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9. Soil degradation

Europe's soil is being irreversibly lost and degraded as a result of increasing and often conflicting demands from nearly all economic sectors. Pressures result from the concentration of population and activities in restricted areas, and changes in climate and land use. Cultivation systems are among the most important influences on the quality of soils in agricultural areas. Consumer behaviour and the industrial sector are contributing to the increase of potential sources of contamination such as municipal waste disposal, energy production and transport, mainly in urban areas. Tourism is a further cause of soil degradation, especially along the coasts of the Mediterranean. Many of the problems stem from past activities and poor management practices in the former Soviet Union and Eastern Europe.

The combined action of these activities affects quality and limits many soil functions, including the capacity to remove contaminants from the environment by filtration and adsorption. This capacity and the resilience of soil mean that damage is not perceived until it is far advanced. This partly explains the low priority given to soil protection in Europe until recently. Moreover, since soil is a limited and non-renewable resource, damage to soil, unlike that to air and water, is not easily recoverable.

Major problems in Europe are irreversible losses due to soil sealing and erosion, continuing contamination from local and diffuse sources, acidification, salinisation and compaction.

The geographical distribution of soil degradation depends on several factors. Soil problems are influenced by the diversity, distribution and specific vulnerability of soils across Europe. They also depend on geology, topography and climate and on the distribution of driving forces. Better integration of soil protection into sectoral policies and better harmonisation of information across Europe is needed to move to a more sustainable use of soil resources.

9.1 The issue

The quality of Europe's soils is a result of natural factors, such as climate and topography, and human activities. As a consequence, there is a wide diversity of soil types, and soil degradation differs markedly across Europe.

Soil has many ecological and socio-economic functions, including the capacity to remove contaminants from the environment by filtration and adsorption. This capacity and soil resilience mean that damage to soil is often not perceived until it is far advanced. Following the precautionary principle and taking account of the slow rate of soil formation, soil can be considered as a limited and non-renewable resource on a 50 to 100 year timescale.

One of the most important influences on the quality of soil is the cultivation systems used in agriculture. Loss of organic matter and consequently soil fertility are often driven by unsustainable practices such as deep ploughing and monoculture, while the continuous use of heavy machinery destroys soil structure through compaction (German Advisory Council of Global Change 1994; EEA, 1999). In addition, overgrazing and intensification, strongly linked in the EU to the implementation of the Common Agricultural Policy, may accelerate the loss of soil through erosion.

In addition to agriculture, consumer behaviour is contributing to increases of sources of soil pollution: municipal waste, energy consumption, transport and emissions of exhaust gases (EEA, 2002b). The major impact of these is a reduction of soil buffering capacity, that is the capacity of soil to adsorb contaminants. The extent of this reduction is difficult to measure although there are signs that it is near to exhaustion in many areas in Europe.

Many of these degradation processes have a direct impact on the global carbon cycle, particularly through the decrease of soil organic matter and the release of carbon dioxide to the atmosphere.

Soil erosion affects large areas of Europe (about 27 million ha in the EU, Oldeman et al., 1991). Climatic conditions make the Mediterranean region one of the areas most severely affected. Changes in land use, such as abandonment of marginal land with very low vegetation cover and increases in the frequency and extension of forest fires, have had a strong impact on soil resources since historical times. In the most extreme cases, soil erosion, coupled with other forms of land degradation, has lead to desertification in some areas of the Mediterranean and Eastern Europe. Soil erosion is an increasing concern in Northern Europe, although to a lesser degree (EEA, 2000b; 2002c).

9.1.1 ***Western Europe***

Soil contamination remains a problem in the WE despite several national and international initiatives during the past ten years to reduce air emissions and control, for example, the application of sewage sludge and the use of landfill for waste disposal. The WE is highly urbanised (built-up areas occupy 15 % of its territory) and competition for the limited land available results in the loss or degradation of soil resources and in particular the sealing of the soil surface at unsustainable rates, for example through urban development and the construction of transport infrastructures.

9.1.2 Central and Eastern Europe

Soil degradation problems in the CEE countries are similar to those in the WE, although there is less soil sealing. Most of the problems are inherited from the former Soviet Union period, when environmental issues were of minor concern. Erosion is the most widespread form of soil degradation, linked to agricultural mismanagement and deforestation (van Lynden, 2000). Past agricultural policies that focused on increasing productivity led to the intensive use of mineral fertilisers, pesticides and heavy machinery. The combined effects of these led to an increased rate of soil loss by erosion, pollution of groundwater and reduction of soil fertility. Increased awareness of environmental issues, the obligation to implement EU legislation upon accession and declining economies are reducing the pressures from agriculture (decreases in fertiliser and pesticide consumption).

Soil contamination is due, to a great extent, to the legacy of inefficient technologies and uncontrolled emissions. Problem areas include some 3 000 former military sites, abandoned industrial facilities and storage sites which may be still releasing pollutants to the environment (DANCEE, 2000). One of the major impacts is groundwater contamination and related health problems. A major concern is the long time needed to regenerate contaminated soil and the considerable investment required for remedial measures.

Conflicts in the Balkans have had impacts, not only in the countries directly involved, but also in neighbouring areas as a consequence of the migration of refugees and increased demand for basic resources (food and firewood). In Bosnia-Herzegovina it has been estimated that the war damaged soil resources in an area of about 6 000 ha through deforestation, erosion, compaction, waste disposal and damage to industrial facilities (REC, 2001).

9.1.3. Newly Independent States

As in the CEE countries, soil degradation in the NIS is a legacy of the former Soviet Union. The recent overall economic decline has reduced pressures on the soil and resulted in a decrease in fertiliser, pesticide and water consumption, and a general slowing of industrial activity (UNEP, 2002). However, pressures on the soil are increasing at the local level, mainly in urban areas and around rural settlements.

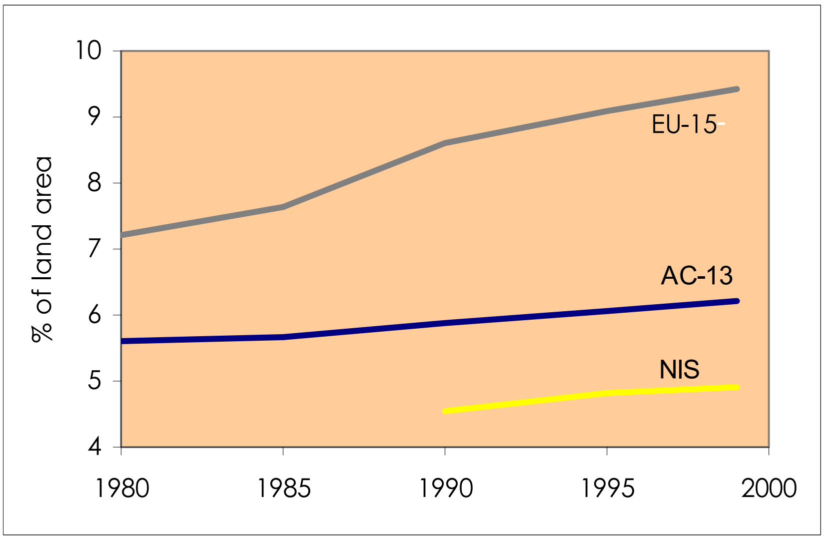
Over the past 50 years, the priority given to increasing the productivity of agriculture, combined with climatic factors, resulted in soil and water pollution from the overuse of pesticides and fertilisers, and the salinisation of large areas as a consequence of unsustainable irrigation schemes and cultivation practices (the best-known case is the environmental disaster of the drying-up of the Aral Sea). The most extreme forms of degradation have resulted in the desertification of large areas. In Kazakhstan an estimated 60 % of the territory is at risk of desertification (UNECE, 2000a). The process is accelerated by the abandonment of marginal land and large-scale collective farms.

Heavy-metal contamination is common around major industrial areas (van Lynden, 2000). The problem is especially acute in the mining and metallurgical complexes of Kazhakstan (Rekacewicz et al., 2000) and in the Caspian area, where oil spills are also a major source of contamination (UNDP and GEF, 1998). Existing and planned oil and gas pipelines in the area are leading, or are expected to lead, to pressures on soil and, among other impacts, to the fragmentation of habitats. Contamination with radioactivity is also important as a result of nuclear weapons tests, improper radioactive waste disposal and the Chernobyl accident (UNEP, 1998).

9.1.4. Policy development

Unlike water and air, soil protection has not generally been the subject of specific policy objectives and targets; rather, it has been addressed indirectly through measures aimed at the protection of air and water or developed within sectoral policies. An important recent advance has been the inclusion of plans for a thematic strategy on soil protection in the 6th Environmental Action Programme in 2001 and the adoption of a Commission Communication on soil protection, endorsed by the European Council in 2002. The Communication calls for the development of a European soil monitoring system capable of providing reliable, comparable and regular information on soil conditions in Europe. Most international programmes also emphasise the need to improve soil monitoring in Europe (EEA, 2000b). However, the key to progress towards a sustainable use of soil resources remains a better integration of soil protection into sectoral policies.

Figure 9.1. Built-up area as percent of total land.



Note: EU-15 includes Austria, Belgium, Denmark, France, Germany, Luxembourg, Netherlands and Spain. AC-13 includes Czech Republic, Latvia, Lithuania, Poland, Romania and Slovakia. NIS countries include Armenia, Azerbaijan, Belarus, Georgia, Moldova, Tajikistan, Ukraine and Uzbekistan.
Sources: For EU15 and Accession Countries: Eurostat New Cronos (2001). For NIS countries: data request EEA.

☹	Soil sealing continues to increase, especially in the WE.

Soil sealing is covering the soil surface with an impervious material or changing its nature so that it becomes impermeable. Soil sealing is not necessarily adverse, but it may lead to a chain of unwanted effects. The greatest impacts are in urban and metropolitan areas where large portions of the land are covered with constructions. The development of transport infrastructures is another important cause. Built-on land is lost to other uses such as agriculture and forestry, and the ecological functions of soil, such as storage of carbon and habitat for unique biota, are limited or impeded. Soil sealing can also result in the fragmentation of habitats and disruption of migration corridors for wildlife species.

Soil sealing can have a major impact on water flows. Run-off water from housing and traffic areas is normally unfiltered and may be contaminated with harmful chemicals. Surface run-off can increase significantly, causing problems of local flood control. Although floods are natural phenomena, they may be intensified by human alteration, as has been observed in Europe in recent years (PIK, 2000). The increasing demand for land for new residential areas or industrial facilities has resulted in the development of areas at high risk of flooding (UNECE, 2000c).

Over the past 20 years, built-up areas have been steadily increasing all over Europe (figure 9.1.). Although geographical coverage is not complete and estimation methods may vary slightly from country to country, socio-economic factors appear to be the main driving forces for this growth. The most dramatic changes have been in WE, where the area of built-up land is increasing more rapidly than the population (EEA, 2002b), a result of the steady increase in the number of households and average residential space per capita since 1980, a trend that has accelerated since 1990 (EEA, 2001). At the same time travelling distances to services increased at the expenses of private transport (EEA, 2000a). As a result, the demand for new buildings and better transport infrastructures continues to rise. In addition, increasing prosperity has led to a higher demand for second homes, inevitably resulting in more soil sealing.

The countries with the highest share of built-up area (between 16 and 20 % of total land area) are Belgium, Denmark and the Netherlands. In most cases, built-up areas have increased at expense of agricultural land, and to a lesser extent forests (EEA, 1999; EEA, 2000b). The effects of these changes can be observed, for example, in Spain, where highly productive agricultural land in the floodplains has been transformed in residential areas, transferring agricultural activities to less productive land. At the same time, intensive cultivation has been introduced to maintain productivity (MMA et al., 2002). In the Mediterranean countries, urbanisation has been growing in the coastal zones of southern France, Italy, southern Spain and the Mediterranean islands, with tourism is the main driving force (EEA, 2000b, see also chapter 2.7 Tourism)

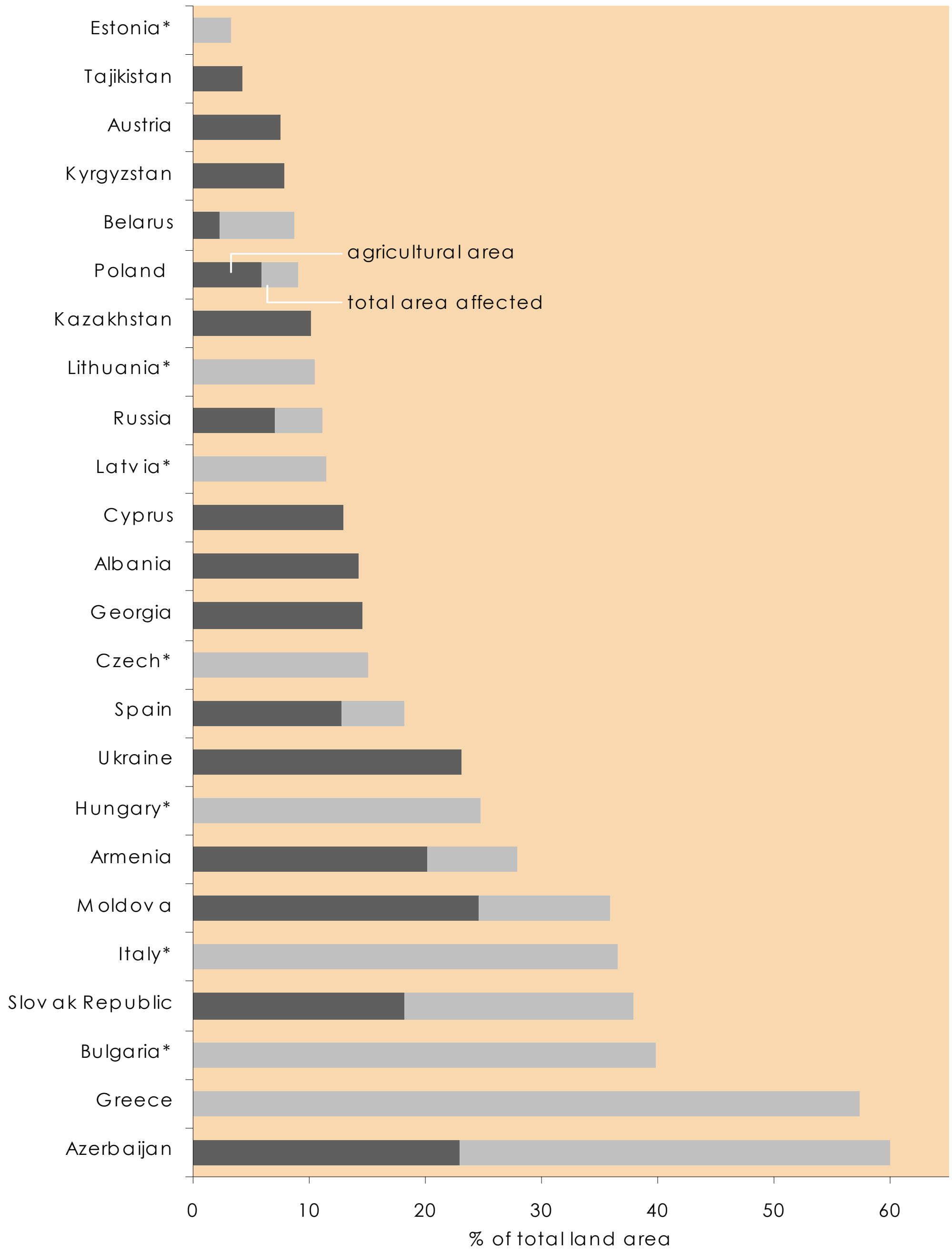
The extent of built-up area in the CEE countries was more or less constant during the late 1970s and the first half of the 1980s. Political and economic changes during the late 1980s resulted in the development of new infrastructures, the migration of rural populations to the cities and the development of new settlements (BEF, 2000). Hungary and the Czech Republic have the highest percentage of built-up area (about 10 % of the total land area). Pressure is also increasing in some coastal zones, for example along the Latvian coasts on the Baltic Sea.

Soil sealing is still a minor problem in the NIS compared to other forms of soil degradation, such as erosion, salinisation and contamination. However, pressure is increasing around industrial and urban settlements and in tourist areas along the coasts of the Black Sea (UNECE, 1999b).

In the EU, policy measures explicitly related to land-use issues, such as spatial planning, have generally been the responsibility of Member States, since the European Commission does not have an explicit competence in this policy area. Although mentioned in the 5th and 6th Environmental Action Plans, spatial planning has only recently been specifically addressed, within the European Spatial Development Perspective (1999), the new European Urban Strategy (under development) and the Communication on Soil Protection (2002).
The inclusion of environmental concerns and objectives in spatial planning is now widely recognised as a major tool for reducing the effects of uncontrolled urban expansion. This has led, for example, to the adoption of measures such as the re-use of underdeveloped or derelict urban areas (brownfields) and the adoption of specific targets in some countries (including Denmark, Germany and the UK) (EEA, 2000b). In 2003 the Commission will present a Communication on *Planning and Environment: the territorial dimension*, addressing the need for rational land-use planning to enable the sustainable management of soil resources, limiting the sealing of greenfields and promoting the re-use of brownfields.

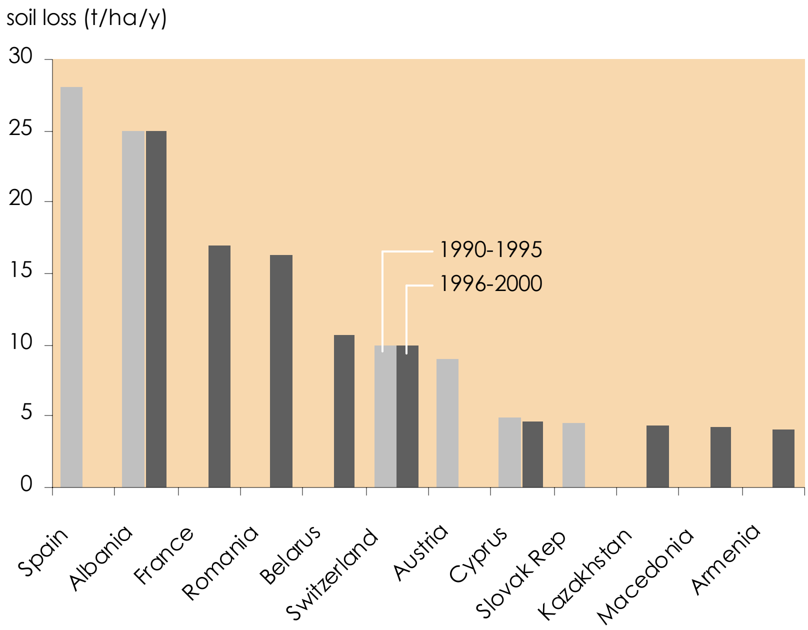
9.2 Soil erosion

Figure 9.2. Area affected (total and agricultural) by erosion in selected countries.



Note: Asterisks indicate that data for agricultural area are not available. Data refer to 1990-1999, except for Austria, Greece, Hungary, Italy, Poland, Slovak Republic and Spain where the data cover 1990-1995.
Source: For EU15: OECD-Eurostat (1997); For Eastern Europe: SOVEUR (2000) and data request EEA (2002); For the NIS: data request EEA (2002).

Figure 9.3. Soil loss per year by erosion from agricultural land



Source: For EU15: OECD-Eurostat (1997), various national sources, EEA. For Eastern Europe and the NIS: national reports and data request EEA (2002).

☹	Unsustainable agricultural practices, coupled with adverse natural and other factors, are increasing the loss of soil through erosion, some of which may be irreversible.

Soil erosion is one of the major and most widespread forms of land degradation. About 17 % of the total land area of Europe is affected to some degree (Oldeman et al., 1991, EEA, 2002a). Soil erosion is a natural process which has been exacerbated by human activities. Major causes are unsustainable agricultural practices, large-scale farming and overgrazing in the WE and CEE, and poor water and irrigation management, especially in the NIS (UNECE, 2001). In the Caucasus, the energy crisis and fuel shortages have caused an increase in woodcutting to obtain firewood for heating since the late 1980s, which has been one of the main drivers of soil erosion in this area (UNEP, 2002). In the past few years, the increase in the frequency and extent of forest fires in the Mediterranean region has also had a significant impact on soil erosion. Tourism and transport may be important driving forces in localised areas (EEA, 2002a).

Soil erosion in Europe is due mainly to water (about 92 % of the total affected area) and less to wind. Wind erosion is localized in northern Europe and CEE (EEA, 2002a).

As the topsoil is eroded and washed away, the fertility and productivity of the remaining soil is reduced. Farmers than have to apply more fertiliser to compensate for yield losses. Erosion is most serious in central Europe, the Caucasus and the Mediterranean region, where 50 to 70 % of agricultural land is at moderate to high risk of erosion (UNECE, 2001). Figure 9.2. shows the area affected in various countries. Available data show that the problem is mainly localised in agricultural areas. Olive plantations and vineyards are among the crops more susceptible to erosion because a high percentage of the soil surface remains uncovered by vegetation all the year round.

Since the rate of soil formation is so slow, any soil loss of more than 1 tonne/ha/yr can be considered as irreversible within a time span of 50-100 years (EEA, 1999). Current rates of erosion in Mediterranean countries (

Figure 9.3.), if confirmed, would mean that irreversible processes of soil degradation (and desertification in the most extreme cases) are already occurring in that area. In some areas the situation is so extreme that there is no more soil left to erode (Grimm et al., 2002).

Soil erosion has a major economic impact. Yearly economic losses in agricultural areas in Europe are estimated at around 53 EUR per ha, while the costs of off-site effects on the surrounding civil public infrastructures reach 32 EUR per ha (García-Torres et al., 2001). In Armenia, for example, the costs of the damage from soil erosion in the past 20 years amounted to 7.5 % of national gross agricultural product (UN-ECE/MNP of Armenia, 2000).

The effects of soil erosion are expected to get worse, as climate change is expected to influence the characteristics of rainfall in ways which might increase soil erosion in Central Europe (Sauerborn et al., 1999).

Policies to combat soil erosion comprise a wide range of actions: adoption of sustainable farming practices (including minimum tillage systems, contouring, terracing or strip cultivation), land planning to determine the most suitable crops for each area, ending set-aside of arable land, reclamation of highly degraded lands or areas affected by desertification, reforestation of watersheds, and incentives to promote more sustainable activities.

The Common Agricultural Policy has undergone a substantial reform since 1992 and since the adoption of Agenda 2000 in 1999. There has been a gradual elimination of many subsidies and a reinforcement of incentives to promote environmentally sensitive agriculture. Soil protection measures have been reinforced and expanded to encourage organic farming, the maintenance of terraces, safer pesticide use, the use of certified composts and afforestation, among others. Implementation of these measures is expected to produce positive effects in the enlarged EU.

9.3 Soil contamination

Soil contamination from diffuse and localised sources can damage several soil functions and contaminate surface and groundwater.

9.3.1. Diffuse sources

The main diffuse sources are atmospheric deposition of acidifying and eutrophying compounds or potentially harmful chemicals, deposition of contaminants from flowing water or eroded soil itself, and the direct application of pesticides, sewage sludge, fertilisers and manure, which may contain heavy metals. The soil functions most affected by contamination are its buffering, filtering and transforming capacities. Currently, the most important problems from diffuse sources are acidification, contamination by heavy metals and the effects of a surplus of nutrients.

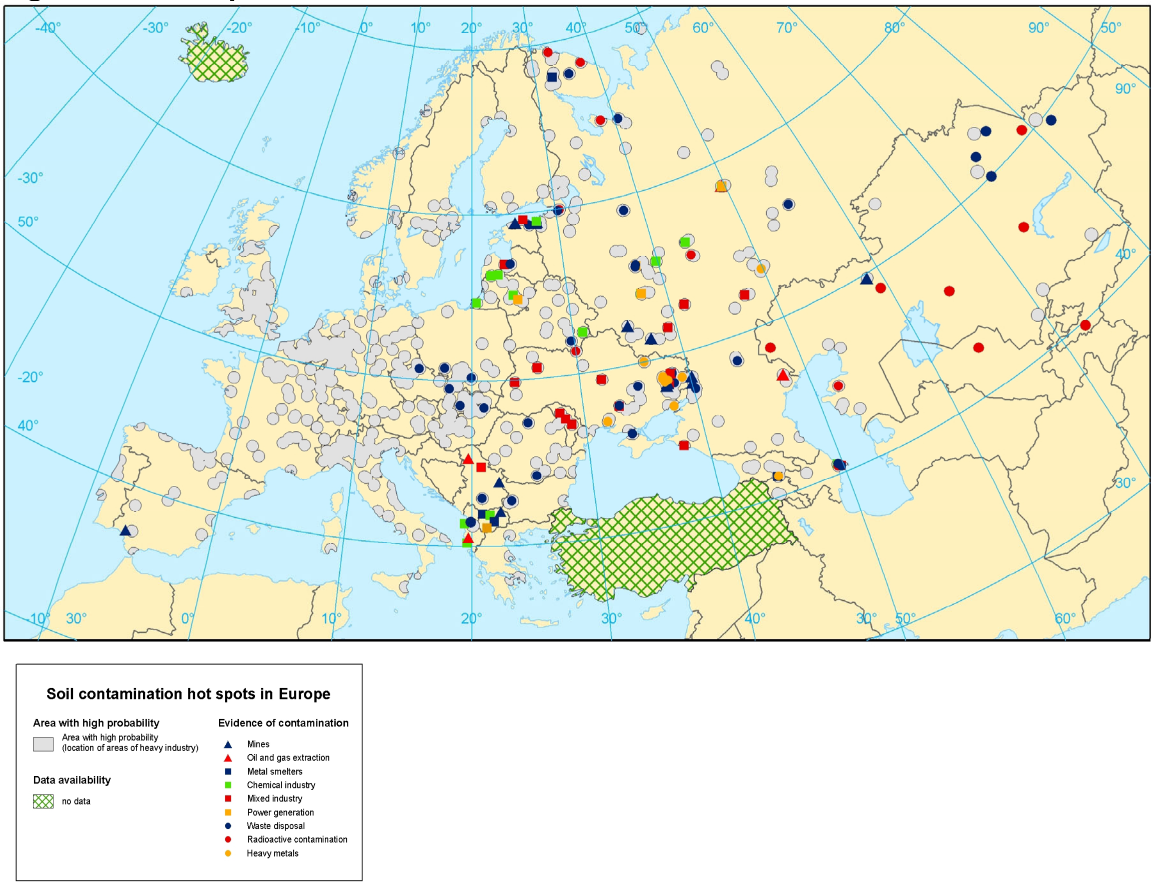
Acidification is the most widespread type of soil contamination in WE and CEE, where vast areas have been affected, especially in Poland (10 million ha) and Ukraine (8 million ha). In relative terms, soil contamination is also important in Hungary, Latvia and Lithuania. High content of heavy metals in soils is reported in Ukraine (about 5 million ha) and in Lithuania (nearly 3 million ha) (van Lynden, 2000). However, the relatively high heavy metal concentrations in Lithuania can be partly explained by high natural background levels. Contamination by pesticides is common in Ukraine (over 5 million ha) and Romania (over 4 million ha), where the estimated degree of contamination is light to moderate (van Lynden, 2000). Considerable contamination by radionuclides is reported for Ukraine as a result of the Chernobyl accident, while radioactive waste from uranium plants is stored without protection in Kyrgysztan and in a former soviet nuclear test site in Kazakhstan (UNECE, 1999a; UNECE, 2000a; UNECE, 2000b).

9.3.2. Localised sources

Soil contamination from localised sources is often related to industrial plants no longer in operation, and to past accidents and improper municipal and industrial waste disposals. However, current activities still cause significant impacts (EEA, 2000b). Soil polluting activities in 12 countries are summarised in Figure 9.5.

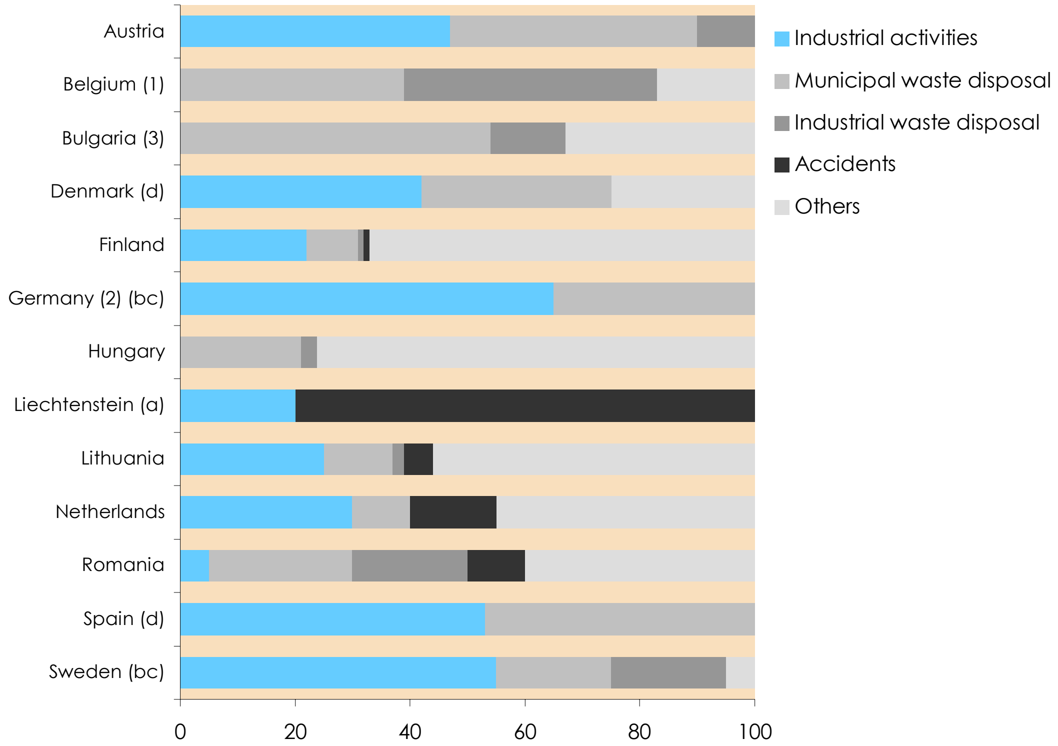
Sites contaminated in these ways can pose serious threats to health and to the local environment as a result of releases of harmful substances to groundwater or surface waters, uptake by plants and direct contact by people, and following explosion of landfill gases.

Figure 9.4. Hot spots of soil contamination.



Source: For EU15: Metal Bulletin Books, 1994. For eastern Europe: Denisov et al.,1997; Mnatsakanian, 1992; UNECE (1999,2000), SOVEUR (2000).

Figure 9.5. Soil polluting activities from localised sources.



Notes: (1) Belgium: data refer to Flanders. (2) Germany: 'Industrial Activities' also includes 'Accidents' and 'Other', and 'Municipal Waste Disposal' also includes 'Industrial Waste Disposal'. (3) Bulgaria: 'Others' include mining sites, former military sites, oil extraction and storage, power plants, storage of manure. (a) Minor accidents are not included. (b) The percentage share refers to the total number of identified, suspected sites. (c) Data refer exclusively to abandoned sites (not in operation). (d) Municipal waste includes industrial waste. The types of industrial activity (either historical or currently in operation) that pose a risk to soils and groundwater, and the spectrum of the various polluting activities, vary between countries. These variations may result in different classification systems and in incomplete information being available in some countries.
Sources: EEA

☹	Soil contamination related to local sources is widespread, mainly in CEE and the NIS and has resulted mainly from waste disposal from municipal and industrial sources and industrial activities.

The largest and probably most heavily affected areas are concentrated around the most industrialised regions in Northwest Europe, from Nord-Pas de Calais in France to the Rhein-Ruhr region in Germany, across Belgium and the Netherlands (Figure 9.4.). Other areas where the probability of occurrence of local soil contamination is high include the Saar region in Germany; northern Italy, north of the river Po, from Milan to Padua; the so-called Black Triangle region located at the corner of Poland, the Czech Republic and the Slovak Republic. However, contaminated areas exist around most major cities and some individual contaminated sites in sparse populated areas (EEA, 2000b).

A wide range of potentially harmful elements and chemical compounds is used in industry. Soil and groundwater contamination can be caused by handling losses, defects, industrial accidents and leaching of hazardous substances at waste disposal sites. Major pollutants include organic contaminants such as chlorinated hydrocarbons, mineral oil and heavy metals. In some parts of Europe, soil is contaminated by artificial radio-nuclides.

In the mining industry, which is a major driver of soil degradation in CEE countries, the risk of contamination is associated with sulphur and heavy-metal bearing tailings stored on sites, and the use of certain chemical reagents such as cyanide in the refining process. Acid mine drainage is a common long-term problem after a serious incident at the Aznalcollar mine in Spain in 1998. The disaster affected a water course nearby for 63 km downstream and the adjacent land (Sol et al., 1999). Another recent accident was the cyanide spill in Romania from the Aurul tailings re-treatment plant at Baia Mare in 2000. This disaster affected plankton and fish in the upper reaches of the Tisza River in Romania and Hungary. The spill occurred in an area already contaminated by heavy metals from a long history of mining and metal processing. Upstream locations unaffected by this particular spill also contained high levels of some heavy metals. Thus, the accident occurred in a region with a number of poorly maintained and operated plants and flotation ponds containing cyanide and/or heavy metals, many of which are leaking continuously (CEC, 2000).

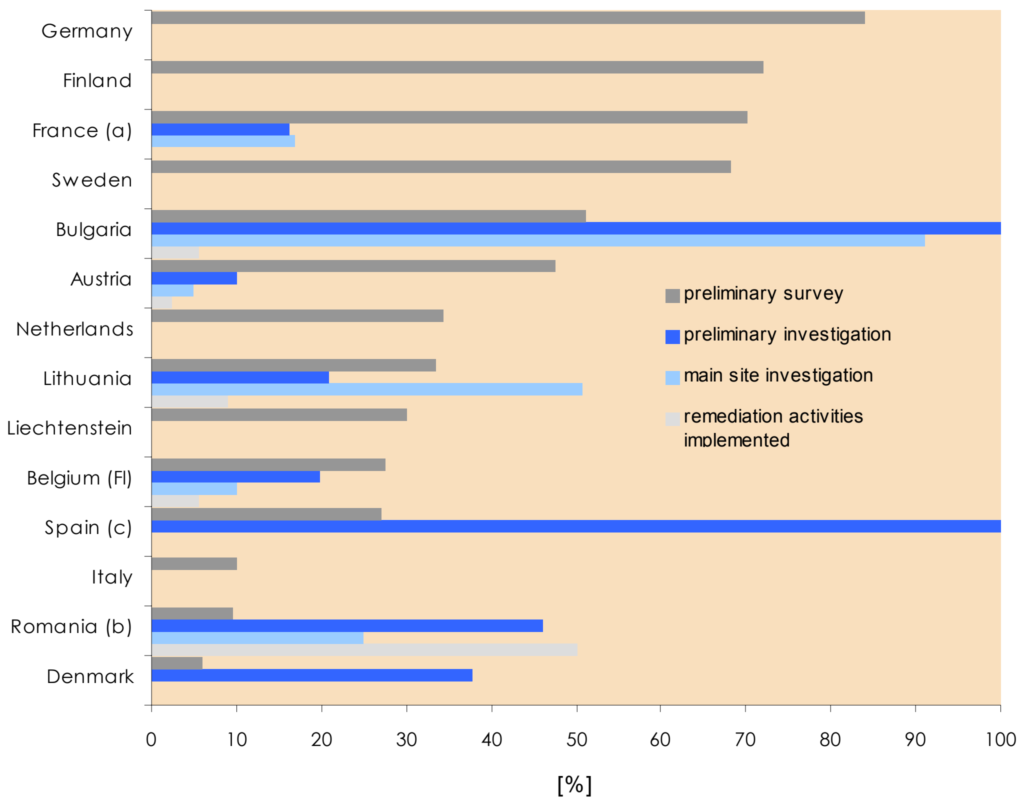
Waste landfilling is another important potentially contaminating activity. On average, 65 % of municipal waste generated in the EU is landfilled. Leaching from waste landfills can enter soil, groundwater and surface water. Of particular concern are landfills that operate or have operated in the past that do not comply with the minimum requirements set by the Landfill Directive (1999/31/EC).

Contaminated land in the CEE is to former military sites as well as to industrial activities and waste management. Inefficient technologies and production systems, in terms of raw material and energy consumption as well as waste production, were common. Heavily contaminated sites covering several thousand square metres probably still represent a considerable risk to human health and the environment.

In WE, the contribution of the military sector to soil contamination is not known, as data on contamination of military sites are not usually available to the public.

New legislative and regulatory frameworks at the national and EU level (Landfill Directive, Integrated Pollution and Prevention Control Directive, Water Framework Directive) are based on the precautionary principle. This should lead to handling losses and accidents at industrial sites resulting in fewer inputs of contaminants and better control of soil contamination (EEA, 2001). Much effort is still needed to characterise and remediate old contaminated sites.

Figure 9.6. Progress in the Management of Contaminated Sites.



Notes: (a) France: mean value of estimated total number of sites according to preliminary; (b) Romania: minimum value of estimated total number of sites according to preliminary survey. Information on completed remediation has not been included. Missing information in the graph indicates that no data have been reported for the particular country.
Source: EEA (1999, 2001).

😐	The first step in the management of contaminated sites (preliminary survey/investigation) is well advanced in most of the surveyed countries, but subsequent phases are progressing slowly.

9.3.3 Management of contaminated sites

The management of local soil contamination is designed to ameliorate any adverse effects where impairment of the environment has been proved, and to minimise potential threats. It is carried out in several steps. Preliminary surveys provide a list of potentially contaminated sites and verify, or not, the existence of contamination and potential harmful effects to human health or the environment. The main site investigation focuses on determining the extent of contamination. The fourth phase is the remediation plan, which includes measures to reduce adverse effects on human health or the environment as well as a remediation investigation. Finally, targets for remediation and/or safety measures can vary according to the proposed land use.

Figure 9.6. summarises progress in the management of contaminated sites in 14 European countries. Preliminary surveys are far advanced in most of the surveyed countries. Further stages are proceeding slowly. However, compared to earlier assessments, data availability and data access have improved.

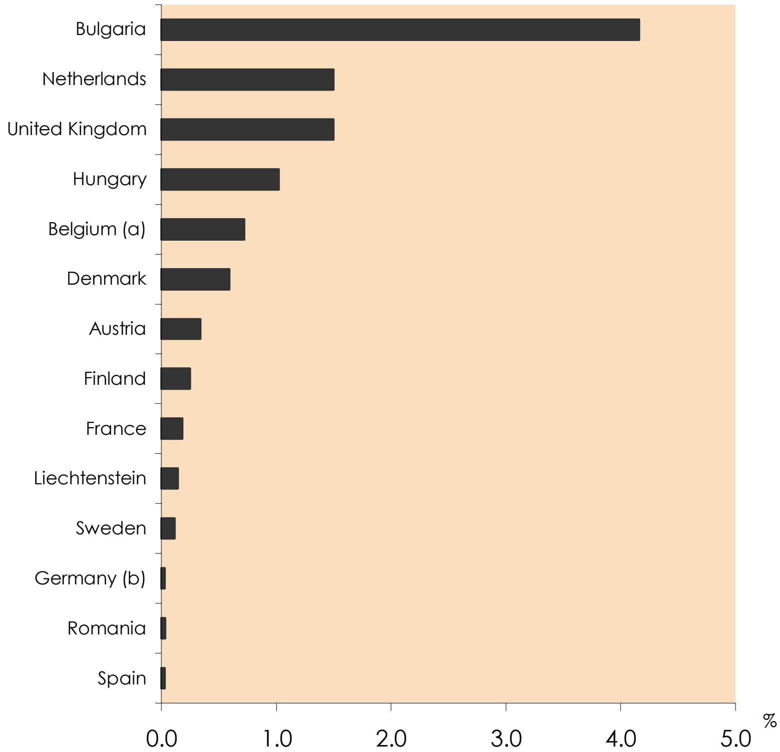
In general, all countries apply the 'polluter-pays' principle, to a different extent. However, a considerable share of total remediation costs has been provided from public money. Many countries have developed special funding tools for the clean-up of contaminated sites. For example in some countries there are voluntary agreements with the petrochemical and oil industry to fund the remediation of abandoned petrol stations, financed by a fee included in the petrol price. Estimates of public expenditures are available from many countries, but information on private expenditures is scarce and depends on approximate estimates.

Annual remediation expenditure varies from 35 to under 2 euro per capita in the reporting countries and has been almost constant from 1997 to 2000. The average cost for the countries surveyed was less than 1 % of GDP (figure 9.7).

In the EU, implementation of new regulations that reflect the precautionary principle should help to avoid local soil contamination in the future In the EU countries where data are available, expenditures on clean-up have remained constant over recent years. In future, most expenditures will probably remain constant, except in countries that have only recently begun to address the problem. Many Accession countries have started investigations, and the setting up specific funding tools and co-operation with the EU are increasing.

In CEE, most countries (e.g. Bulgaria, Lithuania) still do not have strategies and national policies for the management of contaminated sites or specific legislation regulating investigation and clean-up of contaminated land; others (e.g. Poland) have only recently introduced a new law on environmental protection. Hungary has been running a remediation programme since 1996. However, requirements for soil protection are generally included in several legislative acts (e.g. Environment Protection Law, Water Act, Law on Waste, Mining Act). Some countries are in the process of establishing a register of contaminated sites. In Hungary, for example, the results of a first survey are already available and the Slovak Republic is establishing a database of potentially contaminated sites in one district.

Figure 9.7. Expenditure for contaminated sites remediation in selected countries in 1999 as percentage of GDP.



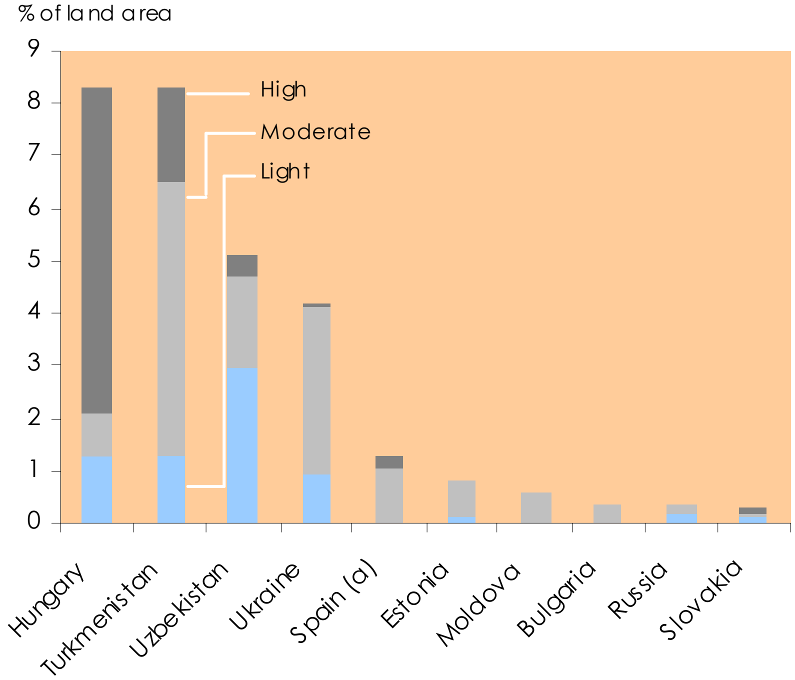
Notes: (a) Belgium: data on remediation expenditures refer to Flanders; data on Purchasing power partiy refer to Belgium. (b) France: data from 2001.
Source: For EU countries and Liechtenstein, data request EEA (2002). For Accession countries: data request new EEA member countries (2002). World Development Indicators database, World Bank, 2001.

☹	Most remediation activities are publicly funded. Expenditures to date have been mainly on surveys. Although significant, they are small (up to 8 %) compared to estimated total remediation costs.

9.4 Salinisation

Salinisation, the accumulation of salts on or near the surface of the soil, results in completely unproductive soils currently found on nearly 5 million hectares in Europe, mainly in the Mediterranean region, Eastern Europe and the NIS (data compiled from European Commission and NIS countries). It is caused by improper irrigation methods and evaporation of saline groundwater, ground water extraction and industrial activities.

Figure 9.8. Area of land affected by salinisation.



Note: Light: some signs of degradation are present, but the process is still in an initial phase. Moderate: salinisation is apparent, but control and full remediation to its current function is still possible with considerable efforts. High: evident signs of degradation. Changes in soil qualities are significant and very difficult, if not impossible, to restore within reasonable limits. (a) Area with light salinisation not available.

Sources: For Hungary, Ukraine, Estonia, Moldova, Bulgaria, Russia and Slovakia: SOVEUR (2000). For Turkmenistan, Uzbekistan and Ukraine: state of environment reports. For Spain: Plan to Combat Desertification (2000).

☹	Moderate to high salinisation is affecting agricultural soils in the Mediterranean area, Eastern Europe and the NIS, mainly as a result of inappropriate irrigation systems.

Irrigated soils in arid regions are particularly affected to larger or lesser extent: for example, about half the irrigated land in Uzbekistan (State Committee of the Republic of Uzbekistan, 2000) and some 16 million hectares (25 % of total irrigated cropland) in the Mediterranean countries (FAO, 1996).

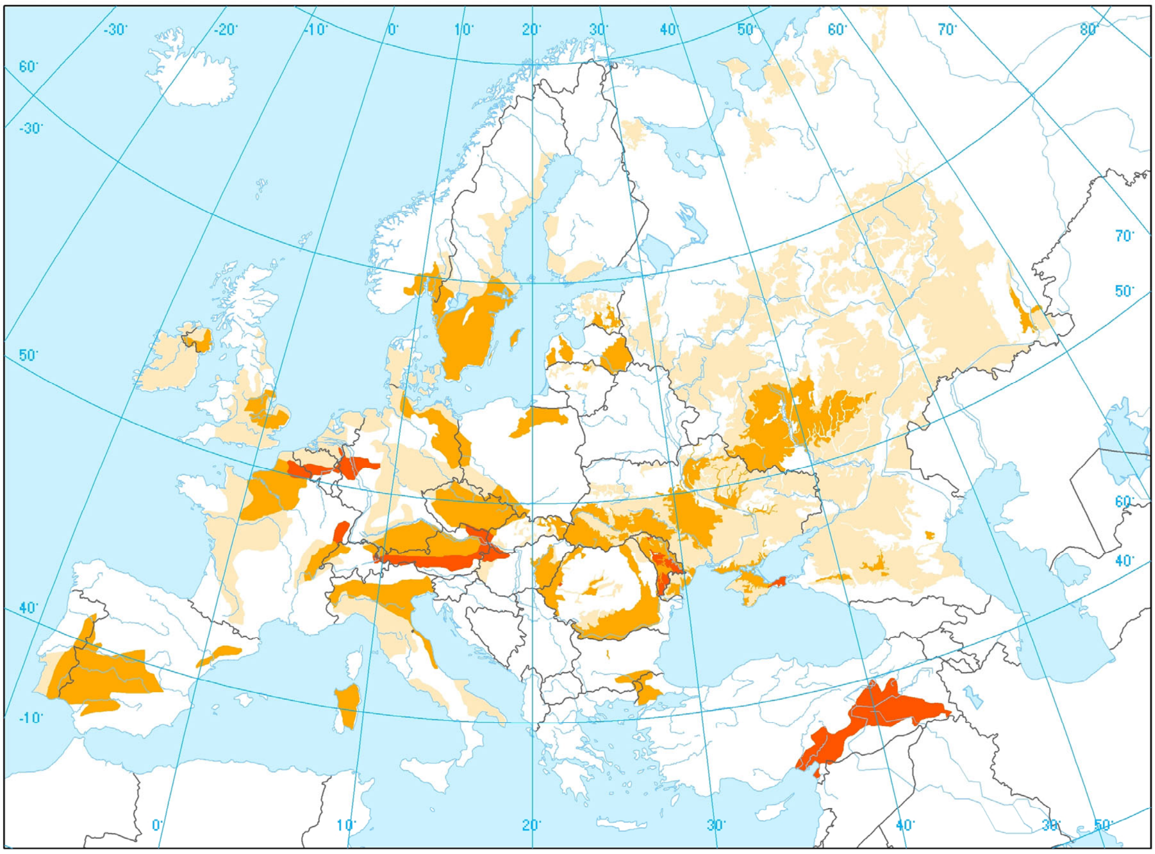
Salinisation has major impacts on the economy. It has been estimated that in the Central Asian republics, salinisation reduced cotton yields from 280 to 230 t/km^2 between the late 1970s and the late 1980s, despite an increased use of fertilisers (Gardner, 1997). Salinisation may also have important off-site effects because salt that has moved to the upper layer of the soil can be carried by the wind to other areas.

Salinisation has a major impact on soil quality and, above certain thresholds, restoration is very expensive if not impossible. Most remediation projects focus on improving soil condition and recovering the land for crop production by improving irrigation systems and the efficiency of water use, and by maintaining drainage systems. However, most of the severely affected areas are abandoned without any attempt at rehabilitation; for example, this applies to about 300 000 ha of affected soil in the Russian Federation (Stolbovoi and Fischer, 1997). Privatisation in the NIS and the lack of economic resources of private owners are making the implementation of improvements to irrigation systems and maintenance of drainage systems difficult. Where drainage is too expensive, planting salt-resistant plants has helped to stabilise the soil and reduce erosion (Mainguet and Létolle, 2000). In most countries, rehabilitation projects are directly linked to programmes to combat desertification.

9.5 Soil compaction

Soil compaction is potentially a major threat to agricultural productivity (EEA, 1995a; Nolte and Fausey, 2000). The repetitive and cumulative effect of heavy machinery on the same piece of agricultural land causes soil compaction - soil particles are pressed together and the pore spaces between them reduced. Soil compaction slows infiltration and increases the volume of surface runoff, thus accelerating water erosion and the loss of topsoil and nutrients. Compaction also changes the quantity and quality of biochemical and microbiological activity in the soil.

Figure 9.9. Degree and extent of soil compaction.



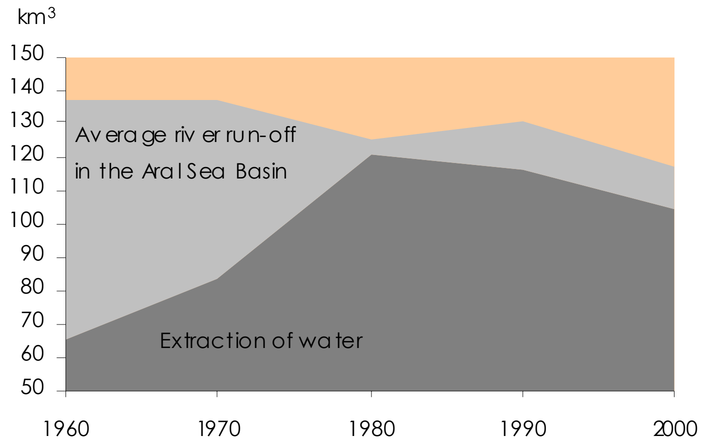
Sources: (van Lynden, 1995), SOVEUR (2000)

While compaction of topsoil can easily be countered by reworking the soil and can eventually be reversed if the biological processes in the soil remain undisturbed, deep compaction of subsoil is persistent and cannot easily be reversed (EEA, 1995b). Deep soils with less than 25 % clay content are the most sensitive to subsoil compaction

(Hébert, 2002). Sensitive soils are common in Belgium, northwest France, Germany, the Netherlands, Poland and the Russian Federation (EEA, 1995b). Soil compaction is the main form of soil degradation in CEE, where it has affected over 62 million ha or 11 % of the total land area in the surveyed countries. Particularly during the former Soviet Union period, heavy machinery was used on soils sensitive to compaction. The degree of compaction is mostly light to moderate, but negative impacts on agricultural productivity have nevertheless been reported in more than half of all areas affected (van Lynden, 2000).

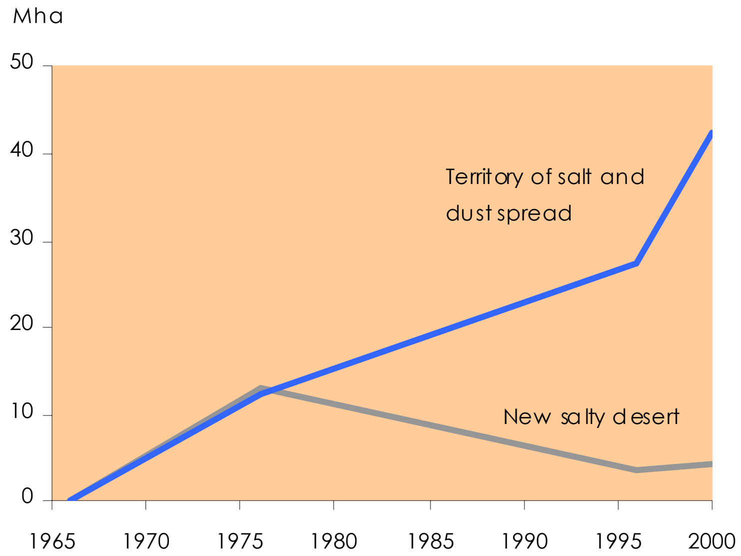
Box 9.1. Aral Sea follow-up problems

Figure 9.10. Water balance in the Aral Sea Basin.



Sources: UNEP/GRID-Arendal

Figure 9.11. Area with problems due to wind erosion and salt deposition



Note: "New salty desert " refers to the territory appeared as a result of the sea drying off
Sources: IFAS

In the 1960s, Central Asia became the major producer of raw cotton in the former Soviet Union. Cotton crops require extensive irrigation and the Aral Sea and its tributaries seemed a limitless source of water at the time. Local population grew from 14 million to about 27 million and the extent of irrigated land from about 4.5 million ha to almost 7 million ha between 1960 and 1980. The demand for water almost doubled (Figure 9.10.)

with more than 90 % of the water withdrawal used for agriculture. The water balance in the basin collapsed and, by the mid 1960s, the Aral sea level began to drop, reaching a critical point in 1980 (mean level decrease 90 cm a year) (Islamov, 1999). By that time, the excessive use of agrochemicals together with industrial and municipal sources of pollution had already seriously degraded the quality of the water. As the sea shrank, enormous quantities of salts accumulated on its bed, leaving nothing more than a salty desert.

Figure 9.11. shows the increase of this new salty desert to its maximum by the mid 1970s. Because of the concentration of toxic salts in the upper layer, lack of nutrients and shortage of fresh water, the resulting desert land has been proving extremely resistant to natural and artificial re-vegetation (Micklin, 1988). However, the most serious problem is the blowing of salt and dust from the dried seabed, the impact of which will last for decades. The area affected by the spread of salt and dust is increasing every year. The disaster has also affected the deltaic ecosystems and biological productivity, in particular fisheries, the basic economy of surrounding communities. Moreover, the population faces appalling health problems. A negative effect on climate has also been observed, which has reduced the crops significantly (Hiltunen, 1998).

In the catchments of the Aral sea, mismanagement of irrigation and drainage infrastructures has resulted in increased river water salinity, soil salinisation and water-logging. In addition, catchment areas have lost about half of their forest cover and soil erosion has intensified. As well as creating considerable environmental problems in the upper watersheds, all these factors have a negative impact on downstream areas.

In the last decade, the countries of the area have taken various initiatives to tackle the problem, with the support of international institutions. In 1994 the Aral Sea Basin Program was launched with the main objectives of rehabilitating the degraded area around the sea, improving management of land and water resources in the basin, and building the capacity of institutions at all levels in order to plan and implement these programmes. The programme had to confront many problems, especially the limited economic resources in relation to the scale of the disaster. Demand for water has levelled off to some extent, however the cultivation of many crops remains inefficient because insolvency of the water users has precluded the use of advanced irrigation techniques. As a result the water balance remains very precarious. Some pilot projects are focusing on integrated management of the land to prevent erosion and rehabilitate the most degraded areas (Aslov, 2000). However, these projects are still at a preliminary stage and extensive action is needed to avoid irreversible losses (Dukhovny and Sokolov, 2000).

References