



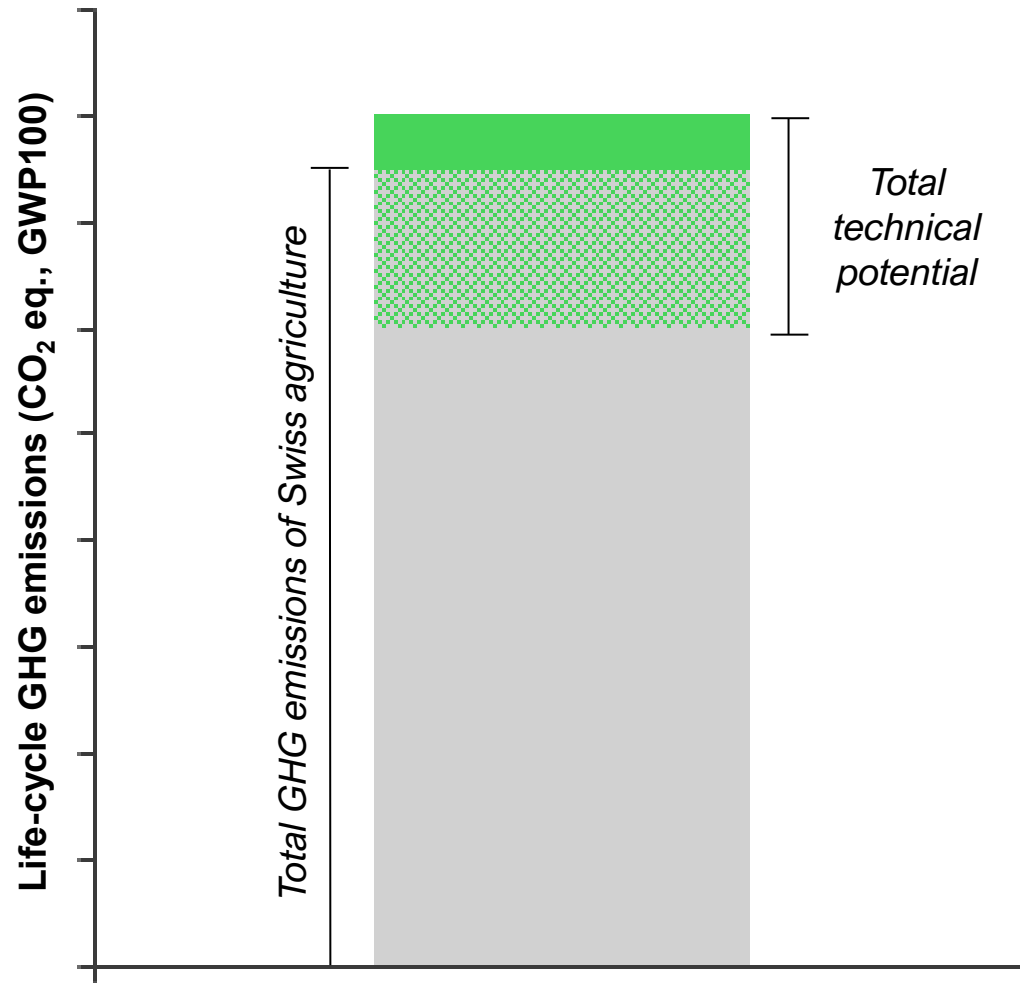
Estimating the remaining climate mitigation potential of a portfolio of technical measures in Swiss agriculture

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15. Ökobilanz-Plattform, 05.05.2026



Research question



What is the **untapped climate mitigation potential** of technical measures in Swiss agriculture?

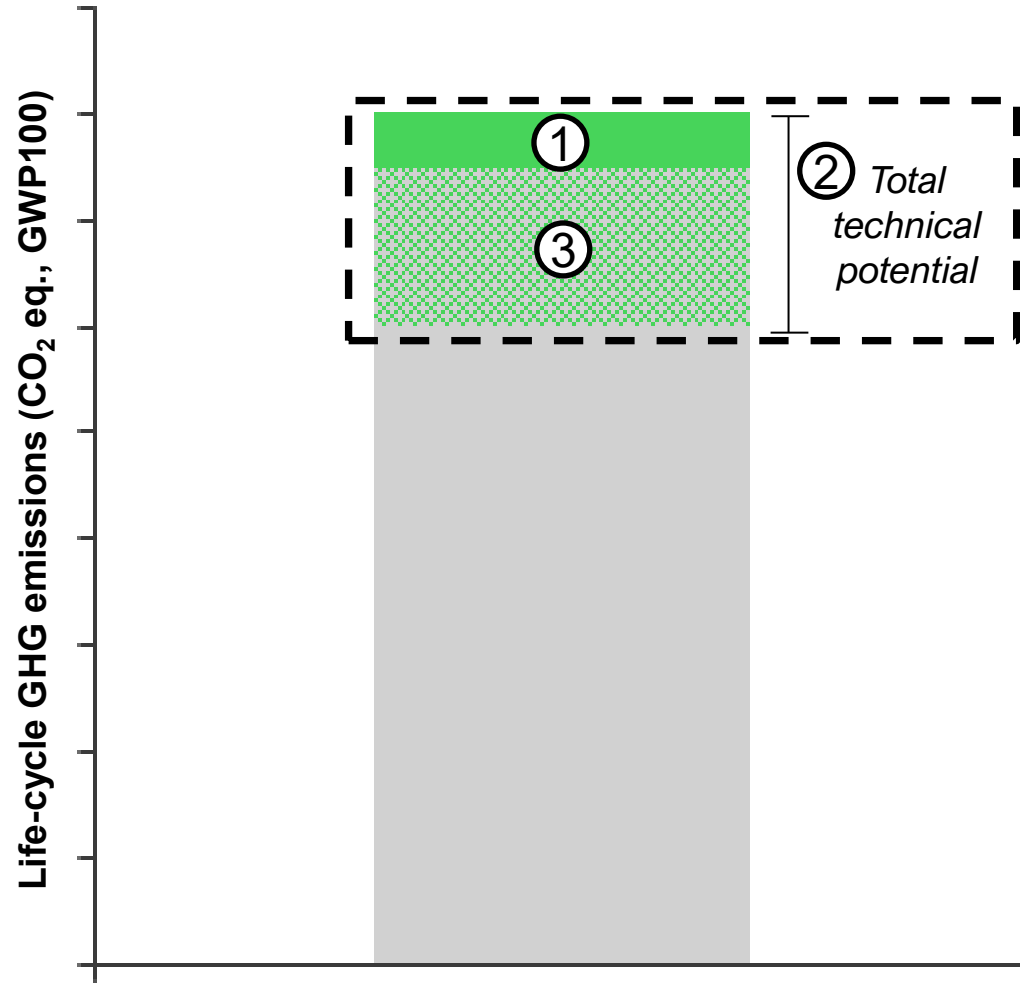
Assumptions:

- **Technical measures have already been implemented on Swiss farms**, contributing to a reduction in net GHG emissions from Swiss agriculture
- **Mitigation potential remains unrealised**, that could be achieved through further implementation of these measures

- GHG reductions already achieved through measure implementation
- ▨ Remaining technical potential



In this presentation



What is the **untapped climate mitigation potential** of technical measures in Swiss agriculture?

- GHG reductions already achieved through measure implementation
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① Starting point: IP-SUISSE Klima-Punktesystem

- 10+ years collaboration with Agroscope
 - catalogue of farm-level technical measures for climate mitigation
 - Translating the implementation of the measures into climate points:
1 point = 1 t CO₂ eq. of lifecycle GHG emission reduction





① Starting point: IP-SUISSE Klima-Punktesystem

Massnahme	Massnahmenmenge für 1 t CO ₂ eq (1 Pkt)
Bezug von Ökostrom	7'470 kWh
Erzeugen von Photovoltaik-Strom	7'470 kWh
Frequenzumformer Melkanlage	350'000 kg Milch
Wärmerückgewinnung Milchkühlung	130'000 kg Milch
Wärmerückgewinnung bei beheizten Ställen	3'120 kWh
Heizen mit Holz: Hackschnitzel Stückholz Pellets	3.6 Schüttraummeter 2.4 Ster 1'110 kg Pellets
Sonnenkollektoren (Solarthermie)	6.3 m ² Dachfläche
Reduzierter Treibstoffverbrauch durch Direkt- oder Mulchsaat	10 ha
Reduzierter Treibstoffverbrauch durch ECOdrive	9.6 ha
Regelmässiger Ersatz Mähklingen	350 ha gemäht

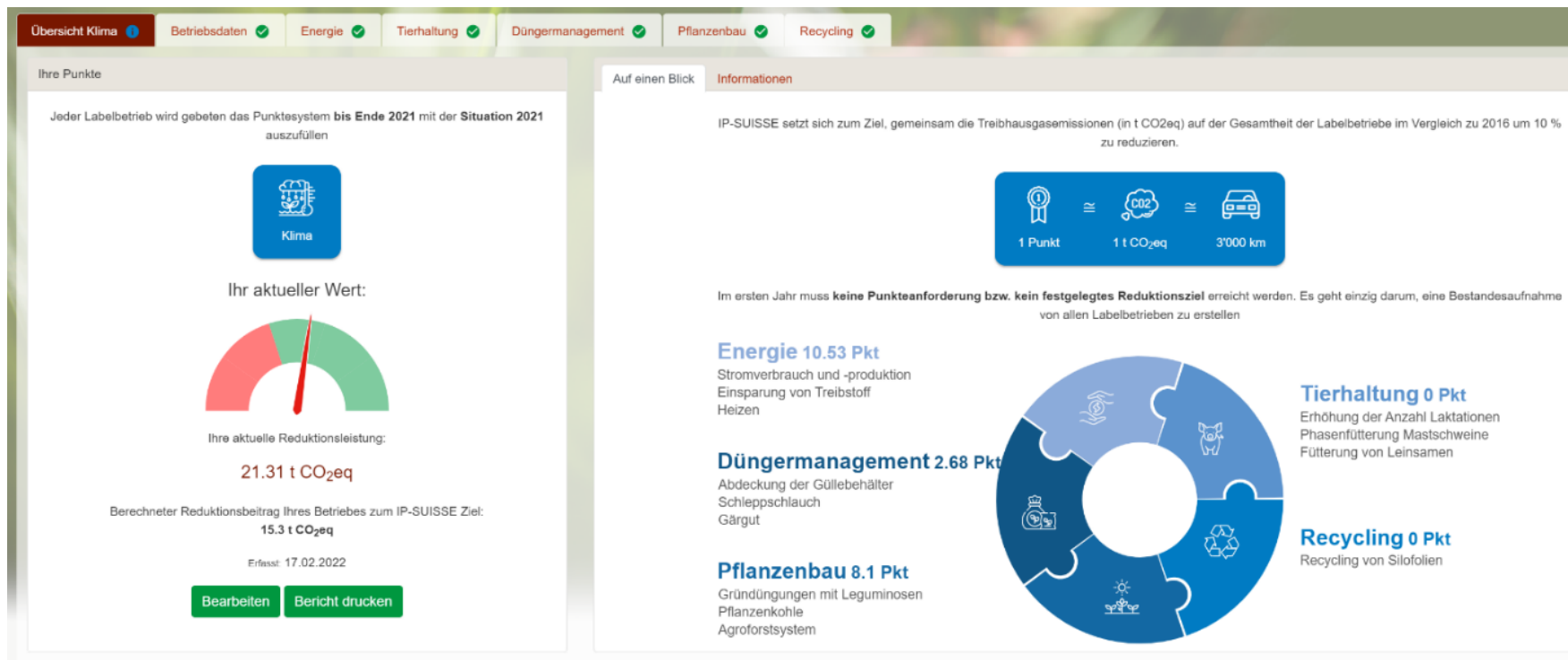
Massnahme	Massnahmenmenge für 1 t CO ₂ eq (1 Pkt)
Erhöhung Anzahl Laktationen bei Milch- oder Mutterkühen	1.8 Kühe*Laktationen
Leinsamen als Milchviehfutter	2'236 kg verfüttert
Phasenfütterung bei Mastschweinen	9.4 Schweine
Güllebehälterabdeckung	23 m ³ Lagervolumen
Schleppschlaucheinsatz	770 m ³ ausgebracht
Folienrecycling (Siloballenfolie / Flachsilofolie)	300 kg Folie
Ersatz von Mineraldünger durch flüssiges Gärgut	28.5 t ausgebracht
Agroforstsystem (Baumdichte: 50 Bäume/ha)	0.18 ha
Anwendung von Pflanzenkohle aufs Feld oder als Futterzusatz	810 kg Pflanzenkohle
Gründüngungen mit Leguminosen	2.2 ha Gründüngung

① Starting point: IP-SUISSE Klima-Punktesystem



■ Monitoring and implementation:

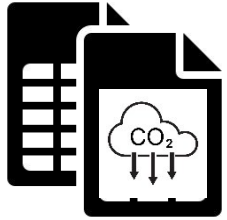
- IP-SUISSE farmers entered data on a web portal, indicating whether a measure had been implemented on the farm and by how much
- both for the baseline (2016/17) and target (2022/23) years





①

IP-SUISSE Klima-Punktkecosystem as a data source

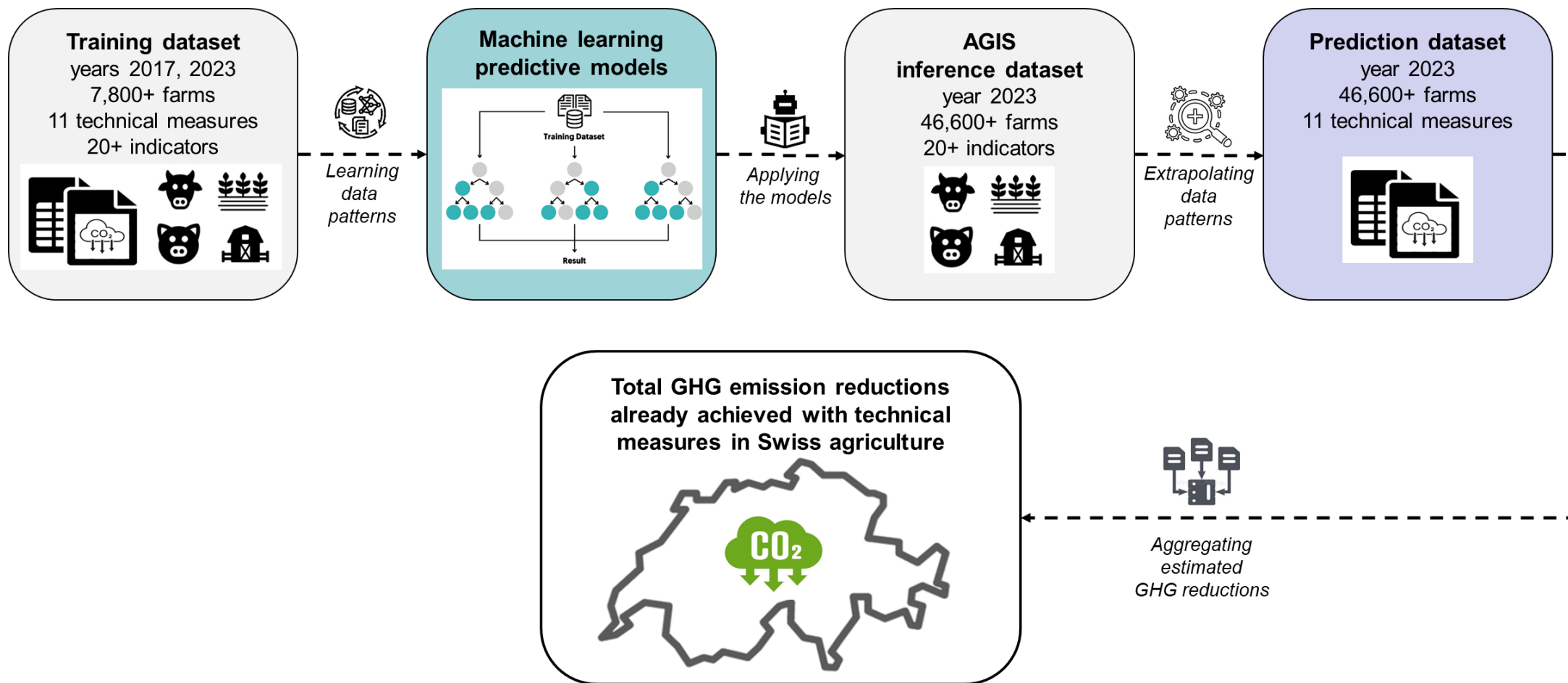


- **Training dataset (7800+ farms)**, indicating for each farm:
 - amount of climate points (i.e. lifecycle GHG emission reductions, in CO₂ eq.) with achieved each technical measure
 - in 2017 and 2023
 - 20+ farm structural indicators (AGIS database)
 - Land area per land use type (arable, grassland, permanent crops, etc.)
 - Livestock units per animal type (cattle, dairy cows, pigs, chickens, etc.)
 - Farm type (specialized, mixed, etc.)
 - Region (valley, hill, mountain)

① Selection of technical measures

Mitigation measures		Mitigation pathways						
Measure category	Technical measure	N ₂ O emission reduction		CH ₄ emission reduction	CO ₂ emission reduction		C sequestration	
		Direct	Indirect, via NH ₃	Enteric fermentation	On farm, energy use reduction	Upstream, input substitution	Soil C	Biomass C
<i>Improved nitrogen management</i>	Slurry tank cover		×			×		
	Application of liquid manure with trailing hose		×			×		
	Application of mixed/liquid digestate		×			×		
	Green manure with legumes	×	×			×		
	Multi-phased feeding for pigs		×			×		
<i>Livestock methane mitigation</i>	Feeding linseed to dairy cows			×				
<i>Reduced on-farm energy use</i>	Reduced tillage				×			
	Heat recovery from milk cooling				×			
<i>Material circularity</i>	Recycling polyethylene plastics					×		
<i>Carbon sequestration</i>	Agroforestry							×
	Biochar application on soil	×	×				×	

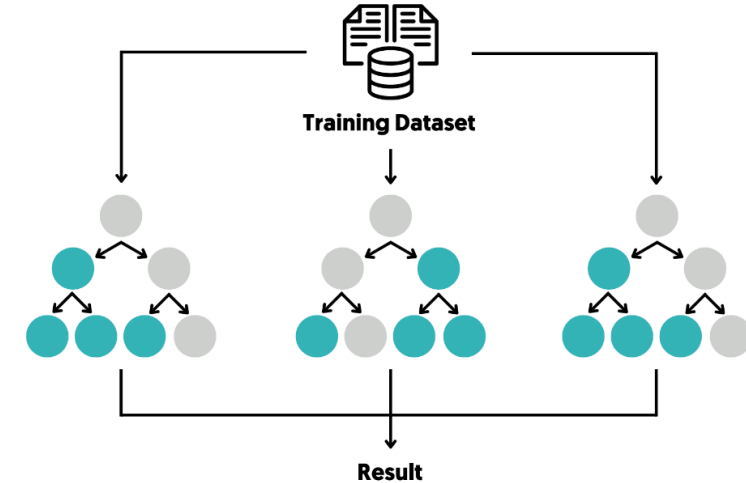
① Estimating climate mitigation already achieved



① Building the predictive models

Applying Random Forest machine learning algorithm

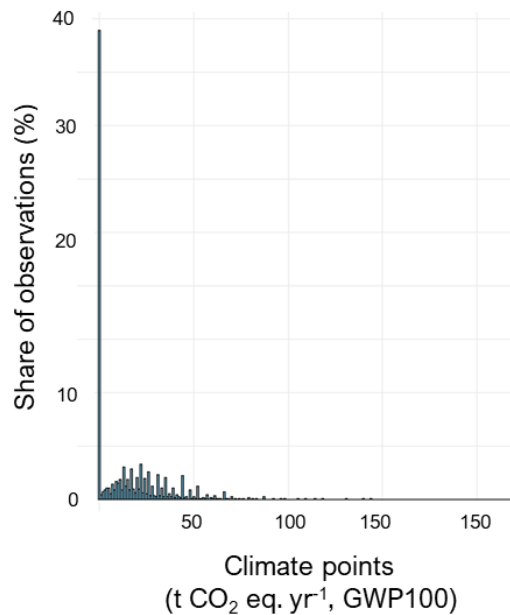
- ensemble learning method
- high accuracy, performs well with high-dimensional data
- captures complex interactions and non-linearities
- appropriate when prediction accuracy is prioritised over interpretability
- applicable both as classifier and for regression



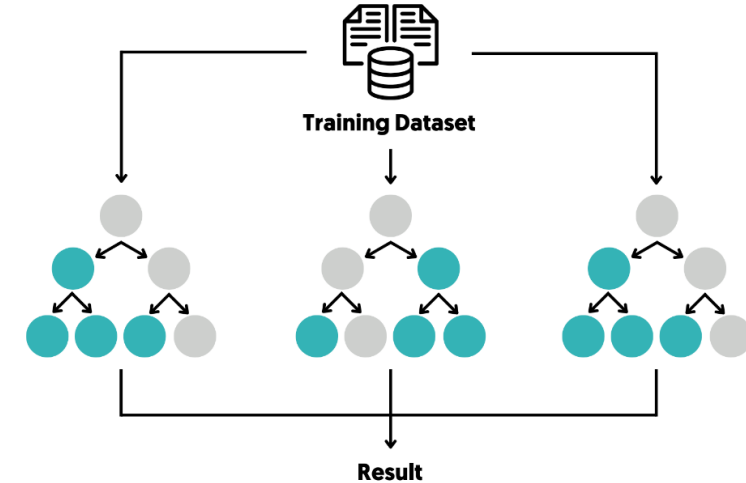
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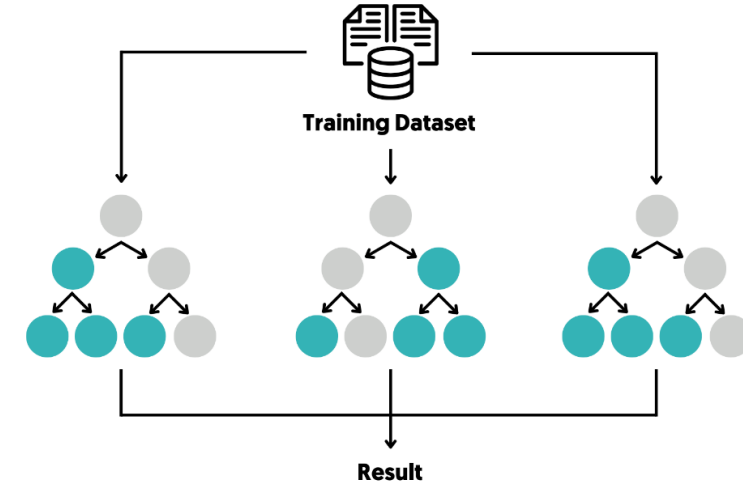
- Highly skewed and imbalanced data
- many 0's, i.e., farms with no implementation



① Building the predictive models

Applying Random Forest machine learning algorithm

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Two-step Random Forest (RF) models:

- **Step 1 (classification): predicts implementation/no implementation** of the measure in a farm
- **Step 2 (regression):** for the farms predicted to implement the measure in Step 1, **predicts the amount of GHG emission reduction** (in t CO₂ eq., GWP100)



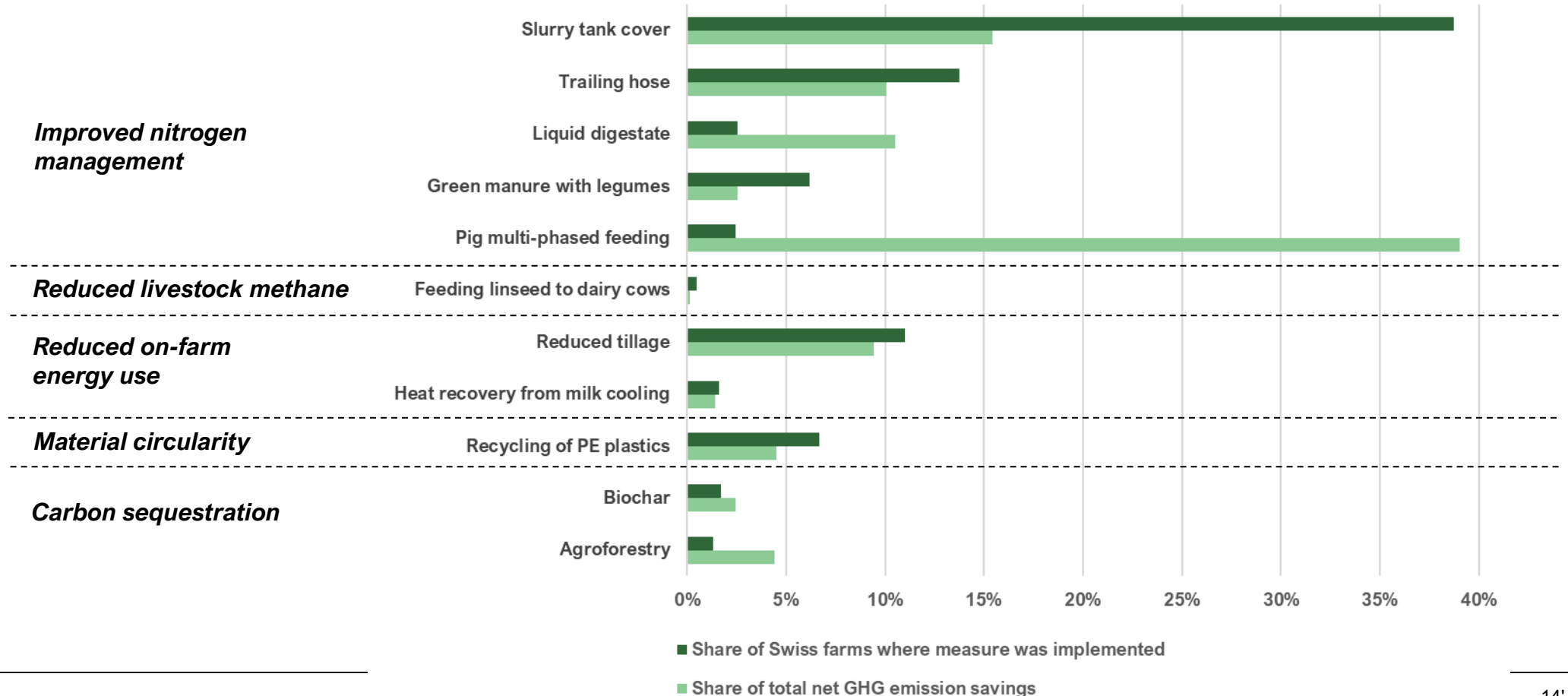
① Model performance: reproducing measure implementation patterns

Measure category	Technical measure	R2	% diff. total predicted vs. total observed
<i>Improved nitrogen management</i>	Slurry tank cover	92%	0.4%
	Trailing hose	89%	0.4%
	Liquid digestate	85%	-1.1%
	Green manure with legumes	85%	0.5%
	Pig multi-phased feeding	97%	0.1%
<i>Livestock methane mitigation</i>	Feeding linseed to dairy cows	78%	-2.8%
<i>Reduced on-farm energy use</i>	Reduced tillage	85%	0.8%
	Heat recovery from milk cooling	95%	-6.8%
<i>Material circularity</i>	Recycling PE plastic	84%	1.1%
<i>Carbon sequestration</i>	Agroforestry	95%	-0.2%
	Biochar	76%	-8.5%
Across all measures:			-0.1%



① Climate mitigation already achieved through current measure implementation

Total net GHG emission reduction in 2023: 150 kt CO₂ eq. yr⁻¹ (GWP100)

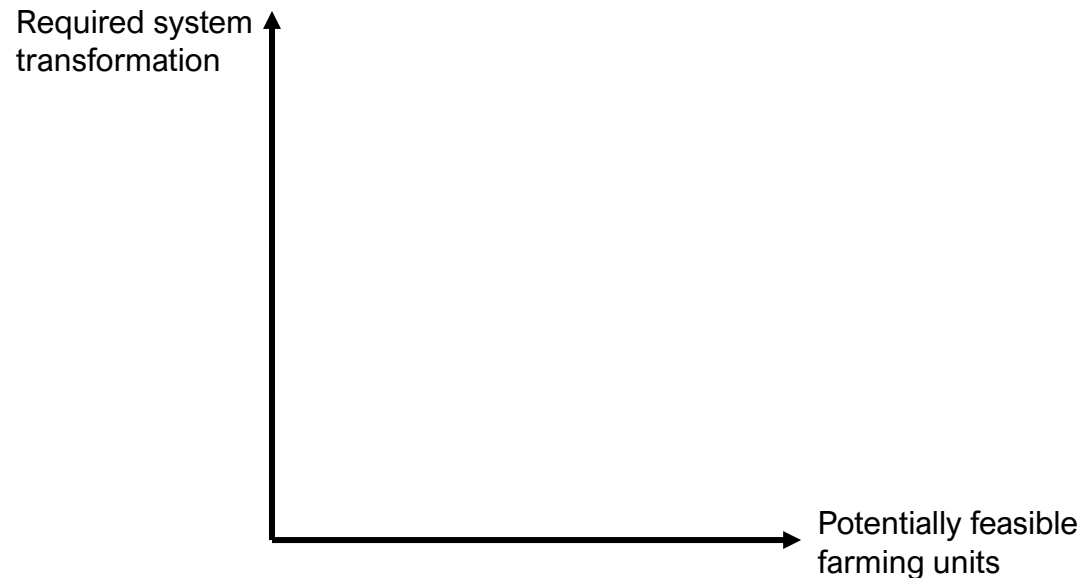


① **Climate mitigation already achieved through current measure implementation**

- **Low to moderate** implementation of considered technical measures
- Measures on **improved nitrogen management account for the largest share of realised mitigation potential** achieved so far (78%)
- **Carbon sequestration measures already contribute significantly (7%)**, despite relatively low implementation
- Measures that can be implemented in **dairy cow production** (feeding linseed, milk heat recovery) **with low implementation and mitigation contribution (3%)**

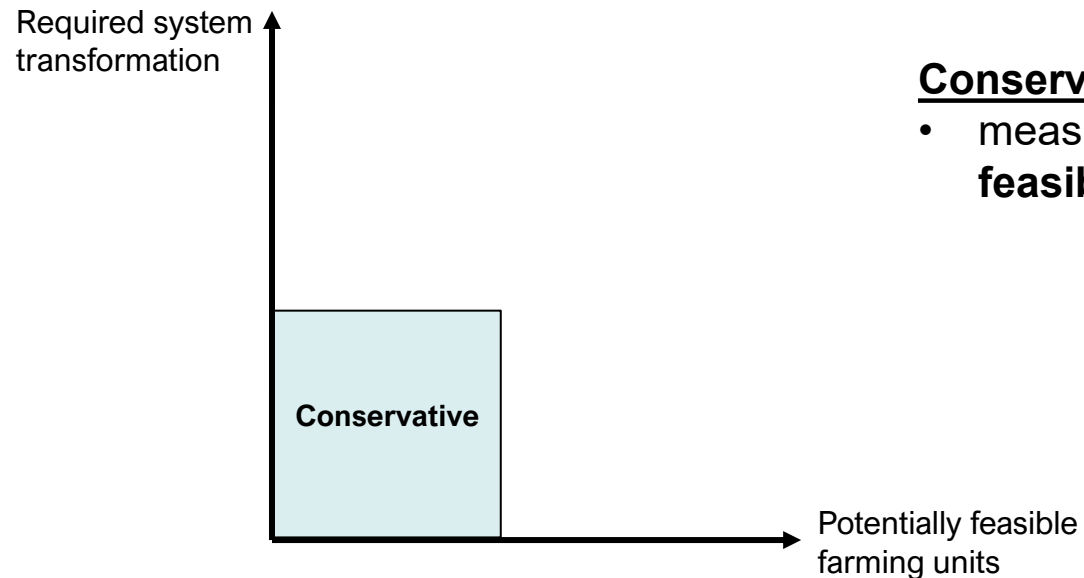
② Estimating technical mitigation potential

- What is the **total net GHG emission reduction achievable through full implementation of a measure** across the Swiss agricultural sector?
- Defining **three incremental scenarios**, based on structural indicators at the sectoral level



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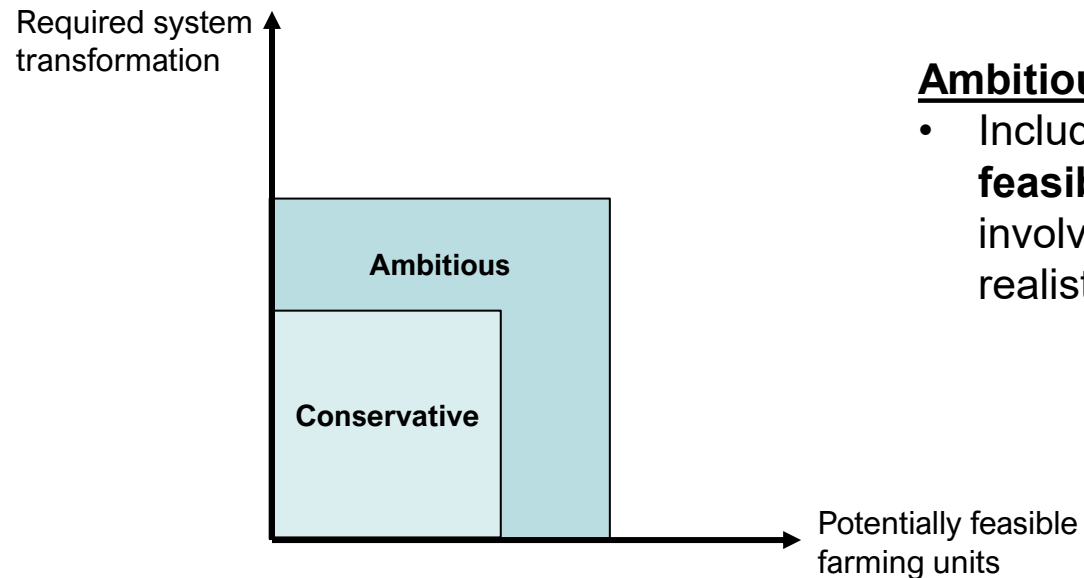


Conservative technical potential scenario

- measure is implemented **only in units that are technically feasible and already proven in practice.**

② Estimating technical mitigation potential

- What is the **total net GHG emission reduction achievable through full implementation of a measure** across the Swiss agricultural sector?
- Defining **three incremental scenarios**, based on structural indicators at the sectoral level

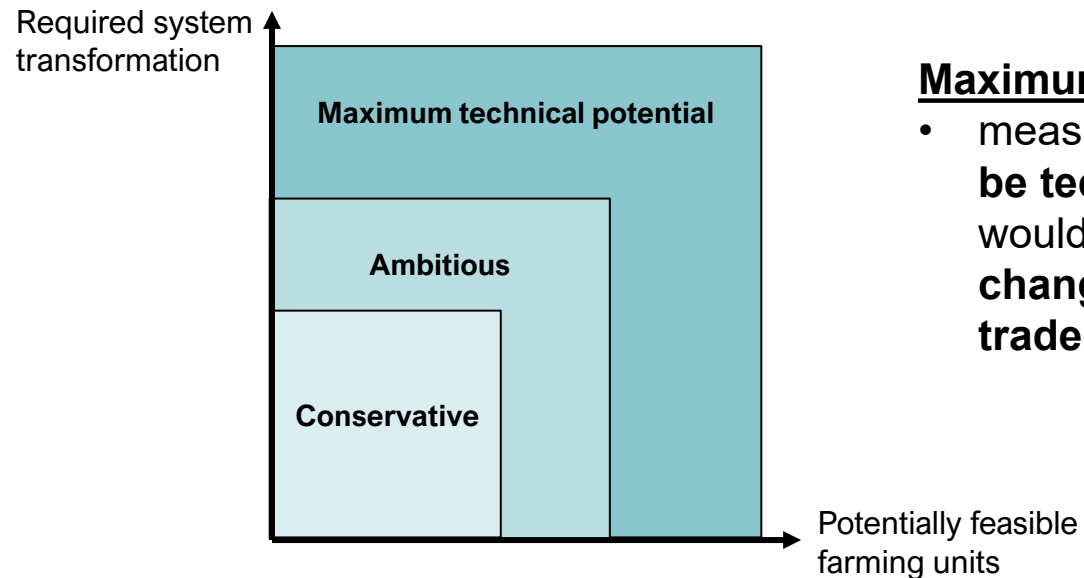


Ambitious technical potential scenario

- Includes all units for which the measure is **technically feasible under present conditions**, including cases involving **adaptations or trade-offs**, while remaining realistically achievable

② Estimating technical mitigation potential

- What is the **total net GHG emission reduction achievable through full implementation of a measure** across the Swiss agricultural sector?
- Defining **three incremental scenarios**, based on structural indicators at the sectoral level

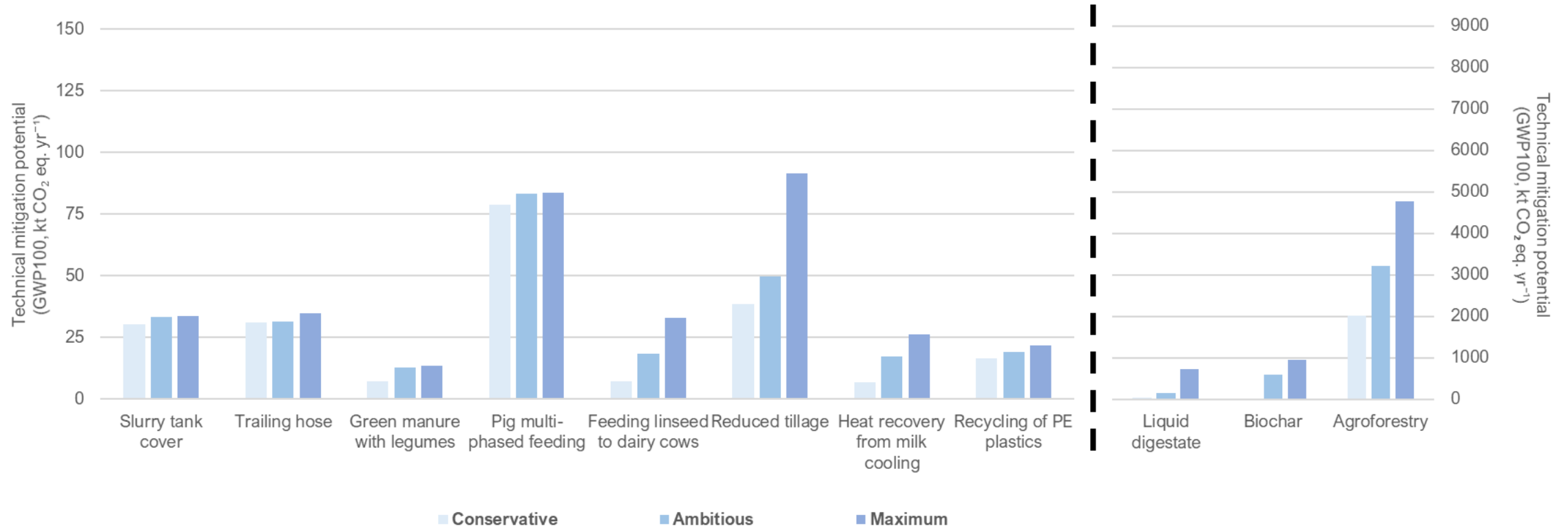


Maximum technical potential scenario

- measure is applied to all units where implementation would **be technically possible in principle**, including cases that would currently require **major innovations, structural change to overcome barriers**, or acceptance of **significant trade-offs**.

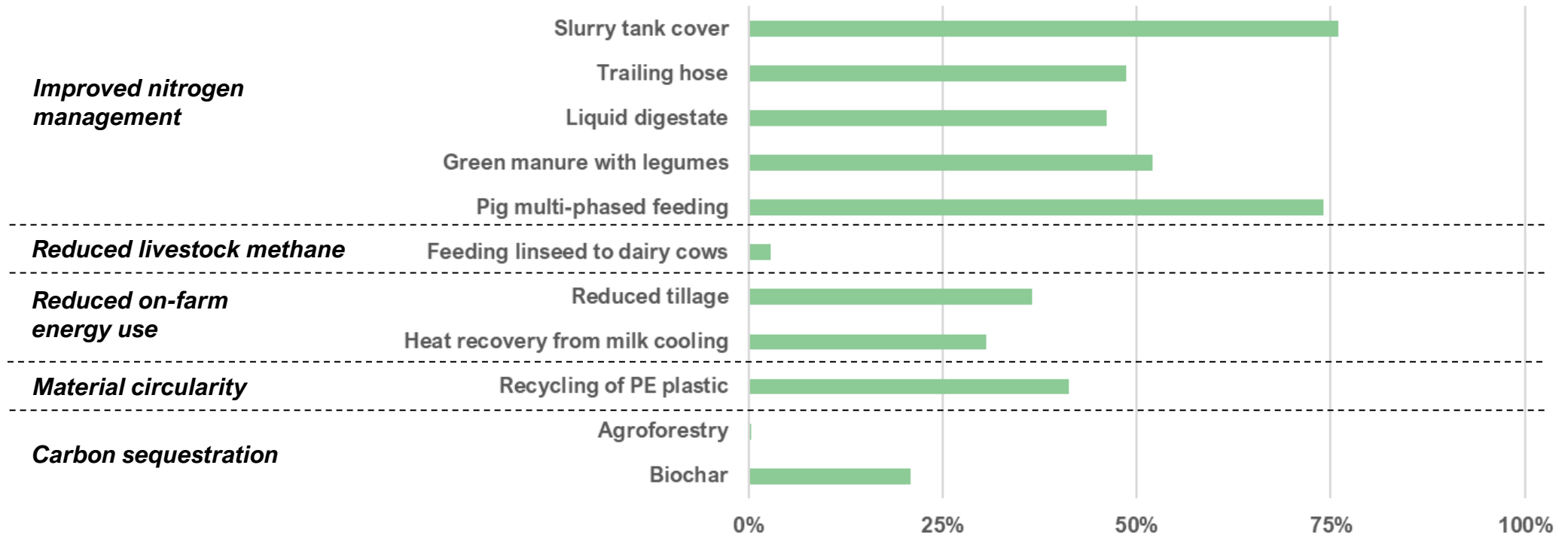


② Estimating technical mitigation potential



③ Remaining technical mitigation potential

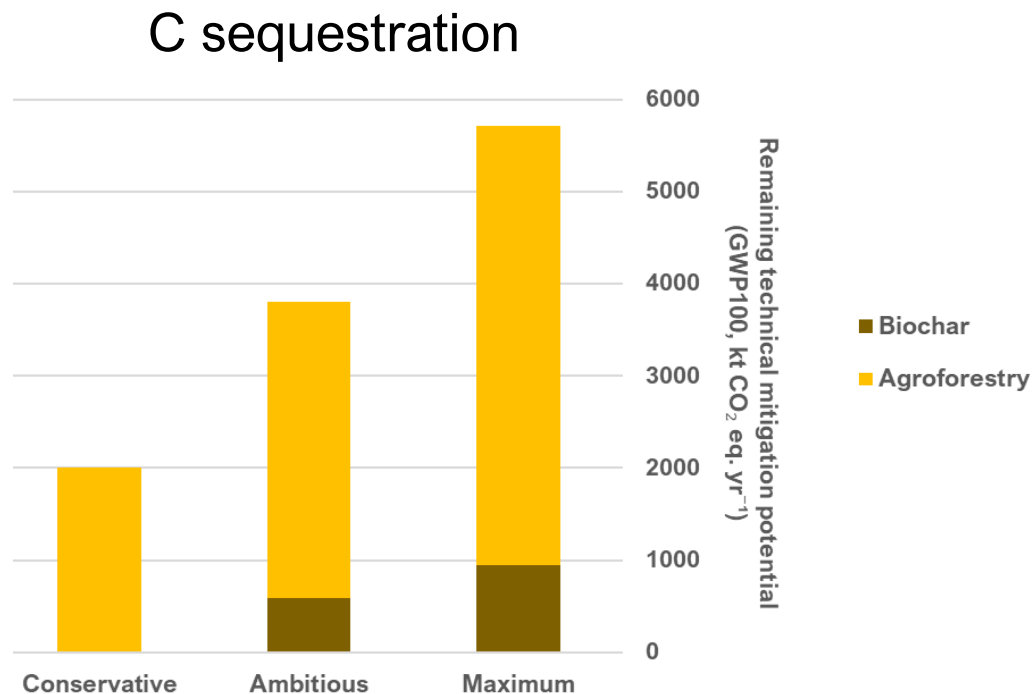
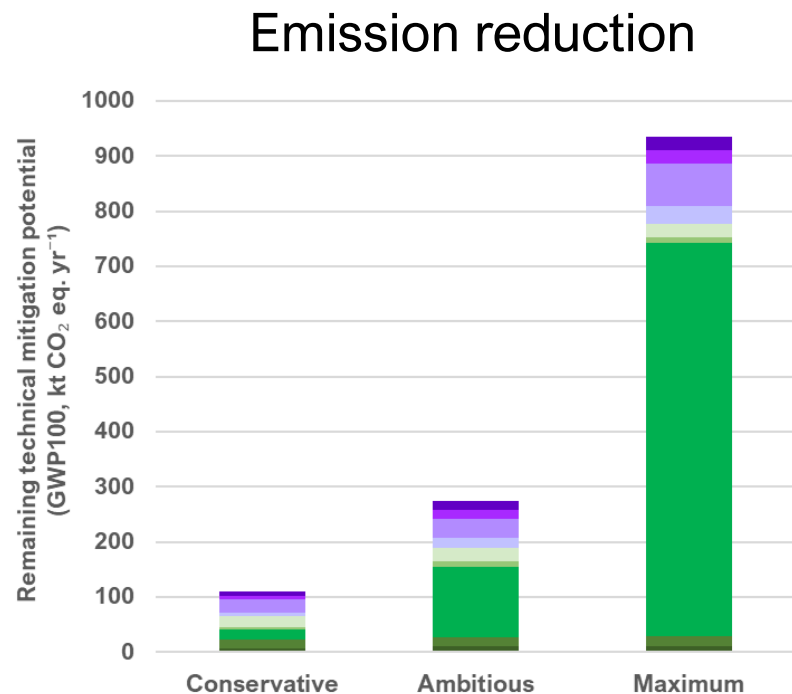
Share of technical mitigation potential already realised
(Conservative scenario)





③ Remaining technical mitigation potential

- Slurry tank cover
- Trailing hose
- Liquid digestate
- Green manure with legumes
- Pig multi-phased feeding
- Feeding linseed to dairy cows
- Reduced tillage
- Heat recovery from milk cooling
- Recycling of PE plastics





Conclusions

- Considerable **untapped potential for climate mitigation in Swiss agriculture**
 - but exact magnitude is **highly uncertain**
- **Moderate** remaining technical mitigation potential from **emission reduction measures**
 - well-established measures still offer contribution for further reductions: multi-phased feeding, trailing hose, reduced tillage
 - Realising the mitigation potential of liquid digestate would largely depends on expanding biogas production capacity and improving the material circularity of agricultural biomass resources
- **Very high** remaining technical mitigation potential from **carbon sequestration**, but:
 - Agroforestry may require support to overcome implementation costs, barriers and trade-offs
 - Biochar is currently constrained by limited domestic capacity for biochar production
 - Carbon sequestration involves complex, site-specific and temporally dynamic processes → robust quantification of the exact long-term mitigation potential is challenging



Danke für Ihre Aufmerksamkeit

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