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What would the logistics for using biomass residues in Switzerland look like, and how would they perform in a life cycle assessment?

Wie müsste die Logistik für die Nutzung von Biomasseresten in der Schweiz aussehen und wie würden sie bei einer Lebenszyklusbetrachtung abschneiden?

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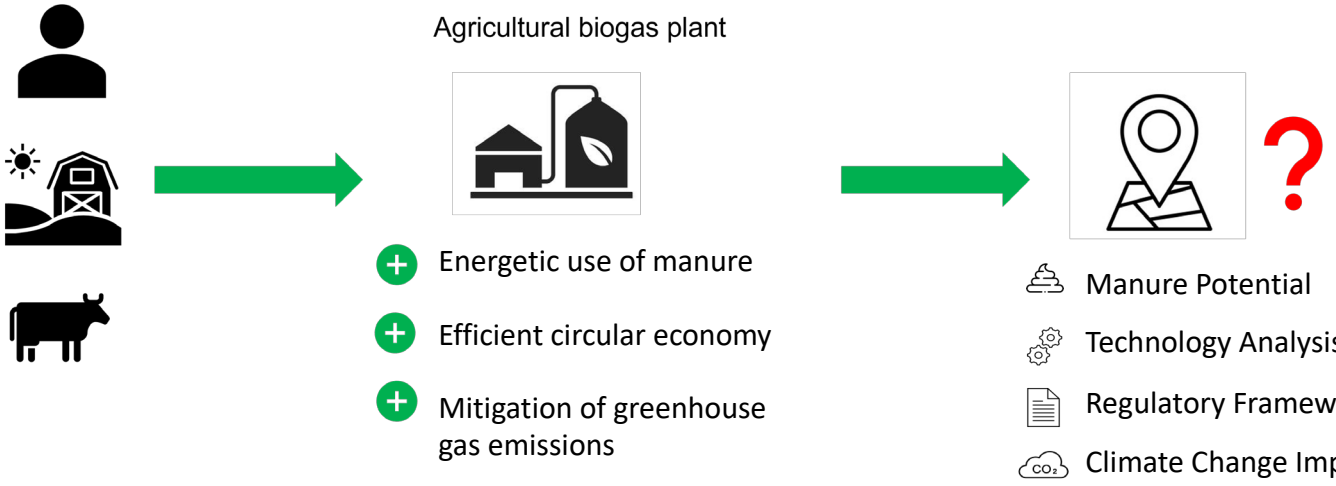
Empa Materials Science and Technology · PSI · ETH zürich · Fachhochschule Nordwestschweiz · Università della Svizzera italiana · zhaw · Universität Basel · EPFL · Scuola universitaria professionale della Svizzera italiana SUPSI · CASALE

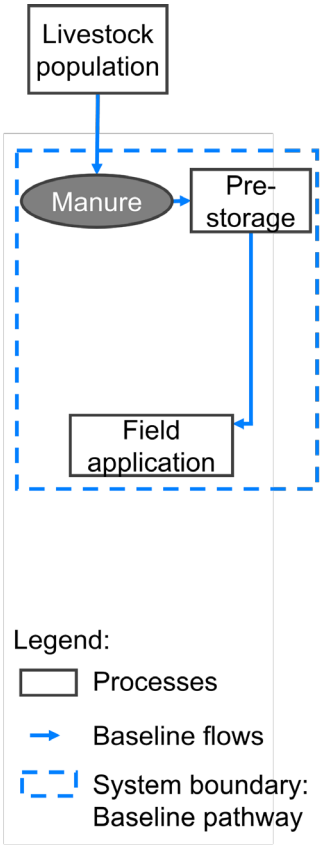
Introduction

- Livestock farming in Switzerland generates ~24 million tonnes of manure per year
- Theoretical primary energy content of around 49 PJ per year
- Currently, <5 % is used for energy → largely untapped potential

Total gross energy consumption in Switzerland: **1’030 PJ/a**



State-of-the art practices



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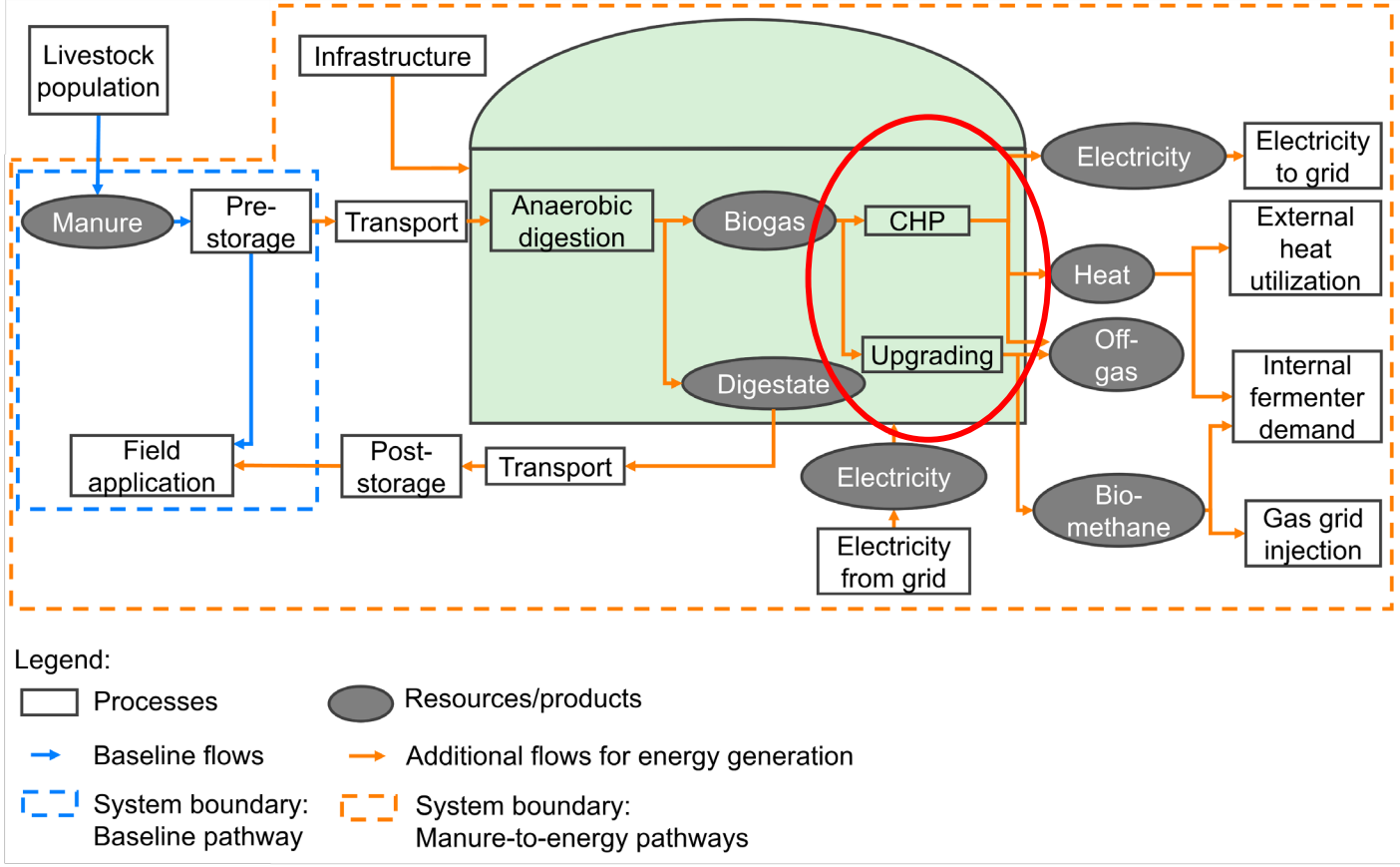
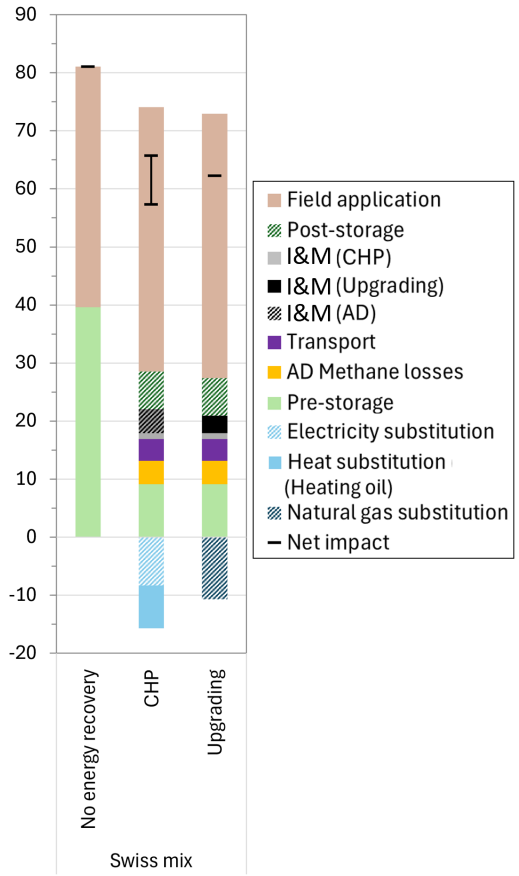


Life-cycle assessment



Swiss manure mix

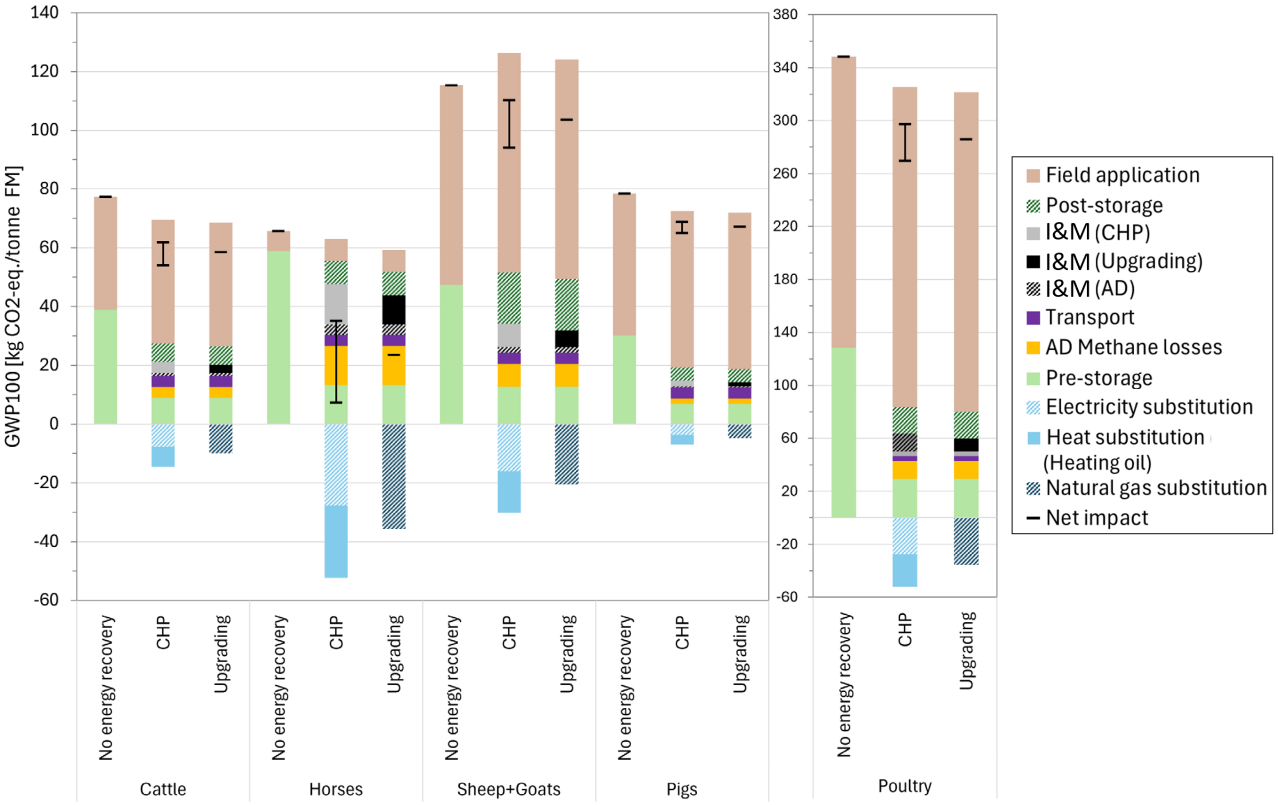
Mitigation potential:

- CHP: 26-36%
- Upgrading: 30%

⚠ → Transport accounts for only ~6% of the net impact.

Reference: Werner, S., et al. (in preparation). *Unlocking manure's energy potential in Switzerland: A GIS-based decision support tool for agricultural biogas plants*. Unpublished manuscript.

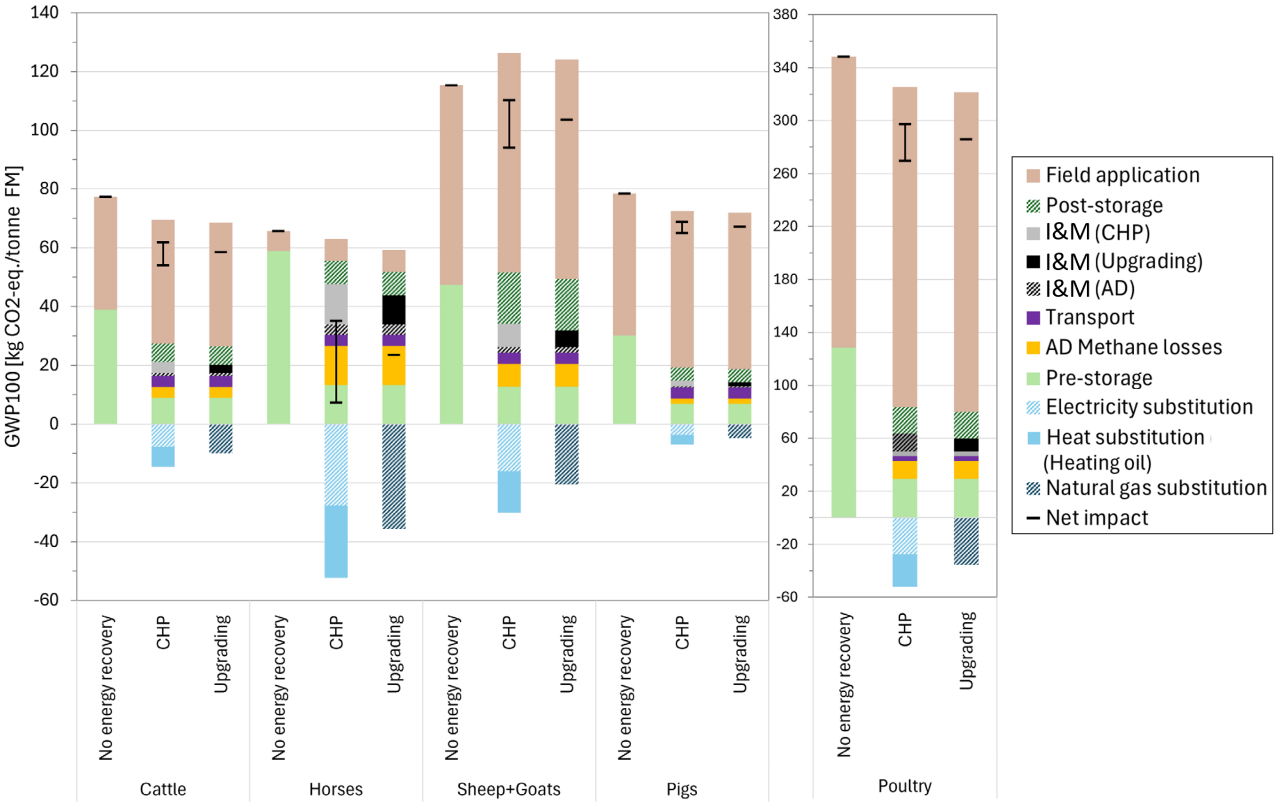
Life-cycle assessment



- Mitigation potential varies depending on the animal categories
- Influenced strongly by:
  - Manure type (solid/liquid)
  - Stabling system
  - Nitrogen content
  - Manure management

Reference: Werner, S., et al. (in preparation). *Unlocking manure's energy potential in Switzerland: A GIS-based decision support tool for agricultural biogas plants*. Unpublished manuscript.

Life-cycle assessment



- Mitigation potential for Switzerland (rough estimate):
  - 19.6 Mio. tonnes of (available) fresh manure produced annually
  - CHP: ~300-460 kt CO_2-eq. per year
  - Upgrading: ~ 370 kt CO_2-eq. per year
- Total agricultural GHG emissions in 2023: 6,001 kt CO_2-eq.

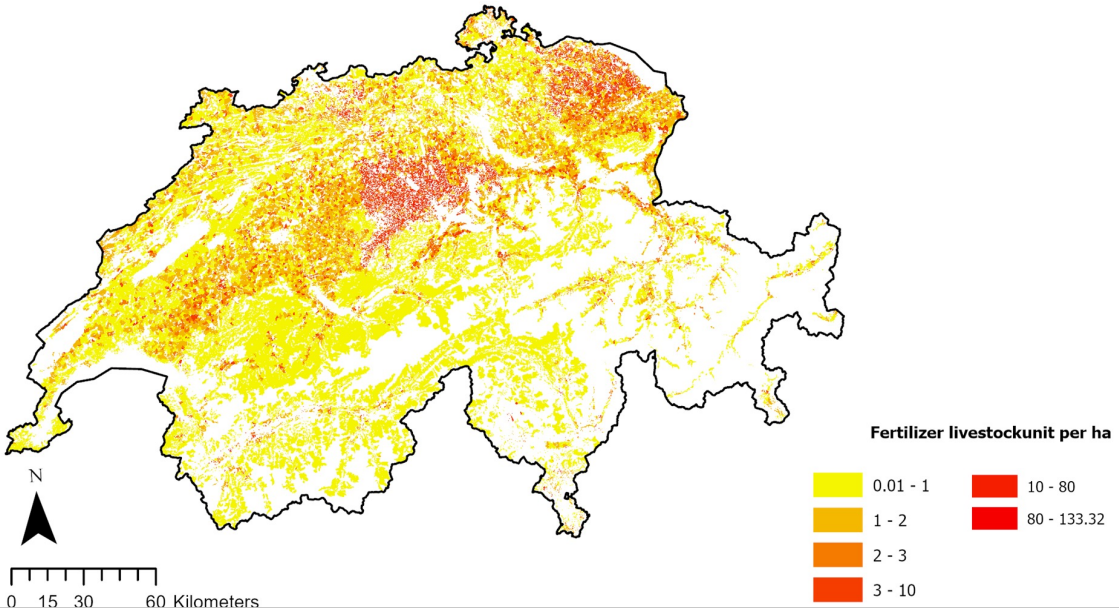
→ ~5–8% mitigation potential in agriculture sector

Reference: Werner, S., et al. (in preparation). *Unlocking manure's energy potential in Switzerland: A GIS-based decision support tool for agricultural biogas plants*. Unpublished manuscript.

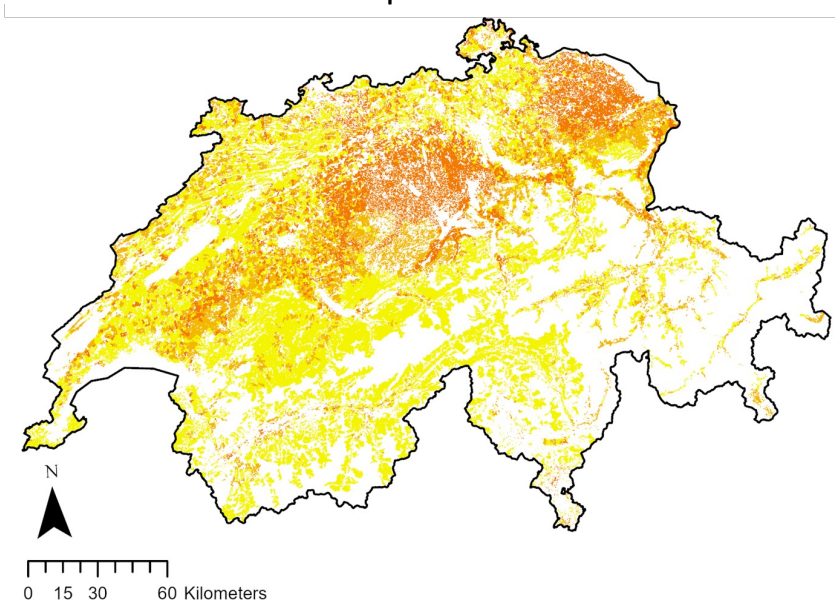
Manure logistics

- Manure as a fertilizer
  - Manure provides essential nutrients (e.g. nitrogen, phosphorus)
  - Manure is normally transported across regions (no limit on distance) to regions with nutrient deficits

No transport



Transport



Reference: Werner, S., et al. (in preparation). *Assessing Eutrophication Impacts from Swiss Agriculture: A Comparison of Manure and Digestate Use as Organic Fertilizers*. Unpublished manuscript.

Manure logistics

- Legal context (RPV) for agricultural biogas plants:
  - Regulations require that more than 50% of processed feed must be of agricultural origin
  - Short manure transport distances (maximum road distance: 15 km)

→ When assessing manure logistics, energy generation and nutrient demand should be considered jointly

Möhring A., (2023), Analyse des Hofdüngermarktes in der Schweiz: Zeitliche Entwicklung und räumliche Verteilung.

Take-home messages

- Manure offers significant renewable energy potential while enabling greenhouse gas mitigation.
- Realizing this potential depends on logistical design and the regulatory context.
- Logistics must balance energy recovery with regional nutrient management.
- Future work will extend this approach to additional manure-to-energy pathways (e.g. hydrothermal gasification/liquefaction).

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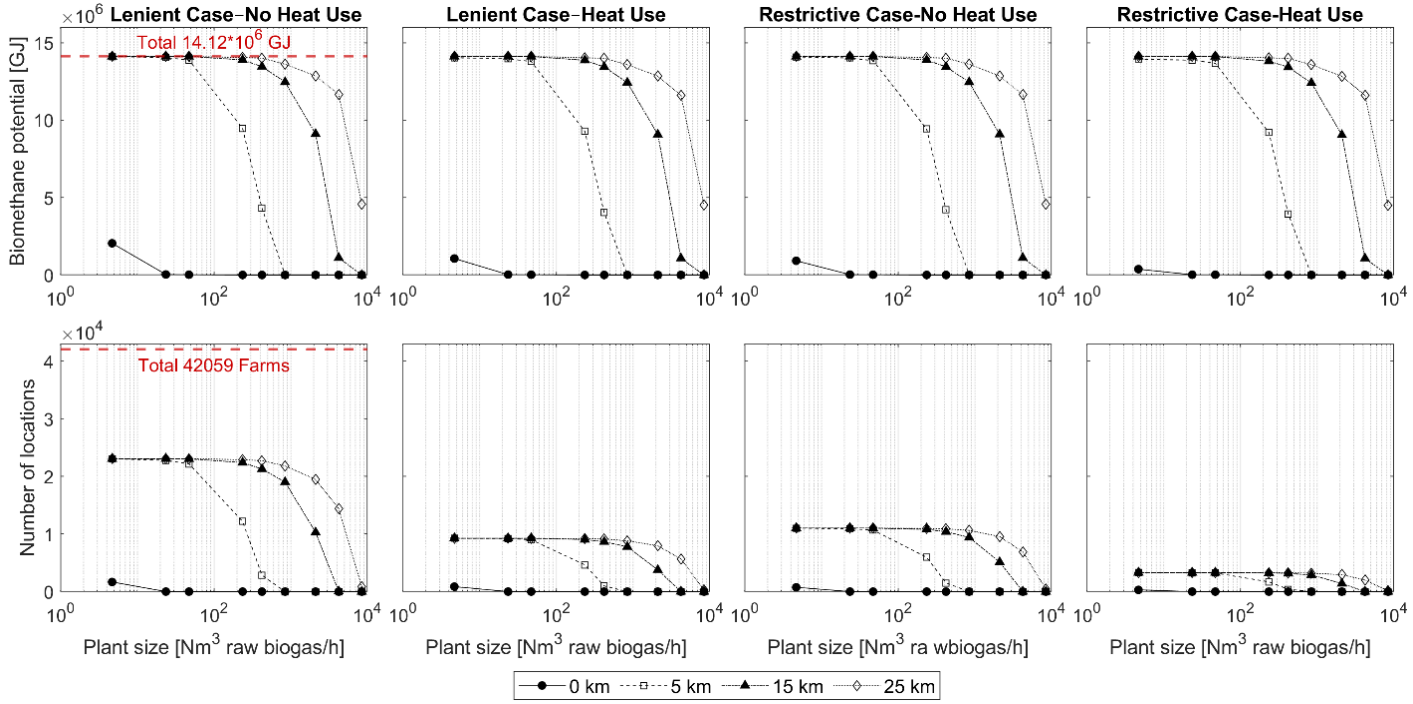
The authors bear sole responsibility for the conclusions and the results presented.

Appendix

National spatial assessment

Biogas utilization via combined heat and power

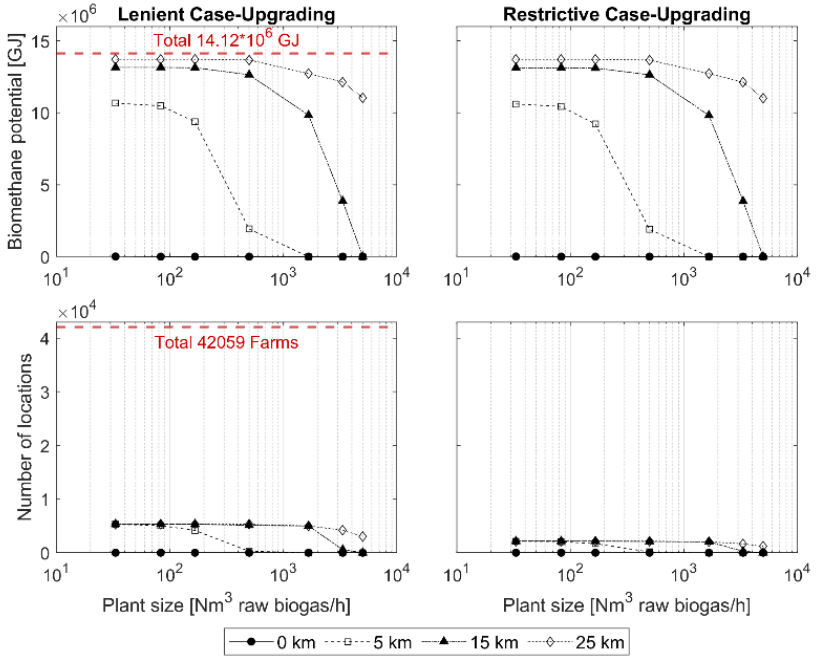


- Overall biomethane potential: moderately sensitive to legal & heat utilization constraints
- Number of suitable locations: highly sensitive
- Exploitation (CHP/upgrading): strongly limited by transport distances

Reference: Werner, S., et al. (in preparation). *Unlocking manure's energy potential in Switzerland: A GIS-based decision support tool for agricultural biogas plants*. Unpublished manuscript.

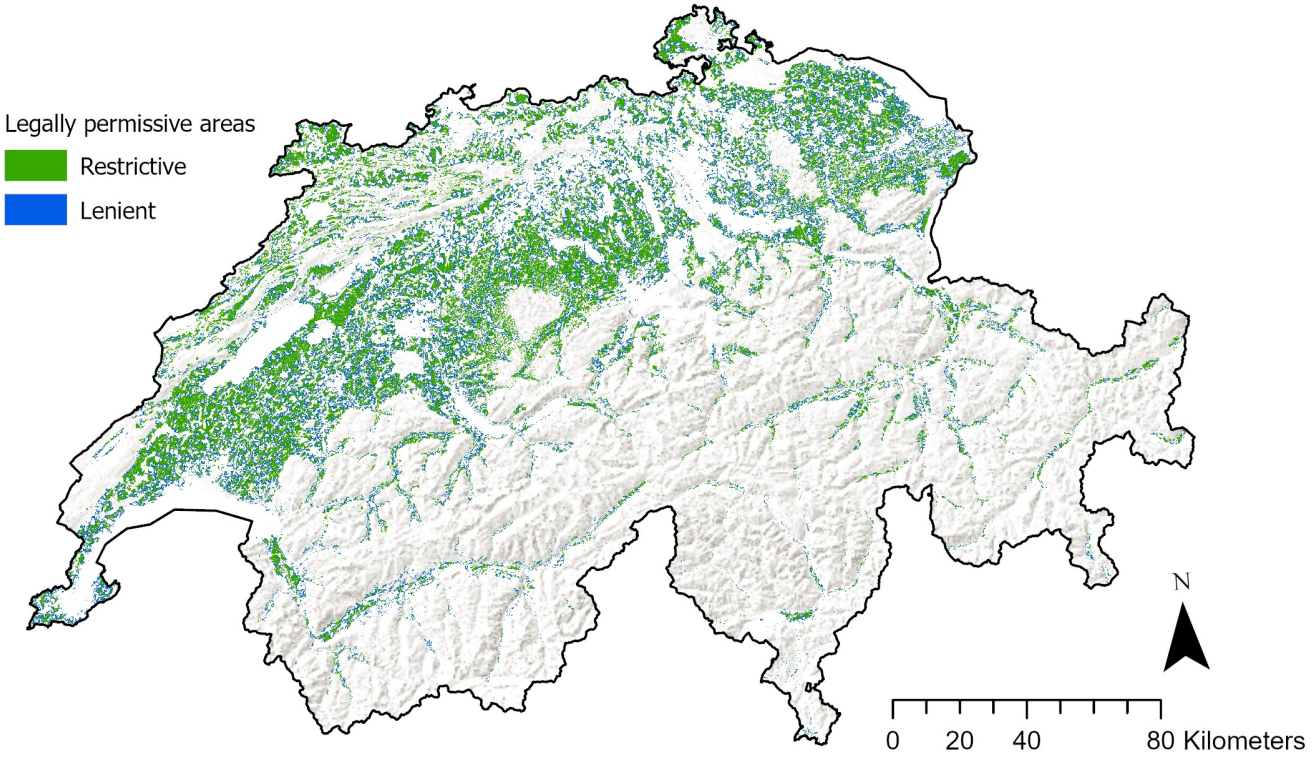
National spatial assessment

Biogas utilization via upgrading



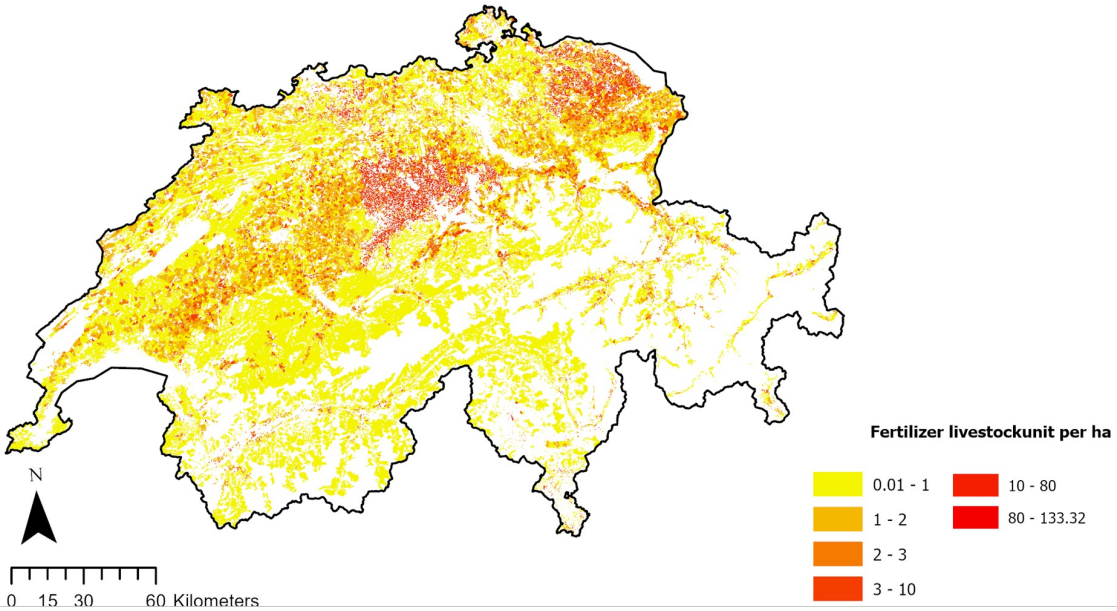
Reference: Werner, S., et al. (in preparation). *Unlocking manure's energy potential in Switzerland: A GIS-based decision support tool for agricultural biogas plants*. Unpublished manuscript.

Legally permissive areas

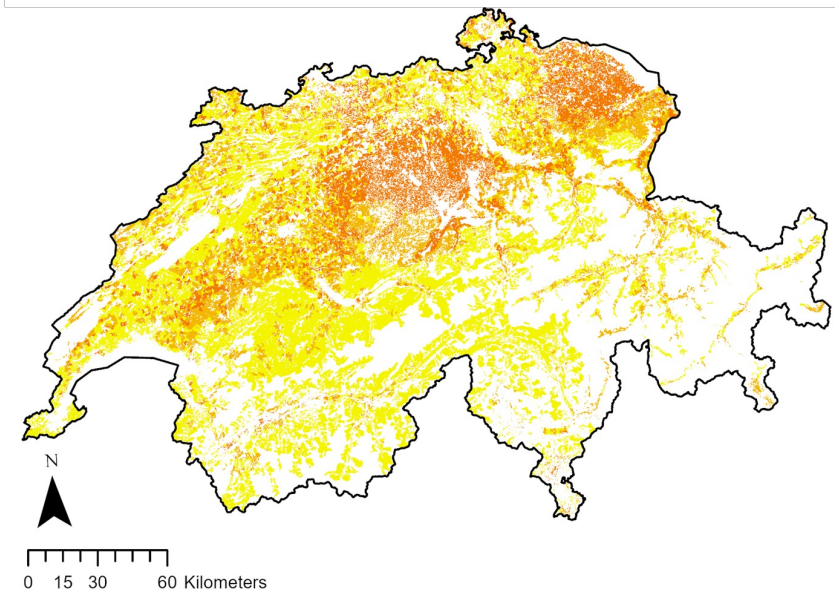


Manure logistics for field application

No transport



Transport



- Manure transport (farm-to-field transport)
- The current average transport distance is 11 km (minimum of 0.8 km and maximum of 29.2 km)
- Total manure transported: approximately 4.4 million tonnes
- Logistics of manure is a key factor for balancing nutrient application across regions

Reference: Werner, S., et al. (in preparation). *Assessing Eutrophication Impacts from Swiss Agriculture: A Comparison of Manure and Digestate Use as Organic Fertilizers*. Unpublished manuscript.