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FAOSTAT ANALYTICAL BRIEF 117

Cropland nutrient balance

Global, regional and country trends

1961–2023

>> FAO Statistics Division

HIGHLIGHTS

- → **At the global level, the cropland nutrient surplus in 2023 was 85 million tonnes (Mt) of nitrogen (N), 7 Mt of phosphorus (P), and 11 Mt of potassium (K) corresponding to 54 kg N per hectare (ha) of cropland, 4 kg P per ha, and 7 kg K per ha.**
- → **Asia has exhibited the highest nitrogen surplus per hectare as of the 1990s and phosphorus surplus per hectare as of the 2000s.**
- → **Although Europe moved below the world average for the cropland nitrogen and phosphorus balances per hectare in the 2000s, it has remained above the world average for the cropland potassium balance per hectare over the entire period.**
- → **The Americas have accounted for more than half of the global total nitrogen from biological fixation since the 2000s.**
- → **Africa has a low nitrogen surplus, and phosphorus and potassium deficits per hectare of cropland.**
- → **Crop residue nitrogen removal averaged 10 kg per ha of cropland at the global level between 1961 and 2023 but 23 kg per ha of cropland for potassium.**

FAOSTAT CROPLAND NUTRIENT BALANCE

BACKGROUND

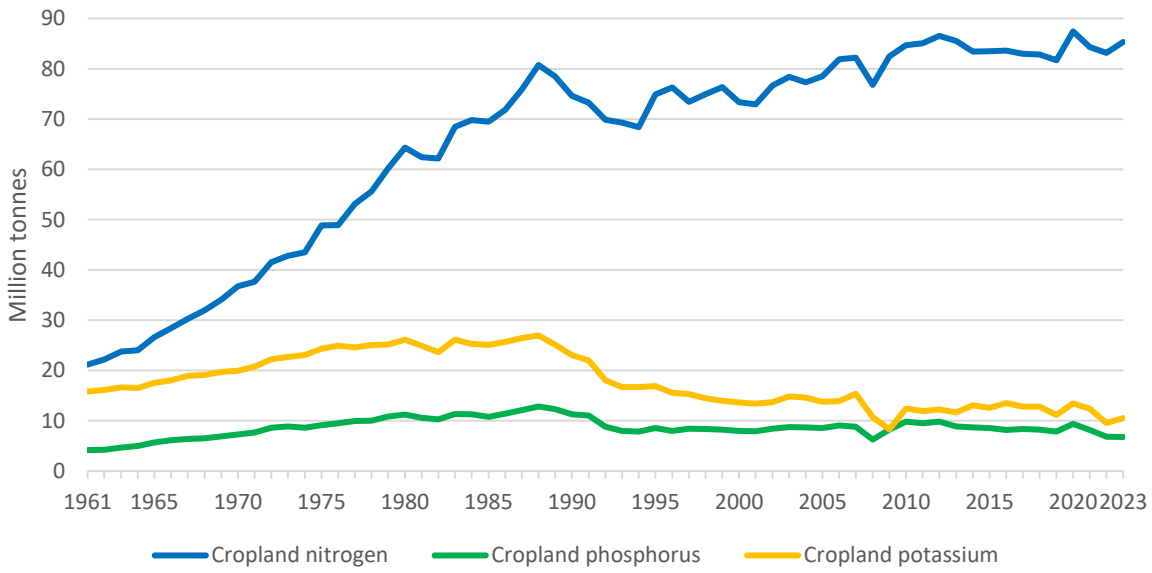
Cropland nutrient balances are an important indicator of nutrient flows that can signal an excess or insufficiency on cropland. The three main nutrients for plant growth are nitrogen (N), phosphorus (P) and potassium (K). Excess nutrient loads on cropland represent environmental risks, while nutrient deficits indicate soil nutrient mining, which may result in lower crop yield and deteriorating soil health. Differences in trends and levels for nutrient use give indications where alternative pathways for sustainable nutrient management may be needed. In cropland, the major inputs of nutrients are *synthetic and mined fertilizers* (sometimes also referred to as mineral fertilizers, *manure applied*, *biological nitrogen fixation*, *atmospheric deposition* (both reduced and oxidized compounds) and *seed*. The primary nutrient output from cropland is in the form of *crop removal* from the harvested main product. The difference between these inputs and outputs is the *nutrient balance* (McLellan *et al.*, 2018), whereas the ratio of outputs divided by inputs is an indicator of *nutrient use efficiency* (SPRPN, 2023).

In this brief, nutrient balances are presented both as total nutrient flows and per area of cropland, all on elemental basis for N, P and K. Global and regional trends are analysed along with highlights of the most important contributors to the overall balance and how these main contributors have changed over time. Country results are presented for the cropland nutrient balance total.

GLOBAL

At the global level, the cropland nutrient surplus in 2023 was 85 Mt of N, 7 Mt of P and 11 Mt of K distributed over cropland at average surpluses of 54 kg N per ha compared with a maximum N surplus of 80 kg per ha per year suggested by the EU Nitrogen Expert Panel (2015), 4 kg P per ha and 7 kg K per ha. Figure 1 shows that there was a substantial, 3.1-fold increase in the total cropland nitrogen balance in the most recent decade compared with the 1960s, while the phosphorus cropland balance remained nearly constant since the 1990s and the potassium balance declined by 29 percent over the same period. The differences in the trends for the three nutrient balances may be the result of a more focused attention on nitrogen as the limiting nutrient for crop production compared to phosphorus and potassium. The increases for nitrogen can mainly be attributed to a growth in the use of mineral fertilizers, which multiplied by 5.9 from 17 Mt in the 1960s to 102 Mt in the last ten years, and a substantially lower increase in crop harvest removal (with a 3.4-fold increase from 29 Mt in the 1960s to 99 Mt over the least ten years). For phosphorus, a 3.1-fold increase in mineral fertilizers use offset a similar increase in crop harvest removal (from 6 Mt to 18 Mt over the same period). The reduction in the potassium cropland balance is due to a larger increase in crop harvest removal (from 13 Mt to 43 Mt) compared to that of mineral fertilizers (from 9 Mt to 29 Mt). However, if crop residue K removal is included, the global K balance becomes negative, indicating ongoing depletion of soil K resources in many regions.

Figure 1: Global cropland nutrient balance by nutrient



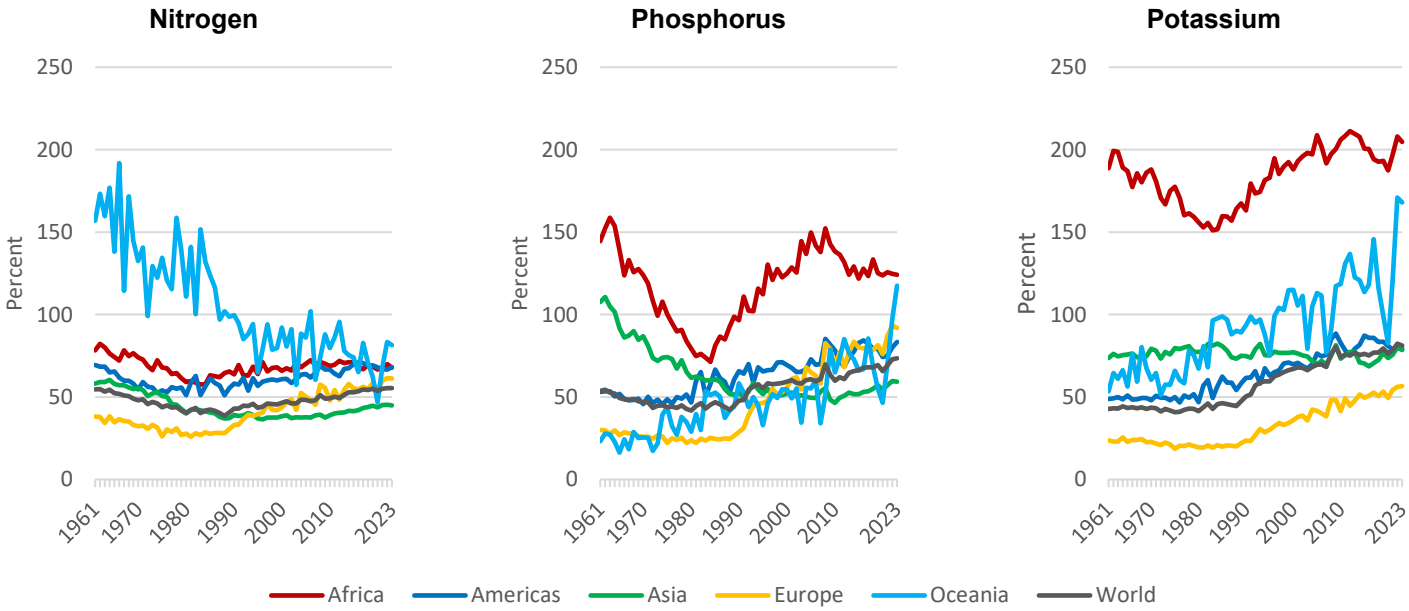
Source: FAO. 2025. FAOSTAT: Cropland nutrient balance. [Accessed December 2025]. https://www.fao.org/faostat/en/#data/ESB. Licence: CC-BY-4.0.

Nutrient use efficiency, calculated as the ratio of nutrient removal from crops to total nutrient input, is a measure of how well crops use available nutrients. High values of nitrogen use efficiency (greater than 90 percent) indicate risks of nutrient mining of soils, while low values (less than 50 percent) indicate risks of for water or air and pollution due to nutrient losses (EU Nitrogen Expert Panel, 2015). As global fertilizer use rose, nitrogen use efficiency declined between the 1960s (52 percent) and the 1980s (41 percent). Since then, although not surpassing the value of the 1960s, nitrogen use efficiency has increased to

54 percent in the most recent decade. Declining values of nutrient use efficiency indicate a proportionally higher use of inputs compared to outputs. At the global scale, less targeted approaches for nutrient applications played a role for the decline up until the 1990s. Afterwards, more effective application of inputs and progresses made in agricultural machinery, improved crop varieties, rotations, agronomic practices and technology contributed to the increase in nitrogen efficiency. Phosphorus use efficiency has followed a similar trajectory with values of 51 percent in the 1960s and 44 percent in the 1980s, but the efficiency in the most recent decade is at an all-time high of 69 percent. Lastly, potassium use efficiency remained stable until 1990, with values of 43 percent in the 1960s and 45 percent in the 1980s before increasing to 59 percent in the 1990s and reaching a record high 78 percent in the most recent decade. Concerns are growing that potassium deficiency may limit crop production in major agricultural regions (Wang *et al.*, 2024). The average nutrient use efficiency over the whole period for the world was 48 percent for nitrogen, 55 percent for phosphorus and 58 percent for potassium (Figure 2), which is below the 2023 levels for all nutrients (55 percent, 73 percent and 81 percent, respectively).

The relative importance of the different inputs contributing to the global total cropland nutrient surplus has also changed since the 1960s. For all three nutrients, mineral fertilizers use has taken an ever increasingly important role. The share of mineral fertilizers in total inputs increased from 31 percent in the 1960s to 56 percent in the most recent decade for nitrogen; during the same period it increased from 56 percent to 74 percent for phosphorus, and from 28 percent to 53 percent for potassium. In contrast to the other two nutrients, the most important input for potassium is manure applied – while manure made up an average of 20 percent of total inputs over the entire period for nitrogen and 30 percent for phosphorus, it contributed to an average of 56 percent of total inputs for potassium.

Figure 2: Nutrient use efficiency by region



Source: FAO. 2025. FAOSTAT: Cropland nutrient balance. [Accessed December 2025]. https://www.fao.org/faostat/en/#data/ESB. Licence: CC-BY-4.0.

REGIONAL

Figures 3 to 5 show that the trends and levels of the cropland nutrient surplus per hectare of cropland differed significantly by region between 1961 and 2023.

Over the whole period, **Africa** was above the world average for nitrogen use efficiency (68 percent) and had the highest phosphorus and potassium use efficiencies (118 percent and 184 percent, respectively), indicating that cropland in the region is running a deficit for these two nutrients. The nutrient use efficiencies for the region in 2023 were 68 percent for N, 124 percent for P and 205 percent for K. The **Americas** were above the world average, although closer than most of the regions, for cropland nutrient use efficiencies (61 percent for N, 63 percent for P and 64 percent for K). The nutrient use efficiencies for the Americas in 2023 were 68 percent for N, 83 percent for P and 79 percent for K. **Asia** used nitrogen over the whole period with almost the same efficiency as the world (44 percent) but more efficiently for phosphorus (63 percent) and potassium (76 percent). However, the nutrient use efficiencies for Asia in 2023 (45 percent for N, 59 percent for P and 79 percent for K) were below the world average – this was mainly due to large N and P surpluses in China and India. The nutrient efficiency in **Europe** was slightly below the global average, although the efficiency for nitrogen and phosphorus use had in recent decades been very close to the world average. This is partly explained by the high proportion of arable forage crops in European cropland, which is not included among the outputs in the database. The nutrient use efficiencies for Europe in 2023 were 61 percent for N, 92 percent for P and 57 percent for K. Trends in Europe and in turn for the world can partially be explained by the introduction in 1991 of the European Union (EU) Nitrates Directive to reduce water pollution caused by leaching and runoff as well as the collapse of the Soviet Union. In **Oceania**, nitrogen use efficiency began high in the 1960s (159 percent) but steadily declined to 70 percent in the most recent decade, whereas phosphorus use efficiency steadily rose and was near the world average in the most recent decade at 71 percent. Potassium use efficiency (93 percent over the whole period) remained above the world average. The nutrient use efficiencies for Oceania in 2023 were 82 percent for N, 118 percent for P and 168 percent for K.

Until the 1980s, nitrogen deposition and biological nitrogen fixation accounted for more than half of total nitrogen inputs in **Africa**. Over the whole period, the region has a low nitrogen surplus per ha of cropland (8 kg N per ha) and a nutrient deficit per ha of cropland for phosphorus (−0.5 kg P per ha) and potassium (−5 kg K per ha). This indicates decades of soil nutrient mining in many parts of the region, also reflected by the high levels of nitrogen, phosphorus and potassium use efficiencies. The share of fertilizer to total inputs rose until the 1990s (from 20 percent in the 1960s to 40 percent in the 1980s for N, from 58 percent to 65 percent for P, and from 23 percent to 36 percent for K) after which it began to decline (reaching 38 percent for N, 65 percent for P and 34 percent for K in the most recent decade). The cropland nutrient balance for the region in 2023 was 13 kg per ha for N, −1 kg per ha for P and −8 kg per ha for K.

The **Americas** have accounted for more than half of the global total nitrogen from biological fixation since the 2000s, and in the most recent decade, nitrogen inputs from biological fixation (22 Mt on average per year) exceeded mineral fertilizer N (21 Mt), mainly due to large areas of soybean cropping. As a result, the fertilizer dependency of this region is low (Quemada and Lassaletta, 2024). The region is near the world average for nutrient surpluses per ha of cropland (32 kg N per ha, 5 kg P per ha and 10 kg K per ha). Over the whole period, manure accounted for 14 percent of total inputs for N, 26 percent for P and 43 percent for K. The cropland nutrient balance for the region in 2023 was 47 kg per ha for N, 3 kg per ha for P and 10 kg per ha for K.

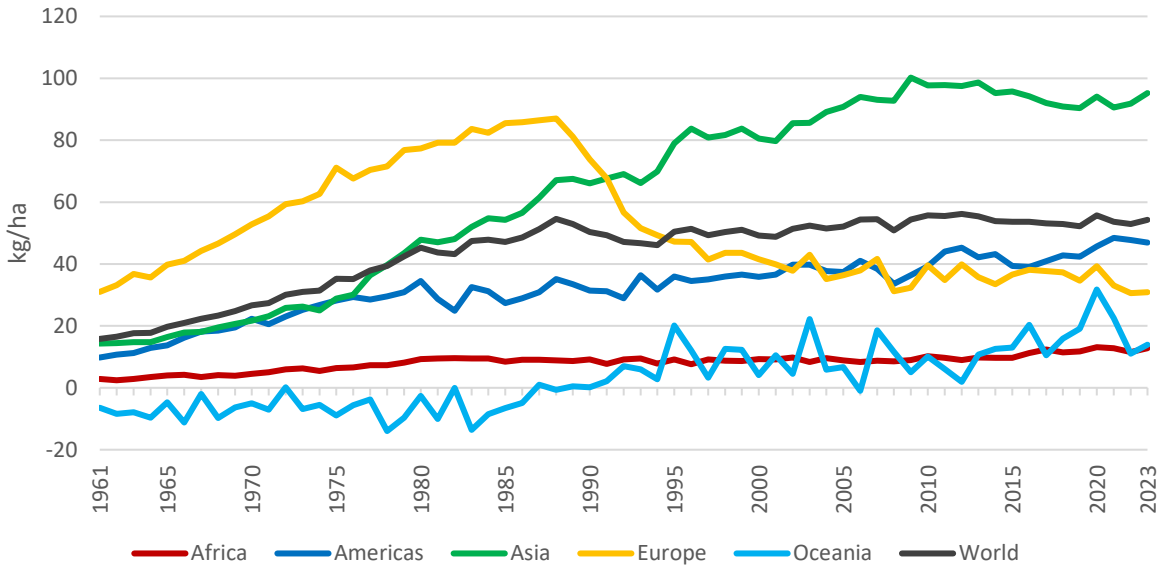
Asia was the biggest contributor of total nutrient inputs to the global total in the most recent decade, accounting for approximately half of total nutrients applied for N (52 percent), P (55 percent) and K (48 percent). Although the region has the highest nitrogen surplus per hectare as of the 1990s (75 kg N per ha of cropland in that decade) and phosphorus balance per hectare as of the 2000s (10 kg P per ha of cropland in that decade), this is not true for the potassium balance per hectare, which averaged 7 kg K

per ha of cropland over the whole period. As of the 2000s, the region became the largest contributor to manure nutrients applied, contributing to more than 40 percent of the world total for all three nutrients. In the most recent decade, Asia was responsible for more than half of global nutrient inputs from mineral fertilizers (60 percent for N, 58 percent for P and 50 percent for K). The cropland nutrient balance for the region in 2023 was 95 kg per ha for N, 10 kg per ha for P and 10 kg per ha for K. Although Asia only contributed 2 percent to the global phosphorous surplus and 9 percent to the global potassium surplus in the 1960s, the region contributed about 40 percent to the global surplus over the entire time period and across all nutrients. In 2023, Asia accounted for 64 percent of the global nitrogen surplus, 85 percent of the global phosphorous surplus and 45 percent of the global potassium surplus.

For **Europe**, a large share of total nutrient inputs come from manure applied, averaging 33 percent for N, 43 percent for P and 63 percent for K over the whole period. The region saw a dramatic drop between the 1980s and the 1990s in the cropland nutrient surplus for the three nutrients: −39 percent for N, −56 percent for P and −42 percent for K. Although the region moved below the world average for the cropland nitrogen and phosphorus balances per hectare in the 2000s (38 kg N per ha and 4 kg P per ha), it has remained above the world average for the cropland potassium balance per hectare over the entire period (averaging 36 kg K per ha per year between 1961 and 2023, as shown in Figure 5). The cropland nutrient balance for the region in 2023 was 31 kg per ha for N, 1 kg per ha for P and 14 kg per ha for K.

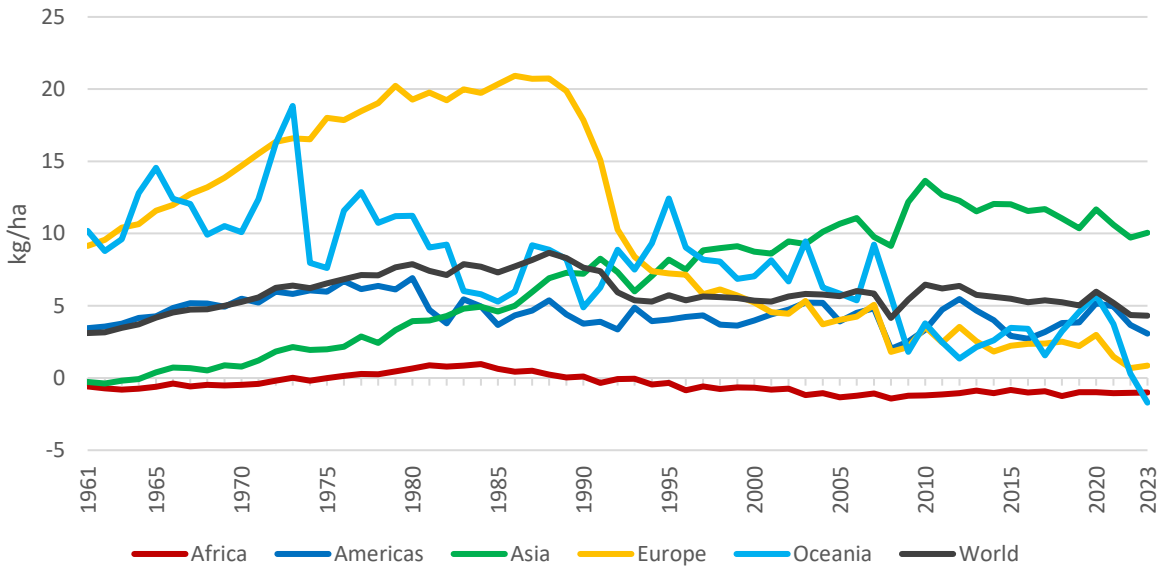
Oceania had a small contribution to the world total, accounting for only 1–2 percent of total inputs and outputs for all nutrients over the whole period. For nitrogen, share of mineral fertilizers in total inputs increased from 33 percent in the 1960s to 44 percent in the 1970s and overtook the share of manure applied, which reduced from 40 percent to 35 percent. The contributions of manure applied remained low for phosphorus (averaging 12 percent over the whole period) but was high for potassium (averaging 58 percent over the whole period). The cropland nutrient balance for the region in 2023 was 14 kg per ha for N, -2 kg per ha for P and −8 kg per ha for K.

Figure 3: Cropland nitrogen balance per cropland area by region



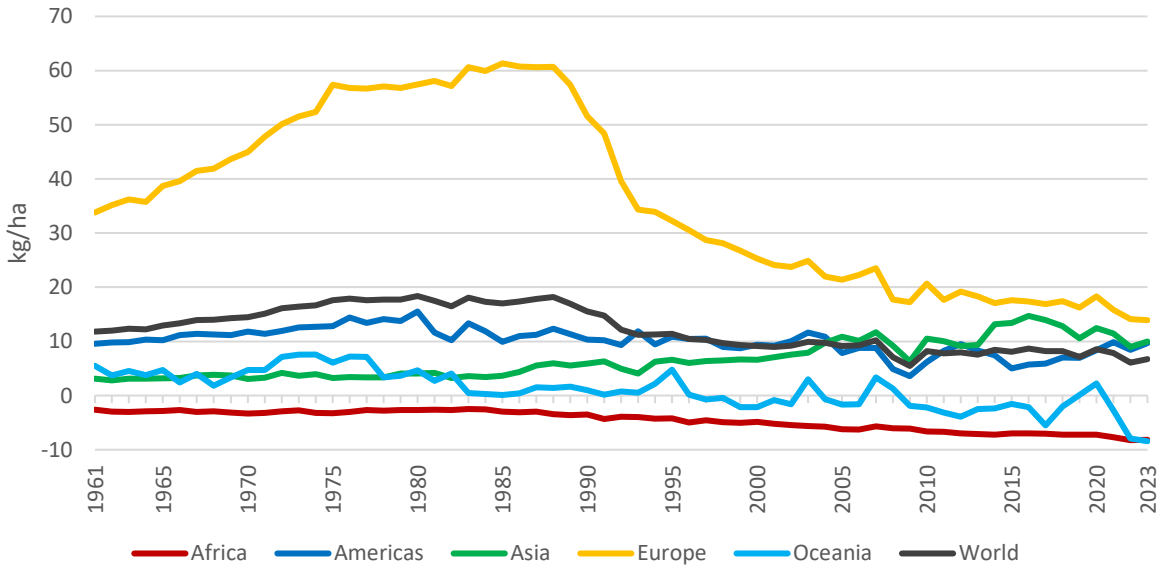
Source: FAO. 2025. FAOSTAT: Cropland nutrient balance. [Accessed December 2025]. https://www.fao.org/faostat/en/#data/ESB. Licence: CC-BY-4.0.

Figure 4: Cropland phosphorus balance per cropland area by region



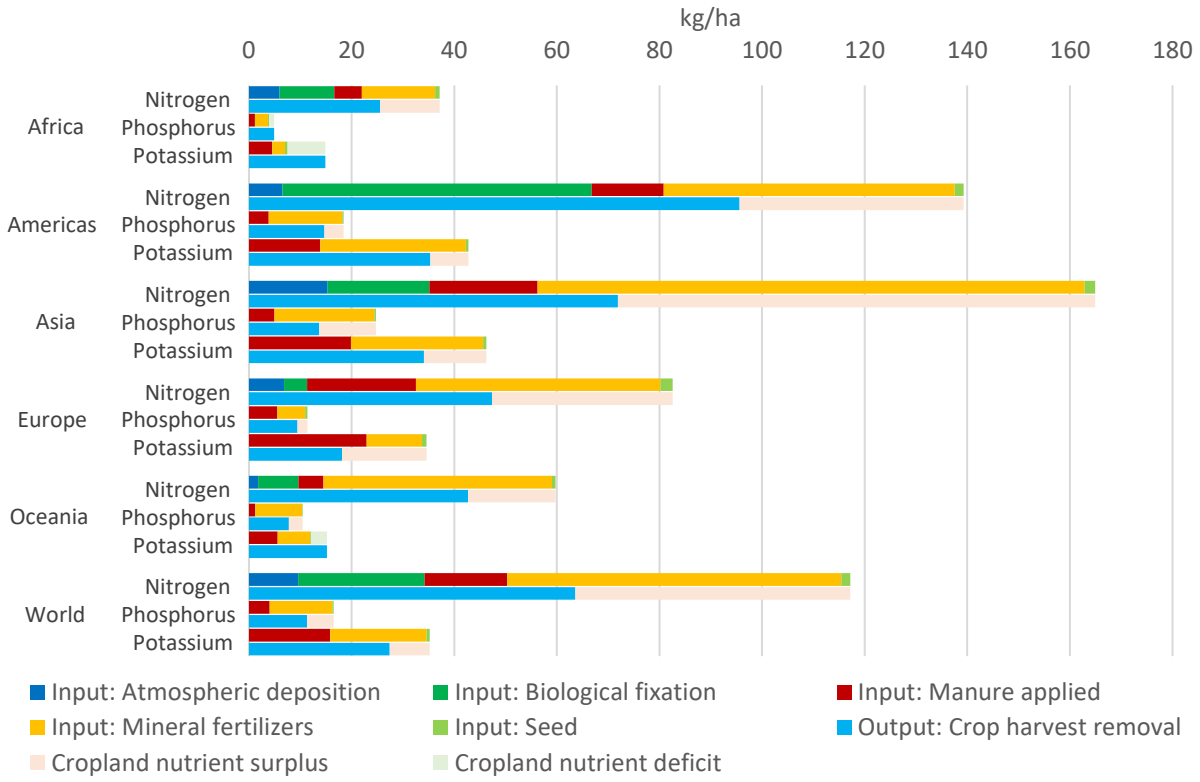
Source: FAO. 2025. FAOSTAT: Cropland nutrient balance. [Accessed December 2025]. https://www.fao.org/faostat/en/#data/ESB. Licence: CC-BY-4.0.

Figure 5: Cropland potassium balance per cropland area by region



Source: FAO. 2025. FAOSTAT: Cropland nutrient balance. [Accessed December 2025]. https://www.fao.org/faostat/en/#data/ESB. Licence: CC-BY-4.0.

Figure 6: Cropland nutrient balances by region and nutrient (2014–2023 average)



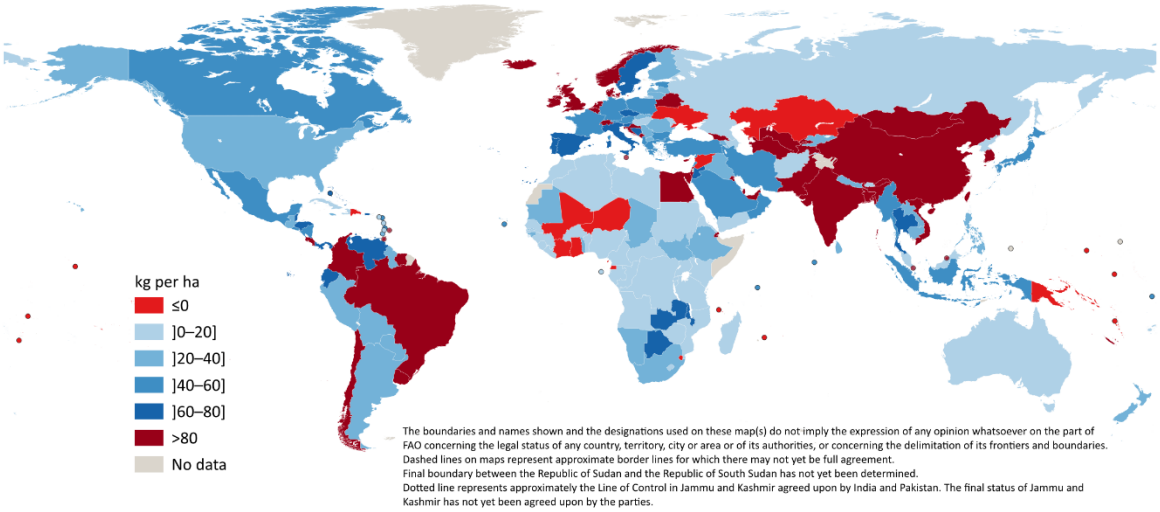
Source: FAO. 2025. FAOSTAT: Cropland nutrient balance. [Accessed December 2025]. https://www.fao.org/faostat/en/#data/ESB. Licence: CC-BY-4.0.

COUNTRY

Figures 7 and 8 show the large heterogeneity in the cropland nitrogen balance per area of cropland and use efficiency among countries in 2023. The thresholds for these maps were derived from the 2015 EU Nitrogen Expert Panel, which specified that the desired maximum N surplus is less than 80 kg per ha and the desired nitrogen use efficiency is between 50 percent and 90 percent. Most countries in Africa have cropland nitrogen balance values of 0–40 kg per ha, while most European countries have a cropland nitrogen surplus of 40–80 kg per ha. As suggested by Figure 4, some of the highest values are found in Asia.

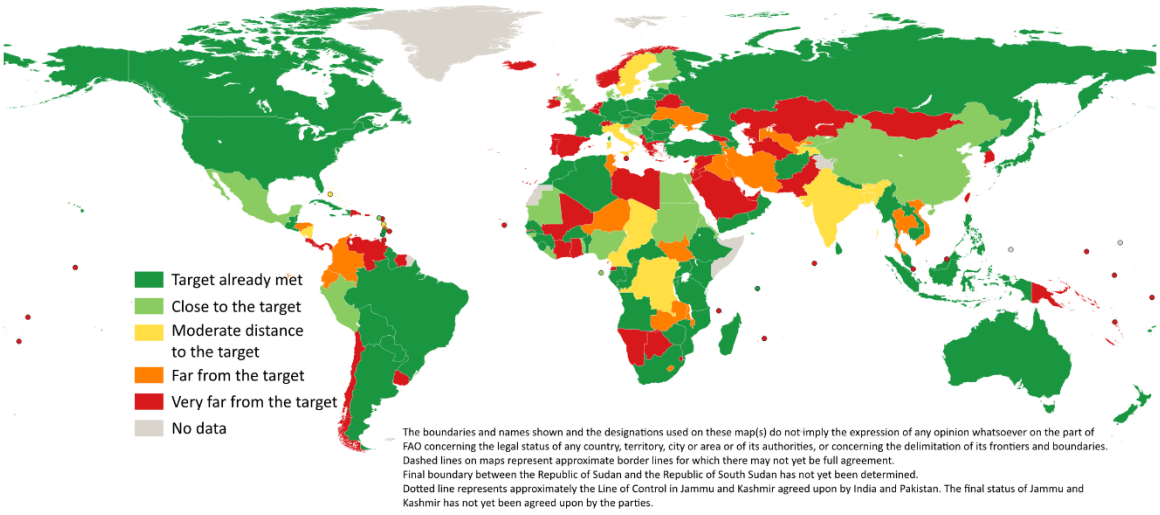
Combining Figures 7 and 8, some countries show differences between their status for the nitrogen balance versus their nitrogen use efficiency. For example, while Brazil is on the upper end of the cropland nitrogen balance, the country has a nitrogen use efficiency within the desired range, indicating that the soybean practices in the country may effectively increase the outputs relative to the inputs. On the other hand, other countries such as Namibia (displaying moderate levels of cropland nitrogen balance but low levels of nitrogen use efficiency) may still be at risk of nutrient depletion. The nitrogen use efficiency captures the efficiency of outputs in terms of the levels of inputs applied, regardless of the order of magnitude. As a result, countries with very low levels of output relative to low levels of inputs (for example in sub-Saharan Africa) can have efficiencies similar to those of countries with high levels of output relative to very high levels of inputs (such as China and India).

Figure 7: Cropland nitrogen balance per cropland area (2023)



Source: FAO. 2025. FAOSTAT: Cropland nutrient balance. [Accessed December 2025]. https://www.fao.org/faostat/en/#data/ESB. Licence: CC-BY-4.0.

Figure 8: Cropland nitrogen use efficiency (2023)

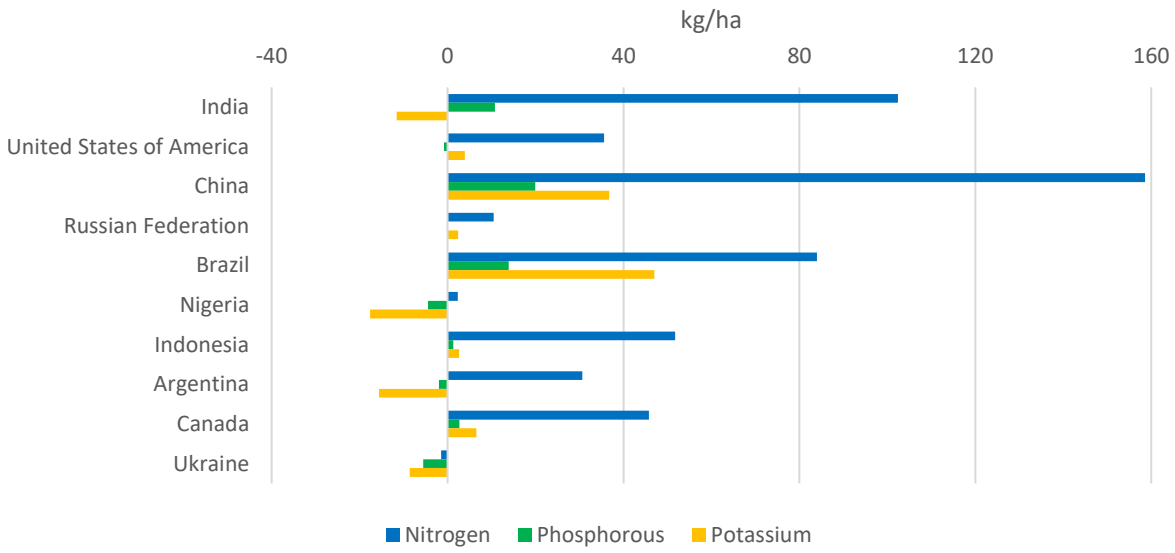


Note: The bounds correspond to those of the proxy measure of the subindicator theme “soil quality” under the environment dimension of Sustainable Development Goal Indicator 2.4.1 (proportion of agricultural area under productive and sustainable agriculture). The proxy metric nitrogen use efficiency (NUE) uses the following bands: 50% ≤ NUE ≤ 90%: target already met; 45% ≤ NUE < 50% or 90% < NUE ≤ 95%: close to the target; 40% ≤ NUE < 45% or 95%< NUE ≤100%: moderate distance to the target; 35%≤ NUE <40% or 100% < NUE ≤105%: far from target; NUE < 35% or NUE > 105%: very far from target.

Source: FAO. 2025. FAOSTAT: Cropland nutrient balance. [Accessed December 2025]. https://www.fao.org/faostat/en/#data/ESB. Licence: CC-BY-4.0.

The countries with the largest cropland area show different profiles of the cropland nutrient balances by nutrient for 2023, as shown on Figure 9. Of these countries, China, India and Brazil all have nitrogen balances higher than the global average, while the United States of America, the Russian Federation, Indonesia, Nigeria, Argentina, Canada and Ukraine all have nitrogen balances lower than the global average. China, Brazil, Indonesia and Canada have surpluses for all three nutrients, while India, the United States of America and the Russian Federation have surpluses for two nutrients (including nitrogen in all cases) and a small deficit in another. Argentina and Nigeria have a surplus for nitrogen and deficits in the other two nutrients. Ukraine has a deficit in all three nutrients, possibly because of the increased price of fertilizers due to the war in the country.

Figure 9: Cropland nutrient balance per cropland area by nutrient, selected countries (2023)



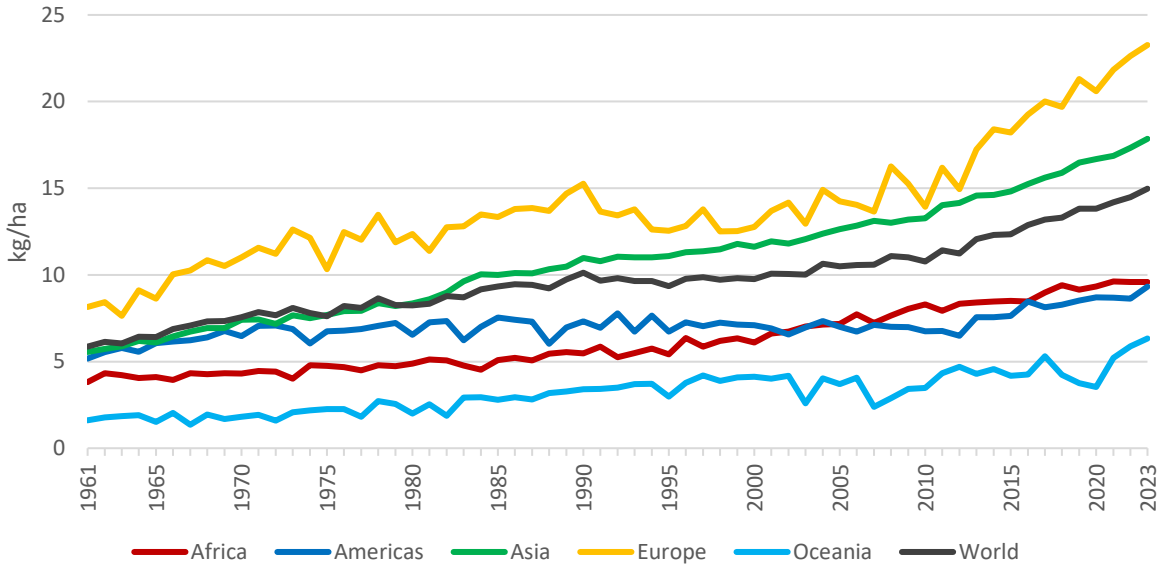
Note: Countries are listed in descending order of cropland area, from China (first) to Ukraine (tenth).

Source: FAO. 2025. FAOSTAT: Cropland nutrient balance. [Accessed December 2025]. https://www.fao.org/faostat/en/#data/ESB. Licence: CC-BY-4.0.

FOCUS: CROP RESIDUE REMOVAL

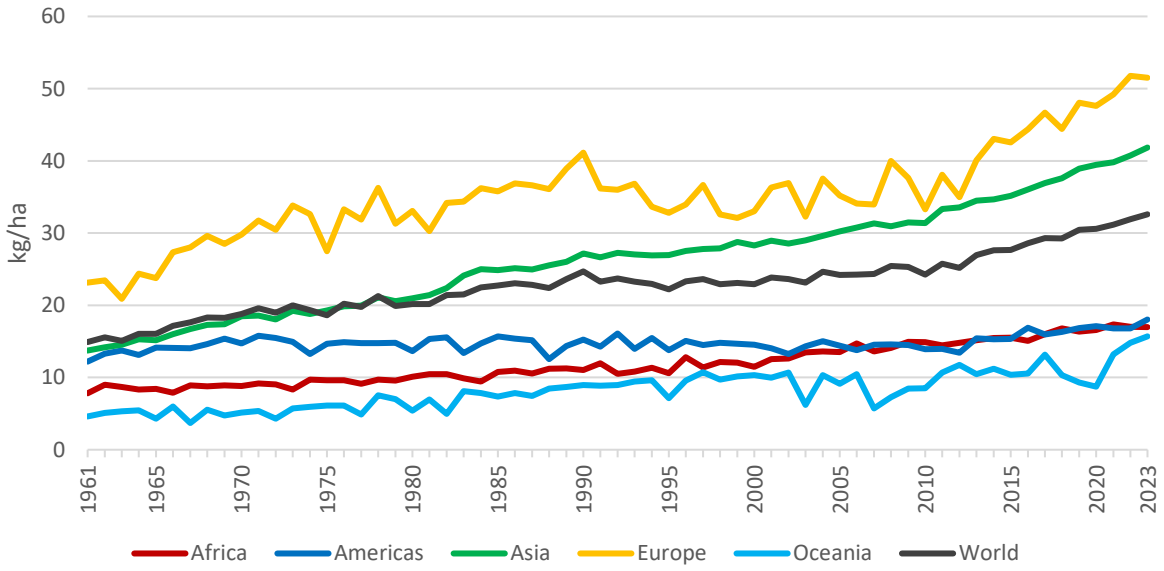
Crop residue nitrogen removal, consisting of direct removal, averaged 10 kg per ha of cropland at the global level over the 1961–2023 period and 14 kg per ha in the most recent decade. Crop residue removal for potassium was higher and averaged 23 kg per ha over the entire period and 30 kg per ha in the most recent decade. As seen in Figures 10 and 11, residue removal was the highest in Europe and reached 23 kg N and 52 kg P per ha of cropland in 2023. The Americas, on the other hand, had residue removal rates in line with the global average until the end of the 1980s but they plateaued afterwards and reached 8 kg N per ha and 17 kg P per ha in the most recent decade, primarily due to more widespread adoption of conservation agriculture practices. Residue removal rates for Asia were in line with the global average in the beginning of the period, but they increased recently and were higher than the global average in 2023 at 18 kg N per ha and 42 kg P per ha. Both Oceania and Africa have had consistently lower residue removal rates, although Africa has continued to increase, reaching 9 kg N per ha and 16 kg P per ha in the most recent decade.

Figure 10: Cropland nitrogen residue removal by region



Source: FAO. 2025. FAOSTAT: Cropland nutrient balance. [Accessed December 2025]. https://www.fao.org/faostat/en/#data/ESB. Licence: CC-BY-4.0.

Figure 11: Cropland potassium residue removal by region



Source: FAO. 2025. FAOSTAT: Cropland nutrient balance. [Accessed December 2025]. https://www.fao.org/faostat/en/#data/ESB. Licence: CC-BY-4.0.

EXPLANATORY NOTES

- The 2025 update of the cropland nutrient balance is a joint effort of FAO with the International Fertilizer Association (IFA) in collaboration with researchers from the University of Maryland Center for Environmental Science, the Swedish University of Agricultural Sciences, CEIGRAM-Universidad Politécnica de Madrid, Wageningen University & Research, the University of Nebraska, the University of Minnesota and the Universitat Autònoma de Barcelona. The group contributed to the overall quality of the data and text within the analytical brief. The FAOSTAT domain Cropland nutrient balance disseminates nutrient flows in a given country and year. The cropland nutrient balance can give an indication of nutrient use efficiency, as it can help quantify excess nutrients leading to environmental risks, for instance, greenhouse gas emissions or pollution from volatilization and leaching/runoff. It can also signal cropland nutrient deficits that limit crop production.
- The 2025 update of the cropland nutrient balance database introduces an important component of the nutrient balance: the crop nutrient output through crop residues, i.e. crop residue is removed from the cropland for other uses (e.g. off-field livestock feed or bedding, cooking, growing mushrooms, industrial uses, etc.). The nutrient output (N, P, K) with crop residues is now included as a new standalone item “crop residue removal”. The new item was estimated based on newly collected expert estimates and available data on crop residue direct removal for each crop–country combination, and crop-specific nutrient concentrations in crop residue. To ensure consistency with previous releases, crop residue removal is however not included in the calculation of nutrient balances or nutrient use efficiencies. Data users are encouraged to do their own analysis, comparing results and trends over time with and without including crop residue nutrient removal.
- The cropland nutrient balance, as presented here, does not account for the heterogeneity of baseline soil nutrient properties across or within countries nor for nutrient retention/mining across successive periods; the indicator also does not account for nutrients in inputs and outputs of crop residues or losses in the form of gaseous emissions and leaching, erosion or runoff into water bodies. Nonetheless, trends over time of the nutrient balance give an important indication of how efficiently agricultural inputs are being applied with respect to outputs as well as an indicator of pollution risk and potential nutrient deficiency. Moreover, a sustained imbalance where removal equals or exceeds inputs over time is an indicator of soil mining risk.
- Estimates of nitrogen losses to the atmosphere through volatilization (in the form of ammonia, nitrous oxide and NO_x) and leaching (in the form of nitrate and dissolved organic nitrogen) are also disseminated for illustrative purposes, to give the reader a better understanding of their relative importance within the overall balance. For phosphorus and potassium, losses to the atmosphere do not occur and there are no data for leaching for these nutrients in the FAOSTAT database. The results analysed in this brief for the nutrient surplus, without accounting for leaching and gaseous emissions, give a better indication of environmental risks.
- The nutrient balance (NB) is calculated as the sum of nutrient inputs from: mineral fertilizers applied to cropland (MF), manure applied to cropland (MA), nitrogen deposition (ND), and biological nitrogen fixation (BF), seed (SD) minus nutrient output from crop harvest removal (CR). Cropland nutrient use efficiency is calculated as the ratio (in percent) of outputs divided by /inputs.
- The definition of cropland corresponds to that of FAOSTAT.

- Data for mineral fertilizers are sourced from the Fertilizers by Nutrient FAOSTAT domain for the element “Agricultural Use” and the items “Nutrient nitrogen N (total)”, “Nutrient phosphate P_2O_5 (total)”, and “Nutrient potash K_2O (total)”.
- IFA data for mineral fertilizers are sourced from the IFA consumption database: https://www.ifastat.org/databases/plant-nutrition.
- For records with data for both FAO and IFA, the average of the two data sources was used.
- Data for chemical compounds are converted to the elements P and K using the mass percent composition conversions of 0.436 for the ratio P to P_2O_5 and 0.830 for the ratio K to K_2O.
- A full description of all the data sources for the domain is available here.

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