Environmental impact assessment of your fertilization program

Please note: The intention of this impact assessment is to raise awareness on the environmental implications of fertilizer production and application and encourage the use of fertilizer application practices that have less of an impact on the environment. This impact assessment is intended as a high-level estimate meant to obtain first insights into the environmental impact of your fertilizer program.

To calculate the environmental impact, assumptions are made on the potential performance of your fertilization program, and there is a strong reliance on average datasets for fertilizer production, meaning the uncertainty of the results is relatively high. The results should therefore should only be used as indicative and not be used for any form of external communication. If you seek a more accurate impact assessment of your fertilization program, contact fertigationLCA@haifa-group.com

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Documentation

The environmental impact assessment is calculated with **Life Cycle Assessment (LCA).** LCA is a science-based method which can be used to calculate the environmental footprint of a product. The assessment shown is calculated **independently for each fertilization program.** This is made possible with data from the NutriNet being sent directly to an LCA model in SimaPro.

The following sections provide detail on the underlying LCA model and its connection to the NutriNet.

What's included in the assessment

This assessment includes all processes from the production of the fertilizer through to the harvest of the crop (i.e. from "cradle" until the farmer's gate) as shown in Figure 1. This means it includes the production of the fertilizers, the transport of fertilizers to farm, the application of fertilizers with tractors, and the direct emissions to air, soil and water resulting from fertilizer application.

The environmental impacts are expressed **per 1 kg of product**.

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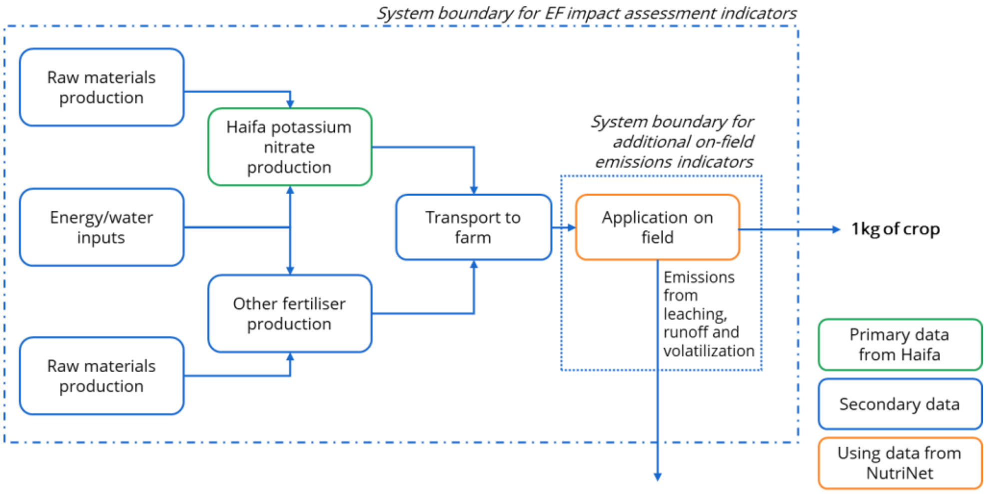

Figure 1. Visual representation showing what's included in the study and the system boundaries for the two types of impact assessment

Underlying data

As shown in Figure 1, the model uses a combination of primary data, secondary data, and data sent from the NutriNet.

Primary data

For Potassium Nitrate produced by Haifa Group, **primary data** on fertilizer production are used.

Secondary data

For the production of all other fertilizers and other supporting processes (e.g. datasets for the impact of transport, energy, and other materials), **secondary datasets** from ecoinvent v3.8(Moreno Ruiz et al., 2021) are used.

Data sent from the NutriNet

The NutriNet provides a recommendation for an optimized fertilizer program after gathering user data on a particular crop growing program and field characteristics. This information is sent from NutriNet to the LCA model using the SimaPro API. This information is then processed by the LCA model, and the estimated environmental impact of the fertilization program is calculated.

When calculating the environmental impact assessment of each individual fertilizer program, the following data is sent to the LCA model:

- **Field characteristics:** depth of soil to rock, precipitation surplus, rooting depth, slope of the field, soil type and clay content, temperature (provided by the user if available, otherwise using default values selected by NutriNet).
- **Expected yield** (calculated by NutriNet)
- **Amount and type of each fertilizer in the program** (recommended by NutriNet)
- **Amount of Nitrogen, Phosphorus and Potassium in the fertilization program** (calculated by the program recommended by NutriNet)

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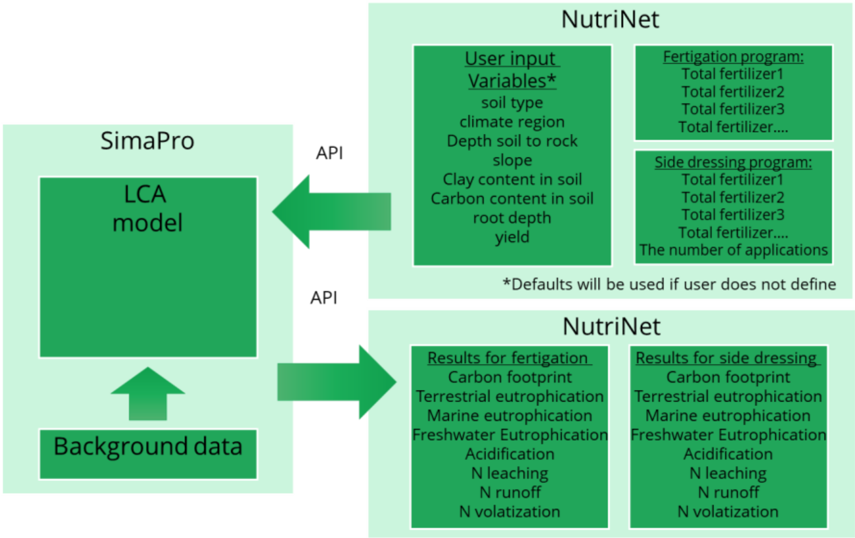

Figure 2. Visualisation of the data flow between NutriNet and SimaPro

Assumptions

To fill data gaps, a number of assumptions are made, including:

- Fertilizer application by rig fertilizer is based on the share of top dressing (by mass) in total fertilizer program
- Transport to farm from local warehouses (50 km)

Methodological and modelling decisions

In this model, the following **allocation methods** are used:

End-of-life: Allocation cut-off by classification.

Multi-functionality:

- For Haifa potassium nitrate production: avoid allocation by expanding the system.
- For background ecoinvent processes: economic allocation (except for energy where allocation is based on exergy).

The LCA model is hosted in the **SimaPro online platform**.

Impact assessment methods

This impact assessment uses life cycle impact assessment (LCIA) methods in combination with additional environmental indicators.

The **Environmental Footprint (EF) impact assessment method** 3.0 (Zampori & Pant, 2019) is used to calculate the impact of the following indicators:

- Climate change (carbon footprint)
- Acidification
- Terrestrial eutrophication
- Marine eutrophication

- Freshwater eutrophication

These indicators were selected as being most relevant for assessing the impact of fertilization programs (following the procedure in the Product Environmental Footprint (PEF) method) based on pilot study conducted by PRé and Haifa. As shown in Figure 1, the EF impact assessment indicators includes all processes within the cradle to farm gate system boundaries. For more information on each of these indicators, please refer to Table 1.

Additional environmental indicators were added to provide further insight on the on-site impacts of fertilizer application. To calculate the emissions of nitrogen from the field, **N-balance approach was used**, using the system boundary for additional on-field emissions indicators shown in Figure 1. This approach is used to calculate the results you see for:

- Nitrogen leaching (flow of nitrate to groundwater)
- Nitrogen runoff (flow of nitrate to rivers)
- Nitrogen volatilization (conversion to ammonia gas which is released to the atmosphere)

Since it is assumed the nitrogen stock does not change, the nitrogen entering the field should be equal to the amount of nitrogen leaving the soil. It's assumed there's no additional input of nitrogen with mineralization, crop residues and fixation, meaning that the only input of Nitrogen into the soil is applied with fertilizer. In addition to these emissions, there is also emissions of indirect N2O resulting from conversions of leached nitrate and volatilized ammonia. Runoff of nitrogen as nitrate from the soil, and leaching of nitrogen as nitrate is based on the MITERRA-EUROPE model (Velthof et al., 2007, 2009).

Equation 1. N-balance equation used to calculate the additional environmental indicators.

$$N_{fertilizer}=N_{harvested}+N_{volatilization}+N_{N2Odirect}+N_{as\ NOx}+N_{runoff}+N_{leaching}$$

Climate change (expressed in kg CO_2 eq.). This impact category represents the increase in the average global temperatures as a result of greenhouse gas (GHG) emissions.

Acidification (expressed in mol H+ -eq.). Acidification has contributed to a decline of coniferous forests and an increase in fish mortality. This can be caused by acidifying substances (such as NOx, NH3 and Sox) being released into the air, water and soil.

Terrestrial eutrophication (expressed in mol N eq.). The eutrophication impacts on terrestrial ecosystems is due to emission of substances containing nitrogen (N). N emissions are caused largely by fertilizers used in agriculture, but also by combustion processes. If too much N is added, some species will start to dominate and outcompete others. For example, fast-growing grasses will displace the more diverse original vegetation, going hand-in-hand with a decrease in biodiversity along the food chain.

Marine eutrophication (expressed in kg N eq.). The eutrophication impacts on marine ecosystems is due to emission of substances containing nitrogen (N). N emissions are caused largely by the agricultural use of fertilizers, but also by combustion processes. If too much N is added, algae and other plants may grow in excess. This can have adverse ecological effects, for example by creating anoxic zones which has negative consequences for the entire marine ecosystem.

Freshwater eutrophication (expressed in kg P eq.). Eutrophication impacts on aquatic freshwater ecosystems is due to emission of substances containing phosphorus (P). P emissions are mainly caused by sewage treatment plants for urban and industrial effluents, and also leaching from agriculture land. In the aquatic environment, P is considered a limiting factor. If too much P is added, algae grows too rapidly. This can have adverse effects, such as leaving water without enough oxygen for fish to survive.

Table 1. Description of the EF impact categories included in the impact assessment.

Comparison between fertigation and top soil fertilizer applications

To compare the environmental impacts of the optimized fertigation fertilization program with those of a top-soil fertilization program, NutriNet creates a second fertilization program based on the same field characteristics, but this time it calculates it according to the nutrient use efficiency and the expected yield of top soil application.
The total data from these two programs is sent separately to SImaPro for processing in the EF model to calculate the environmental impact. Because of differences in the amount and type of fertilizer used in each program, as well as the different expected yield, the total environmental effect per Kg produce varies.

The environmental impacts of these two programs are sent from SimaPro to the NutriNet API and displayed on an unique screen in NutriNet.

Table 1 shows the NUE used in the model for each application method. Fertigation has a higher NUE than application with top dressing due to the low and continuous application rate.

Table 2. NUE of each element for top dressing and fertigation, sourced from literature (Hagin et al., 2002; Suvarna & Singh, 2021).

Material	Top dressing	Fertigation
Nitrogen use efficiency	50%	90%
Phosphorus use efficiency	30%	60%
Potassium use efficiency	50%	80%

References

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