Mid-term report on soil pollutant emission

Deliverable D1.7

INNOVATIVE DECISION-MAKING TOOL FOR DEFINING THE MOST SUITABLE MANURE MANAGEMENT STRATEGIES TO ACHIEVE A SUSTAINABLE LIVESTOCK FARMING SYSTEM DURING THE WHOLE VALUE CHAIN

Proposal number: 101135400-2

Deliverable D1.7 – Mid-term report on soil pollutant emission			
Deliverable Number	D1.7	**Lead Beneficiary**	6-ILVO
Deliverable Name	Mid-term report on soil pollutant emission		
Type	presentation	**Dissemination Level**	PU-Public
Due Date (month)	**M12**	**Work Package No**	WP1

Grant Agreement No:	**1011135400**	**Project acronym:**	**NUTRITIVE**
Project Title:	**INNOVATIVE DECISION-MAKING TOOL FOR DEFINING THE MOST SUITABLE MANURE MANAGEMENT STRATEGIES TO ACHIEVE A SUSTAINABLE LIVESTOCK FARMING SYSTEM DURING THE WHOLE VALUE CHAIN**		
Financing scheme:	HORIZON-CL6-2023-ZEROPOLLUTION-02		
Project coordinator:	**MEDRAR**		
Principal beneficiary:	6-ILVO		
Project start date:	11/07/2024	**Duration of the project:**	48 month
Deliverable:	Deliverable 1.7 – Mid-term report on soil pollutant emission		
Contractual delivery date:			
Actual delivery date:			
Type of deliverable	Presentation		
Dissemination Level	PU-PUBLIC		
Authors:	6-ILVO		
Contributors:			
Version:			

History of change			
Version:	**Author:**	**Date:**	**Comments:**
1.0	All WP1 partners	04/06/2025	Presentation M12 meeting assembled
1.1	All WP1 partners	06/06/2025	Final presentation M12 meeting based on final comments from the partners
1.2	Geertrui Rasschaert Laurens Tuts (EV-ILVO)	25/03/2026	Reopened deliverable. Reply to comments from experts during the first review with following sections updated: 1. Table of content was corrected 2. Executive summary was added

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1. Introduction

Livestock farming is a key sector that involves 40 % of the total agricultural activity in Europe. representing a total value for products equal to € 170 billion. However, there is an increasing concern due to livestock farming's contribution to environmental pollution since it generates more than 1.4 billion tonnes/year of manure leading to significant greenhouse gases (GHG) and air pollutants emissions (NH3, NOX)as well as to soil and water contamination caused by hazardous manure chemicals and biological contaminants (called here emerging contaminants). In this context extensive effort has been carried out for years to assess the detrimental effects of farming systems and to develop abatement methods to be implemented. However, despite major advancements, many fundamental issues are beyond the scope of existing legislation.

The main objective of NUTRITIVE is to develop a decision-making tool (DSS, decision support system) able to define the most efficient and sustainable (in its three pillars: environmental, economic, and social) manure management strategies for a given livestock farm limiting manure air emissions as well as soil and water contaminants. This will allow for the formulation of technical guidelines and recommendations that will support policy makers with enhanced knowledge to establish requirements for future European policies.

To fulfil this objective, the project is divided into six work packages (WP): WP1 Up-to-date inventory; WP2 Novel management strategies/technologies investigation; WP3 Modelling and Life Cycle Assessment (LCA); and WP4 Guidelines formulation; WP5 Communication, dissemination, and exploitation; WP6 Management (Figure 1).

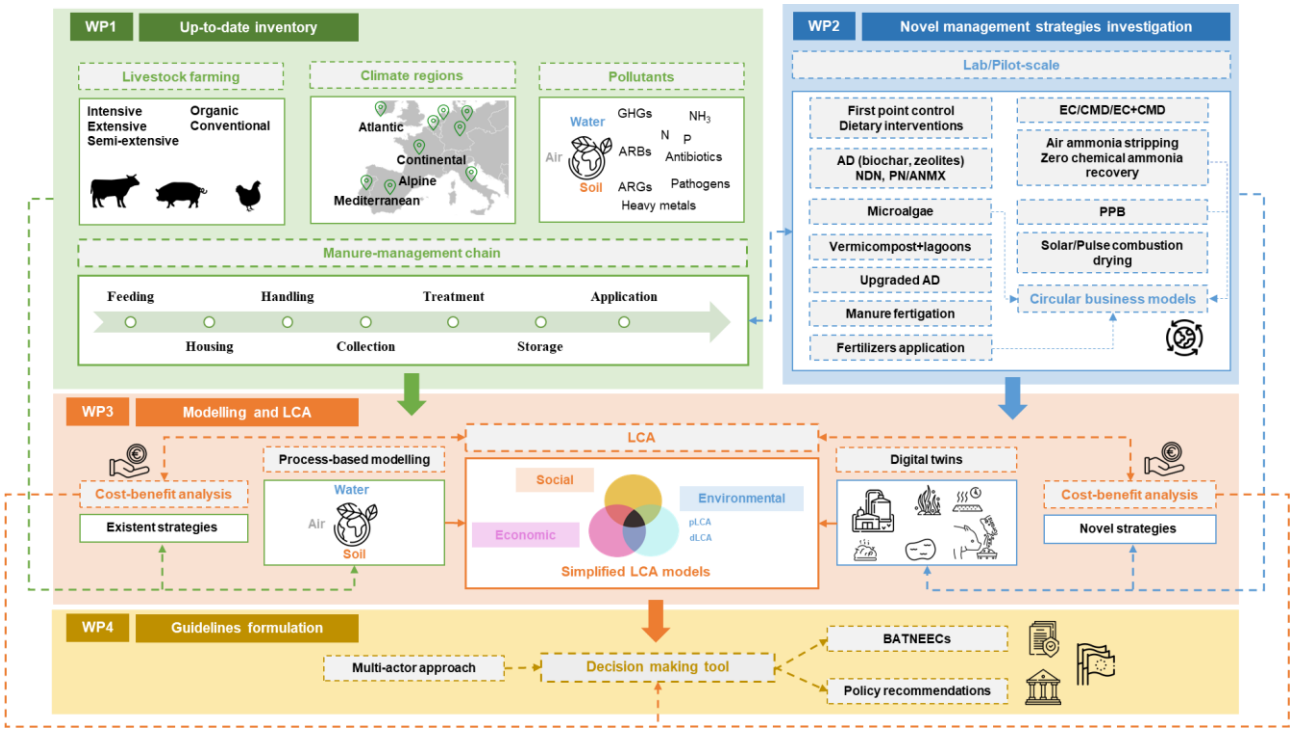


Figure 1. NUTRITIVE methodology.

NUTRITIVE anticipates a wide spread of the project outcomes, with the synthesis of the consortium as a baseline: 22 partners (4 Chinese) from 8 different countries across Europe, covering 6 climatic regions (2 Chinese ones), representing the whole supply chain experts, from animal feed to soil application.

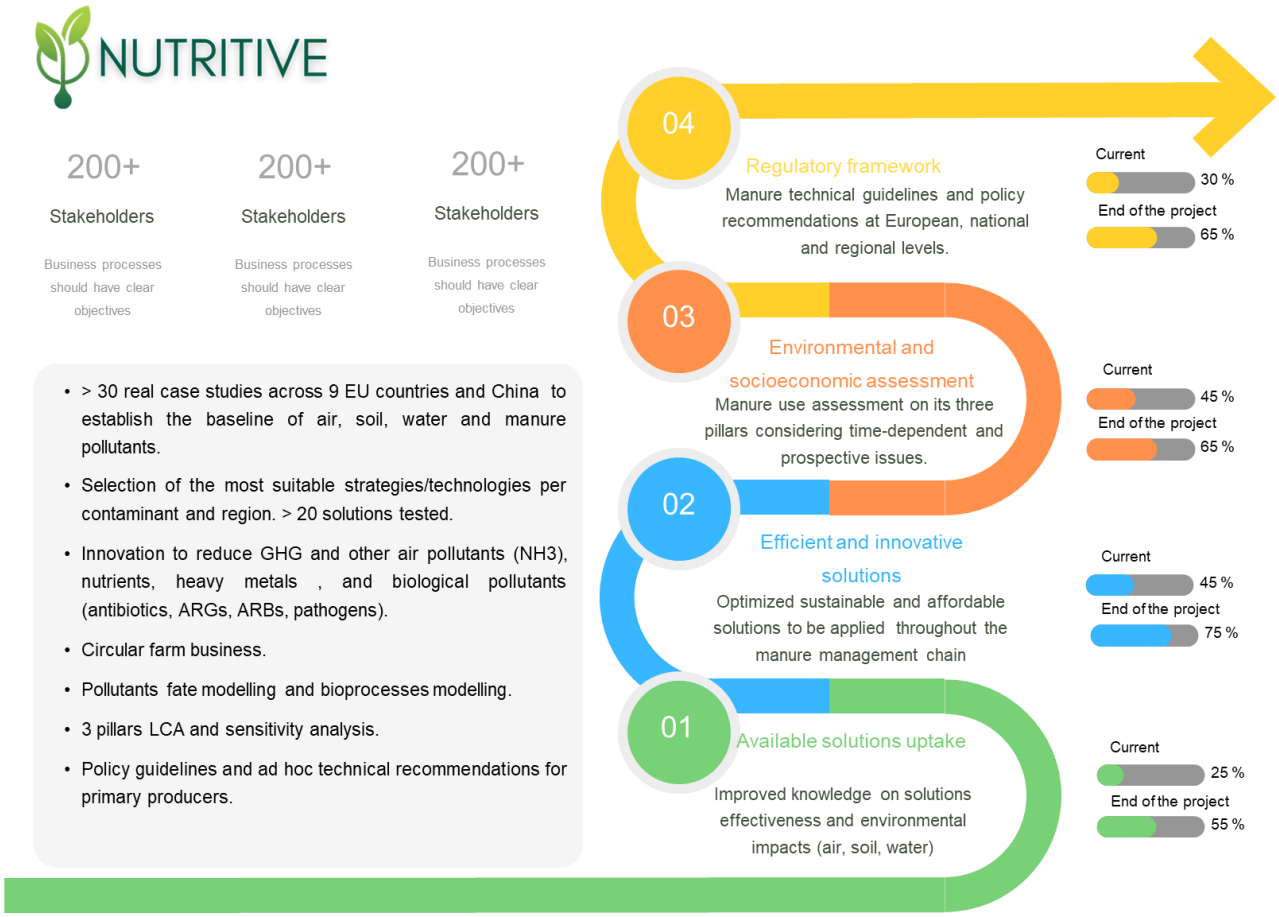


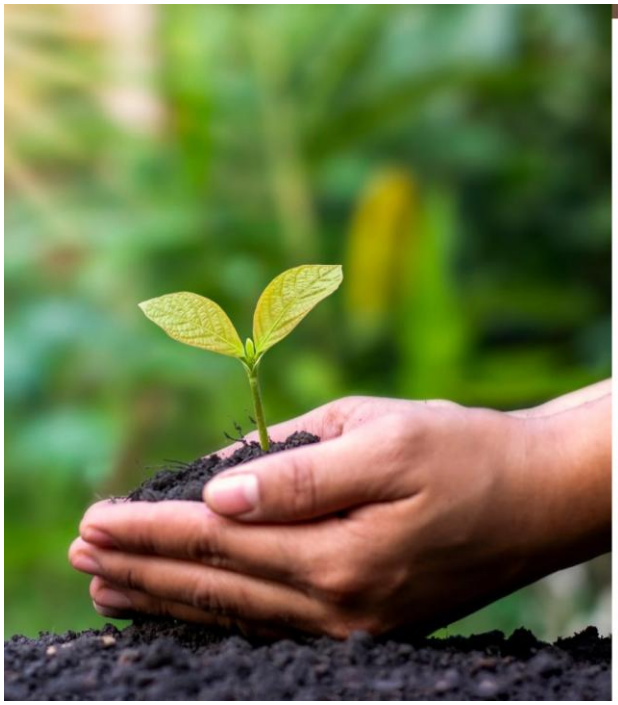
Figure 2. NUTRITIVE overview.

2. Mid-term report on pollutant emission

All deliverables D1.3 , D1.5, D1.7 and D1.9 are bundled into one presentation in cooperation with all the WP1 partners, which was presented during the M12 meeting in Turin. This table provides an overview of which deliverable to be found on which dia slides.

Deliverable 1.3	Air pollutants	Dia 10 - 12
Deliverable 1.5	Manure pollutants	Dia 13 - 15 Dia 19 -21
Deliverable 1.7	Soil pollutants	Dia 13 - 15 Dia 22 - 23
Deliverable 1.9	Water pollutants	Dia 13 – 15 Dia 16 - 18

Dia 1



ILVO
Flanders research institute for agriculture, fisheries and food

WP1: Up to date inventory

NUTRITIVE

Clean environment and zero pollution
(HORIZON-CL6-2023-ZEROPOLLUTION-02)

Dia 2

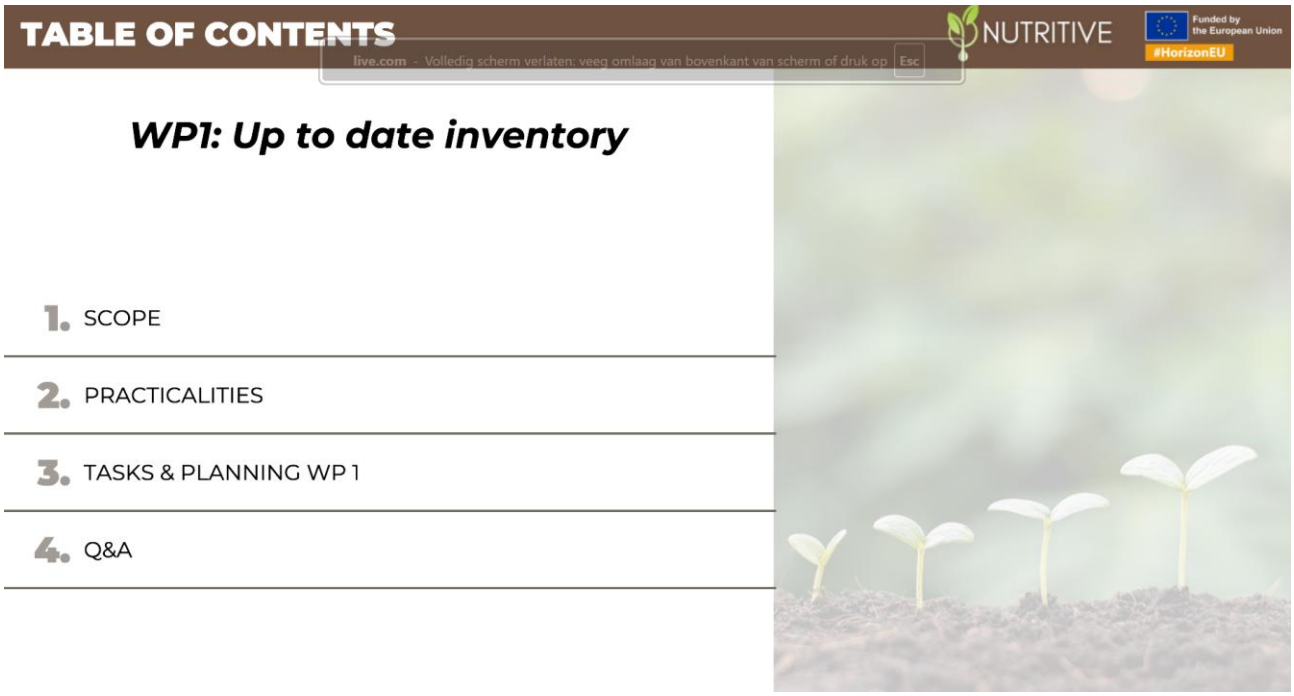
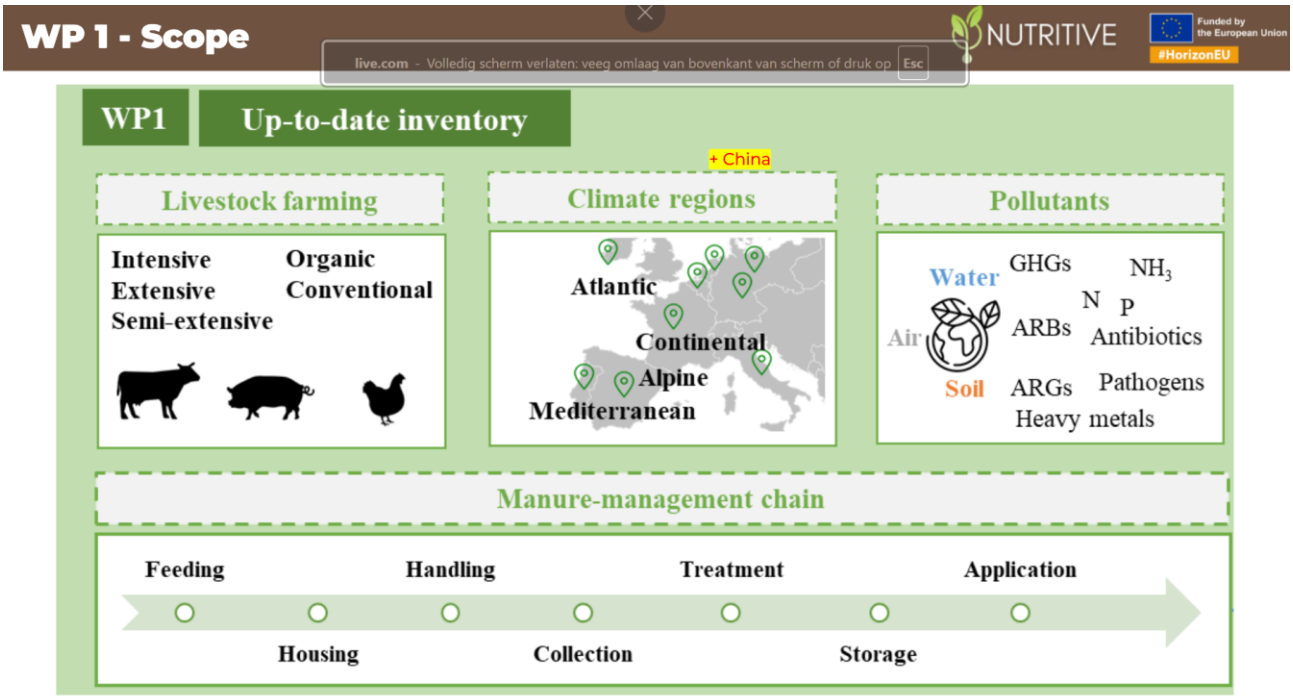


TABLE OF CONTENTS
NUTRITIVE
Funded by the European Union
#HorizonEU
live.com - Volledig scherm verlaten: veeg omlaag van bovenkant van scherm of druk op Esc
WP1: Up to date inventory
1. SCOPE
2. PRACTICALITIES
3. TASKS & PLANNING WP 1
4. Q&A

Dia 3


WP 1 - Scope
live.com - Volledig scherm verlaten: veeg omlaag van bovenkant van scherm of druk op Esc
NUTRITIVE
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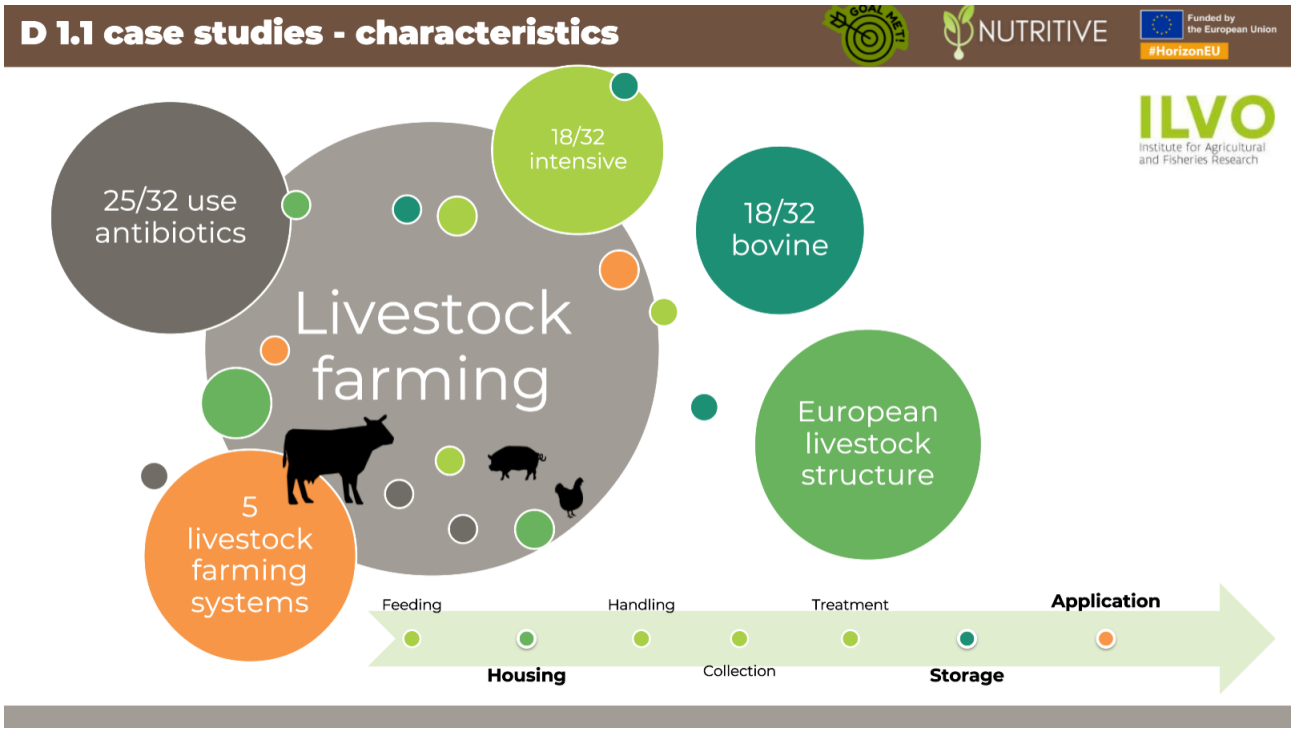
WP1
Up-to-date inventory
+ China
Livestock farming
Intensive
Extensive
Semi-extensive
Organic
Conventional
Climate regions
Atlantic
Continental
Alpine
Mediterranean
Pollutants
Water
Air
Soil
GHGs
NH_3
N
P
ARBs
Antibiotics
ARGs
Pathogens
Heavy metals
Manure-management chain
Feeding
Housing
Handling
Collection
Treatment
Storage
Application

Dia 4

	Milestones
M 1.1 (M3)	Definitive list of selected case study farms (Report on selected farms (D1.1))
M 1.2 (M24)	Inventory on manure pollutants (Data on pollutants assessed in air, soil, water and manure (D1.4, D1.6, D1.8, D1.10))

MID		Deliverable	Description
	D1.1	Case studies	Report on final case studies selected
	D1.2	Protocol on samples management	Harmonized procedures for soil, water and manure samples management and analysis
D1.3	D1.4	Air pollutants	Emission calculations regarding air pollutants assessment
D1.5	D1.6	Manure pollutants	Data on pollutants measured in manure for the different case study farms
D1.7	D1.8	Soil pollutants	Data on pollutants measured in soil for the different case study farms
D1.9	D1.10	Water pollutants	Data on pollutants measured in water for the different case study farms

Dia 5


D 1.1 case studies - characteristics
NUTRITIVE
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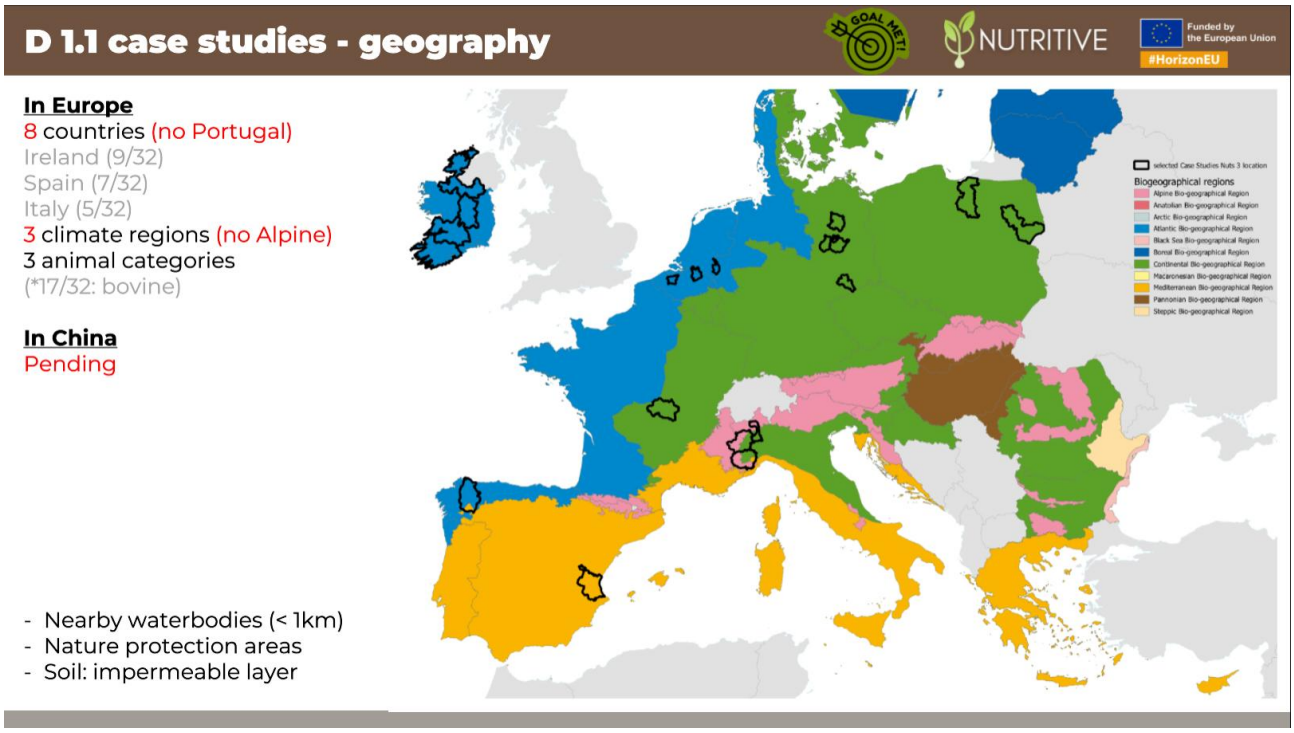
ILVO
Institute for Agricultural and Fisheries Research
25/32 use antibiotics
18/32 intensive
18/32 bovine
Livestock farming
European livestock structure
5 livestock farming systems
Feeding
Handling
Treatment
Application
Housing
Collection
Storage

Dia 6


D 1.1 case studies - geography
GOAL MET!
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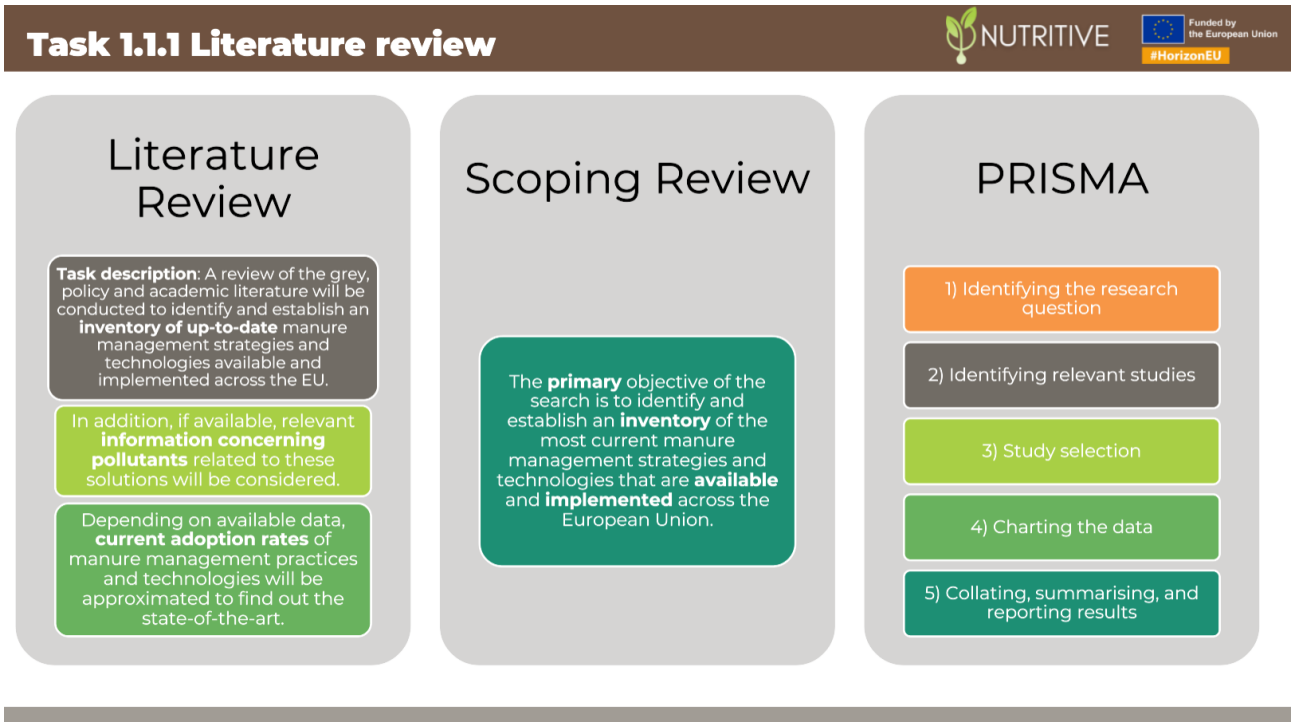
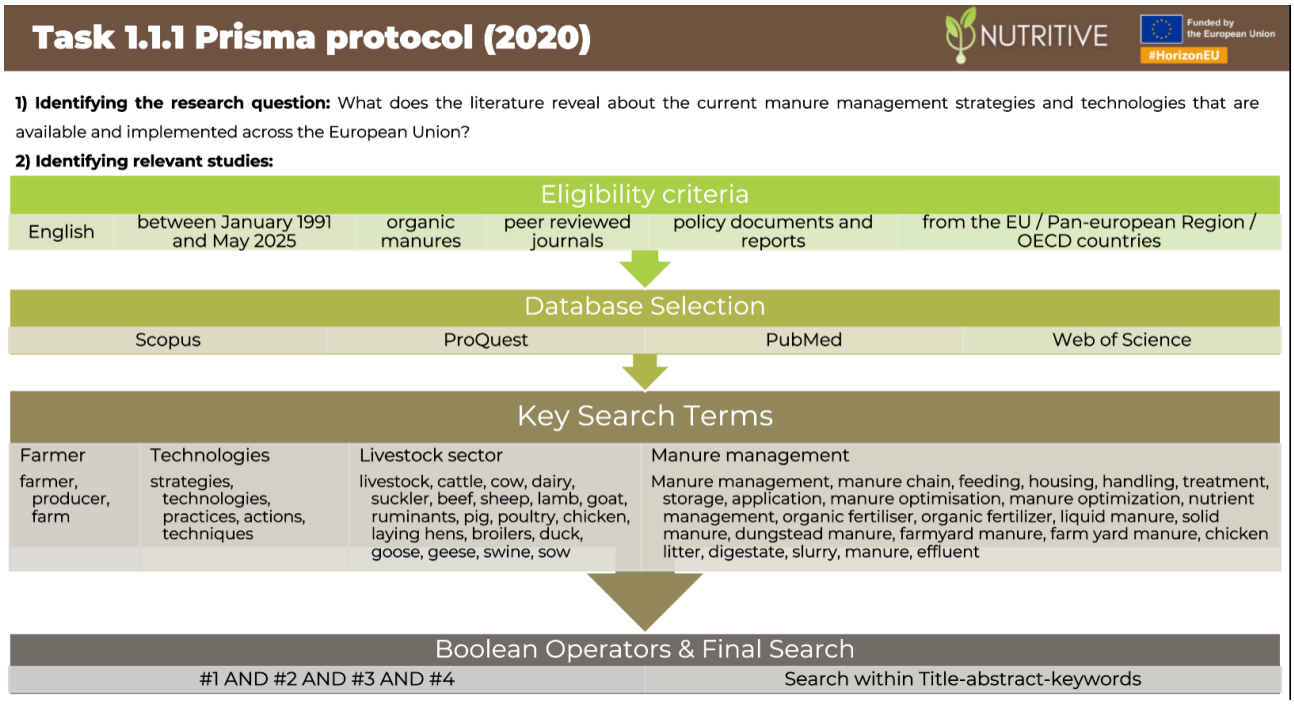
In Europe
8 countries (no Portugal)
Ireland (9/32)
Spain (7/32)
Italy (5/32)
3 climate regions (no Alpine)
3 animal categories
(*17/32: bovine)
In China
Pending
- Nearby waterbodies (< 1km)
- Nature protection areas
- Soil: impermeable layer
Biogeographical regions

Dia 7



Task description: A review of the grey, policy and academic literature will be conducted to identify and establish an inventory of up-to-date manure management strategies and technologies available and implemented across the EU. In addition, if available, relevant information concerning pollutants related to these solutions will be considered. Depending on available data, current adoption rates of manure management practices and technologies will be approximated to find out the state-of-the-art.

Dia 8


Task 1.1.1 Prisma protocol (2020)
NUTRITIVE
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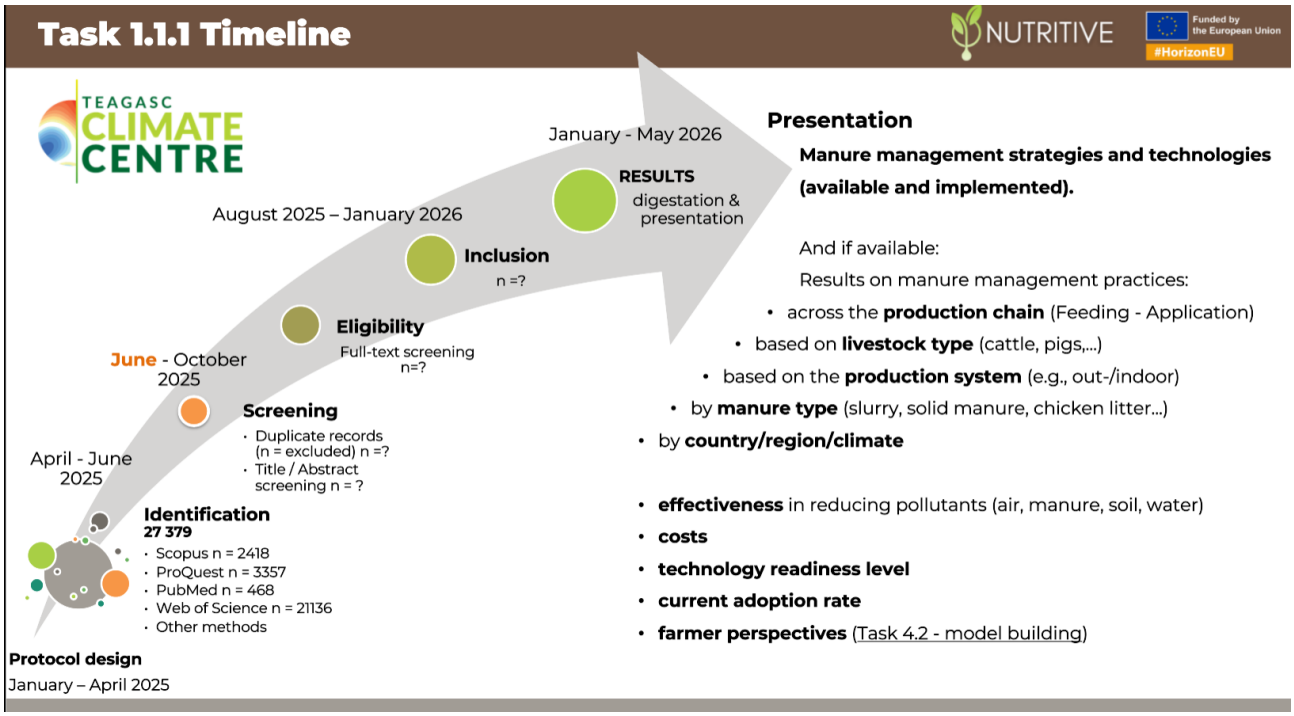
1) Identifying the research question: What does the literature reveal about the current manure management strategies and technologies that are available and implemented across the European Union?
2) Identifying relevant studies:
Eligibility criteria
English
between January 1991 and May 2025
organic manures
peer reviewed journals
policy documents and reports
from the EU / Pan-european Region / OECD countries
Database Selection
Scopus
ProQuest
PubMed
Web of Science
Key Search Terms
Farmer
farmer, producer, farm
Technologies
strategies, technologies, practices, actions, techniques
Livestock sector
livestock, cattle, cow, dairy, suckler, beef, sheep, lamb, goat, ruminants, pig, poultry, chicken, laying hens, broilers, duck, goose, geese, swine, sow
Manure management
Manure management, manure chain, feeding, housing, handling, treatment, storage, application, manure optimisation, manure optimization, nutrient management, organic fertiliser, organic fertilizer, liquid manure, solid manure, dungstead manure, farmyard manure, farm yard manure, chicken litter, digestate, slurry, manure, effluent
Boolean Operators & Final Search
#1 AND #2 AND #3 AND #4
Search within Title-abstract-keywords

Dia 9


Task 1.1.1 Timeline
NUTRITIVE
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#HorizonEU
TEAGASC CLIMATE CENTRE
January - May 2026
RESULTS
digestation & presentation
August 2025 – January 2026
Inclusion
n =?
Eligibility
Full-text screening n=?
June - October 2025
Screening
Duplicate records (n = excluded) n =?
Title / Abstract screening n = ?
April - June 2025
Identification
27 379
Scopus n = 2418
ProQuest n = 3357
PubMed n = 468
Web of Science n = 21136
Other methods
Protocol design
January – April 2025
Presentation
Manure management strategies and technologies (available and implemented).
And if available:
Results on manure management practices:
across the production chain (Feeding - Application)
based on livestock type (cattle, pigs,...)
based on the production system (e.g., out-/indoor)
by manure type (slurry, solid manure, chicken litter...)
by country/region/climate
effectiveness in reducing pollutants (air, manure, soil, water)
costs
technology readiness level
current adoption rate
farmer perspectives (Task 4.2 - model building)

Dia 10

Task 1.3 air pollutant assessment: progress

Evaluation of mitigation options and their combinations based on the calculated emissions

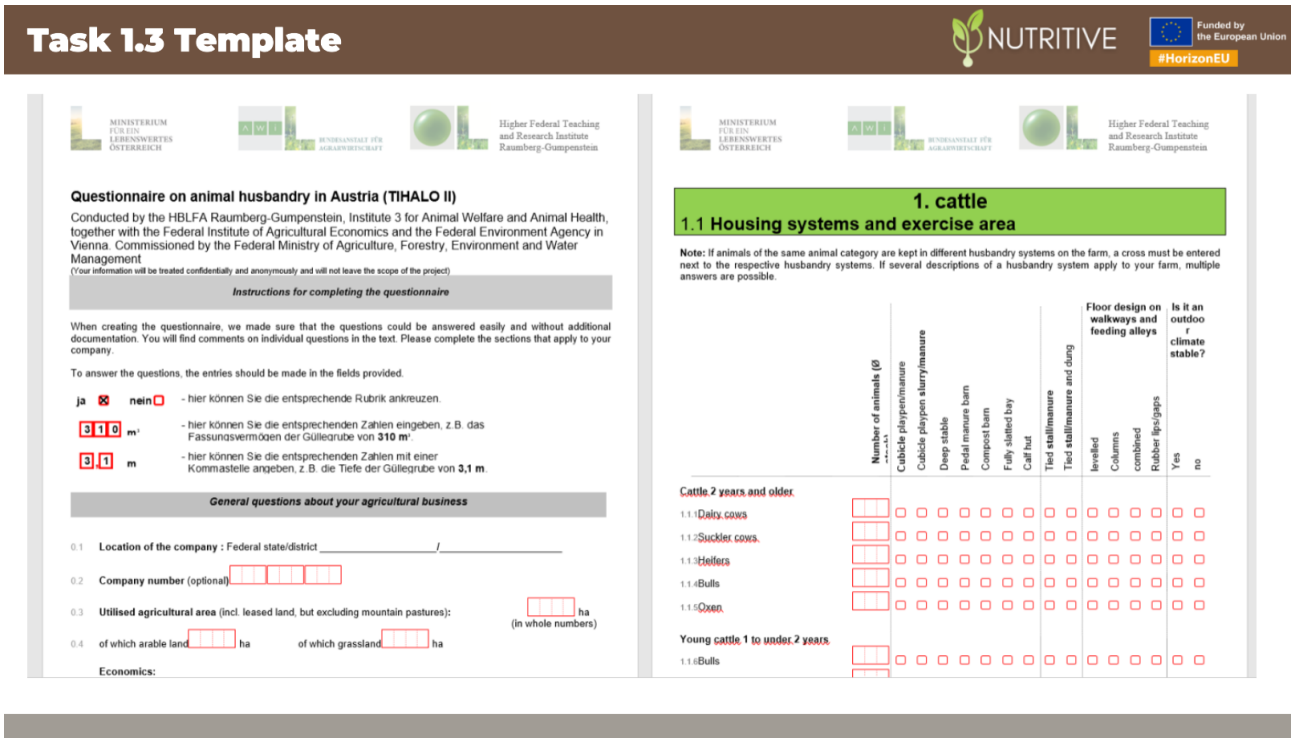
Baseline and mitigated scenarios will be compared with national averages from GHG and NH3 inventory reports.

- Different option of data collection methodology and tools were considered
- Data collection template:
  - MilKey template>>>too extensive
  - **Template from Austria**
    - Used for Austrian and Swiss national emission inventory reporting
    - Proven and tested methodology
    - Survey that can easily be filled in together with the farmer
    - Includes all livestock types considered in NUTRITIVE
    - Flexible model for emission and emission mitigation calculation

ATB Leibniz-Institut für Agrartechnik und Bioökonomie

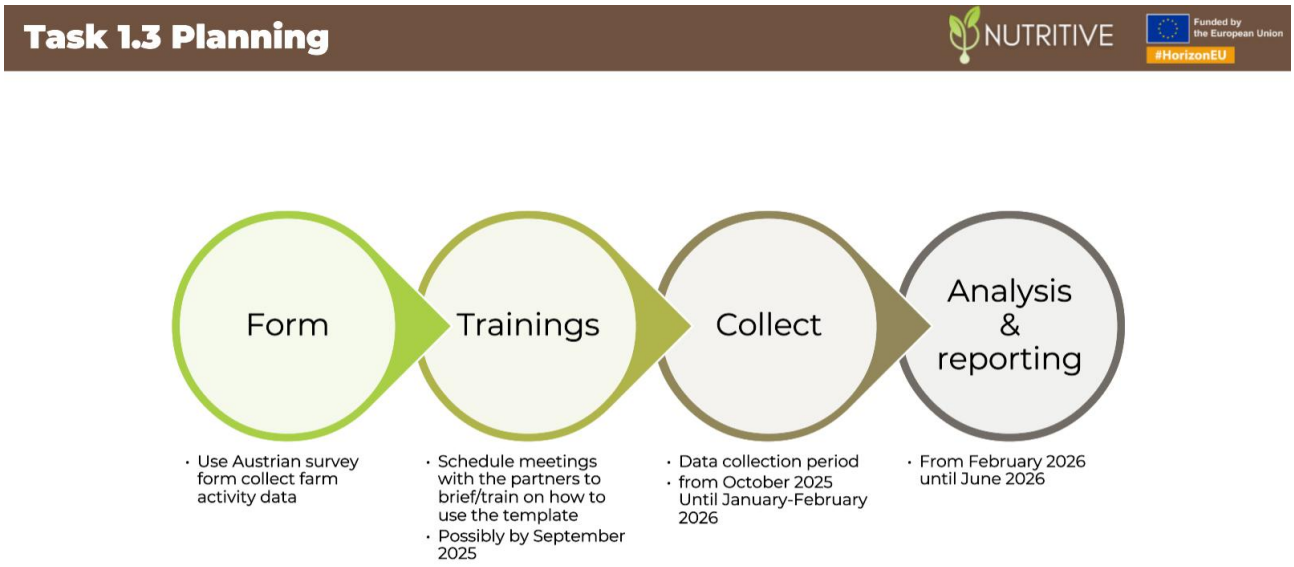
Deliverable 1.3

Dia 11



Deliverable 1.3

Dia 12



Deliverable 1.3

Dia 13

Task 1.4 – 1.5 – 1.6: Pollutant assessment

Samples will be sent to ILVO or USC where the analysis will be carried out:

Sample	Antibiotics	Antibiotic resistance genes	Pathogens	Antibiotic resistant bacteria	Heavy metals	Task Leader
Manure	ILVO	ILVO	Self-reliant	Self-reliant	Self-reliant	STA
Soil	ILVO	ILVO	ILVO	ILVO	ILVO	ILVO
Water	USC	USC	Self-reliant	Self-reliant	Self-reliant	USC

! Self-reliant = Case-study is responsible for own analysis following requirements in SOP

→ *In some cases:* STA will do additional manure analyses, USC will do additional water analyses

Regarding
timeline,
sampling,
storage,
shipment procedures:

D1.2 + reach out to task leaders for consultation

Manure: a.scarlata@staengineering.it

Soil: laurens.tuts@ilvo.vlaanderen.be

Water: marta.carballa@usc.es

Deliverable 1.5

Deliverable 1.7

Deliverable 1.9

Dia 14

D1.2 Protocol pollutant assessment

- Harmonized protocol for soil, water and manure samples management and analysis (**Deliverable D1.2**)
  --> Nutritive-cloud

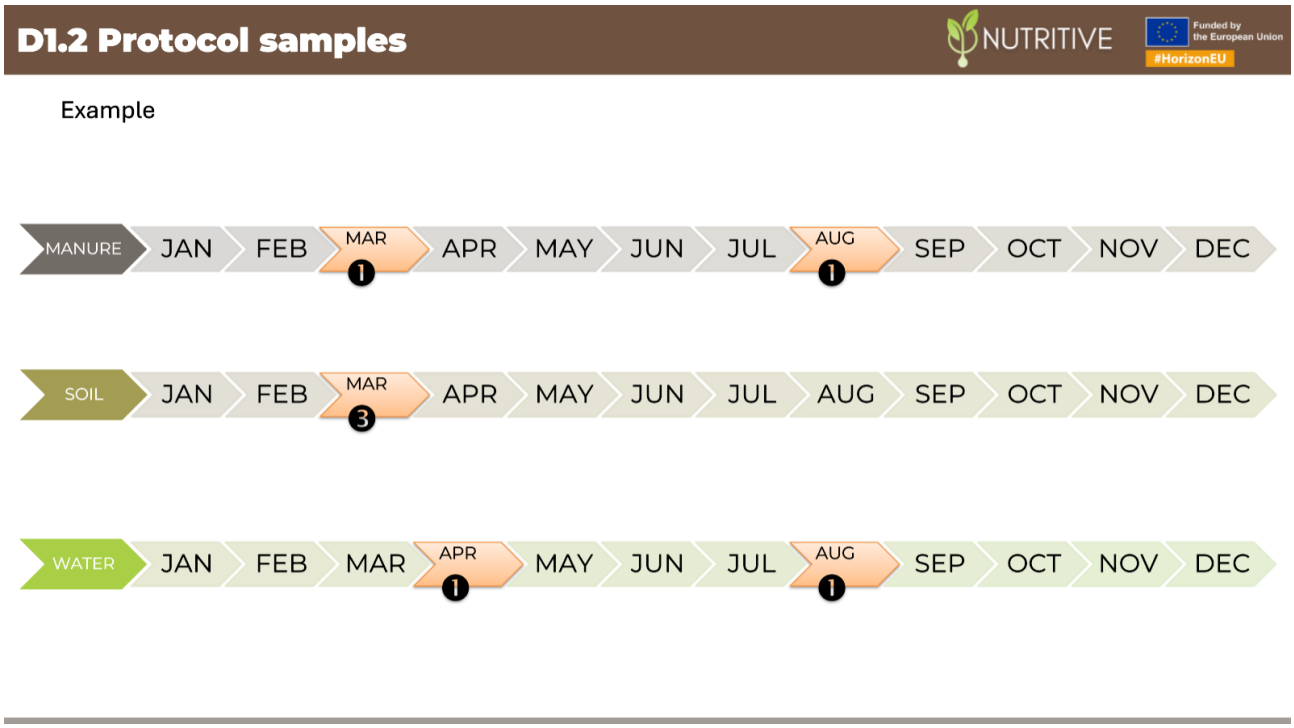
- Target Pollutants
  - Antibiotic residues
  - Antibiotic resistance genes
  - Pathogens
  - Antibiotic resistant bacteria
  - Heavy metals

- Samples **Sampling characteristics** (when, how many?)
  - **Manure** — All manure used for fertilization in 2 periods (dry and wet)
  - **Soil** — 3 samples: before (T1), immediately after (T2), and 2 to 3 weeks after fertilization (T3) (dry or wet period)
  - **Water** — Surface water sample 3 to 4 weeks after application of manure on the soil in 2 different periods (dry and wet)

Specific timeline depends on the case study

Deliverable 1.5
Deliverable 1.7
Deliverable 1.9

Dia 15



Deliverable 1.5
Deliverable 1.7
Deliverable 1.9

Dia 16

Task 1.6 Water pollutants assessment

Antibiotic residues

Sulfonamides
- Sulfadoxine
- Sulfadiazine
- Sulfamethazine
- Sulfisoxazole
- Sulfamethoxazole

Tetracyclines
- Chlortetracycline hydrochloride
- Doxycycline hyclate
- Oxytetracycline
- Tetracycline

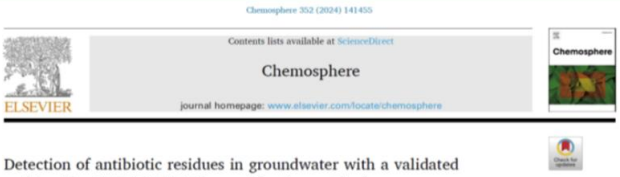
Macrolides
- Clarithromycin
- Azithromycin
- Roxithromycin
- Erythromycin

Diaminopyrimidines
- Trimethoprim

β-lactam
- Cefalexin

Fluoroquinolones
- Flumequine
- Ciprofloxacin

Lincosamides
- Lincomycin hydrochloride


Chemosphere 352 (2024) 141455

Contents lists available at ScienceDirect

Chemosphere

journal homepage: www.elsevier.com/locate/chemosphere

Detection of antibiotic residues in groundwater with a validated multiresidue UHPLC-MS/MS quantification method

Laurens Tuts [a,b,*], Geertrui Rasschaert [a], Marc Heyndrickx [a,c], Nico Boon [b], Ralf Eppinger [d], Ilse Becue [a]

Deliverable 1.9

Dia 17

Task 1.6 Water pollutants assessment

Water samples received so far

Ghent (Belgium) - ILVO

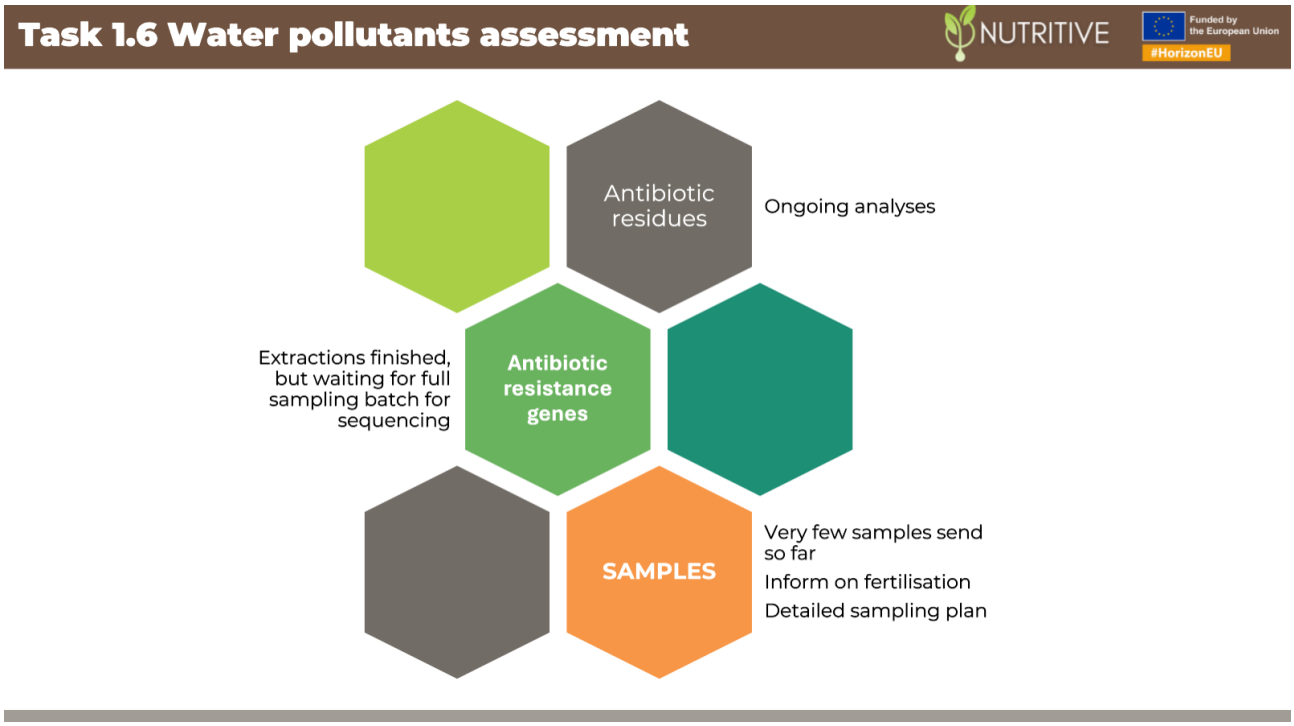
1. CS20, 18/04/2025
2. CS21, 07/04/2025

Galicia (Spain) - MEDRAR

1. Sat as Pandas: Cow 1.1-23, Vilalba (Lugo), 04/06/2025
2. Ouiteiro SC: Cow 1.2-25, Chantada (Lugo), 04/06/2025
3. A Cernada: Cow 1.3-33, Palas de Rei (Lugo), 04/06/2025
4. Buzabella: Cow 1.4-36, Castro de Rei (lugo), 04/06/2025
5. Labradela: Pig 1.5-24, Cervo (Lugo), 04/06/2025
6. Lucía Váquez Calviño: Poultry 1.6-22, Chantada (Lugo), 04/06/2025

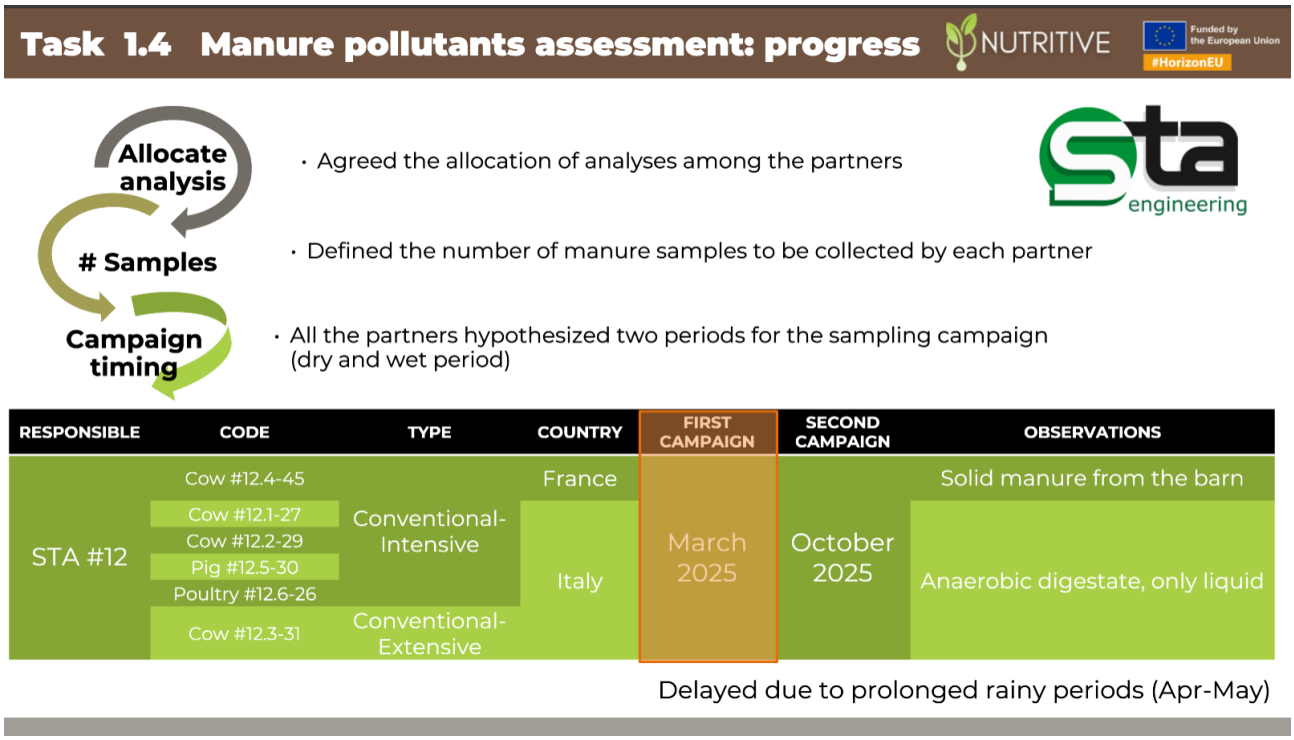
Deliverable 1.9

Dia 18



Deliverable 1.9

Dia 19



What have we done in the past months:

Agreed the allocation of analyses among the partners

Defined the number of manure samples to be collected by each partner

All the partners hypothesized two periods for the sampling campaign (dry and wet)

Deliverable 1.5

Dia 20

Task 1.4 Present work

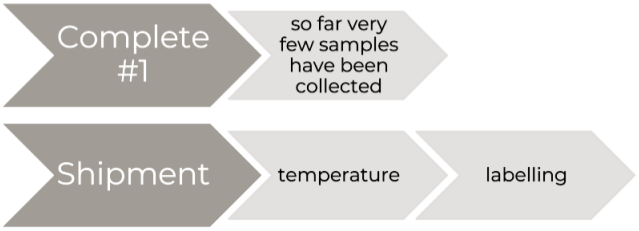
- Collecting (and receiving) samples from #1 campaign

RESPONSIBLE	CODE	TYPE	COUNTRY	SAMPLING	OBSERVATIONS
STA #12	Cow #12.4-45		France	To be collected	Solid manure from the barn
	Cow #12.1-27	Conventional-Intensive	Italy	29/04/2025	Anaerobic digestate, only liquid
	Cow #12.2-29			09/04/2025	
	Pig #12.5-30			10/04/2025	
	Poultry #12.6-26			To be replaced?	
	Cow #12.3-31	Conventional-Extensive		11/04/2025	

Issues, replace with organic-extensive cattle case study?

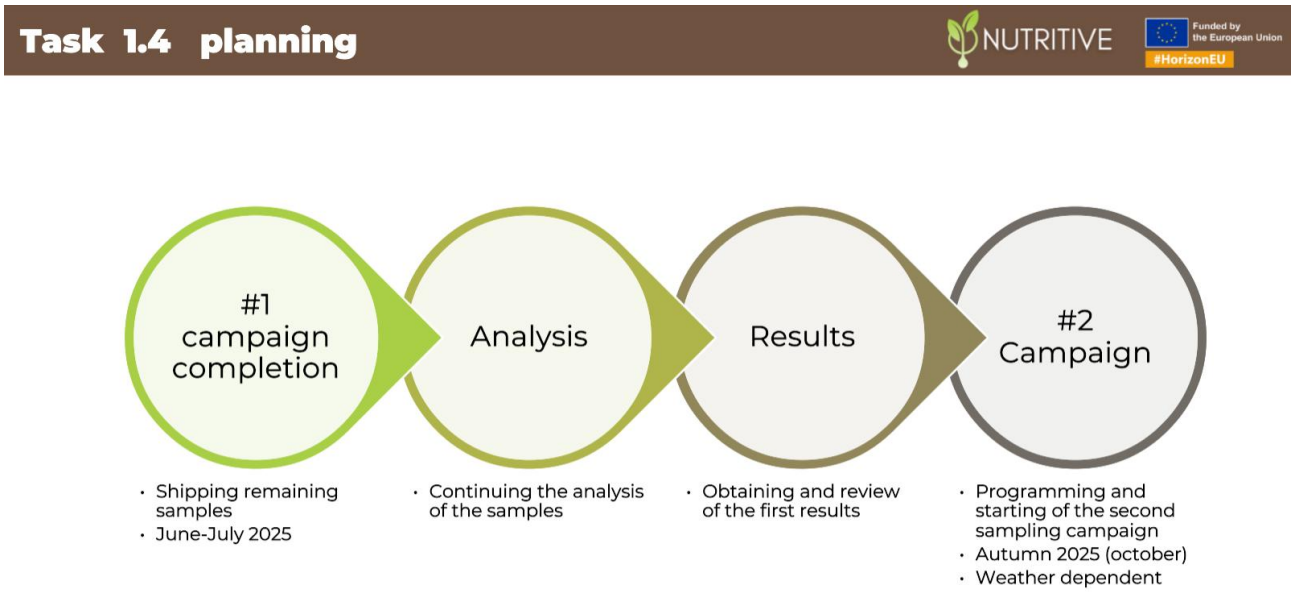
- Analysing (and shipping) samples Example

PARAMETER	MANURE	
	Nº SAMPLES	RESPONSIBLE
PH-CHEM	12	STA
Heavy metals	12	STA
ARBs	12	STA
Pathogens	12	STA
ARGs	12	EV ILVO
Antibiotic residues	12	EV ILVO



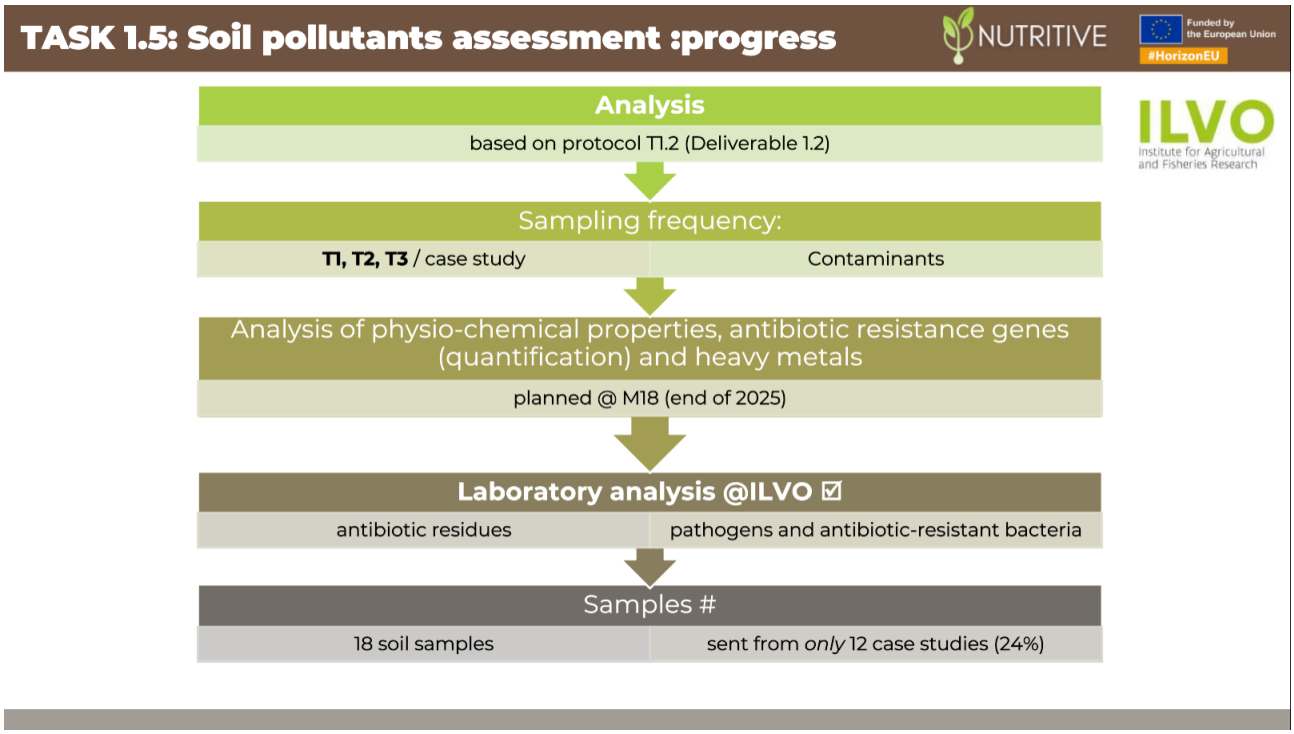
Deliverable 1.5

Dia 21



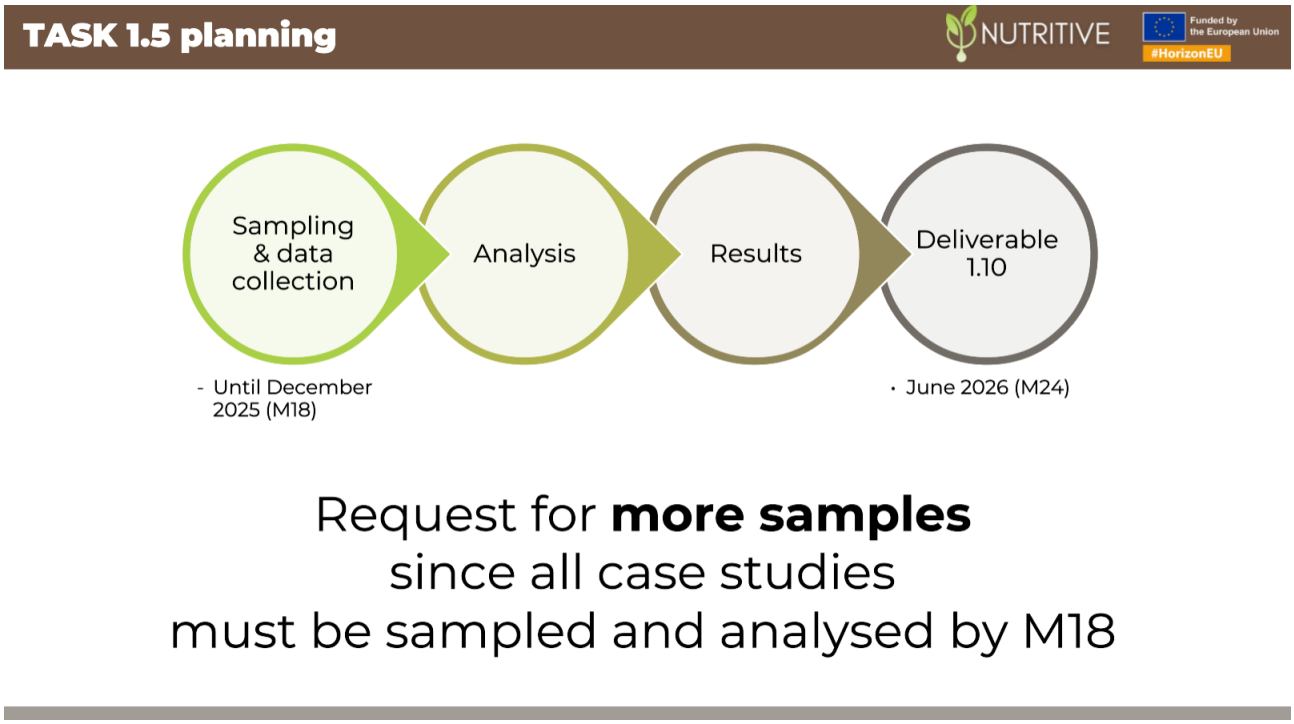
Deliverable 1.5

Dia 22



Deliverable 1.7

Dia 23



Deliverable 1.7

Dia 24

WP1 – Tasks & planning

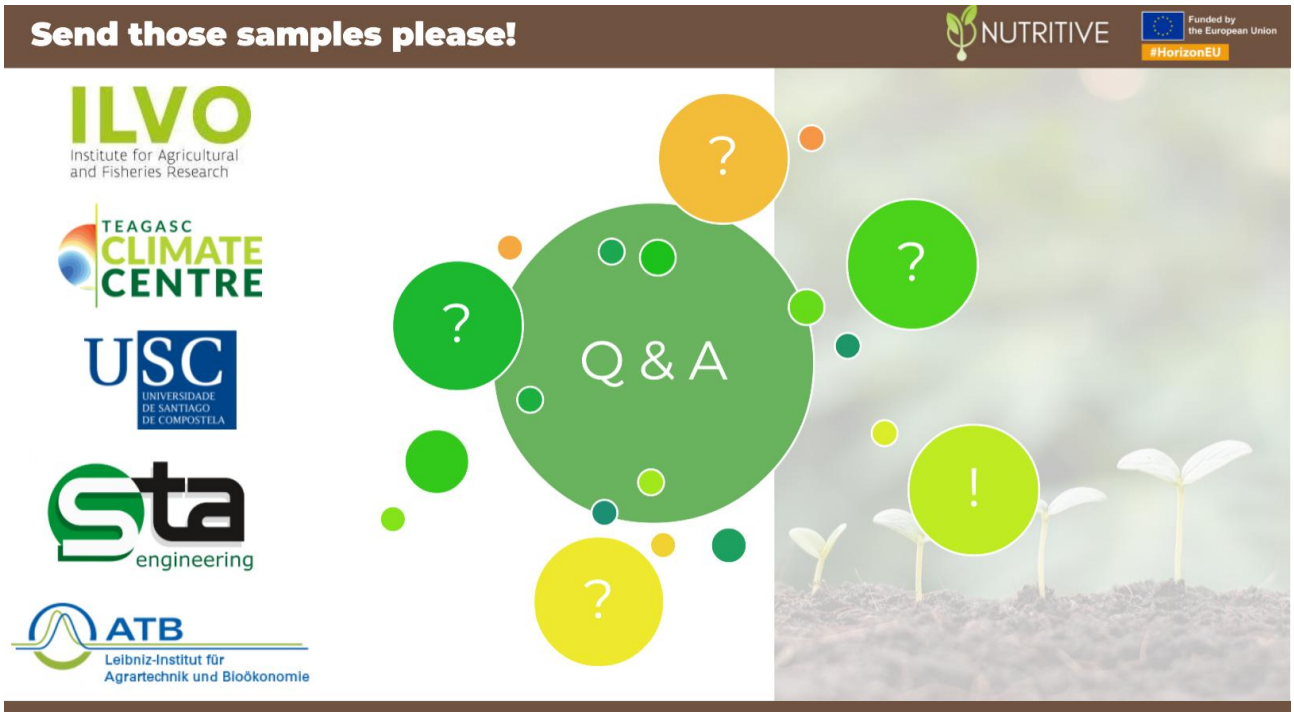
WP1	November 2024	June 2025	July - August 2025	September 2025	November 2025	May 2026
TEAGASC	Subtask 1.1.1 Literature review					
ILVO	Subtask 1.1 case studies selection					
	Task 1.1. Literature review and Case studies definition					
		Task 1.5 Soil pollutants assessment				
USC	Task 1.2 Protocol on samples management					
		Task 1.6 Water pollutants assessment				
STA		Task 1.4 Manure pollutants assessment				
ATB		Task 1.3 Air pollutants assessment				

Survey trainings
Status updates
#2 campaign

	Milestones
M 1.1 (M3)	**Definitive list of selected case study farms (Report on selected farms (D1.1))**
M 1.2 (M24)	Inventory on manure pollutants (Data on pollutants assessed in air, soil, water and manure (D1.3, D1.4, D1.5, D1.6))

		Deliverable	Description
D1.1		**Case studies**	**Report on final case studies selected**
D1.2		**Protocol on samples management**	**Harmonized procedures for soil, water and manure samples management and analysis**
D1.3	D1.4	Air pollutants	Emission calculations regarding air pollutants assessment
D1.5	D1.6	Manure pollutants	Data on pollutants measured in manure for the different case study farms
D1.7	D1.8	Soil pollutants	Data on pollutants measured in soil for the different case study farms
D1.9	D1.10	Water pollutants	Data on pollutants measured in water for the different case study farms

Dia 25


Send those samples please!
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Institute for Agricultural and Fisheries Research
TEAGASC
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engineering
ATB
Leibniz-Institut für Agrartechnik und Bioökonomie
Q & A
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Dia 26

3. Executive Summary

Work Package 1, within the Nutritive project, includes the assessment of manure-derived chemical and biological pollutants and how they transfer between manure, soil, water, and air.

At the time of this mid-term report (M12), efforts have been made regarding air, manure, and soil pollutants. The mid-term report on water pollutants is scheduled for M18. Regarding Task 1.3 (air pollutant assessment), a structured data collection template was introduced to assess air pollutant emissions across the selected case studies, aligned with international emission inventory guidelines. After evaluating different approaches, a template based on the Austrian and Swiss national emission inventory reporting systems was selected. This flexible tool supports emission and mitigation calculations across all livestock types included in the project. In the coming months, project partners will be trained in its use, after which farm-level data collection will begin.

Based on the 32 selected case studies (D1.1) and the protocol established under D1.2, provisions for the sampling and analysis of contaminants were made. It became clear that case study 26 (poultry, Italy) was no longer feasible for sampling. Additionally, not all case studies could deliver manure, soil, and water samples. For example, only manure samples were expected from case study 28 (poultry, Belgium), since poultry manure cannot be used as raw fertilizer in Belgium. Other case studies were not located in the direct neighbourhood of water bodies.

For Tasks 1.4 (manure) and 1.5 (soil), agreements were reached on the allocation of analyses among partners, as well as on the number and timing of samples. The first sampling campaign, initially planned for March 2025, experienced delays in several case studies due to prolonged rainfall *(Ireland)* and logistical and shipment issues. Therefore, samples have been collected from 12 case studies to date. Laboratory analyses on antibiotic residues, antibiotic-resistant bacteria, and pathogens have been conducted for the collected samples, while analyses of antibiotic-resistant genes and physico-chemical properties are pending until sufficient samples are collected.

The limited number of samples available at M12 highlights the urgency of completing and shipping the remaining samples from the first sampling campaign to the designated laboratories. Overall, this work is progressing toward a comprehensive dataset that will support further modelling, life cycle analysis, and the development of practical guidelines and decision-support tools in later tasks of the project.