressure is particularly high, a lower threshold for the indicators of Check 1 should be applied to classify an area as TSA. However, most of the final proposed thresholds are absolute (Yes/No), and the use of percentiles has been avoided. As a consequence, as long as further research results on thresholds are not available, we define TSA as those resulting from Check 1 and those that being defined as APT, a lower threshold of Check 1 is suitable (presence of national/regional natural or cultural catalogued sites).

### 3.3.7 Final identification of TSA:

Finally, according to the reasoning of ASSET D2, Transport sensitive areas are defined as noise, air pollution, infrastructure or accidents transport sensitive areas. The latter classification will be relevant when designing policy measures.

As many proposed indicators are conceived to express different effects, i.e., are identical for all four effects, the summary here is presented based on the possible combination of indicators from Check 1 and Check 2, showing the type of resulting TSAs:

| An area is a TSA if: | Type of TSA |
|---|---|
| Population density is above the fixed threshold | Noise, Air pollution, Infrastructure, accidents TSA |
| Population density is above the 75% of the fixed threshold value and it is an APT defined by check 2 topography indicator | Noise, Air pollution, Infrastructure TSA |
| Sensitive land-use functions are present | Noise, Air pollution TSA |
| Number of elderly (65+) or children (-14) is above the fixed threshold | Noise, Air pollution TSA |
| Number of elderly (65+) or children (-14) is above the 75% of the fixed threshold value and it is an APT defined by check 2 topography indicator | Noise, Air pollution TSA |
| Catalogued as Natura 2000 site, a UNESCO biosphere reserve or UNESCO world heritage site | Noise, Air pollution, Infrastructure, accidents TSA |
| Catalogued as national/regional natural or cultural site and it is an APT defined by check 2 topography indicator | Noise, Air pollution, Infrastructure, accidents TSA |
| Included in the European Coastal erosion layer. | Infrastructure TSA |
| Number of overnight stays/Km2 or the number of visits to attraction sites is above the fixed threshold | Noise, Air pollution, Infrastructure TSA |
| Number of overnight stays/Km2 or the number of visits to attraction sites is above the 75% of the fixed threshold value and it is an APT defined by check 2 topography indicator | Noise, Air pollution, Infrastructure TSA |
| Connectivity Index is above the average value calculated within Natura 2000 sites | Infrastructure TSA |
| The road tunnel is longer than 500m (≥ 500m). | Accidents TSA |
| The area is a ground water protection zone. | Accidents TSA |

**Table 37: Transport Sensitive Areas identification.**

## 3.4 DESIGN AND CHOICE OF POLICY MEASURES

The evaluation and cross comparison of case studies has dealt with the important issue of extracting the lessons learned from case studies, in order to improve future applicability of the ASSET methodology. During the project development, the task of designing a framework as common as possible for the case studies evaluation was pursued, especially due to the variety of case studies geographical context and approaches. The provision of a harmonized policy evaluation on each case study was partially possible thanks to similar conceptual methods, the effort on the use of comparable monetary evaluations, and provision of analogous input parameters. On the other hand, the objectives pursued, models used and techniques of assessment were different from site to site, which limits the initial idea of contributing to achieve an identification of the most efficient package of policy measures by sensitive area, whereas contributing to get a comprehensive picture of the know-how and main priorities within the EU.

While the generalization of the case studies findings was not the key objective of the project, it is worth to review the valuable work done by case studies regarding the design and choice of policy measures on each site and contour conditions, trying to establish analogies, if any, within the TSA typologies.

Section 2.9. has already reviewed the policy packages modelled on each case study, their main results and several comments raised by the case studies. To highlight the predominant use of pricing measures (in 9 out of 10 case studies) and regulatory measures (mostly traffic restrictions to certain areas to petrol powered vehicles). On the other hand, there have been sufficient examples of policy packaging tests to recommend accompanying measures to be implemented along all market-based or regulatory measures. Although not the scope of case studies, and therefore not deeply analysed, public awareness on the need of such measures and the effects that are expected and a public debate on the use of revenues will always help to achieve acceptability between stakeholders.

One of the most important outcomes derived from case studies performance is the discussion on the interactions of policy instruments between different areas. There have been examples where the application of measures in a TSA results on undesired effects on neighbouring / other TSAs. This is a key issue for future application of the TSA concept, relevant for all type of TSA.

Similarly to the issues discussed on the use of indicators and the scale of work, the ideas presented in sections 3.2.2 and 3.2.3 could help on the management of these interactions. It is crucial to define the study area based on the administrative or geographical context, but on the interdependencies in terms of transport system networks. The application of a given measure in one specific place could lead to undesired effects in places relatively far away that could also be sensitive or at least not suitable for additional transport related impacts. This also requires a harmonised definition of indicators and thresholds for sensitiveness in order to avoid arbitrary application of the concept.

It is worth reminding here that TSAs require, compared to other areas, additional extraordinary measures in order to prevent or mitigate the local impacts caused by the presence (or potential presence) of a transport route, as the impacts caused are particularly high. And, as Deliverable 1 (Sessa et al., 2008) and deliverable 4 (Gühnemann et al.2008) stated, “extraordinary measures require additional instruments or more stringent implementation of existing measures in situations in which local conditions heavily affect TSAs”. Deliverable 4 continues stating that the latter definition implies local applicability and prompt results in terms of the environmental pressures exercised on TSAs, and undertakes a revision of possible measures in order to proposed suitable candidates.

Based on the measures reviewed and the policy packages proposed for each TSA typology done by Deliverable 4, the following paragraphs will summarise policy packages implementation and potential lessons learned by TSA typology.

### 3.4.1 Policy measures on mountainous areas.

As previously stated, Deliverable 4 offered an overview of policy packages for TSAs to be considered in mountainous areas (from ASSET D4 pg 12):

| Area type : Mountainous areas | | | | | |
|---|---|---|---|---|---|
| **Main policy** | **Required accompanying measures** | **TSA Suitability** | | | |
| | | N | AP | I | A |
| ***Road transport*** | | | | | |
| MP1: differentiated distance based charges<br>MP2: route based charges | - technology<br>- rule on use of revenue<br>- categorisation of vehicles<br>- information | +<br>+ | ++<br>+ | | +<br>++ |
| MR1:area wide low emission zones<br>MR2: temporal access restrictions<br>MR3: zonal permits / quotas<br>MR4: restrictions for hazardous goods<br>MR5: stricter enforcement / sanctions | - categorisation of vehicles<br>- information<br>- enforcement<br>- exemptions | o<br>++<br>++<br><br>+ | ++<br>+<br>++<br><br>+ | | <br>+<br><br>++<br>+ |
| MM1: user charge + environmental zones<br>MM2: tradable access / crossing permits | - categorisation of vehicles<br>- information<br>- enforcement<br>- legal framework | ++<br>++ | ++<br>++ | | o<br>+ |
| MI1: infrastructure improvement | - SEA, EIA | + | + | ++ | ++ |
| ***Rail transport*** | | | | | |
| MP3: subsidies<br>MP4: scarcity and noise track charges | - legal framework<br>- earmarking of revenues | +<br>++ | +<br>+ | | |
| MR6: temporal restrictions for freight | - legal framework<br>- train classification | + | + | | |
| MI2: infrastructure improvement<br>MI3: intermodal terminal investment | - legal framework<br>- SEA, EIA | + | + | ++ | ++ |

Explanations: ++ highly suitable; + positive impact; o low impact

**Table 38. Overview of policy packages for TSAs to be considered in mountainous areas.**

Mountainous case studies have worked with different extraordinary measures. While the Pyrenees case study modelled the introduction of various charges for HGV in different TSAs (MM1 in the above table) found within the more global (TSA) Pyrenean area as well as speed reductions to minimise noise and air pollution in populated TSAs and/or access restrictions to a road stretch (MR4), the Alps case study assessed the introduction of a crossing permit (MM2), the so-called Alpine Crossing Exchange (ACE).

The market based crossing exchange permit for the Alps (ACE) limits the number of lorries allowed to cross the Alps. The best assessment is given to a coordinated introduction of the measure in all Alpine countries. In this case, the right to cross the Alps by road costs about 100 to 150 € per lorry leading to a large shift of transport from road to rail.

Restricted HGV access on a corridor in the Pyrenees gave negative results due to redistribution effects, whereas speed reductions achieve good results in terms of minimising noise and air pollution effects, as well as improving general road safety.

Common conclusions on both Alpine and Pyrenean regions are:

- The focus on one TSA or single corridor is not able to give the full picture of impacts as the measures can lead to redistribution of traffic between the different corridors that would be minimised if a larger area is considered.
- Extraordinary measures on mountainous case studies lead to a large shift of transport volumes from road to rail. The capacities for Alpine an Pyrenean crossing rail freight traffic have to be large enough to cope with the shifted transport volumes from road (MI measures)
- The need to properly consider special measures for short haul transport, such as a price reduction for short transport distances, in order to limit the negative impact on regional commerce.
- Coordinated implementation is required in all interested border countries to reduce overall road freight transport volumes.

The effects of an additional introduction of a low emission zone (LEZ) have also been analysed in the Alps. It was shown that the positive effects on air quality are so small that that the LEZ cannot be recommended considering the implementation and control costs.

Both case studies dealt only with goods transport, but as stated by the Alpine case study “if the environmental effects in the Alpine valleys should be reduced by a still larger amount, passenger transport must also be addressed.”

### 3.4.2 Policy measures on agglomeration areas.

Similarly to the assessment on mountainous areas, Deliverable 4 also provided an overview of policy packages for TSAs to be considered in agglomerations areas (from ASSET D4 pg 11):

| Area type : Urban / Agglomeration | | | | | |
|---|---|---|---|---|---|
| **Main policy** | **Required accompanying measures** | **TSA Suitability** | | | |
| | | **N** | **AP** | **I** | **A** |
| ***Road transport*** | | | | | |
| UP1: differentiated distance based charges | - technology | + | ++ | | o |
| UP2: cordon charge | - rule on use of revenue | + | + | | o |
| UP3: area pricing | - categorisation of vehicles | + | + | | o |
| | - information | | | | |
| UR1:area wide low emission zones | - categorisation of vehicles | o | ++ | | o |
| UR2:zonal access restrictions | - information | ++ | ++ | | ++ |
| UR3: temporal access restrictions | - enforcement | ++ | + | | o |
| UR4: stricter enforcement and sanctions | - exemptions | + | + | | + |
| UI1: infrastructure improvement | - land-use planning, SEA, EIA | + | + | ++ | ++ |
| UI2 : land use planning | | ++ | ++ | + | |
| UM1: area pricing or cordon charge + environmental zones | - categorisation of vehicles<br>- information | ++ | ++ | | o |
| ***Rail transport*** | | | | | |
| UP4: subsidies from cross-financing | - legal framework<br>- pricing measures | + | + | | |
| UP5: track charges | - legal framework<br>- use of revenues | + | + | | |
| UR5: restrictions for freight | - legal framework<br>- train classification | + | + | | |
| UI3: infrastructure improvement | - land-use planning, SEA, EIA | + | + | ++ | ++ |
| ***Airports*** | | | | | |
| UP5: differentiated landing charges | - regulation / technology | ++ | ++ | | |
| UR6: operational restrictions | - regulation / technology<br>- enforcement | ++ | + | | |
| UR7: noise quotas / budgets | - regulation / technology<br>- enforcement | ++ | + | | |
| UM3: tradable permits | - Regulation / technology<br>- enforcement<br>- establishment of trading rules | ++ | + | | |
| UI4: runway planning and alignment | - SEA/EIA | + | + | ++ | |
| ***Water transport (Ports)*** | | | | | |
| UP6:- differentiated port charges | - regulation /technology | ++ | + | | |

Explanations: ++ highly suitable; + positive impact; o low impact

**Table 39. Overview of policy packages for TSAs to be considered in urban/agglomeration areas.**

Copenhagen and Budapest are the case studies more directly dealing with agglomerations, although the Trans-Peninne and Frankfurt Airport case study also included in the analysis some considerations on urban contexts.

Copenhagen tested eight measures individually (see table 25) and no combined packages have been assessed. Some of the policy packages are also alternatives e.g. toll ring (PP7) and road pricing (PP8) where only one policy package would be implemented. Most of the measures introduced are technology –based (NOx reduction equipment on HDV, ban for certain pollutant vehicles, introduction of low emission vehicles) whereas a "German environmental zone regulation" (UR1) and a toll ring and road pricing scheme (UP3) are also considered.

On the other hand, Budapest case study proposed an access fee (UP3) that should be a part of the so-called 'transport charging strategy', which contains the unified public transport fares, parking fees, and considers also fuel prices, on the base on the price of a single public transport ticket. Budapest case study points on regulation of both the city's generated and transiting traffic in order to improve the local environmental conditions. The restrictions and higher charges only in parking are not sufficient, because the through-going traffic should also be restrained. For this an area access fee can be considered which (combined with a low emission zone scheme) is able to reduce congestion (driver) and reduce air pollution, noise (indicators) to improve the liveability of the inner areas.

One of the conclusions derive from Copenhagen is that measures introducing cleaner emission vehicle technology as part of an environmental zone were more effective in reducing environmental impacts than pricing measures (toll and road pricing) and traffic management.

Of course, it is not trivial to design policy packages as a number of criteria may guide the definition of policy packages such as the environmental impacts, the time aspect of implementation and achieved benefits, implementation and user costs, legal and political feasibility etc. Both case studies shown that it is technical challenging and resource demanding to assess impacts of a larger number of policy packages in a comprehensive way that encompasses: traffic impacts, environmental impacts, environmental costs, implementation costs, etc, and therefore results should be taken with caution. However, it is true that both agglomeration case studies have tested similar measures with good results and have also pointed out further thoughts that should be taken into account for future applications.

It is very interesting that Budapest case study highlights the need to introduce the proposed measure as integrated within a more comprehensive city strategy in order to get good results. That is in fact a combination of different policies that could facilitate the synergies that TSAs action is looking for. It is also stated that recent infrastructure developments and political circumstances will need to be considered before the measure is launched, although the acceptance of such kind of measure is increasing since the traffic and air quality issues are more and more severe. The regulatory measures (technology improvements) modelled by Copenhagen could also help to get even better results in such a whole city strategy.

It is also worth to mention the existence of potential undesired effects reported by Budapest, namely an overall time losses due to rerouting. Whereas the introduction of measures would be beneficial to the TSA, an analysis of a wider area (metropolitan area) response is more than recommended in order to detect and minimise potential unintended effects that could limit the advantages found in the TSA after the implementation of the proposed measures.

Regarding the Frankfurt Airport case study, not intrinsically a urban-type, and given that air pollution and noise are the major problems, regulatory (Emission Trading Scheme ETS-EU) and pricing instruments (Kerosene tax) in order to restraint traffic in these areas have been considered. It is said that in the air traffic sector, the most efficient solution for addressing the environmental damages from transport activity is to combine market based instruments with the application of technical and regulative measures.

Model results obtained by the case study found that kerosene tax produces better results than charges, and there would be even better effects if the fleet would be renewed. An interesting approach that was also tested is the CDA (Continuous Descent Approach), where the aircraft stays higher for longer, descending continuously, requiring significantly less engine thrust than prolonged level flight. This policy package became important already and will be more important in the future, if the approach procedures will be improved and further developed.

Changing transport related issues in air traffic is very complicated in comparison to the other modes, because airports (and Ports) depend on the demand they are capable to attract, and therefore political measures in a strong law regulated sector from the international level (and national/regional) required previous widespread agreements to respect competitiveness between nodes.

### 3.4.3 Policy measures on non-mountainous areas.

A number of non-mountainous areas were also considered in ASSET case studies to test the methodology developed, as this typology is of course very important in the EU context. As a consequence, Deliverable 4 also provided an overview of policy packages for TSAs to be considered in agglomerations areas non-mountainous areas (from ASSET D4 pg 13):

| **Area type : Non-mountainous ecosystems** | | | | | |
|---|---|---|---|---|---|
| **Main policy** | **Required accompanying measures** | **TSA Suitability** | | | |
| | | **N** | **AP** | **I** | **A** |
| ***Road transport*** | | | | | |
| EP1: differentiated distance based charges | - technology | + | ++ | | + |
| EP2: route based charges | - rule on use of revenue | + | + | | ++ |
| | - categorisation of vehicles | | | | |
| | - information | | | | |
| ER1: low emission zones | - categorisation of vehicles | o | ++ | | |
| ER2: seasonal access restrictions | - information | ++ | + | | + |
| ER3: zonal permits / quotas | - enforcement | ++ | ++ | | |
| ER4: restrictions for hazardous goods | - exemptions | | | | ++ |
| ER5: stricter enforcement / sanctions | | + | + | | + |
| EM1: user charge + environmental zones | - categorisation of vehicles | ++ | ++ | | o |
| | - information | ++ | ++ | | + |
| | - enforcement | | | | |
| | - legal framework | | | | |
| EI1: infrastructure improvement | - SEA, EIA | + | + | ++ | ++ |
| EI2: mitigating measures for habitats | | | | | |
| ***Rail transport*** | | | | | |
| EP3: subsidies | - legal framework | + | + | | |
| | - earmarking of revenues | | | | |
| ER5: temporal / operating restrictions for freight | - legal framework | + | + | | + |
| EI4: infrastructure improvement | - legal framework | + | + | ++ | ++ |
| EI5: mitigating measures for habitats | - SEA, EIA | | | ++ | |
| ***Airports*** | | | | | |
| EI6: runway planning and alignment | - SEA/EIA | + | + | ++ | |
| ***Inland Waterway Transport*** | | | | | |
| EP5: differentiated harbour fees | - categorisation of vessels | + | + | | + |
| EP6: lock fees | - rules on revenue use | + | + | | + |
| ER6: route / operating restrictions | - legal framework | + | + | | + |
| EI6:infrastructure and planning | - SEA/EIA | + | + | ++ | |
| | - legal framework water protection | | | | |

Explanations: ++ highly suitable; + positive impact; o low impact

**Table 40. Overview of policy packages for TSAs to be considered in non mountainous areas.**

The case studies that have dealt with non-mountainous areas are Omberg in Sweden, Trans Peninne Corridor in the UK, Cuenca del Manzanares in Spain and Lipno in the Czech Republic.

Tourism is an important factor for this TSA typology, which both politicians and regional market actors would like to see increasing. Therefore, there is a conflict between trough traffic or the growing number of tourists entering the region by car/coach (also generating additional HGV traffic for supplies etc) and the sensitive area. Therefore this typology ascertains also valuable examples on the conflict that was presented and that was the motivation of the ASSET project itself.

The measures applied by this TSA typology on the case studies have varied from road infrastructure improvements (combined or not) with pricing policies, to cordon charge schemes or speed limitations, as well as different supportive measures for non-motorised modes. Overall, it has been a very rich experience, as different combinations of measures in so many contour conditions have derived in a number of relevant points of interest that will undoubtedly help future application of the methodology. This section tries to extract the most interesting conclusions from all these four case studies, without losing the perspective applied on each of them.

Lipno case study introduced measures to support the environmentally friendly transport modes. It involves namely public passenger and non motorised transport. In the field of public transport support the new less-emitting and less-noise buses are planned to purchase and introduce into operation. Also, several segments of cycling routes are planned being part of the over-regional cycling route. On the other hand, traffic restriction in terms of vehicle speed limits and restrictions to the most polluting vehicles are also planned.

Omberg case study considered pricing policies and infrastructure planning and investment, both packed and on isolation. There is an old road that passes an area of high cultural, natural and touristic value. Due to the strategic location of the area it has not been seen feasible by politicians to redirect traffic from the area and reduce the encroachment from the road. Contrary, the increasing demand of transport and especially road freight transport “demands” an improvement of the old road. However, such an improvement will be accompanied by an unacceptable increase in the visual and physical intrusion. The politically accepted solution is to build a new road outside the core of the area. The new road will attract passenger cars but will hardly change the behaviour of HGV drivers as they have a higher rate of distance dependent cost in relation to time dependent cost compared to car drivers. To redirect also HGVs, it is necessary to implement some kind of demand management measure.

Omberg case study states that a toll solution is a rather expensive way to solve this problem, whereas the possibility to include encroachment cost into a kilometre charge (or tax) system with a different charge for this area looks more promising (although limited by the current Eurovignette directive). In fact, encroachment of the infrastructure and the traffic on the landscape is considered the crucial component and therefore plays a key role in the policy package chosen.

On the other hand, Manzanares case study reveals that speed reduction produces better results than the distance based charge in terms of reduction in vehicle flows and environmental and health burdens. Moreover, its cost of implementation and maintenance are much lower. It is worth to highlight that the benefits in terms of air quality that occurred between 2004 (base case) and 2020 in Manzanares are very large even if no transport policy is implemented (BAU scenario), due to the renewal of the fleet. The analysis of the potential spill over effects caused by the transport policy measures is also highlighted by Manzanares case study, as something that future research activities could include.

However, whereas speed reductions deter traffic from the Cuenca Alta del Manzanares Natural Park to remote roads, the adverse effects that may appear in other areas had not been taken into account. This is a relevant point that previous sections of this report have tried to revise, and also other case studies have duly highlighted.

Relevant conclusions on the later point are also drawn by Trans-Peninne case study. This case study has analysed pricing policies in a setting where the price setting strategies of two Transport Sensitive Areas have a direct consequence on each other's welfare. The study highlights the importance for a regulator to be at the upper level to take into account both local and global impacts when setting charges for cordons, as there is a potential of falling into a trap when local environment may be improved but traffic simply reroutes and diverts itself on to non-managed areas. The problem is merely shifted away but not solved. The research carried out reveals that cordon charging alone might be a too blunt instrument to achieve the full benefits of environmental protection while retaining user benefits, although it still showed overall positive welfare impacts. Therefore, it seems necessary to undertake an analysis of a wider area than that previously anticipated by solely looking at a specific TSA. Transport system interactions should delimit the minimum area that would need to be analysed, complementing that area size by other aspects (see section 3.2.2).

As the Trans Pennine case study reveals, accompanying measures can mitigate some of the encountered effects and would improve the welfare results further. A motorway toll might prevent the extensive rerouting problems encountered. In addition, site specific measures such as differentiated lorry bans or low emissions zones could alleviate some of the environmental problems and, thus, decrease the charges necessary to cover environmental costs. Moreover, in a real world application, charging would need to be accompanied by other measures, i.e., improvements in public transport.

Another conflict issue in the Omberg case study is that the policy packages that seems to be the most suitable to protect this region from encroachment, especially the area of Omberg/Tåkern, are also those that cause the greatest increase in emissions of air pollutions that could probably be mitigated by e.g. stricter emission standards. The importance of sensible decision-making in the planning of new infrastructure, based on comprehensive studies and environmental assessments, in transport sensitive areas is an essential outcome of this case study.

Enhancing the acceptance and compliance with the measures proposed is a common concern in case studies. As Omberg points out, one option is to inform all relevant actors about the reason why a charge is needed, how it will be designed, the levels of the charge, etc. Manzanares case study also stated that increasing of travel costs is not well accepted by society, nor the reduction on speed limit. Therefore, it would be necessary to launch an information campaign to make people aware of the need of such policies. However, quoting Omberg again, although earmarking of revenues to transport-sector purposes has been shown to be an important factor to gain public acceptance for road pricing, the practical implementation in Sweden is more problematic due to a legal system that discourages earmarking. This is quite an interesting issue, as similar barriers are found in other countries.

### 3.4.4 Policy measures on maritime areas.

ASSET methodology was also tested in relation to maritime areas by undertaking a case study on the Mediterranean Sea. Whereas indicators and thresholds for sensitive areas were design for land transport related impacts, it was considered useful to carry out an analysis on maritime environment. Deliverable 4 also presented an overview of policy packages for TSAs in marine and coastal areas (from ASSET D4 pg 13):

| **Area type : Marine and coastal areas** | | | | | |
|---|---|---|---|---|---|
| **Main policy** | **Required accompanying measures** | **TSA Suitability** | | | |
| | | **N** | **AP** | **I** | **A** |
| ***Water transport*** | | | | | |
| CP1: differentiated harbour fees | - classification of vessels | + | + | | + |
| CP2: differentiated fairway fees | - rules on revenue use | + | + | | + |
| CP3: oil compensation fund | | | | | ++ |
| CR1: MARPOL regulations | - legal framework | o | + | | ++ |
| CR2: other access restrictions | - classification of vessels | o | + | | ++ |
| CI1: infrastructure and planning | - SEA/EIA<br>- legal framework water protection | + | + | ++ | + |

Explanations: ++ highly suitable; + positive impact; o low impact

**Table 41. Overview of policy packages for TSAs to be considered in marine and coastal areas.**

Mediterranean case study clearly stated that policy packages in the Maritime sector must combine economic incentives and technical measures to address effectively environmental issues. There is in fact high potential for reducing emissions from regulative and technical measures. The economic incentives as the differentiated Port dues and fairway scheme in Sweden may improve the degree of implementation of the technical measures in a more cost effective way.

Similar to what has been said referencing the Frankfurt Airport case study and the need of a common international regulation for air transport, the international regulations and safety standards in the maritime sector should be implemented by all the coastal countries of the Mediterranean Sea. Integration and cooperation between involved parties (i.e. Flag States, port States and Coastal States) as well as the reinforcement of the regional position are necessary for preventing pollution from maritime transport related activities including accidental oil spill tankers.

The Mediterranean case study has addressed mainly policy issues. In particular, the transferability of the Swedish scheme to the Mediterranean Sea appears to be difficult, unless a dedicated Regulator (Agency) is set up at EU level. In fact, it should be considered that the Swedish scheme was born after a common agreement between the Swedish stakeholders (Port authorities, ship owners and the Swedish Maritime Administration) was set up. The agreement (working on a voluntary basis) was underpinned by a common sharing of environmental concerns and a common institutional and cultural context. On the other hand, the European Ports are characterized by an extreme variability of regulations and administrative tradition, which makes difficult a voluntary agreement without the legislative preconditions that only a dedicated administrative level is able to provide. A specific commitment in this direction from a European Agency would be needed.

In the Maritime sector, the most cost effective solution for addressing the environmental damages from transport activity is to combine market based instruments with the application of technical and regulative measures. In the Maritime sector the traditional instruments for traffic demand management, e.g. pricing, regulation, etc, may be not effective in consideration of the practical absence of congestion. Ports suffer in general of overcapacity and the episodes of congestion depend primarily on the lack of land based infrastructure provision (terminal, rail/road connections) rather than on demand. This implies that the most cost effective way is to focus on the supply side measures; in particular through the combination of technical measures associated with economic instruments for ensuring an implementation which takes in duly account transport user's preferences and provides incentives for good environmental practices.

## 3.5 ENVIRONMENTAL BURDENS AND ECONOMIC VALUATION OF EFFECTS

Section 3.2.4. of the present report shown the impact of the necessarily assessment at three different scales on the ASSET methodology. Whereas the indicators and thresholds defined above are aimed at effectively identifying TSAs EU-wide based on information and data available at both European and local scale, the assessment of environmental burdens and economic valuation of effects will assist in the choice of the optimal policy package to be adopted on each area. The choice should be based on the analysis of local costs and benefits, but also on the impacts at larger scale and even global results. As it has been argued, the optimal choice should protect those areas with unique features, while minimising or eliminating undesired or unintended in other areas.

The main challenge for policy makers is to devise strategies and measures that reconcile the current and future growth in mobility with the need to reduce emissions and environmental damages. Finding an acceptable trade off based on flexible and pragmatic policies should be the ultimate ASSET goal. In order to reach the latter, all case studies assessed the measure of the effectiveness of specific policy packages, and, as far as possible, have used common values for external costs to facilitate harmonisation. However, as section 2.7 described, it was not always possible to use similar approaches for all case studies when undertaking the assessment of environmental burdens and the economic valuation of effects.

Whereas the diversity and large variety of case studies points out the actual context and richness of the potential TSA in Europe and serves as a valuable test for the proposed methodology, this diversity also makes difficult the use of "one size fits all" approach. Different TSA typologies and contour conditions demand different assessments. But all of them have dealt with similar pollutants when calculating emissions, and methodologies used are scientifically sound.
The quantification of people affected by noise needs specific data at very local scale. The use of generalized data may affect the robustness of the impact and therefore the economical assessment, but detailed local scale analysis were out of the scope of the case studies due to the lack of data and time. Buildings layout, local topography, vegetation, manmade features, structures and the relative location of noise receptors and sources to these features are all aspects of the environmental setting that can influence noise impact potential, and generally have not been considered. However, noise assessment in case studies reveal that general approaches are suitable, presenting the minimum requirements for an in deep analysis at local scale when needed.

There have been also good examples of comprehensive consideration of accidents in relation to TSA areas, which will be very valuable for future applications of the methodology. On the other hand transport infrastructure impacts were scarcely considered, as the attention of case studies was mostly placed in well-known areas that present unique features and where existing infrastructures and transport impacts are already above or near preoccupant values.

The main outcome from case studies performance regarding calculation and assessment of environmental burdens is the need to also assess CO2 emissions as global regulator, capable of highlighting situations that could easily be very beneficial for a given local area but detrimental for the global protection. The assessment of its emissions will help in the identification of the best package of policy measures.

The economic valuation of environmental impacts was, however, one of the main concerns during case studies analyses. CS results show difficulties in applying HEATCO project factor costs due to various and numerous reasons, as stressed in section 2.8. A comprehensive and EU-wide system to calculate external costs is very much needed. Different economic dimension and valuation of the costs produced by transport impacts from country to country would probably require different approaches to calculate external marginal costs for human based impacts. However, it is also clear that more homogeneous values are needed across Europe in order to make possible the development of sound cross-border assessments, specially when dealing with biodiversity. Differences between country values are far too high, which makes a cross-border approach to the calculation of external costs controversial.

A general conclusion after the use of the existing costs for environmental impacts, is that the strongly focus on human impacts and underestimate negative impacts on nature protection (and recreation). E.g. HEATCO only proposes a value based on population exposed to noise at point of residency, there is no noise value for sensitive habitats or recreation.

In addition, the reason behind the identification and effective management of TSAs is that transport related impacts on TSAs deteriorates the quality of the area clearly more than in another area, because the local impacts caused are particularly high. Therefore, external environmental marginal costs should also be higher in TSA than in other areas, but we still do not have solid grounds to propose a given figure. How much higher?. It surely depends, again, on particular local features, the characteristics of sensitiveness on each particular area. However, in order to apply the TSA concept EU-wide, generalizations on these values would need to be adopted and assumed, to facilitate a feasible approach to the problem. More research on this matter is again needed.

## 3.6 Transferability

This section aims at summarise the main points of interest raised by case studies in order to comprehensively facilitate the transferability of ASSET methodology to other contour conditions. A questionnaire including transferability aspects was sent to all case studies during WP6, and the content of this section is mainly based on the responses, derived from the evidence gained on its application on case studies. Finally, the questionnaires also gave light to what would be the expected reaction of the different stakeholders identified by case studies.

### 3.6.1 ASSET methodology.

What may appear simple to implement from best practices or abroad examples may turn out to be complicated from the standpoint of gaining the necessary support from the respective politicians and stakeholders to enter into a new approach to solve different problems in specific situations.

As with any interactions that involve crossing cultural boundaries, we should also recognize the differences in terms of missions and goals, which are of relevance for the implementation of measures in a given situation. The approach in the implementation of a common methodology could be different from country to country, or even within each nation, in a diverse territory as the EU. Therefore the methodology should be proven and established enough to maintain its basis and avoid misinterpretations whereas letting certain flexibility for its concrete application.

But in fact, local conditions, interest, political circumstances and the maturity of the concepts that are managed may of course be key components of the actual application and the degree of acceptability that different measures will gain in different situations. It is well proven that the internal and context-dependent complex relationships that affect transferability issues have been often underestimated.

The diversity of case studies undertaken in ASSET is a good example of how dissimilar contour conditions might be. It will be completely different the approach that should be taken for the application of the measures proposed (which are not equal, of course) in the Alps than in the Pyrenees, but also quite diverse those to be applied at the Balkans. Taking account even different TSA typologies, the importance of the issue is evident. However, it is considered that the methodology proposed is solid enough to facilitate the basis for a common understanding within the EU, using similar tools that are now available (specially the ASSET Web GIS tool) and the approach to define, identify and delimit TSAs.

Regarding the responses facilitated by case study' partners, it is worth noting that the main concern is placed on how particular conditions on each territory will impact in the concrete application of the ASSET principles. General suitability to all potential situations is perceived as guaranteed, although more efforts could be placed on adapting the methodology to the various scales of work. It is believed that previous section of the present deliverable, in which the problems of scale and their impacts in the methodology are discussed, could solve some of these concerns. Specifically, the delimitation of a comprehensive area of study and the assessment of potential undesired effects, as well as the use of different indicators depending on the scale.

In general, case studies responses reflect that the scale of work is an important variable in determining the extent to which ASSET methodology can be transferred successfully between situations. New indicators (and thresholds for those indicators) could be added when more accurate data are available at local scale, enriching the knowledge on what should be exactly a TSA when diverse and complex parameters are available.

Once TSAs are defined, proposals for policy measures to urgently improve the current situation should be devised.. In so doing, the following caveats have to be considered:

- The focus on one TSA or single corridor inevitably fails to provide a full picture of impacts, as measures adopted at a single area/corridor level can lead to redistribution of traffic between the different corridors that would be minimised if a larger area is considered. Hence, the choice of the application area of a policy should take into account transport interdependencies as well as implementation costs and the legislative powers of implementing institutions.
- Coordinated implementation is required, in particular in cross-border applications, in order to reduce overall transport volumes and avoid traffic diversion and relocation of environmental impacts. This also holds true for smaller scale applications if more than one authority is involved.
- Accompanying measures are necessary for fiscal as well as regulatory instruments in order to improve acceptability and to reduce undesired impacts e.g. through use of revenues for extending capacities for alternative modes: Extraordinary measures on mountainous case studies lead to a large shift of transport volumes from road to rail. The capacities for Alpine and Pyrenean crossing rail freight traffic have to be large enough to cope with the shifted transport volumes from road. It is also necessary to properly consider special measures for short haul transport, such as a price reduction for short transport distances, in order to limit the negative impact on regional commerce.

### 3.6.2 Reaction of stakeholders

During the life time of the ASSET project, stakeholders have been formally involved twice[5], including representatives from:

1. the scientific community: researchers, academics, and experts on environmental analysis, national parks, and ecology, including e.g. National research institutes. Their main interest in ASSET has been focussed on the definition of thresholds for the identification of sensitive areas
2. Environmental agencies and bodies: NGOs and environmental authorities (national and European): e.g. T&E, EEA, interested in the ASSET outcomes, in particular as far as the environmental mapping of sensitive areas and the identification of thresholds for the assessment of environmental damages, are concerned
3. Policy makers: at national, European and local level: e.g. Member States representatives, National ministries experts (Ministries of Transport, Environment), consultancies, etc, interested in the policy implication of the identification of transport

[5] Namely at the June 2009 Workshop in Segovia and at the Final Conference in November 2009 in Brussels.

sensitive areas and the related efficiency and effectiveness of policy packages and measures.

In general, the stakeholders reactions can be summarised as follows (classified by the respective areas of interests):

- **Scientific issues**. The ASSET indicators and thresholds may be too crude when changing the scale of analysis. More detailed indicators could be needed at local level. The suggested thresholds may be not very useful without the indication of the appropriate scale, and in some case difficult to apply, especially the "percentile" ones. The intrinsic difficulty of defining them beforehand has been stressed; and it has been suggested that the thresholds already defined at national and EU level for instance in the framework of air quality and noise regulations could be used for assisting the identification of thresholds. The importance of improving the evaluation of side effects of transport activities has been stressed, with a particular reference to environmental and social aspects

- **Environmental agencies**. The ASSET web tool has been well received, in terms of compatibility of data sets and GIS requirements with the European standards, e.g. the DG TREN standards for GIS data representation. Issues like the future maintenance of the web site have been raised, leaving the door open to future investment and developments. However, several problems still remain to be solved:

  - the integration with transport data networks (e.g. from transport networks as TRANS-TOOLS)
  - the possibility to enlarge the geographical scope of the tool to new accession countries
  - the possibility to include the calculation of external costs, e.g. integrating the ASSET web tool with the GRACE tool (http://www.grace-eu.org/) and in general to serve transport policy evaluation

- **Policy issues**. The suitability of the ASSET approach to delimit the area where extraordinary policy measures should be applied (e.g. the perimeter of a urban charging scheme) has been discussed and highlighted as a key issue to be solved. It has been suggested that policy implementation needs a coordinated approach, in particular in cross-border applications, in order to reduce overall transport volumes and avoid traffic diversion and relocation of environmental impacts. This also holds true for smaller scale applications if more than one authority is involved.

Multidisciplinary and horizontal issues cutting across the above topics have also been raised by the stakeholders, e.g. the degree to which the ASSET outcomes serve the implementation of pricing policies. To this purpose, two aspects have been discussed:

1. Internalization of external costs. This is an issue not explicitly addressed by the ASSET case studies, that have in general estimated the environmental toll of transport activities without analysing the degree to which this is covered by the designed charges.
2. Impacts assessment of pricing policies. Interesting input have been provided by the ASSET case studies, both in terms of modal shifts and traffic detours arising from charging schemes (in the Alpine, Pyrenees and Manzanares case studies), and in terms

of policy implementation, as the need to take account of regulatory and institutional measures in supporting pricing measures.

# 4 Project Conclusion

## 4.1 Further research

ASSET has set the foundations of a comprehensive approach to the definition and identification of Transport Sensitive Areas and the design of effective policy measures for their protection, aiming at balancing their environmental protection with the provision of an efficient transport system. Throughout the life of the project several barriers arose in the form of scientific knowledge gaps, methodological difficulties and insufficient data availability. These issues have already been highlighted in the corresponding sections of this document and comprehensive proposals have been presented.

Amendments to some of these issues have been reported in this Deliverable, some of which were directly originated by the Case Studies application of the ASSET approach, while others were emerged at a later stage, when the Case Studies were reviewed and discussed, with the contribution of experts and stakeholders.

However, several questions still require further development in order to achieve a comprehensive and mature management of the Transport Sensitive Areas at a European scale, as well as a valid conceptual approach for national or regional Administrations.

Research needs have been highlighted throughout this report in the concerned sections and are briefly summarised below:

### 4.1.1 Definition of Indicators & thresholds

The ASSET approach is indicator driven, and the definition of indicators and thresholds is therefore a key issue for success. Overall, Case Studies performance has revealed that more research is needed for application to concrete, local situations. While the experience gathered over time in dealing with mountainous areas and related strategic studies have facilitated the definition and availability of data to successfully proceed with the analysis at a transnational geographical level, this is less true for local levels of analysis, where the indicators proposed were found less suitable and new indicators have been proposed, although more knowledge is needed to fully use them.

This is especially true for Check 2 indicators, since several case studies encountered difficulties in the identification of areas were the presence of a transport route would lead to particularly higher pressures. Among the proposed indicators for Check 2, only the topography indicator is widely used, being a suitable indicator especially for mountainous areas (although urban case studies have developed a way to adapt this indicator to the urban context). Even though the topography indicator was selected assuming that steep topography exacerbates air pollution, noise, infrastructure and accidents, further and more precise indicators reflecting these phenomena are required. The two former impacts (air pollution and noise) could be assessed at a local scale by means of meteorological indicators, but Case Studies performance revealed the need for further effort in data production and gathering in this respect. Indicators oriented towards infrastructure and accidents Check 2 analysis need to be further developed.

Although the finally proposed indicator set is considered to be comprehensive, the main difficulty with Check 1 lies in the definition of suitable thresholds. Thresholds need to be defined for indicators like population density and overnight stays or tourist visits. The difficulty here is to find a good threshold that can be applied at all scales of work and situations EU-wide. On the other hand, the connectivity index has revealed as a complex and effort demanding indicator for its individual calculation on case studies, but its relevance would recommend a more comprehensive EU-wide calculation, which will offer the threshold value too, as GIS tools can provide good and widespread results valid for all scales of work.

### 4.1.2 Design and Choice of Policy Measures

The difficulty in drawing straight policy conclusions, i.e. a definitive generalization of the insights from the ASSET case studies, originates from two main factors:

1. The Transport Sensitive Areas as identified by the ASSET methodology are complex and heterogeneous in scale and type. They vary from urban areas (agglomerations) to wider mountains and naturalistic sites and areas, involving different receptors, human and other natural species (biodiversity). The transport impacts to be considered are manifold, i.e. in practice all the side-effects of transport activities as studied in the past years and acknowledged by a robust stream of scientific evidence have to be addressed: from noise to air pollution, accidents, and damages from infrastructure provision (separation effects, encroachment, etc). The only exception is the congestion, depending on traffic volume and lack of infrastructure provision, and as such not included in the ASSET criteria for identifying the sensitiveness to transport activity[6]
2. The ASSET case studies, in order to take in due account this intrinsic complexity along a two years and half research project, have been designed to provide illustrative examples addressing all the type of TSAs: urban areas, mountain areas, marine and naturalistic areas, making at the same time problematic to draw clear conclusions. Additional case studies would be required to fill the gaps emerged from the project exemplary cases.

Namely:_

- When approaching the design and choice of policy measures, case studies performance has highlighted that the definition of the case study area is a crucial issue, which can alter the results of the assessment depending on whether the impacts on surrounding areas have been considered or not. This question affects both market-based and regulatory measures, since they are likely to result in traffic rerouting that may migrate environmental burdens to adjacent areas. Therefore, while the use of administrative limits and geographical context for the case study area delimitation is still highly recommended, it is also essential to include interdependencies with

[6] See the ASSET D2 for the related discussion: “A transport sensitive area (TSA) is an area where the presence of a transport route deteriorates the quality of the area clearly more than the presence of the same transport route in another area because the local impacts caused are particularly high”... “This definition is independent of the traffic volume and even of the presence or absence of a transport infrastructure”…” The traffic volume (actual or predicted) becomes relevant as soon as policy measures become the focus of the discussion: Only in sensitive areas with damaging traffic volumes (i.e. traffic volumes above a threshold that is acceptable for the area under discussion) policies have to be found to reduce the impacts caused in the sensitive area.” ASSET D 2 , Identification and assessment of sensitiveness, page 13

surrounding (or even distant areas, depending on the scale of the case) as delimitation criteria. Further insight on how to properly approach this task is required.

- A second key issue that requires further research relates to the packaging of policy measures. A common conclusion from case studies is that the combination of different kinds of policies may result in better results. But precise knowledge on which combinations of measures provides the most efficient synergies under each contextual characteristic is still lacking.

- Linked to this latter issue, a shared concern is the acceptance and compliance of the society with the proposed measures. It is assumed that accompanying information and public awareness measures are required, but there is little scientific ground provided on how these kinds of measures can enhance the performance of the policy measures tested.

### 4.1.3 Environmental Burdens and Economic Valuation of Effects

Although it was not always possible to use similar approaches for all case studies when undertaking the assessment of environmental burdens and the economic valuation of effects, all case studies used scientifically sound methodologies for that purpose. Steps forward in the adoption of a common framework for this approach would be valuable, but not essential. More critical is the need for consensus on issues like the pollutants to be considered when assessing air quality, and the extent to which buildings layout, local topography, vegetation, manmade features, structures and the relative location of noise receptors and sources, have to be considered when assessing noise. This would provide a solid ground for a really harmonized and fully comparable assessment framework (despite of the differences in the methods and tools used for calculation). Further research on the consideration and assessment of infrastructure related impacts also seems to be needed.

As shown in the Omberg case study, in fact, other effects arising from transport infrastructure development as land take, barrier effects and visual intrusion, i.e. the so called encroachment effect, need to be appropriately considered, implying the development of contingent valuation methods for the monetary evaluation, further developing the HEATCO methodology assumed in ASSET as common basis for the evaluation (http://heatco.ier.uni-stuttgart.de/).

Finally, another relevant concert that arouse after complying with the cross comparison of case studies is the clear anthropocentric approach to impact evaluation. This strong focus on human impacts leads to the underestimation of negative impacts on nature protection (and recreation) which may distort the sign of the overall assessment, especially in the event of rerouting (as already mentioned above), where potential environmental benefits are opposed to time losses, both affecting the social welfare, but with a clear opposed character. Research efforts to develop more environmentally oriented assessment methods are required.

## *4.2 Conclusions*

The cross site evaluation, building upon the findings of the entire ASSET project, allows to formulate a number of preliminary conclusions which deserve to be validated by further research on Transport Sensitive Areas in Europe:

- Case studies have helped to reach a comprehensive and context independent TSA definition, as an **area where the actual or potential presence of a transport route deteriorates the quality of the area clearly more than in another area, because the local impacts caused are particularly high.**

- The definition is established as a **twofold concept**, compound by areas that are generally **vulnerable to transport pressures (VA)** because the presence of sensitive ecosystems, populated areas, heritage sites, etc. **plus areas where transport pressures would be significantly higher than normal due to environmental conditions (APT)** , i.e., topographical steepness**.** Vulnerable Areas intrinsically define TSA, whereas APT areas need also a certain character of vulnerability to become TSA.

- Therefore, the definition finally achieved is clear on what is to be considered as a TSA under EU procedures and legislation, giving concise and detailed indicators, and developing suitable thresholds as far as possible. The concept has been managed with the aim at being applied on EU regulation, creating a solid framework to avoid misinterpretations and context-dependent definitions, setting agreed criteria based on firm principles and consensus.

- It has been proved that few but well established indicators work really well in big areas. Topographic conditions, protected areas, and even population density seems to set up the general framework for regional scales in order to look for solutions at that level. Population density also gives good results at this scale, even when no clear threshold to be applied at EU level is defined at this point. General indicators are widely available, and present the minimum requirements for a TSA analysis and policy package application.

- The need to assess the results derived from the application of measures at different scales of work has been fully argued. Local environment may be improved but traffic simply reroutes and diverts itself on to non-managed areas and the problem is merely shifted away but not solved. Therefore, it is vital for a regulator to be at the upper level to take into account both local and more general impacts The analysis at the broader scale (national/EU wide) should identify these situations and solve them, opting for the best balanced solution at all scales and different locations.

- But it is also important to include in the analysis the areas that could be affected by undesired or unintended effects due to the application of the policy measures considered. It would have little sense to implement a policy package that, while improving the situation of a given TSA, is worsening other areas or even global conditions to an unacceptable level. The latter was clearly stressed by case studies

- It is also fundamental that there is a global regulator monitoring the performance of the measures. The idea is to ensure that the positive effects in one specific area do not produce negative overall effects as a result of rerouting, an increase in the number of vehicles-kilometre. This can actually be detrimental to the overall welfare.

- Generalization of the case studies findings is not the key objective of the project. However, the application of policy measures and the outcomes derived by case studies, and summarised here, should be considered in future applications of the methodology and policies proposed in ASSET. It was not the aim of ASSET to develop new forecasting tools for transport and policy assessment in TSAs but to test our concept with existing tools in order to achieve a wider coverage of types, modes and regions. The lessons learned here will be helpful in the future, and allow setting up more solid grounds.

- Among the points mentioned throughout the text, the monetization of environmental and health effects, its use in transnational projects, and the need to define higher external environmental marginal costs in TSAs are still open issues that will need to be further researched.

- It is worth to highlight the transnational scope of several case studies where two or more countries are involved, which may have implications in the development of the ASSET approach, especially in the economic valuation of environmental and health effects, as well as in the design and choice of policy measures. The potential application of the approach and methodology in wide areas, under the jurisdiction of different authorities or governments, is a fundamental outcome of the project.

- It also highlighted the potential application in areas with major through transport flows, especially transnational traffic, so that decisions on transport are not placed in the area. A common, harmonised approach defined at the EU-level is considered to be very helpful in this regard.

- Even if there are no one-size-fits-all solutions, there are processes which can help to identify the best solutions, and which allow the possibility of involving administrations in the future of transport and TSAs, and this is what is meant by the outcome of ASSET.

- Despite the heterogeneity of policies tested in the case studies , a first series of important conclusions on the applicability of instruments to different types of TSAs have been reached, but further research into the design of policy packages and implementation issues is required in order to avoid undesired impacts and optimise output.

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