

Mid-term report on manure pollutant emission

Deliverable D1.5

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 D1.5 – Mid-term report on manure pollutant emission			
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Type	presentation	Dissemination Level	PU-Public
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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 with an explanation regarding missing manure samples.

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Mid-term report on manure pollutant emission

Deliverable 1.5

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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, NO_x) 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).

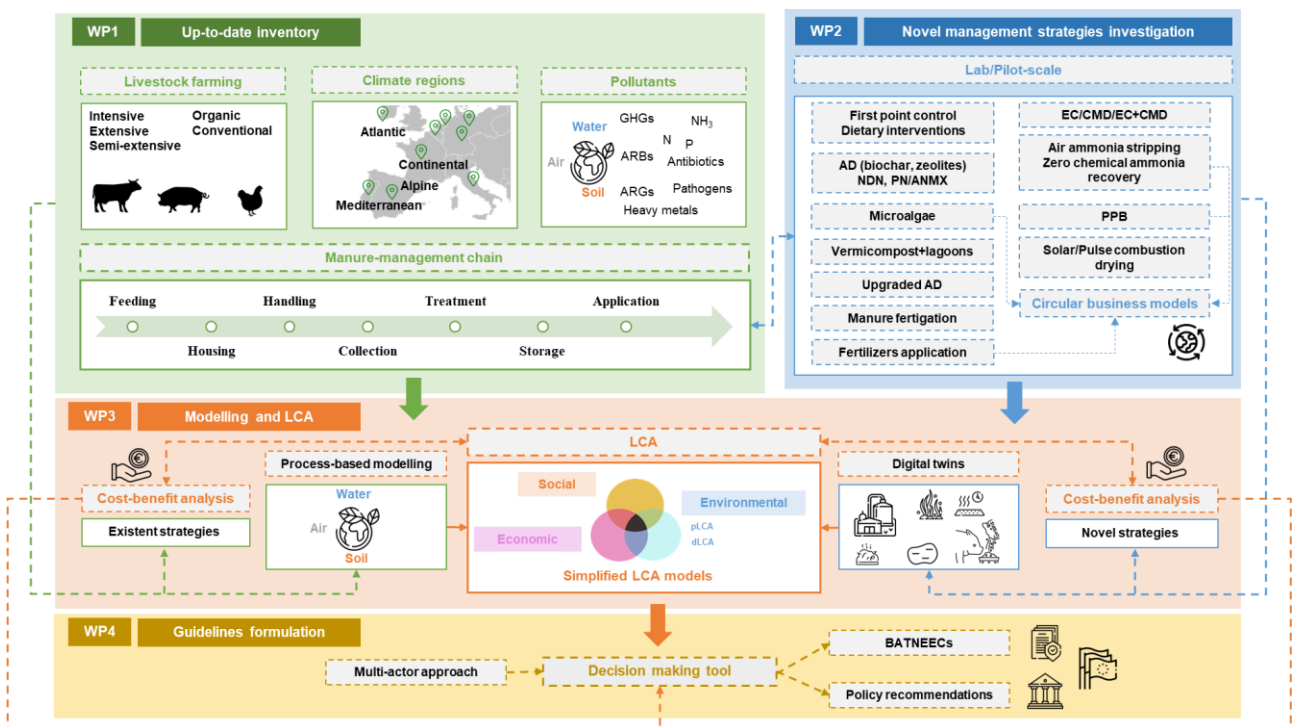


Figure 1. NUTRITIVE methodology.

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.

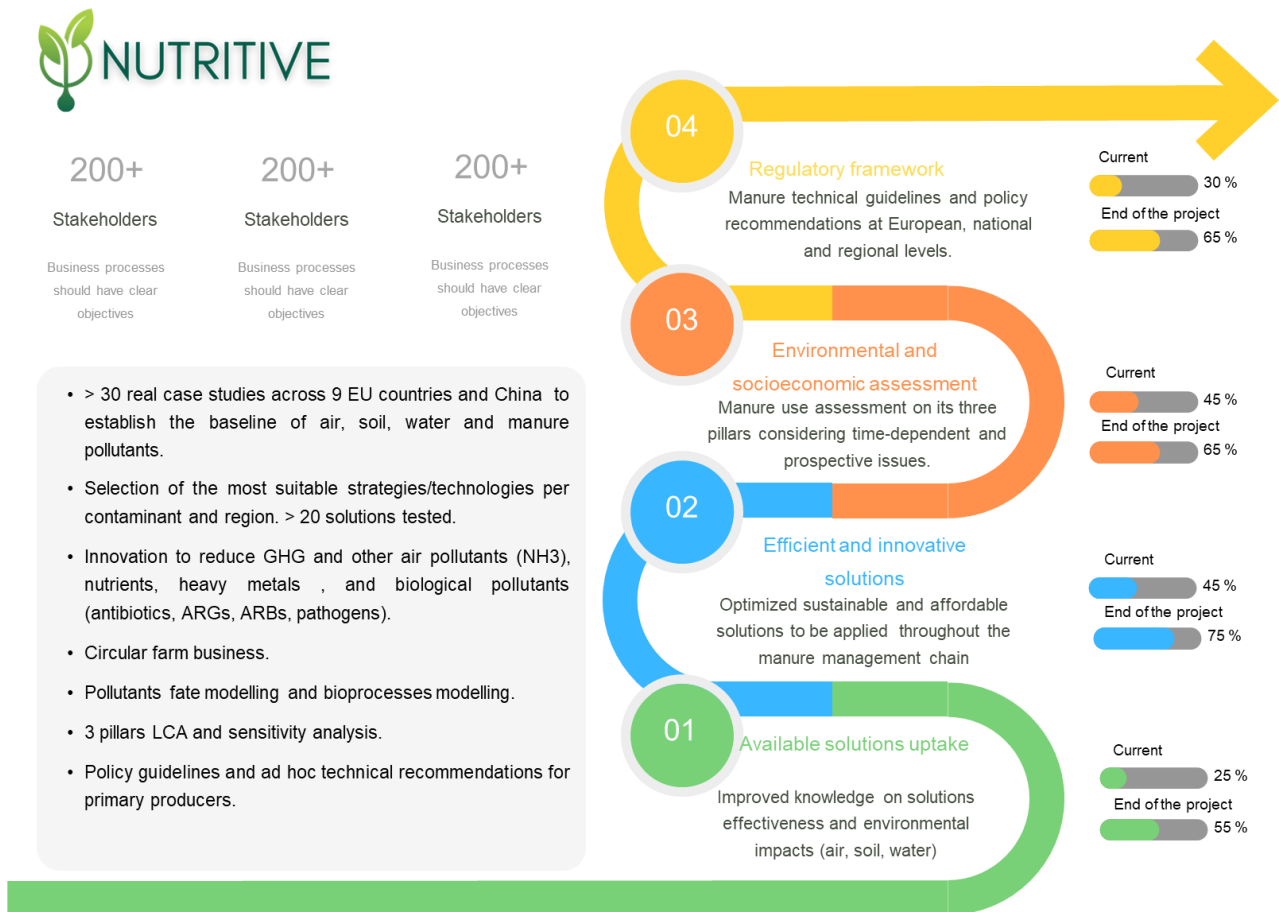


Figure 2. NUTRITIVE overview.

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**WPI: Up to date inventory****NUTRITIVE**Clean environment and zero pollution
(HORIZON-CL6-2023-ZEROPOLLUTION-02)

Dia 2


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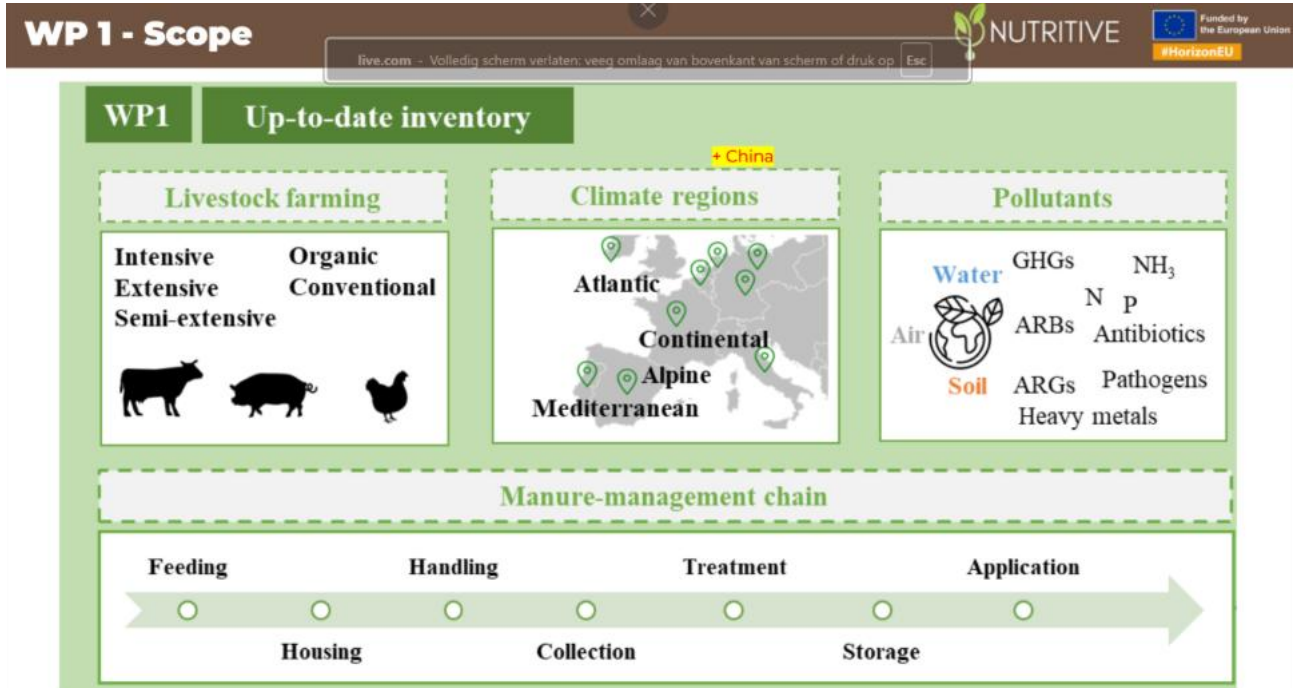
NUTRITIVE
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WP1: Up to date inventory

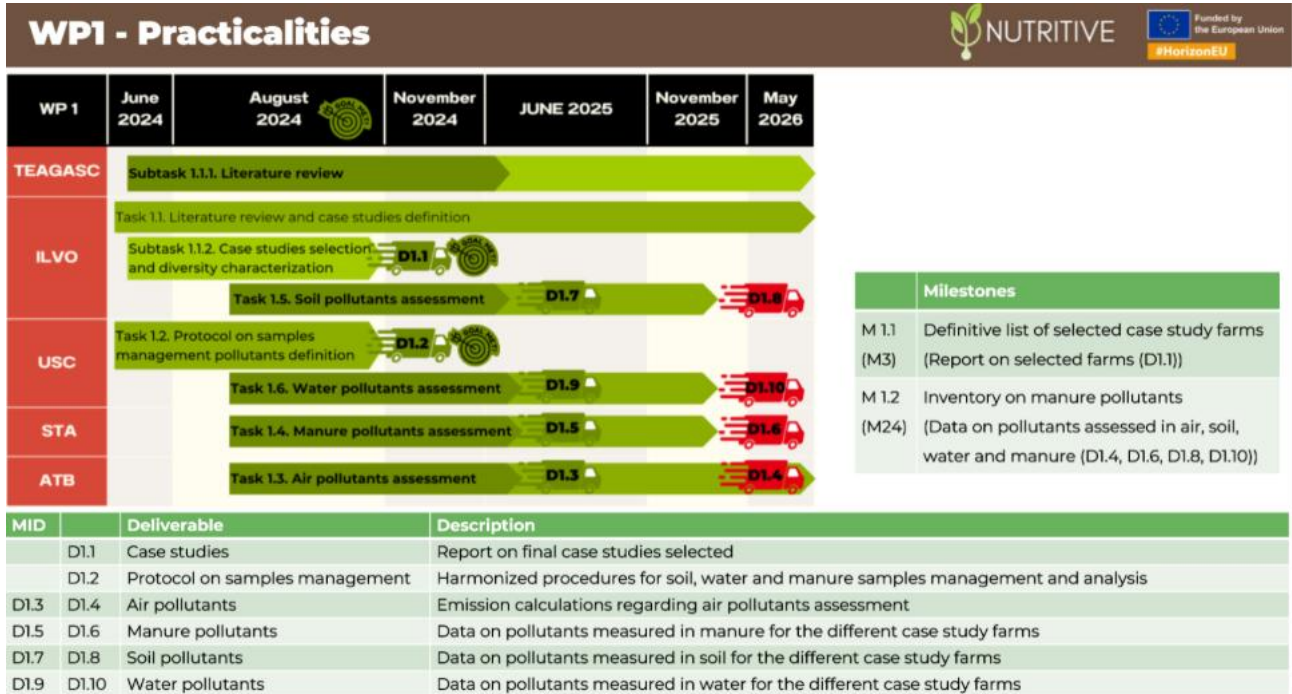
1. SCOPE
2. PRACTICALITIES
3. TASKS & PLANNING WP 1
4. Q&A



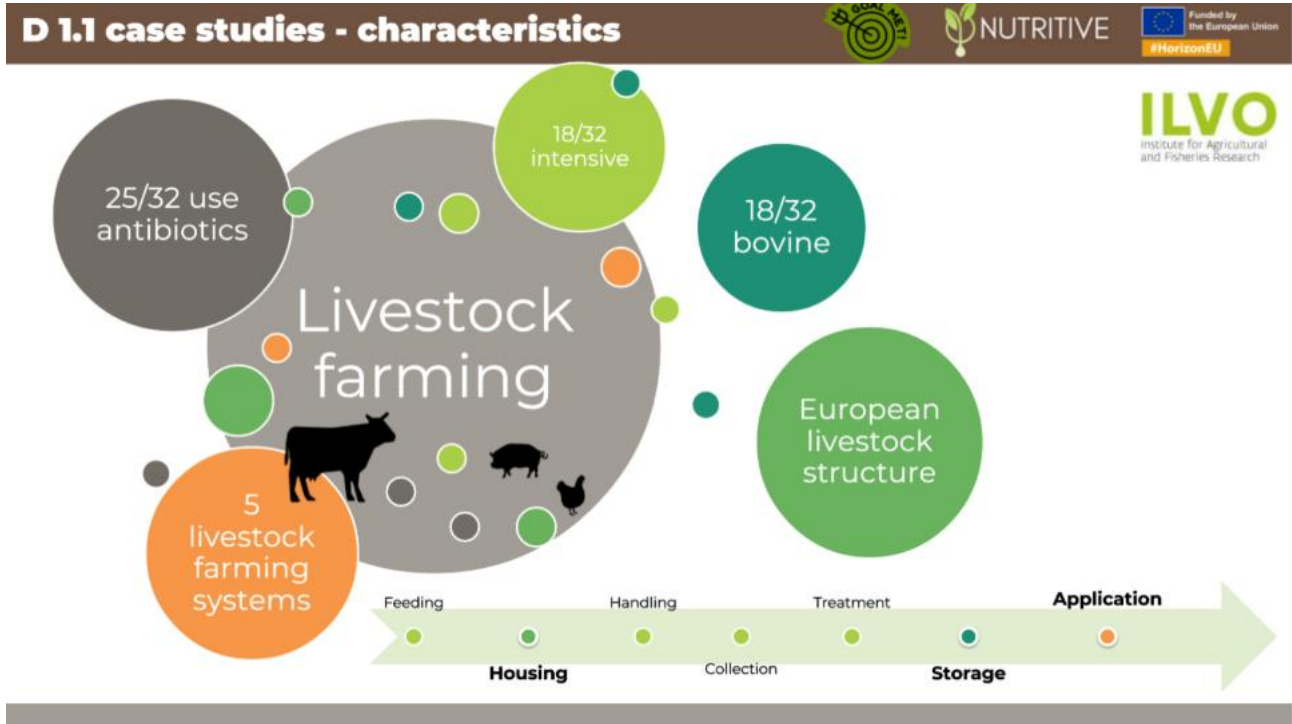
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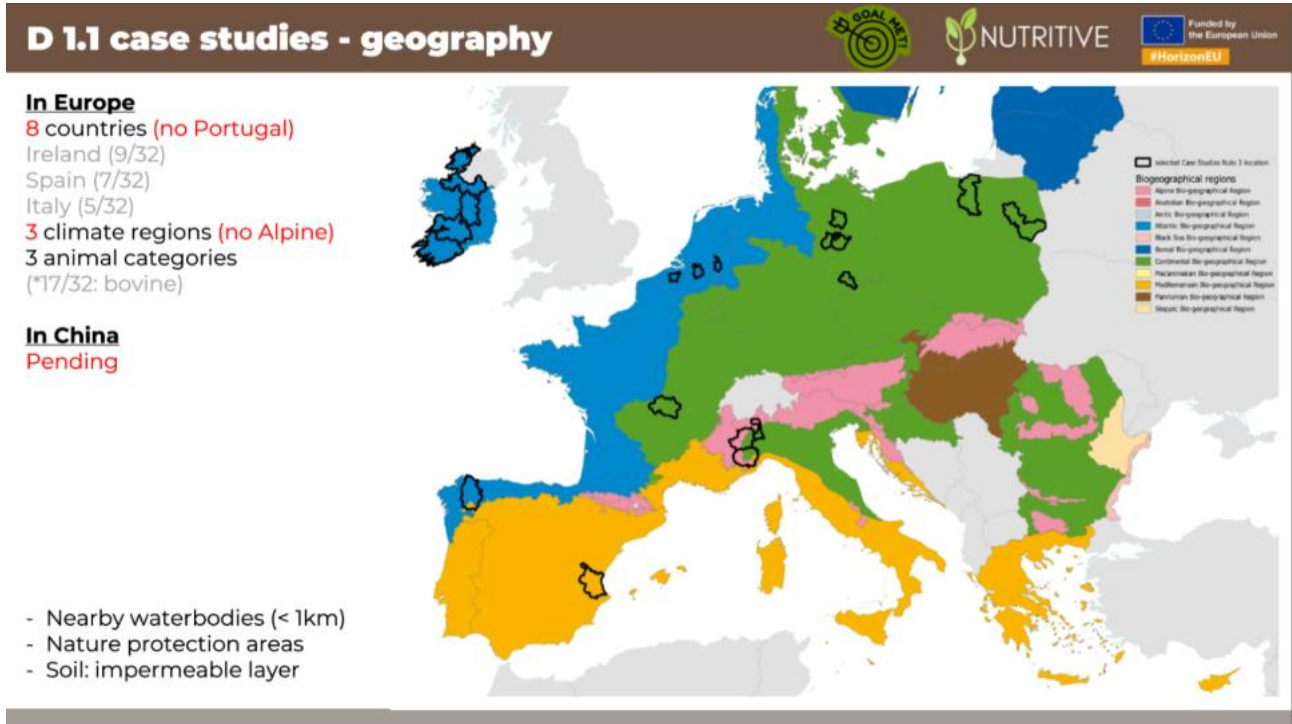
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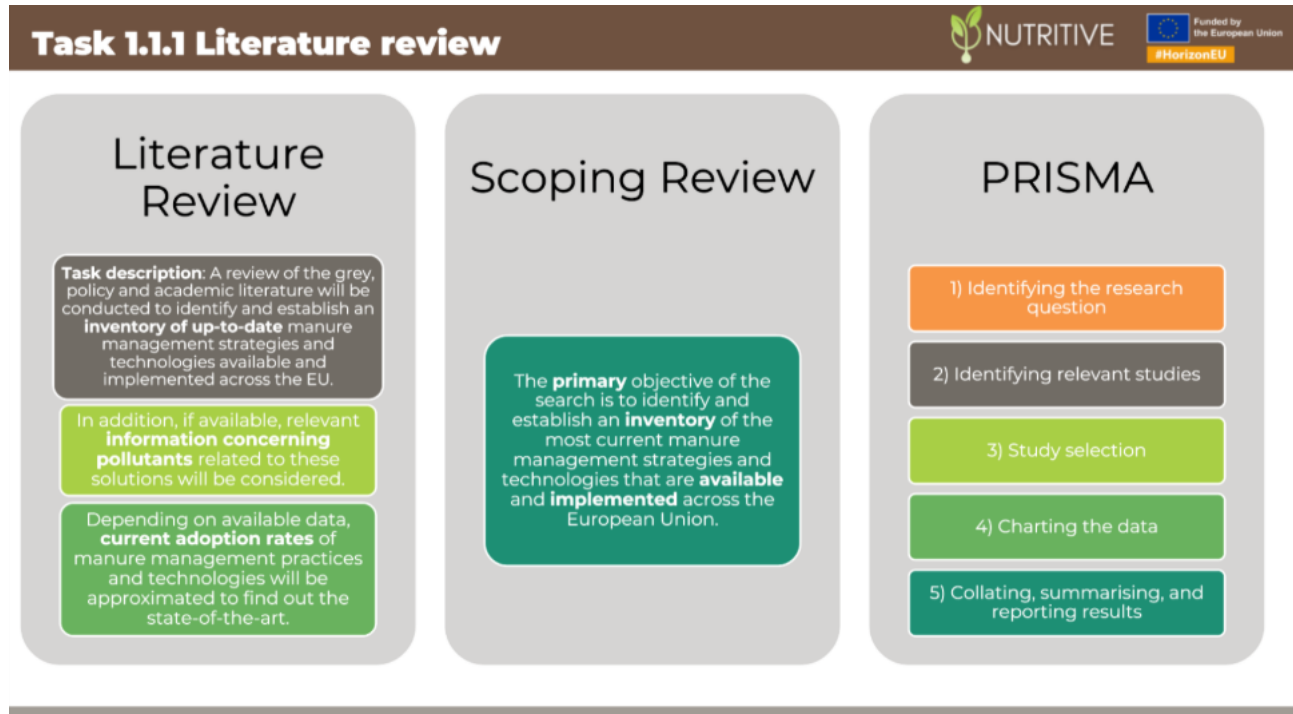
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Dia 6



Dia 7

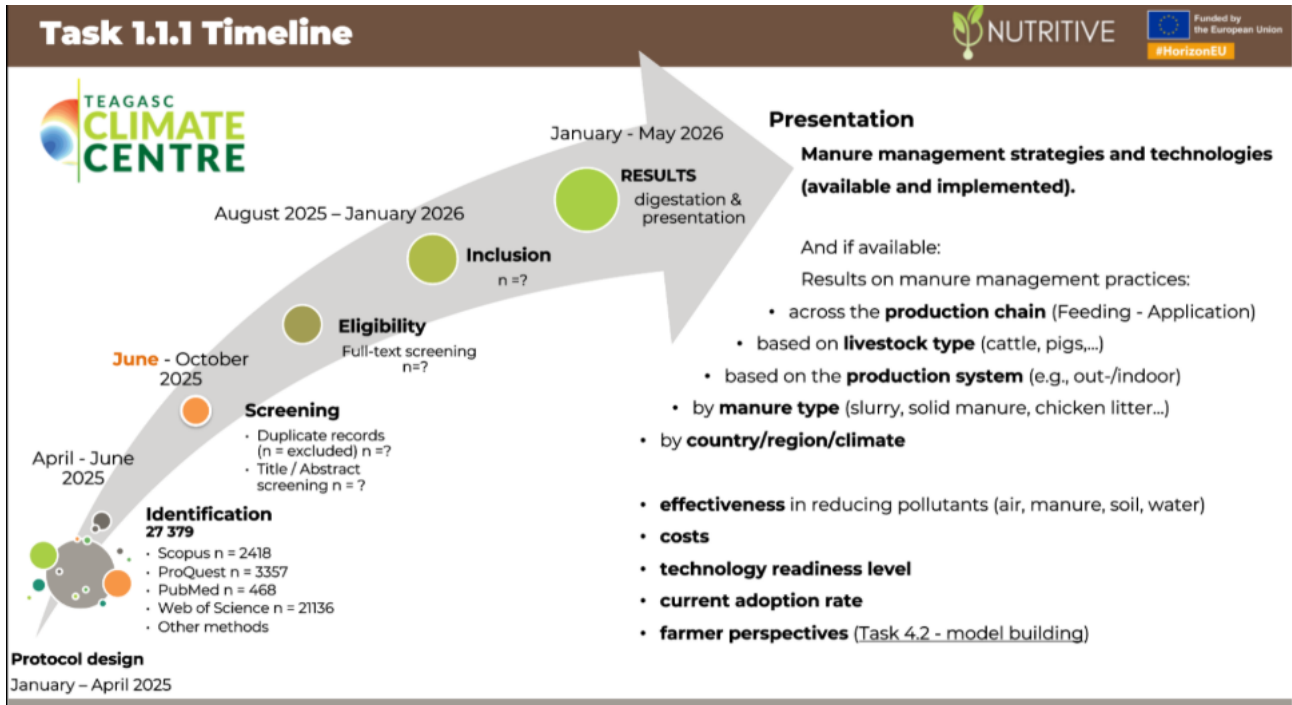


Task description: A review of the grey, policy and academic literature will be conducted to identify and establish an inventory of up-to-date manure management strategies and technologies available and implemented across the EU. In addition, if available, relevant information concerning pollutants related 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



Dia 9



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.

- o Different option of data collection methodology and tools were considered
- o 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

Deliverable 1.3

Dia 11

Task 1.3 Template

Questionnaire on animal husbandry in Austria (TIHALO II)
Conducted by the HBLFA Raumberg-Gumpenstein, Institute 3 for Animal Welfare and Animal Health, together with the Federal Institute of Agricultural Economics and the Federal Environment Agency in Vienna. Commissioned by the Federal Ministry of Agriculture, Forestry, Environment and Water Management.

(Your information will be treated confidentially and anonymously and will not leave the scope of the project)

Instructions for completing the questionnaire

When creating the questionnaire, we made sure that the questions could be answered easily and without additional documentation. You will find comments on individual questions in the text. Please complete the sections that apply to your company.

To answer the questions, the entries should be made in the fields provided.

ja **nein** - hier können Sie die entsprechende Rubrik ankreuzen

m² - hier können Sie die entsprechenden Zahlen eingeben, z.B. die Fassungsvermögen der Güllegrube von **310** m³

m - hier können Sie die entsprechenden Zahlen mit einer Kommastelle angeben, z.B. die Tiefe der Güllegrube von **3,1** m

General questions about your agricultural business

01 Location of the company : Federal state/district _____ / _____

02 Company number (optional)

03 Utilised agricultural area (incl. leased land, but excluding mountain pastures): ha (in whole numbers)

04 of which arable land ha of which grassland ha

Economics:

1. cattle

1.1 Housing systems and exercise area

Note: If animals of the same animal category are kept in different husbandry systems on the farm, a cross must be entered next to the respective husbandry systems. If several descriptors of a husbandry system apply to your farm, multiple answers are possible.

	Number of animals (if applicable)	Floor design on walkways and feeding alleys							Is it an outdoor climate stable?				
		Cubicle playpen slurry/manure	Deep stable	Pond manure barn	Compost barn	Fully slatted bony	Call hut	Tier stallmanure	Tier stallmanure and dung	Invelled	Columns combined	Rubber sprays	Yes
Cattle 2 years and older:													
1.1.1 Dairy cows	<input type="text"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.1.2 Suckler cows	<input type="text"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.1.3 Heifers	<input type="text"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.1.4 Bulls	<input type="text"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.1.5 Oxen	<input type="text"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Young cattle 1 to under 2 years:													
1.1.6 Bulls	<input type="text"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Deliverable 1.3

Dia 12

Task 1.3 Planning



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:

Manure: a.scarlata@staengineering.it

Soil: laurens.tuts@ilvo.vlaanderen.be

Water: marta.carballa@usc.es




D1.2 + reach out to task leaders for consultation


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

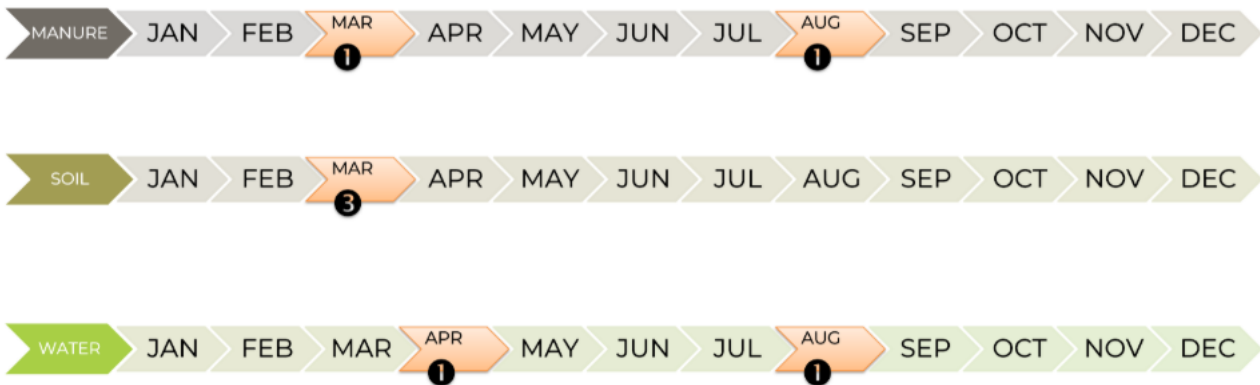
Deliverable 1.7

Deliverable 1.9

Dia 15

D1.2 Protocol samples  

Example



Deliverable 1.5
Deliverable 1.7
Deliverable 1.9

Dia 16

Task 1.6 Water pollutants assessment

Antibiotic residues

Sulfonamides

- Sulfadoxine
- Sulfadiazine
- Sulfamethazine
- Sulfoxazole
- Sulfamethoxazole

Tetracyclines

- Chlortetracycline hydrochloride
- Doxycycline hyclate
- Oxytetracycline
- Tetracycline

Fluoroquinolones

- Flumequine
- Ciprofloxacin

Chemosphere 352 (2024) 141455
Contents lists available at ScienceDirect
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,c}, Geertrui Rassehaert^a, Marc Heyndrickx^{a,c}, Nico Boon^b, Ralf Eppinger^d, Ilse Becue^a

Macrolides

- Clarithromycin
- Azithromycin
- Roxithromycin
- Erythromycin

Diaminopyrimidines

- Trimethoprim

β-lactam

- Cefalexin

Lincosamides

- Lincomycin hydrochloride

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

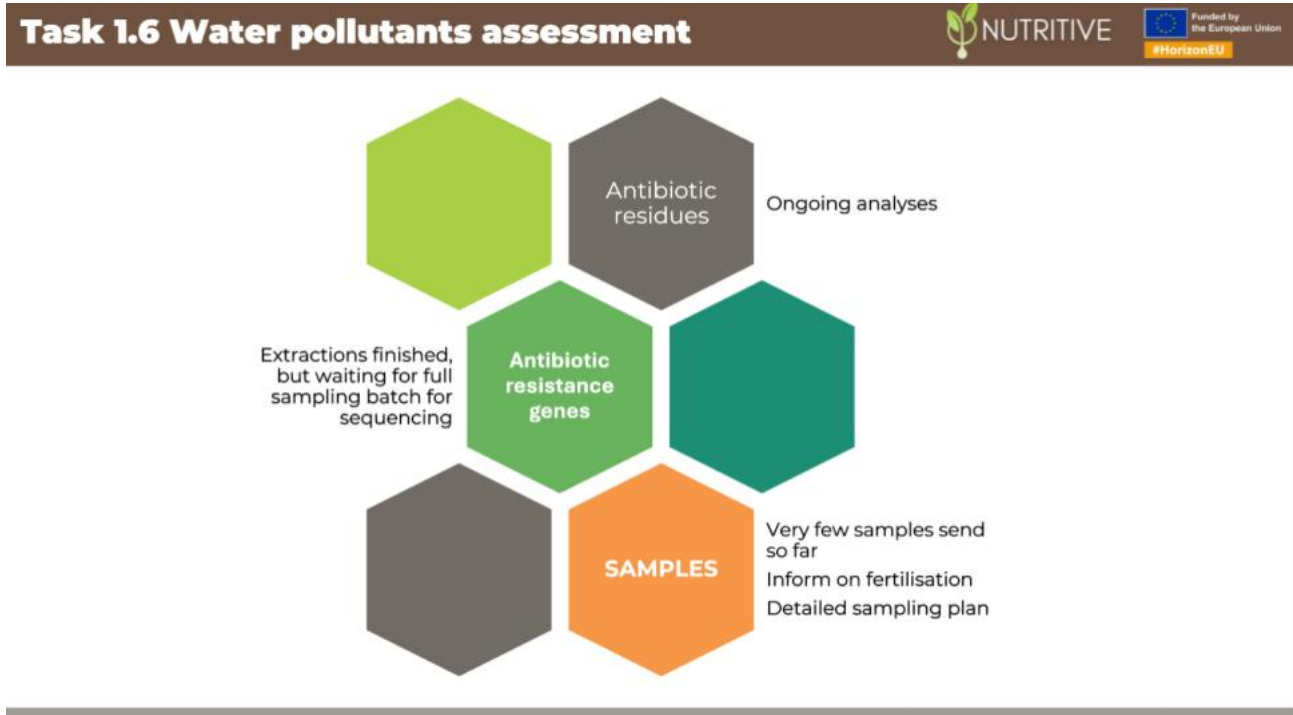
Galicia (Spain) - MEDRAR



1. Sat as Pandas: Cow 1.1-23, Vilalba (Lugo), 04/06/2025
2. Outeiro 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 Vázquez Calviño: Poultry 1.6-22, Chantada (Lugo), 04/06/2025



Deliverable 1.9


Dia 18




Deliverable 1.9

Dia 19

Task 1.4 Manure pollutants assessment: progress  



- 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 period)



RESPONSIBLE	CODE	TYPE	COUNTRY	FIRST CAMPAIGN	SECOND CAMPAIGN	OBSERVATIONS		
STA #12	Cow #12.4-45		France	March 2025	October 2025	Solid manure from the barn		
	Cow #12.1-27	Conventional-Intensive	Italy			March 2025	October 2025	Anaerobic digestate, only liquid
	Cow #12.2-29							
	Pig #12.5-30							
	Poultry #12.6-26							
Cow #12.3-31	Conventional-Extensive							

Delayed due to prolonged rainy periods (Apr-May)

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		29/04/2025	Anaerobic digestate, only liquid
	Cow #12.2-29			09/04/2025	
	Pig #12.5-30	Italy	10/04/2025		
	Poultry #12.6-26		To be replaced?		
Cow #12.3-31	Conventional-Extensive		11/04/2025		

- Analysing (and shipping) samples

Example

PARAMETER	MANURE	
	N° 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

Issues, replace with organic-extensive cattle case study?

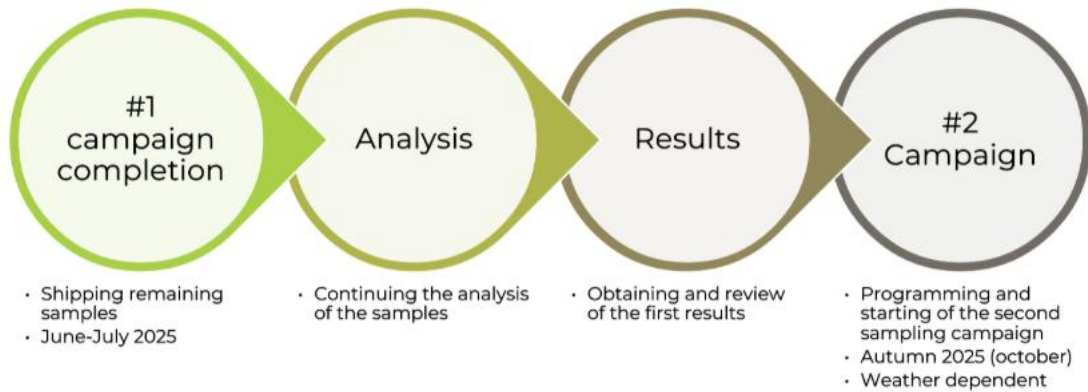
```

graph LR
    A[Complete #1] --> B[so far very few samples have been collected]
    C[Shipment] --> D[temperature]
    D --> E[labelling]
    
```

Deliverable 1.5

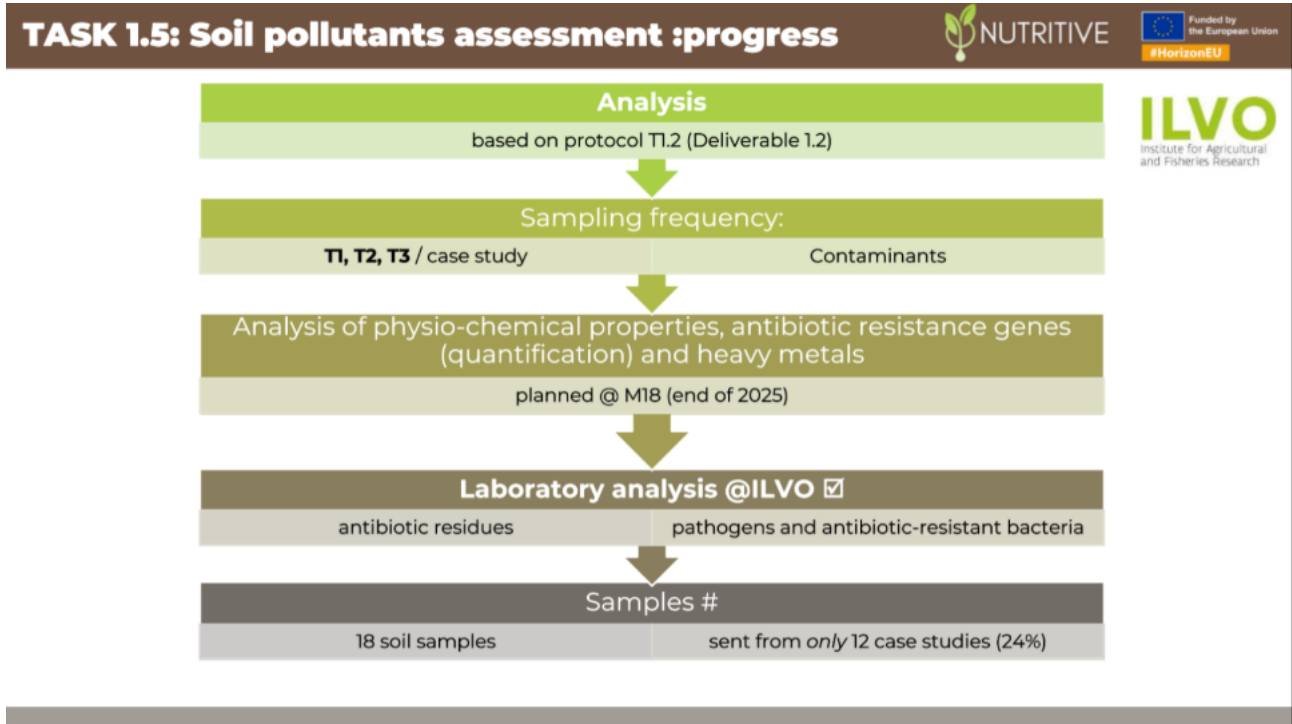
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Task 1.4 planning  



Deliverable 1.5

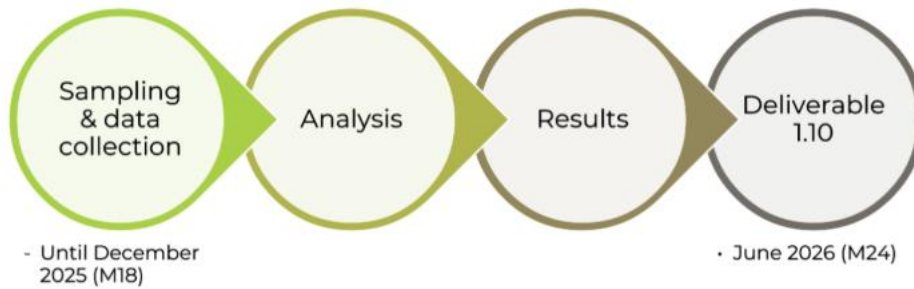
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Deliverable 1.7

Dia 23

TASK 1.5 planning



Request for **more samples**
since all case studies
must be sampled and analysed by M18

Deliverable 1.7

Dia 24

WPI – Tasks & planning

WPI	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					
USC	Task 1.5 Soil pollutants assessment					
	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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ILVO
Institute for Agricultural and Fisheries Research

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UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Sta
engineering

ATB
Leibniz-Institut für Agrartechnik und Bioökonomie

Q & A

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.