Farm-level modelling and digital monitoring of non-CO2 greenhouse gas emissions in Austria (nonCO2farm)

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Research background and motivation

Globally
agriculture as largest emitter of anthropogenic non-carbon dioxide (non-CO2) GHG emissions

Austria
about 10% of national GHG emissions from agriculture

financial accounting

Farm-level
financial accounting established,
CH4 and N2O accounting underexplored

environmental accounting

Research objectives

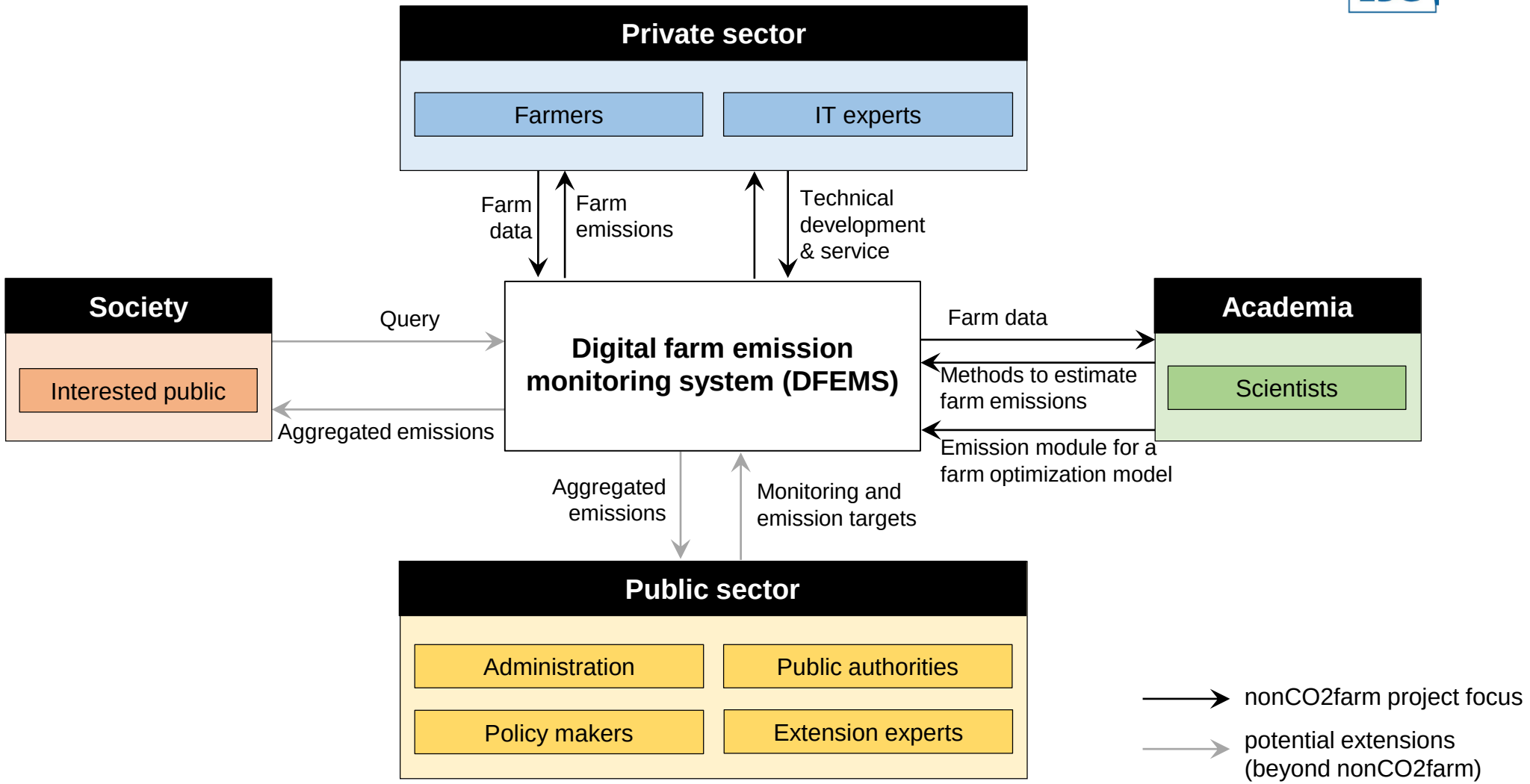
1. Development of a structured and reproducible approach (protocol) and a **prototype of a digital non-CO2 farm emission monitoring system**.

2. Development and modelling of mitigation scenarios to **assess cost-effective mitigation measures** and **emission reduction potentials** at farm level.

3. Development of a concept for a **web-based dashboard** to communicate (modelled) non-CO2 farm emissions and mitigation potentials of farm management practices to different user groups.

Research approach

Potential user groups of a DFEMS



Data and methods

Protocol for the DFEMS

Literature review on mitigation potentials on farms and calculation procedures for farm emission monitoring

- farm mitigation measures selected and categorized by potential impact
- calculation procedures for non-CO2 farm emissions explored and tested
- emission factors by farm management practices

→ focus on differences in calculation procedures, emission factors and data requirements between Tier 1, Tier 2 and Tier 3 approaches

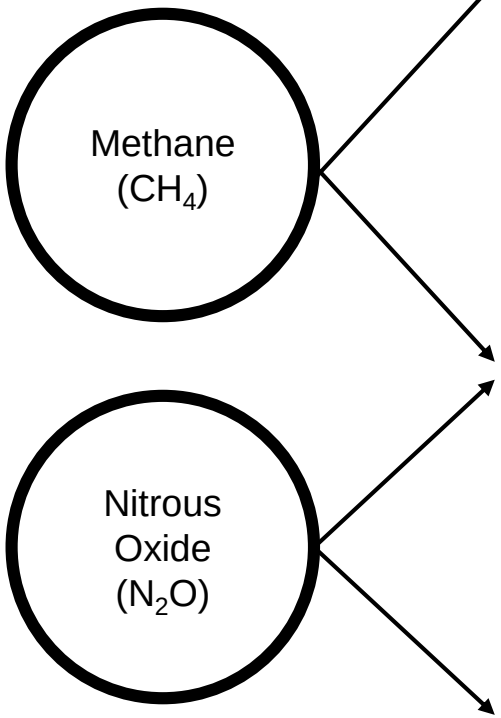
- farm emission monitoring systems conceptually developed and analyzed by comprehensiveness, data requirements, user friendliness

1. Calculating Gross Energy - Dairy Cattle							
Source for calculation		**Data Input/ Coefficient**	**Unit**				
Tab. 10.4 (IPCC, 2019)	$Coefficient_{maintenance}$						
	non-lactating cows, steer, heifers, calves	0.322	MJ/day and kg				
	bulls	0.37	MJ/day and kg			Coefficient	
	lactating cows	0.386	MJ/day and kg			Farm level data input	
	live-weight of animal	676	kg				
Equ. 10.3 (IPCC, 2019)	**= Net energy for maintenance**	**51.17**	**MJ/day**				
Tab. 10.5 (IPCC, 2019)	$Coefficient_{activity}$						
	Stall	0	dimensionless				
	Pasture	0.17	dimensionless				
	Grazing larger areas	0.36	dimensionless				
Equ. 10.4 (IPCC, 2019)	**= Net energy for activity**	0	MJ/day				
	$Coefficient_{growth}$						
	females	0.8	dimensionless				
	castrates	1	dimensionless				
	bulls	1.2	dimensionless				
	live-weight of animal	676	kg				
	mature body weight	676	kg				
	average daily weight gain	0	kg/day				
Equ. 10.6 (IPCC, 2019)	**= Net Energy for Growth**	0	MJ/day				
	milk production	25	kg/day				
	fat content of milk	4.2	%				
Equ. 10.8 (IPCC, 2019)	**= Net Energy for Lactation**	78.75	MJ/day				
	hours of work	0	h/day				
Equ. 10.11 (IPCC, 2019)	**= Net Energy for Work**	0	MJ/day				
	$Coefficient_{preg}$						
Tab. 10.7 (IPCC, 2019)		0.1	dimensionless				
Equ. 10.13 (IPCC, 2019)	**= Net Energy for Pregnancy**	**5.12**	**MJ/day**				
	digestibility of feed	72	%				
Equ. 10.14 (Gibbs & Johnson 1993 in IPCC, 2019)	**= Ratio net energy avail.in diet for NE_m to consumed digestible energy (REM)**	0.53					
Equ. 10.15 (IPCC, 2019)	**= Ratio net energy avail. f. growth to consumed digestible energy (REG)**	0.00					
Equ. 10.16 (IPCC, 2019)	**= Gross Energy**	**351.89**	**MJ/day**				
2. Calculating the methane emission factor							
	Methane conversion factor	6.3	%				
	Energy content of methane	55.65	MJ/kg CH4				
	= Methane emission factor	**145.40**	**kg CH4/animal and year**				

Excerpt of a farm-specific calculation of CH4 emissions from cattle farming (dairy cows) following a Tier 2 approach.

First results

Identified data gaps at for farm emission monitoring



Category	Identified farm-level data gap
Enteric fermentation	▪ Characterization of livestock categories (age, weight, animal breed, performance) ▪ Animal performance per livestock category ▪ Livestock housing system ▪ Feed characteristics – Feed ratio for livestock categories – Quality of feeding components ▪ Feed intake estimates for typical animal per livestock category
Manure Management	▪ Amount of manure produced ▪ Manure management - Storage type and cover - Duration of storage - Manure treatment ▪ Information on manure removal
Managed Agricultural Soils	▪ Amount of “N sources” applied to the soils

First results

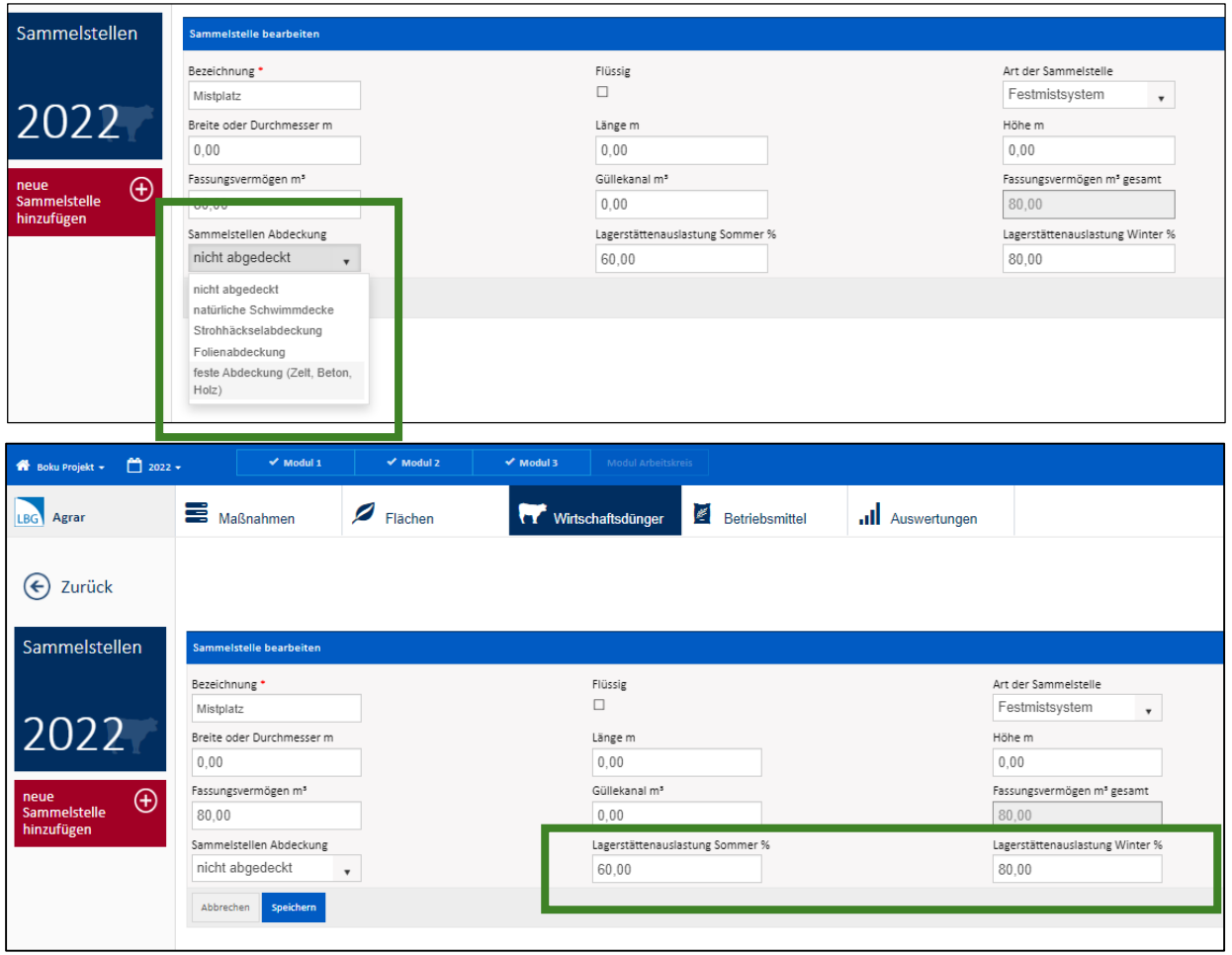
Extension of an existing web-based farm management system

Close identified data gaps for farm emission monitoring

- determine the type of question (open, closed)
- determine categories for closed questions
- determine the unit for data query and emission calculation

Advantages of extending an existing farm management system

- large network of potential users (i.e., farmers)
- many years of experience and trust
- build on established standardized procedures for data collection, plausibility checks, exchange and data protection



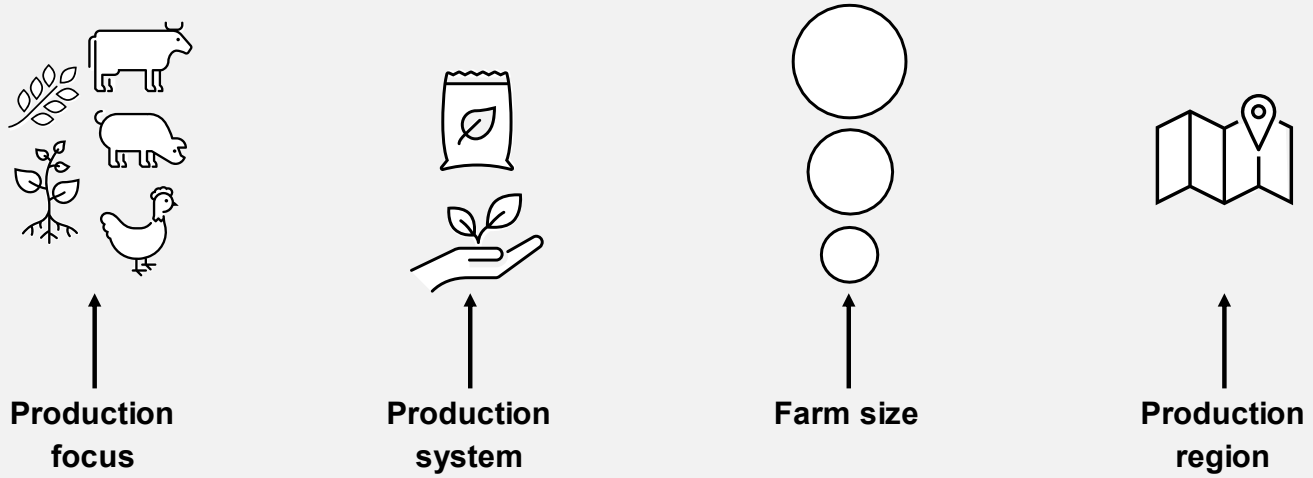
Extension of the LBG Agrar System: Two examples for newly implemented queries about manure management

Ongoing activities

Data collection for test farms

Selection criteria for test farms (>20 contacted): purposive sampling

- representing the heterogeneity of Austrian farms (i.e. maximum variation in the sample)
- farm types and farming activities differentiated by production focus (e.g. livestock farms, crop farms), production system (e.g. conventional, organic), farm size, production region
  → and to be implemented in the farm optimization model FAMOS

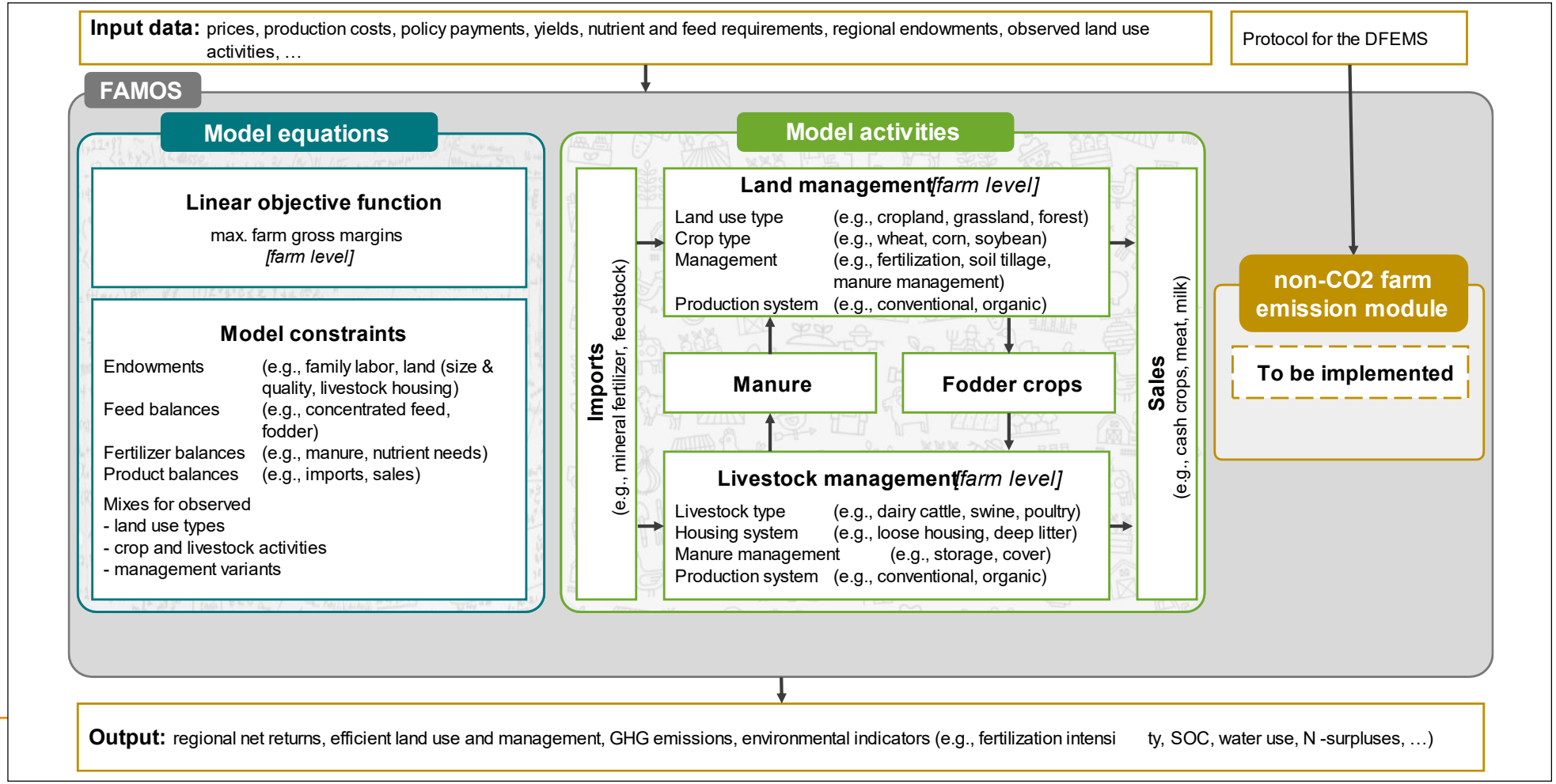


Data and methods

Farm emission accounting and mitigation policy impact modelling

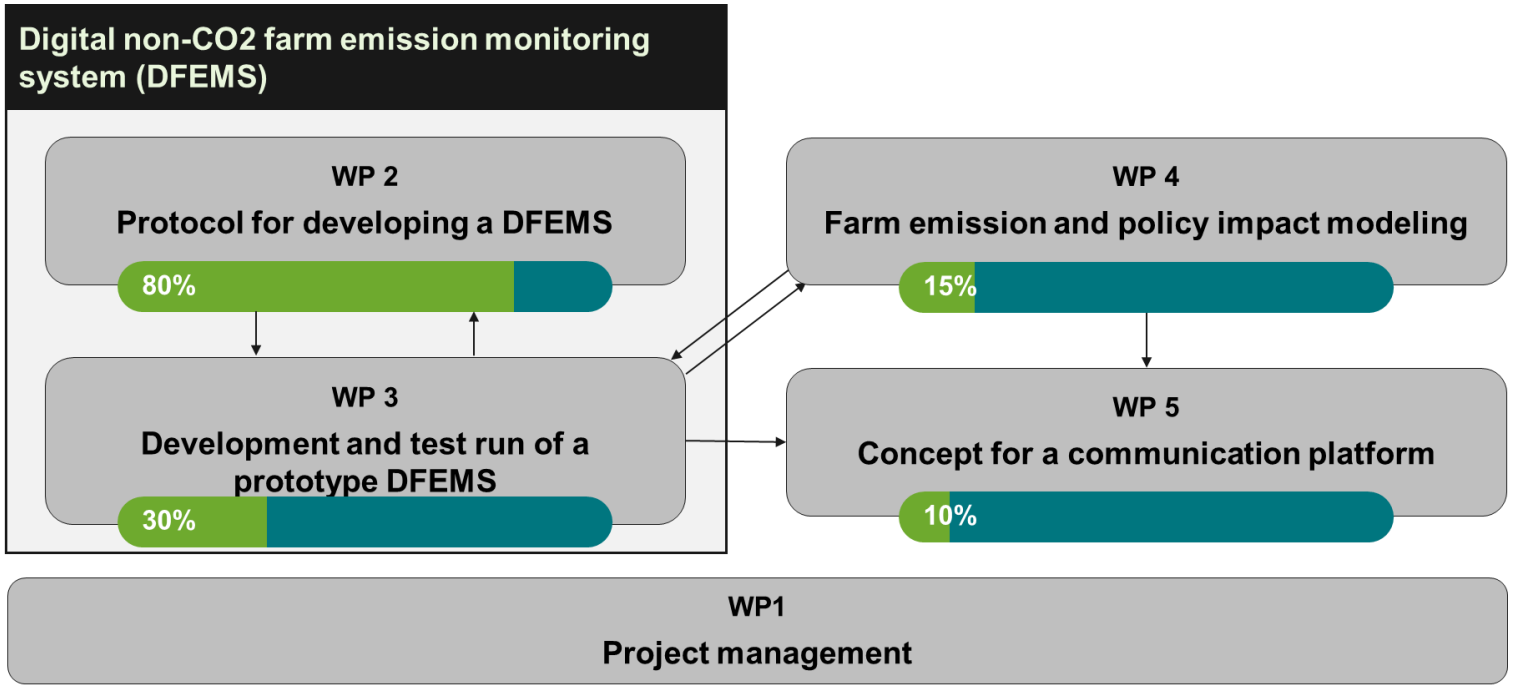
Schematic overview of the farm optimization model FAMOS

Data for model development, application and validation: partially available and partially requested



Project progress and experienced challenges

Project start:01.12.2021
Project end: 30.11.2024



Challenges and adaptations

- Delay in project milestones, mainly due to personnel changes
  → cost-neutral project extension has been approved
- Harmonization of multiple data sources for model development, application and validation (e.g. different aggregation levels)

Related (ACRP) projects

ACRP projects (completed)

- CASAS (Carbon Sequestration in Austrian Soils): Analysing the effects of soil management (crop residue management and tillage) on SOC storage as well as the economic impact of a “4-per-mille” soil management scenario.
- NitroClimAT (Nachhaltiges Stickstoffmanagement unter den Klimawandelszenarien in Österreich): Analysing agricultural management practices for Austria with regard to costs and losses (emissions) of reactive nitrogen into the environment.

Many research projects deal with GHG emissions in agriculture. However, we are not aware of any research project that systematically and comprehensively investigates how non-CO2 emissions from crop and livestock production can be monitored at farm-level.

Other related projects

- KLILASZ (Climate Protection and Agricultural Scenarios - Investigation of Greenhouse Gas Reduction Measures in Austria)
- FarmLife (Life cycle assessment of Austrian farms)

Next steps

Ongoing and upcoming project activities

- Calculating farm-level non-CO2 emissions for 20-25 test farms (considering newly queried farm data)
- Refining queries and implementing output files in the web-based farm management system
- Data preparation and processing for their use in the farm optimization model FAMOS
- Developing a non-CO2 farm emission accounting module in FAMOS, based on the tested calculation procedures
- Applying FAMOS for mitigation scenarios
- Developing a concept of a digital communication platform for the DFEMS results

Dissemination activities

- *Conference proceedings (in preparation)*: Modelling of non-CO2 greenhouse gas emissions for Austrian farms. Annual conference of the Austrian Society of Agricultural Economics. (*Working title)*
- *Working paper (in preparation):* Protocol for implementing a digital farm non-CO2 emission monitoring system. (*Working title).*
- *Journal article (in preparation):* Integrated modelling of fertilizer and climate change scenarios on reactive nitrogen emissions in agricultural production in Austria. (*Working title*).

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