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PRACTICE ABSTRACT

# OPTIMISING FERTILISER COSTS FOR SUSTAINABILITY

Combining life-cycle assessment and linear programming to optimise social fertiliser costs

## SHORT SUMMARY FOR PRACTITIONERS

EN version

Bio-based fertilisers can contribute to regional nutrient circularity, but the question remains whether their production and use is beneficial to both the farmer and the environment. One way to investigate this, is to look closer into a farmer's private costs as well as the external costs to the environment, together referred to as total social costs. The external costs of fertiliser production and consumption can be estimated by means of life cycle assessment, of which the resulting impacts are transferred into monetary terms by means of monetary valuation coefficients. Based on these private and external costs, a social cost optimisation model can be formulated considering a range of fertilisers, to determine the optimal fertiliser mix. In this study, this social cost minimisation approach is applied to a conceptual Flemish leek farmer who aims to ensure sufficient nutrient uptake while being constrained by nutrient standards and the availability of on-farm residues. The results suggest that mineral fertilisers have an important role in the fertiliser mix despite their environmental externalities. Nevertheless, there is also a role for bio-based fertilisers such as compost and pig slurry, although the optimal application rates depend on their social costs, which are largely determined by ammonia emissions.

## SHORT SUMMARY FOR PRACTITIONERS

NATIVE version

Biogebaseerde meststoffen kunnen bijdragen aan regionale nutriëntencirculariteit, maar de vraag blijft of de productie en het gebruik ervan voordelig is voor zowel de landbouwer als het milieu. Een manier om dit te onderzoeken, is om zowel de private kosten van een boer als de externe kosten voor het milieu nader te bekijken, samen de totale maatschappelijke kosten genoemd. De externe kosten van de productie en consumptie van meststoffen kunnen worden geschat door middel van levenscyclusanalyses, waarvan de resulterende impacten in geld worden uitgedrukt door middel van monetaire waarderingscoëfficiënten. Op basis van deze private en externe kosten kan een maatschappelijk kostenoptimalisatiemodel worden geformuleerd dat een reeks meststoffen in beschouwing neemt om de optimale meststoffenmix te bepalen. In deze studie wordt deze aanpak voor maatschappelijke kostenminimalisatie toegepast op een conceptuele Vlaamse preiteler die streeft naar een voldoende nutriëntenopname terwijl hij wordt beperkt door nutriëntennormen en de beschikbaarheid van reststoffen op het bedrijf. De resultaten suggereren dat minerale meststoffen een belangrijke rol spelen in de meststoffenmix, ondanks hun externe milieueffecten. Toch is er ook een rol weggelegd voor biogebaseerde meststoffen zoals compost en varkensdrijfmest, hoewel de optimale toepassingsdosering afhangt van hun maatschappelijke kosten, die grotendeels worden bepaald door ammoniakemissies.

RUSTICA

Demonstration of circular bio-based fertilisers and implementation of optimized fertiliser strategies and value chains in rural communities

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 101000527

De Keyser E., Rowe T., Giacomella L., Jansinski D., Mathijs E., Vranken L. (2024). Combining Life-Cycle Assessment and Linear Programming to Optimize Social Fertilizer Costs. *Journal of Environmental Managment.* https://doi.org/10.1016/j.jenvman.2024.122225

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## CONTEXT

This study focuses on the role of fertilisers within regional nutrient cycles. Established technologies to convert organic residues into bio-based fertilisers include composting and anaerobic digestion. In order for the resulting fertilisers to be applied, they need to offer benefits to the farmer while avoiding environmental and health risks.

## PROBLEM

Fertilisers bring along external costs related to their environmental emissions during production and application. Environmental impact assessment methods such as life-cycle assessment (LCA) provide a comprehensive evaluation of these impacts. By weighting the impacts according to their damage costs, these impacts can be translated into tangible costs borne by society, i.e., external costs. The combined total of private costs to the farmer and external costs to society, is referred to as social costs. While some example of environmental and economic optimisation studies exists in the fertiliser domain, determining optimal fertiliser mixes for certain case studies, the monetary valuation is currently still missing.

## SOLUTION

This study aims to determine the socially optimal fertiliser mix on farm level, expressed as the application rates of different fertilisers, considering a Flemish leek farmer. Cost minimisation models are often solved using linear programming (LP) techniques in which the objective function is optimised subject to a set of linear constraints. In our study, this approach allows for cost accounting of private and external costs, the latter based on monetary valuation of environmental impacts estimated through LCAs of the studied fertilisers. The model constraints ensure resource optimisation and account for nutrient requirements and regulatory limits. Several sensitivity analyses are carried out to check the robustness of the results.

## OUTCOME

1. Total social fertiliser costs for leek farming in Flanders amount to €3773-€8584/ha, where private costs contribute only €81/ha.
2. A mix of mineral fertiliser, animal manure (i.e., pig slurry) and compost is optimal in both the private and social optimum.
3. Compared to the private optimum, the societal optimum proves that it would be interesting to convert part of the leek residues into compost after anaerobic digestion instead of buying certified compost and leaving crop residues on the field after harvest.
4. Sensitivity analyses point out that the results change with higher social costs of pig manure and crop residues, which can be related to increases in ammonia emissions. In those cases, it becomes optimal to convert more crop residues into compost.

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## PRACTICAL RECOMMENDATIONS

- ✓ Currently, many Flemish horticultural farmers use a combination of pig slurry and mineral nitrogen with application rates of roughly 20 ton/ha and 80 kg N/ha respectively. Our analyses point towards possible social and private cost savings by using less of both.
- ✓ Combined fertilisation strategies where both bio-based and mineral fertilisers are used, are favored.
- ✓ In contrast to the current practice of leaving crop residues on the field, it can be interesting to cooperate with value chain actors for the treatment of crop residues to compost.
- ✓ It is important to monitor ammonia emissions to ensure minimal external costs.

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