



# Addressing Nutrient Management Performance

June 2014

International Fertilizer Industry Association (IFA)

International Fertilizer Industry Association (IFA) – 28, rue Marbeuf – 75008 Paris – France  
Tel. +33 1 53 93 05 00 – Fax +33 1 53 93 05 45/47 – [ifa@fertilizer.org](mailto:ifa@fertilizer.org) – [www.fertilizer.org](http://www.fertilizer.org)

## Addressing Nutrient Management Performance

### Key Principles

Globally shared goals, targets and indicators, such as those envisaged for the Sustainable Development Goals, help to align global efforts to end poverty and hunger, and to improve the sustainability of agricultural systems and the prosperity of rural livelihoods.

Plant nutrients play an essential role in such efforts:

- They increase agricultural productivity, improve the nutritional value of foods, and support farm families through increased incomes and better nutrition.
- Their effective and efficient use supports sustainable agriculture by increasing yields on existing arable land.

To increase productivity and bridge the yield gap of smallholder farmers – while reducing the environmental impact of fertilizers – governments, business and civil society need to empower farmers to use fertilizers judiciously.

Enhancing nutrient use efficiency is an important goal, but any **quantitative targets must be science-based and provide for feasible measurement. Indicators of efficiency must be complemented by indicators of effectiveness** reflecting (i) productivity per unit land area, and (ii) maintenance of an appropriate level of the soil's nutrient-supplying capacity.

Plant nutrients, especially, nitrogen (N), phosphorus (P) and potassium (K), are essential inputs for producing crops and providing enough food, feed, fibre and bioenergy for a fast-growing and wealthier world population. Maintaining soil fertility requires replacing nutrients removed from the field by the harvested products. Plant nutrients applied to the field can be from recycled organic sources (e.g. livestock manure) or mined or manufactured (mineral fertilizers). Fertilizers and recycled organic sources are complementary. Used in an integrated manner, they alleviate soil nutrient deficiencies and help farmers to achieve desired yield goals. Thus, their use underpins the increasing agricultural productivity that is essential for global food and nutrition security now and in the future.

Agricultural systems require large volumes of nutrients and produce outputs valued for their nutrient content. As they are open systems, **nutrient losses cannot be entirely avoided**. The fertilizer industry has long pursued the goal of **reducing nutrient losses while enhancing crop productivity and maintaining soil fertility, supporting farmers to obtain the best return (yields) on their investment (inputs)**. Reducing nutrient losses is beneficial to farmers and all those involved in crop nutrition, who need to work together to improve nutrient performance. Given the complexity of nutrient

cycles, one area where partnership is particularly needed is finding methods to measure impacts and tools to monitor performance.

An important way to reduce nutrient losses while improving productivity and maintaining soil fertility is the efficient application of fertilizers and recycled organic sources, such as manure. Other good agricultural practices, such as soil conservation and smart crop/cultivar choice and rotation, are complementary. In this connection, IFA and its members promote **nutrient stewardship**, i.e. the efficient and effective planning and management of plant nutrients in a manner that improves the social, economic and environmental performance of mineral and organic fertilizers. Nutrient stewardship is implemented site- and crop-specifically, based on well-established scientific management principles related to the source, rate, timing and placement of nutrients.

Quantitative targets for indicators provide tangible objectives against which progress can be measured over time. To be meaningful, however, such targets require an agreed and correct baseline against which to measure progress, as well as realistically attainable limits and an effective means of measurement. The quality and accuracy of the data at hand needs to be assessed, together with its consistency across different global regions.

A major challenge for improving the way fertilizers are managed is transferring knowledge among agronomists, advisers, extension workers, NGOs and hundreds of million farmers worldwide. With the deterioration of many public extension services in the last decades, there is a great **need to improve outreach** and enable adaptive management by farmers around the world, in particular the approximately 70% of the world's farmers that are smallholders. IFA is keen to step up its partnerships in support of such a goal, and believes that farmers' outreach would produce a relevant indicator to measure progress on agricultural sustainability.

**Outreach to farmers can be measured in different ways**, such as:

1. the number of extension workers and/or agri-input dealers providing advice on nutrient stewardship practices to farmers;
2. the number of farmers reached by nutrient stewardship programmes; or
3. the agricultural area covered by nutrient stewardship programmes.

It is important to establish sound baselines and effective ways to measure not only expanded outreach to farmers, but also the **concrete impacts of such outreach in terms of reducing nutrient losses while enhancing crop productivity and maintaining soil fertility**. The fertilizer industry is increasing its investment in research and education programmes assessing these impacts, for example through the 4R Research Fund in North America.

**Nutrient use efficiency (NUE) is often suggested as a nutrient management performance indicator**. However, it is not a system-wide and performance-wide (agronomic, economic, social and environmental) indicator. IFA believes that because of the limitations of NUE, it **should only be used in combination with other types of indicators relating to crop productivity** (e.g. yield per area unit) **and soil fertility** (e.g. soil organic carbon). Moreover, there are different ways to express NUE, and data availability and reliability are often insufficient to assess actual NUE correctly. The results of NUE measurement must also be interpreted with care, taking into account site- and cropping system-specific conditions. An example of such interpretation is the Nutrient Use Geographic Information System (NuGIS) reported by the International Plant Nutrition Institute for the United States, and currently being extended to other countries.

Given these uncertainties, IFA is of the opinion that **setting quantitative NUE targets today is premature** since such targets run the risk of being meaningless. **A multi-stakeholder effort to undertake a scientifically driven consultation** to agree on NUE indicators, their measurement and targets, and needed complementary indicators would be useful.

**Effective and efficient nutrient use is vital for increased productivity as well as sustainability.** It is urgent to move towards **expanding and improving outreach to farmers**, while considering how the impact of such outreach could be **more systematically tracked and measured**. At the same time, IFA suggests undertaking a concerted effort to agree on a **more holistic way to measure nutrient management performance**.

# Measuring Nutrient Management Performance: Eight Key Considerations

Enhancing NUE is an important goal, but **any quantitative targets must be science-based and provide for feasible measurements** of both baseline and future performance. Moreover, **NUE cannot be considered in isolation from other important nutrient performance indicators**, especially indicators of effectiveness. A multi-stakeholder effort could undertake a scientifically driven consultation on NUE indicators, their measurement and targets, and needed complementary indicators. Given the complexity of defining NUE and setting quantitative NUE targets, IFA suggests that the result of this process should be an **agreed and workable method for assessing NUE**. A NUE indicator **should not aim at measuring actual performance or setting quantitative targets** as such. Instead, the indicator **should be used to monitor the long-term NUE trend** in the regions under investigation.

## I. NUE as part of a set of complementary indicators

NUE is an important measure of the economic, social and environmental performance of agricultural systems; however, it is **not a sufficient indicator in itself** as it does not convey the overall performance of the agricultural system.

NUE should not be used and interpreted in isolation. **Indicators of effectiveness must complement indicators of efficiency**. Indicators of effectiveness must reflect **productivity per unit land area and maintenance of the soil nutrient supply capacity**. Such indicators might include – but are not limited to:

- crop yield,
- actual yield relative to attainable or potential yield,
- animal productivity per unit land area,
- soil test levels for nutrients, as appropriate to the region.

Other indicators of sustainability, such as **farm gate economic performance, soil organic matter or greenhouse gas emissions**, are related to the management of crop nutrients and may be added to the indicators of efficiency and effectiveness listed above. However, these indicators also require consideration of an array of other factors including soil management and land use changes, in an appropriate life-cycle analysis.

## II. Recommended method for expressing NUE

There are different methods of expressing NUE. **Each measurement requires different data and aims at responding to different questions**.

**For environmental stewardship purposes, IFA recommends using the output/input ratio**, also called “removal efficiency” or “partial nutrient balance”. This indicator calculates the amount of nutrients removed by the harvested portion of the crop per unit nutrient applied. It can also be used on a whole-farm basis with respect to livestock operations. The output/input ratio is often the most

appropriate method for estimating NUE because it is relatively actionable and scalable from the farm to the global level and the required data are usually available, at least for cropping systems. Comparisons of cropping systems to farming systems will need to recognize that different proportions of the full food chain are represented.

The output/input ratio is a useful indicator, but it **tells little unless it is associated with other system indicators** that reflect current productivity compared to potential productivity if nutrient stewardship is optimized.

### III. Data availability and reporting

Data or estimates are available for total fertilizer consumption by country.

Data on fertilizer use by crop, fertilizer consumption at the sub-national level, manure recycling, biological nitrogen fixation and atmospheric deposition are often either not available or less reliable.

Data on nutrient concentration in harvested products should be updated and, ideally, regionalized because we recognize that, for some nutrients, there may be considerable regional differences in concentration.

Manure is difficult to take into account due to problems related to its distribution, and only “recoverable” manure (manure effectively applied to the field) should be considered. As a result, monitoring NUE in mixed crop/livestock systems is more challenging.

For most grain legumes, it is reasonable to assume that biological nitrogen fixation equals crop removal as a proxy.

Applying the output/input ratio requires a structured and consistent way to both report and monitor nutrient use (fertilizer and manure) and removal with the harvested product.

A multi-stakeholder concerted effort involving governmental agencies, scientists and industry would be necessary to improve the coverage and quality of the required data.

### IV. Measuring trends vs. actual values

Data availability and reliability are often insufficient to assess actual NUE correctly. Moreover, nutrient applications have residual effects (a few years for nitrogen, and at least a decade for phosphorus), which makes estimating actual use efficiency even more challenging. Moreover, most crops and pastures are produced in various sequences where fertilizer input and use efficiency will vary from phase to phase in the rotation.

For these reasons, **NUE expressions are usually more relevant for assessing trends than for estimating precise actual NUE levels**. In addition, **analysis of long-term trends (ten years or more) should be preferred**, when data are available, because the assessment of short-term trends can be misleading.

### V. Nitrogen use efficiency vs. nutrient use efficiency

Nitrogen is subject to more risks of loss to the environment than phosphorus and potassium. It also has a wider range of environmental impacts than phosphorus (water quality) and potassium (none). In addition, it is frequently the most limiting nutrient for crop production. Therefore, the focus tends to be on nitrogen and, to a lesser extent, on phosphorus. However, addressing nutrient use efficiency

may be somewhat justified since **from a sustainability perspective (which encompasses eradicating hunger) all nutrients are relevant in the long term.**

## VI. Too high vs. too low NUE

**A low output/input ratio can characterize significant nutrient losses to the environment**, unless there is a need to build up soil nutrient levels. In contrast, a **high output/input ratio usually reflects situations of soil nutrient mining** unless soil nutrient levels are above optimum. **These situations should receive equal attention**, as both are unsustainable. Therefore, **the goal should be to “improve” NUE**, which requires increasing use efficiency when it is too low and reducing it when it is too high while also monitoring soil nutrient levels.

## VII. Interpreting NUE

The results of NUE measurement should be interpreted with care, taking into account site- and cropping system-specific conditions and soil and climate differences which cannot be changed.

To be meaningful, **NUE expressions should be used to monitor trends, and should be combined with complementary indicators** reflecting crop productivity and soil fertility.

## VIII. Setting quantitative targets for NUE

Because different countries have different biophysical conditions, starting points and development pathways, **country targets are preferable to a global target**. National targets would make it possible to discriminate between countries, depending on their fertilizer consumption and nutrient management performance.

Countries, especially large ones with heterogeneous agro-ecological conditions, might want to set sub-national targets by land resource region, province or farming system.



### Contact

Patrick Heffer  
Senior Director, Agriculture Service  
pheffer@fertilizer.org

International Fertilizer Industry Association (IFA)  
28, rue Marbeuf  
75008 Paris, France  
Tel: + 33 1 53 93 05 00  
ifa@fertilizer.org  
www.fertilizer.org