Livestock waste and animal by-product management

Deliverable 8: Final Report and Project Closure

Technical Support Instrument

Supporting reforms in 27 Member States

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Abbreviations

Abbreviation	Full name
ABP	Animal by-Product
AD	Anaerobic Digestion
BAT	Best Available Techniques
CAP	Common Agricultural Policy
CEAP	Circular Economy Action Plan
DG REFORM	Directorate-General for Structural Reform Support
DoE	Department of Energy
EC	European Commission
ERDF	European Regional Development Fund
ETS	Emissions Trading System
GHG	Greenhouse Gases
IED	Industrial Emissions Directive
KPI	Key Performance Indicator
LSU	Livestock Units
MARDE	Ministry of Agriculture, Rural Development and Environment
MECI	Ministry of Energy, Commerce and Industry
NECP	National Climate and Energy Plan
O&M	Operation and Management
PPP	Public-Private Partnership
RENURE	Recover Nitrogen from Manure
RRP	Recovery and Resilience Plan
TSI Regulation	Technical Support Instrument

1. Executive summary

This report (Deliverable 8) summarises the key findings, results, and recommendations from the entire Livestock Waste Management project in Cyprus. This executive summary provides an overview the key findings/results of each deliverable, whilst also highlighting the results of the project, its key achievements, and its recommendations.

Deliverable 1: Inception report

Deliverable 1 reviewed and analysed the approach set out in the proposal for the project following inputs from both DG Reform and the beneficiary during the kick off meeting. It provided a refined view of the project plan, tasks and risks as well as the agreed governance and stakeholder mapping to ensure a successful project.

Deliverable 2: A report on the state of play assessment and development of a desired to-be scenario

Deliverable 2 analysed the current state of livestock waste and ABP management in Cyprus, identifying significant volumes of waste and key problem areas. It provided a comprehensive assessment of existing practices and proposed a to-be scenario for sustainable management aligned with EU policies.

- Estimated a daily production of 7,617 m³/day of mixed livestock excrement, primarily from pigs, cattle, poultry, and sheep.
- Created heat maps showing concentrated waste areas, with Nicosia producing the most waste at 3,260 m³/day, followed by Larnaca at 2,795 m³/day.
- Estimated biogas production potential at 658,600 m³/day, with pig and cattle waste contributing 32% and 36%, respectively.
- Conducted a volume/production adjustment for farms with more than 300 LSU, identifying 148 such farms contributing a reduced total of 3,578 m³/day of livestock waste, and a biogas production potential of 284.450 m³/day.
- Classified ABPs into three categories and identified that in 2021, the total quantity of ABPs managed by existing facilities was 49,140 tonnes.
- Highlighted gaps in national legislation and recommended alignment with EU directives.

The to-be scenario proposed the establishment of 12 treatment facilities, including:

- Three anaerobic and aerobic treatment plants with capacities ranging from 280 to 290 m³/day.
- Six anaerobic treatment plants with capacities ranging from 100 to 320 m³/day.
- Two small anaerobic treatment plants with a capacity of 50 m³/day each.
- Upgrades to four existing anaerobic and aerobic treatment plants to handle additional waste volumes.

Deliverable 3: Feasibility Study Including the Determination of Fee Issues and Defining Policies on Compensation

Deliverable 3 conducted a feasibility study for the proposed to-be scenario, focusing on technical, financial, and operational aspects.

- Reduced the number of proposed treatment plants from 12 to 6 due to environmental impact concerns and logistical complexities associated with pipeline infrastructure, opting instead for truck transportation.
- Recommended specific Best Available Techniques (BATs) for livestock and ABP waste management:
    - Incineration for high-risk Category 1 ABPs.

    - Rendering for Category 2 ABPs.
    - Anaerobic digestion for livestock waste.
- Detailed technical specifications for the six proposed treatment plants, including capacities ranging from 100 to 600 m³/day, with processes such as waste homogenisation, anaerobic digestion, and mechanical separation.
- Determined gate fees of EUR 13.40/m³ for livestock waste and EUR 182.19/t for ABPs, inclusive of transportation costs.
- Evaluated various management models:
    - State-owned: Government-funded construction and operation.
    - Public-Private Partnership (PPP): Government finances construction, and private sector manages operation with payments for services. This model was recommended for its potential to ensure financial sustainability and operational efficiency.

Deliverable 4: Establishment of Management Facilities

Deliverable 4 identified suitable technologies and techniques for treating livestock waste and ABPs in the Orounda region, providing technical specifications for a pilot plant and guidance for the tendering and licensing processes. Specifically:

- Evaluated incineration and rendering for Category 1 and 2 ABPs, recommending rotary kiln incineration for Category 1 and rendering for Category 2.
- Outlined the process flow for the Orounda treatment plant:
    - Waste collection and transportation to the treatment plant.
    - Category 1 ABPs treated through incineration and Category 2 ABPs through rendering.
    - Livestock waste and rendered ABP material homogenised and fed into anaerobic digesters.
    - Digestate separated into solid and liquid fractions, with the liquid treated through aerobic digestion and reverse osmosis, and the solid fraction composted.
- Provided detailed guidelines for permitting and compliance with national and EU regulations.
- Offered criteria for evaluating tenderers and awarding contracts to ensure successful project implementation.

Deliverable 5: National Strategy for Livestock Waste Management

Deliverable 5 developed a comprehensive national strategy for livestock waste management, integrating regulatory, technical, and operational elements to guide long-term management efforts. The strategy is built on six fundamental vertical strategic pillars, each addressing specific gaps and challenges within the sector through specified objectives: These are:

Legal and Policy Framework:

- Align existing and forthcoming national policies with the EU green agenda, aiming for a net-zero sector by 2050.
- Improve community and environmental quality through pollution prevention and control.
- Incorporate circular economy and energy and climate principles into livestock waste and ABPs management.

Finance and Infrastructure:

- Secure funds for financial support programs to involve farmers in modernising and expanding waste management infrastructure.

- Allocate funds for establishing and enhancing public infrastructure, supporting private efforts in biogas plant development.
- Ensure alignment with Best Available Techniques (BAT) to enhance efficiency and reduce GHG emissions.

Research and Development:

- Enhance process efficiency through collaboration with academic institutions and industry stakeholders.
- Foster innovation in technologies and methodologies to maximise by-product utilisation.
- Establish a mechanism to review, analyse, and disseminate best practices and monitor emerging technologies.

Collaborations and Partnerships:

- Strengthen inter-sectoral collaborations and governance for sustainable waste management.
- Establish international partnerships for technology adoption and sector growth.

Monitoring and Reporting:

- Establish an effective monitoring and reporting mechanism to oversee the strategy's implementation.
- Implement a procedure for annual review of progress and corrective actions.

Awareness and Training:

- Enhance public awareness of sustainable waste management through a targeted communications plan.
- Strengthen stakeholder capacity through targeted training on waste management techniques, design principles, environmental impacts, and funding opportunities.

Deliverable 6: Action Plan and Roadmap

Deliverable 6 outlined an action plan to operationalise the national strategy, detailing specific actions, interventions, and priorities necessary for implementation.

- Identified high-priority actions, such as establishing new treatment facilities and upgrading existing ones to handle increased waste volumes.
- Recommended mechanisms for monitoring progress and evaluating the effectiveness of implemented actions, ensuring the national strategy remains on track and achieves its intended outcomes.
- Due to the emerging and evolving landscape it was agreed by the Steer Co that a time dependant road map would not be provided. In its place a prioritisation of actions/activities and supporting guidance provide beneficiaries with the next steps for them to follow in order to make progress.

Deliverable 7: Specialised and Tailored Training

Deliverable 7 focused on the training needs analysis and the development of a tailored training curriculum to enhance stakeholder knowledge and skills.

- Identified significant gaps in knowledge, particularly regarding feasibility studies and relevant technologies for waste management.
- Developed a comprehensive curriculum covering legislative considerations, waste assessment methodologies, and management solutions.
- Conducted six training sessions with a total of 36 stakeholders from various departments participating.

- Post-training surveys showed significant improvements in participants' knowledge, with increases of 12% to 36% across various topics.
- Reported high overall satisfaction with the training, with an average rating of 4.3 out of 5.

Synthesis of Lessons Learned

The project provided several important lessons that can guide future initiatives.

- Establishing Smaller, Specialised Working Groups: To manage the complexities of data discrepancies and ensure accurate data collection, it is essential to establish smaller, specialised working groups with defined roles. This approach improves data reliability and supports better decision-making by allowing for tailored and precise solutions.
- Proactive Engagement of Local Private Sector Expertise: Engaging local private sector experts early and continuously ensures that solutions are technically sound and practically applicable to local contexts. This collaboration enhances the comparability and applicability of project outcomes, leading to more sustainable and effective results.
- Focus on Continuity, Capacity Building, and Flexibility: Embedding necessary know-how into project departments through training and knowledge transfer activities is crucial. Maintaining flexibility in project delivery while adhering to specific requirements allows the project to adapt to sector changes and funding conditions, ensuring continued relevance and effectiveness.
- Expanding the Scope for Comprehensive Understanding: Broadening the scope of investigation beyond initial focus areas provides a more comprehensive understanding of challenges. This expanded view supports the development of robust solutions applicable across various regions, enhancing the project's strategic direction.
- Implementing a Pilot Treatment Plant for Scalable Insights: Developing a detailed technical specification for a pilot treatment plant offers invaluable theoretical insights. This replicable model can be adapted to design and implement other treatment plants, enhancing the efficacy of waste management strategies across the island.

Key Achievements

The livestock waste management project in Cyprus has achieved several significant milestones, positioning it as a pioneering initiative in the sector.

- Achievement 1: The project conducted the first comprehensive analysis of livestock waste and ABPs management practices across the Republic of Cyprus. By collating and examining quantitative data from diverse sources, the study effectively mapped the current waste management landscape, highlighting critical areas in need of intervention.
- Achievement 2: The project successfully developed a national strategy for livestock and ABPs management, addressing key inefficiencies in current practices and overcoming regulatory and infrastructure limitations.
- Achievement 3: The project achieved significant success in obtaining 'buy-in' from the government to address the pressing issues arising from the poor management of untreated livestock waste.
- Achievement 4: The project successfully engaged regional authorities, providing them with a comprehensive understanding of the current waste management landscape and the proposed future directions.

Integrated Recommendations

Recommendations for Cypriot authorities to facilitate the implementation of the project’s outcomes include:

- Establish cross-ministerial working group led by MARDE to drive forward on the incentivisation and implementation of additional treatment plants.
- Examine all funding mechanisms and define incentivisation tools with which to stimulate the operation of new treatment plants whilst remaining in compliance with EU competition law.

- Examine measures with which to increase the compliance with which existing treatment plants operate.
- MARDE to continue to engage high priority communities to stimulate action for the implementation of measures which will increase treatment in relevant areas

2. Purpose of this report

Project Context

The Directorate-General for Structural Reform Support (DG REFORM) of the European Commission (EC) has commissioned PwC EU Services to provide technical support to Cyprus's national authorities in integrating circular economy principles into the livestock and animal by-products (ABPs) waste management. This engagement aligns with DG REFORM's mission to foster growth-enhancing administrative and structural reforms by utilising EU funds and technical expertise. Cyprus has formally requested support from the EC under Regulation (EU) 2021/240, commonly known as the Technical Support Instrument ("TSI Regulation") with the project funded by the European Union via the Technical Support Instrument and implemented by PwC, in cooperation with the European Commission. This report, Deliverable 8: Final report and closure of the project, is the last of eight deliverables for this project.

The beneficiary of this reform is the Ministry of Agriculture, Rural Development and Environment (MARDE). Within this ministry, the Department of Environment and the Veterinary Services hold the overall responsibility for implementing the project. Other key stakeholders contributing or influencing this reform are the Department of Agriculture, Water Development Department, the Agricultural Research Institute, and the Energy Service of the Ministry of Energy, Commerce and Industry. Furthermore, the project extends its influence on other essential stakeholders, which include the farming community and local authorities, enriching the multi-layered nature of the project.

Livestock waste and ABPs are significant sources of environmental pollution and can pose a serious threat to human and animal health when mismanaged. Efficient management is essential for the sustainability of the livestock sector and environment protection. Current and forthcoming EU regulations and directives, including the Industrial Emissions Directive (IED) mandate treating livestock waste and ABPs to prevent pollution and protect public health. Moreover, effective waste management aligns with renewable energy objectives and the transition towards a circular economy, positioning Cyprus for future efficiencies.

The management of livestock waste and ABPs in Cyprus has emerged as a critical matter due to its far-reaching environmental, social, and economic implications. Current practices, although evolving, are fragmented and lack consistency. This results in environmental risks and lost opportunities for sustainable resource management. A robust and adaptable action framework, informed by local and international best practices, can significantly contribute to the Cyprus's sustainable development.

Objectives and structure of the deliverable

The final deliverable seeks to summarise the tasks performed, describe the main achievements of the project, and deliver recommendations for further actions, including the evaluation and monitoring of project outcomes. The recommendations included within, serve as practical considerations for future similar projects in other Member States.

The structure of the deliverable is as follows:

- **Section 2** summarises the main objectives, methodological approach, as well as the key findings and tasks of the project deliverables. This includes:
    - Deliverable 2, which analyses existing practices and establishes a future to-be scenario for sustainable management aligned with EU policies.
    - Deliverable 3, which assesses the feasibility of implementing the proposed to-be scenario, focusing on technical specifications, financial feasibility, and management models.
    - Deliverable 4, which details the technical and operational planning for biogas production units in the Orounda region, emphasising the selection of suitable technologies and compliance with environmental standards.

    - Deliverable 5, which presents a national strategy to guide long-term management efforts, integrating regulatory, technical, and operational elements.
    - Deliverable 6, which outlines an action plan to operationalise the national strategy, detailing actions, interventions and priorities.
    - Deliverable 7, which presents the training plan designed and delivered to support stakeholders in the implementation of the strategy.
- **Section 3** evaluates the effectiveness of project monitoring indicators and provides insights into the performance of the project's implementation.
- **Section 4** discusses insights and knowledge gained from the project, emphasising important lessons that can guide future initiatives in similar contexts.
- **Section 5** highlights the main achievements of the project, illustrating the most significant and immediate advantages realised from the project activities.
- **Section 6** provides recommendations for policymakers in Cyprus, designed to facilitate and complement the implementation of the project's outcomes.
- **Section 7** covers the promotional and informative materials created to disseminate the findings and benefits of the project to a broader audience, ensuring visibility and sustained impact.

3. Overview of findings

Deliverable 1 – Inception report

Objective

Deliverable 1 constitutes the first out of eight project deliverables. The primary objective of the Inception Report is to:

1. Ensure that the understanding of the project environment closely aligns with the expectations of the MARDE, the Veterinary Services, and the DG REFORM. The Inception Report is also intended to identify preliminary issues following a first round of engagement with the MARDE and key stakeholders whilst providing an outline of potential project risks and mitigations, and a description of the agreed methodology and work plan.

To achieve this objective, the following key activities were undertaken:

- **Forming the Steering Committee:** Relevant stakeholders were identified and engaged, including MARDE and DG REFORM, to communicate the project and its objectives.
- **Kick-off Meeting:** A kick-off meeting was held on 21st June 2022, involving various stakeholders from MARDE, Department of Environment, Veterinary Services, and more. This meeting set the stage for discussing the project scope, methodology, risks, and mitigations.
- **Follow-up Meetings:** Additional meetings with stakeholders were scheduled to refine the project methodology and discuss data availability and required legislative amendments.
- **Data Collection and Review:** An initial set of data and information was collected from MARDE and reviewed to refine the project methodology. This step ensured that the methodology is based on accurate and comprehensive data.
- **Stakeholder Engagement Plan:** An up-to-date stakeholder engagement plan was developed, detailing how continuous engagement would be maintained throughout the project.
- **Risk and Mitigation Record:** Potential project risks were identified along with their mitigations to ensure smooth project execution.

The Inception Report serves as a roadmap and foundation for the subsequent deliverables of the project. It provides a comprehensive understanding of the project environment, ensuring alignment with stakeholders' expectations and preparing the ground for the effective implementation of subsequent project activities.

Deliverable 2 – A report on the state of play assessment and development of a desired to-be scenario

Objectives

Deliverable 2 constitutes the second out of eight project deliverables. The overarching objectives of the deliverable are to:

1. Analyse the current state of livestock waste ABPs management with an aim to provide a comprehensive analysis of the existing waste management practices in Cyprus. This involves amongst other, assessing the current waste streams and identifying the volumes of livestock waste based on quantitative data obtained from various sources and identifying key problem areas, paving the way for sustainable solutions.

2. Evaluate the Cyprus and European Union (EU) legal framework, focusing on laws, regulations, and policies related to livestock waste and ABPs management. This analysis involves reviewing relevant national and European Union legislation to identify gaps and areas for improvement. The aim is to see if the existing legal framework supports sustainable livestock waste management practices and aligns with broader European environmental goals.

3. Develop a to-be scenario for sustainable livestock waste management that represents an ideal future state for livestock waste and ABPs management in Cyprus. This scenario is intended to address the shortcomings identified during the current state of play analysis and align with EU policy frameworks.

Methodological overview

Deliverable 2 provides a detailed examination of the current state of livestock waste and ABPs management in Cyprus, forming the foundation for the project's proposed strategic advancements. Deliverable 2 builds on the Deliverable 1: Kick-off and inception report, it includes the state of play analysis of the current situation in Cyprus whilst it also recommends the to-be scenario and the enablers of the management of livestock waste and animal by-products in Cyprus. As per the Request for Service, its main purpose is to define and present the to-be scenario taking into consideration the legal, regulatory, organisational, operational, and technical challenges. The to-be scenario will then be taken forward into Deliverable 3 where a feasibility study will be carried out to scrutinise the applicability and effectiveness of the to-be scenario.

To develop a comprehensive understanding of the current state of play, the report employed extensive quantitative research methods, field research and stakeholder engagement to create a snapshot of the livestock waste scenario in Cyprus. This involved collecting data from multiple sources, including competent authorities, the Veterinary Services and the Department of Agriculture, livestock farm registers and environmental impact assessments, to analyse the volume and distribution of livestock waste produced across different regions. Key metrics such as the number of livestock, the distribution of farms, the type of livestock waste produced, and its potential for biogas production were quantified. This data collection was integral in illustrating the scale and impact of livestock waste management on local ecosystems.

Building on the detailed examination of the current state of livestock waste and ABPs management in Cyprus, the report also delves into the legislative and policy frameworks at both the national and European levels. The analysis identifies shortcomings in the existing legal system and governance processes, highlighting areas for improvement. Specifically, it identifies several gaps and limitations in the existing regulations that hinder effective waste management. These include inadequate enforcement mechanisms, outdated provisions that fail to address modern environmental challenges, and a lack of integration with EU directives. The analysis pinpoints specific legislative reforms needed to facilitate a transition to more sustainable practices, emphasising the alignment of national laws with broader EU environmental goals.

At the European level, the deliverable aligns its recommendations with the EU's ambitious environmental policies, particularly those promoting a circular economy. It examines the impact of EU regulations and directives on Cyprus's livestock waste management, including the Common Agricultural Policy (CAP), the Waste Framework Directive, and the Renewable Energy Directive. It highlights how EU policies can drive national changes and support Cyprus in achieving higher environmental standards through compliance and adaptation to EU-wide sustainability targets.

The final section of deliverable 2 aims to develop the to-be scenario, which outline potential future states for livestock waste management in Cyprus. This scenario is developed through a collaborative approach involving key stakeholders from government, industry, and local communities. Each scenario describes potential treatment plants, their capacity, and locations, as well as the operational regimes and financial mechanisms required to ensure economic viability.

Summary of key findings from core tasks

Task 1: A state of play analysis of the current situation in Cyprus

Task 1.1 – Number of livestock farms

The current livestock waste management practices in Cyprus are characterised by a predominantly linear structure, where a significant portion of the outputs is not utilised as valuable end-use products, leading to waste and environmentally harmful emissions. Waste generated includes a mix of solid and liquid materials, as well as ABPs, derived from pigs, cattle, poultry, rabbits, sheep, and goats. The livestock waste is either applied directly to agricultural fields as fertiliser or transported to treatment facilities. At treatment facilities, this waste is processed through anaerobic or aerobic digestion, resulting in biogas and digestate. Biogas is used to produce thermal energy and electricity, while digestate, the residual by-product, is separated into solid and liquid components. These components have varied uses, with solids often turned into animal bedding or compost, and liquids used as fertilizer.

Based on the register of Livestock Farming and the Annual Livestock Population Review of 2021 of the Veterinary Services and the Department of Agriculture (DoA) of the MARDE, in Cyprus, **a total number of 3.270 recorded livestock farms exist**, of which 70 are pig farms (~2%), 393 are cattle farms (~12%), 128 are poultry farms (~4%), 25 are rabbit farms (~1%), while most livestock holdings concern sheep and goat farms and amount to a number of 2.654 (~81%) farms. In total the heads of livestock species are as follows:

- Pigs - 359.363
- Cattle - 86.372
- Poultry - 3.441.161
- Sheep and Goat - 513.309
- Rabbit - 73.854.

The following Table 1 provides an overview of the concentration of livestock in Cyprus, showing the percentage distribution of farms and livestock heads across the island's five districts.

Table 1. Distribution of livestock and farms by district in Cyprus.

District	Livestock		Farms	
	Number	Percentage	Number	Percentage
Nicosia	2.556.480	57%	783	24%
Larnaca	1.149.406	26%	998	31%
Limassol	280.340	6%	633	19%
Famagusta	256.054	6%	316	10%
Paphos	231.779	5%	540	17%

Task 1.2 – Distribution and estimation of livestock waste

As part of deliverable 2, a countrywide evaluation was conducted, focusing on the quantity and distribution of livestock excrement. **The lack of detailed farm-level data necessitated using standard waste production rates per animal species as specified in Annex II of the R.A.A. 281/2014 Decree, combined with livestock population data provided by the Department of Agriculture and the Veterinary Services.**

Based on the above mentioned R.A.A., for cattle, the waste production rate used was 0.0318 m³/day per animal (average value), with a manure density of 1,065 kg/m³. For poultry, specifically broilers, a waste production rate of 0.056 kg/day per hen was applied, while for laying and breeding hens a waste production rate of 0.112 kg/day per hen was applied, with a manure density of 330 kg/m³. As regards pig excrement, this was estimated using production rates for pregnant, lactating and young sows of 0.016, 0.03 and 0.006 m³/day, respectively, for weanlings 0.0046 m³/day and for fattening pigs 0.006 m³/day, with an average density of pig excrement of 1000 kg/m³. For rabbits, the daily manure production rate was assumed to be 0.089 litters per kilogram of animal weight (Greek Law No 3891/134991), with an average weight of 4 kg for doe rabbits and 2 kg for the other rabbits. Using these rates, it was calculated that **Cyprus produced a total of 7,617 m³/day of mixed livestock excrement in 2021**. The distribution across the five districts was as follows: Nicosia (3,260 m³/day, or 43%), Larnaca (2,795 m³/day, or 37%), Limassol (670 m³/day, or 9%), Famagusta (515 m³/day, or 7%), and Paphos (377 m³/day, or 5%). In Nicosia, 49% of the excrement came from pigs, 27% from cattle, 13% from poultry, 11% from sheep and goats, and 0.1% from rabbits. In Larnaca, cattle accounted for the majority (47%), while in Limassol and Paphos, sheep and goats made up 46% and 77%, respectively.

GIS software was used to create a heat map (Figure 1 below) to visualise the geographic distribution and density of livestock waste production, using a 3 km radius from each farm "point". **The largest production area was in the wider rural area of Orounda, with 1,194 m³/day**. Other significant areas included Aradippou Municipality (722 m³/day), Achna (720 m³/day), Dhali (695 m³/day), and Athienou (612 m³/day). The heat map revealed the spread and concentration of livestock excrement, providing crucial data for biogas potential assessment.

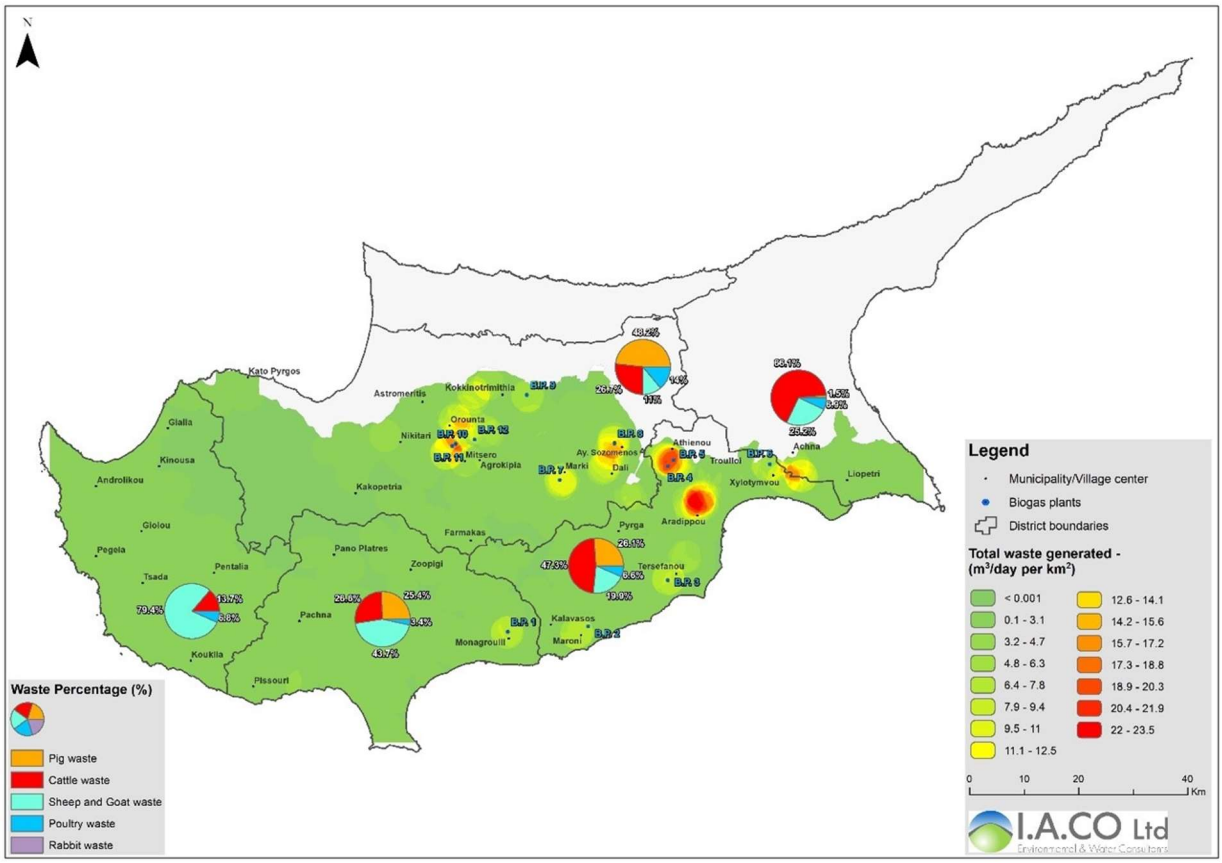

Figure 1: Distribution of Livestock excrement produced throughout Cyprus and livestock excrement proportion per animal species per District (Heat map)

Task 1.3 – Biogas Production Potential in Cyprus from livestock waste calculations for all farms and those above 300 LSU

Biogas production in Cyprus is derived from the anaerobic digestion of livestock waste, where microorganisms break down biodegradable material in the absence of oxygen. This process produces biogas, a mixture primarily consisting of methane (50%-70%) and carbon dioxide (30%-50%), with trace amounts of other particulates and contaminants. Biogas has various applications, including heat and electricity generation, and can be upgraded to biomethane or renewable natural gas, offering a sustainable energy source.

In the context of this report, **the potential for biogas production from livestock excrement was estimated using a set of empirical production factors**. These factors were obtained through collaboration with local biogas producers in Cyprus operating equipment from Weltec Biopower GmbH. The factors/coefficients employed are empirical in nature and have been obtained after a series of actual measurements taken at operational biogas plants, specifically at anaerobic digesters within the EU.

To estimate biogas production potential in Cyprus, the estimated daily livestock excrement production in 2021 of 7,617 m³/day was used. This quantity translates into **a biogas production potential of about 658,600 m³/day based on fresh excrement**. Pig waste contributed about 208,660 m³/day (~32%), cattle excrement about 234,640 m³/day (~36%), poultry about 16,930 m³/day (~2%), and sheep and goats about 198,370 m³/day (~30%).

The areas with a significant biogas production potential within Cyprus (>580 m³/day/km2), also called “hot spots” and marked in a light-yellow colour on the map, are the wider rural areas of:

- Orounda (114,996 m³/d, ~24%)
- Aradippou (60,867 m³/d, ~13%)
- Dhali (60,992 m³/d, 13%)
- Athienou (51,382 m³/d, 11%)
- Achna (40,844 m³/d, 9%)
- Tersefanou (39,849 m³/d, 8%)
- Margi (36,445 m³/d, 8%)
- Kokkinotrimithia (30,444 m³/d, 6%)
- Monagroulli (20,015 m³/d, 4%)
- Maroni (18,292 m³/d, 4%).

Due to the nature of livestock farming and to avoid overestimating the potential, it was essential to identify which populations of species would, in fact, contribute to the day-to-day operations of a treatment plant. Factors such as the fertilisation practices in small farms being dependent on livestock waste and that most sheep and goat farmers ‘walk’ their animals in open grazing areas mean that these populations need to be excluded. Furthermore, and in agreement with the Steering Committee, **the threshold of 300 Livestock**

Units (LSUs) was used to identify the relevant livestock population whose waste would contribute to the analysis[1].

The conversion of livestock heads to LSUs was carried out utilising the Eurostat definition. To give a sense of the scale see the Table 2 below.

Table 2. Number of livestock heads in farms with over 300 LSU.

LSU category	Cattle heads	Poultry heads	Pigs' heads
300	415	14403	1306

Applying this analysis resulted in a total of 148 livestock farms being taken forward in the analysis, of which 55 are pig farms (~37%), 61 are cattle farms (~41%), 29 are poultry farms (~20%), and only 3 are goat and sheep farms (~2%).

The total livestock waste produced by the 148 farms, based on the data for 2021, amounted to 4.213 m^3/d with a biogas production potential of 333.500 m^3/d. Pig waste /excrement was calculated at about 2.450 m^3/d (~58%), cattle excrement was calculated at about 1.340 m^3/d (~32%), poultry excrement was calculated at about 387 m^3/d (~9%) and sheep and goats' excrement was calculated at about 36 m^3/d (~1%).

Accordingly, the biogas production potential from pig waste was estimated at 206.150 m^3/day (~62%), from cattle waste at 113.750 m^3/day (~34%), from poultry waste at 9.200 m^3/day (~3%) and finally from sheep and goat waste at 4.400 m^3/day (~1%). With that said, **the total livestock waste produced throughout Cyprus and considered in this feasibility study, adjusted for the minimum threshold, reduced from 7.617 m^3/day (see section 2.1.2 above) to 3.578 m^3/day.**

The distribution of the livestock waste produced per farm with a livestock population above 300 LSUs throughout Cyprus is shown in the following heat map (Figure 2 below). A summary of the mixed livestock excrement produced per farm with a livestock population of more than 300 LSUs per hot spot area, their composition and their corresponding biogas production potential is also shown in the below Table 3.

[1] The threshold of 300 Livestock Units (LSU) does not reflect the recent amendments to the Industrial Emissions Directive (IED), which now exempts cattle. Furthermore, the calculated outputs have not been updated to accommodate the amendment reducing LSUs for poultry to 280.

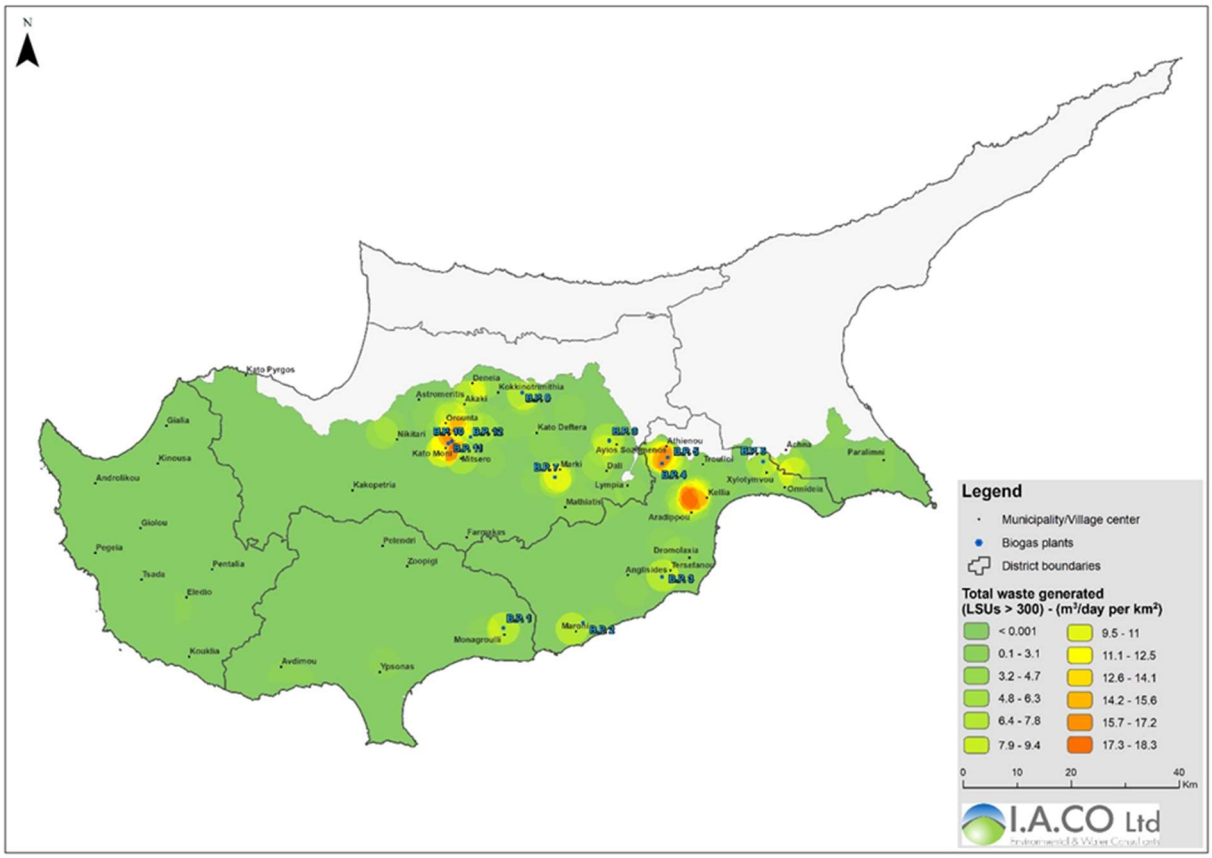

Figure 2: Distribution of Livestock excrement produced throughout Cyprus for the threshold of 300 LSU

Table 3: Mixed livestock excrement production per farm with a livestock population above 300 LSUs per hot spot, their composition, and their corresponding biogas production potential.

District	Hot Spot /WRA	Mixed Livestock Excrement (LE) produced (m^3/d)	Biogas Production Potential (m^3/d)
Nicosia	Kokkinotrimithia	293	19.750
	Orounda	1.032	84.400
	Dhali	268	20.700
	Margi	287	19.200
Larnaca -Famagusta	Aradippou	496	41.300
	Athienou	410	32.900

District	Hot Spot /WRA	Mixed Livestock Excrement (LE) produced (m^3/d)	Biogas Production Potential (m^3/d)
	Achna	181	15.400
	Tersefanou	251	21.100
	Maroni	169	13.700
Limassol	**Monagroulli**	191	16.000
Total m^3/day		**3.578**	**284.450**

The following heat map (Figure 3) shows the distribution of biogas potential production throughout Cyprus as it was estimated from livestock excrement produced per animal species and farm with a livestock population above 300 LSUs.

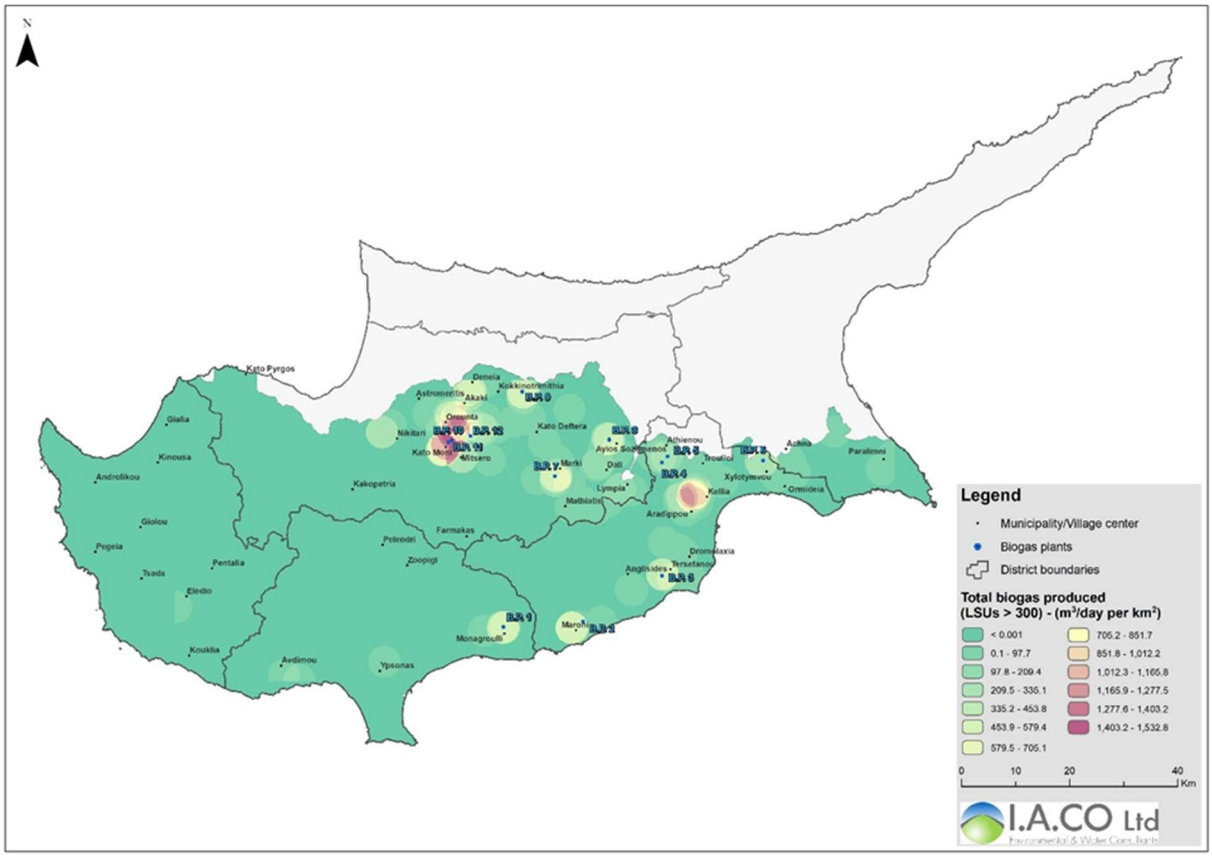

Figure 3: Biogas production potential throughout Cyprus for the threshold of 300 LSUs

Task 1.4 – Animal by Products Categories and Sources

Animal by-products in Cyprus are classified into three categories according to Regulation (EC) No. 1069/2009:

- Category 1: Includes entire bodies and all body parts, such as hides and skins, derived from animals subject to Transmissible Spongiform Encephalopathies (TSE) eradication measures.
- Category 2: Comprises manure, non-mineralised guano, and digestive tract content.
- Category 3: Contains carcasses and parts of slaughtered animals.

The management of ABPs varies according to their category. Category 1 and Category 2 ABPs are treated through processes such as pressure sterilisation, leading to the production of meat and bone meal, which is sent for incineration, and animal fat, which undergoes further processing. Category 3 ABPs, which include by-products like whey waste or scraps from butcheries, are often used as animal feed or subjected to anaerobic digestion to produce biogas.

In Cyprus, the key sources of ABPs from 2017-2021 include slaughterhouses, meat processing facilities, butcheries, dairy product facilities, and supermarkets. Notable figures include:

- Red Meat Slaughterhouses: Three in total—two in Nicosia and one in Pafos.
- Poultry Slaughterhouses: Twenty-five across Cyprus.
- Rabbit Slaughterhouses: Ten in total.
- Minced Meat Facilities, Meat Preparation, and Cutting Facilities: A total of 107 registered facilities.
- Dairy Processing Plants: Another 107 registered facilities.

ABPs are an important part of the waste stream from livestock farming and meat processing. They encompass a variety of materials, including animal parts, manure, and other waste products. The "ABPs Production and Management" section provides detailed information on the sources, categories, and quantities of ABPs produced in Cyprus, along with the existing management facilities and the processes used for their treatment.

Records from the Veterinary Services covering the years 2017-2021 indicate a diverse range of ABPs sources across the country. For instance, there are **three registered red meat slaughterhouses**, **25 poultry slaughterhouses and 10 rabbit slaughterhouses**.

The **total quantity of ABPs received and managed by four registered facilities in Cyprus in 2021 amounted to 49,140 tonnes.** This quantity comprises three categories of ABPs: Category 1, which includes high-risk materials like whole animal bodies; Category 2, which encompasses manure and other non-mineralised waste; and Category 3, which covers safer materials such as slaughterhouse by-products.

Among these, Category 3 ABPs represent the largest portion, accounting for approximately 82% of the total ABPs managed in 2021, or about 40,100 tonnes. Category 2 ABPs make up around 10%, totalling 5,056 tonnes, while Category 1 ABPs constitute about 8%, amounting to 3,990 tonnes.

Task 1.4.1 – Livestock Waste and Animal by Products Management

Cyprus has 11 livestock and industrial waste treatment facilities that use anaerobic treatment technology to produce biogas, often combined with internal combustion units (Combined Heat and Power, or CHP) for cogeneration of electricity and thermal energy. Additionally, **one more anaerobic treatment plant is to be commissioned soon in Agios Ioannis (Malountas) in the Nicosia District** within a slaughterhouse installation, aiming to further treat animal by-products after rendering (sterilisation) treatment; **This will bring raise the total to 12 livestock and industrial waste treatment facilities.**

Eight of these facilities are located within large pig farms, primarily serving their own waste but also processing waste from other nearby livestock farms, including poultry, cattle, and food or drink industries (such as cheese factories, distilleries, and olive mills, depending on the season). One anaerobic treatment plant is located in a large slaughterhouse and serves additional sources, including meat processing and minced meat facilities, butcheries, dairy product facilities, and other livestock farms. Two facilities are not directly tied to specific livestock units or other facilities, providing treatment for various livestock farms and industries, including pig, poultry, and cattle farms.

The total waste treatment capacity of these 11 anaerobic treatment plants is 2,170 m³/day. Their maximum electrical power output is 8,571 kW, while their maximum thermal power output is 8,732 kW. This capacity does not include the power output of the new plant to be commissioned in Agios Ioannis. Each plant has a unique structure for waste collection, storage, and treatment. Pig waste and other types of livestock waste are typically collected and stored in central tanks before being pumped to the treatment facilities through pipelines or other means.

The total waste treatment capacity as well as electrical and thermal power of the 12 anaerobic treatment plants is as follows:

- Total Waste Treatment Capacity: The combined waste treatment capacity of the 12 anaerobic treatment facilities is 2,170 m³/day.
- Installed Electrical Power: The total installed electrical power for these facilities is 8,571 kW.
- Installed Thermal Power: The total installed thermal power for these facilities is 8,732 kW.

The 12 facilities are distributed across various districts in Cyprus, including Nicosia, Limassol, Larnaca, and Famagusta. Their capacities range from 75 m³/day to 460 m³/day. Electrical power outputs vary between 230 kW and 2,100 kW, while thermal power outputs range from 230 kW to 2,100 kW.

According to the Energy service of the MECI, the below present the energy production and consumption figures from the existing Biogas Plants for the year 2021:

- **Total Electric Energy Produced:** In 2021, a total of 56,927 MWh was produced by the biogas plants. Of this, 15,166 MWh (~27%) was used to meet the energy needs of the livestock farms, while 41,761 MWh (~73%) was fed into the EAC grid.
- **Total Thermal Energy Produced**: The total thermal energy produced by these plants was 58,174 MWh.
- **Fuel Oil Consumption:** In 2021, these biogas plants consumed a total of 1,270,927 litters of fuel oil.
- **Total Biogas Consumption:** The total biogas consumption for these plants was 25,443,555 m³.

Task 1.5 - Profiling and categorisation of areas considering the 3 key factors

With this information the inputs to enable the profiling of areas was complete (see Figure 4 below). The GIS analysis that followed base on the above three criteria and its corresponding three classes, could lead to a maximum of 27 combinations of different profile categories, e.g. Wh.Bm.Ts which corresponds to **W**aste **h**igh, **B**iogas **m**oderate and **T**reatment plant of **s**ufficient capacity. The analysis generated 16 different profile categories which can be seen in the map below. Where the red are the areas of greatest need for treatment plants and the green where existing treatment plants have sufficient capacity to treat the livestock waste with minor upgrades.

Profile Category Code	Profile Category	Profile Category Code	Profile Category
1	Wh.Bh.Ta	10	Wl.Bl.Ta
4	Wh.Bl.Ta	15	Wm.Bm.Ti
7	Wh.Bm.Ta	3	Wh.Bh.Ts
12	Wm.Bl.Ta	6	Wh.Bl.Ts
14	Wm.Bm.Ta	9	Wh.Bm.Ts
2	Wh.Bh.Ti	11	Wl.Bl.Ts
5	Wh.Bl.Ti	13	Wm.Bl.Ts
8	Wh.Bm.Ti	16	Wm.Bm.Ts

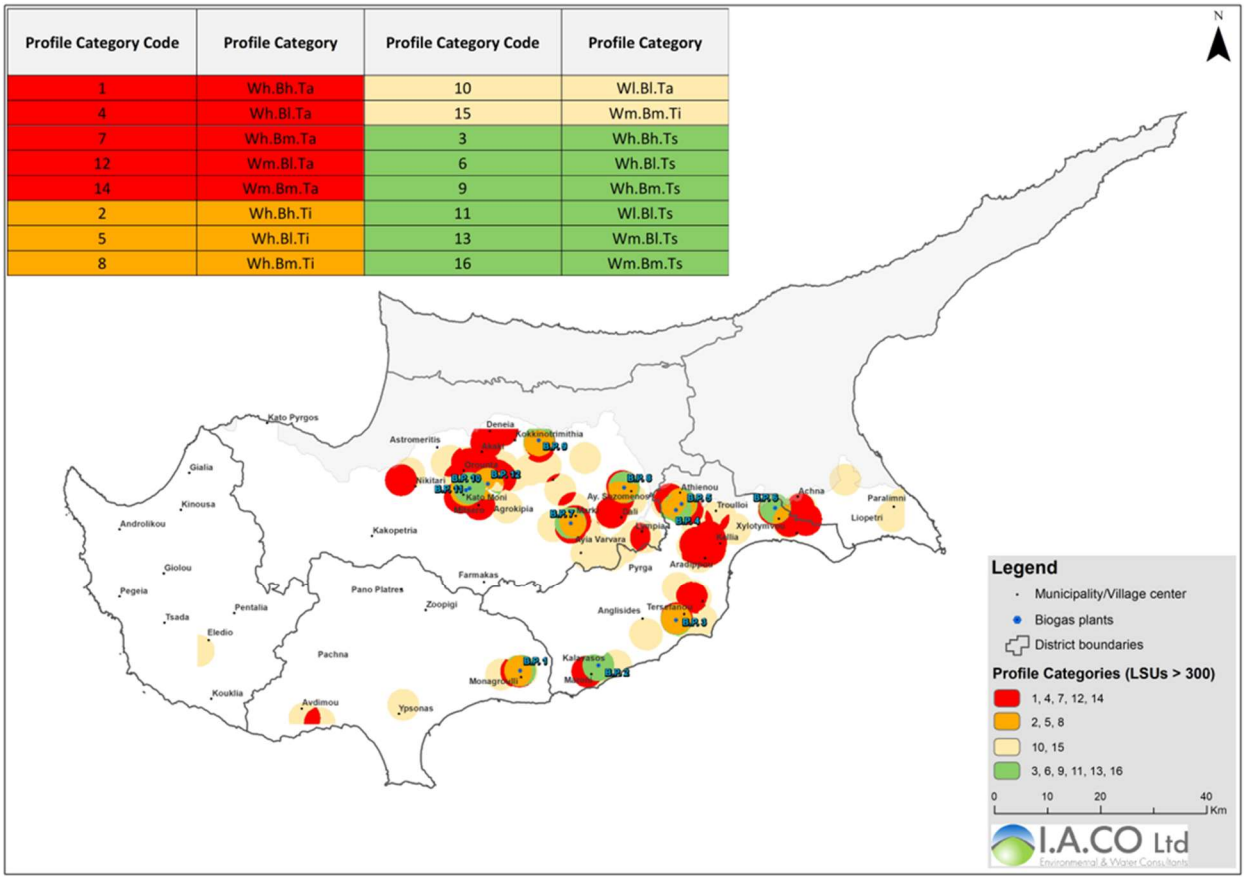

Figure 4: Profile areas mapped for analysis of the farms above 300 LSUs.

It is important to note that this analysis was also produced for the un-constrained version where the threshold of 300 LSUs was not applied. However, the outcome of the most problematic areas remains the same and identifies the below hotspot areas:

Most problematic large areas:

- Orounda
- Aradippou
- Achna
- Dali
- Dromolaxia
- Koutrafas.

Most problematic small hotspots:

- Maroni
- Lympia
- Athienou
- Avdimou.

The outputs of this analysis are the foundations of the analysis carried out in Section 5 Development of the to-be scenarios.

It is important to note that ABPs have not been included in the above analysis, however, their management is an integral part of the project. According to European Commission (EC) regulations ABPs are split into 3 categories as shown below.

- **Category 1** material contains entire bodies and all body parts, including hides and skins [e.g., animals killed in the context of TSE (Transmissible Spongiform Encephalopathies) eradication measures].

- **Category 2** material (e.g., manure, non-mineralised guano, and digestive tract content).

- **Category 3** material (e.g., carcasses and parts of animals slaughtered).

In Cyprus the main sources of ABPs are slaughterhouses, meat processing facilities, butcheries, dairy product facilities and supermarkets. At the time of drafting the deliverable there were only four registered facilities for ABPs management in Cyprus and a single co-incineration plant (Vassiliko). This ultimately creates a monopoly for the incineration of ABPs in Cyprus, something that is considered in the to-be recommendations. In 2021, the total quantity of ABPs received and managed by the 4 operational facilities, reached 49.140 tonnes (t). It is highlighted that the above quantity is very small and accounts for only 3% of the 1,5 million m^3 annual production of livestock waste production from farms with more than 300 LSUs.

Task 1.6 – Resource flow mapping

To better visualise the livestock waste management sequence in Cyprus, especially when it comes to treatment via Anaerobic Digestion (AD) facilities, a resource flow map was developed showing the sources of livestock waste and ABPs, the extent to which these are treatment and the output of the treatments.

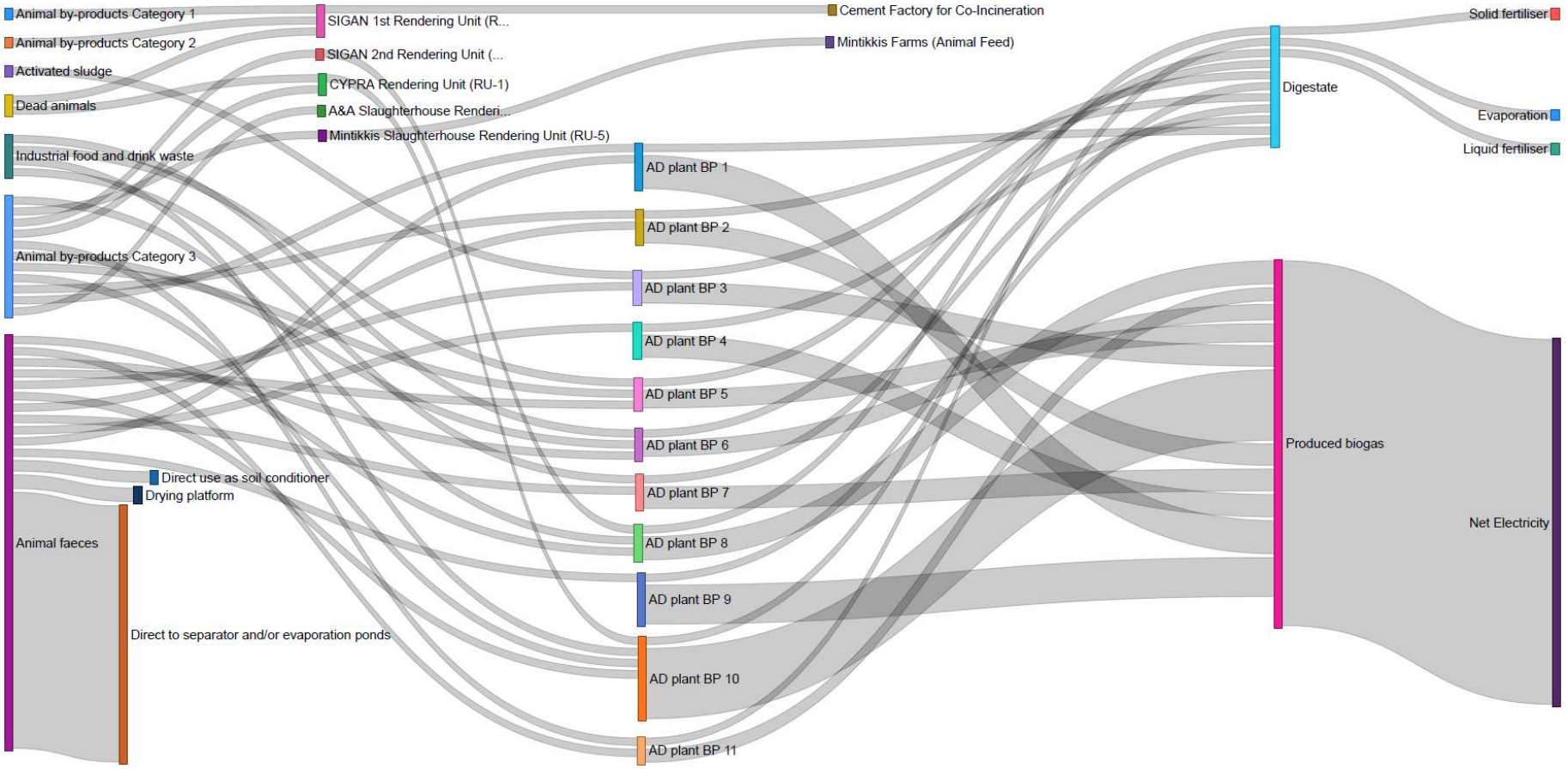

Figure 5: Resource flow diagram (Waste, digestate and fertiliser flows in tonnes/annum, Biogas in m3/annum, Net electricity in KWh/annum)

Based on the analysis done, it is estimated that today 52% of livestock waste from large farms (with more than 300 LSUs) is being treated by existing treatment plants. The to-be scenario will address the remaining 48% of untreated livestock waste.

Task 2 – The Cyprus Legal Framework of livestock waste and animal by-products management.

The extent to which the legislative framework enforces and enables the effective management of livestock waste is a factor to Cyprus' ability to transform from a largely linear to circular livestock value chain to a more sustainable one. Therefore, it was essential to assess the main national laws and regulations in terms of their scope, governance, and operationalisation. This assessment identified a number of shortcomings, summarised in table 4 below.

The key shortcomings identified per category are described below.

- **Scope** – Shortcomings in the current legislation that relate to the way through an animal husbandry facility is licensed, in which a regulation is enforced, and certain actions are monitored.

- **Governance** – shortcomings in the current governance mechanisms exist with respect to the monitoring and enforcement of legislation. Furthermore, the governing process to issue permits is lengthy resulting in delays.

- **Operational Arrangements** – there are numerous shortcomings in operationalising legislation where today the cost associated with waste treatment make operating treatment plants financially unappealing. On the production side the volume of waste prevents true economies of scale to be realised whilst on the sales side the absence of natural gas grid infrastructure, lack of end-use purpose for the treated wastewater and Cyprus' energy isolation prohibits the use of incentives utilised across the EU-27 (e.g. Carbon Credits, Certificate of Ownership etc.). All the above put an operational strain on making the treatment plants profitable.

Table 4. Mapping of shortcomings of today's legislation with respect to the area of root cause.

National Legislation (CY)	Shortcomings in terms of:		
	Scope	Governance	Operational Arrangements
Water Pollution Control (106(I)/2002), KDP 737/2003 and 433/2006	√	√	
Code of Good Agriculture Practice (R.A.A. 263/2007)		√	√
Nitrification due to agricultural activities and determination of areas vulnerable to nitrification (R.A.A. 534/2002, 186/2008, 41/2011, 281/2014)			√
General terms for the discharge of waste from wastewater treatment plants (R.A.A. 379/2015)		√	√
Regulation (EC) No 1069/2009 and (EU) No 142/2011 regarding animal by-products and derived products not intended for human consumption			√
Cyprus' Integrated National Energy and Climate Plan			√
Industrial Emissions (Integrated Pollution Prevention and Control) Law of 2013 (L.184(I)/2013)		√	

Task 2.1 - The European Union policy framework of livestock waste and animal by-products management

Following the identification of the upcoming EU policies, strategies, and actions related to the management of livestock waste and ABPs, the findings were linked to the key components of the livestock waste and ABPs management value chain. The Sankey Diagram below (see Figure 6) depicts the relationship between EU policy areas and the value chain components of livestock waste management and ABPs management. management value chain.

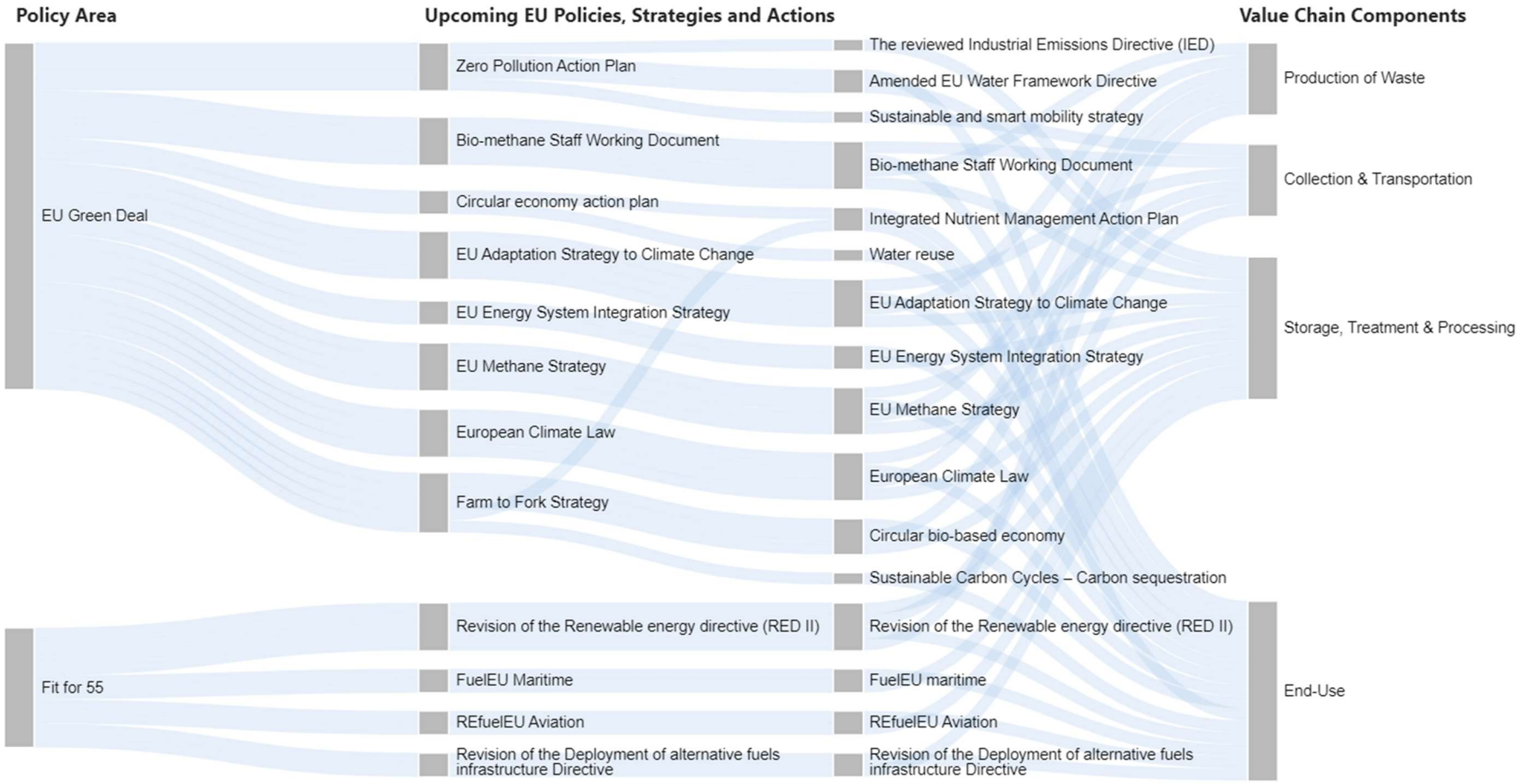

Figure 6: How the EU Policy Framework influences the components of the value chain.

Task 3: Development of the to-be scenarios

The comprehensive analysis of anticipated livestock population trends in Cyprus, forms a crucial element and the foundations for the planning and operation of future livestock waste and ABPs treatment facilities. This was done using data from the Register of Livestock Farming and the Annual Livestock Population Reviews for the years 2011 to 2021, forecasts have been made up to 2030. The analysis indicates divergent trends: the populations of pigs and sheep and goats are projected to decline, whereas those of cattle and poultry are expected to increase.

Several variables could influence these trends, including market demand for animal products, considerations of animal welfare, and the potential for diseases or epidemics. Governmental initiatives, such as the Department of Agriculture's plans for the demolition and relocation of problematic livestock installations, along with zoning regulations under the Rural Development Programme, could also significantly impact the future distribution of livestock. Climate change adds another layer of complexity, as it could create unfavourable conditions for livestock farming, thereby affecting the generation of waste.

Given these uncertainties, the report recommends designing treatment plants with a 10% increase in capacity to accommodate future changes. These plants will also have the flexibility to be upgraded or modified to adapt to actual waste volumes. In the event of underestimation, the aerobic digesters' capacity can be increased. If overestimation occurs, the facilities have the capability to process other forms of organic waste, such as municipal or industrial waste.

Building on the current state analysis, the defined profile areas and the relevant policies and legislation associated with the to-be scenario was defined by answering two key questions:

I. **What should be the arrangements of plants examined in the feasibility study?**

II. **What recommendations will support the successful implementation?**

Task 3.1 What should be the arrangements of plants examined in the feasibility study.

The criteria used to identify if profile areas could be grouped are:

- Solids/Liquids % content of generated waste.
- Service area of e.g., a proposed treatment plant,
- Waste collection method.
- Possible use and marketability of treatment end-products (biogas, digestate, treated wastewater).

The analysis clustered the profile areas into the following areas produced the following agglomerations, illustrated in the Figure 7 below.

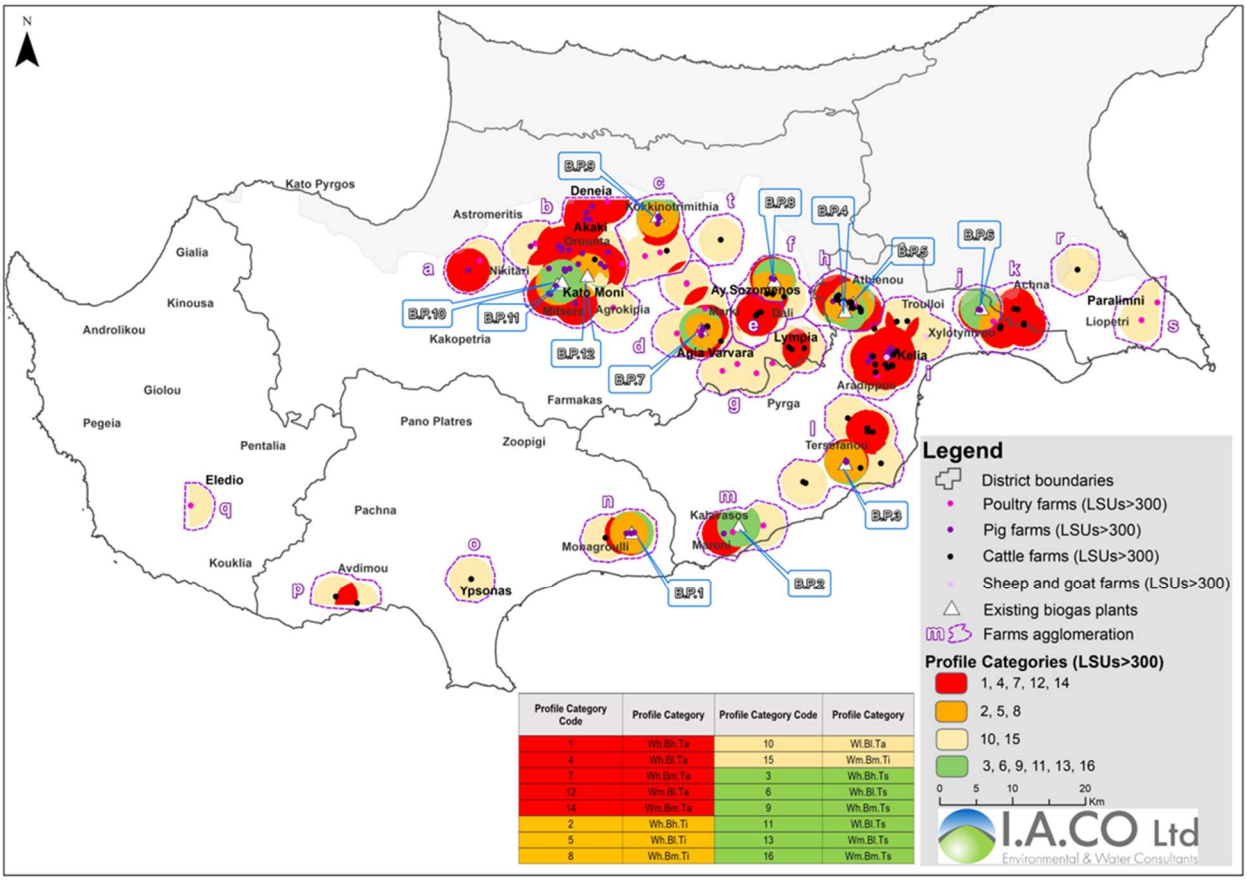

Figure 7: Farms agglomerations generated to calculate the remaining waste requiring treatment.

By developing these agglomerations two approaches to managing livestock waste can be implemented. These approaches are summarised in the Table 5 below.

Table 5: Possible profile solutions to manage livestock waste depending on waste composition.

Solids / Liquids % content	Possible Use and Marketability of treatment end-products (biogas, digestate, treated wastewater)			Definition of collection method	Treatment Plant Capacity / Service Area
	Biogas	Digestate	Treated wastewater		
High Solids Content (i.e., waste coming mainly from cattle/ poultry/ sheep and goat farms)	Electricity production*	Soil Conditioner / Compost	Evaporation / Irrigation	Truck/ Sewer	Max Service Area of 5 km radius
High Liquid Content (i.e., waste coming mainly from pig farms)	Electricity production*	Compost	Irrigation/ Evaporation	Sewer/Truck	Max Service Area of 3 km radius
** At areas with proximity to Airports or Ports (e.g., Dromolaxia, Aradippou) provision of possible Biofuel production could be considered in the proposed Treatment Plants.*					

Based on the agglomeration analysis and the two general approaches, the location, type, capacity, and priority of the treatment plants in the to-be scenario have been defined, the full list is shown in table 5 and summarised as follows:

- 3 x Anaerobic and Aerobic Treatment Plants with proposed capacity ranging from 280 to 290 m^3/day;
- 6 x Anaerobic Treatment Plants with proposed capacity ranging from 100 to 320 m^3/day;
- 2 x Small Anaerobic Treatment Plants with proposed capacity of 50 m^3/day;
- Upgrade of 4 existing Anaerobic and Aerobic Treatment Plants.

Table 6: Recommendations for each farm agglomeration.

Area (villages)	Agglomeration	Presence of Treatment Plant	Remaining Waste requiring treatment (m^3/day)	Recommendations (to be examined at a later stage)	Prioritisation
Aradippou wider area	**i**	No	555 *half high solid content/ half high liquid content*	1 Anaerobic and Aerobic TP ~290m^3/day 1 Anaerobic TP ~320m^3/day*	High
Orounda wider area	**b**	Yes (3)	506 *high liquid content*	2 Anaerobic and Aerobic TP ~280m^3/day each*	High
Achna wider area	**k**	No	237 *high solid content*	1 Anaerobic TP ~260m^3/day	Medium
Tersefanou - Dromolaxia wider area	**l**	Yes (1)	128 *high solid content*	1 Anaerobic TP ~180m^3/day	Medium
Koutrafas	**a**	No	102 *high liquid content*	No recommendations - Treatment Plant (TP) of 75m^3/day planned	Medium
Marki wider area	**d**	Yes (1)	85 *high solid content*	1 Anaerobic TP ~100m^3/day	Medium
Ayia Varvara - Lympia wider area	**g**	No	85 *high solid content*	1 Anaerobic TP ~100m^3/day	Medium
Dali - Nisou	**e**	No	78 *high solid content*	1 Anaerobic TP ~100m^3/day	Medium
Athienou	**h**	Yes (2)	50 *high solid content*	Upgrade existing both TPs by ~28m^3/day each, or Upgrade 1 existing TP by ~55m^3/day	Low
Dali - Agios Sozomenos	**f**	Yes (1)	46 *high solid content*	Upgrade existing TP by ~50m^3/day (or Small Anaerobic)	Low
Avdimou	**p**	No	44 *high solid content*	1 Small Anaerobic ~50m^3/day	Low
Kokkinotrimithia wider area	**c**	Yes (1)	23 *high solid content*	Upgrade existing TP by ~40m^3/day (or Small Anaerobic)	Low
Monagroulli	**n**	Yes (1)	11	Upgrade existing TP by ~12m^3/day	Low
Episkopi Pafou	**q**	No	10 *high solid content*	1 Small Anaerobic ~50m^3/day	Low
Paralimni	**s**	No	19	Combine with Agglomeration "l"	-

Area (villages)	Agglomeration	Presence of Treatment Plant	Remaining Waste requiring treatment (m^3/day)	Recommendations (to be examined at a later stage)	Prioritisation
Ypsonas	**o**	No	17	No recommendations - TP planned (planned capacity not known**)	-
Frenaros	**r**	No	14	Combine with Agglomeration "l"	-
Strovolos	**t**	No	14	Combine with Agglomeration "c"	-
Xylotympou	**j**	Yes (1)	0	No recommendations	-
Maroni wider area	**m**	Yes (1)	0	No recommendations	-

** One station in Aradippou and one station in Orounda area are proposed to include pre-treatment in order to receive ABPs*
*** There is no information on the planned Treatment Plant's capacity as this is planning and decisions are not mature yet. However, the remaining waste requiring treatment in this agglomeration is very low, therefore, any planned treatment facility is expected to be able to accommodate this quantity.*

According to this prioritisation, the high priority farm agglomerations are limited to the wider Aradippou area and wider Orounda area, where the following Treatment Schemes are proposed:

- **Aradippou**: 1 Anaerobic and Aerobic Treatment Plant of a capacity approximately 290m^3/day, and 1 Anaerobic Treatment Plant of a capacity approximately 320m^3/day. This differentiation between the two plants is due to the fact that the area agglomeration has a relatively equal mixture of high solid content and high liquid content waste. Furthermore, this station could have the potential provision of possible Biofuel production due to its proximity to the airport;

- **Orounda**: 2 Anaerobic and Aerobic Treatment Plant of a capacity approximately 280m^3/day. The requirement for two facilities to split the waste treatment in this agglomeration, is mainly due to the surface area of the wider area of Orounda in combination with the high liquid content of the waste associated with this area. Taking the 3km radius service area of a treatment plant set for this type of waste into consideration, the surface area of this agglomeration indicates the recommendation of two treatment plants to cover the wider area of Orounda;

In each of these high priority areas, a pre-treatment plant for accepting ABPs is recommended. The selection of these treatment plants to include pre-treatment in order to be able to accept ABPs, is based on the known spatial distribution of ABPs production which is 57% from the Nicosia district, 26% from the districts of Larnaca/Famagusta and 16% from the districts of Paphos/Limassol.

The remaining 48% of livestock waste that will be treated through the development of the new treatment plans listed in Table 5 above, can be categorised in terms of priority as follows: High priority waste to be treated, 52%; Medium priority waste to be treated 37%; and low priority waste 10%.

Task 3.2 What recommendations will support the successful implementation?

The successful implementation of the to-be scenario hinges on the more holistic considerations that one must take into account when designing such a strategic and all-encompassing transformation. These include but are not limited to the below shown:

i. Legislative reforms to encourage and govern the industry;

ii. Operational and financial regimes to ensure economic viability of the farmers, treatment plants and consumers of the output;

iii. Sustainability of the proposed / implemented waste management solutions;

iv. Permitting and licensing to manage entry into the sector;

v. Inspecting and monitor mechanisms to oversee the compliance of the various parties;

vi. Reduction in the risk of monopolies.

The recommended legislative reforms address the pain points identified in table 3 and can be grouped in the below thematises:

- Enable the monitoring of legislation through more effective mechanisms, appropriate staffing and austere penalties due to non-compliance.

- Promote the adoption of green technologies; and

Supporting treatment plants to be more profitable through reforms including support to establish necessary infrastructure, encouragement of the use of their outputs (wastewater, fertiliser, electricity). The operational and financial regimes are vital to the scenario's successful operationalisation. The recommended optimal operation regime for the sustainable management of livestock waste and ABPs includes:

- Centralised, government-owned and privately operated treatment plants;

- Financially viable gate fees and feed-in tariffs (€ per kWh), to be determined during the feasibility study;

- Financial support for the existing livestock waste and ABPs treatment facilities; and

- Fiscal incentives and support policies to encourage private investment in treatment facilities.

To ensure the sustainability of the proposed waste management solution, it is crucial to design a value chain in which the principles of the circular economy are thoroughly embedded. At its core is the aim that all nutrients from organic and biodegradable waste be returned to the soil to regenerate nature. When applied to livestock faming, this entails maximising the volume of waste treated to produce biogas, which is then converted into electricity, thermal power/energy, and biofuels (e.g., biomethane), while utilising the by-products of the process by producing soil conditioner /improver or compost and irrigation water.

To make informed decisions regarding farming practices, enforcement of environmental law and management of livestock waste and ABPs treatment plant performance to the ensure the efficacy of their processes, competent authorities will need to implement efficient and effective monitoring systems with logical and viable key performance indicators. Such a system should be implemented through digital means including KPIs which monitor the consistency, timeliness, accuracy, and relevance of data.

To ensure the uptake in the proposed treatment plants one must ensure that the processes that enable this are as clear and concise as possible, thus reducing any resistance to apply for a license or permit. To achieve this, it is recommended to align the application process to a digital one to make it as efficient as possible. Furthermore, to avoid duplication of effort and inefficiencies across the government the relevant processes should be reviewed and improved in line with the underway One Stop Shop project.

In light of Vassiliko cement factory’s exclusive role in treating category 1 and 2 (fallen animals) ABPs, it is crucial to explore various approaches for managing this relationship. Suggestions span from enhancing communication to foster public understanding/acceptance, to considering adjustments to the fee structure that Vassiliko is allowed to implement.

Having defined the to-be scenario, the project’s next steps are to carry out the feasibility study on the to-be scenario as specified in Deliverable 3 (Feasibility study including the determination of fee issues and defining policies on compensation).

Objectives

Deliverable 3 constitutes the third out of eight project deliverables. The overarching objectives of the deliverable are to:

1. Describe the Best Available Techniques (BATs) for livestock and ABP waste management given the unique needs of Cyprus' livestock ecosystem, to be utilised by competent authorities in the future;

2. Apply these BATs to the current state situation and design the specifications of the national treatment plan (which is comprised now out of 6 treatment plants);

3. Through the design of the plants' technical and operational aspects, conduct a financial feasibility study to enable the development of a gate fee, which is the fee to be applied to pig and cattle farmers for treating their waste. To achieve this, the technical specifications, including the treatment techniques, considered for each of the six proposed treatment plants, and their relevant alternative solutions (if those apply / exist) are presented and

4. Present the potential management models of the various scenarios of building and operating the treatment plants (i.e. state owned versus Public-Private Partnership (PPP)) and the compensation and fee scheme.

Methodological overview

Deliverable 3 offers a comprehensive feasibility study for managing livestock waste and ABPs in Cyprus, following the groundwork laid out in Deliverable 2. The deliverable aims to develop a framework focused on the technical, financial, and operational aspects of implementing a national strategy for livestock waste management, building upon the to-be scenario developed in Deliverable 2.

The deliverable incorporates insights from various stakeholders, ensuring that the financial feasibility study is grounded in practical considerations and account the interests of different parties, including government agencies, industry representatives, and local communities. This collaborative approach aims to foster broad support for the proposed strategy and ensure its successful implementation.

The technical design on the basis of BATs forms a critical aspect of this deliverable. This section of the deliverable explores the technical design of the proposed treatment facilities, focusing on the six plants across Cyprus. The technical design also draws on best practices from other EU Member States to ensure compliance with EU directives and to promote a circular economy approach. Each plant's capacity, operational structure, and treatment process are detailed, providing a clear understanding of the technical requirements. Specifically, the technical design model highlights waste homogenisation, anaerobic digestion with biogas production, and digestate treatment. This section offers insights into the expected outputs from the treatment process, such as electricity, thermal energy, soil conditioner or compost, and treated water for irrigation. The methodological approach in this section is rooted in other technical feasibility studies.

The financial model and gate fee determination aspect of the report provides a detailed analysis of the capital and operational expenses, revenue streams, and other financial parameters. Gate fees are calculated to cover treatment costs while ensuring the plants remain financially sustainable. This methodology includes cost analysis, revenue projections, and financial modelling to determine the appropriate gate fees for livestock waste (EUR 13.40/m³) and ABPs (EUR 182.19/t).

Finally, the regulatory and organisational framework section evaluates the regulatory and organisational frameworks required for successful implementation. It explores legal and regulatory requirements, considering both Cyprus and EU legislation. The analysis identifies potential barriers and suggests reforms to support the proposed waste management strategy. The report also examines different management

models, including Public-Private Partnerships (PPPs), to guide the operational structure of the treatment plants.

Summary of key findings from core tasks

Task 1: Updated treatment plant agglomerations and associated livestock waste amounts to be processed

Deliverable 3 offers a revised approach to the development of agglomerations, originally proposed as part of subsection 5.3.3 of Deliverable 2 which suggested, as part of the first iterations of the to-be scenario, 12 agglomerations for livestock waste treatment. However, **the updated methodology in Deliverable 3 reduces this number to 6 agglomerations** due a reassessment of the complexities surrounding pipeline infrastructure and its environmental impact, leading to the decision to use truck transportation instead of pipelines (see table 7 below). The remaining livestock waste amounts to be processed by each agglomeration were determined based on the capacity of existing waste treatment plants and the untreated waste generated by farms exceeding 300 LSUs.

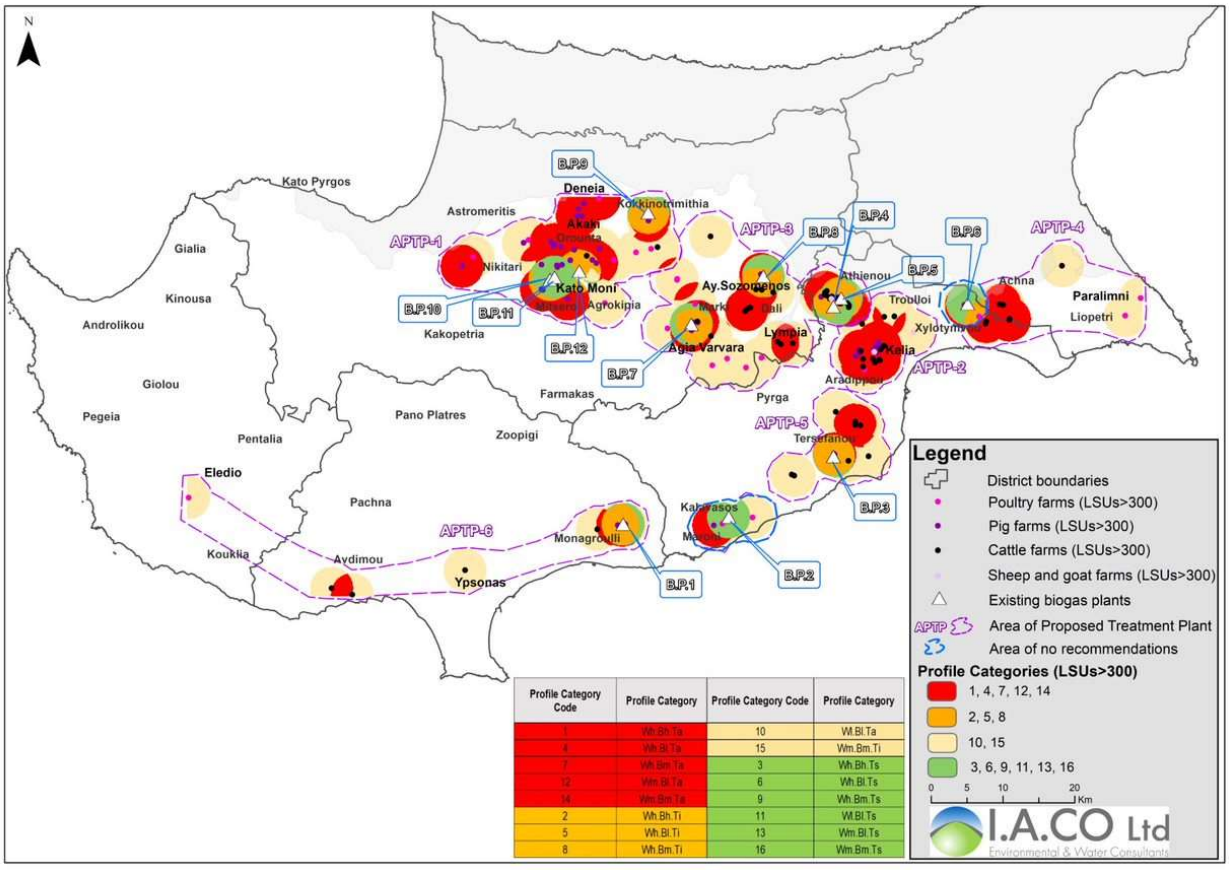

Figure 7: The six treatment plant agglomerations used to calculate the remaining livestock waste requiring treatment.

The updated methodology for determining treatment plant agglomerations is also built upon additional criteria beyond those used in Deliverable 2. The additional factors considered include:

1. The percentage (%) of solid versus liquid content of waste generated and

2. Waste collection method (i.e., use of pipelines (3km radius) versus the use of trucks)).

With these criteria, the approach towards area profiling was enhanced, resulting in the generation of 16 different profile categories. These categories were grouped into three profile groups: Most, Moderate, and Low, based on sub-criteria such as livestock waste production per km², biogas potential, and the presence of treatment plants. These factors influenced the updated treatment plant agglomerations.

The revised methodology led to six treatment plant agglomerations, down from the 12 originally proposed in Deliverable 2. This adjustment was driven by a reassessment of the complexities surrounding pipeline infrastructure and its environmental impact, prompting a shift to truck transportation. The remaining livestock waste amounts to be processed by each agglomeration were determined based on the capacity of existing treatment plants and the untreated waste generated by farms exceeding 300 LSUs.

Table 7: Revised agglomerations based on a reassessment of the complexities surrounding pipeline infrastructure and its environmental impact. The table also shows the prioritisation of the proposed treatment plans as well as the remaining livestock wastes.

Proposed treatment plants	Area (Communities)	Remaining livestock waste composition				Remaining livestock waste (m^3/day)	Prioritisations	Proposed treatment plant capacity (m^3/day)
		Pig	Cattle	Poultry	Sheep and Goat			
Plant 1	Orounda, Kokkinotrimithia, Koutrafas	68%	6%	26%	0%	543*	High	600
Plant 2	Aradippou	47%	46%	3%	4%	555	High	600
Plant 3	Marki, Agia Varvara, Dali, Nisou, Lympia, Athienou, Strovolos	14,4%	60,4%	22,4%	2,8%	448	Medium	500
Plant 4	Achna, Frenaros, Paralimni	0%	93%	7%	0%	270	Medium	300
Plant 5	Tersefanou, Dromolaxia	0%	100%	0%	0%	144	Low	150
Plant 6	Avdimou, Monagroulli, Episkopi (Paphou), Ypsonas	0%	100%	0%	0%	78**	Low	90

Prioritisation of the treatment plants was the product of the following calculation for each area agglomeration:

$$\boldsymbol{Capacity\ of\ waste\ produced\ -\ Capacity\ of\ waste\ treated\ (existing\ treatment\ plants) = Remaining\ untreated\ waste}$$

* After consultation with the Department of Environment (DoE), some of the farms were excluded due to the fact that they were programming to terminate their operation

** After consultation with the Department of Environment (DoE), it was decided to exclude the one poultry farm located in the district of Paphos because of the significant distance and the quantity (10m^3/day) and type of the waste (solid), as well as the one piggery (waste production: 27m^3/day) located in Monagroulli due to its proximity with the existing treatment facility B.P.1

Task 2: Best Available Techniques (BAT) for the livestock waste and animal by-products treatment

The European Commission has adopted BAT reference documents (BREFs) for a range of industrial processes. These documents are the result of information exchange among experts from industry, member state authorities, research institutes and NGOs. As part of this chapter of deliverable 3, BATs related to the treatment of ABPs, and livestock waste were evaluated in terms of their applicability and suitability for the Cyprus livestock waste management sector.

The primary BATs for treating these ABPs are:

- **Incineration**: This process involves burning ABP waste at high temperatures to reduce volume and eliminate pathogens. Rotary kilns are a common method for incineration.
- **Rendering**: Involves processing ABPs to produce protein meal and animal fats through pressure sterilisation at 133°C for 20 minutes.
- **Composting**: A natural process that converts ABPs into compost material through decomposition.
- **Anaerobic Digestion**: Uses microorganisms to break down organic matter in the absence of oxygen, producing biogas.
- **Landfill**: Although less common, landfilling may be used for certain types of ABPs, requiring proper design and management

As part of the research on BATs emphasis was also given to BATs for treating livestock waste, focusing on processes and the type and volume of waste to be processed. A typical process includes steps for a) receiving and pre-treatment, b) treatment, c) post-treatment, d) and storage/disposal.

Techniques for treating livestock waste include:

- **Anaerobic Digestion**: The primary treatment method for biogas production.
- **Composting**: Converts solid manure into nutrient-rich compost.
- **Separation**: Mechanical separation techniques such as decanter centrifuges or belt filter presses.
- **Aerobic Treatment:** Treats liquid fractions with aerobic digesters, nitrification/denitrification reactors, or flotation tanks

Finally, best practices for livestock waste and ABPs management from other EU Member States and the UK were also investigated to identify varying approaches to ABPs treatment, disposal fees, and financial support mechanisms. As part of section 4.3 of the report, the differences in disposal practices, such as government-funded schemes, public-private partnerships, and insurance systems were evaluated. This exploration provided insights into how Cyprus can adopt successful approaches from other regions to enhance its livestock waste management practices.

Furthermore, the real-life instances identified provided tangible illustrations regarding the scope and rationale behind public administrations' support towards farmers in covering the costs associated with dead animal collection, processing, and disposal. The identified facilities that practice sustainable waste management (which covers livestock waste) and utilise circular economy principles also provided us with the evidence of combining a variety of waste streams (i.e., manure, organic municipal waste, meat meal, etc.), which contributes to cost reduction and maximising economic viability in terms of economies of scale.

Therefore, the conceptual design and technical specification of the proposed treatment plants was aligned with the BATs and sustainable waste management practices, such as utilising the rendering process for

Category 2 ABPs (dead animal) and combining the output of the rendering process (i.e., meat meal) with livestock waste (manure) as an additional waste stream into the biogas treatment plant.

Task 3: Conceptual design and technical specification of the proposed treatment plants

The conceptual design and technical specification of the proposed treatment plants with different scenarios and alternatives were developed by applying the BATs to the remaining livestock waste (m^3/day), waste composition (liquid vs solid) and the ABP (dead animal) quantity (in t).

Several technical alternatives and scenarios were taken into consideration for the treatment plants to identify the most suitable based on their comparative advantages and disadvantages.

The following scenarios (shown in Table 8 below) were considered as the most suitable for each of the six treatment plants and used in the financial model:

Table 8: Description of the treatment processes for the proposed treatment plants

Proposed treatment plants	Description of the treatment processes
Orounda and Aradippou treatment plants	Category 1 and Category 2 dead animals will be collected and processed separately. Specifically, Category 1 dead animals will be processed in an incineration plant (combustion, 850°C and 1300°C), while Category 2 dead animals will be processed in a rendering plant (sterilisation 133°C, 20min, 3 bar). Then the sterile material (mixture of meat mill and fat) can be treated together with the livestock waste in a biogas plant. Livestock waste and sterile material will first be homogenised in a homogenisation tank and then pumped into anaerobic digesters, where anaerobic microorganisms decompose the organic matter leading to biogas production. The produced biogas will be collected and used to produce electricity and heat in appropriate Combined Heat and Power (CHP) generators. The digestate will be drained in a decanter centrifuge separator. The remaining liquid phase is first treated in aerobic digesters combined with nitrification /denitrification (Sequencing Bach Reactor (SBR). The final process step comprises the application of a three-stage Reverse Osmosis (RO) procedure. The treated water will be stored temporarily in an appropriate irrigation tank for irrigating crops and the concentrate (brine) will be stored in an open lagoon/pond to evaporate. The solid fraction (dewatered sludge) will be transported to a composting unit to produce compost of good quality (see figures 0.1-0.3 below). In the meantime, it will be stored on a platform type tank.
Marki-Dhali-Athienou and Achna-Frenaros and Tersefanou-Dromolaxia treatment plants	Livestock waste will first be homogenised in a homogenisation tank and then pumped into anaerobic digesters, where anaerobic microorganisms decompose the organic matter leading to biogas production. The produced biogas will be collected and used to produce electricity and heat in appropriate Combined Heat and Power (CHP) generators. The digestate will be drained in a decanter centrifuge separator. The remaining liquid phase is first treated in aerobic digesters combined with nitrification /denitrification (Sequencing Bach Reactor (SBR). The final process step comprises the application of a three-stage Reverse Osmosis (RO) procedure. The treated water will be stored temporarily in an appropriate irrigation tank for irrigating crops and the concentrate (brine) will be stored in an open lagoon/pond to evaporate. The solid fraction (dewatered sludge) will be transported to a composting unit to produce compost of good quality (see figures 0.1-0.3 below). In the meantime, it will be stored on a platform type tank.

Avdimou-Ypsonas treatment plant	Livestock waste /manure will first be homogenised in a homogenisation tank and then pumped into anaerobic digesters, where anaerobic microorganisms decompose the organic matter leading to biogas production. The produced biogas will be collected and used to produce electricity and heat in appropriate CHP generators. The digestate will be drained in a decanter centrifuge separator or a belt filter press. The remaining liquid phase will be stored in an open storage /evaporation pond to evaporate. This fraction can also be used as a liquid fertilizer. The solid fraction (dewatered sludge) will be stored in an open platform, and it can be used as a soil conditioner / improver.

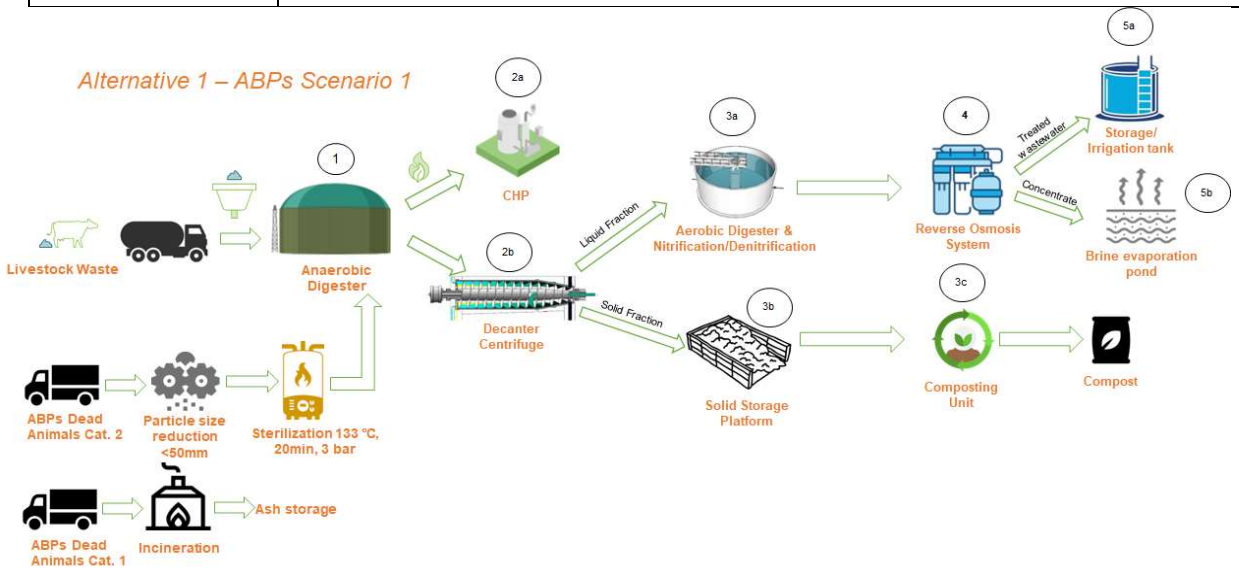

Figure 8: Orounda and Aradippou treatment plants (note only Orounda will process ABPs (dead animals))

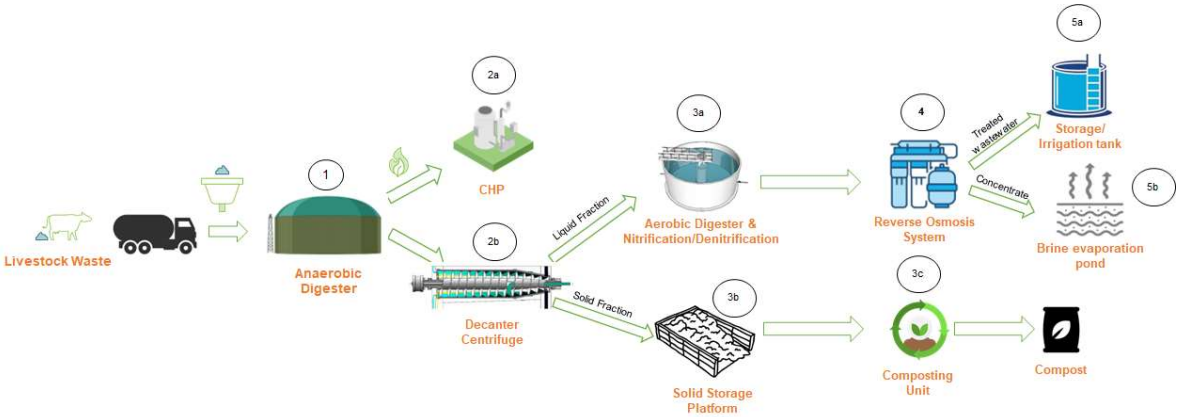

Figure 9: Marki-Dhali-Athienou and Achna-Frenaros and Tersefanou-Dromolaxia treatment plants:

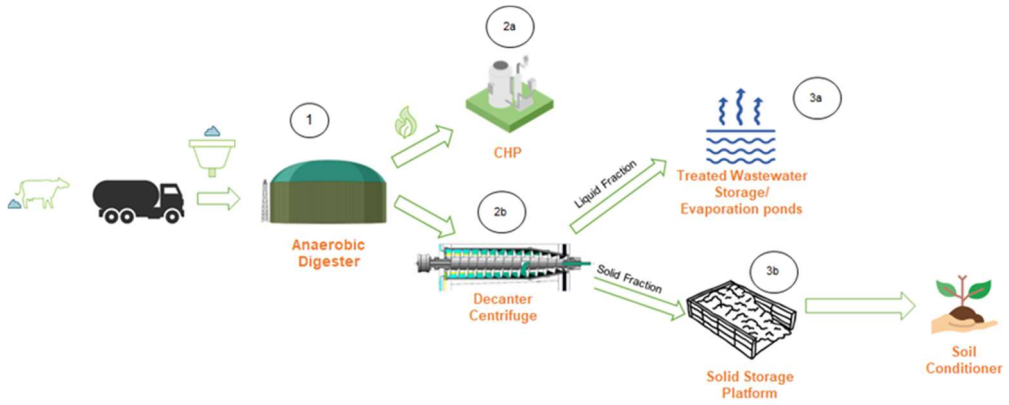

Figure 10: Avdimou-Ypsonas livestock waste treatment plant:

Task 4: Financial estimates and projections based on the conceptual design and technical specification were used to determine the viable gate fee

The treatment facilities generate electricity, compost, and irrigation water as by-products. However, the revenue generated from the sale of by-products alone is insufficient to cover the operational costs of the facilities. Therefore, it is necessary to charge farms for the treatment of livestock waste (manure) and processing/disposal of ABP (dead animal).

It was agreed with the Competent Authorities (Ministry of Agriculture Rural Development and Environment, Department of Environment, Veterinary Services, Department of Agriculture) that the gate fee should enable the facilities to break even operationally and to recover the capital costs incurred.

To determine the gate fee, Net Present Value (NPV) models were applied, in which a detailed model of the plant's revenues, operational expenses, and capital expenditures was created and discounted back to the present value. The following are the respective gate fees for the two waste streams:

- **Livestock waste (manure) gate fee**: EUR13.40/m^3 (which includes transportation costs equal to EUR 6.44/m^3. This is a significant increase from the current market rate of EUR 2.00 – EUR 3.00/m^3. Current market rate does not include the use of the aerobic digester and desalination process (i.e. RO) if the aerobic digester were used, market estimates imply it would cost between EUR12 - EUR15/m^3. The increase in price demonstrates the need for a robust management model and subsidy schemes to make the treatment of waste appealing and affordable to the farmers.

- **ABP (dead animals) gate fee**: EUR 182.19/t (which includes transportation costs equal to EUR 79.59/t). The ABP treatment facility benefits from the use of the Orounda livestock waste treatment facility (i.e. using meat meal as an additional waste stream in Orounda livestock waste treatment facility). In the scenario where a standalone ABPs plant[2] was to be established the gate fee would be higher as it would not benefit from the revenue from the sale of the by-products (i.e. electricity).

Task 5: Management model to operationalise the proposed treatment plans

Having designed the plants and the gate fee to make such a plan feasible, it was paramount to thoroughly evaluate the different proposed treatment option scenarios to successfully implement the national strategy plan (deliverable 5 of this project) into operational practice. Therefore, within the report options for the involvement of the private sector are analysed. Concerning the management of the system, different models can be utilised, each with their respective advantages and disadvantages which are identified in the report. For the purposes of the financial model, a Public-Private Partnership (PPP) management model was used, where the government finances the construction of the projects, and as a result, the private

[2] The proposed treatment facility will operate as a standalone system dedicated exclusively to managing and treating animal by-products derived from dead animals.

sector company (can be a consortium) receives payments for the Engineering, Procurement and Construction, (EPC) services during the implementation phase and an Operation and Maintenance (O&M) fee to run the plants.

Deliverable 4 – Establishment of management facilities with biogas production units for livestock waste and other animal by-products in the Orounda region

Objectives

Deliverable 4 constitutes the fourth out of eight project deliverables. The overarching objectives of the report are to:

1. Identify the most suitable techniques and technologies for treating livestock waste and animal by-products and ensure that the selected techniques align with the specific needs of the Orounda region's livestock ecosystem and can be implemented by competent authorities in the future.

2. Determine the optimal pilot plant for livestock waste treatment by comparing various alternatives and selecting the most effective one for the Orounda region, considering environmental, technical, and financial aspects.

3. Define the technical specifications for the pilot plant by outlining the required equipment, processes, and performance requirements. This objective guides the tendering stage of the project to ensure clarity for prospective tenderers.

4. Support Beneficiaries in tendering and licensing processes by providing guidance on the assessment of tenderers' eligibility and award criteria. It also aims to define the permitting and licensing requirements to ensure compliance with all relevant legislation and regulatory frameworks.

5. Outline the monitoring and inspection requirements to ensure the safe operation of the pilot plant. It aims to maintain compliance with environmental and operational standards, contributing to the plant's long-term sustainability and success.

Methodological overview

Deliverable 4 builds upon the findings of previous deliverables to offer an examination of BATs and technical specifications for the Orounda pilot project, focusing on livestock waste and ABPs management in Cyprus. The deliverable's methodology draws on various sources, including detailed assessments, stakeholder engagement, and subject matter expertise, to present a clear pathway for establishing a pilot plant in the Orounda region.

Best Available Techniques, as these are defined by the European Union's (EU) Industrial Emissions Directive (IED), are considered to develop a comparative assessment focused on their application to Orounda’s waste streams, emphasising how these techniques can significantly reduce emissions, waste volume, odours, and nutrient losses. Chapter 3 of the deliverable also provides a comparative assessment of two key treatment scenarios relating to the management of ABPs of Category 1 and 2 (dead animals): 1) incineration and 2) rendering or composting. A multi-criteria analysis evaluates these options based on financial, environmental, and technical aspects, helping to identify the optimal configuration for the treatment plant. This thorough analysis is crucial for determining the most suitable approach for managing waste streams in the wider Orounda region.

After exploring the BATs, the report outlines the technical specifications for the proposed treatment plant. Section 4 of the deliverable provides a detailed technical specification of the proposed treatment plant, covering its processes, equipment, and technologies. Specifically, it considers four treatment process: Livestock waste and ABPs are collected and transported to the treatment plant, where livestock waste is unloaded into designated reception areas, and ABPs are directed to either incineration or rendering units based on their category. Technical specifications for the equipment and technologies chosen for the Orounda plant are also provided, including design flows for livestock waste and ABPs, accounting for variations in waste input. Quality characteristics are specified to ensure compliance with environmental permits and legislation, with design capacities for incineration, rendering, and biogas plants outlined alongside quality parameters for incoming waste, ensuring efficient and effective operation.

To ensure an appropriate governance, the deliverable addresses licensing, permitting, monitoring, and supervision obligations for constructing and operating the pilot plant. Specifically, it identifies the required licenses from Cypriot authorities, including environmental impact assessments and approvals from various departments, ensuring compliance with national and European legislation. Section 4 also outlines a monitoring program, detailing the frequency and parameters to record, ensuring the plant's ongoing compliance with emissions permits, environmental standards, and technical performance. This governance aspect is essential for the plant's long-term sustainability.

Finally, the deliverable's final section offers guidance on the tendering process, outlining criteria for evaluating prospective tenderers based on their economic, financial, technical, and professional standing. The approach ensures that the best candidates are selected, supporting the project's successful implementation. The section also provides clear guidelines on assessing tenderers and awarding the contract, facilitating a smooth transition from planning to construction and operation.

Summary of key findings from core tasks

Task 1: Best Available Techniques for processing of livestock waste

Task 1 of deliverable 4, delves into the BATs treatment methods related to the management of ABPs of Category 1 and 2 (dead animals).

Category 1 ABPs are considered high-risk due to their potential to carry disease. Treatment options include incineration or co-incineration, which reduce volume and pathogen load. Rotary kiln incineration is recommended for its efficiency, ensuring full destruction of pathogens and compliance with European standards.

Category 2 ABPs include materials not suitable for human consumption. These can be managed through rendering, which uses pressure sterilisation to produce meat meal and animal fat that can then be fed into the livestock waste treatment plant for further processing. Specifically, Category 2 ABPs can be mixed with livestock waste for anaerobic digestion, producing biogas and digestate.

Two treatment options were evaluated for Category 1 and Category 2 ABPs:

1. **Scenario 1**: Category 1 ABPs (dead animal) will be processed in an incineration plant, while Category 2 ABPs (dead animal) will be processed in a rendering plant and the output of the rendering process (mixture of meat meal and fat) can then be treated with livestock waste in a biogas plant (anaerobic digesters). The implementation of this scenario has a lower risk of contamination, although the biogas production potential will be lower.
2. **Scenario 2**: Only SRM from Category 1 ABPs (dead animal) will be incinerated following the appropriate SRM removal process. The remaining Category 1 ABPs will be able to be treated as Category 2 material and therefore together with Category 2 ABPs (dead animal) will be processed in a rendering plant. The output of the rendering process can then be treated with livestock waste in a biogas plant (anaerobic digesters).
   The implementation of this scenario increases the biogas production potential by 11.9% but poses higher contamination risks and requires skilled personnel.

The assessment concludes that **Scenario 1** is the preferred choice, balancing effective waste management with lower contamination risks and technical complexity.

Additionally, the processes for managing livestock waste, particularly manure are considered and outlined. Anaerobic digestion serves as the primary treatment for livestock waste in Orounda. During this process anaerobic microorganisms decompose the organic matter leading to biogas production and the digestate, which undergo further processing. Mechanical separation, using decanter centrifuges or belt filter presses, separates solid and liquid fractions, allowing each to be treated independently. The liquid fraction will first be treated in aerobic digesters combined with nitrification /denitrification process (sequencing batch reactors (SBR)) or in the case of separation in belt filter presses air flotation could be followed, significantly reducing environmental impact.

The deliverable employs a three-step comparative assessment methodology to evaluate the alternative treatment scenarios:

1. **Qualitative Analysis:** This considers technical aspects of each option, including equipment availability, operational complexity, and infrastructure requirements.

2. **Quantitative Analysis**: This evaluates financial implications, covering treatment costs per ton, revenue streams from by-products, and potential economic benefits.

3. **Sensitivity Analysis:** This examines the robustness of each option to varying assumptions and scenarios, including fluctuations in energy prices, treatment costs, and regulatory changes.

The assessment concludes with a recommendation for **Alternative 1:** Mechanical Separation through Decanter Centrifuge, followed by Aerobic Digestion combined with Nitrification-Denitrification process, as the preferred option. This scenario balances technical feasibility, environmental sustainability, and economic viability, allowing for comprehensive waste treatment.

Task 2: Technical specification of recommended technologies for the Orounda pilot project

Task 2 of Deliverable 4 describes the technical specifications of the equipment and processing technologies chosen for the Orounda project. The proposed treatment processes for livestock waste and ABPs in the wider Orounda complex area, and Category 1 and 2 ABPs collected from across Cyprus, are outlined for the Orounda Waste Treatment Plant (WTP).

The Orounda WTP consists of **three** main treatment processes:

1. **Waste collection, transportation and temporary storage:** ABPs and livestock waste are collected separately from livestock farms and transported to the treatment plant. Liquid manure is unloaded into a collection tank, while solid manure is placed on a platform-type tank. ABPs are unloaded in the reception areas of the incinerator and rendering unit, and then directly fed into the process equipment.

2. **Category 1 and Category 2 ABP treatment:** Category 1 ABPs are directly fed into a rotary kiln incinerator, which reduces their volume and hazard through a two-stage process, resulting in ash that is collected in a closed container. Category 2 ABPs are shredded and heated in a cooker at 133°C for 20 minutes and 3 bar pressure, and then conveyed to a silo-type tank for storage. The sterile material is then sent to the livestock waste treatment facilities.

3. **Livestock waste and sterile material treatment:**

    - **Homogenisation and anaerobic digestion:** Livestock manure and sterile material are homogenised before entering the anaerobic digesters, producing biogas and digestate.

    - **Mechanical separation:** The digestate is drained in a decanter centrifuge separator, separating the solids from the liquid.

    - **Aerobic digestion – nitrification/denitrification:** The liquid phase undergoes aerobic digestion combined with nitrification-denitrification process to further reduce the organic load as well as to remove nitrates.

    - **Three-stage reverse osmosis:** The liquid phase is then treated through a three-stage reverse osmosis process, yielding nutrient concentrate and clean water.

    - **Composting/co-composting**: The solid fraction (dewatered sludge) is composted by the windrow pile composting method in an open site area with the addition of “green waste / pruning”.

Section 4.3 of the deliverable 4 also provides detailed technical specifications for the equipment and technologies chosen for the Orounda livestock waste treatment plant, divided into three areas:

1. **General provisions:** This covers the general flow of waste streams to the treatment plant, incorporating a 10% safety factor to accommodate variability in waste production rates. The expected daily flow of mixed livestock waste and sterile material is 606 m³ or 501.8 tonnes.

2. **Required performance levels/treatment performance:** This area outlines the expected performance levels for the treatment processes, detailing the quality characteristics of treated effluents and by-products, ensuring compliance with national and European regulations. Parameters such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), and nutrient concentrations are monitored to ensure the treated effluents are suitable for irrigation or disposal, and the solid fraction can be used as a soil improver.

3. **Project design:** This section details the equipment and technologies chosen for the Orounda WTP, including:

    - Category 1 ABP Treatment: **Rotary kiln incineration** to reduce volume and hazard, generating flue gases and solid residues.

    - Category 2 ABP Treatment: **Rendering** to produce sterile material, which is then fed into the livestock waste treatment process.

    - Livestock Waste Treatment: This includes **homogenisation, anaerobic digestion, mechanical separation, aerobic digestion, reverse osmosis, and composting**.

Task 3: Technical support for the permitting and inspection requirements, monitoring and supervision obligations

Task 3 of Deliverable 4 provides an overview of the permitting and inspection requirements, alongside monitoring and supervision obligations for the Orounda pilot project. This section outlines the crucial regulatory framework and the necessary licenses and permits required for the construction and operation of the livestock waste treatment and biogas production plant.

The development and operation of the Orounda Waste Treatment Plant entail obtaining several critical licenses and permits from various regulatory authorities to ensure compliance with national and European regulations:

- **Environmental Impact Assessment study – formal opinion (DoE):** A comprehensive Environmental Impact Assessment (EIA) is required, culminating in a formal opinion issued by the Department of Environment. This assessment is critical for obtaining subsequent approvals and integrating environmental considerations early in the project planning stages.

- **Exemption from the obligation to hold a license for construction and operation of an electricity production plant by biomass (CERA):** For biogas plants like those proposed in Orounda, an exemption from CERA is necessary, indicating the plant meets specific criteria that negate the need for a conventional construction and operation license.

- **Town planning permit (DTPH):** This permit is essential for the construction of any new facility, ensuring that the project adheres to local urban planning and land use regulations.

- **Building permit (DAO):** Issued by the District Administration Office, this permit authorises the construction of the facility, confirming that the designs comply with national building codes.

- **Industrial emissions permit (DoE):** This permit ensures that the plant's operations will meet strict environmental standards, particularly concerning emissions and waste management.

- **Connection agreement (EAC):** A formal agreement with the Electricity Authority of Cyprus (EAC) for the connection of the biogas plant to the national grid to sell electricity produced from biogas.

- **Approval for receiving and rendering of ABP of Category 1 and 2 (VS):** The Veterinary Services must approve the facility's processes for handling and rendering animal by-products to ensure they meet health and safety standards.

- **Exemption from the obligation to hold an operation license (CERA):** Similar to the construction exemption, this exemption is necessary for the operation phase, underlining the plant's compliance with specific operational standards that preclude the need for a full license.

- **Operation license for the livestock waste management/biogas production plant (VS):** Required for the legal operation of the plant, ensuring all processes meet regulatory standards for waste management and biogas production.

- **Incineration plant registration (VS):** The plant must be registered as an incineration facility, particularly for the disposal of Category 1 ABPs, with the Veterinary Services.

- **ABPs transport and collection registration (VS):** Registration is necessary for vehicles and processes involved in the transportation and collection of animal by-products, ensuring compliance with health and safety regulations.

Monitoring and supervision are integral to maintaining compliance with environmental and operational standards. Under Task 3, the report also details a robust monitoring framework set by the industrial emissions permit, which includes:

- The recording of incoming waste (type, quantities, producer, etc.);

- The recording of quantities and quality of purified water and the way of its disposal;

- The recording of quantities and quality of compost produced and the way of its disposal;

- The quantities and type of raw materials used;

- The recording of various operational parameters;

- The environmental monitoring in the wider area (odours, air quality, groundwater quality, soil quality, etc.) and

- The recording of accidents and other parameters.

Task 4: Guidance on the tendering process – technical eligibility, award criteria and assessment

To assist the tender team in deciding on the most suitable tenderers for the 'Orounda pilot treatment plant' Request for Proposal (RFP), Task 4 provides a comprehensive guideline on the eligibility criteria and a thorough assessment process for the proposals received. These recommendations are grounded in practices observed in similar government tenders and have been discussed and agreed upon with representatives from the Ministry of Agriculture (MARDE) and its Veterinary Services. They are also in alignment with the government's approach to conducting such tenders.

The management model for the proposed Orounda pilot treatment plant is a design-build-operate (maintain) model under a Public-Private Partnership framework. This model stipulates that the government will fund the construction phase while the private sector, potentially a consortium, receives payments for the engineering, procurement and construction (EPC) services as the project progresses, with funding sources being the national budget and/or EU Funds. Post-construction, the private sector will manage the

operation and maintenance of the facility, compensated by an operation and maintenance fee, given the government's role in financing the initial capital expenditure.

For **the tendering process**, the documents will differentiate financial proposals for the design-build phase and the operate-maintain phase for a predefined period, such as 10 years. The key requirements for the tendering process and the method of contract award include:

Economic and financial standing: Economic operators must demonstrate a stable financial status by showing an average annual turnover equal to or exceeding a set amount over the last three years (for example on a reference tender of EUR 11,19 m where the Design-Build was 6,20m EUR and Operate-Maintain was EUR 4,99 m the requirement for the average annual turnover was set at EUR 5 m). If the economic operator is a consortium, this requirement can be met collectively. Additionally, economic operators can leverage the capacities of other entities, provided they can access these resources when needed.

Technical and professional ability: Economic operators must have successfully completed at least one relevant project in the last ten years that includes design, build, and operation of a waste treatment plant with a minimum capacity of 400 m^3/day, along with a requirement for successful operation post-commissioning. It's critical that these projects demonstrate the ability to handle operations without significant faults, which reflects on their technical competence and reliability.

Tender evaluation – award criteria: The evaluation process involves detailed price schedules for both the design-build and operation-maintenance phases. The bids will undergo an arithmetic check for any errors, which will be corrected accordingly. Tenders will be ranked based on the corrected total tender amounts, with the contract being awarded to the lowest bid that meets all criteria. Special attention will be given to abnormally low bids, which may be subject to further scrutiny to ensure that they are feasible and do not compromise on quality or compliance.

Contract assignment: The project will be divided into two contracts: one for design-build and another for operation-maintenance. This separation ensures clarity and focus for each phase, facilitating detailed planning and execution.

Deliverable 5 – National strategy for the management of livestock waste and other animal by-products in Cyprus

Objective

Deliverable 5 constitutes the fifth out of eight project deliverables. The overarching objective of the deliverable is to:

1. Deliver a national strategy for the management of livestock waste and other animal by-products in Cyprus, addressing inefficiencies in current practices and regulatory and infrastructure limitations. This strategy aims to transform these challenges into opportunities for the sector and an asset for the Cypriot economy, aligning with European sustainability and net-zero goals. Through a data-driven approach, the strategy provides a comprehensive roadmap to coordinate and enhance effective livestock waste initiatives, guiding Cyprus towards a sustainable and economically viable future for the livestock sector.

Methodological overview

Deliverable 5 serves to create a strategic framework that sets clear directives for advancing the management of livestock waste and other animal by-products (ABPs) in Cyprus, aiming to transform current practices into a more sustainable and economically beneficial system. The framework is structured around several key components:

2. **Strategic vision:** This element articulates a long-term goal for Cyprus's livestock waste management sector, aiming for net-zero emissions by 2050, aligning with European sustainability targets. The vision emphasises integrating circular economy principles to maximise resource efficiency and reduce environmental impacts.

3. **Horizontal enablers and accelerators:** These foundational elements support the realisation of the strategic vision. They include governance structures to oversee and coordinate strategy implementation and funding mechanisms to ensure financial resources are available and effectively used.

4. **Strategic pillars and objectives:** The strategy is built on six strategic pillars, each addressing specific challenges and gaps identified in the sector. These pillars are:

    1. Legal and policy framework: Ensuring policies are aligned with EU directives and fostering a regulatory environment conducive to sustainable practices.

    2. Finance and infrastructure: Securing funding and developing the necessary infrastructure to support modern waste management practices.

    3. Research and development: Promoting innovation in waste treatment and resource recovery technologies.

    4. Collaborations and partnerships: Strengthening cooperation between governmental bodies, private sector, and international partners to enhance sector capabilities.

    5. Monitoring and reporting: Establishing robust mechanisms to track progress and adapt strategies as needed.

    6. Awareness and training: Enhancing knowledge and skills among stakeholders to support the strategy's goals.

    Each pillar comprises specific objectives aimed at tackling the sector's challenges, designed to ensure that all actions contribute holistically to the vision of a sustainable, net-zero emissions

livestock sector by 2050. The strategy emphasises a data-driven approach, allowing for continuous adaptation and alignment with evolving environmental standards and market conditions.

Summary of key findings from core task

Task 1: Draft National Strategy

The current state of the Cypriot livestock waste and ABPs management sector is plagued with a plethora of inefficiencies, the main ones being the:

- Underutilisation of resources,
- Increased environmental and health impacts,
- Regulatory and infrastructure limitations,
- Wasted value potential.

These challenges and gaps are what the national strategy aims to, not only address, but turn into an opportunity for the sector and an asset for the Cypriot economy. Simultaneously, achieving alignment with the European sustainability and net-zero goals, of which livestock waste management plays a central role.

The national strategy offers a holistic roadmap to coordinate and enhance effective livestock waste initiatives, through the development of strategic objectives, always following a data driven approach, capable of continuous adaptation. It serves as a pivotal tool that can guide Cyprus towards a more sustainable and economically viable future for the livestock sector.

For the development of the national strategy a robust and systematic methodological approach was adopted, which was undertaken in 3 key steps:

1. Consolidation of key findings from previous deliverables;
2. Synthesis of the strategic framework; consisting of a vision, horizontal enablers and accelerators, strategic pillars and their respective objectives (see Figure 2) and
3. Development of the Strategy with stakeholder engagement.

This deliverable is structured around the key sections outlined below.

Strategic vision: This section provides the vision for the strategy up until 2050 guided by circular economy principles and European goals, providing the necessary direction to the stakeholders. The essence of the vision has been condensed within the vision statement presented below:

"Drive the Cypriot livestock waste and animal by-products management sector towards sustainability, with a goal to achieve a net-zero livestock sector by 2050." By integrating circular economy principles, the aim is to reduce emissions, prevent pollution and reduce the use of chemical fertilisers. By committing to mitigating biological risks and pollution, the aim is to foster a more resilient and modern farming community.

Horizontal enablers and accelerators

A. Governance structure (horizontal enabler):

- Objective A.1: Establish a governance structure within MARDE to oversee and coordinate the implementation of the national strategy for livestock waste and ABPs management.

- Objective A.2: Establish a cross-ministerial coordination framework to enhance synergy and joint action in the implementation of the national strategy for livestock waste and ABPs management.

B. Funding mechanism (horizontal accelerator):

- Objective B.1: Ensure sufficient funding is dedicated from diversified sources for the successful implementation of the national strategy.

- Objective B.2: Optimise the allocation and utilisation of the financial resources through the development of a mechanism.

Strategic pillars and objectives

The national strategy is designed on six fundamental vertical strategic pillars, which provide the core building blocks of the strategy, ensuring that the roadmap addresses every critical aspect of the sector whilst paving the path for the sustainable transition. Each pillar is designed to address a specific set of gaps and challenges within the livestock waste and ABPs management sector, providing the structure required to address them comprehensively.

The six strategic pillars which build the foundations on which the objectives have been grouped are as shown in Figure 10 below.

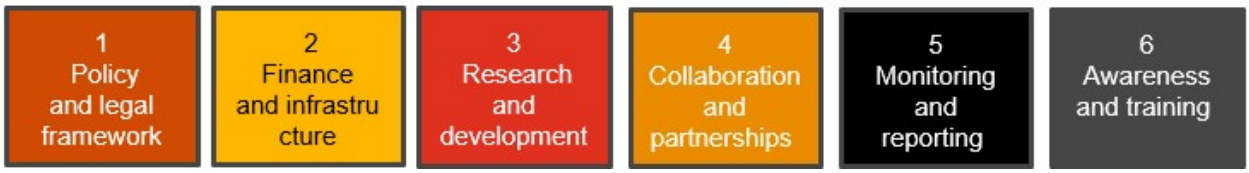

Figure 10: Strategic pillars

Furthermore, each pillar has been broken down into specific objectives which are tailored to bridge specific gaps and challenges. An overview of each strategic pillar and their respective objectives can be seen below.

1. **Legal and policy framework:**

- Objective 1.1: Align both the existing and forthcoming national policies with the EU green agenda, transitioning to a net-zero sector for livestock farming from a waste management perspective in Cyprus by 2050.

- Objective 1.2: Improve the quality of life in the communities and surrounding environment through pollution prevention and control and minimise the spread of diseases and odour.

- Objective 1.3: Incorporate circular economy and energy and climate principles in the value chain of livestock waste and ABPs management by enhancing this specific policy landscape.

2. **Finance and infrastructure:**

- Objective 2.1: Secure the appropriate funds for providing financial support programs to enable farmers' direct involvement in the modernisation and expansion of the livestock waste and ABPs management infrastructure, via increasing the biogas production and encouraging the upgrades for the production of biomethane.

- Objective 2.2: Allocate the necessary funds for the establishment, enhancement, and expansion of vital public infrastructure, complementing the private efforts of farmers in biogas plant development, supporting in this way the effective utilisation of products and by-products from the biogas treatment process, thereby ensuring the modernisation and optimisation of the livestock waste and ABPs management sector.

- Objective 2.3: Ensure continuous alignment with evolving Best Available Techniques (BAT) to enhance efficiency and reduce GHG emissions to support the sector in transitioning towards the net-zero goal by 2050.

3. **Research and development:**

   - Objective 3.1: Enhance process efficiency of livestock waste and ABPs management sector through expertise and collaboration with academic institutions and industry stakeholders nationally and internationally, accelerating the modernisation and expansion of the livestock waste and ABPs management infrastructure.

   - Objective 3.2: Foster innovation in technologies and methodologies to maximise the value and utilisation of by-products generated from livestock waste treatment processes.

   - Objective 3.3: Establish a mechanism to review, analyse, and disseminate best practices and monitor and promote emerging technologies, techniques, and cutting-edge solutions at a national and international level.

4. **Collaborations and partnerships**

   - Objective 4.1: Strengthen inter-sectoral collaborations and governance for enhancing the sustainable waste management of livestock and ABPs.

   - Objective 4.2: Establish international partnerships and collaborations for technology adoption and enhanced livestock waste and ABPs sector growth.

5. **Monitoring and reporting:**

   - Objective 5.1: Establish an effective monitoring and reporting mechanism to oversee the implementation of the national strategy for the management of livestock waste and ABPs in Cyprus.

   - Objective 5.2: Establishing a procedure for annual review of strategy’s implementation progress and a corrective action framework for the national strategy.

6. **Awareness and training:**

   - Objective 6.1: Enhance public awareness and understanding of sustainable livestock waste management through the design and implementation of a robust, targeted communications plan, thereby fostering a supportive environment for the national strategy's objectives.

   - Objective 6.2: Strengthen the sector's capacity by delivering targeted training to primary stakeholder groups, covering essential areas such as waste management techniques, design principles, environmental impacts, and relevant funding opportunities, thereby improving the maturity of understanding and practical skills within the sector.

Using the findings of this deliverable an action plan and a roadmap will be developed to ensure the successful and timely implementation of the objectives and the realisation of the strategic vision. The road map will focus on the shorter term (i.e. up to 2030) of the 2050 strategy to ensure relevance and early action to move the strategy forward over this first period.

Deliverable 6 – Action plan and roadmap for the management of livestock waste and other animal by-products in Cyprus

Objectives

Deliverable 6 constitutes the sixth of eight project deliverables. The overarching objectives of the deliverable are to:

1. Create an action plan based on the strategic pillars and objectives developed as part of the Deliverable 5 into actionable recommendations and interventions.

2. Provide a detailed future state overview reflecting the NECP's revised targets and the action plan's alignment with these objectives. Prioritise the development of treatment facilities in key areas like Orounda, Aradippou, and Marki to ensure Cyprus meets its 2030 targets and continues toward the 2040 strategic goals.

3. Conduct a comprehensive comparison of qualitative and quantitative factors between areas identified as hotspots for new treatment plant development, specifically Orounda and Aradippou. This analysis will guide the prioritisation of infrastructure development, considering factors like capital and operational expenditures, community impact, and alignment with NECP targets, alongside the implications of recent amendments to the Industrial Emissions Directive.

4. Identify funding opportunities to bridge the infrastructure funding gap critical for implementing the sustainable management of livestock waste and animal by-products in Cyprus.

5. Outline a strategic framework for effectively managing the transition towards sustainable livestock waste and animal by-product management practices in Cyprus. This objective aims to provide a detailed description of change management principles, tailored to address the specific political, intellectual, and commercial dynamics of stakeholders involved.

6. Describe strategic communication approaches that facilitate the effective dissemination and adoption of the national strategy for managing livestock waste and animal by-products in Cyprus. Under this objective, the methods and plans for proactive communication, tailored to the various stages of strategy implementation are described.

It is important to note that whilst it was evident that RRP funding had been reallocated away from Orounda, the action plan had to be supportive of the designed strategy of centrally operated treatment plants, as was expected over the majority of the duration of this project. As a result, it was agreed with DG Reform and the beneficiary during the Steering Committee meeting to evolve deliverable 6 so as to provide guidance and interventions without 'locking' the beneficiary into an unsupported timeline, in doing so enabling the necessary flexibility in their next steps.

Methodological overview

Deliverable 6 represents a step in advancing the strategic vision for sustainable livestock waste and ABP management in Cyprus, as outlined in Deliverable 5. This deliverable transitions from defining the strategic objectives to detailing the practical steps and methods for achieving these goals within the framework of Cyprus's national strategy. The deliverable is designed to direct the efforts of various stakeholders, including government bodies, the private sector, and local communities, toward a cohesive and effective implementation of this strategy.

The deliverable integrates the six strategic pillars identified in deliverable 5, each addressing specific challenges and gaps within the waste management sector. These pillars guide the development of specific recommendations, actions and interventions in Deliverable 6. The action plan details both upstream and downstream strategies, focusing on enhancing waste treatment processes and valorising by-products such as biogas into higher-value products like biomethane and potentially hydrogen. Additionally, the action plan's development involved a process of prioritising recommendations to align closely with national

targets, particularly those specified in the revised 2023 National Energy and Climate Plan (NECP). This strategic alignment ensures that each step taken is not only aimed at meeting these targets but doing so efficiently and sustainably, reflecting a commitment to resource conservation and environmental protection.

Furthermore, the implementation strategy acknowledges the varied progress and challenges in treating different types of livestock waste. Thus, it prioritises actions based on their potential impact and feasibility, focusing on areas like Orounda, Aradippou, and Marki for the development of treatment facilities. These efforts are designed to ensure that Cyprus meets its impending 2030 NECP targets while setting a sustainable course towards the 2040 goals. Four implementation scenarios are presented to guide decision-making, illustrating different levels of intervention and their respective impacts on NECP targets. Each scenario includes detailed financial implications, providing a basis for informed decisions regarding the allocation of resources and the scheduling of infrastructure developments.

The approach to developing the action plan utilises a two-tier system that hinges on core and enabling pillars, ensuring a systematic progression from policy formulation to practical implementation. Specifically, the policy and legal framework as well as the infrastructure and finance pillars of the national strategy are considered are core pillars. These pillars are pivotal in setting a robust foundation for implementing the to-be scenario and achieving the NECP 2030 targets. The national strategy pillars of governance, funding mechanism, research and development, collaborations and partnerships, awareness and training are considered as supporting pillars. These facilitate the strategic execution of the action plan, ensuring effective governance, optimising funding, and enhancing stakeholder engagement.

The recommendations and associated actions within the action plan are strategically categorised into upstream and downstream segments to address different stages of the waste management and valorisation process. Upstream recommendations and actions enhance waste collection and initial treatment processes to optimise biogas and compost production, focusing on the adoption of advanced technologies and facility improvements. On the other hand, downstream recommendation and actions, focus on converting biogas into higher-value products like biomethane and exploring hydrogen production, aimed at maximising economic value and integrating with national energy systems.

Appendix A of the report addresses the significant funding challenges Cyprus faces in transitioning to sustainable livestock waste and ABP management. It identifies a range of funding opportunities and financial instruments that could potentially bridge these gaps. The focus is on leveraging both local initiatives and European support mechanisms to catalyse necessary investments for enhancing infrastructure, optimising waste collection, and developing high-value products. It explores various funding options used by other EU Member States, highlighting the potential use of funds like the European Regional Development Fund (ERDF), Cohesion Fund, and the Just Transition Fund for the next programming period.

Appendix B provides essential technical guidance to support the effective implementation of the national strategy for managing livestock waste and ABPs in Cyprus. This appendix addresses the practical aspects of the strategy, offering detailed technical specifications, implementation protocols, compliance guidelines, operational instructions, and capacity-building resources. The focus is on enabling beneficiaries to carry out the interventions successfully, ensuring that the infrastructure and processes meet the necessary standards and regulations. By providing comprehensive guidance, Appendix B aims to facilitate the efficient and sustainable management of livestock waste and ABPs, contributing to the overall goals of the national strategy.

At the same time, Appendix C delves into the systematic approach of change management essential for integrating the governmental agricultural strategy. It outlines key change management principles and frameworks designed to manage transitions effectively. The emphasis is on ensuring that changes in organizational goals, processes, or technologies are effectively adopted and integrated, thereby maximizing stakeholder engagement and mitigating resistance. The appendix also discusses how a structured process of planning, implementing, and monitoring changes can facilitate smooth transitions within the agricultural sector.

Finally, Appendix D emphasises the critical role of strategic communication in supporting the implementation of the national strategy for livestock waste and ABP management. It describes the approach to defining key messages, tailoring communication strategies to different stakeholder groups, and outlining a detailed communication and engagement plan. The focus is on ensuring clarity in

communication, the evolution of key messages as the strategy is implemented, and the effective use of various communication channels to engage stakeholders and facilitate the adoption of the strategy.

Summary of key findings from core task

Task 1: Prepare a draft action plan for effective management of livestock waste in Cyprus

Within the report, several key issues are addressed, most importantly two key issues that have heavily affected the prioritisation of various interventions within the action plan. These are:

1. The revised targets within the 2023 draft version of NECP[3];

2. The amended Industrial Emissions Directive[4].

With these priorities in mind the following implementation scenarios were drafted, with their main purpose, the achievement of the revised targets within the 2023 draft version of NECP. It is a comparison between four different implementation scenarios, which are integral to the action plan.

*Table 9: Comparison of four implementation scenarios for 2030. The analysis is indicative and based on the data available at the time of the analysis. * An additional EUR2.3M must be considered for the ABP treatment.*

		Scenario 1 No intervention	**Scenario 2** Meet the targets for pig and cattle only	**Scenario 3** Meets all 2030 NECP targets		**Scenario 4** Full implementation of the To-be scenario
				Variation 1 (3.1)	**Variation 2 (3.2)**	
Treatment Plant(s)		-	TP2 - Aradippou	TP1 - Orounda, .. TP3 - Marki,..	TP1 - Orounda, .. TP2 - Aradippou,..	Construct all six TPs
Percentage of livestock waste treated and extent to which NECP targets are met (red = not achieved, green = achieved)		Pig 62% 🟥 Poultry 8,5%🟥 Cattle 10% 🟥	Pig 73% 🟩 Poultry 11%🟥 Cattle 19%🟩	Pig 79% 🟩 Poultry 42% 🟩 Cattle 21%🟩	Pig 87% 🟩 Poultry 30% 🟩 Cattle 20% 🟩	Pig 95% 🟩 Poultry 55% 🟩 Cattle 48% 🟩
Financial implications over 10-year period (using avg. ETS price - EUR 85 / tonne[3])		EUR 24.7M	EUR 19M (saving EUR 5.7M)	EUR 11.7M (saving EUR 13M)	EUR 12.7M (saving EUR 12M)	EUR 0 (saving EUR 24.7M)
Cost to build and operate	**CAPEX**	-	EUR 13.5M	EUR 26.5M	EUR 27.2M	EUR 56.1M
	OPEX Annual	-	EUR 4.2M	EUR 8.0M	EUR 9.0M	EUR 17.6M

[3] European Commission (n.d.). Energy strategy - National energy and climate plans (NECPs). [online] Available at: https://commission.europa.eu/publications/cyprus-draft-updated-necp-2021-2030_en

[4] "Revision of the Industrial Emissions Directive | Think Tank | European Parliament." Www.europarl.europa.eu, 5 Mar. 2021, www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)733570.

For the development of the action plan a robust and systematic methodological approach was adopted, which was undertaken in 4 key steps:

1. Consolidation of key findings from previous deliverables;

2. Synthesis of the action plan; consisting of pillars, including horizontal enablers and accelerators, and their respective recommendations, actions, and interventions;

3. The categorisation of recommendations into upstream and downstream segments, aiding in creating a clear, targeted approach for each stage of the product lifecycle;

4. Development of the action plan with stakeholder engagement.

The action plan was structured around the sections outlined below:

1. Infrastructure and finance (Pillar 2);

2. Policy and legal framework (Pillar 1);

3. Horizontal enabler – governance structure;

4. Horizontal accelerator – funding mechanism;

5. Research and development (Pillar 3);

6. Monitoring and reporting (Pillar 5);

7. Awareness and training (Pillar 6).

A summary version of the action plan, in which recommendations are shown in bold with associated actions combined into succinct statements, can be found below:

Infrastructure and finance (Pillar 2) – upstream

- **Construct and upgrade treatment plants (TPs):** Actions include deciding on the most beneficial scenario from four options, constructing all remaining TPs as per the to-be scenario, and enabling the construction of small, private TPs to complement the larger infrastructure plans.

- **Ensure financial viability for TP operators and farmers:** Actions include developing necessary infrastructure for local storage, collection, and transportation of livestock waste from small and medium farms to larger TPs and enabling efficient transportation of livestock waste between locations.

- **Ensure competitive gate fees:** Actions include adjusting gate fees (EUR 13.40/m^3 including transportation costs) to be market competitive and financially viable for farmers, using available state aid and incentives for infrastructure improvements like storage, collection, and transportation to reduce costs.

- **Align with Best Available Techniques (BAT**): Actions encompass monitoring global advancements in BAT to enhance operational efficiency and reduce GHG emissions in Cyprus, along with identifying and integrating best practices from European TPs that use innovative technologies for sustainable livestock waste management.

- **Develop alternative strategies for cattle farmer participation:** Actions involve identifying and establishing incentive mechanisms for cattle farmers to encourage voluntary participation in waste treatment programs, addressing the challenges posed by recent amendments to environmental directives.

Infrastructure and finance (Pillar 2) – downstream

- **Enable biomethane production upgrades:** Actions include developing infrastructure to upgrade biogas treatment plants (TPs) to produce biomethane and constructing necessary storage and refuelling facilities to boost biomethane availability for transportation and other uses in Cyprus by 2030, aligning with the 2023 draft National Energy and Climate Plan (NECP).

- **Enable synthesis of green hydrogen from biomethane:** Actions involve commissioning a feasibility study to assess the potential for producing green hydrogen from biomethane, comparing it to traditional hydrogen production methods. If viable, actions extend to constructing the necessary infrastructure for green hydrogen production at existing and new TPs and promoting the development of market and distribution channels for green hydrogen, enhancing its accessibility and use in Cyprus.

Policy and legal framework (Pillar 1) – upstream

- **Streamline permitting processes for waste management facilities:** Actions include implementing a simplified licensing and permitting platform to accelerate the acquisition of necessary permits for operating waste treatment facilities that utilise biogas for cogeneration and the production of hydrogen and biomethane.

- **Enhance monitoring and enforcement:** Actions involve strengthening mechanisms to effectively regulate nitrification from agricultural activities and prevent illegal dumping of livestock waste, ensuring compliance with environmental standards.

- **Enhance the legal and policy framework on Energy Communities:** Actions include integrating biogas plants into the upcoming frameworks for Citizen Energy Communities and Renewable Energy Communities, facilitating investment in community-owned and cooperative treatment plants. This is being developed by the Cyprus Energy Regulatory Authority and other relevant upcoming regulations to support sustainable energy practices.

Policy and legal framework (Pillar 1) – downstream

- **Enhance legal and policy framework on Guarantees of Origin (GOs):** Actions include strengthening the implementation and application of existing legislation for GOs to encourage investment in renewable energy sources (RES) products derived from livestock waste and ABPs.

- **Set clear targets for livestock waste management:** Actions involve establishing specific, measurable targets for various stages of the livestock waste management process, both upstream and downstream to ensure systematic improvements and accountability within the sector.

- **Ensure high quality standards for biomethane and hydrogen production:** Actions include aligning national standards with European standards for biomethane and hydrogen gas quality. This involves not only adopting EU standards but also actively participating in discussions to harmonize standards across borders.

Horizontal accelerator – funding mechanism

- **Establish a robust governance structure:** Actions include setting up an effective governance structure within MARDE to guide and coordinate the implementation of the national strategy for livestock waste and ABPs management. Additionally, create a cross-ministerial coordination framework to enhance synergy and joint action in the implementation of the national strategy.

Horizontal accelerator – funding mechanism

- **Establish a detailed funding mechanism**: Actions include developing a robust funding strategy by 2030 to support the sustainable management of livestock waste and ABPs. Additionally,

optimise the allocation and use of financial resources through a centralized mechanism to ensure efficient fund distribution and utilisation.

Research and development (Pillar 3)

- **Enhance process efficiency of livestock waste and ABPs management sector:** Actions include collaborating with academic institutions and research institutes, and establishing collaborations with specific, key stakeholders and organizations to accelerate the modernisation and expansion of the management infrastructure.

- **Foster innovation in technologies and methodologies:** Action involves identifying the optimal method for distributing biomethane across Cyprus to maximise the value and utilisation of by-products generated from livestock waste treatment processes.

Collaborations and partnerships (Pillar 4)

- **Strengthen inter-sectoral collaborations and governance:** Actions include investigating potential collaborations between farms and hydrogen producers as part of the 'green valley' initiative, encouraging the establishment of energy communities to enhance the management of livestock and ABPs waste, and employing supply-driven business models like industrial symbiosis. This approach facilitates the reuse of waste and by-products across different sectors, optimising the use of underutilised resources and enhancing sustainability in industrial processes.

Monitoring and reporting (Pillar 5)

- **Establish an effective monitoring and reporting mechanism**: Actions include establishing oversight for the national strategy implementation, utilising technology for streamlined monitoring and reporting in livestock waste management and promoting transparency and collaboration through regular stakeholder engagement and clear performance targets.

- **Establish a procedure for annual review of strategy's implementation progress and a corrective action framework:** Actions involve setting up a procedure for annual review of the strategy's implementation to evaluate and monitor KPIs, and establishing a framework for corrective actions to be triggered if gaps or delays are identified.

Awareness and training (Pillar 6)

- **Enhance the adoption of composted digestate as fertilizer:** Actions include running awareness and education campaigns to promote the use of composted digestate as a sustainable fertilizer alternative among farmers and implementing pilot projects and showcasing case studies to further enhance its adoption.

- **Streamline the permitting processes for livestock waste management facilities:** Action involves developing and implementing training programs for stakeholders and users of the new or expanded One-Stop Shop (OSS), ensuring adoption and efficient utilization of the streamlined processes.

Deliverable 7 – Report on specialised and tailored training

Objective

Deliverable 7 constitutes the seven out of eight project deliverables. The overarching objective of the deliverable is to:

1. Enhance the capacity of relevant Cypriot authorities in managing livestock waste and ABPs through a structured training program. This objective will be achieved by following an overarching three-phase approach: 1) Conducting a training needs assessment, 2) developing a tailored training curriculum, and 3) evaluating the impact of the training.

Methodological overview

The training development and delivery followed PwC's strategic approach which is composed of five key phases. In the Analyse Phase, a training needs assessment was conducted to define the scope of training, identify the target audience, and prioritise content through close consultation with the project's primary beneficiaries. During the Design Phase, a training plan was developed specifying the details of each training course, including duration and the targeted audience. The training curriculum was designed to adhere to the training scope, content prioritisation, and tailored it to specific audiences. For the Development Phase, training materials were created based on the main findings of the project and training requirements, followed by a quality review to ensure accuracy and relevance. Securing training review and approval was essential to validate content and ensure it met educational standards and organisational objectives. The Delivery Phase involved conducting the training sessions for competent authorities, the tender evaluation committee, Cypriot authorities, and relevant stakeholders. Lastly, the Evaluation Phase measured the training's effectiveness through surveys to determine if the training achieved its stated objectives and whether they had a positive impact on the knowledge and understanding of the audience.

Two comprehensive training modules were delivered as part of this project, with each module repeated three times, resulting in a total of six training sessions. These trainings aimed to ensure that the participants are well-versed in various aspects related to the livestock waste management sector. The overarching topics covered in these sessions included legislative considerations such as the upcoming amendments to the Industrial Emissions Directive, the methodology used for assessing the quantity and the composition of animal waste and animal by-products, and the categorisation of livestock areas into different profiles to identify problematic areas. The training modules also addressed management solutions for livestock waste and animal by-products, the selection BATs, and the technical design for proposed treatment plants. Additionally, the methodology for selecting the best alternative processing methods and conducting feasibility studies was covered, including the evaluation of gate fees for the to-be scenario. These trainings aimed to build capacity and raise awareness among the participants, ensuring they are prepared to implement these methodologies effectively in their work.

Summary of key findings from core task

Task 1: Carry out a training gap analysis as well as a training needs assessment and develop a structured and inclusive training plan

A training needs analysis was conducted to identify the gaps in knowledge and skills among stakeholders involved in livestock waste management. The results from this 5-step analysis are summarised below:

1. **Stakeholder Identification and Training Focus:**
   - **Stakeholder groups:** The analysis identified central and regional government officials as the primary stakeholders who would benefit from the training.
   - **Training areas**: The training was tailored to address the specific needs of these groups. For central government officials, the focus was on improving their ability to liaise effectively with other officials and enhance communication across departments. For regional government officials, the training aimed to deepen their understanding of waste management challenges specific to their regions and mobilize local communities.

2. **Survey assessment:**
    - A questionnaire was distributed to prospective training attendees to identify gaps in knowledge that could be addressed through targeted training. Stakeholders responded to six questions using a 5-point sliding scale ranging from "very unaware" to "very aware" to gauge their familiarity with specific topics related to livestock waste management.

3. **Knowledge gaps identified**

The survey results revealed significant knowledge gaps in the following areas:

- **Feasibility studies and gate fees:** Stakeholders showed a low awareness of the principles of conducting feasibility studies and determining gate fees.
- **Relevant technologies:** There was a general lack of awareness regarding the most relevant techniques and technologies for the sustainable management of livestock waste and ABPs.

These findings highlighted the need for targeted training to enhance stakeholders' capacity in these areas.

4. **Training curriculum development**

Based on the results of the needs assessment, a training curriculum was developed to address the identified knowledge gaps. The curriculum included the following key components:

- Methodology for Assessing the Quantity and Composition of Animal Waste and ABPs: Tools and techniques for accurate waste assessment.
- Best Available Treatment Methods and Techniques (BATs): Relevant treatment methods aligned with Best Available Techniques Reference Documents (BREFs).
- Methodology for Conducting Feasibility Studies and Determining Gate Fees: Practical skills for economic assessment and planning.

5. **Analysis of the survey results**

The analysis of the survey results identified that the areas of greatest need were the feasibility study and analysis of gate fees, as well as the understanding of relevant technologies and their implementation in Cyprus.

Task 2: Design delivery and evaluation of the training

The training program was designed to cater to the specific needs of both central and regional government officials involved in livestock waste and animal by-product management. The content was crafted to be highly relevant and practical, ensuring that participants could apply theoretical knowledge to the unique challenges faced in Cyprus. Each training session was interactive, fostering engagement and allowing participants to ask questions pertinent to their roles.

The delivery phase included overall 6 training sessions delivered to 38 stakeholders on the 18th, 19th of April and 9th of May, targeting competent central and regional authorities and community registrars from the identified hot spot areas. This approach ensured that the training was not only informative but also tailored to the audience's needs, enhancing their capacity to address local waste management issues effectively.

The effectiveness of the training program was assessed through a series of surveys administered to the participants. Despite a relatively low response rate of 21% attendees, the feedback received was positive. The evaluation phase involved comparing pre- and post-training survey results to identify improvements in knowledge and remaining gaps. The analysis showed improvement in the average scores of all questions / topics following the training. The increase in scores ranged from 12% to 36%, with the highest improvement observed in question 5 (i.e. I am aware of the principles of conducting a feasibility study to determine the gate fees and feasibility of a treatment plant). Participants' scores increased from 3.3 in the initial assessment to an average of 4.0 in the post-training survey. The consistent improvement across all questions highlights the comprehensive impact of the training, effectively enhancing participants'

understanding and skills across a broad range of topics related to livestock waste management. Furthermore, participants rated the course as good to very good (4 to 5).

4. Analysis of project monitoring indicators

Overview of initial indicators

The present section aims to conduct a final assessment of the quality assurance processes that were implemented to mitigate the risks identified during the execution of the project. The assessment is structured around several key indicators, which will be systematically to determine a final achieved result score. Each indicator has been selected based on its relevance and impact on the overall quality and success of the project. The evaluation process will integrate quantitative and qualitative data, reflecting a comprehensive view of the project's performance against the set objectives.

This approach ensures that the final score is not only representative of the outcomes but also reflective of the effectiveness of the quality assurance and risk management strategies implemented throughout the project lifecycle. This evaluation will provide a robust basis for understanding the project's achievements and areas for improvement.

Indicator	Element evaluated	Formula and data to be collected	Target	Result Achieved
Project Timeliness	Deliverables delivered on time as per project plan	QI1=NoD_on_time NoD_on_time = Number of Deliverables (8 in total) completed on time in the reference period	QI1=8	8
Written quality of deliverables	Written deliverable received with no critical comments	QI2=NoD_no_cc = Number of deliverables (8 in total) accepted by DG REFORM and beneficiaries with no critical comments	QI2>8	8
Quality and supply of PwC personnel	Number workforce resources replace	QI3=NoR/NoE x 100 NoR = Number of resources replaced on request of the DG REFORM or beneficiaries NoE = Total number of active experts	QI3<5%	0%
Participation in engagement activities	Number of participants outside of PwC	QI4=NoEP NoEP = Number of external participants (outside PwC) engaged in the project	QI4>30 persons	36

5. Synthesis of lessons learned

This section is designed to capture and consolidate the knowledge gained during the execution of the project. Specifically, it outlines the challenges encountered, identifying areas where a change in approach overcame or minimised these difficulties. Through this process, the section aims to reduce the risk of repeating similar scenarios in future engagements. Each challenge will be thoroughly examined, with the associated lessons clearly explained. The insights provided aim to help other organisations enhance their project management practices and outcomes by considering potential challenges and limitations, thereby promoting a culture of continuous improvement in similar projects.

1. **Challenge overview:** In the initial phase of our project, specifically during the preparation of deliverable 2 (i.e. current state of play), determining the most representative data to use was a significant challenge. This data was crucial for assessing both the volumes of livestock and ABP waste produced as well as the volumes currently being treated. The primary issue arose from discrepancies among various data sources and the uncertainty about how accurately these figures represented the actual conditions across all the various farms.

   Lesson Learned: Establishing smaller, specialised working groups with defined roles

   To better manage similar challenges in future projects, it is essential to establish smaller, specialised working groups that focus specifically on intricate tasks such as data validation and reconciliation. These groups are more agile and can delve deeper into specific issues, allowing for the development of more tailored and precise solutions rapidly.

   A critical factor in the effectiveness of these groups is task specificity along with clear roles and responsibilities assigned to each team member. In a project multifaceted such as this, clarity enhances efficiency and reduces overlaps or gaps in the team's efforts. Additionally, it is important that an initial effort is made to identify potential data sources and the responsible personnel associated with these sources before the actual request for data is made. This preparatory step is crucial to avoid delays in the data acquisition process and ensures that the data collection phase proceeds smoothly without hindrances.

   By implementing these strategies, smaller working groups can better manage the complexities of diverse data sources and ensure that the data used in project reports is accurate and reflective of true conditions. This approach not only improves data reliability but also supports better decision-making and leads to more dependable project outcomes supported by a multi-stakeholder consensus.

2. **Challenge overview:** A significant challenge in the project was ensuring that the solutions designed were both comparable across different contexts and applicable to the local environment. This required the use of the best available techniques to create an optimal "to-be" scenario that was well-suited to local needs, realities, and constraints.

   Lesson Learned: Proactive engagement of local private sector expertise

   The lesson learned from addressing this challenge is the critical importance of proactively engaging local private sector expertise. This approach involves collaboratively designing the envisioned to-be scenario, in a manner that is not only technically sound but also grounded in the practical realities of the local context.

   Engaging local experts early and continuously throughout the project ensures that the suggestions devised are not only based on the best international practices and technical expertise but are also tailored to meet the specific needs and constraints of the local environment. This local involvement is crucial because the project's success depends heavily on the local private sector's engagement, knowledge, willingness, and resources.

   By incorporating local insights and expertise, the project benefits from a deeper understanding of the applicable context, which enhances the comparability and applicability of the solutions developed. This

strategic collaboration leads to more sustainable and effective project outcomes, ensuring that the solutions are not only designed with leading practices in mind, but also considering the on the ground reality.

3. **Challenge overview:** One of the core challenges encountered during the project was maintaining the relevance of the project's outputs in the face of a dynamically changing environment. This was particularly critical given the evolving nature of the farming sector and the specific Recovery and Resilience Plan (RRP) funding guidelines for the Orounda treatment plant.

   Lesson Learned: Focus on continuity, capacity building and flexibility

   The key lesson learned from this challenge is the importance of focusing on continuity and capacity building while incorporating flexibility into the project's execution. To ensure the project remained relevant, it was essential to embed the necessary know-how into the departments involved with the project. This involved training and knowledge transfer activities that equipped these departments with the latest skills and understanding necessary to adapt to changes effectively.

   Moreover, maintaining flexibility in project delivery while strictly adhering to the tender's specific requirements was crucial. This dual approach ensured that the project could adjust to changes in the sector or funding conditions without compromising on compliance or project goals.

   By emphasising both capacity building and flexibility, the project was better positioned to respond to sector shifts and funding changes, ensuring that the outputs remained relevant and effective. This strategic focus on adaptability and skill enhancement within relevant departments promotes sustained project success and relevance, even as external conditions evolve.

In tackling the issues of the livestock waste management project, a focused approach on livestock waste and ABPs across government-owned areas of the island was initially requested by the beneficiaries to address issues in Orounda. However, it was decided that the project should exhibit a wider focus, leading to a broader examination. This change of focus significantly enhanced the project's foundational knowledge and strategic direction.

1. **Lesson Learned: Expanding the scope for comprehensive understanding**

   The decision to broaden the scope of investigation beyond the initial focus area provided a deeper, more comprehensive understanding of livestock waste management challenges. This expanded view has been instrumental in creating a robust foundation for addressing similar issues elsewhere. By not confining the analysis to a single locality, the project developed a substantial base of knowledge that now informs broader strategic approaches and solutions applicable across various regions.

2. **Lesson Learned: Implementing a pilot treatment plant for scalable insights**

   Furthering the scope of the project led to the development of a detailed technical specification for a pilot treatment plant. The theoretical insights gained from this pilot project are invaluable, as they provide a replicable model that can be used to design and implement other treatment plants. This approach demonstrates the power of pilot projects to generate scalable and reusable solutions that can adapt to the needs of different hotspot areas, thereby enhancing the overall efficacy of waste management strategies across the island.

   By embracing these lessons, future projects can benefit from a more comprehensive understanding and scalable solutions, ultimately fostering continuous improvement and greater effectiveness in livestock waste management.

6. Key achievements realised throughout project execution

Throughout the lifecycle of this project, our collective efforts have focused on achieving tangible results that have met the set objectives set forth during the inception phase of the project. The achievements detailed in this section represent the most significant and immediate advantages realised from the project activities. Specifically, an "achievement," in the context of this project, is defined as a significant and immediate advantage resulting from the project overall activities. It represents a vital change that the project aimed to realise, which has been or will be delivered by the project's end as a result or outcome.

The achievements listed in this section not only demonstrate immediate benefits but also establish a solid foundation that strategically positions the livestock waste management sector for future compliance with EU sustainability standards. These efforts collectively contribute to a long-term vision, aiming to align Cyprus more closely with the broader environmental goals of the European Union.

Achievement 1: The project marks the first comprehensive analysis of livestock waste and ABPs management practices across the Republic of Cyprus. By collating and examining quantitative data from diverse sources, this study has effectively mapped the current waste management landscape, highlighting critical areas in need of intervention, and setting a benchmark for future improvements. The main outcome of this endeavour is the development of a 'to-be' scenario, which outlines an ideal future state for the management of livestock waste and ABPs. Through this forward-looking scenario, the project has also prioritised infrastructure development, considering capital and operational expenditures, community impact, and compliance with National Energy and Climate Plan (NECP) targets.

Achievement 2: This project has successfully developed a national strategy for livestock and ABPs management, addressing key inefficiencies in current practices, and overcoming regulatory and infrastructure limitations. The strategy is designed to convert challenges into opportunities within the sector, turning it into an asset for the Cypriot economy and the livestock waste management sector.

Achievement 3: The project has achieved significant success in obtaining 'buy-in' from the government to address the pressing issues arising from the poor management of untreated livestock waste. This endorsement is crucial as it ensures that the necessary actions and reforms needed to tackle these challenges are supported at the highest levels of government, fostering a conducive environment for implementing sustainable waste management practices.

Achievement 4: This project successfully engaged regional authorities, providing them with a comprehensive understanding of the current waste management landscape and the proposed future directions. By informing and involving these key local stakeholders, the project has not only raised awareness but also positioned regional authorities to play a more prominent and proactive role in shaping the future of sustainable practices within the livestock waste management sector. This engagement is instrumental in ensuring that future initiatives are tailored to local needs and supported by those who directly influence regional policy and implementation.

7. Integrated recommendations for Cypriot Authorities

Strategic recommendations

This section consolidates the insights from all previous deliverables into strategic advice specifically crafted for the Cypriot authorities. It presents a series of recommendations designed to facilitate and complement the implementation of the project's outcomes. These recommendations aim to provide policymakers and regulatory bodies with essential tools and insights to effectively integrate and implement these findings into Cyprus's existing waste management framework. The guidance offered is structured to enhance the project's overall impact and support the successful application of sustainable practices within the national context.

- **Establish cross-ministerial working group led by MARDE to drive forward on the incentivisation and implementation of additional treatment plants –** To promote the development of additional treatment plants and align with NECP targets, it is crucial to establish a cross-ministerial working group led by the MARDE. This group will be tasks with advancing the incentivisation and implementation strategies for new treatment facilities across Cyprus. This recommendation is critical because it ensures a coordinated and unified approach to achieving national sustainability goals. A cross-ministerial group can effectively address the interconnections between various stakeholders and ministries, providing a cohesive strategy that integrates technical, regulatory, and financial perspectives. This approach not only facilitates the streamlined execution of treatment plant projects but also enhances compliance with European Union directives and supports broader objectives of environmental sustainability and public health protection.
- **Examine all funding mechanisms and define incentivisation tools with which to stimulate the operation of new treatment plants whilst remaining in compliance with EU competition law –** To facilitate the expansion and efficiency of new treatment plants, it is essential to review and refine funding mechanisms and incentivisation tools. Ensuring compliance with EU competition law is crucial, as it promotes fair competition and prevents market distortion. Properly structured incentives can attract private investment and encourage the adoption of innovative technologies, contributing to environmental sustainability. This approach includes appropriately employing state aid guidelines, engaging in public-private partnerships, conducting transparent bidding processes, offering innovation-specific incentives, ensuring regulatory flexibility, and aligning incentives with EU Directives. These steps will not only support Cyprus's environmental goals but also enhance the economic viability of new projects in accordance with European Union standards.
- **Examine measures with which to increase the compliance with which existing treatment plants operate** – Ensuring that existing treatment plants are in compliance with the appropriate treatment processes is crucial for several reasons. It significantly reduces greenhouse gas emissions and pollution, protecting local ecosystems and public health. Improved efficiency maximises waste utilisation, conserves energy and water, and generates valuable by-products, promoting a circular economy and lowering operational costs. Moreover, these enhancements ensure a more comparable and fairer market for farmers to sell their waste to due to the higher gate fees that will be necessary to ensure the sustainability of running compliant processes.
- **MARDE to continue to engage high priority communities to stimulate action for the implementation of measures which will increase treatment in relevant areas –** To stimulate action and implement measures that will increase treatment capacities in relevant areas, MARDE should continue to engage high priority communities. This engagement is crucial for developing localised solutions that address specific needs, fostering stakeholder buy-in, and optimising

resource allocation. By focusing on areas with significant waste management issues, MARDE can ensure compliance with regulations, promote sustainability, and achieve environmental and health benefits. Enhanced treatment facilities can reduce pollution, improve public health, and create economic opportunities. Engaging communities helps ensure that new measures are effective, sustainable, and supported, thereby improving livestock waste management practices across Cyprus.

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