
Nitrogen Use Efficiency (NUE)

an indicator for the utilization of nitrogen in food systems

The main resources for global food production (land, soil, water, biodiversity, nutrient elements) are finite and some even scarce. Moreover wasting resources is often harmful to society and the environment. The pressure on our natural resources is large, and increasing in near future due to the projected increase in human population in the world and changes in food consumption patterns. There is a need for communications about resource use efficiency and for measures to increase the use efficiency of nutrients in relation to food production, including nitrogen. Nitrogen has two faces: it is generally scarce in developing countries and in excess leading to environmental impacts in developed countries. Here, we propose nitrogen use efficiency (NUE) as an indicator in crop and animal production systems as well as for whole food production – consumption systems. The proposed indicator provides in addition to nitrogen output, and nitrogen surplus a set of indicators that can help improve nitrogen management. NUE can be estimated at different spatial and temporal scales.

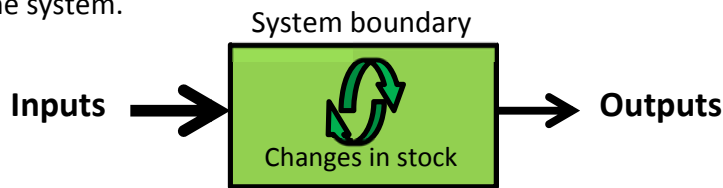
Who are 'we'?

Key persons from science, policy and industry communities in Europe have been invited by Fertilizers Europe to establish the **EU Nitrogen Expert Panel**. The general objective of the Expert Panel is to contribute to improving NUE in food systems in Europe, through (i) communicating a vision and strategies on how to improve NUE in food systems in Europe; (ii) generating new ideas, and recommending effective proposals and solutions; and by (iii) acting as referee in controversial issues, and (iv) by communicating about nitrogen issues as authority. The Panel gathered for the first time in Windsor, United Kingdom on 15-16 September 2014, and agreed on a definition of NUE as indicator for agricultural productions at national scale, as presented here. There were 12 experts from science, 4 from policy and 3 from industry. They came from 9 EU countries.

Our definition of NUE

There are various indicators for estimating NUE in crop and animal production and whole food systems, especially in science, but none is used in common practice so far. We propose an easy-to-use indicator, applicable to all systems. It is based on the mass balance principle, i.e. using nitrogen input and nitrogen output data for its calculation ($NUE = output / input$; see below). NUE values should always be interpreted in relation to nitrogen surpluses (input – output; see below) and productivity levels (nitrogen output). For estimating NUE, data and information are required about (i) the nitrogen inputs to the farm or to the system and nitrogen outputs in harvested products, (ii) the nature of the system (e.g. farm, crop system, housing system, ...)

and its boundaries, (iii) the time span of the analyses, and (iv) possible changes in the stock of nitrogen in the system.



A graphical presentation of NUE

The Panel proposes NUE to be reported as percentage or mass fraction, together with the yield (nitrogen output) in $\text{kg ha}^{-1} \text{yr}^{-1}$, nitrogen surplus in $\text{kg ha}^{-1} \text{yr}^{-1}$, a description of the system, the period, and also possible changes in the nitrogen stock of the system. This would provide a system specific indicator which can be used to improve nitrogen management. Here, we propose a two-dimensional input – output diagram, to present NUE, nitrogen output and nitrogen surplus in a coherent manner, together with possible reference or target values (Figures 1a, 1b, 1c). Evidently, reference and target values for NUE, nitrogen output and nitrogen surplus must be agreed by policy and practice. Changes over time in NUE, nitrogen yield and nitrogen surplus may be plotted in the graph, allowing a direct interpretation of the evolution of the system.

Fig. 1a: Definition of acceptable boundaries for N output/input ratios giving a desirable range for NUE
(all values are provisional and only serve as examples)

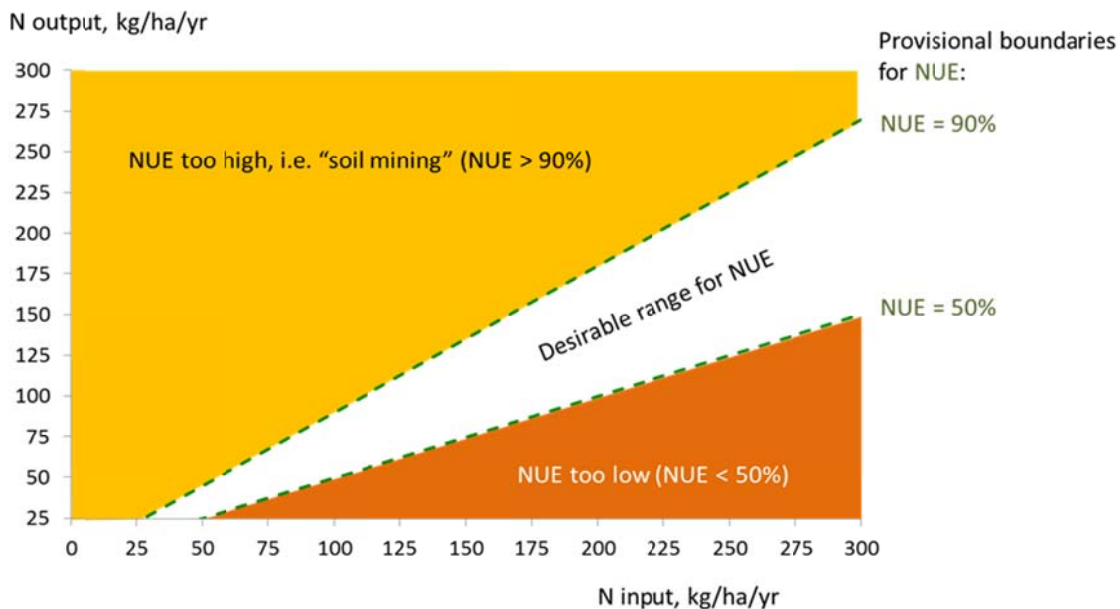


Fig. 1b: Definition of acceptable boundaries for N output/input ratios giving a desirable range for NUE – supplemented by a desired minimum productivity level (all values are provisional and only serve as examples)

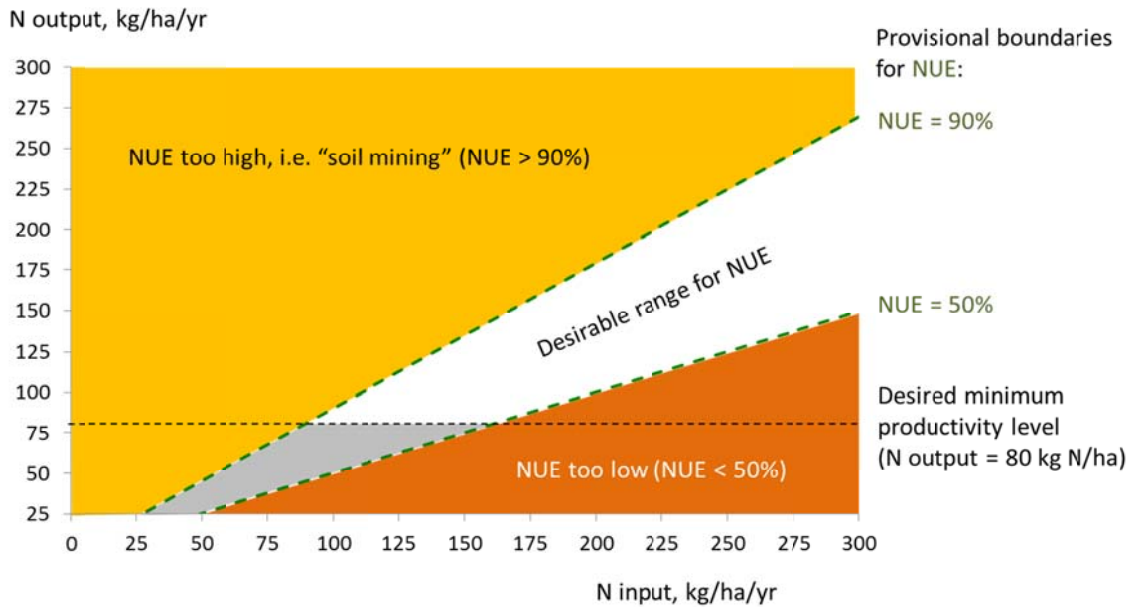
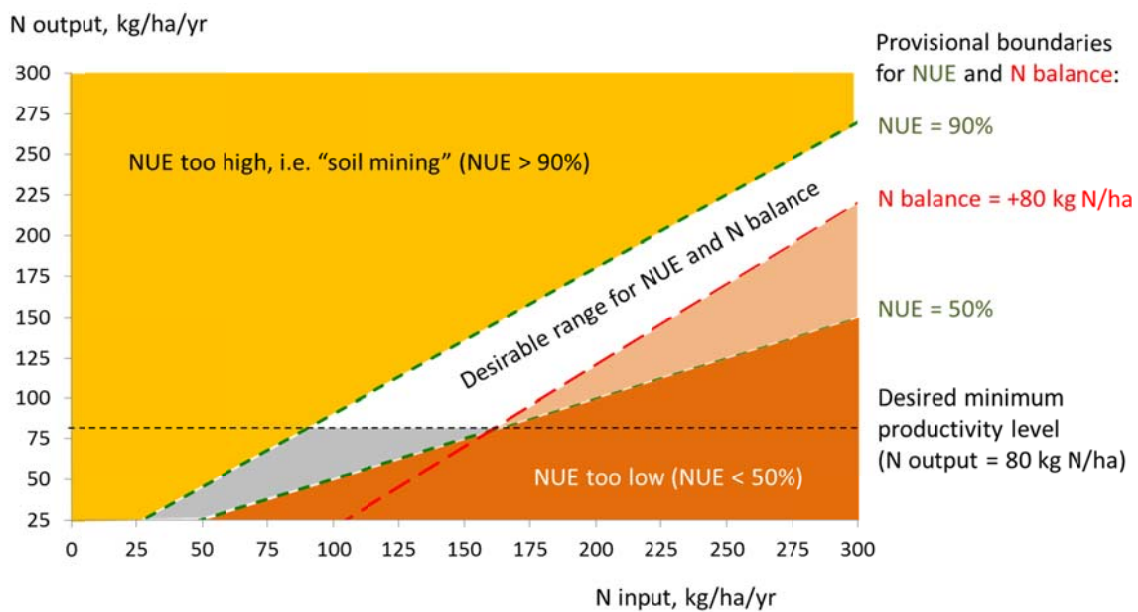


Fig. 1c: Definition of acceptable boundaries for N output/input ratios giving a desirable range for NUE – supplemented by an acceptable N balance surplus (all values are provisional and only serve as examples)



Figures 1a, 1b and 1c. A two-dimensional nitrogen input – output diagram for presenting NUE (1a), nitrogen output (1b) and nitrogen surplus (1c). Provisional reference values have been plotted for NUE ($O/I = 0.5$ and 0.9), nitrogen output ($O=80$) and nitrogen surplus (nitrogen balance $I-O=+80$), all in $\text{kg ha}^{-1}\text{yr}^{-1}$. NUE values > 0.9 may indicate soil mining; $\text{NUE} < 0.5$ refers to low efficiency; Low nitrogen output (O) and high nitrogen surpluses ($I-O$) are unwanted.

For example, sustainable intensification aims at increasing yield (nitrogen output) whilst staying within the acceptable NUE corridor, i.e. moving system from bottom left to top right.

Future work of the EU Nitrogen Expert Panel

The Panel will continue its work on nitrogen use efficiency. It will seek cooperation with bodies working on similar or related subjects, including EUROSTAT, OECD, UNEP and its GPNM, and European Commission. It will seek also cooperation with farmers' organizations and industries involved in food production – consumption systems.

The Panel will meet twice a year and is working now on NUE indicators for whole food production – consumption systems and also for farming systems. The challenge is also here to derive scientifically sound and easy-to-use indicators. Future work will also relate to best management practices for enhancing NUE in crop and animal production and food systems.