



ENVIRONMENTAL PERFORMANCE OF AGRICULTURE IN OECD COUNTRIES SINCE 1990:

Chapter 1 Section 1.5 Soil

This document is an extract from Chapter 1 of the OECD publication (2008) *Environmental Performance of Agriculture in OECD countries since 1990*, which is available on the OECD website which also contains the agri-environmental indicator time series database at: www.oecd.org/tad/env/indicators

This text should be cited as follows: OECD (2008), *Environmental Performance of Agriculture in OECD countries since 1990*, Paris, France, www.oecd.org/tad/env/indicators

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1.5. SOIL

KEY TRENDS

Overall for the OECD there has been some improvement or stability in soil erosion, from both water and wind. An increase in the share of agricultural land within the tolerable erosion risk class has been accompanied by a reduction in areas at moderate to severe erosion risk.

Soil erosion from water for most OECD countries shows that the major share of agricultural land is within the tolerable erosion category and is not considered a concern. Almost a third of OECD member countries had more than 20% of agricultural land within the moderate to severe risk classes in the period 2000-02 (Greece, Hungary, Italy, Korea, Mexico, Portugal, Slovak Republic, Spain, Turkey). Over the average period 1990 to 2004 the share of land within these erosion risk classes, predominantly arable land, generally decreased or remained stable, although information on trends across OECD countries is limited.

Soil erosion from wind is also diminishing, although the number of countries for which wind erosion is a concern is smaller than for water erosion but cross country data are limited. Wind erosion is most prevalent in semi-arid areas or where soils exist in a very dry state for extended periods (Australia, Canada, Hungary, Iceland, Poland, United States).

Where **risks of erosion remain**, this is largely attributed to the: continued cultivation of fragile and marginal soils; overgrazing of pasture, especially in hilly areas; and poor uptake of soil conservation practices. In some regions erosion is aggravated by the increasing incidence and severity of droughts and/or heavy rainfall events, and in some countries land clearing (Mexico and Turkey). The reduction in agricultural land susceptible to moderate to severe risk of erosion is mainly linked to the growing uptake of soil conservation practices, such as the adoption of reduced or no tillage, and the conversion of agricultural land to forestry.

Estimates show that the **costs of soil erosion damage can be considerable**. On-farm costs correspond essentially to the agricultural production foregone as a result of soil degradation lowering crop productivity. Off-farm costs, resulting from off-farm sediment flows, include: extra expense to treat drinking water; costs of dredging rivers, lakes and reservoirs; damage to roads and buildings; and harmful effects on aquatic ecosystems, including recreational and commercial fishing.

Indicator definitions:

- Area of agricultural land affected by **water erosion** in terms of different classes of erosion, i.e. tolerable, low, moderate, high and severe.
- Area of agricultural land affected by **wind erosion** in terms of different classes of erosion, i.e. tolerable, low, moderate, high and severe.

Concepts and interpretation

Soil erosion, principally by water and to a lesser extent wind, is considered to be the highest priority soil quality issue for some OECD countries. Other soil degradation processes, including compaction, acidification, toxic contamination and salinisation largely relate to specific regions in some countries and therefore it is not possible to provide an overview of OECD trends (Chapter 3).

Soil plays a key role in maintaining a balanced ecosystem and in producing quality agricultural products (OECD, 2003). There can be a significant time delay between recognising soil degradation and developing conservation strategies, in order to maintain soil health and crop productivity. The intensity of rainfall, degree of protective crop cover, slope and soil type are the controlling factors of water erosion. The process of wind erosion is also controlled by climate (soil moisture conditions), crop cover and soil type and involves detaching and transporting soil particles (mainly silt and fine sand) over varying distances. Loss of topsoil by erosion also contributes to the loss of nutrients. Soil tillage practices can also contribute to erosion by moving soil on hilly landscapes, i.e. removing soil from the slopes' top to the bottom (Lobb *et al.*, 2003; Torri, 2003).

Indicators for soil erosion from water are generated by models, most often variants of the Universal Soil Loss Equation (USLE). Although these models take account of soil type, topography, climate and crop cover, they are using generalized inputs that provide estimates of soil erosion risk rather than actual field measurement values. Some OECD countries have well established soil monitoring systems (*e.g.* the **United States**) that provide field observations to directly validate national risk estimates. Other OECD countries are in the early stages of implementing similar field measurement systems (*e.g.* **Australia, Canada and New Zealand**); while others, including several **European Union** countries, are in the process of designing such monitoring systems (EEA, 2005; Montanarella *et al.*, 2003). It is important to stress that these trends only concern on-farm soil erosion.

While the USLE is commonly used by most OECD countries, the limits of risk of soil erosion classes reported from tolerable to severe vary between some countries (see OECD website database), but, a standardised scale has been used by OECD to present these data. Agricultural soils can "tolerate" a certain amount of erosion without adversely impacting on long-term productivity because new soil is constantly being formed to replace losses. The tolerable limit varies between different soil depths, types and agro-climatic conditions, but typically ranges from 1 tonne/hectare/year on shallow sandy soils to 6 tonnes/hectare/year on deeper well-developed soils. OECD's scale of soil erosion risk categories ranges from tolerable erosion (< 6 tonnes/hectare/year) through low, moderate, high and finally to severe erosion (> 33 tonnes/hectare/year). However, not all countries use these class limits as some consider tolerable erosion as less than 4 tonnes/hectare/year (*e.g.* the **Netherlands**, and the **Czech and Slovak Republics**).

Changes in agricultural land cover and use (Sections 1.1 and 1.8), farm production intensity (Section 1.1), and management practices and systems (Section 1.9) are the key **driving forces** covered by the soil erosion indicators which describe the **state** (or risk) of on-farm erosion. These indicators are useful tools for policy makers as they provide an assessment of the long-term environmental sustainability of management practices and the effectiveness of soil conservation measures. They can also be related to a range of soil quality issues including the loss of soil organic matter and soil biodiversity (Chapter 2). Changes in soil management practices (Section 1.9) are a **response** to improving soil quality and soil erosion risks.

Recent trends

The OECD trend shows some improvement or stability in most cases for soil erosion, from both water and wind. This is highlighted by an increase in the share of agricultural land within the tolerable erosion risk class relative to a reduction in areas at moderate to severe erosion risk, notably in those countries where soil erosion is a significant environmental issue, such as in **Canada** and the **United States**. The overall reduction in agricultural land susceptible to a high risk of erosion is mainly linked to both the increased uptake of soil conservation practices, such as the adoption of reduced or no tillage (Section 1.9), and also the conversion of agricultural land to forestry (Section 1.8). Where risks of erosion still remain a concern this is largely attributed to the: continued cultivation of fragile and marginal soils; overgrazing of pasture, especially in hilly/mountainous areas; and the poor uptake of soil conservation practices. Also, in some regions soil erosion is being aggravated by the increasing incidence and severity of droughts and/or heavy rainfall events (e.g. **Australia, Italy** and **Spain**), and in some countries clearing of native vegetation and forests (e.g. **Mexico** and **Turkey**).

Research shows that there are several costs associated with soil erosion damage, which can be considerable (e.g. see **Australia**, the **United Kingdom** and the **United States**, Chapter 3). On-farm costs refer mostly to the agricultural production foregone as a result of soil degradation lowering crop productivity. Off-farm costs, resulting from off-farm sediment flows, include: extra expense to treat drinking water; costs of dredging rivers, lakes and reservoirs; damage to roads and buildings; and harmful effects on aquatic ecosystems, adversely affecting recreational commercial fishing.

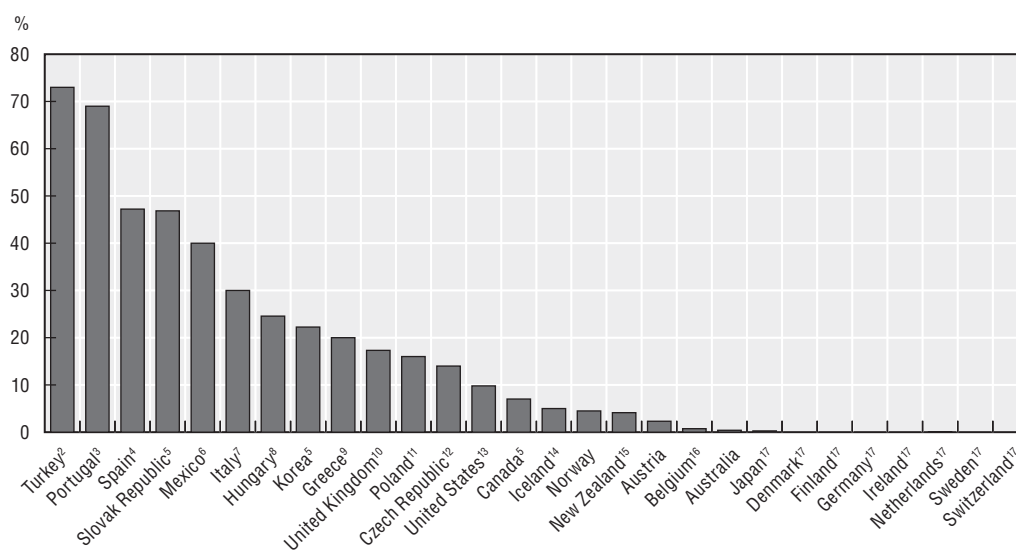
Soil erosion from water for most OECD countries shows that the major share of agricultural land is within the tolerable water erosion category and thus erosion is not considered a concern (Figure 1.5.1). Almost a third of OECD countries have more than 20% of agricultural land within the moderate to severe risk classes for the average period of 2000-02 (Figure 1.5.1). Over the period 1990 to 2004 the share of land within the moderate to severe erosion risk classes generally decreased or remained stable, although information on trends is limited (Figure 1.5.2, Chapter 3).


Soil erosion from wind depicts a similar trend, although the number of countries for which this is a serious problem is much smaller than for water erosion. Trends in the OECD agricultural land area within the modest to severe wind erosion risk categories are mainly stable or downwards over the 1990s, but cross country data are limited. Wind erosion is most prevalent in arid and semi-arid areas or where soils can exist in a very dry state for extended periods.

Soil erosion can originate from a number of economic activities (e.g. forestry, construction, off-road vehicle use) and natural events (e.g. fire, flooding and droughts). In most cases, however, the major share of soil erosion is accounted for by agricultural activities. In general, cultivated arable and permanent crops (e.g. orchards) are more susceptible to higher levels of soil erosion compared to pasture areas. This is because land under pasture is usually covered with vegetative growth all year. In **Spain** and the **United States**, for example, of agricultural land in the moderate to severe water erosion risk classes, arable and permanent cropland accounted for 75% and nearly 90%, respectively, over 1995-99 (OECD website database). However, where pasture is located on fragile soils with steep topography and subject to intensive grazing, problems of soil erosion can be more acute than on cultivated land, for example, in **Italy, New Zealand** and the **United Kingdom**.

Figure 1.5.1. **Agricultural land area classified as having moderate to severe water erosion risk¹**

Average 2000-02



StatLink  <http://dx.doi.org/10.1787/287065145113>

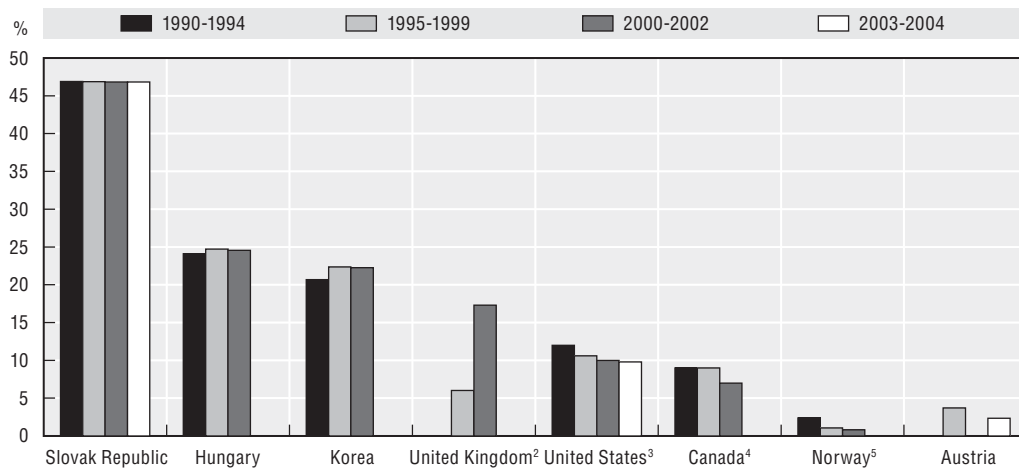
1. Risk of water erosion greater than 11 t/ha/y of soil loss, unless otherwise indicated.
2. Share of agricultural land of risk to elevated erosion rates, but t/ha/y not specified.
3. Covers all land including agricultural land, and covers high risks, but not defined source OECD (2001), Environmental Performance Review of Portugal.
4. Average 1987-2000 of actual area affected by erosion above 12t/ha/year.
5. Data for 2002-04.
6. Source: Chapter 3, Mexico country section.
7. Soil erosion risk greater than 10 t/ha/y, for all land, including agricultural land, 1999.
8. Data for 2000-02.
9. Covers all land, including agricultural land. Source: Montanarella et al. (2003).
10. For England and Wales. Data reported in terms of erosion events (not t/ha/y) occurring annually or every 3 years for moderate to severe erosion categories.
11. Data for 2005.
12. Data for 1999, severe risk classified as greater than 7.5 t/ha/y.
13. Water erosion on cropland, pasture land and Conservation Reserve Program land, above 11 t/ha/year for 2003.
14. Late 1990s, permanent grassland only, comprising 95% of the total agricultural land area. Moderate to severe erosion not classified by soil loss but by farmland.
15. No specific years provided.
16. Data for Flanders (1998) and Wallonia (1995-99).
17. These countries report that the risk of moderate to severe water erosion was between zero or less than 0.5%, of the total agricultural land area over the period 2000-02.


Source: OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France; and OECD Agri-environmental Indicators Questionnaire, unpublished; and national sources.

About 17% of the total land area in **Europe** is affected, to some degree, by soil erosion, but only 4% is affected by severe erosion. Soil erosion in Europe is mainly due to water (about 92% of the total) and less to wind, while it is becoming apparent that there is a trend towards shifting the balance from severe to tolerable erosion risk classes (EEA, 2005; Montanarella et al., 2003). In 2002 the European Commission launched “Towards a thematic strategy for soil protection” aiming to consider, amongst other issues, soil protection measures as a way of addressing problems of soil erosion (EUROPA, 2003).

The Mediterranean region of Europe is particularly at high risk to soil erosion from water, mainly **Italy, Portugal, Spain, Turkey**, and to a lesser extent **Greece** (Figure 1.5.1). Frequent dry periods followed by outbreaks of rain increases the risk of severe soil erosion, particularly in areas of the Mediterranean with steep topography, fragile soils and little

Figure 1.5.2. Trends in agricultural land area classified as having moderate to severe water erosion risk¹



StatLink  <http://dx.doi.org/10.1787/287073572653>

Note: Finland, Germany, Ireland, Japan, Netherlands, Sweden and Switzerland report that the risk of moderate to severe water erosion over the period 1990-2004 (see Figure 1.5.1) was between zero to less than 0.5% of the total agricultural land area.

1. Risk of water erosion greater than 11 t/ha/y of soil loss, unless otherwise indicated.
2. For England and Wales. Data reported in terms of erosion events (not t/ha/y) occurring annually or every 3 years for moderate to severe erosion categories.
3. Water erosion on cropland, pasture land and Conservation Reserve Programme land for 1992, 1997, 2001 and 2003 greater than 11 t/ha/year.
4. Values for 1991, 1996 and 2001 respectively for cropland and summer fallow.
5. Only for severe erosion category classified as greater than 8 t/ha/y.

Source: OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France; and OECD Agri-environmental Indicators Questionnaire, unpublished.

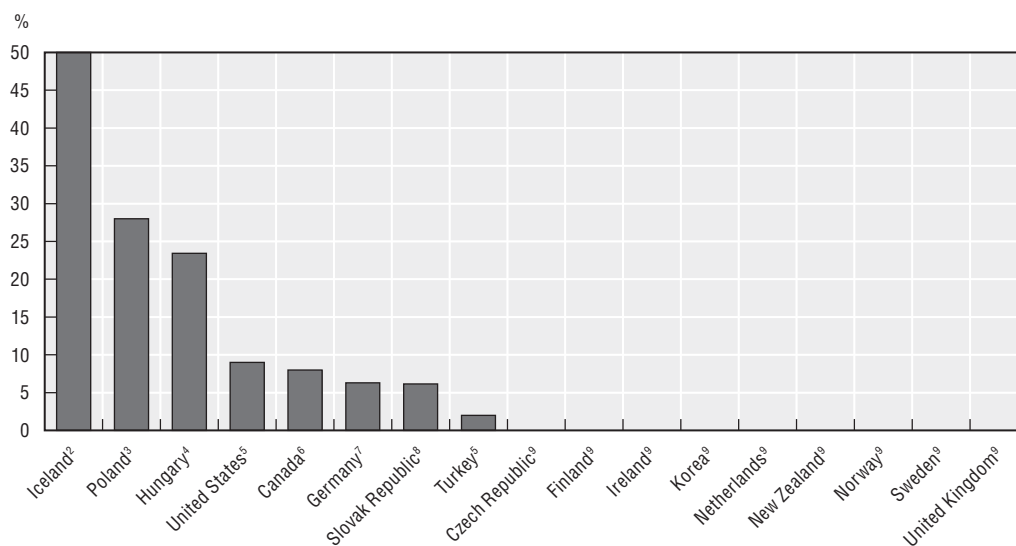
vegetation cover. While other parts of Europe are less prone to severe cases of erosion, there is concern over erosion risks from water and wind in central Europe (the **Czech and Slovak Republics, Hungary, Poland**) and wind erosion in **Iceland** (Figures 1.5.1-1.5.3). Evidence for these countries suggests, however, that soil erosion risks are being exacerbated by the relatively poor uptake of soil management practices and limited area of land under protective cover over the year (Section 1.9 and Chapter 3).


In North America, **Canada** and the **United States** have experienced a decrease in the amount of land classified as belonging to the moderate to severe water erosion class (Figure 1.5.2). In **Mexico**, however, soil erosion is a key environmental concern, with around 40% of all land in the moderate to severe risk erosion classes (Figure 1.5.2). Mexican agriculture is estimated to account for nearly 80% of soil degradation from overgrazing, tillage burning, excess tilling and poor uptake of soil conservation practices (Chapter 3).

In the **United States**, concern over soil erosion has been influential in reducing the risk of erosion to agricultural soils over many decades. By 2003, areas under moderate to severe risk were under 10% of total agricultural land compared to 12% in 1992 (Figures 1.5.1-1.5.3). Soil conservation policy targets for *Highly Erodible Land* (HEL) requires farmers to implement conservation plans to protect the soil or risk losing Federal farm programme benefits. Payments for no tillage practices are generally higher than those for reduced tillage practices. Erosion processes vary between regions, for example, semi-arid western States suffer from wind erosion, while eastern States are more prone to water erosion (Claassen et al., 2004; and Chapter 3).

Figure 1.5.3. **Agricultural land area classified as having moderate to severe wind erosion risk¹**

Average 2000-04



StatLink  <http://dx.doi.org/10.1787/287144865677>

1. Risk of wind erosion greater than 11 t/ha/y of soil loss, unless otherwise indicated.
2. Late 1990s, permanent grassland only, comprising 95% of the total severe erosion not classified by soil loss but by farmland.
3. Data for 2005.
4. Data show agricultural land covered by all wind erosion risk categories from tolerable to severe erosion risk for 1995-99.
5. Share of agricultural land of risk to elevated erosion rates, but t/ha/y not specified.
6. Data for period 2000-02, for cropland and summer fallow only.
7. Data for 1995-99.
8. Data for 2003-04.
9. These countries report that the risk of moderate to severe wind erosion was very limited between zero and less than 0.5% of the total agricultural land area.

Source: OECD (2001), *Environmental Indicators for Agriculture*, Vol. 3, Paris, France and OECD Agri-environmental Indicators Questionnaire, unpublished; and national sources.

Soil erosion from water in **Canada** has seen some reduction over the 1990s, declining to about 7% of cropland and summer fallow area with a moderate to severe risk of water erosion by 2000-02 compared to 9% in 1990-94 (Figure 1.5.2). This has been attributed to better management of soils and greater farmer awareness of minimising soil erosion. Research on wind erosion indicates that about 8% of the cropland and summer fallow area is at moderate to severe risk (Figure 1.5.3), which is a decrease from 11% in the early 1990s. Changes in management practices, such as an increase in vegetative protective cover (Section 1.9) are acknowledged as being the reason of this decrease (Lefebvre et al., 2005).

For **Australia**, evidence from the late 1990s suggests that there may be some reduction in soil erosion rates (Hamblin, 2001). But, in 1999, some 11% of farmers experienced significant soil degradation caused by water erosion and 2% encountered severe wind erosion, while on average, 90% of Australia's soil erosion from agriculture comes from 20% of the agricultural land area (National Land and Water Resources Audit, 2002). Farming practices have exacerbated the extent and rate of soil degradation with up to a third of the total area of rangeland showing acute symptoms of soil degradation, and 50-65% of crop land at risk in any one season from wind erosion. Soil erosion studies in Australia have revealed high costs, estimated annually at AUD 80 million (USD 45 million) in infrastructure repairs

and AUD 450 million (USD 250 million) in water quality contamination as the result of soil erosion (Chapter 3). However, problems of soil degradation through salinity, acidity and sodicity are a much greater problem in Australia than soil erosion (Chapter 3).

New Zealand experiences high rates of natural erosion due to extremes of climate and topography, but soil quality has come under pressure from overgrazing. About two-thirds of pastoral land is sustained with improved land management practices, estimated to cost USD 12 million annually, which has included reforestation in some areas (Chapter 3). However, only about 4% of agricultural land is estimated to be in the moderate to severe risk classes for soil erosion from water (Figure 1.5.1).

In **Korea** the main process of soil erosion on agricultural land is water erosion, as over half the annual rainfall is concentrated in the summer months, with over 20% of farm land classified as having moderate to severe risks (Figure 1.5.1). During the period 1990 to 2002 the land classified as having moderate to severe water erosion risk decreased by around 15 000 hectares, but its share in the total agricultural land area rose, as the decrease in the area of agricultural land was greater by about 220 000 hectares over this period (Figure 1.5.2). Annual soil loss from dry crop land is 32 tons/hectare/year (26 million tons per year), contrary to paddy rice fields experiencing only 0.02 ton/hectare/year (0.02 million tons per year) (Hur *et al.*, 2003). This is mainly because paddy fields may act as a buffer and prevent raindrops and water flow from directly affecting the soil's surface, and is also important in **Japan** where 55% of agricultural land is under paddy rice production (Chapter 3).

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