Organisation for Economic Co-operation and Development
Organisation de Coopération et de Développement Économiques

ENVIRONMENTAL PERFORMANCE OF AGRICULTURE IN OECD COUNTRIES SINCE 1990:

Chapter 1 Section 1.2
Nutrients

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

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1.2. NUTRIENTS

KEY TRENDS

Overall the quantity of OECD agricultural nutrient balance surpluses declined between 1990-92 and 2002-04, by –4% for nitrogen and –19% for phosphorus, potentially reducing the environmental pressures on soil, water and air. OECD nutrient use efficiency (*i.e.* the ratio of nutrient outputs to nutrient inputs) has also improved, but more markedly for phosphorus than nitrogen. In part this trend reflects the increase in the OECD total use of inorganic nitrogen fertilisers by 3% over the period 1990-92 to 2002-04 compared to a reduction of –10% for phosphate fertilisers, although livestock manure is also an important source of nutrient surpluses for most countries.

While the intensity of nutrient balance surpluses per hectare of agricultural land across the OECD declined by 17%, for nitrogen, the reduction was larger at 37% for phosphorus. Despite the greater reduction in phosphorus compared to nitrogen surpluses from agriculture, the accumulation of phosphorus in agricultural soils is a concern (because of its physical interaction in the environment), particularly the future potential pollution of water bodies.

Nutrient balance surpluses increased mainly in non-European OECD countries, including Australia, Canada, New Zealand, and the United States, although Spain was an exception to this trend, as well as Hungary, Ireland and Portugal where nitrogen surpluses (but not phosphorus) have risen. But in most countries where nutrient surpluses have been rising they mostly had an intensity of nutrient surplus per hectare of farmland well below the OECD average in 2002-04. At the same time for countries where nutrient surpluses have sharply decreased some of them continue to have the highest intensities of nutrient surpluses across the OECD, notably Belgium, Japan, Korea, and the Netherlands.

Where increases in nutrient surpluses into the environment have been the highest over the period 1990-92 to 2002-04 this is largely linked to an overall expansion in agricultural production, especially leading to a greater use of fertilisers and growth in livestock numbers. For Australia and to a lesser extent Hungary, however, it has been the very high rates of growth in fertiliser use that has mainly driven the rising nitrogen surpluses, as overall livestock numbers have declined, although for Canada, New Zealand, Portugal, Spain and the United States, both fertiliser use and livestock numbers have increased.

Overall where ***adoption of nutrient management plans*** and environmental farm plans has been high relative to most other OECD countries, this has had an impact in reducing nutrient surpluses. Even so, for many such countries there is further potential to reduce nutrient surpluses to levels that are not environmentally damaging. Also for some countries where nutrient use efficiency is low by average OECD levels (Japan, Korea), their nutrient surplus intensity per hectare is higher than the OECD average and they have a poor uptake by farmers of nutrient management plans.

The ***principal sources of nutrient inputs*** into OECD farming systems derive from inorganic fertilisers and the nutrient content of livestock manure, which together comprise around 67% of nitrogen inputs and 97% of phosphorus inputs for the OECD on average in 2002-04. In some countries, however, inputs of nitrogen from atmospheric deposition and biological nitrogen fixation can be important. For nutrient outputs, or the uptake of nutrients by harvested crops and pasture, this varies greatly across countries depending on different agro-ecosystems, for example, largely pasture based in Ireland and New Zealand but mainly cereals in Hungary and Japan.

In most countries there is ***considerable variation in the level and trends of regional nutrient balance surpluses*** around national average values. Regional variations are largely explained by the spatial distribution of intensive livestock farming and also cropping systems that require high nutrient inputs, such as maize and rice relative to wheat and oilseeds.

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Indicator definitions:

- Gross balance between the quantities of **nitrogen** (N) inputs (*e.g.* fertilisers, manure) into, and outputs (*e.g.* crops, pasture) from farming.
- Gross balance between the quantities of **phosphorus** (P) inputs (*e.g.* fertilisers, manure) into, and outputs (*e.g.* crops, pasture) from farming.

Concepts and interpretation

Inputs of nutrients, such as nitrogen and phosphorus, are important in farming systems as they are critical in raising crop and forage productivity, and a nutrient deficiency can impair soil fertility and crop yields. A build up of surplus nutrients in excess of immediate crop and forage needs, however, can lead to nutrient losses representing not only a possible cause of economic inefficiency in nutrient use by farmers, but especially a source of potential harm to the environment. This can occur in terms of water pollution (*e.g.* eutrophication of surface water caused by nutrient runoff and groundwater pollution by leaching), and air pollution, notably ammonia, as well as greenhouse gas emissions. An additional environmental issue concerns the sustainability of phosphorus resources, as world reserves are diminishing (Johnston and Steén, 1997).

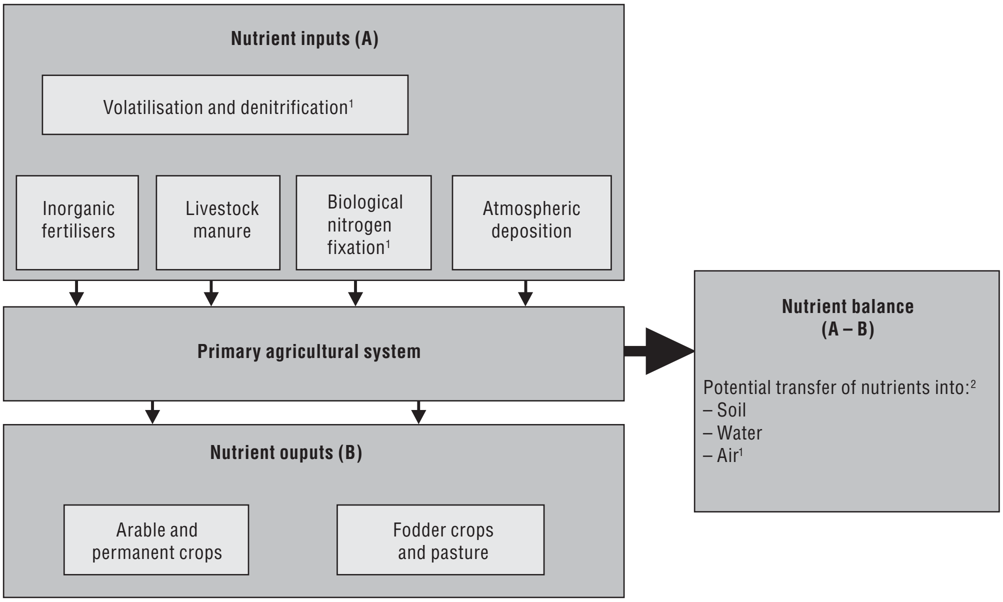
There are a complex range of physical processes that affect nutrient supplies in an agricultural system, illustrated by nutrient cycles (OECD, 2005a; 2005b). The extent to which these processes can harm the environment will depend on the: type of nutrients applied to crops; efficiency of crop nutrient use; type of crop and livestock systems; environmental assimilative capacity of an agro-ecosystem; farming practices; and economic and policy drivers (*e.g.* fertiliser prices and crop subsidies).

The OECD ***gross nutrient balances*** are calculated as the difference between the total quantity of nutrient inputs entering an agricultural system, and the quantity of nutrient outputs leaving the system (Figure 1.2.1). This calculation can be used as a proxy to reveal the status of environmental pressures, such as declining soil fertility in the case of a nutrient deficit, or for a nutrient surplus the risk of polluting soil, water and air. The methodology has been jointly developed by OECD country nutrient experts and the OECD and Eurostat Secretariats (OECD, 2007a; 2007b).

The nutrient balance indicator is expressed here in terms of the kilograms of nutrient surplus (deficit) per hectare of agricultural land per annum. This expression of nutrient balances facilitates the comparison of the relative intensity of nutrients in agricultural systems between countries (*e.g.* very high in **Korea** and very low in **Australia**, Figures 1.2.2 and 1.2.8), and also helps describe the main sources of nutrient inputs and outputs. In addition, the nutrient balances are expressed in terms of changes in the physical quantities of nutrient surpluses (deficits), which provide an indication of the trend and level of potential physical pressure of nutrient surpluses into the environment (*e.g.* rising in **Canada** and declining in **Finland**, Figures 1.2.2 and 1.2.8).

It should be stressed that the methodology is a gross balance calculation which takes account of all the total potential, not effective, losses of nutrients into the environment (*i.e.* soil, water and air). This includes for the ***nitrogen balance*** ammonia (NH_3) volatilisation during the process of manure accumulation and manure storage and nitrogen losses from the soil (leaching, denitrification, and ammonia volatilisation). Denitrification, which is the

Figure 1.2.1. **Main elements in the OECD gross nutrient (nitrogen and phosphorus) balance calculation**



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1. Applies to the nitrogen balance only.
2. Nutrients surplus to crop/pasture requirements are transported into the environment, potentially polluting soils, water and air, but a deficit of nutrients in soils can also occur to the detriment of soil fertility and crop productivity.

Source: OECD (2007a; 2007b).

conversion of soil nitrate to nitrogen gases, mainly occurs under anaerobic conditions (*e.g.* wet paddy rice and wet soil conditions). This process leads to the release of both dinitrogen gas (N_2) which is not harmful to the environment or human health, and also nitrous oxide (N_2O) which although released in small amounts is a very potent greenhouse gas (see Section 1.7.3). The components of the ***phosphorus balance*** are similar to the nitrogen balance, but exclude emission factors for volatilisation and biological nitrogen fixation.

While the nutrient balances are calculated at the national level, the same methodology can be used to estimate regional (sub-national) balances. This is important given the significant spatial variation in balances around national average values. Hence, national values need to be interpreted with caution. At present, however, nutrient balances in this section are only provided at the national level, although some examples of regional balances are discussed for illustrative purposes at the end of the section (Figure 1.2.12).

Caution is required in linking trends in nutrient balances and environmental impacts, as the balances only reveal the *potential* for environmental pollution and are not necessarily indicative of actual resource depletion or environmental damage. The information provided by nutrient balances, however, is useful for analytical purposes, such as modelling the environmental effects of agricultural and agri-environmental policies. This is because of its input-output and whole farm system approach to nutrients, rather than the more limited value of a fertiliser use per hectare indicator which only provides a restricted view of nutrients in farming systems, especially as it excludes livestock manure.

Limitations of nutrient balances include the accuracy of the underlying nutrient conversion coefficients and also the uncertainties involved in estimating nutrient uptake by areas of pasture and some fodder crops. In addition, environmental events like droughts and

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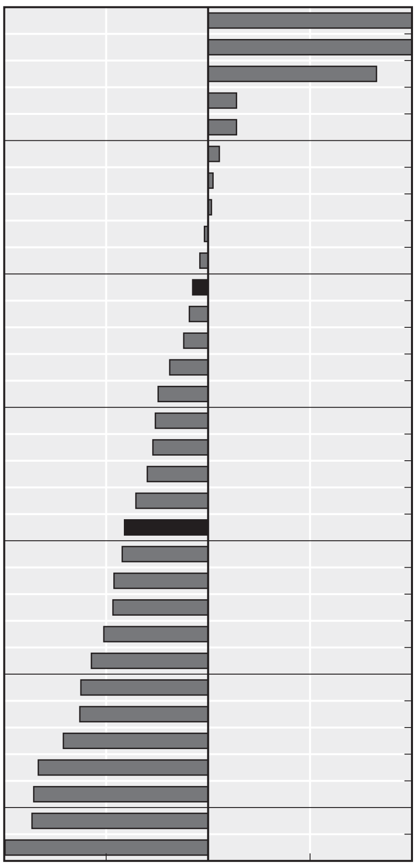
Figure 1.2.2. **Gross nitrogen balance estimates**

Change in the nitrogen balance (tonnes N)[1]



	Balance expressed as tonnes of nitrogen (N)				Balance expressed as kg nitrogen per hectare of total agricultural land		
	Average		Change		Average		Change
	1990-92	2002-04	1990-92 to 2002-04		1990-92	2002-04	1990-92 to 2002-04
	000' tonnes N		000' tonnes N	%	Kg N/ha		%
Canada[2]	1 168	2 101	934	80	19	35	85
Hungary[2]	136	217	82	60	21	37	74
New Zealand	407	576	169	41	31	46	46
Ireland	337	360	24	7	76	83	9
Portugal	168	180	12	7	42	47	13
United States	14 621	15 024	402	3	34	37	7
Spain	966	977	12	1	32	33	5
Australia[3]	7 574	7 636	62	1	16	17	5
Italy	588	582	–5	–1	33	39	16
Korea	465	456	–9	–2	213	240	13
OECD	**41 238**	**39 681**	**–1 557**	**–4**	**88**	**74**	**–17**
Switzerland	121	116	–6	–5	77	76	–1
Iceland	17	16	–1	–6	7	7	–5
Czech Republic	332	300	–31	–9	77	70	–9
Norway	92	81	–11	–12	92	77	–16
Japan	935	813	–121	–13	180	171	–5
Poland	922	797	–125	–14	49	48	–2
Mexico	2 768	2 354	–414	–15	27	22	–18
France	1932	1 589	–343	–18	63	54	–16
EU15	**9 989**	**7 935**	**–2 054**	**–21**	**113**	**83**	**–26**
Sweden	193	152	–41	–21	57	48	–16
Turkey	1 493	1 148	–346	–23	37	28	–24
Germany	2 515	1926	–589	–23	145	113	–22
Belgium	344	256	–88	–26	255	184	–28
Austria	226	161	–65	–29	66	48	–27
United Kingdom	1 022	702	–320	–31	56	43	–23
Denmark	493	338	–156	–32	178	127	–29
Netherlands	688	443	–245	–36	345	229	–34
Finland	211	123	–88	–42	83	55	–34
Luxembourg	29	16	–12	–43	229	129	–44
Slovak Republic	197	111	–85	–43	80	46	–43
Greece	278	130	–149	–53	32	15	–52

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1. The gross nitrogen balance calculates the difference between the nitrogen inputs entering a farming system (*i.e.* mainly livestock manure and fertilisers) and the nitrogen outputs leaving the system (*i.e.* the uptake of nutrients for crop and pasture production).
2. For Canada, change in the nitrogen balance is +80%. For Hungary, change in the nitrogen balance is +60%. For Greece, change in the nitrogen balance is –53%.
3. Average for the period 2002-04 is an OECD estimate.

Source: OECD Secretariat (2007).

floods will affect the efficiency of plants to fix nutrients, the soil science of nutrients is not well understood (*e.g.* soils vary in their capacity to store nutrients), while there is limited information on the varietal mix of legumes in pastures to accurately estimate pasture uptake of nitrogen. While other approaches that estimate agricultural nutrient surpluses can overcome some of these problems, such as the farm gate balance method (van Eerdt and Fong, 1998) and the **New Zealand** Overseer model (Ledgard *et al.*, 2005), the data required to calculate such models are not widely available across most OECD countries.

As an environmental ***driving force***, nutrient balance indicators link to the ***state*** (or concentration) of nutrients in water bodies (Section 1.6.2) and ammonia, and greenhouse gas emissions (Section 1.7). ***Responses*** to these changes in the state of the environment are revealed through indicators of nutrient management and environmental farm planning, including organic farming (Section 1.9).

Recent trends

Overall OECD agricultural nutrient balance surpluses (tonnes) declined between 1990-92 and 2002-04, by 4% for nitrogen and 19% for phosphorus, potentially reducing the environmental pressures on soil, water and air (Figures 1.2.2, 1.2.8). OECD nutrient use efficiency (*i.e.* the ratio of nutrient outputs to nutrient inputs) has also improved, but more markedly for phosphorus than nitrogen (Figures 1.2.7, 1.2.11). In part this trend reflects the increase in the OECD total use of nitrogenous fertilisers by 3% over the past 15 years compared to a reduction of 10% for phosphate fertilisers (Figure 1.2.5), although livestock manure is also an important source of nutrient surpluses for most countries. Moreover, while the intensity of nitrogen surpluses per hectare of agricultural land across the OECD declined by 17%, for phosphorus the reduction was larger at 37% (Figures 1.2.2, 1.2.8). Despite the greater reduction in phosphorus compared to nitrogen surpluses from OECD agriculture, the accumulation of phosphorus in agricultural soils is a concern (because of its physical interaction in the environment), particularly for the future potential pollution of water bodies.

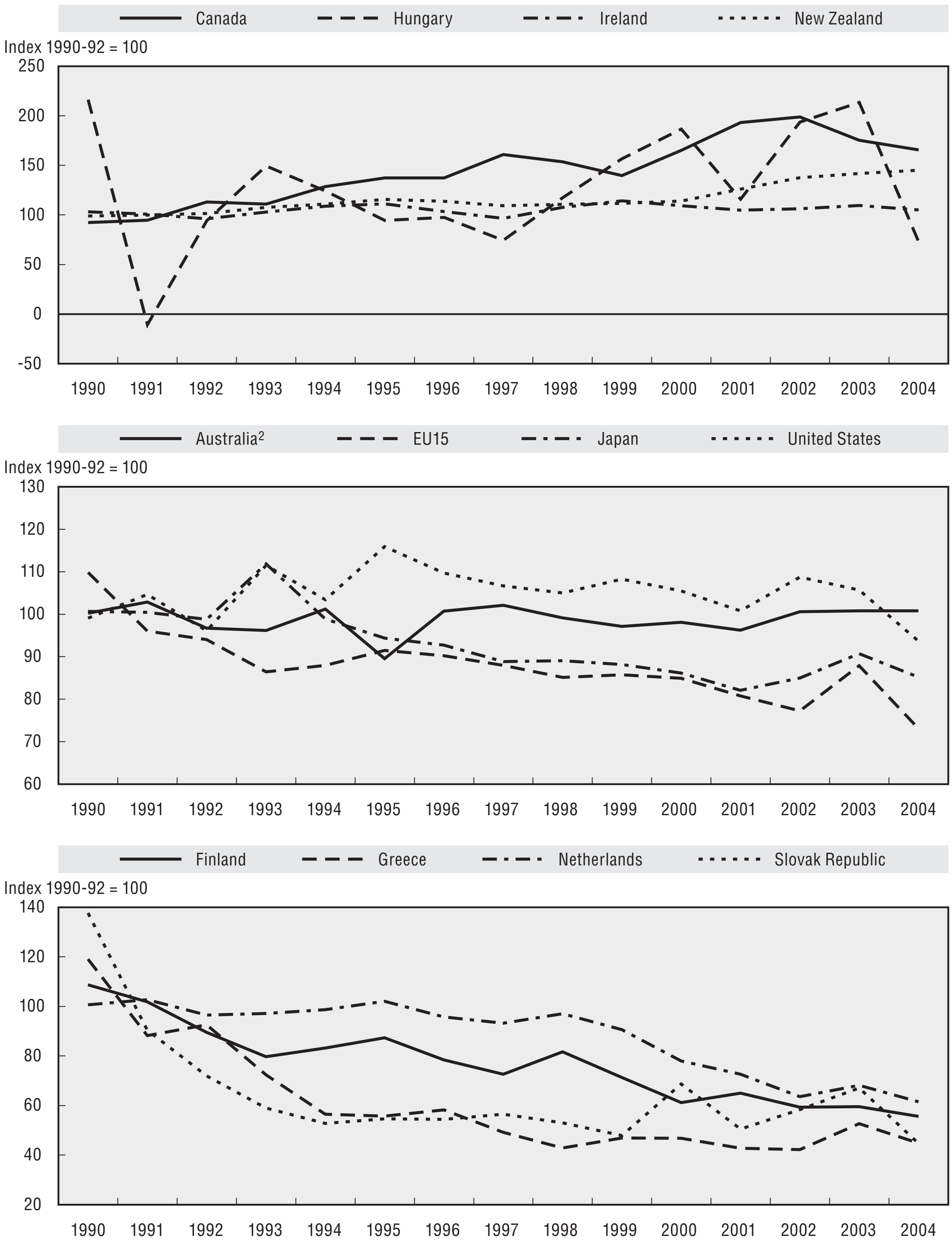
1.2.1. Nitrogen balance

Total tonnes of OECD nitrogen (N) balance surplus declined by 4% over the period 1990-92 to 2002-04 (Figure 1.2.2). N surpluses showed the largest increases mainly in non-European countries (**Canada, New Zealand**), but also rose in **Australia** and the **United States**, and in Europe for **Hungary, Ireland, Portugal** and **Spain**. But despite the increases in nitrogen surpluses in these countries, with the exception of **Ireland**, they had an intensity of kgN/ha of agricultural land well below the OECD average in 2002-04 (Figure 1.2.2). At the same time for many countries where tonnes of N surpluses have shown large reductions over the past 15 years some of them continue to have the highest intensity of kgN/ha of agricultural land across the OECD area, notably **Belgium, Denmark, Germany, Luxembourg** and the **Netherlands** (Figure 1.2.2).

Where increases in N surpluses into the environment have been the highest over the period 1990-92 to 2002-04 this is largely linked to an overall expansion in agricultural production, especially leading to a greater use of fertilisers and growth in livestock numbers (Figures 1.2.3, 1.2.4). For **Australia** and to a lesser extent **Hungary**, however, it has been the very high rates of growth in nitrogen fertiliser use (Figures 1.2.4, 1.2.5) that has mainly driven the rising nitrogen surpluses, as overall livestock numbers have fallen in these countries over the past 15 years, although for **Canada**, **New Zealand**, **Portugal**, **Spain** and the **United States**, both nitrogen fertiliser use and livestock numbers have increased.

Problems of N surplus disposal are also associated with rising animal stocking densities and structural changes in the livestock industry toward large confined operations, especially for pigs, poultry and to a lesser extent dairy cattle (OECD, 2003; 2004). In the **United States**, for example, with the growing number and size of confined livestock operations, over 60% of manure is produced on farms that have insufficient land on their properties to fully absorb the waste (Chapter 3). In addition rising fertiliser demand and growth in N surpluses is, in part, explained in some countries by the expansion in crop production

Figure 1.2.3. **Gross nitrogen balances[1] for selected OECD countries**



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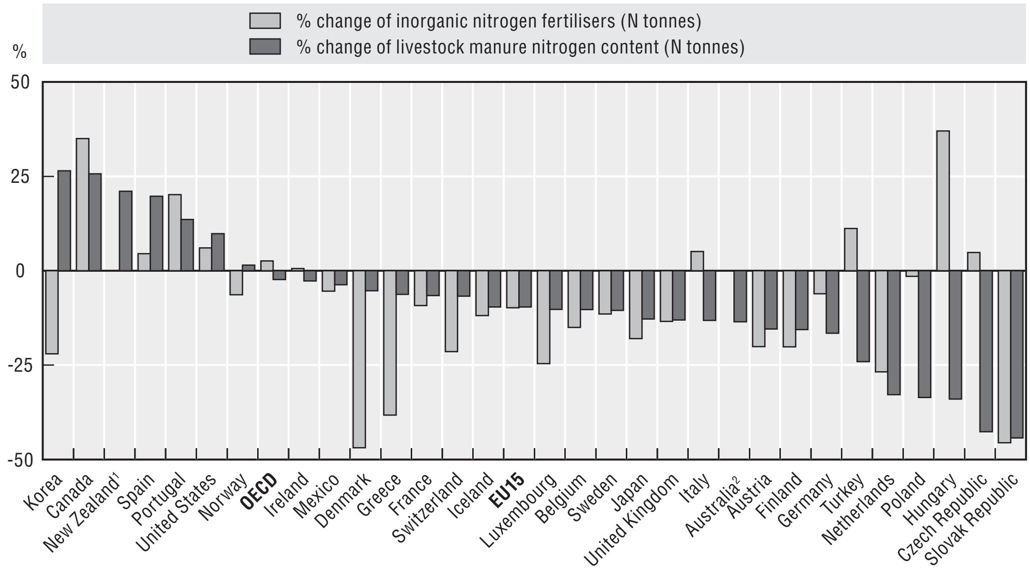
1. The gross nitrogen balance calculates the difference between the nitrogen inputs entering a farming system (*i.e.* mainly livestock manure and fertilisers) and the nitrogen outputs leaving the system (*i.e.* the uptake of nutrients for crop and pasture production).
2. The period 2002-04 is an OECD estimate.

Source: OECD Secretariat (2007).

Figure 1.2.4. **Inorganic nitrogen fertilisers and livestock manure nitrogen input in nitrogen balances**

1990-92 to 2002-04



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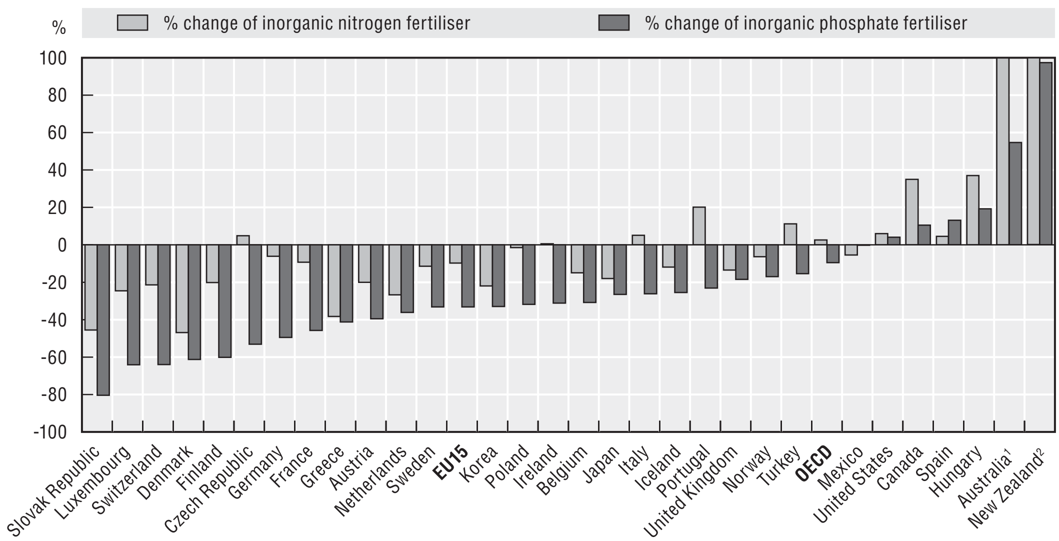
1. For New Zealand, the change in inorganic nitrogen fertilisers is +421%.
2. For Australia, the change in inorganic nitrogen fertilisers is +113%.

Source: OECD Secretariat (2007).

Figure 1.2.5. **Agricultural use of inorganic nitrogen and phosphate fertilisers**

In tonnes product weight % change 1990-92 to 2000-04



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1. For Australia, the change in nitrogen fertiliser is 113%.
2. For New Zealand, the change in nitrogen fertiliser is 421%.

Source: OECD Secretariat (2007).

together with a shift in cropping patterns to crops requiring higher fertiliser inputs per kg of output (*e.g.* from wheat to maize, see OECD, 2005, Figure 1.2.2, Section 1.1), such as in **Australia, Canada** and the **United States**. But changes in nitrogen fertiliser use are also because of different agricultural systems between countries (*e.g.* the reduction in rice production in Korea and Japan, but higher use of fertiliser to increase pasture yield in **New Zealand**), restrictions on using fertilisers (**Denmark, Netherlands, Norway**), and relatively greater improvements in N fertiliser use efficiency compared to reducing N emissions from livestock in some cases.

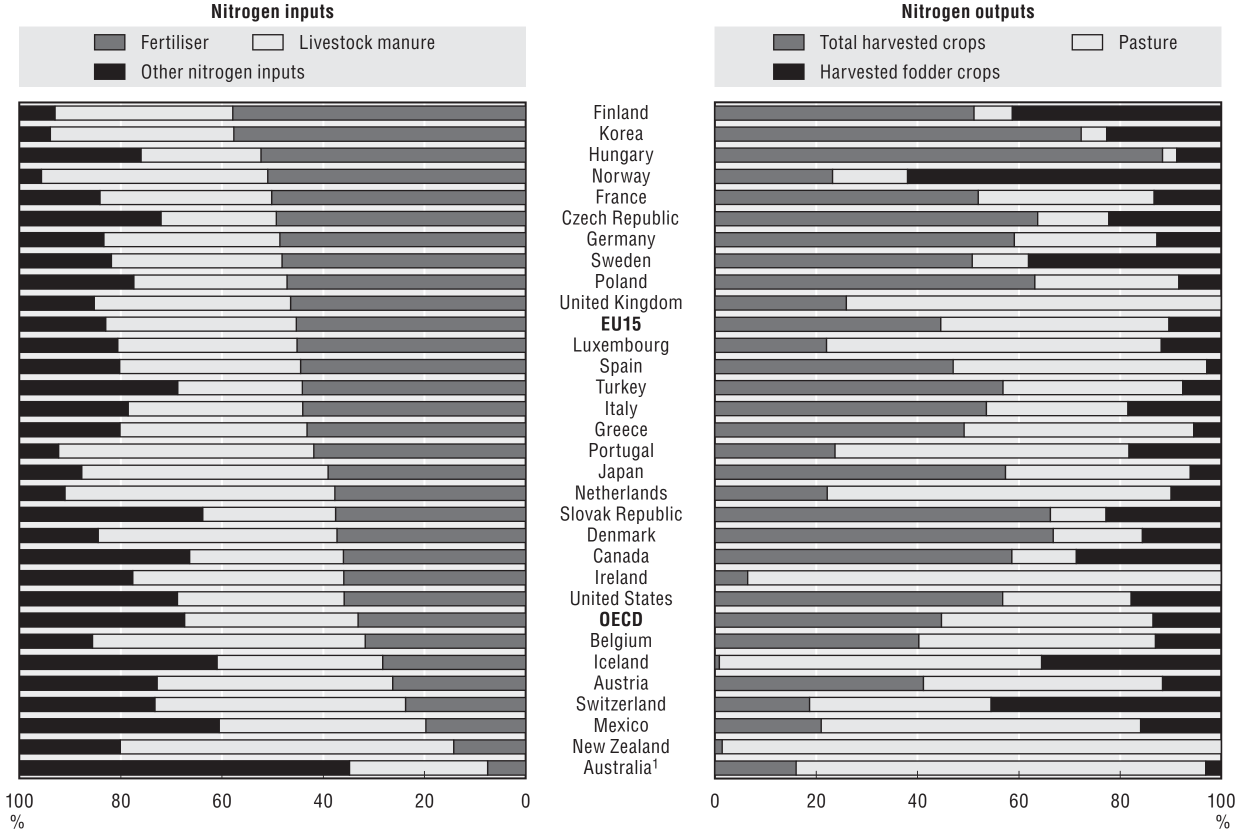
For some countries where N surpluses have risen over the past decade, the uptake of nutrient management plans (NMPs) has been relatively low (**Ireland, New Zealand, Spain**), but for **Canada, Korea** and the **United States** while the uptake of NMPs has been also been relatively low, adoption rates have risen over the 1990s (Section 1.9). Overall where adoption of nutrient management plans and environmental farm plans has been high relative to the OECD average, this has had an impact in reducing N surpluses. Even so, for many such countries there is further potential to reduce agricultural N surpluses to levels that are not potentially environmentally damaging (**Belgium, Denmark, Finland, Germany, Netherlands, Norway, Switzerland**). Moreover, in those countries (**Czech** and **Slovak Republics, Hungary, Poland**) which experienced a sharp reduction in N surpluses following the collapse in farm support levels after the transition to a market economy in the early 1990s, their N surpluses are beginning to rise as they integrate into the **EU25**, markedly so for **Hungary** (Figures 1.2.2, 1.2.3).

The principal sources of N inputs into OECD farming systems derive from nitrogen fertilisers and the nitrogen content of livestock manure, which together comprise around two-thirds of N inputs for the OECD on average (Figure 1.2.6). In some countries, however, other inputs of N, especially from atmospheric deposition (**Australia, Belgium, United Kingdom**) and biological nitrogen fixation can be important (**Ireland, Japan, New Zealand**) (Figure 1.2.6). For certain countries increasing quantities of sewage sludge are being recycled on agricultural land as a fertiliser. Use of sewage sludge in the **EU15** rose by 7% (1995-2000), with larger increases reported for **Ireland, Italy** and **Spain** (EEA, 2005). While the use of sewage sludge as a source of farm nutrients can bring agronomic benefits, its use raises a number of environmental and health concerns (*e.g.* risks of pollution from heavy metals and pathogens) which require careful monitoring (EEA, 2005; Chapter 3). This was the reason why **Switzerland** has decided to forbid the sewage sludge recycling on farmland from 2006 (Chapter 3). ***N output***, or the uptake of N by crops and pasture, varies greatly across countries depending on different agro-ecosystems, for example, largely pasture based in **New Zealand** but mainly harvested crops in **Hungary** (cereals) and **Japan** (rice) (Figure 1.2.6).

Trends in overall N use efficiency (*i.e.* the ratio of N output to N input in an agricultural system, Figure 1.2.7) indicate that a considerable number of countries have improved N use efficiency over the period 1990-92 to 2002-04 (notably for **Belgium, Finland, Greece, Germany, Luxembourg** and **Turkey**). This is partly linked to improvements in reducing inorganic fertiliser input use per unit volume of crop output. In a number of countries, nutrient surpluses from livestock have fallen through altering feeding patterns, storing manure in closed storage systems rather than spreading waste on fields, and also by changing the timing and technologies used to spread manure on fields (OECD, 2003; 2004). But performance is variable across OECD countries. For example, in **Australia** the management of captured manure systems on dairy farms is poor (Chapter 3), while in **Switzerland** most livestock manure is usually stored in some form or other (OECD, 2004).

Figure 1.2.6. **Contribution of the main sources of nitrogen inputs and outputs in nitrogen balances**

Average 2002-04



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1. The average for the period 2002-04 is an OECD estimate.

Source: OECD Secretariat (2007).

Also for some countries where N use efficiency is low by average OECD levels (**Japan, Korea**) they are also countries with higher than the OECD average intensity of kgN/ha of farmland and poor uptake by farmers of nutrient management plans (Section 1.9).

For a few countries N use efficiency has declined over the past 10 years (mainly **Canada, Hungary** and **Korea**), largely due a combination of a substantial rise in fertiliser use and livestock manure relative to reduced N uptake from crops and forage (Figure 1.2.7). In **Canada**, for example, the decline in N use efficiency over the period 1996 to 2001 was attributed to an increase in pulse crop acreage (*i.e.* greater biological nitrogen fixation) without a concurrent decrease in fertiliser application, lower crop yields, and growing livestock densities in some areas (Lefebvre *et al.*, 2005).

1.2.2. Phosphorus balance

There was a –19% reduction in the OECD total agricultural phosphorus (P) balance surplus (tonnes) over 1992-92 to 2002-04 (Figures 1.2.8, 1.2.9). This was a much larger percentage reduction than for OECD nitrogen surpluses, mainly because of the substantial decrease in phosphate fertiliser use by 10% (Figure 1.2.5). For a considerable number of countries P surpluses (tonnes) declined by more than 50% over the past 15 years (Figure 1.2.8).

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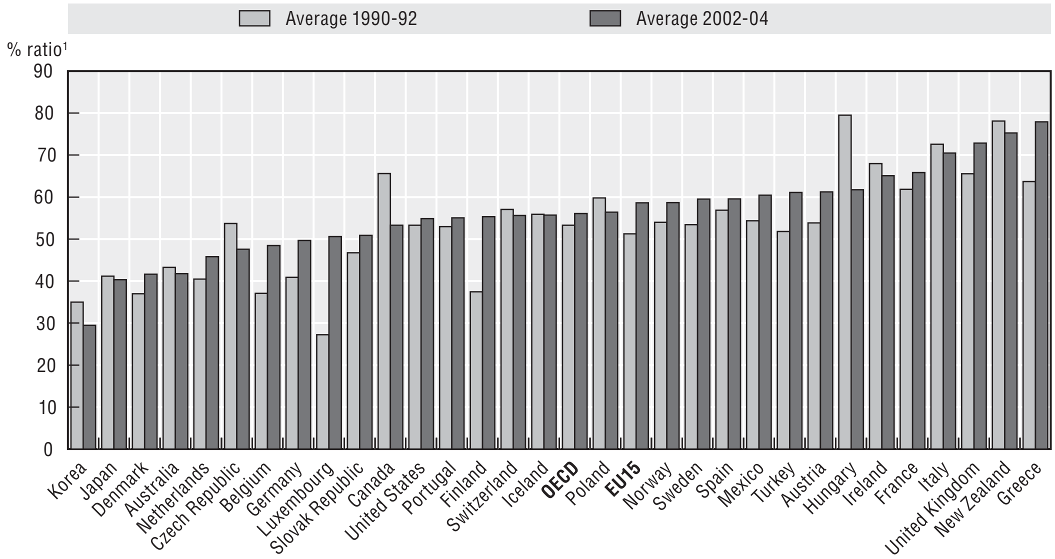
Figure 1.2.7. **Nitrogen efficiency[1] based on gross nitrogen balances**



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1. Nitrogen efficiency measured as the percentage ratio of total nitrogen uptake by crops and forage (tonnes) to the total nitrogen available from fertiliser, livestock manure, and other nitrogen inputs (tonnes).

Source: OECD Secretariat (2007).

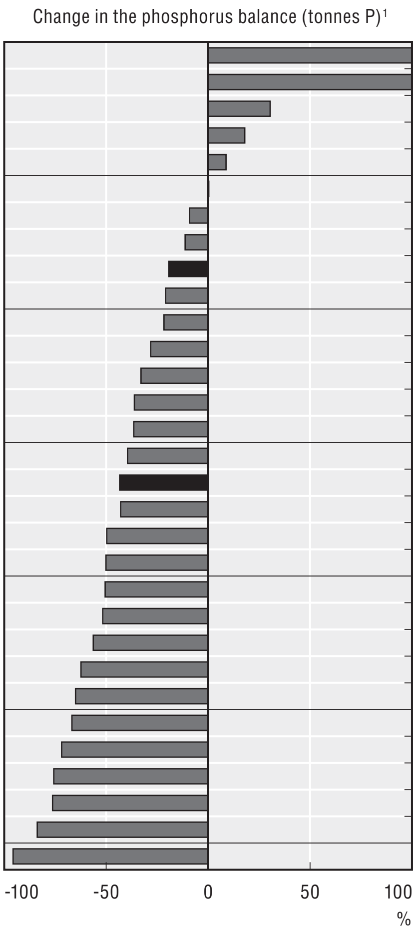
However, the intensity of kgP/ha of agricultural land for some of these countries still remain among the highest across the OECD, notably for the **Netherlands** (Figure 1.2.8). This is in contrast to many of the countries where tonnes of P surpluses have risen although their intensity of kgP/ha of agricultural land was well below the OECD average in 2002-04, notably **Australia, Canada** and the **United States**. For **New Zealand** where the tonnes of the P surplus (tonnes) rose by nearly 130 %, the P intensity level is higher than the OECD average partly reflecting the over 420% rise in phosphate fertiliser use (Figure 1.2.5).

Nearly all the ***P inputs*** into OECD farming systems derive from phosphate fertilisers and the phosphorus content of livestock manure, comprising together well over 90% of P inputs for almost all OECD countries (Figure 1.2.10). As with nitrogen, ***P output***, or the uptake of P by crops and pasture, varies greatly across countries depending on different agro-ecosystems (Figure 1.2.10).

The decline in OECD phosphate (P_2O_5) fertiliser use by 10% over the period 1990-92 to 2002-04 (Figure 1.2.5), largely explains the marked improvement in ***P use efficiency*** (*i.e.* the ratio of P output to P input) over the past 15 years compared to N use efficiency changes (Figures 1.2.7 and 1.2.11). In addition, the improvement in P use efficiency and reduction in P surpluses (tonnes) for most OECD countries is partly because P is more stable in the soil than N and hence, more likely to remain in the soil over longer periods. Thus, repeated phosphorus application to agricultural soils (both from fertilisers and spreading manure) over past decades has led to the gradual accumulation of P in farmed soils for many OECD countries as readily available reserves for crops to harness or to leach into water bodies.

As farmers have become aware of the build-up of P in their soils through more widespread use of soil nutrient tests (Section 1.9), this has led them to reduce P_2O_5 application rates, although this has been reinforced in some cases with government

Figure 1.2.8. **Gross phosphorus balance estimates**



	Balance expressed as tonnes of phosphorus (P)				Balance expressed as kg phosphorus per hectare of total agricultural land		
	Average		Change		Average		Change
	1990-92	2002-04	1990-92 to 2002-04		1990-92	2002-04	1990-92 to 2002-04
	000' tonnes P		000' tonnes P	%	Kg P/ha		%
New Zealand[2]	76	174	98	128	6	14	136
Canada[3]	37	82	45	123	1	1	137
Australia	309	403	94	30	1	1	35
Spain	194	229	36	18	6	8	23
United States	1 300	1 415	115	9	3	3	13
Portugal	59	59	0	0	15	15	5
Norway	15	14	–1	–9	15	13	–13
Korea	103	92	–12	–11	47	48	2
OECD[4]	**4 743**	**3 829**	**–914**	**–19**	**16**	**10**	**–37**
Iceland	4	3	–1	–21	2	1	–21
United Kingdom	274	215	–59	–22	15	13	–13
Japan	339	243	–95	–28	65	51	–21
Italy	242	162	–80	–33	14	11	–22
Denmark	47	30	–17	–36	17	11	–33
Ireland	44	28	–16	–37	10	6	–35
Turkey	354	214	–140	–39	9	5	–40
EU15	**1 844**	**1 043**	**–800**	**–43**	**18**	**10**	**–48**
Belgium	55	31	–24	–43	41	23	–45
Greece	69	35	–34	–50	8	4	–49
Poland	89	45	–45	–50	5	3	–43
Netherlands	75	37	–38	–51	38	19	–49
Mexico	176	85	–91	–52	2	1	–53
Switzerland	19	8	–11	–56	12	5	–55
Austria	26	10	–16	–62	7	3	–61
Finland	51	18	–33	–65	20	8	–60
Sweden	18	6	–12	–67	5	2	–65
France	404	114	–290	–72	13	4	–71
Germany	281	68	–212	–76	16	4	–75
Luxembourg	6	1	–5	–76	48	11	–77
Czech Republic	43	7	–36	–84	10	2	–84
Slovak Republic	36	2	–35	–96	15	1	–96
Hungary[5]	–9	–1	n.a.	n.a.	–4	–1	n.a.

StatLink http://dx.doi.org/10.1787/286525166013

n.a.: Not available.

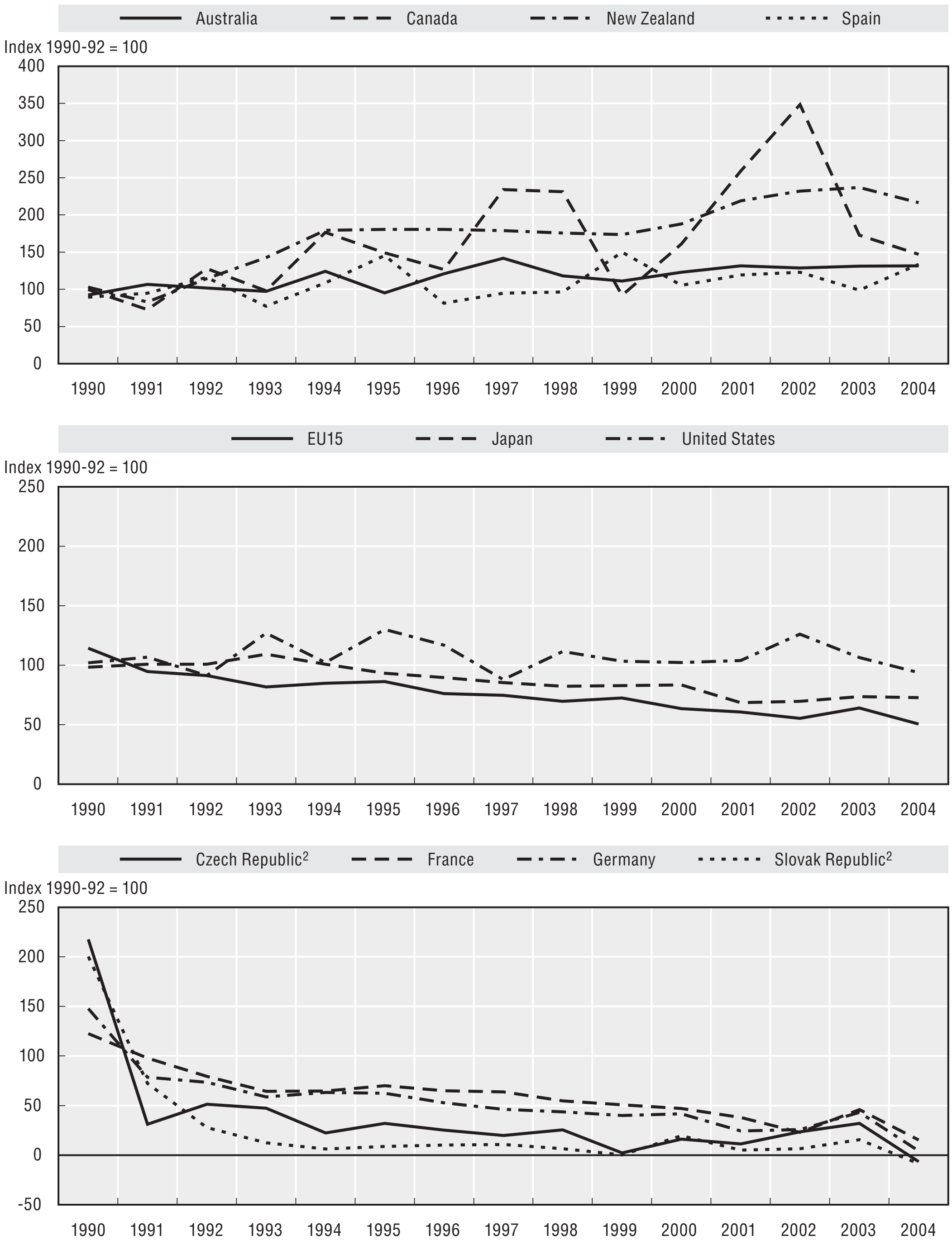
1. The gross phosphorus balance calculates the difference between the phosphorus inputs entering a farming system (*i.e.* mainly livestock manure and fertilisers) and the phosphorus outputs leaving the system (*i.e.* the uptake of phosphorus for crops and pasture production).
2. For New Zealand, change in the phosphorous balance (tonne P) is +128%.
3. For Canada, change in the phosphorous balance (tonne P) is +123%.
4. OECD excludes Hungary.
5. The phosphate (P) balance for Hungary was in deficit over the period and is not shown in the figure. But between 1990-92 to 2002-04 the P deficit was reduced, moving closer towards a balance between P inputs and P outputs. Over the period 1985-90 the Hungarian P balance was in surplus.

Source: OECD Secretariat (2007).

measures to limit the use of P_2O_5 (Johnston and Steén, 1997; USDA, 2003). Gains in P use efficiency have also been achieved through changing livestock husbandry practices, especially by altering animal feed dietary composition (OECD, 2003; 2004).

The physical properties of P in the environment are different compared to N, but ***the accumulation of P in farm soils beyond crop needs in many OECD countries is a growing environmental concern***. The retention of particulate P in soils is generally high compared

Figure 1.2.9. **Gross phosphorus balance[1] for selected OECD countries**



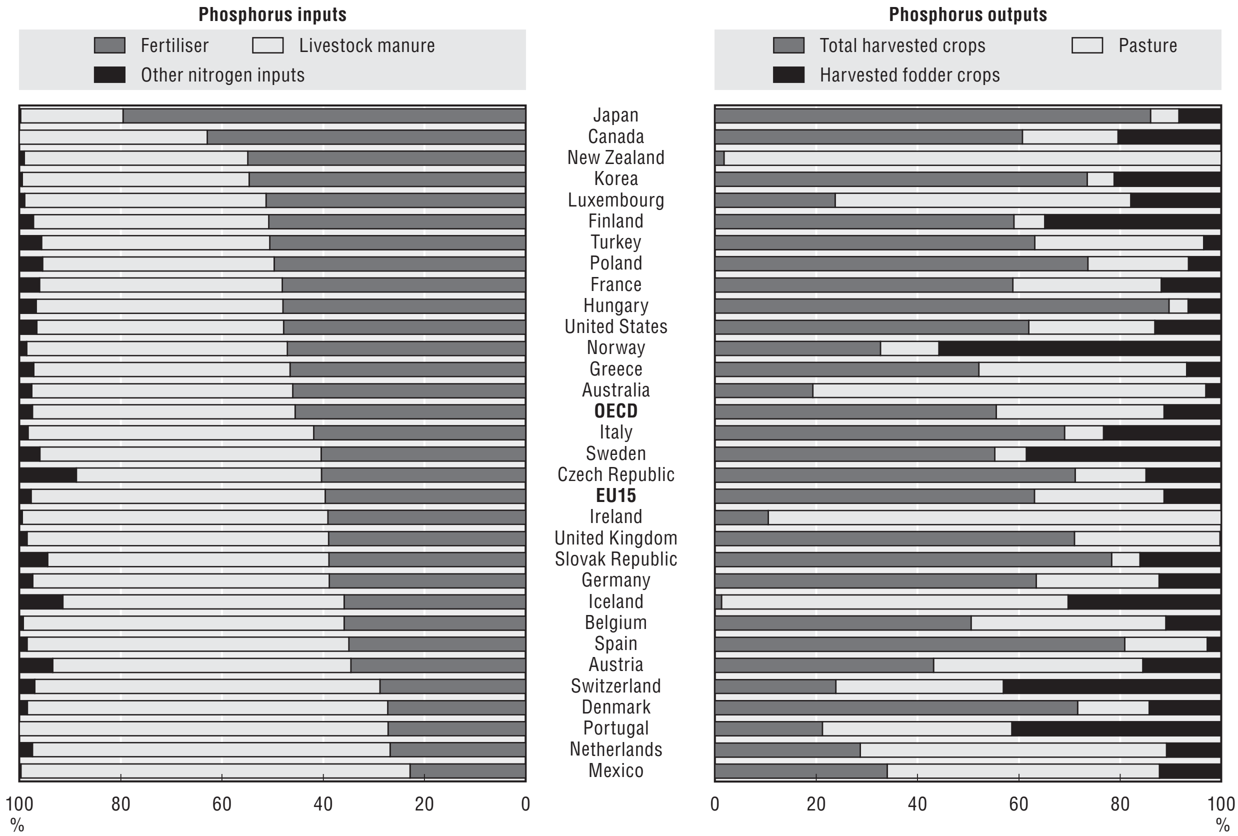
StatLink http://dx.doi.org/10.1787/286545884853

1. The gross phosphorus balance calculates the difference between the phosphorus inputs entering a farming system (*i.e.* mainly livestock manure and fertilisers) and the phosphorus outputs leaving the system (*i.e.* the uptake of phosphorus for crops and pasture production).
2. The P balances for the Czech and Slovak Republics were in deficit for 2004.

Source: OECD Secretariat (2007).

Figure 1.2.10. **Contribution of the main sources of phosphorus inputs and outputs in phosphorus balances**[1]

Average 2002-04



StatLink http://dx.doi.org/10.1787/286656618516

1. The gross phosphorus balance calculates the difference between the phosphorus inputs entering a farming system (i.e. mainly livestock manure and fertilisers) and the phosphorus outputs leaving the system (i.e. the uptake of phosphorus for crops and pasture production).

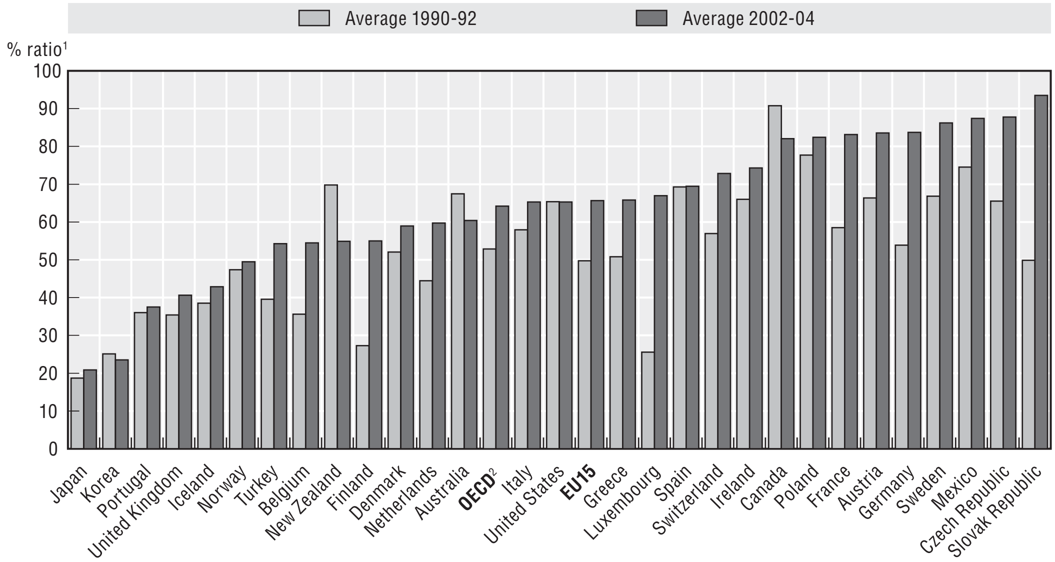
Source: OECD Secretariat (2007).

to N, hence, it is usually transported with long time lags into surface water through soil erosion rather than leaching into groundwater, unlike the more rapid transport of N from soils into water bodies (dissolved phosphorus, however, can leach more rapidly, while varying geological and soil conditions can also affect phosphorus absorption and run-off). Therefore, it is likely that there will be a considerable time lag for many countries between reductions in P surpluses leading to lower P concentrations in water supplies. Indeed, P concentrations in rivers and lakes could continue to rise for the foreseeable future, while the implications for groundwater are unclear (Section 1.6.2). In addition, the increasing uptake of low and conservation tillage practices as part of soil management practices in many countries (Section 1.9) is also aggravating P accumulation in soils, as soils are less easily eroded and hence, the P remains in the soil for longer periods. Moreover, the field application of livestock manure to balance fertiliser needs can result in the over application of phosphorus.

1.2.3. Regional (sub-national) nutrient balances

National nutrient balance indicators can mask important regional (sub-national) variations across a country, especially where more intensive agricultural production

Figure 1.2.11. **Phosphorus efficiency[1] based on phosphorus balances**



StatLink http://dx.doi.org/10.1787/286668251868

1. Phosphorus efficiency measured as the percentage ratio of total phosphorus uptake by crops and forage (tonnes) to the total phosphorus available from fertiliser, livestock manure, and other phosphorus inputs (tonnes).
2. OECD average and figure excludes Hungary, because the phosphate (P) balance for Hungary was in deficit over the period shown in the figure. But between 1990-92 to 2002-04 the P deficit was reduced moving closer toward a balance between P inputs and P outputs. Over the period 1985-90 the Hungarian P balance was in surplus.

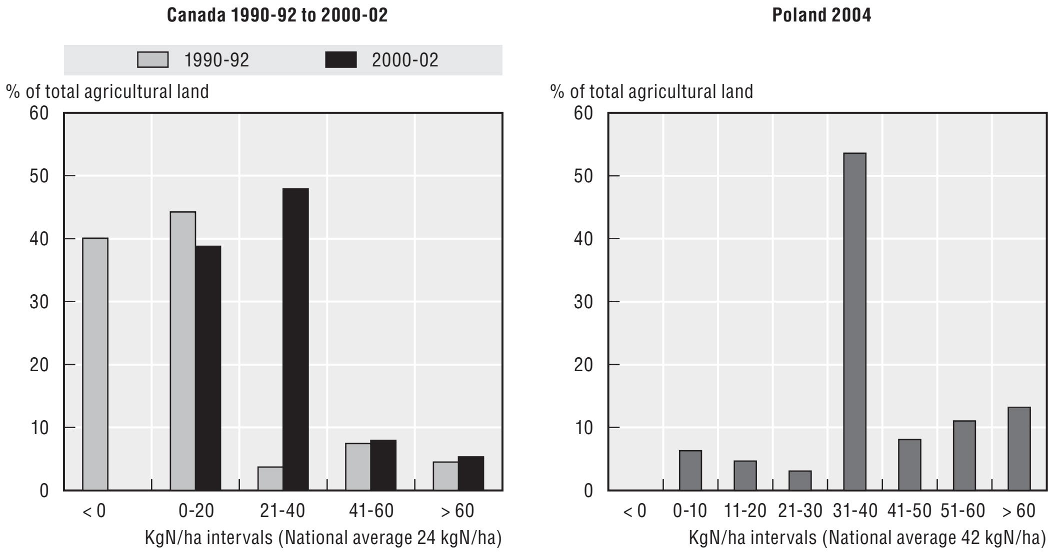
Source: OECD Secretariat (2007).

systems are spatially concentrated in a small part of the overall agricultural land area. While **Australia**, **Canada**, **Mexico**, and the **United States**, for example, are amongst OECD countries with the lowest nutrient surplus intensities (expressed as kgN/P/ha of agricultural land) there are regions within these countries where excess nutrients place a considerable pressure on the environment or where nutrient deficits are undermining crop productivity (Figures 1.2.2, 1.2.8).

In **Canada**, for example, the national N balance spatially disaggregated reveals some important developments not revealed by the average national value (Figures 1.2.2 and 1.2.12). In 1990-92 about 40% of the agricultural area had a N deficit, but a decade later this situation had improved with no land reported as having a N deficit. However, with the gradual increase in N surpluses over the 1990s there was a substantial increase in the share of farmland with a N surplus between 21-40 kgN/ha, and 10% of farmland with a surplus over 41 kgN/ha by 2000-02, compared to a national average of 28 kgN/ha, largely due to increased acreages of legume crops, higher livestock numbers and a decrease in crop output through lower yields (Lefebvre *et al.*, 2005). Similarly, in **Poland**, where the national average N surplus in 2002-04 was 46 kgN/ha, nearly one-quarter of agricultural land had a surplus greater than 50 kgN/ha (Figure 1.2.12).

The spatial variations in nutrient balances are usually explained by regional differences in farming systems. In **Italy**, for example, the Northern regions have a N surplus twelve times higher than Southern regions, due to the concentration of livestock production and maize cultivation (requiring high fertiliser inputs) in the North compared to the South (Chapter 3). Also in **Germany**, for those areas where livestock are concentrated, N surpluses are more than double the national average (Chapter 3).

Figure 1.2.12. **Spatial distribution of nitrogen balances in Canada and Poland**



StatLink http://dx.doi.org/10.1787/286670438537

Source: Lefebvre *et al.* (2005). Polish Ministry of Agriculture and Rural Development.

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