PLUREL

Driving Forces and Global Trends

Module 1

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PERI-URBAN LAND USE RELATIONSHIPS – STRATEGIES AND SUSTAINABILITY ASSESSMENT TOOLS FOR URBAN-RURAL LINKAGES, INTEGRATED PROJECT, CONTRACT NO. 036921

D 1.3.1

Environmental drivers – method & baseline

Research Strategy and Baseline Profile

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SIXTH FRAMEWORK PROGRAMME

Contents

Document history

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Abstract

Objectives/aims

This deliverable (D1.3.1) is an important output of WP1.3 and performs 2 key functions; to outline the WP1.3 research strategy and to present the baseline profile that provides a framework for the investigation of environmental drivers of change.

Methodology

The description of the research strategy offers a useful insight into the approaches being followed during the study of the impact of environmental drivers of change on peri-urban land use relationships. An important element of this strategy is the preparation of a baseline profile. This incorporates descriptions of recent trends and current status of four environmental resources (air, biodiversity, soil, water) being explored within WP1.3. In doing so, the baseline profile raises awareness of the environmental resources that play an important role in shaping peri-urban land use relationships. Further, the baseline profile will be utilised within WP1.3 to consider the potential impacts of future drivers of change on the environmental resources that influence land use change in urban and peri-urban areas.

Results / findings / conclusion

There are major impacts from current trends in peri-urbanization, on the environmental media of soil, air, water and bio-diversity. These are both direct cause-effect relationships, and indirect impacts from systemic effects.

Popular science description of main results

Air quality is a problem mainly from road transport in urban and peri-urban areas. In areas of heavy industry there is also emissions from power generation, industrial processes.

Soil erosion is a problem which is due to compound effects of rural decline and abandonment: rapid urbanization and loss of landscape structure: climate change impacts, heatwaves and drought:

Water resource shortages, water quality problems and flooding are each inter-related, and an outcome of peri-urbanization, with climate change, landscape degradation etc.

Key words

Research methods, baseline profile, European environment, air quality, biodiversity, soil, water.

Classification of results/outputs:

For the purpose of integrating the results of this deliverable into the PLUREL Explorer dissemination platform as fact sheets and associated documentation please classify the results in relation to spatial scale; DPSIR framework; land use issues; output indicators and knowledge type.

Spatial scale for results: **Regional, national, European**	**European**
DPSIR framework: **Driver, Pressure, State, Impact, Response**	**The full DPSIR range is involved**
Land use issues covered: **Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation**	**All landuses and activities with environmental impacts**
Scenario sensitivity: **Are the products/outputs sensitive to Module 1 scenarios?**	**The results will be sensitive to scenarios (not covered in this report)**
Output indicators: **Socio-economic & environmental external constraints; Land Use structure; RUR Metabolism; ECO-system integrity; Ecosystem Services; Socio-economic assessment Criteria; Decisions**	**Mainly focused on environmental and ecosystem output indicators.**
Knowledge type: **Narrative storylines; Response functions; GIS-based maps; Tables or charts; Handbooks**	**Methodology and baseline report**

How many fact sheets will be derived from this deliverable:	1

1. Introduction

The description of the research strategy offers a useful insight into the approaches being followed during the study of the impact of environmental drivers of change on peri-urban land use relationships. An important element of this strategy is the preparation of a baseline profile. This incorporates descriptions of recent trends and current status of four environmental resources (air, biodiversity, soil, water) being explored within WP1.3.

Role in PLUREL work programme

This deliverable (D1.3.1) is an important output of WP1.3 and performs 2 key functions; to outline the WP1.3 research strategy and to present the baseline profile that provides a framework for the investigation of environmental drivers of change.

Objectives of WP and links to other WPs

- To provide a focused analysis of the future role and impact of environmental drivers within the processes of urbanization and peri-urban land use change.

This report will inform mainly D1-3-2 and D1-3-3

Contributions to PLURELs end-products of report is in the form of baseline scoping and methodology.

Structure of the deliverable

- Firstly an introduction and context
- The second part is an outline of the methodology for analysis
- The third part is a baseline description of the four selected environmental variables: air, water, soil and biodiversity.

2. Research Strategy

1.1. Introduction and context

Contemporary challenges associated with urbanisation, including urban sprawl and associated pressure on peri-urban areas, are negatively impacting on the lives of Europe's citizens and the natural environment. PLUREL module 1 concerns an investigation of the most significant forces driving change in urbanization processes and peri-urban land use relationships. Environmental drivers of change play an important role in this respect. Indeed, they can accelerate the advance of harmful impacts on humans and ecosystems. Accordingly, Work Package 1.3 (WP1.3) provides a focused analysis, at the European level, of the potential impacts of alternative future trends and scenarios concerning environmental drivers on urban development and peri-urban land use processes. This report describes the strategy around which this assessment is based and also presents a baseline profile that provides a framework for understanding the potential impacts of environmental drivers.

The drivers considered within WP1.3 fall into two distinct categories; climate change and anthropogenic environmental pressures. These environmental drivers have been selected due to the significance of their potential and actual influence on the essential environmental resources (air, biodiversity, soil and water) that play a fundamental role in processes of land use development and change. In WP1.3, the focus will be on 'direct' climate change impacts. Direct impacts refer to changes to climatic variables, namely temperature and precipitation, and the frequency and intensity of associated events including flooding, drought, heat waves and storms. These direct impacts have a range of knock-on effects, which can be environmental, economic and social (e.g. biodiversity loss, increased insurance in flood risk zones, changing holiday patterns). These will be explored in the context of peri-urban land use relationships.

The impact of five anthropogenic environmental pressures (i.e. derived from human activities) on peri-urban land use relationships are considered within WP1.3. These pressures are urbanization, transport, energy generation, agriculture, and tourism. Although there are other anthropogenic pressure impacting on the environment, the five being addressed within WP1.3 are considered most relevant and significant in the context of the PLUREL agenda. They are also key influences on the environmental resources (air, biodiversity, soil and water) that are a crucial element of the environmental platform around which the development of urban areas (and human societies more broadly) is based. The status of these environmental resources can impact directly on urbanisation processes; for example plans for urban expansion can be compromised by inadequate water supplies, something which may become more common as environmental drivers such as climate change intensify. The current status of the environmental resources (on a European scale) is explored in greater detail within the baseline profile (see section 2).

WP1.3 provides a Global and European context for the rest of the PLUREL project to work within concerning environmental drivers and their impacts on environmental resources and peri-urban land use relationships. The findings of WP1.3 will be utilised throughout PLUREL, particularly in Module 2 where the impacts of environmental drivers will be interpreted in terms of land use and resource demands and functions operating within the arena of peri-urban land use relationships. WP1.3 therefore has an important role to play in meeting PLUREL's key objective, which is to develop strategies for sustainable urban and peri-urban land use relationships. WP1.3 can support the achievement of this objective through enhancing understanding of the environmental drivers that impact on Europe's Rural-urban Regions and that influence peri-urban land use relationships within these areas. This can help to provide a more solid framework for sustainable urban development and change avoiding the problems for humans and biodiversity often associated with the expansion of urban areas.

1.2. Aims and objectives

The following aim and associated objectives will guide the research and dissemination activities within WP1.3.

Research aim:
To provide a focused analysis of the future role and impact of environmental drivers within the processes of urbanization and peri-urban land use change.

Research objectives:
1. To develop a baseline profile and scenario framework to explore the impact of climate change and anthropogenic environmental pressures on essential environmental resources (including air, biodiversity, soil and water).
2. To explore the key impacts of climate change trends and scenarios on environmental resources.
3. To explore the key impacts of trends and scenarios concerning anthropogenic environmental pressures on environmental resources.
4. To consider the impact of future changes to environmental resources (stimulated by climate change and anthropogenic environmental pressures) on urbanisation and peri-urban land use relationships.

1.3. Research strategy

The WP1.3 research strategy is designed to meet the aim and objectives outlined above. The approach is structured into three main layers:
1. Development of a baseline profile and PLUREL scenario framework to facilitate the exploration of the impact of environmental drivers on key environmental resources.
2. Review of future projections and PLUREL scenarios to assess prospective changes to environmental drivers, and subsequently to consider corresponding impacts of these future changes on environmental resources.
3. Synthesis and analysis of findings concerning future environmental driver/ environmental resource impacts in the context of urbanization processes and peri-urban land use relationships.

The strategy layers are represented graphically in Figure 1.

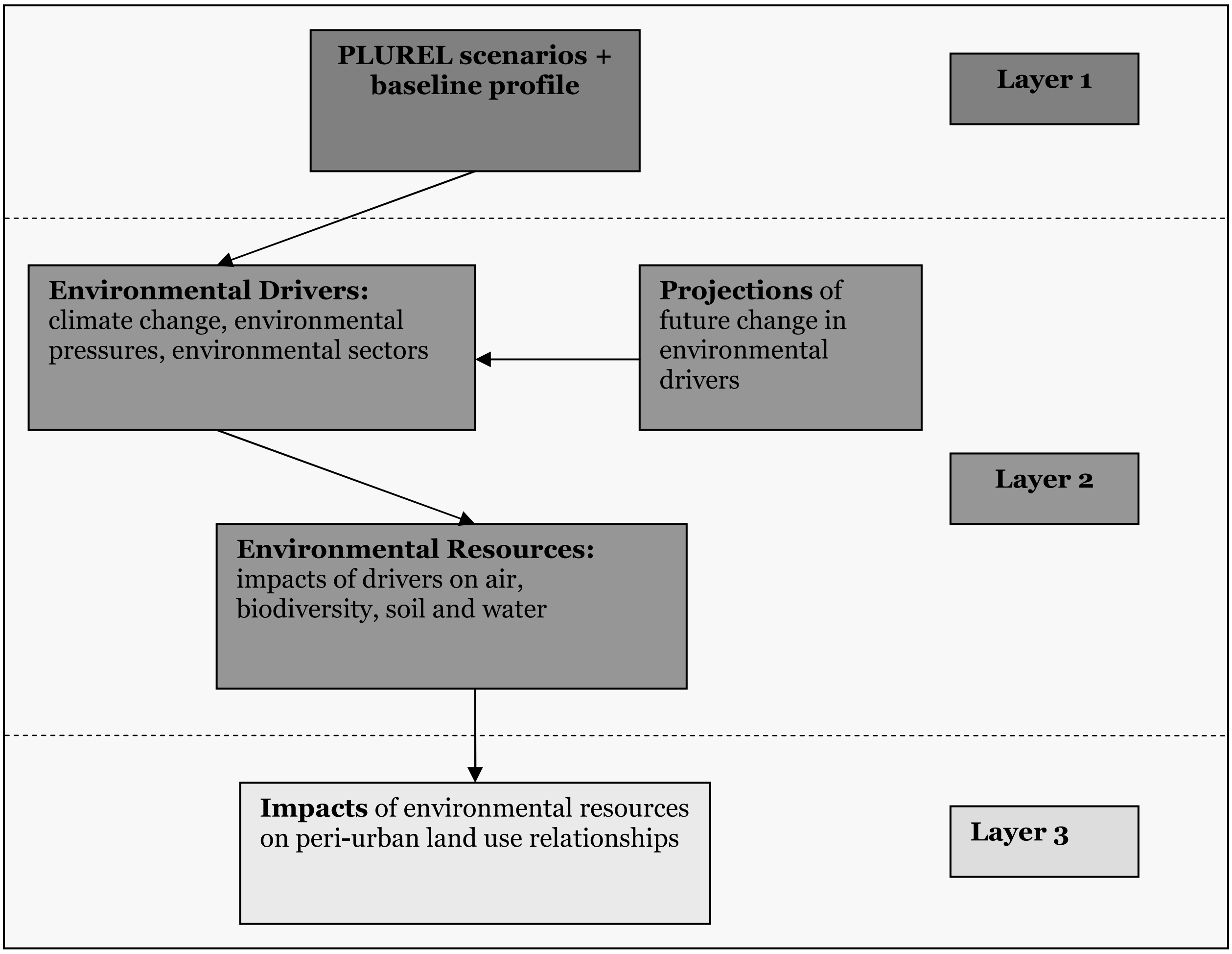

Figure 1: Assessing the impacts of environmental drivers on peri-urban land use relationships.

Strategy layer 1: A key element of the first layer of the research strategy is the development of a PLUREL scenario framework in co-ordination with the other M1 work packages. Environmental drivers are not exogenous and discreet. They are often linked in combinations of two-way cause and effect with other social, economic and technological changes. Scenarios provide a means of considering several possible future world development trajectories, therefore enabling different prospects for environmental drivers to be explored in a systematic way. Accordingly, WP1.3 is linked horizontally across M1 to allow a PLUREL scenario framework to be developed on a common basis. An existing scenario approach (the IPCC SRES scenario set) has been modified for use within M1 to produce a 'shock-based' set of scenarios. These revolve around the key elements of the SRES scenarios with the addition of system shocks, including events such as an increase in water crises across Europe. The PLUREL scenarios are explored in greater details within a separate deliverable report.

The development of an environmental resource baseline profile is an important element of the first layer of the strategy and is described in greater detail in section 2 below. The baseline profile presents a broad overview of recent trends and current status, at a European scale, of the environmental resources (air, biodiversity, soil and water) being explored within WP1.3. This baseline data (gathered via a document review process) provides a framework to consider the future impacts of environmental drivers on environmental resources and subsequently on peri-urban land use relationships.

Strategy layer 2:
The second layer of the research strategy concerns an investigation of future projections and scenarios relating to and impacting on the environmental drivers being studied within WP 1.3 (climate change, anthropogenic environmental pressures). The distinction between scenario and projection studies can be usefully clarified at this point. According to the Oxford English Dictionary, a scenario can be defined as: "A sketch, outline, or description of an imagined situation or sequence of events", whilst a projection can be defined as: "A forecast based on present trends". Via analysis of projections and scenarios, data and insights into the possible future evolution of environmental drivers will be utilized to enhance understanding of potential changes to key environmental resources (air, biodiversity, soil and water).

The second layer of the strategy therefore involves gathering data on projections relating to each of the environmental drivers, for example how could transport and agriculture change in the future over Europe. Where possible, further data will be gathered on 'extreme cases,' for example countries with the greatest potential to be impacted on by climate change or that are predicted to experience the highest rates of urban growth. The findings of this element of the research will be used to investigate and document how environmental resources may be impacted on in the future by environmental drivers behaving differently than at present.

In addition to the review of projections, the PLUREL scenarios developed within Module 1 will be analysed and interpreted to explore potential changes to the nature of environmental drivers under the different possible futures proposed by the scenarios. A systematic approach will be taken with each PLUREL scenario considered in the context of each environmental driver to explore how, for example, the A1 hyper-tech scenario may affect anthropogenic environmental pressures in the future. These insights will be used to assess the associated impacts on environmental resources under these circumstances. This 'impact cascade' approach is represented diagrammatically in Figure 2.

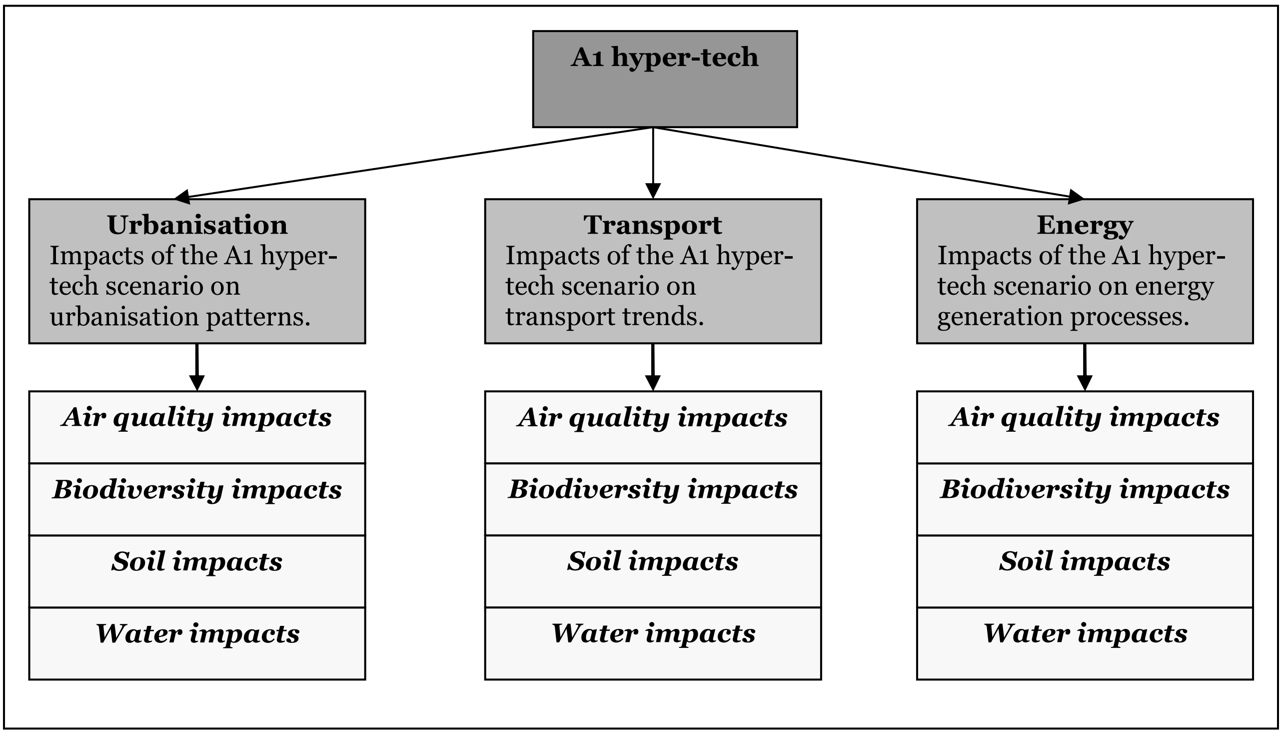

Figure 2: Sample scenario/pressure/resource impact cascade.

The data gathered during layer 2 will be used to assess how environmental resources impacted on by environmental drivers may evolve in the future. With this information, it is then possible to consider how urbanisation and peri-urban land use relationships will evolve in the future as a result changes to the nature of environmental resources such as soil and water. The consideration of these issues is the central concern of the third layer of the research strategy.

Strategy layer 3: Layer 3 focuses on exploring the linkages of cause and effect operating between PLUREL scenarios, environmental drivers, environmental resources and peri-urban land use relationships. The different elements of this analysis are represented within Figure 3, which indicates the different issues being considered within this assessment.

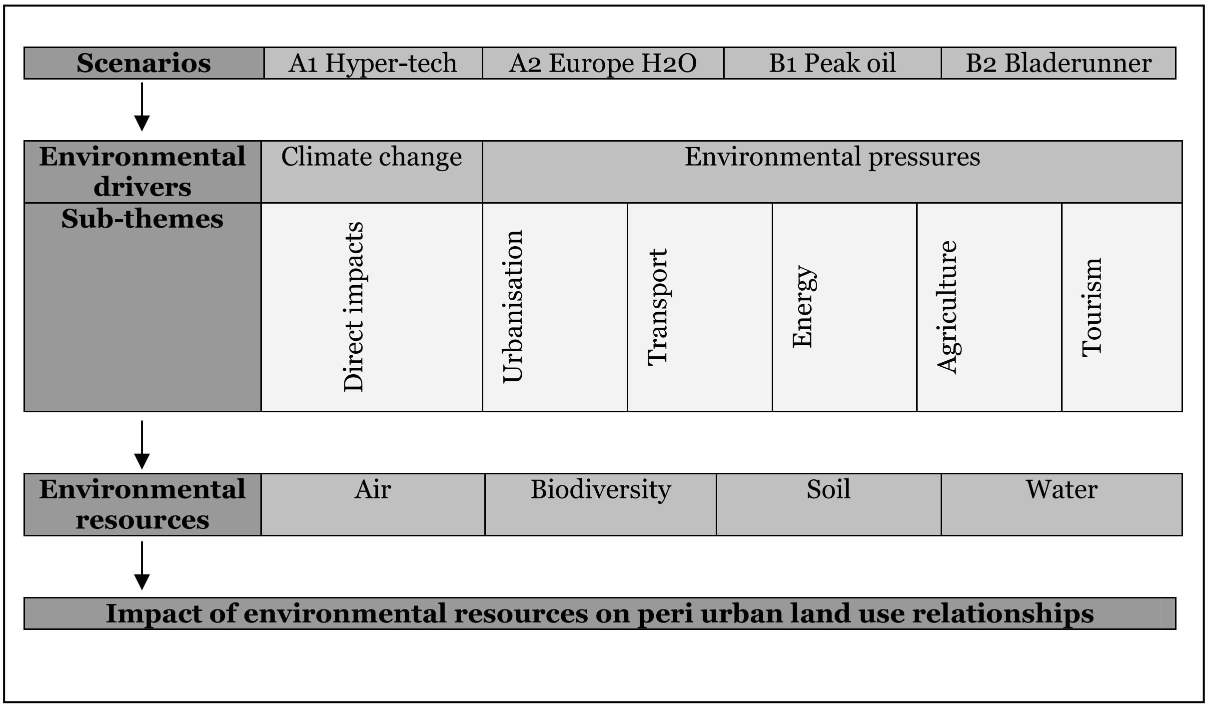

Figure 3: Exploring the impact of environmental drivers on environmental resources and peri-urban land use relationships.

In order to enable this process to look beyond generic impacts at the European scale, the M2 typology of urban-rural regions will be considered. This includes six urban-rural region types (which are described in greater detail within deliverable 2.1.3):

1. *Metropolitan:* NUTS region clusters of metropolitan areas, with several large core cities or metropolitan nuclei within the metropolitan area, lacking peri-urban patterns.
2. *Urban mono-centric:* NUTS regions with one large core city within a peri-urban area with or without adjacent small sub-centres with dispersed small settlements lacking larger sub-centres
3. *Peri-urban mono-centric:* NUTS regions with one medium-size core city within a peri-urban to rural area, with or without adjacent small sub-centres, with dispersed small settlements lacking larger sub-centres
4. *Urban poly-centric: (+ Metropolitain):* NUTS regions with one or few large core cities within a peri-urban area with larger sub-centres (and dispersed small settlements)

5. *Peri-urban poly-centric:* NUTS regions with few medium-size core cities within a peri-urban to rural area with or without dispersed small settlements lacking larger sub-centres
6. *Deep rural:* NUTS regions without small or medium-size core cities within a rural area populated by dispersed small settlements

Alongside these urban-rural region types, the different PLUREL time frames will also be considered to provide an additional dimension to the assessment. These time frames are:

- Short term (present day to 2015).
- Medium term (2016-2025).
- Long term (2026-2050).

A systematic assessment of urban and peri-urban land use impacts will not be undertaken for each of the possible chains of cause and effect between four PLUREL scenarios, two categories of environmental drivers, four environmental resources, three PLUREL time frames and six urban-rural region types. Instead, the aim of layer 3 will be to look more deeply into a smaller number of representative sample issues whilst also providing an overview of the impact of environmental drivers on peri-urban land use relationships. Relationships and feedbacks concerning those issues that are most relevant and significant in the context of the PLUREL agenda will be selected for further more detailed investigation, for example concerning the impact of climate change on water issues in southern European metropolitan areas.

A structured causal chain analysis (CCA) will be utilized to aid this process. CCA provides a conceptual model that gives this element of WP1.3 a strong methodological framework. The outputs of the CCA analysis will be given visual expression in the form of 'problem trees' as described by the European Commission (EC 2004). The problem trees provide a summary picture offering a simplified version of reality regarding the relationship between environmental drivers, environmental resources and peri-urban land use impacts. Working in this way, the CCA approach provides a framework for identifying and understanding the impacts of environmental drivers on peri-urban land use relationships. It is important to emphasise that although the causal chain appears linear, there are complex feedback loops operating within the systems being explored within PLUREL. These will be explored within the CCA approach and illustrated within the problem trees where relevant.

3. Baseline profile

As described above, the aim of WP1.3 is essentially to assess the possible future impacts of environmental drivers, acting through key environmental resources, on urbanization processes and peri-urban land use relationships. An important element of the WP1.3 research approach is the development of an environmental resource baseline profile to provide a framework and context for this assessment. The baseline profiles included within this report incorporate descriptions of recent trends and outline the current status of the four environmental resources (air, biodiversity, soil, water) being explored within WP1.3. In doing so, they raise awareness of the environmental resources that play an important role in shaping peri-urban land use relationships, and will be of use to stakeholders within and beyond PLUREL. The data included within these profiles will be utilised at subsequent stages of WP1.3 to consider the impact of the PLUREL scenarios and selected environmental drivers on the four key environmental resources.

The baseline profiles for each of the four environmental resources follow a standard format incorporating;

1. An introduction to the environmental resource providing an overview of the drivers of and impacts associated with related problems. A series of headline messages concerning the current state of the environmental resource are also included and the relevance of the resource to the PLUREL agenda is outlined.
2. The identification of key peri-urban land use relationships associated with the environmental resource. These are presented in table format and are broadly based around the three key land use relationships – core>peri-urban, core>rural, peri-urban>rural - with relevance to PLUREL. Due to complex chains of cause and effect, it cannot be expected that all relationships will be identified. Further, relationships will differ from region to region due to factors including climate and level of economic development. Significant generic relationships are therefore emphasised.
3. A table incorporating baseline data describing key issues relating to the environmental resource. The tables provide a means of succinctly presenting an overview of the most important elements of the baseline situation concerning each environmental resource. Each resource is broken down into different elements (e.g. water is considered in terms of flooding, supply, demand and quality). The geographical extent of the issues is highlighted (on a European scale) and associated impacts are described.

Baseline profiles for each of the environmental resources being considered within PLUREL (air, biodiversity, soil and water) are included below.

2.1. Air Quality

Despite success stories in recent years concerning considerable reductions in a number of harmful air pollutants, improving air quality remains one of Europe most important environmental challenges. Indeed, the costs associated with air pollution on human health alone have been estimated to run to several hundred billion Euros annually. Further negative impacts on ecosystem health, crop productivity and buildings (often historic treasures) demonstrate the significance of air pollution for Europe's population and biodiversity. Consequently, air quality is an area in which European policy makers have been particularly active over recent decades.

Several sectors are responsible for much of the total emissions of air pollutants, the most significant of which are road transport, energy generation, industry and agriculture. Emissions of pollutants from these sectors include particulates, ozone, nitrogen oxides and sulphur dioxide. Negative impacts on humans (especially in urban areas southern, eastern and central Europe) and ecosystems across the continent result from direct exposure to or deposition of these pollutants (Figure 4 identifies some of the drivers of poor air quality and highlights some of the most significant associated impacts). Technological developments including abatement solutions in road transport (fitting catalytic converters on vehicles) and within the energy industries (fuel switching and emission control) coupled with stricter legislation have generated significant improvements in air quality. Nevertheless, emissions of particulates (microscopic pollutant particles that penetrate deep into the lungs) and the creation of ground level ozone (which harms humans, crops and ecosystems) remain specific contemporary concerns.

Headline messages concerning Europe's air quality are highlighted below. These issues are explored in detail within Table 2.

- Transport (by road, sea and air) is the key cause of Europe's most stubborn air pollution challenges. These include problems associated with ground level ozone and particulates in urban areas.
- In urban areas, a significant percentage of the population is exposed to air pollution (from a number of substances) above levels thought to be safe for human health.
- Emissions of particulates are believed to be most significant air pollutant in terms of numbers of human deaths (almost 400000 in 2000).
- The cost of damage to human health caused by air pollution has been estimated at between 305-875 billion Euros/year.
- In terms of ecosystem health, the key threats posed by air pollution are acidification and eutrophication, both of which can cause significant damage to biodiversity.
- There have been some notable success stories. These include addressing acid rain and its associated impacts (particularly over Scandinavia) and reducing emissions of some toxic chemicals including lead and benzene.

(N.B. Issues concerning greenhouse gas emissions are not included in this air quality baseline profile. Climate change is discussed as one of the key environmental drivers impacting on the environmental resources being considered within PLUREL. Current status and recent trends concerning greenhouse gas emissions are described in the environmental drivers report.)

	Exogenous influences: Economic growth/decline, lifestyle choices, global markets, technological change, demographic change, climate patterns.	
Driving forces: Fossil fuel combustion (energy generation, transport), agriculture, industry, waste incineration.	**AIR QUALITY** (including emissions of acidifying and eutrophying substances, particulates, ground level ozone, toxic chemicals and greenhouse gases)	**Impacts:** Ecosystem degradation (acidification, eutrophication), human health problems, damage to buildings, reduced crop yields.
	Responses: Abatement technologies (industry and transport), pollution control legislation, transport policy, spatial planning, agricultural policy and practice.	

Figure 4: Air Quality 'issue cross'.

Air quality is a key element of the PLUREL environmental drivers baseline profile. Within the PLUREL project, the environmental drivers sub-theme of air quality relates to a range of air pollutants including emissions of acidifying and eutrophying substances, particulates, ground level ozone, toxic chemicals and greenhouse gases. Air pollution is a transboundary environmental issue and concerns a range of pollutants which have numerous of drivers, sources and effects. Acknowledging the complex interrelationships between urban, peri-urban and rural areas is central to understanding the causes of air quality problems and to developing solutions to address these challenges. Examples of peri-urban land use relationships relating to air quality are highlighted in Table 1.

Air Quality – peri-urban land use relationships
• Ozone is created by photochemical reactions amongst pollutants contained within urban smogs. As smogs drift to peri-urban and rural areas, chemical reactions may intensify thus increasing ozone levels in these areas.
• Ground level ozone originating in urban areas can have significant negative impacts on crop yields in rural areas.
• Rurally focused agricultural processes are responsible for the creation of several air pollutants (e.g. nitrogen, methane) that have far reaching impacts on human health and ecosystems.
• Generators of air pollutants, including the power stations and industrial plants that service Europe's predominantly urban populace, are often situated in peri-urban and rural areas.
• Air pollution is often a transboundary issue with ecosystem impacts including acidification and eutrophication arising from pollutants generated sometimes thousands of kilometres away. Toxic chemicals also travel long distances.
• Travel from peri-urban and rural areas into urban centres (for work, shopping etc) generates air pollution around transport corridors and in urban cores.

Table 1: Examples of peri-urban land use relationships concerning air quality.

AIR QUALITY			
	Issue	***Geographical distribution***	***Associated Impacts***
Acidifying pollutants	Key acidifying substances are nitrogen oxides (NOx), sulphur dioxide (SO2) and ammonia (NH3). Fuel combustion (NOx and SO2) and animal farming (NH3) are responsible for 95% of emissions. Shipping in Europe's waters, which falls outside current regulatory mechanisms, accounted for around 1/3 of NOx and SO2 (2000 figures).	In the EU-15, NOx, SO2 and NH3 are each is responsible for around 1/3 of total emissions. In ascension countries, SO2 makes up around 2/3 of total emissions. Sulphur deposition remains high in a belt stretching from south east Poland through the Balkans into northern Greece and in the far north of Europe.	Impacts of acidifying substances can be felt far from their origin. Acidification damages ecosystems, e.g. killing fish in lakes, limiting tree growth. Ecosystems in south east Sweden, north west France, north west and south east Germany, and Hungary are particularly at risk. Damage to buildings and health problems can also arise.
	Between 1990 and 2002, emissions of acidifying substances fell by 44%. Since 1990, reductions have been most pronounced in the energy industries (-52%), agriculture (-25%) and transport (-13%). Recent falls are principally due to reductions in SO2 emissions of around 60% since 1990. There has been less progress in reducing NOx deposition due to traffic growth (despite the introduction of catalytic converters). NH3 emissions fell substantially in the ascension countries but only slightly in the EU-15.	Changes in energy generation, industrial processes and road transport technology have driven significant reductions in emissions of acidifying substances between 1990 and 2002 in many European countries. Levels fell by almost 70% in Germany and 60% in the UK. However, Spain and Portugal saw only slight decreases whilst Greece experienced a slight increase in emissions over this period. Reductions have been even greater in the ascension countries (including Czech Republic, Latvia, Slovakia) due to economic restructuring.	Europe's ecosystems are now increasingly protected from acidification. In northern Europe, where soils have a low capacity to neutralize acids, reductions are particularly beneficial. Despite recent falls, around 10% of Europe's ecosystems (including over 25% of forests) receive acidifying substances above critical loads. In Sweden, 14000 lakes remain affected by acidification and will take years to recover. 7000 are regularly limed to prevent further damage.
Eutrophying pollutants	The buildup of excess nutrients (principally NH3 and NOx in the context of air pollution) in water bodies and soils causes eutrophication. In 2000, NH3 and NOx each contributed roughly 50% of Europe's total emissions of eutrophying air pollutants. Agriculture, road transport and the energy industries are the key source of these pollutants. Slow progress in reducing nitrogen deposition has hampered efforts to the control the impacts of eutrophication, which have shown little improvement since the 1980s.	Ecosystems across much of continental Europe are at risk of eutrophication. However, ecosystems over large parts of the UK and Scandinavia (apart from Finland) are more tolerant to this process, and also generally receive lower nitrogen loads. In these areas impacts are therefore less pronounced. In the EU 15 and ascension countries the sectoral contribution of eutrophying pollutants is broadly similar, with agriculture, road transport and the energy industries releasing around 40%, 20% and 15% respectively.	In 2000, over 30% of the total area of Europe's ecosystems was damaged by eutrophication. This figure has fallen little since 1980. Algal blooms are a key impact of eutrophication in water bodies. They harm biodiversity through reducing oxygen levels and available light, and can also be toxic. On land, eutrophication disturbs species composition. Human impacts can include health problems and reduced amenity and recreation value of water bodies.
Ground level ozone	The generation of ozone is a complex process involving photochemical reactions between 'ozone precursors' which include NOx, methane (CH4), carbon monoxide (CO) and non-methane volatile organic compounds (NMVOC). NOx and NMVOC make up 85% of total emissions of ozone precursors. Road transport is the key generator of ozone precursors, with solvents, industrial processes and the energy industry also making a significant contribution.	Over Europe, emissions of ozone precursors fell by around 1/3 between 1990-2000. Sectoral reductions have been achieved, for example within energy industries (-34%), transport (-31%), and agriculture (-28%). UK, Germany, Netherlands and Finland have seen the largest reductions and are on target to meet ozone precursor targets. Portugal, Spain, Greece, Ireland and Belgium are in danger of missing their targets. Many central and eastern European countries have achieved reductions of over 1/3.	Ozone harms plants (natural and agricultural) damaging foliage and reducing seed production and crop yield. Ozone also impacts on human health (contributing to respiratory and heart disease) accelerating the deaths of around 20000 people/year, and causing many millions to take medication for respiratory problems.

	Annual average ozone concentrations have risen by around 8% since 1996, although short term concentration levels have remained relatively stable. Ozone levels can be particularly high during the summer months when there is low rainfall and wind to disperse ozone precursors. Ozone levels can be highest in rural areas as the photochemical smog that creates ozone can travel long distances worsening in toxicity as it moves.	Health related ozone target values are exceeded across Europe, particularly in southern, central and eastern areas. In 2000, several cities of around 6 million people saw levels above target values on more than 50 days. In 2002, around 30% of urban inhabitants experienced unsafe levels for more than 25 days/year. Hotspots include northern Portugal, northern Italy, some Greek islands, and south east France. Problems are rare in northern Europe.	In 2002, over 1/3 of agricultural land was exposed to ozone levels above target values, particularly southern and eastern Europe. Long term values for agricultural crops are exceeded in over 90% of areas (apart from the UK, Ireland and northern Scandinavia).
Particulates	Particulate pollution consist of fine particles PM10 (>10 µm) and PM2.5 (>2.5 µm), and PM10 precursors (SO2, NOx, and NH3) that react chemically to form particulates. In the EU-15 in 2000 fuel combustion accounted for 78% of particulates. Across Europe, the key generators of particulates are the energy industry (30%), road transport (22%) and industry (17%). Shipping contributes 20-50% in ports and coastal areas.	Particulate pollution is most prevalent in urban areas, along transport corridors and around heavy industry. Localized hotspots exist under these conditions. In the EU-15, transport is the highest contributor of particulates whilst in ascension countries it is energy industries.	Particulates are the key cause of air pollution related deaths in Europe. Around 45% of Europe's urban population are exposed to particulate levels beyond limit values set to protect human health. Anthropogenic PM2.5 contributed to around 348000 premature deaths in 2000.
	Across Europe, emissions of particulates fell by 39% between 1990 and 2002, principally due to reductions in SO2 and NOx. Fewer PM10 from the energy industry also contributed to this improvement. Generally, particulate levels continue to fall. Abatement measures in energy generation, industrial processes and road transport have driven these reductions.	Many countries reduced their emissions of particulates by more than 20% during the 1990s. Some, including Czech Republic, Germany, Lithuania and the UK, achieved over 50% reductions. However, Portugal and Greece saw slight increases. Further, target values for PM10 are exceeded in many European cities (especially in Spain, Holland, Belgium and Germany) and also in some rural areas.	Despite falling particulate levels, significant associated health impacts remain. The Benelux, northern Italy, and parts of Poland and Hungary suffer most from negative impacts on human health. In these countries, particulates reduce average life expectancy by around 2 years.
Toxic chemicals	Activities including burning fossil fuels, waste incineration and some industrial processes (e.g. metal production) create emission of toxic chemicals. Heavy metals (including cadmium, lead and mercury), benzene, persistent organic pollutants (POPs) (including chlorine and bromine), and polycyclic aromatic hydrocarbons (PAH) are of particular concern due to their impact on human and ecosystem health. Data on emissions of toxic chemicals is limited by poor monitoring and reporting in some countries. However, abatement technologies (in industry and road transport) have driven large reductions in toxic chemical emissions.	During the 1990s, emissions of cadmium fell by around 50% across most of Europe, although over this period Spain saw an increase of 36%. Significant reductions in lead emissions (over 80%) have been achieved in many western European countries, principally because lead is used much less in petrol. Similarly, in numerous central and eastern Europe countries there have been reductions of lead emissions of over 50%. Although chemicals such as heavy metals and POPs have been regulated for some time in Europe, they persist in the environment, particularly the far north of Europe where they condense out of the cold air. Further, localised hotspots remain around urban areas and industrial zones.	Although toxic chemicals are found in very small quantities in humans, they accumulate over time to cause health problems. Cadmium and lead are particularly harmful even at low concentrations. Some heavy metals and POPs impede neurological development, and are thought to contribute to learning difficulties in children. Benzene, and some PAHs' are known carcinogen. Links between local traffic density and leukaemia in children have been identified. POPs interfere with hormone release (endocrine disrupters) and are responsible in part for large falls (50%) in sperm counts.

Table 2: Air Quality - key baseline data.

2.2. Biodiversity

According to the United Nations Convention on Biological Diversity, biodiversity concerns the variability amongst living organisms and the ecological complexes of which they are a part. The Earth's biodiversity is currently threatened. Human demands for food, fresh water, timber, fibre and fuel have risen steadily with increasing population and affluence. Similarly, land and water is increasingly under pressure from development and pollution. Via complex chains of cause and effect, many of which are not fully understood, these pressures are having a range of associated impacts, not least the loss of habitats and the decline of species diversity (see Figure 5). These losses can often be irreversible. Indeed, some scientists fear that we are in the midst of a great global extinction event for which humans are largely responsible. Europe is facing a considerable challenge as many of the continent's large ecosystems are being rapidly degraded or used unsustainably. Significantly, less than 20% of the continents land surface remains unmanaged. Due to the tran-boundary nature of many of the causes and impacts of biodiversity loss, this is an issue of global concern. Europe has a responsibility to preserve its habitats and species.

In an effort to address this challenge, EU Member States are aiming to halt biodiversity loss by 2010 via initiative such as the Birds and Habitats Directives. This is a bold target which reflects the seriousness of this issue which has the potential to jeopardise the health and wellbeing of present and future generations. The loss of habitats and species for short term private economic gain (e.g. logging, draining wetlands, exploitation of fish stocks) can lead to a loss to society of more valuable long term benefits associated with ecosystems and the services they provide. Ecosystem services include maintaining soil structure and fertility, climate regulation, water purification, the absorption and treatment of waste, providing for recreation, and promoting human wellbeing. It is clear that negative impacts on biodiversity have consequences that go far beyond the visible loss of habitats and species. Biodiversity conservation is therefore not merely about preserving nature but involves safeguarding the ecological framework that provides for the long term stability of human societies.

Headline messages concerning the state of Europe's biodiversity are highlighted below. These issues are explored in detail within Table 4.

- Biodiversity is crucial to the provision of the ecosystem services (many of which are impossible for humans to replicate) that societies depend on for current prosperity and future sustainability.
- Europe is the continent on which humans have most significantly affected biodiversity. Few areas of high conservation value are truly natural.
- Urban sprawl is driving large losses of habitat. An area three times the size of Luxembourg was covered in hard surfaces during the 1990s. Agricultural land and wetlands suffered in particular from this land use change.
- The pace of species loss is spiralling. The current rate of loss may be around 1000 time higher that the natural rate of 1 species/million/year.
- Although Europe does not have high levels of biodiversity of in global terms, around 800 species of plants and 335 vertebrate species are currently threatened.
- Much of Europe's biodiversity has been shaped by agriculture. Semi-natural farmland is home to some of Europe's most valuable biodiversity. Loss of traditional farming methods is severely threatening this biodiversity.
- The Mediterranean region houses much of Europe's biodiversity. Tourism and changes in farming practices are impacting on this resource.
- Key habitat types (including mountains, fresh water bodies, wetland and forests) and their associated species are experiencing declines in quality and diversity.

	Exogenous influences: Demographic change, economic growth/decline, technology, cultural development, religious beliefs, climate change.	
Driving forces: Invasive species, land use change, agriculture, natural resource use, urbanisation, tourism, forest management, pollution.	**BIODIVERSITY** (including habitat loss and species loss)	**Impacts:** Reduced genetic diversity, disruption to ecological processes, threats to agriculture and food security, decline in human wellbeing, rural poverty.
	Responses: Sensitive urban development, spatial planning, agricultural and forestry policy/practice, conservation, education.	

Figure 5: Biodiversity 'issue cross'.

Within PLUREL, the environmental drivers sub-theme of biodiversity considers both habitats and species. Due to the fundamental link between land use change, biodiversity and the indispensable ecosystem services upon which economies and societies depend, biodiversity is a key environmental resource to be considered within PLUREL. Although almost 100 million ha of Europe's land surface is covered by conservation legislation, most biodiversity is found outside protected zones. The PLUREL agenda, with its focus on peri-urban land use relationships, resonates clearly with the need to take a broad holistic perspective to the conservation of biodiversity (see Table 3). This baseline profile takes a broad overview of biodiversity loss from a European perspective. Emphasis is also placed on threatened habitat types which harbour significant levels of biodiversity. These include high nature value farmland, mountains, freshwater, wetlands and forests (see Table 4).

Biodiversity – peri-urban land use relationships
• Development activity in urban areas can reduce the extent of habitats (e.g. wetlands, woodlands, semi-natural farmland) and associated biodiversity.
• Demand for food to feed urban populations encourages the intensification of agriculture and the loss of semi natural farmland that is crucial to biodiversity.
• Migration in Europe, particularly from east to west, leads to the abandonment of high nature value farmland and corresponding sprawl of towns and cites, both of which harm biodiversity.
• Tourism and associated development is damaging habitats in biodiversity rich locations such as Mediterranean coasts and islands and Alpine mountain areas.
• Pollution from urban areas and industry creates problems such as acidification and eutrophication which degrade habitats and harm species.
• Urbanisation processes, particularly laying transport routes, fragment habitats making them less able to maintain viable populations of certain species.
• The expansion of coastal urban areas and those around rivers leads to the loss of wetlands and floodplains, habitats that are rich in biodiversity.
• The suburbanisation of rural areas is blurring the divide between rural and urban areas and is driving the loss, fragmentation and degradation of habitats.

Table 3: Examples of peri-urban land use relationships concerning biodiversity issues.

BIODIVERSITY			
	Issue	***Geographical distribution***	***Associated Impacts***
Species loss	Europe contains around 1000 species of vertebrates, 10000 plant species and 100000 invertebrate species (not including marine species). 42 % of native mammals, 15 % of birds, 45 % of butterflies, 30 % of amphibians, 45 % of reptiles and 52 % of freshwater fish are threatened. Drivers of species loss include habitat loss/fragmentation and invasive species.	Prime biodiversity areas situated in Europe include the Mediterranean and parts of the Caucasus and Arctic regions. Species most vulnerable to extinction include specialist, endemic and migratory species, and those at the top of food chains and with low populations. Urbanization in western Europe and abandonment of agricultural land in central and eastern Europe have led to biodiversity losses. Some threatened species, including the beaver, otter, vulture and certain raptors, are recovering.	Loss of species leads to a decline in genetic diversity. This increases vulnerability of species to change and reduces their ability to recover from shocks. There is also a greater chance of rapid non-linear change in ecosystems if certain species are lost (e.g. fisheries collapse, disease emergence, increases in invasive species). Further, species loss can reduce the stability of ecological processes (e.g. soil fertility, water purification) at an ecosystem level.
	The Mediterranean is home to the largest numbers of plant and animal species in Europe. Over four times the number of plant species (52% of which are endemic) is found there than exist in the rest of Europe. 95% of original vegetation cover has been lost. Invasive species are significantly impacting on biodiversity levels. Conservation International has designated the area as a 'biodiversity hotspot'.	Locations with especially high biodiversity value are the Greek and Balkan mountains and the islands. Mediterranean coastal zones and islands are under particular pressure from tourism growth – 110 million people holiday there every year. Grazing, fires, urbanisation and deforestation all negatively impact on species numbers. Only 4% of the area is under some form of protection.	Species loss in grasslands has been shown to reduced productivity and carbon sequestration, and increases the loss of nutrients into groundwater. There are also impacts of species loss on agriculture and food production as services they provide include pest control, pollination and enhancing soil fertility. Although not accounted on national balance sheets, this effectively represents a loss of capital assets.
Habitat loss	Europe has a wide range of habitat types including permafrost, deserts, semi-tropical lagoons and Arctic fjords. Factors including urbanisation and farm restructuring are driving habitat loss. Over 65000 sites are designated for protection under legislation including the Birds and Habitats Directives. These sites currently cover around 15% of western Europe and 9% of eastern Europe.	During the 1990s, around 2% of heath, scrub and tundra were lost, whereas wetland mires, bogs and fens shrunk by around 3.5%. A 5% increase in artificial habitat (800000 ha) and 2.5% growth in inland surface water account for much of these losses. The Natura 2000 network protects some habitats – almost 100 million ha is protected. Spain and Sweden have the largest areas under protection with 10 and 5 million ha respectively. Cyprus, France, Ireland and Malta have a low percentage of their lands protected.	Habitat loss and species loss are closely related. For example declines in wetland birds and butterflies can be attributed to habitat loss, degradation and fragmentation. Loss of habitats (e.g. wetlands, forests) increases vulnerability to natural disasters (e.g. flooding, wildfires). Loss of habitat and associated species also impacts on human health and wellbeing. It also contributes to poverty, particularly in rural areas, with the poor often impacted disproportionally.
Agriculture	Arable and permanent grassland covers 45% of Europe's land surface and is home to much of the continents biodiversity. Almost ¼ of Europe's countryside can be described as 'high nature value farmland'. Intensification and abandonment is threatening habitats and associated species.	Southern and eastern Europe houses the largest semi-natural areas (including semi-natural and mountain pastures, steppe and deheses). Intensification is common in many areas. Land abandonment is most common in mountain regions, areas at risk of forest fires, and central and eastern Europe where economies are restructuring.	Agricultural intensification impacts on biodiversity through increased use of chemical inputs, habitat loss and fragmentation, high water use, and monoculture. Abandonment leads to a loss of semi-natural habitat which can have richer biodiversity levels than unmanaged land. Specialist species are loosing out to generalists.
	17% of existing Natura 2000 sites and 35% of total proposed sites are 'agri-ecological.' Farmland habitats rich in biodiversity are at risk from urbanization, tourism, agricultural change,	Farm restructuring across Europe has led to extensive loss of species rich habitats including hay meadows, grasslands and blanket bogs. Pasture and grassland habitats are at particular risk from abandonment. 30% of Estonian	In Germany, habitat loss and fragmentation driven by agricultural intensification has led to a decline in 400 vascular plant species. Around ¼ of farmland bird and butterfly populations have been in decline since 1980.

	transport and climate change. 33% of habitat types listed under the Habitats Directive are threatened by agricultural intensification.	farmland has been abandoned, which has led to a 50% loss of permanent grassland habitat.	Intensification of agriculture leads to the loss of habitats including coppice, ponds and wetlands.
	Estimates indicate that 50% of European species are dependant on agricultural habitat. Agricultural change and loss of traditional systems of land management have reduced biodiversity on farmland habitats. Almost half of the world's domestic animal breed diversity is found in Europe. A significant number of these are at risk of extinction.	As biodiversity thrives under extensive/traditional farming systems, areas where agriculture has modernized and intensified have seen the greatest losses. Countries most affected by farmland bird loss (a good indicator of the general state habitat biodiversity) are Belgium, France, the Netherlands, Sweden and the United Kingdom. Traditional cropping and grazing systems in southern and remote areas of Europe help to maintain biodiversity.	Humans rely on just 14 species of mammals and birds for 90% of their food form animals, and just four species provide 50% of our energy from plants. Their dominance puts less commercial species at risk reducing genetic diversity to the detriment of long term agricultural sustainability. Crop productivity (hay yields) declines with falls in plant diversity.
Mountains	Mountains are one of Europe's most valuable yet vulnerable habitats - 2500 of Europe's 11500 vascular plant species exist mainly beyond the tree line. Mountains shelter many endemic species. Industry, tourism and agricultural abandonment are taking their toll on mountain biodiversity.	Mountains in Spain are valuable repositories of plants, many of which are endemic; e.g. 3000 species live in the Baetic and sub-Baetic Mountains. Around 1/3 of Alpine vascular plant species are now threatened or extinct. Populations of some endangered carnivores and herbivores are increasing.	Once lost, this diversity of flora can no longer be used by human – ¼ of modern medicines have their origin on traditional plant remedies.
Fresh water	Europe has around 1.2 million km of rivers and 600000 lakes larger than 0.01 km2. Most European freshwater ecosystems have been altered (by structural modifications, pollution, drainage etc) and few are in their natural state. Water quality has improved considerably in recent years to the benefit of some biodiversity.	Area of seasonally inundated floodplain on the middle Danube in Hungary has fallen by 93%. Dykes along the River Tisza have impacted on fish spawning sites reducing fish catches by 99%. There have been recent declines in returning Salmon to the Thames despite improvements in the 1970s and 80s. Loss of small rivers and lakes in a key threat to biodiversity.	Fish, plants animals and invertebrates remain threatened by changes to freshwater ecosystems. There is a general trend towards fewer and more stress tolerant species. Original and specialist species are increasingly threatened. Chemical pollution is contributing to endocrine disruption in some species.
Wetlands	Wetlands are one of Europe's most biologically productive habitats. However, habitat loss and fragmentation, declines in traditional uses and pollution are causing extensive losses.	In north west Europe, more than 60% of wetland areas were lost during the 20th Century. Between 1990-2000, mire, bog and fen habitats declined by 3.4% (over 100000 ha).	There has been an overall fall in the ecological quality of Ramsar sites (which cover 19% of total wetland areas). There has been a 40% decline in wetland butterfly populations since 1980.
Forests and woodlands	30% of Europe is forested, around 25% of which is protected. Forests have grown by 0.6% (or 600000 ha) since 1990, and continue to grow. Aside from some boreal forests, most are managed. They are important for biodiversity - 30% of birds with unfavorable conservation status live in forests - and are valued for reasons including water cycle regulation, recreation, and carbon sequestration.	Afforestation has been highest in Ireland, Iceland and Mediterranean countries, and is occurring mostly on abandoned farmland. Forest fires in the Mediterranean are increasing in frequency, and currently number around 50000 per year. In the Boreal forests pressure from logging and natural resource exploitation is threatening the integrity of their ecosystems.	In most countries, the ecosystem services provided by forests equate to roughly three times the value of felling them for timber and fuel. Forests biodiversity value falls as management intensity increases (drainage, removal of dead wood, reduction in old growth forest etc). Forest butterfly populations have seen falls of almost 25% since 1980. In Alpine areas, forest loss raises the risk of avalanches, landslides and erosion.

Table 4: Biodiversity - key baseline data.

2.3. Soil

Soil is crucial to the sustainable growth of human societies and the health of ecosystems. Soil is a multi-functional medium and provides the basis for 90% of the food, fibre and fuel used by humans. It is also a raw material and is used for construction activities. Soil performs a range of 'ecosystem services' on which human societies depend. For example, soil plays an important role in the water cycle via storage and filtration, in nutrient cycles (including carbon and nitrogen), and climate regulation through carbon capture and storage. As it forms slowly, soil is a non-renewable resource on a 50-100 year timeframe.

Soil degradation takes several forms including erosion, contamination, sealing, compaction and salination. Different parts of Europe suffer from different forms of soil degradation. Erosion and salination are more prevalent in southern and eastern Europe, where as contamination and sealing are more widespread in northern and western member states. The causes of soil degradation also vary from location to location. Soil functions are damaged by a range of conflicting and competing demands acting on Europe's limited supply of land. Unsustainable agricultural practices, industrial activity, urbanisation, tourism, transport and other forms of land use change contribute to loss of soil quality.

The loss of soil functions has negative impacts for humans and ecosystems (Figure 6). Soil degradation is an incremental cumulative process. Contamination can overwhelm the natural capacity of soils to remove pollutants from the environment. Impacts on human health can arise from contamination of drinking water and increased dust levels. Erosion reduces the capacity of soils, sometimes totally, to sustain agricultural production and natural ecosystems. Soil erosion can also impact on infrastructure, for example through the siltation of dams and damage to irrigation equipment. Soil compaction and sealing reduces infiltration capacity increasing flood risk and diffuse pollution. Many of these impacts occur offsite; that is they are felt away from the point of soil degradation (e.g. diffuse pollution) and can be delayed to some point in the future (e.g. groundwater pollution). Onsite impacts principally concern loss of agricultural productivity.

Headline messages concerning the state of Europe's soils are highlighted below. These issues are explored in detail within Table 6.

- Until recently, a low priority has been afforded to soil degradation issues. However, this belies the significance of soils for human societies and natural ecosystems.
- Europe is experiencing a slow but widespread degradation of soil functions, with certain 'hotspots' suffering to a much greater extent.
- Key soil degradation problems experienced in Europe are soil sealing, contamination, erosion, compaction and salination.
- Soil erosion is one of the most widespread forms of land degradation, and affects over 17% of Europe's land surface to some degree.
- In some areas, especially around the Mediterranean, Balkan Peninsula and Black Sea, soil functions are badly degraded, in some cases irreversibly.
- In certain southern and eastern member states soil erosion has proceeded to an extent that desertification has set in, and the soil can no longer support agriculture or ecosystems.
- In northern Europe, key problems include acidification and contamination from urbanisation and industrial activity.

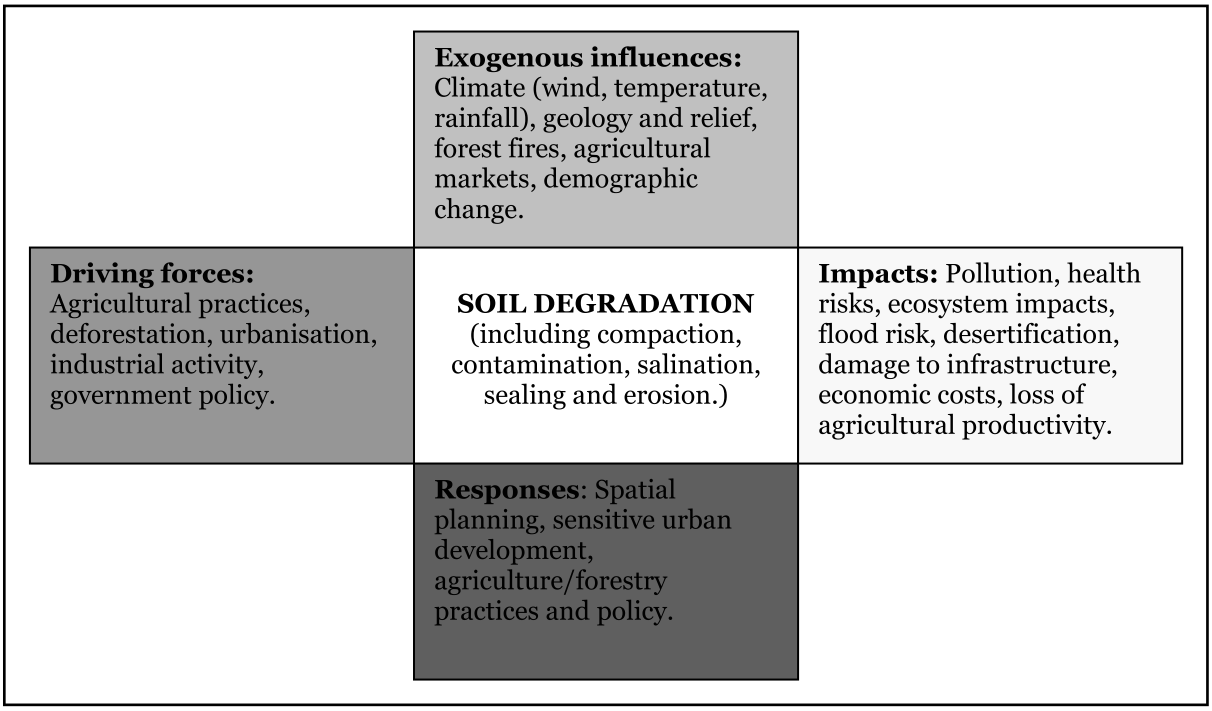

Figure 6: Soil degradation 'issue cross'.

The focus of the PLUREL environmental drivers soil sub-theme is soil degradation; that is the loss of soil functions due to human activity. Soil deterioration concerns loss of soil functions as a consequence of a combination of natural factors (e.g. climate, relief) and human drivers. After many years of misuse, all European member states are now affected by soil degradation to some degree. Due to the importance of soil to human societies and ecosystems, impacts of soil degradation on peri-urban land use relationships are widespread, some examples of which are introduced in Table 5.

Soil – peri-urban land use relationships
• Urbanisation (building houses, roads, retail parks etc) leads to soil sealing, often at the expense of agricultural land. This impacts biodiversity, and increases flood risk and diffuse pollution. • Unsustainable agricultural practices encourage soil erosion and loss of soil productivity. Impacts include diffuse pollution, increased pressure on marginal farmland and in extreme cases desertification. • Use of heavy farm machinery compacts soils lowering their infiltration capacity. Increased flooding and diffuse pollution can occur as a result. • Poorly managed irrigation approaches can encourage salination of soils (particularly in southern Europe). Mobilised by the wind, this salt can worsen soil productivity in other areas. • Contamination of soils can occur from numerous sources including air pollution, industry, agriculture, urbanisation and waste disposal. Contaminated soils can be very difficult to clean and can limit development opportunities and restrict agricultural activity. • Deterioration of agricultural soils can lead to land abandonment. This can negatively impact biodiversity and lead to urban in-migration areas as farmers seek employment elsewhere. • Serious soil degradation is occurring in areas neighbouring Europe, including north Africa and central Asia. Associated harm to people's livelihoods could put pressure on Europe's boarders.

Table 5: Examples of peri-urban land use relationships concerning soil issues.

SOIL DEGRADATION			
	Issue	***Geographical distribution***	***Associated Impacts***
Soil erosion	Soil erosion is one of the most significant and extensive forms of land degradation. Soil erosion is driven by natural factors (climate-rainfall, wind/ relief-slopes, aspect/ geology-soil type, soil structure) and human activity (agricultural practices, deforestation, construction activity). Erosion by water affects 16% of Europe's total land area, whilst wind erosion affects 1.5%.	Around 17% of Europe's land area (114 million ha) is affected by soil erosion to some degree. Almost 25 million ha is eroded to a high or extreme extent. A significant proportion of the remainder is moderately affected. The problem is worsening in northern Europe (the loess zone), yet it is the Mediterranean region and eastern Europe that is most severely impacted. For example, in Greece, over 50% of non-agricultural land is affected.	Key impacts of soil erosion include reduced agricultural productivity, diffuse pollution to land, water and air, siltation of dams and erosion of roads. The impact of offsite impacts is usually greater than immediate onsite effects. The mean total annual economic cost of soil erosion is estimated at 10bn euros/year (2003 figures)
	Soil erosion is a particular problem in the Mediterranean. Causes of soil erosion in this region include overgrazing, unsustainable irrigation practices, moves away from traditional crops, increased frequency of forest fires, and intense summer rainfall.	Spain suffers from the highest rates of soil loss - 28 tonnes/ha/year (1996-2000). Due to slow rates of soil formation, losses of over 1 tonne/ha/year are considered irreversible over a period of 50-100 years. In some areas accelerating soil erosion is now irreversible and desertification is taking hold.	Key impacts are often onsite and relate to loss of soil productivity. In extensive areas soils are now very thin and can no longer support profitable cultivation. Land abandonment and rural depopulation follow.
	Unsustainable agricultural practices are a major cause of soil erosion across Europe. These include intensification, overgrazing, excessive ploughing of fragile soils, poor irrigation approaches, cultivation of erosion prone crops (e.g. maize), and forest clearing.	In central Europe, the Caucasus and the Mediterranean, 50–70 % of agricultural land is at moderate to high risk of erosion. Olive groves and vineyards are particularly at risk (a high percentage of ground remains uncovered). In southern Europe around 100 million ha of land has a low or very low level of organic carbon in the topsoil.	Soil erosion and the associated loss of topsoil and nutrients reduce soil productivity and hence crop yields. Related impacts include increased use of fertiliser and diffuse pollution. Estimates of the economic impacts indicate that soil erosion can reduce the gross value added by agriculture by 8%, equating to a loss of 53 Euros/ha/year.
Soil compaction	Soil compaction is caused by excessive use of heavy machinery. It is most common in areas where agriculture is intensive.	Soils that are particularly susceptible to compaction exist in Belgium, northwest France, Germany, the Netherlands and Poland. Compaction is the dominant form of soil degradation in central and eastern Europe where it has affected over 60 million ha (11 % of the total land area).	Increased runoff leads to negative impacts on agricultural productivity due to soil degradation from loss of nutrients and topsoil. Reduced infiltration increase downstream flood risk. Contaminated runoff impacts on aquatic ecosystems through siltation and eutrophication.
Salination	Salination occurs where there is a build up of salts close to the surface of soils. The principal causes of salination are unmanaged irrigation, over-abstraction of groundwater, industrial activity and evaporation of saline groundwater.	Mediterranean countries are particularly badly affected, with 16 million ha (representing 25 % of total irrigated cropland) suffering from salination. Almost 10% of Hungary's land area is significantly affected by salination. Other central and eastern European countries are also negatively impacted.	Salination reduces the productivity of soils and can render them unusable. Salinated soils are expensive to restore, and in some cases it is impossible to return soils to their original state. Negative offsite impacts concern windblown salt which can damage agricultural land.
Soil contamination	Causes of soil contamination include deposition of air pollutants (acidification, eutrophication), industrial processes/accidents/dereliction,	Areas from the Nord-Pas de Calais in France to the Rhein-Ruhr region in Germany are affected. Hotspots exist around the Saar region in Germany and north of the river Po in Italy.	Damaged soil can be expensive to remedy and in extreme cases can be irreversible in human timeframes. This causes problems for urban

	military activity, urbanisation, unsuitable waste disposal, and over use of agricultural chemicals and fertilisers. Key problems include acidification and soil contamination by heavy metals and nutrients. Soil contamination is prevalent around major cities, the most heavily industrialised areas of north west Europe, and areas of intensive agricultural fertiliser use.	There are also problems in central and eastern Europe around the 'Black Triangle' encompassing parts of Poland, Czech Republic and Slovak Republic. 'Industrial desertification' in the Ukraine due to mining and heavy industry extends to 3% of the countries land area. Around 5 million ha of land in the Ukraine is impacted by heavy metals. In Romania more than 4 million ha of soil is contaminated by pesticides.	expansion, agriculture, industry, human health and biodiversity. Soil contamination negatively affects the filtering and buffering capacity of soils, reducing its capacity to absorb pollutants. This leads to surface and groundwater pollution with associated impacts on agriculture, industrial processes and drinking water. The mean total annual cost of soil contamination is estimated at around 25bn euros/year (2003 figures).
	Acidification is the most common cause of soil contamination in Europe, and is the only widespread form of diffuse soil pollution. It is caused by deposition of air pollutants (including sulphur dioxides, nitrogen oxides, ammonia) created by industry, agriculture, transport and domestic activity.	In Poland, nearly 25% of soils have a pH less than 4.5. In the Ukraine, over 11 million ha of agricultural land is affected by acidification. Air pollution from western, central and eastern Europe causes acidification in Scandinavia. Here the soils have a low natural buffering capacity and thresholds for acidification are often breached.	See above.
Soil sealing	Soil sealing occurs where built infrastructure (relating to urbanisation, transportation, housing etc) covers natural soils with artificial surfaces (roads, pavements etc). Often it is agricultural land that is lost.	Soil sealing is a particular problem in the intensively urbanised western European countries - . Tourism is a significant driver of soil sealing in Mediterranean countries. At present, central and eastern Europe suffer less from soil sealing.	Once sealed, soils ecological functions (e.g. filtration, absorption, carbon sequestration) are largely lost. Natural runoff patterns are affected leading to increased flood risk and pollution of water courses by contaminated runoff.
	Due to extensive urbanization, soil sealing is a particular problem in western Europe where the area of built up land is increasing faster than the population. Socio-economic factors (e.g. increase in size and number of households, urban sprawl) are increasing this trend.	15% of western Europe's land is urbanized. Hotspots include the Ruhr region where 78% of land is covered by artificial surfaces. In cities including Palermo and Bratislava artificial surfaces have doubled in 50 years. Countries with the most urbanised land area (16-20%) are Belgium, Denmark and the Netherlands. There are particular problems with soil sealing in Benelux, Switzerland and Germany. In Germany, over 120 ha of soil are lost daily (1997 figures)	Land becomes unusable for agriculture, forestry etc. This leads to intensification of farming and use of marginal land. Soil sealing also leads to a loss in green space areas which have an important role in nature conservation, flood risk management and improving urban air quality. Further, topsoil removed prior to development cannot be replaced if buildings are subsequently demolished.

Table 6: Soil - key baseline data.

2.4. Water

Water is central to environmental, social and economic systems. It provides a range of indispensable services including diluting wastes, supporting agricultural and industrial production, offering space for recreation, and providing and maintaining natural habitats. Water follows a natural cycle from source to sea, and humans now exert a significant influence over many elements of this cycle. Driving forces including agriculture and urbanisation harm water resources and associate impacts (including over-abstraction of groundwater, pollution and inefficient use) are now a real hazard for the European environment (see Figure 7). Although many rivers are getting cleaner, pesticide and heavy metal pollution remain a threat to human health and ecosystems. Flooding is Europe's most common and economically costly natural disaster, and drought can have major impacts on agricultural productivity in water stressed regions.

Addressing water quality and quantity issues can have significant benefits for humans and ecosystems. This is increasingly acknowledged as the multifaceted values of water are beginning to be recognised and understood. Indeed, efforts to improve water quality have been Europe's most expensive environmental enterprise to date accounting for more than half of all environmental investments. Some countries spend almost 1% of GDP on related issues, principally for treating wastewater. Protecting against flooding can also be a costly endeavour. Point source pollution to surface waters is increasingly coming under control. However, addressing diffuse pollution from agriculture and urban areas is now a key challenge for policy makers with concern for water resources.

Headline messages concerning Europe's waters are highlighted below. These issues are explored in detail within Table 8.

- Nearly half of Europe's population lives in water stressed countries.
- In terms of water supply problems, hotspots exist around large cities, small islands and Mediterranean coastal resorts.
- Overall, abstraction rates have been decreasing since the 1990s.
- There is a north/south split concerning water use, with industry and domestic demands dominating in the north and agriculture in the south.
- Floods are Europe's most common natural disaster and affect around 1.5% of the population. Central and eastern Europe has been particularly badly affected in recent years.
- Water quality in Europe's rivers and bathing waters is generally improving, but around 20% of surface waters remain seriously threatened by pollution.
- Concentrations in rivers and lakes of oxygen consuming substances (ammonia and organic matter), nitrate and phosphorous are falling. Regional and localised problems remain, especially around large cities and areas characterised by intensive agriculture and/or industry.
- In some regions groundwater supplies are threatened by over-abstraction and pollution from contaminants including nitrates and heavy metals.

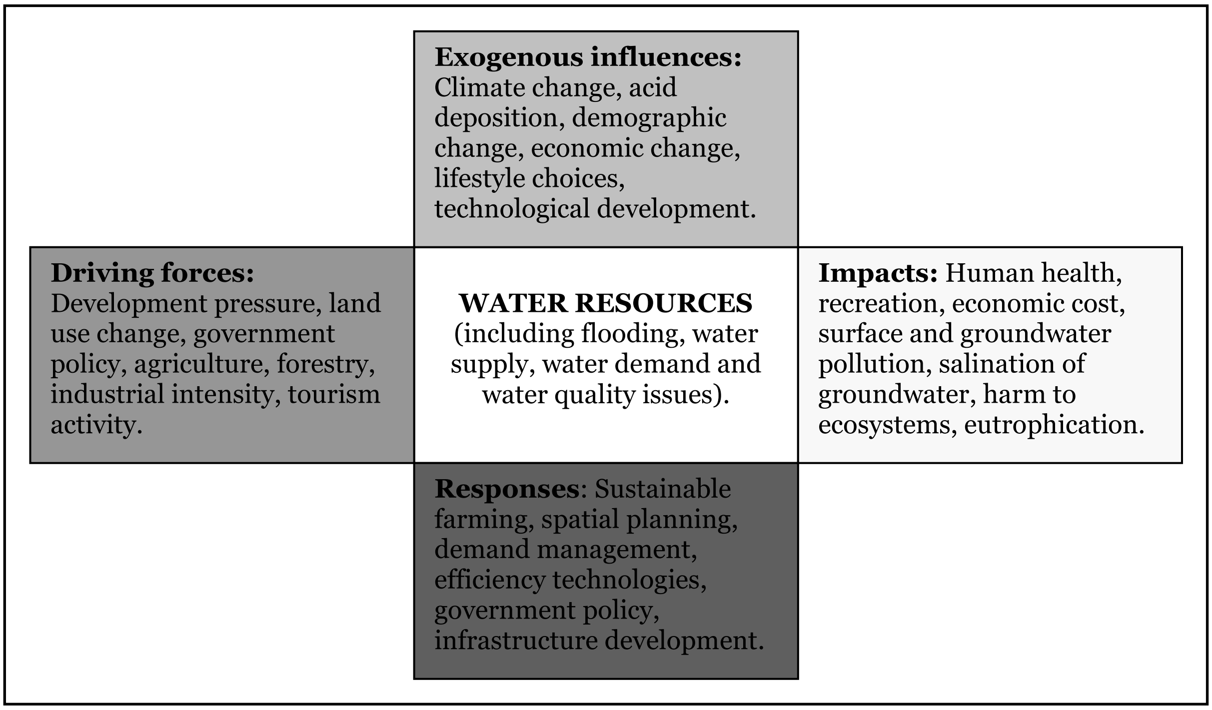

Figure 7: Water resources 'issue cross'.

Within PLUREL, the environmental drivers sub-theme of water relates to the issues of flooding, water demand, water supply and water quality. Inland and coastal water resources provide the focus for the study, and marine waters are not considered. In all of these areas, Europe faces significant challenges, each of which will be exacerbated by climate change. Due to the pervasive nature of water within socio-economic and environmental systems, peri-urban land use relationships are extensive in space and time (see Table 7).

Water resources – peri-urban land use relationships
• Diffuse pollution from agriculture has significant negative impacts (locally and downstream) on water quality (in rivers, lakes and aquifers) and aquatic biodiversity. • Unsustainable farming practices (e.g. soil compaction, late sowing of winter crops) increases runoff from fields worsening downstream flooding, soil erosion and diffuse pollution problems. • Demand for water for agriculture leads to abstraction from water bodies. In some regions this causes impacts including habitat/biodiversity loss and salination of groundwater and soils. • Surface sealing (for roads, carparks etc) increases the volume and speed of rainwater runoff raising the threat of downstream flooding and local flash flooding. Runoff can be contaminated (by oil, salt etc) worsening water quality. • Demand for water by urban dwellers pressures supplies in peri-urban and rural areas. Potential problems include over abstraction from aquifers and surface water bodies. • Improved wastewater treatment around urban settlements limits the release of pollutants (including nitrates, phosphorous and organic matter) into water bodies raising water quality. • Water resource problems (flooding, water stress etc) can limit development potential. For example, it may not be possible to expand housing provision due to a lack of water supplies.

Table 7: Examples of peri-urban land use relationships concerning water issues.

WATER			
	Issue	***Geographical distribution***	***Associated Impacts***
Flooding	Globally, floods are the most common natural disaster and have doubled in frequency since 1996. Different types of flooding include river, coastal, groundwater, flash and urban (overwhelming drainage systems). In Europe, between 1998 and 2002 there were over 100 significant flood events. Land use change in urban and rural areas is increasing flood risk and associated damages. Deforestation contributes to local flash floods.	Central and eastern Europe has been particularly badly affected in recent years. Annual damages (1998-2002) in the Czech Republic were 0.76% of GDP. In recent years floods have occurred several times in north west Romania, south east France, central and southern Germany, north Italy and east England. 10 million people and over 150 billion Euros of assets are at risk along the banks of the Rhine. 1.5 million people are at risk in England and Wales.	Human health (death, contaminated water) and wellbeing is affected. There are significant financial costs (e.g. disruption to business, damage to infrastructure). Environmental impacts include inundation of wastewater treatment, mobilisation of pollutants, soil erosion and damage to wetlands and riparian habitats. Considerable sums are spent to protect against floods - around 800 million Euros annually in England and Wales alone.
	Almost half of Europe's natural disasters are floods. Between 1998-2002 floods caused 700 deaths and around 25 billion Euros of insured economic losses. Economically, they are the most costly natural disaster. Although floods are common, it is extreme events that cause the most significant impacts.	In May 1998 torrential rain in Campania (Italy) caused flash flooding that killed around 300 people. Floods caused by heavy rain in central Europe in August 2002 affected 11 countries and 4.2 million people, leaving 112 dead and 250000 displaced. Around 15 billion Euros of damage was caused.	The negative impacts of flood are environmental, economic and social. However, flooding is a natural process and has beneficial impacts including recharging aquifers, maintaining habitats (e.g. wetlands, mires) and maintaining soil fertility.
Water supply	Total rainfall over Europe is around 3500 cubic km/year. Approximately 300 cubic km/year is withdrawn from for human use - equivalent to the combined discharge at the mouths of the Danube, Rhine and Loire rivers. Despite this relative abundance, water supply problems are common.	Much of Europe's rain falls in the north, which is generally sparsely populated. Many major cities are in the drier south. Nearly half of EU citizens live in water stressed countries which include Belgium, England and Germany. Cyprus, Italy, Malta and Spain are particularly water stressed.	Lack of water leads to the unsustainable use of groundwater resources. Over-abstraction of surface waters can create low flows in rivers, damaging associated ecosystems and concentrating pollutant loads. Water shortages can threaten agricultural production and development in urban areas.
	Europe is characterised by variable annual water availability per capita. Consequently, Europe's relative water abundance is more theoretical than real. Indeed, 31% of the population lives in regions that experience periods of high water stress and droughts are not uncommon. Populations are particularly exposed to drought in Spain, Italy and south east England.	Countries with a low level of annual water per capita (<1700m3/year) include Malta, Cyprus, Denmark, Czech Republic and Belgium. Countries with a high level of annual water per capita (<15000m3/year) are concentrated in Scandinavia and the Baltic region. Agriculture and tourism pressure water resources in southern Europe in the summer, precisely when demand is highest and supply at its lowest.	Low water availability can interact with extreme weather to create drought. In 1999 a year of drought in Spain lead to agricultural losses valued at 3 billion Euros. In 2000 Romania had its worst drought in 50 years with 40% of agricultural production affected. There are also environmental effects of droughts with wetlands being particularly vulnerable. Soil erosion can also be exacerbated.
	Groundwater supplies are under strain in many areas. In 60% of European cities with more than 100000 people, groundwater is being used at a faster rate than it can be replenished.	Groundwater is being over-exploited in parts of central and eastern Europe and southern Spain. Localised problems are also seen around major cities and areas in southern Europe where agriculture is intensive and the tourism sector is booming.	Over-abstraction is leading to saltwater intrusion into groundwater around the Mediterranean coasts of Spain, Italy and Turkey, and also in Denmark. In Malta, much groundwater can not be utilised for domestic use or irrigation – desalination is needed.
Water demand	On average, 21 % of Europe's annually renewable freshwater resources are abstracted for human use. In	The water exploitation index (WEI) - a measure of water use against available supplies - fell in 17 countries during	Over-exploitation of water resources pressures available supplies in rivers, lakes and aquifers to the

	some countries where water resources are less abundant, high levels of demand are leading to unsustainable use of available supplies.	1990s, largely from institutional and economic change. The WEI increased in 5 countries (inc. Portugal, UK, and Greece) during the 1990s.	detriment of ecosystems, recreation, housing provision, economic development (agriculture, tourism, industry etc) and human health.
	At the EU level, water use is split between agriculture (37 %), the energy sector (32 %), households (24 %) and manufacturing (13 %). These figures vary from region to region.	Northern countries use water principally for industrial (especially power stations) and domestic uses, whilst in southern Europe the use of water for agriculture (especially irrigation) dominates.	Abstraction impacts on the quality, quantity and ecological integrity of water resources resulting in environmental, economic and social impact.
	Over-abstraction of water from rivers, lakes and aquifers is a particular problem in Mediterranean countries where it is used for agriculture and in some cases by the tourism industry.	In the EU-15, 85% of irrigated land exists in Mediterranean countries. In England, where water is abundant, agriculture accounts for 1% of water use. In Spain, Portugal and Greece, this figure is over 70%.	In parts of Spain, only 10% of rainfall reaches rivers due to over abstraction and evaporation. Salination of groundwater is a problem around the Mediterranean coastline.
Water Quality	Improved wastewater treatment has reduced concentrations of oxygen consuming substances (e.g. organic matter and ammonia) by 20-30% in around half of Europe's rivers during the 1990s. However, levels increased at 10% of monitoring stations over this period.	Rivers in northern Europe show the lowest concentrations. In some EU-10 and ascension country (e.g. Bulgaria, Hungary, Czech Republic) levels in rivers remain higher (e.g. ammonia significantly above background levels), although decreases have occurred in recent years.	Eutrophication is caused by the excessive build up of nutrients in water bodies. This disrupts the natural balance of ecosystems and can result in impacts including algal blooms. Aquatic biodiversity in these waters suffers from a lack of oxygen. The aesthetic and recreation value of water bodies is also reduced by eutrophication.
	Modification of river structure (canalisation, dredging, straightening etc) has been widespread across Europe where many rivers can no longer be classed as natural.	90 % of Danish rivers are canalised, culverted or regulated. In Germany only 10 % of rivers are considered to be largely natural. Scandinavian countries have a greater proportion of natural rivers.	Modifications alter the natural behavior of rivers, damaging habitats and impacting on ecological processes. In France, modifications have degraded 64 (out of 76) wetlands of national importance.
	Small decreases have been seen in nitrate level in Europe's rivers. Nevertheless, in 2000-2001, rivers in 14 EU countries exceeded the EU Drinking Water Directive's nitrate requirements. Diffuse pollution from agriculture is the main source of nitrates. Consumption of nitrogen fertiliser started to decline in the late 1980's, although recently levels have risen in nations where agriculture is intensifying (especially the EU-10).	Countries with the highest agricultural land use and population densities (e.g. Denmark, Germany, Hungary, UK), generally have higher nitrate concentrations than those with the lowest (e.g. Estonia, Norway, Finland, Sweden). Over 20% of rivers tested in Spain and France and several eastern European countries (e.g. Lithuania, Poland, Hungary) show an upward trend in nitrates. Czech Republic and Denmark have no rivers showing this trend.	Nitrate pollution has significant negative impacts, which are principally associated with eutrophication. Addressing nitrate pollution at source is around 10 times cheaper than post-pollution cleanup. Costs are estimated at 50-150 Euros/hectare/year to introduce farming methods to meet Nitrates Directive standards. As it can take many years for nitrates to reach water sources, a legacy is being left for future generations.
	There have been significant reductions (in some cases by over 1/3) in phosphate concentrations in Europe's rivers. Phosphate content of household detergents has fallen and wastewater treatment is now more effective. Phosphorus produced per person has fallen from around 1.2–1.6 kg/year in the 1980s to 0.9–1 kg/year in 2003.	The largest reductions have been experienced in countries that preciously had greatest point source pollution problems. For example, in Denmark and the Netherlands, point-source pollution has dropped by 90 % with associated reductions in phosphate levels. Estonia also achieved a 90 % reduction in point-source discharges to surface water.	Despite decreases in phosphate levels, eutrophication and its associated impacts remains an intractable problem over much of Europe. Indeed, impacts associated with eutrophication have lessened little in many areas since the early 1980s.

	At the EU level, concentrations of nitrates in groundwater have remained quite stable since the 1990s. However, there are significant regional differences, and around 1/3 of Europe's groundwater exceeding nitrate guideline values.	Nordic countries (e.g. Norway) generally have low nitrate concentrations in groundwater. Where agriculture is more widespread and intensive (e.g. UK, Germany, Hungary) levels are much higher.	Nitrates pollute groundwater that is used for drinking creating potential human health problems. Remediation has significant economic costs. Denitrification of UK drinking water costs around EUR 30 million a year.
	Across the EU, coastal and inland bathing waters have improved in quality since the 1990s. By 2003, 97 % of designated coastal bathing waters and 92 % of designated inland bathing waters met mandatory quality standards.	In 2003, all designated coastal bathing waters in the Netherlands and Belgium met mandatory standards. Finland was the worse performer. In 2003, Ireland, Greece and the UK achieved full compliance with standards for inland waters, although only 11 sites were designated in the UK (Germany designated 1572). Italy had the lowest level of compliance.	Improving bathing waters has clear benefits in terms of recreation and spin-off economic gains. Further, ecosystems also stand to benefit from cleaner bathing waters. Commercial coastal fishing stocks also stand to benefit.

Table 8: Water - key baseline data.

4. References

References within the **research strategy chapter**:

- European Commission (EC) (2004) Aid Delivery Methods Volume 1: Project Cycle Management Guidelines, EuropeAid Cooperation Office, Brussels.

The references on which the **air quality baseline profile** is based are:

- European Environment Agency (2003) *Europe's environment: the third assessment - summary*, European Environment Agency, Copenhagen.
- European Environment Agency (2004) *EEA Signals 2004: A European Environment Agency update on selected issues*, European Environment Agency, Copenhagen.
- European Environment Agency (2005) *Air pollution in Europe 1990-2000*, European Environment Agency, Copenhagen.
- European Environment Agency (2005a) *European environment – state and outlook 2005: summary*, European Environment Agency, Copenhagen.
- European Environment Agency (2005b) *The European environment – state and outlook 2005*, European Environment Agency, Copenhagen.

The references on which the **biodiversity baseline profile** is based are:

- European Environment Agency (2003) *Europe's environment: the third assessment - summary*, European Environment Agency, Copenhagen.
- European Environment Agency (2004) EEA Signals 2004: *A European Environment Agency update on selected issues*, European Environment Agency, Copenhagen.
- European Environment Agency (2005) *European environment outlook, European Environment Agency*, Copenhagen.
- European Environment Agency (2005a) *The European environment – state and outlook 2005*, European Environment Agency, Copenhagen.
- European Environment Agency (2006) *Progress towards halting the loss of biodiversity by 2010*, European Environment Agency, Copenhagen.
- Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-being: Synthesis*, Island Press, Washington DC, USA.

The references on which the **soil baseline profile** is based are:

- European Environment Agency (2000), *Down to earth: Soil degradation and sustainable development in Europe – a challenge for the 21st Century*, European Environment Agency, Copenhagen.
- European Environment Agency (2003) *Europe's environment: the third assessment - summary*, European Environment Agency, Copenhagen.

- European Environment Agency (2003a), *Europe's environment: the third assessment*, European Environment Agency, Copenhagen.

- European Environment Agency (2003b), *Assessment and reporting on soil erosion – Background and workshop report*, European Environment Agency, Copenhagen.

- European Environment Agency (2004) *EEA Signals 2004: A European Environment Agency update on selected issues*, European Environment Agency, Copenhagen.

- European Environment Agency (2005) *European environment outlook*, European Environment Agency, Copenhagen.

- Görlach, B., R. Landgrebe-Trinkunaite, E. Interwies, M. Bouzit, D. Darmendrail and J.-D. Rinaudo (2004): *Assessing the Economic Impacts of Soil Degradation. Volume IV: Executive Summary*. Study commissioned by the European Commission, DG Environment, Study Contract ENV.B.1/ETU/2003/0024. Berlin: Ecologic

The references on which the **water baseline profile** is based are:

- Dartmouth Flood Observatory webpage – http://www.dartmouth.edu/~floods

- European Environment Agency (2001) *Sustainable water use in Europe – Part 3: Extreme hydrological events: floods and droughts*, European Environment Agency, Copenhagen.

- European Environment Agency (2003) *Europe's environment: the third assessment - summary*, European Environment Agency, Copenhagen.

- European Environment Agency (2003a) *Mapping the impacts of recent natural disasters and technological disasters in Europe*, European Environment Agency, Copenhagen.

- European Environment Agency (2004) *EEA Signals 2004: A European Environment Agency update on selected issues*, European Environment Agency, Copenhagen.

- European Environment Agency (2005) *The European environment – State and outlook 2005*, European Environment Agency, Copenhagen.

- European Environment Agency (2005a) *European environment outlook*, European Environment Agency, Copenhagen.

- UNESCO (2003) *Water for People, Water for Life - Executive Summary*, UNESCO Division of Water Sciences, Paris.

- World Business Council for Sustainable Development (WBCSD) (2005) *Water: Facts and Trends*, WBCSD, Geneva.

4. Further reading

Air quality

Journals
- Atmospheric Environment (Elsevier)

Webpages
- http://www.eea.europa.eu/themes/air (European Environment Agency air pollution webpage
- http://air-climate.eionet.europa.eu/ (European Topic Centre on Air and Climate Change)
- http://www.greenfacts.org/air-pollution/index.htm (Green Facts webpage - scientific facts on air pollution)
- http://www.eea.europa.eu/themes/air (European Environment Agency air pollution homepage)

Biodiversity

Journals
- Biodiversity and Conservation (Springer Verlag)

Webpages
- http://biodiversity.eionet.europa.eu/ (European Topic Centre on Biological Diversity)
- http://ec.europa.eu/environment/nature/index_en.htm (DG Environment Nature and Biodiversity homepage)
- http://www.unep-wcmc.org/ (United Nations Environment Programme – World Conservation Monitoring Centre)
- http://www.ecnc.nl/ (European Centre for Nature Conservation)
- http://www.cbd.int/ (Convention on Biological Diversity)
- http://www.unep.org/ (United Nations Environment Programme)
- http://www.millenniumassessment.org/en/index.aspx (The Millennium Ecosystem Assessment)
- http://www.eea.europa.eu/themes/biodiversity (European Environment Agency biodiversity homepage)

Soil

Journals
- European Journal of Soil Science (Blackwell Publishing)
- Water, Air and Soil Pollution (Springer Netherlands) – N.B. Also useful for additional information on the air quality and water baseline profiles.

Webpages
- http://eusoils.jrc.it (European Soil Portal)
- http://ec.europa.eu/environment/soil/index.htm (DG Environment European Soil Strategy)
- http://terrestrial.eionet.europa.eu/ (European Topic Centre on Land Use and Spatial Information)
- http://www.isric.org/ (International Soil Reference and Information Centre)
- http://www.eea.europa.eu/themes/soil (European Environment Agency soil homepage)

Water

Journals

- Water Research (Elsevier)

Webpages

- http://www.unep.org/themes/freshwater/ (United Nations Environment Programme Freshwater homepage)
- http://www.worldwater.org/ (The World's Water)
- http://www.unwater.org/flashindex.html (United Nations Water Homepage)
- http://www.worldwatercouncil.org/ (The World Water Council)
- http://www.eea.europa.eu/themes/water (European Environment Agency water homepage)