Definition:

$$\frac{Embodied\ Nitrogen}{Nitrogen\ fertilizer}$$

Description

Benefit: Refers to the total amount of nitrogen in the harvested product. The indicator is relevant for the assessment of food or feed quality as nitrogen content is indicative of the amount of proteins. Furthermore, high protein concentrations are essential for some uses in bio-refineries.
Protein rich crops will show high efficiencies in this impact area.

Resource: Nitrogen fertilizer is considered a stressed resource for several reasons. While the supply of nitrogen is effectively unlimited, its production is highly energy intensive and its application results in emissions of ammonium and nitrous oxide, creating a conflict between nitrogen fertilizer application and climate change mitigation targets.
Depending on the application rate and type of nitrogen fertilizer (in combination with site specific conditions), diffuse pollution and contamination of water resources is also relevant. Diffuse nitrogen pollution may also strongly affect nutrient poor natural ecosystems and alter species composition.
Finally, fertilizer application is a relevant factor in farmers' cost calculations.

Correlation with soil management

[27] Strategies to improve N use efficiency on Irish dairy farms: Optimization of application of N fertilizers and organic manures (timing, rate, form, method of application). Incorporation of N fixing forage legumes into grass swards. Improved grazing management and grass utilization (offsetting concentrate feed import) and better soiled water management
[68] Agricultural systems can reduce fertilizer use and can achieve higher nitrogen use efficiency by facilitating biological nitrogen fixation
[91] Increasing farm size and new technologies for fertilizer application could increase nitrogen use efficiency in Chinese cropland
[157] For sustainable agricultural systems is required to improve the efficiency of crop nitrozen recovery and to reduce gaseous and leaching losses. Poultry manure, rice hulls and mineral fertilizer combination may represent a good soil amendment to obtain a high yield with a lower environmental impact, at least in the short-term
[259] Effectiveness of fertilization strategies using bio-digestion waste derivatives as compared to conventional practices using animal manure and chemical fertilizer
[260] Inoculation of rice with dark septate endophytic (DSE) fungi represents a strategy to improve green manure-N recovery, grain yield per plant, and grain quality in terms of micronutrients contents in cropping systems with a low N input

Correlation with soil functions

[27] Land with more free draining soils was related to higher nitrogen use efficiency
[82] Change in soil N stock influences system N efficiency

Strength & weaknesses pertaining to measurement of this impact area

Embodied Nitrogen: can be used to calculate nitrogen use efficiencies (NUE) (e.g., the share of nitrogen recovered by plants relative to the amount of nitrogen fertilizer applied). However, efficiency measures are less suited to assess risks of environmental contamination by nitrogen fertilizer than nitrogen budgets (i.e. amount recovered – amount applied).

Sample Indicators

Indicator values from		Survey	
Experiment or direct measurement		Statistical- or census data	
Expert assessment		Literature values	
Model		Maps or GIS	
Stakeholder participation		Not provided	

Table 1: Field Scale

Indicator	**Unit**	**Indicator values from**
[259] Nitrogen use efficiency (Plant N uptake/Amount of N applied in fertilization)	kg ha^{-1} * (kg $ha^{-1})^{-1}$	
[260] N recovery efficiency (10%) (Amount of N in the plants derived from C. ensiformis-15 N/Amount of applied N as 15N-labeled green manure (NGM))	mg $plant^{-1}$ * (mg $plant^{-1})^{-1}$	
[260] Fraction of N in the plant derived from finely ground C. ensiformis N (N in excess in rice plant/N in excess in green manure)	mg $plant^{-1}$ * (mg $plant^{-1})^{-1}$	

Table 2: Farm Scale

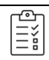
Indicator	Unit	Indicator values from
[27] Nitrogen use efficiency (Total nitrogen output (N milk + N crop + N livestock)/Total N input (fertilizer + concentrates + forage feeds + livestock imports))	kg * kg^{-1}	
[82] System nitrogen efficiency (Net N output (Animals + milk + high protein crops + low protein crops + manure)/Net N input (Fertilizer + biological N fixation + seed input + high protein feed + low protein feed + manure) + net indirect losses (occurring during production and transport of inputs) + change in soil N))	kg * kg^{-1}	 , 
[82] Nitrogen use efficiency (N output (Animals + milk + high protein crops + low protein crops + manure)/N input (Fertilizer + biological N fixation + seed input + high protein feed + low protein feed + manure))	kg * kg^{-1}	
[157] Nitrogen use efficiency (Nitrogen measured in plant biomass at harvest – amount of Nitrogen coming from the initial soil/Total amount of applied Nitrogen (MF: mineral fertilizer; P + F: poultry manure and mineral fertilizer; R + F: rice hulls and mineral fertilizer and P + R + F: poultry manure, rice hulls and mineral fertilizer))	g * g^{-1}	

Table 3: National Scale

Indicator	Unit	Indicator values from
[68] Full-Chain nitrogen use efficiency (Embodied Nitrogen in Food/Total nitrogen input (fertilizer + biological nitrogen fixation + atmospheric deposition + net N import of food and feed) + changes in N stock (annual net balance of national imports and exports of food and feed))	Kton * $Kton^{-1}$	
[83] System nitrogen efficiency (Net N output (Animal products + crops + manure)/Net N input (fertilizer + biological N fixation + atmospheric N depostiton + manure + crops + animals) + net N indirect losses (occurring during production and transport of inputs) + change in soil N))	kg * kg^{-1}	
[83] Nitrogen use efficiency (N output (Animal products + crops + manure)/Net N input (Fertilizer + biological N	kg * kg^{-1}	

fixation + atmospheric N depostiton + manure + crops + animals))		
[91] Nitrogen use efficiency in the cropland (Total N in the crop (including seed and straw)/Total N input (fertilizer, manure, biological nitrogen fixation, atmospheric deposition, straw recycled, irrigation))	Tg * Tg $^{-1}$	 , 

References

ID	Citation	[1]Soil type/ texture
27	Buckley, C., et al. (2016). "Farm gate level nitrogen balance and use efficiency changes post implementation of the EU Nitrates Directive." Nutrient Cycling in Agroecosystems **104**(1): 1-13.	n/a
68	Erisman, J. W., et al. (2018). "An Integrated Approach to a Nitrogen Use Efficiency (NUE) Indicator for the Food Production-Consumption Chain." Sustainability **10**(4).	n/a
82	Godinot, O., et al. (2014). "SyNE: An improved indicator to assess nitrogen efficiency of farming systems." Agricultural Systems **127**: 41-52.	n/a
83*	Godinot, O., et al. (2016). "Indicators to evaluate agricultural nitrogen efficiency of the 27 member states of the European Union." Ecological Indicators **66**: 612-622.	n/a
91	Gu, B., et al. (2017). "Nitrogen use efficiencies in Chinese agricultural systems and implications for food security and environmental protection." Regional Environmental Change **17**(4): 1217-1227.	n/a
157	Machado, D., et al. (2010). "The use of organic substrates with contrasting C/N ratio in the regulation of nitrogen use efficiency and losses in a potato agroecosystem." Nutrient Cycling in Agroecosystems **88**(3): 411-427.	Sandy-loam texture

[1]**Soil type/ texture:** If provided, what are type and texture of the soils studied in the paper?

*The impact area discussed on this factsheet is not a focus of the cited paper

259	Vaneeckhaute, C., et al. (2014). Assessing nutrient use efficiency and environmental pressure of macronutrients in biobased mineral fertilizers: A review of recent advances and best practices at field scale. Advances in Agronomy. **128:** 137-180.	Sandy loam
260	Vergara, C., et al. (2018). "Dark Septate Endophytic Fungi Increase Green Manure-N-15 Recovery Efficiency, N Contents, and Micronutrients in Rice Grains." Frontiers in Plant Science **9**.	Haplic Planosol; Sandy soil (3% clay, 5% silt, and 92% sandy)