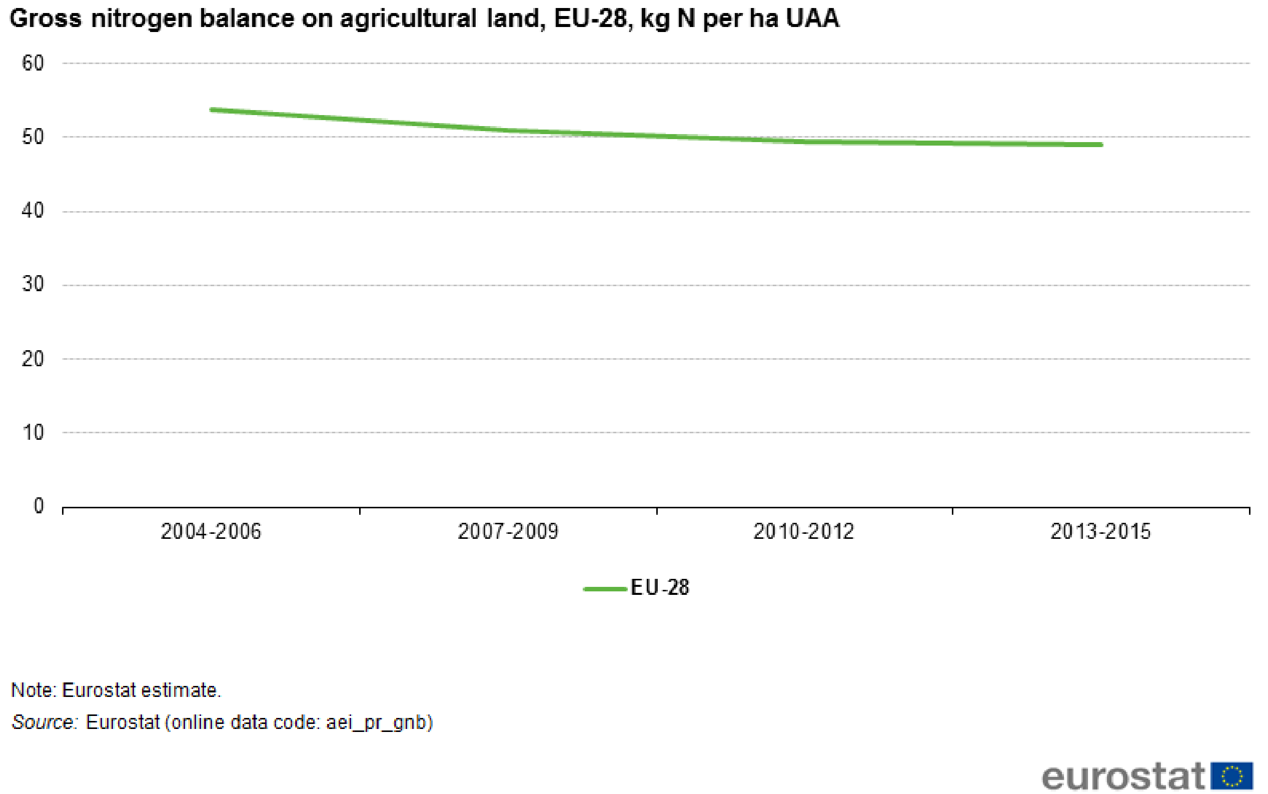
Agri-environmental indicator - gross nitrogen balance

Statistics Explained

Data from April 2018
Planned update: May 2022



Gross nitrogen balance on agricultural land, EU-28, kg N per ha UAA, 2004-2015 Source: Eurostat (aei_pr_gnb)

This article provides a fact sheet of the European Union (EU) agri-environmental indicator **gross nitrogen balance** . It consists of an overview of recent data, complemented by all information on definitions, measurement methods and context needed to interpret them correctly. The gross nitrogen balance article is part of a set of similar fact sheets providing a complete picture of the state of the agri-environmental indicators in the EU.

Analysis at EU level

The gross nitrogen balance for the EU-28 decreased from an estimated average of 54 kg N per ha per year in the period 2004-2006 to 49 kg N per ha per year in the period 2013-2015 (Figure 1).

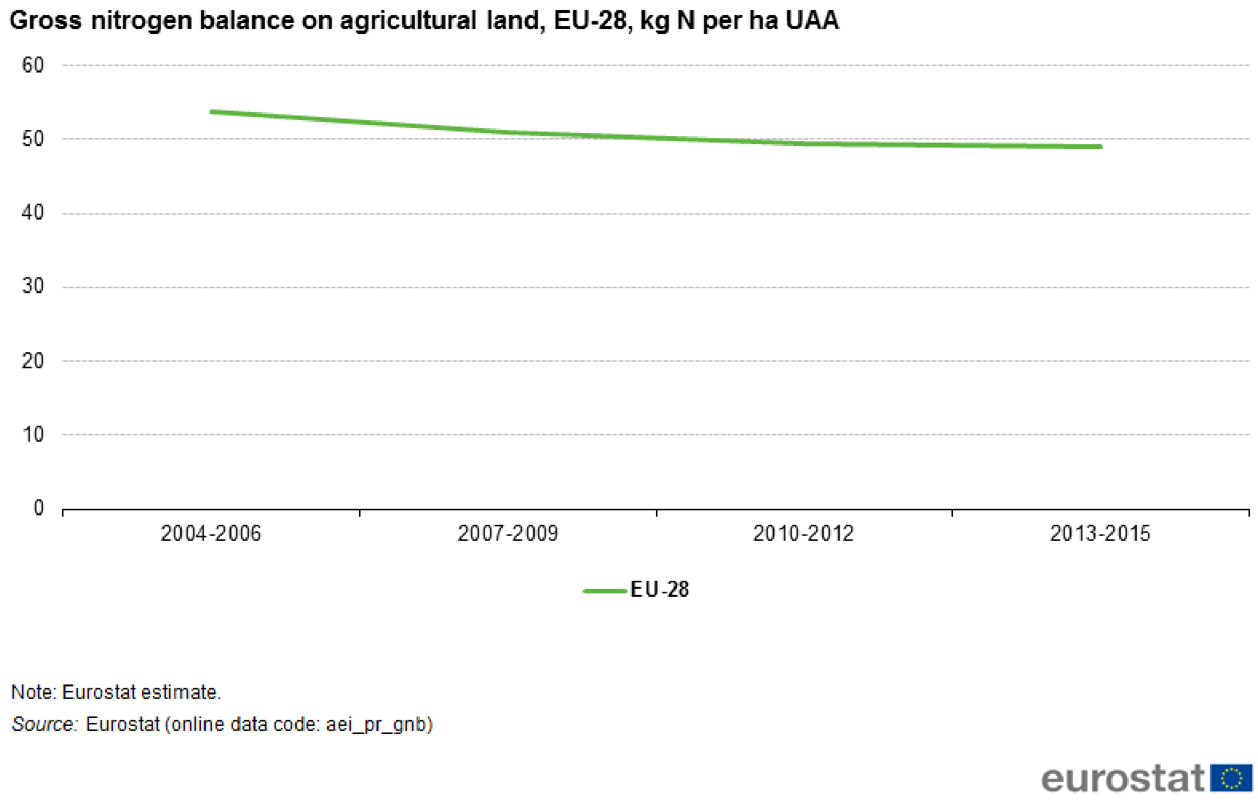


Figure 1: Gross nitrogen balance on agricultural land, EU-28, kg N per ha UAA Source: Eurostat (aei_pr_gnb)

The inputs of the gross nitrogen balance consist of mineral fertilisers , manure and organic fertilisers , atmospheric deposition, biological nitrogen fixation and seeds and planting material. Mineral fertilisers accounted for 45 % of the nitrogen input in the EU in 2014 (country data are not complete for 2015, therefore 2014 values are used for this section). Manure accounted for 38 % of the nitrogen input in the same year. The nitrogen input from seeds and planting materials is negligible. The re-use of nitrogen through the use of compost , sewage sludge , industrial waste etc. is also quite insignificant. Data on other organic fertilisers (except manure) are lacking in many countries and significance of these fertilisers could be underestimated. Data is mostly lacking on manure withdrawals, i.e. manure removed from agriculture and reused elsewhere. Biological nitrogen fixation is on average 6 % of total nitrogen input in the EU-28. The level of atmospheric deposition depends on ammonia (NH_3) emissions (of which agriculture is the main source), nitrogen oxides (NO_x) emissions (where the contribution of agriculture is not significant) and climate conditions (transport through air to other regions). Atmospheric deposition was on average 8 % of total inputs in the EU-28.

Analysis at country level

As explained in the section on Data used and methodology the current balances are not comparable between countries due to differences in definitions, methodologies and data sources used by countries. In this section, some trends at Member State level are highlighted.

Few countries showed an increasing trend in GNB when monitored as 3-year averages from 2004-2015. Only the Czech Republic, Cyprus, Latvia and Austria (Table 1) belonged to this group, and the increases are moderate. A decreasing trend was shown in nine EU countries; Denmark, Greece, France, Croatia, Lithuania, Malta, the Netherlands, Sweden and the United Kingdom, over the same years 2004-2015. For Greece, France, Malta and the Netherlands the decrease stagnated over the years 2010-2015. Four EU countries: Italy, Poland, Portugal and Slovenia, as well as the EFTA countries Norway and Switzerland, had a stable trend from 2004-2015 with no real changes. No clear trend could be identified in the remaining 11 EU countries: Belgium, Bulgaria, Germany, Estonia, Ireland, Spain, Luxembourg, Hungary, Romania, Slovakia, and Finland. Here, the 3-year averages increased or decreased from data point to data point without consistency.

Gross nitrogen balance on agricultural land, 2004-2015, kg N per ha UAA

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Belgium	146	146	152	145	124	129	142	143	143	138	132	132
Bulgaria	19	25	24	36	16	20	14	12	24	16	28	28
Czech Republic	67	71	82	86	80	56	67	79	88	76	63	98
Denmark	121	111	102	105	106	87	90	88	83	87	80	80
Germany	84	85	94	79	84	65	78	89	75	79	66	82
Estonia	36	21	32	22	36	25	31	32	28	23	22	22
Ireland	59	57	55	47	27	29	34	23	29	44	40	42
Greece	79	72	79	88	69	65	71	52	50	56	59	59
Spain	36	38	36	34	27	31	35	29	34	29	39	39
France	52	51	46	52	52	39	40	52	40	45	45	42
Croatia	110	110	112	120	117	63	81	94	88	51	58	65
Italy	64	63	74	68	65	60	59	63	80	70	66	66
Cyprus	172	152	153	159	201	178	191	199	184	179	194	194
Latvia	16	16	21	20	17	22	29	28	24	28	28	28
Lithuania	40	35	50	28	34	35	44	40	29	31	25	25
Luxembourg	145	129	129	123	122	120	127	138	125	127	129	129
Hungary	22	19	27	47	20	26	38	31	42	38	27	39
Malta	261	233	232	244	215	200	169	132	141	147	147	147
Netherlands	213	206	213	198	175	172	173	172	169	169	160	189
Austria	31	19	26	31	30	21	26	28	30	41	30	41
Poland	39	45	62	52	57	48	52	53	48	55	40	48
Portugal	39	44	28	43	33	36	41	39	43	37	42	41
Romania	0	12	13	32	14	18	-1	-11	16	4	-1	9
Slovenia	53	44	69	60	45	55	46	50	57	69	43	45
Slovakia	29	34	40	50	29	29	46	32	41	41	19	38
Finland	53	49	56	43	51	38	57	50	48	47	48	49
Sweden	44	44	50	45	51	30	42	42	32	35	31	32
United Kingdom	96	91	87	88	82	84	90	85	87	88	85	83
Norway	101	109	110	113	104	101	96	110	103	116	105	100
Switzerland	59	59	64	60	64	59	65	54	57	60	57	60

Note: Eurostat estimates for Estonia (2015), Romania and Croatia (2004-2014), Belgium, Bulgaria, Denmark, Greece, Italy, Cyprus, Latvia, Lithuania, Luxembourg, and Malta (2004-2015).
Source: Eurostat (online data code: aei_pr_gnb)

eurostat

Table 1: Gross nitrogen balance on agricultural land, 2004-2015, kg N per ha UAA Source: Eurostat (aei_pr_gnb)

Nitrogen use efficiency

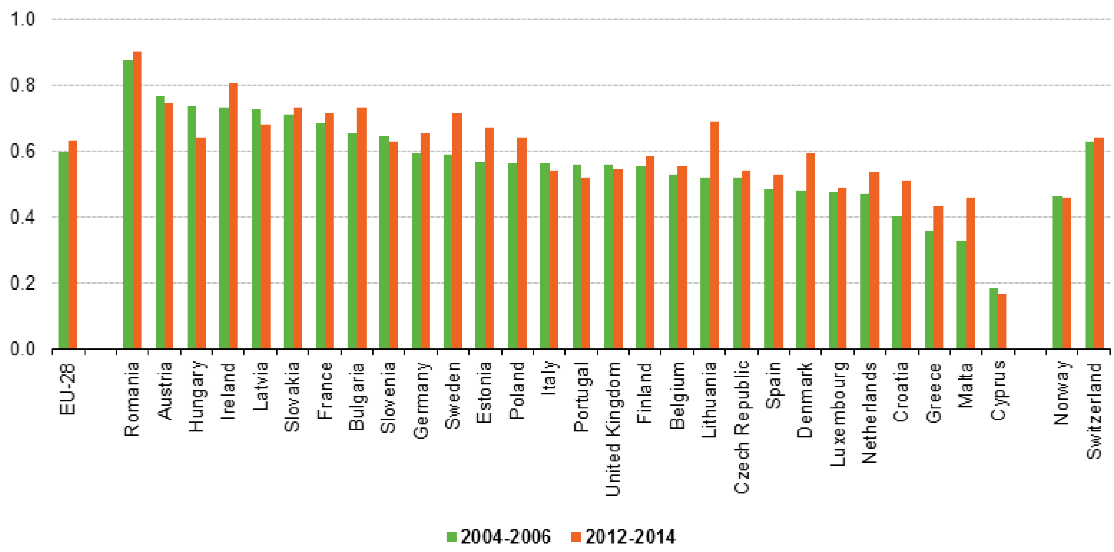
Another way of presenting the results of the gross nitrogen balance is the nitrogen use efficiency (NUE) ratio, which is defined as total nitrogen outputs divided by total nitrogen inputs. It gives an indication of the relative utilisation of nitrogen applied to an agricultural production system. In principle, by decreasing the nitrogen surplus over time, the nutrient use efficiency increases. NUE depends on the production system and its management; it increases as the nitrogen output in harvested products increases and/or the nitrogen input decreases. Conversely, NUE is low when the nitrogen output in harvested products is relatively low and the nitrogen input relatively high. Many combinations are possible, but the ideal case would be a high nitrogen output via harvested products combined with a high NUE and a low nitrogen surplus.

The highest value of NUE does not necessarily mean the best and desirable results. Rates which may be close to or above 1.0 would indicate a risk of soil depletion, as the nutrient uptake by crops exceeds the amount of nutrients applied to the soil. From a longer-term perspective, this trend cannot be considered sustainable.

The development of the NUE indicator is still in progress. For proper interpretation, NUE should be reported together with the nitrogen output in harvested products (as indicator for the productivity of the system), and the nitrogen surplus (as proxy for the potential nitrogen loss to the environment).

Figure 2 shows that the overall NUE in the EU-28 increased only slightly between 2004-2006 and 2012-2014. It could indicate improved utilisation of nutrients applied to the field in a considerable number of Member States. Figure 2 also shows that in most countries the average NUE 2012-2014 had increased compared to the period 2004–2006.

Nitrogen use efficiency, 2004-2006 and 2012-2014 (nitrogen output/nitrogen input)



Note: Eurostat estimates for EU-28, Belgium, Bulgaria, Denmark, Greece, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Malta, and Romania (2004-2014).
Source: Eurostat (online data code: aei_pr_gnb)

Figure 2: Nitrogen use efficiency, 2004-2006 and 2012-2014) Source: Eurostat (aei_pr_gnb)

The evolution of NUE as the aggregate for EU-28 between 2004 and 2014 is shown in Figure 3a, and nitrogen output in harvested products in Figure 3b. NUE and nitrogen output in harvested products have roughly the same development, which is inversed to the GNB over the same time period (Figure 3c). In summary, the trends indicate that while the nitrogen losses to the environment are slightly decreasing the productivity is slightly improving in the EU-28, as is the nutrient use efficiency.

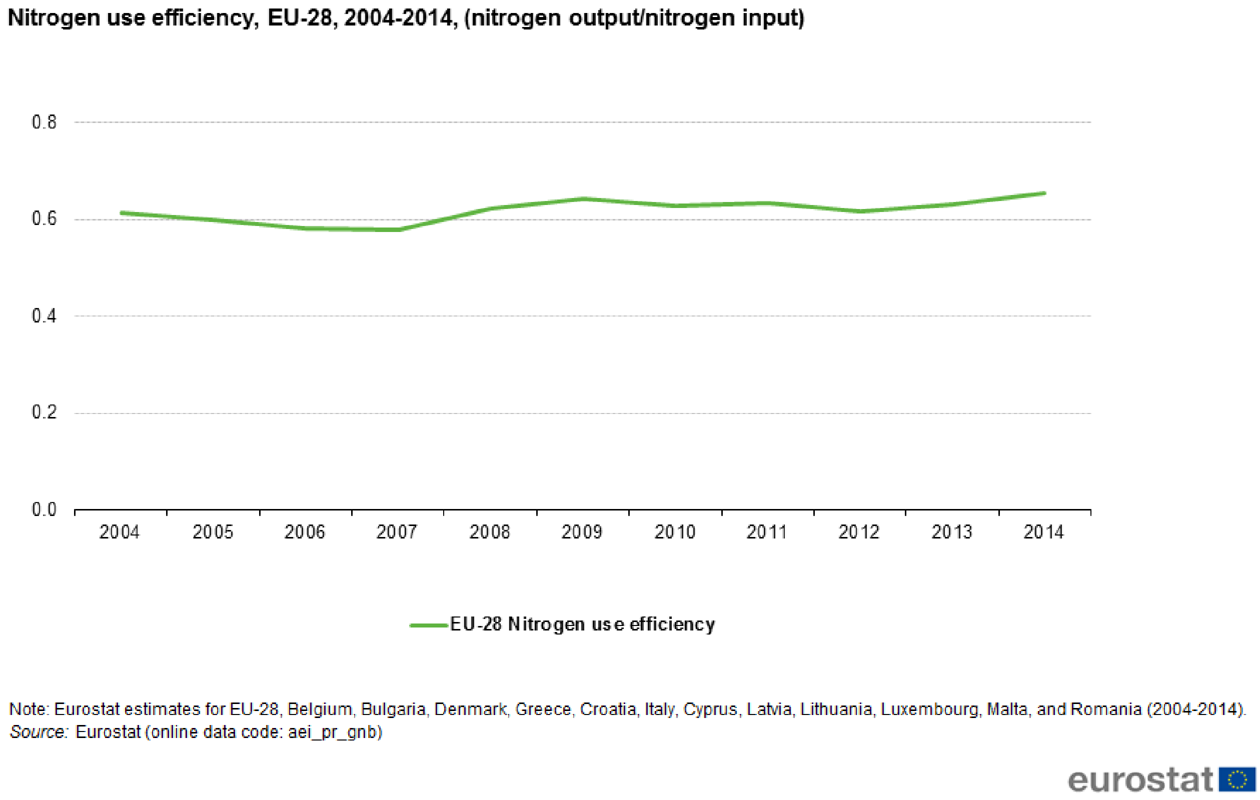


Figure 3a: Nitrogen use efficiency, EU-28, 2004-2014 Source: Eurostat (aei_pr_gnb)

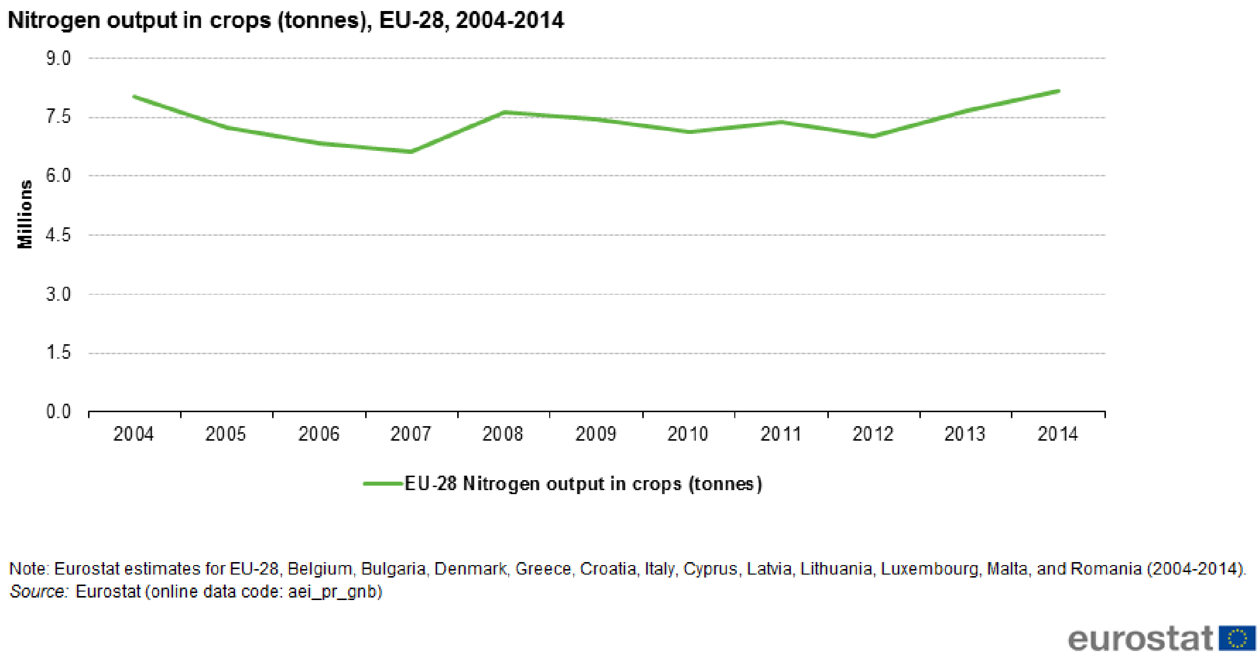


Figure 3b: Nitrogen output in crops (tonnes), EU-28, 2004-2014 Source: Eurostat (aei_pr_gnb)

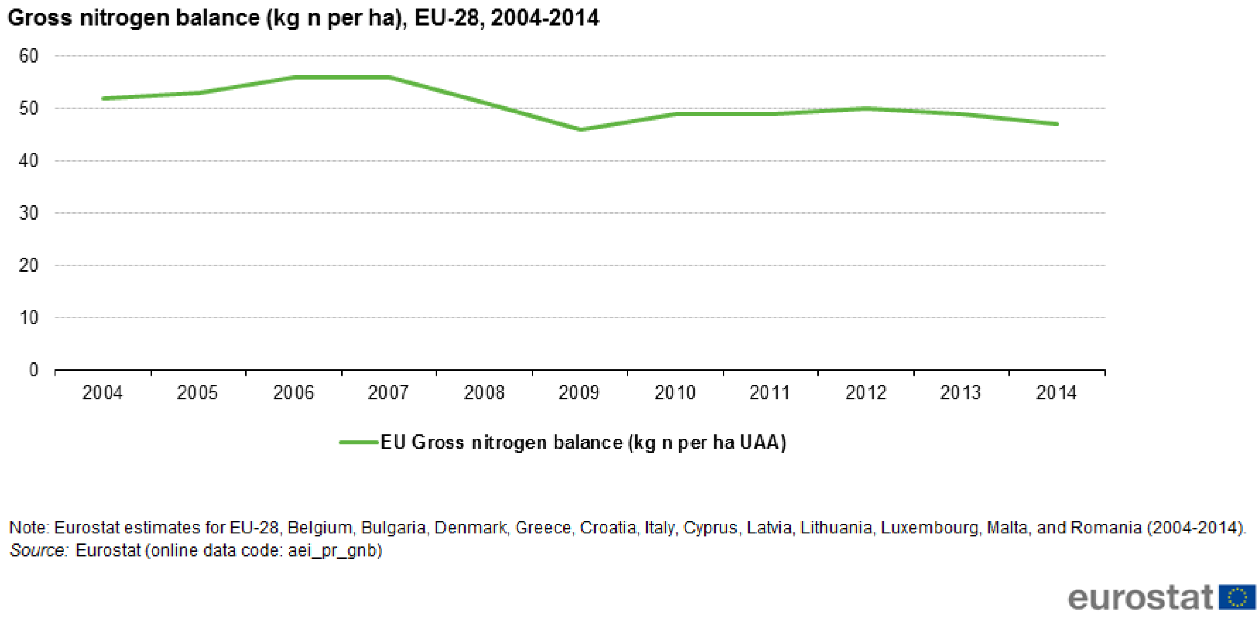


Figure 3c: Gross nitrogen balance (kg n per ha), EU-28, 2004-2014 Source: Eurostat (aei_pr_gnb)

The NUE indicator may be useful for presenting how different strategies can contribute towards improving relative utilisation of nutrients applied to agricultural production systems, depending on the initial situation. Depending on context, both intensification and extensification strategies may contribute. In some contexts the main drive may be to increase food production and resource use efficiency, in other contexts the priority may be to protect soil and habitats from degradation.

Source data for tables and graphs

- AEI - gross nitrogen balance: tables and figures

Data sources

Indicator definition

Potential surplus of nitrogen on agricultural land (kg N per ha per year).

Links with other indicators

This indicator has links to a number of other AEI indicators that describe developments in some of the main contributory factors.

Data used and methodology

Due to missing data nutrient balances have been estimated by Eurostat for several countries and several years (Table 1). These estimations were based on data available in Eurostat's dissemination database, international public data collections, and published research, and confirmed with the countries in question as reasonable estimates. For 2015, no detailed estimates have been made and therefore no detailed analysis covers this year.

The methodology of the nitrogen balances is described in Eurostat/OECD Nutrient Budgets handbook . The gross nitrogen balance lists all inputs and outputs into and out of the soil and calculates the gross nitrogen surplus as the difference between total inputs and total outputs. The gross nitrogen surplus per ha is derived by dividing the total gross nitrogen surplus by the reference area. The reference area of the current version of balances uploaded in Eurostat database is the UAA. It should be noted that some countries use slightly different methodologies; Austria, the United Kingdom and Spain fall into this group. It means that the time series are comparable within the countries, but the individual values should not be compared with other countries' individual values.

The **inputs of the nitrogen balance** are:

- Fertilisers , which consist of:

- inorganic fertilisers,
  - organic fertilisers (excluding manure).

- Gross manure input, which is calculated from:

- manure production (nitrogen excretion; according to the current methodology no reductions are made for nitrogen losses due to volatilisation in stables, storages and with the application to the land);
  - manure withdrawals (manure export, manure processed as industrial waste, non-agricultural use of manure, other withdrawals);
  - change in manure stocks;
  - manure import.

- Other nitrogen inputs, which consist of:

- seeds and planting material;
  - biological nitrogen fixation by leguminous crops and grass-legume mixtures;
  - atmospheric deposition.

The **outputs of the gross nitrogen balance** are:

- Total removal of nitrogen with the harvest of crops (cereals, dried pulses, root crops, industrial crops, vegetables, fruit, ornamental plants, other harvested crops);

- Total removal of nitrogen with the harvest and grazing of fodder (permanent grassland and fodder from arable land including temporary grassland);

- Crop residues removed from the field.

The nitrogen input and output is estimated for each item of the balance from basic data by multiplying with coefficients to convert the data into nitrogen content. Basic data (fertiliser consumption, livestock numbers, crop production, agricultural area) are mostly derived from agricultural statistics. Coefficients are mainly estimated by research institutes and can be based on models, statistical data, measured data as well as expert judgements.

Climatic conditions have a big impact on the balance through the impact on yield and therefore nitrogen output. Climate and weather conditions are beyond the control of the farmer. To dampen the effect of weather conditions on the balance the results presented in this fact sheet with regards to the nutrient balance are presented not referring to a particular year but as an average for a certain period. Input prices can have the same distorting effect.

Context

The gross nitrogen balance lists the nitrogen inputs to agricultural soils and nitrogen outputs removed from the soil. The main indicator from the gross nitrogen balance is the gross nitrogen surplus (GNS) which is calculated as the difference between total nitrogen inputs and total nitrogen outputs. The GNS can also be expressed in kg N per ha per year, by dividing the surplus by the reference area. The gross nitrogen balance provides insight into links between agricultural nitrogen use and losses of nitrogen into environment. A persistent surplus indicates potential environmental problems, such as ammonia (NH3) emissions (contributes to acidification , eutrophication , nitrate leaching (resulting in pollution of drinking water and eutrophication of surface waters) or nitrous oxide emissions (a potent greenhouse gas). A persistent deficit indicates the risk of decline in soil fertility.

Policy relevance

The Farm to Fork strategy [1] under the European Green Deal [2] identifies excess of nutrients in the environment as a major source of air, soil and water pollution, negatively impacting biodiversity and climate. The Commission will act to reduce nutrient losses by at least 50%, while ensuring no deterioration on soil fertility. This will reduce the use of fertilisers by at least 20% by 2030. The gross nitrogen balance is an important indicator for the quantified Green Deal targets[3]. Improved nutrient management as part of more sustainable farming systems is included in the green architecture of the future Common Agriculture Policy , contributing to several specific objectives of the policy.

While several human activities influence water quality, agriculture remains a major source of water-related problems. Since gross nutrient balances provide information on the links between agricultural input use, such as nitrogen, loss of nutrients to the environment and the sustainable use of soil nutrient resources, it is one of two main indicators for the EU Common Agriculture Policy's Context indicator 40: water quality . It is also an indicator used in the reporting under the Nitrates Directive [4].

The 7th Environment Action Programme (EAP) calls for further efforts to manage the nutrient cycle in a more sustainable way and to improve efficiency in the use of fertilisers. Nitrogen balance on agricultural land is used as an annual indicator in support to the monitoring of the 7th EAP .

Eurostat provides data from EU countries on nitrogen balance to the OECD for use in the OECD indicator set on agri-environment .

Several other policies are indirectly linked to the gross nitrogen balance:

- The Clean Air Policy on the reduction of national emissions of certain atmospheric pollutants. The National Emission reduction Commitments (NEC) Directive [5] sets national reduction commitments for the five pollutants (sulphur dioxide, nitrogen oxides, volatile organic compounds, ammonia and fine particulate matter) responsible for acidification, eutrophication and ground-level ozone pollution which leads to significant negative impacts on human health and the environment. It also transposes the reduction commitments for 2020 taken by the EU and its Member States under the revised Gothenburg Protocol and sets more ambitious reduction commitments for 2030 so as to cut the health impacts of air pollution by half compared with 2005.
- The Habitats Directive [6] and the Birds Directive [7]. These Directives aim to ensure biological diversity through the conservation of natural habitats and wild flora and fauna within the European territory. Farmers who have agricultural land in Natura 2000 sites may face restrictions in using their land, such as reduction in the use of fertilisers.
- The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change (UNFCCC) . The major feature of the Kyoto Protocol is that it sets binding targets for 37 industrialized countries and the European community for reducing greenhouse gas (GHG) emissions. Reporting is done by the countries through the submission of annual emission inventories and national reports under the Protocol at regular intervals. Items to be reported under the Protocol include the application of mineral nitrogen fertilisers by agriculture, livestock excretion, emission factors etc.

[1] A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system, COM/2020/381

[2] The European Green Deal COM/2019/640

[3] Recommendations to the Member States as regards their strategic plan for the Common Agriculture Policy COM(2020)846

[4] Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources

[5] Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants on the reduction of national emissions of certain atmospheric pollutants

[6] Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora

[7] Directive 2009/147/EC on the conservation of wild birds

Agri-environmental context

The gross nitrogen balance indicates the total potential risk to the environment (air, water and soil). The output side of the balance presents the nutrient uptake by harvested (and grazed) crops and fodder, and crop residues removed from the field; i.e. the agricultural production from the soil. The input side of the balance counts all nitrogen supplied to the soil. Sustainability could be defined by preserving and/or improving the level of production without degrading the natural resources. The harvest and grazing of crops and fodder means that nutrients are removed from the soil. To sustain soil fertility this removal of nutrients should in principle be compensated by supplying the same amount of nutrients. Fertilisers and manure are therefore necessary to supply the crops with nitrogen for growing.

However, not all of nitrogen in fertilisers and manure reaches the crop. Part of the nitrogen is lost due to volatilisation in animal housing, storage and during application to the land. Moreover, organic nitrogen in manure first needs to be mineralised before being available to the crop, which means that part of the nitrogen may need different amounts of time for being available to plant (depending on soil characteristics and climate conditions – temperature and precipitations). Yield and therefore the uptake of nitrogen by crops is not only determined by inputs but also by non-controllable factors like weather. Furthermore, the risk of nitrogen leaching and run-off does not only depend on the nitrogen excess, but also on the type of soil, precipitation rates, soil saturation, temperature, etc. Abating measures to reduce nitrogen emissions directly impact the amount of nitrogen in manure and fertilisers applied to the soil. A higher emission rate means lower nitrogen content of manure/fertilisers applied to the soil, but means a higher contribution to environmental problems related to GHG and NH3emissions. Lowering the emission rate means increasing the rate of nitrogen in manure/fertilisers, and therefore increasing the potential risk of leaching and run-off.

Therefore, the estimated nitrogen surplus by itself does not determine the actual risks to the air, water and soil. The actual risk depends on many factors including climate conditions, soil type and soil characteristics, soil saturation, management practices such as drainage, tillage, irrigation, etc. However, the gross nitrogen balance indicator presents a link between the agricultural activities and the environmental impact and identifies the factors which determine the nitrogen surplus and shows the change over time.

Other articles

- Agri-environmental indicators (online publication)
- Agri-environmental indicators - fact sheets

Publications

- Agriculture, forestry and fishery statistics - 2020 edition

Database

- Agri-environmental indicators (aei) , see:

Gross Nutrient Balance (aei_pr_gnb)

Dedicated section

- Agri-Environmental Indicators
- Climate Change
- Sustainable Development

Methodology

- Eurostat/OECD Nitrogen Budgets handbook
- Gross nutrient balance (aei_pr_gnb_esms)
- ESS agreement on data collection

Legislation

- Commission Communication COM(2006)508 final - Development of agri-environmental indicators for monitoring the integration of environmental concerns into the common agricultural policy
- Agri-Environmental Indicators , see:

Legislation: Commission Staff working document accompanying COM(2006)508 final

External links

- European Commission - Agriculture and Rural Development

- An environmentally sustainable CAP
  - Agri-Food Data Portal
  - The Common Agricultural Policy (CAP)
- European Commission – Environment

- Water
- European Commission – Climate Action

- Climate strategies & targets
- OECD - Agri-environmental Indicators and Policies
- Fertilizers Europe
- EU Nitrogen Expert Panel
- European Centre of the International Nitrogen Initiative
- European Nitrogen Assessment [8]
- Our Nutrient World [9]
- Too much of a good thing [10]
- United Nations Environment Programme (UNEP)

Notes

[8] Mark A. Sutton, et al (eds). Nitrogen in Europe - The European Nitrogen Assessment, Cambridge, 2011

[9] Sutton M.A. et al. Our Nutrient World. The challenge to produce more food, energy with less pollution. Key Messages for Rio+20. Centre for Ecology; Hydrology, 2012.

[10] Mark A. Sutton, Oene Oenema, Jan Willem Erisman, Adrian Leip, Hans van Grinsven; Wilfried Winiwarter. Too much of a good thing. Nature, Volume: 472, Pages: 159–161, 2011