AFTER LIFE PLAN LIFE ClimaMED

Project overview

The LIFE ClimaMED project (CCM/GR/000087) has developed and demonstrated an integrated system for the measurement, monitoring and management of greenhouse gas (GHG) emissions and soil organic carbon (SOC) dynamics in Mediterranean agricultural systems. The project combined advanced sensing technologies, digital infrastructure and agronomic methodologies to establish a novel Monitoring–Reporting–Verification (MRV) framework at field level. The system integrates field-based measurements, remote sensing, modelling approaches and management data into a unified operational platform.

The central outcome of the project is the development of an interoperable technological and methodological ecosystem, consisting of:

- a LiDAR-based GHG monitoring system,
- a LoRa telemetry network,
- a Center of GHGs Monitoring and Management (CMM) platform, and
- a Low-GHG Certification System

Together, these components form a coherent architecture capable of supporting climate-smart agriculture, carbon farming schemes and policy-aligned MRV systems across Europe.

BENAKI PHYTOPATHOLOGICAL INSTITUTE
FORTH FOUNDATION FOR RESEARCH AND TECHNOLOGY - HELLAS
HELLENIC REPUBLIC Ministry of Rural Development and Food
TECHNICAL UNIVERSITY OF CRETE
CeRSAA CENTRO DI SPERIMENTAZIONE E ASSISTENZA AGRICOLA
UNIVERSITAS Miguel Hernández
Green Projects
EnviTech

Objectives

Development and demonstration of an innovative LIDAR system for GHG monitoring	Designing and deployment of a novel optical system capable of measuring CO_2, CH_4 and N_2O emissions directly in the field (Tier 3). The system enables continuous, real-time monitoring at field level, moving from model-based estimations to actual measurements.
Development of a methodology for SOC stock change estimation	An integrated methodology combining multispectral imaging, soil analysis and field measurements to quantify SOC dynamics. This approach provides a structured framework for estimating SOC changes under real agricultural conditions, offering a first step towards operational SOC monitoring systems.
Creation of a GIS-based monitoring platform (CMM)	A digital platform capable of collecting, processing and visualizing spatial data on GHG emissions and SOC changes. The CMM integrates data from LiDAR devices and meteorological stations, enabling real-time analysis and supporting decision-making at farm, regional and national levels.
Improvement of GHG reporting methodologies (Tier 3 approach)	Moving beyond conventional Tier 1 methodologies by developing protocols based on real-time, spatial data. This enhances accuracy, reduces uncertainty and supports more robust carbon accounting systems aligned with EU policy needs.
Development of an integrated monitoring and decision-support system	Beyond individual tools, the project creates a complete system combining measurement devices, telemetry, modelling and digital infrastructure. This integrated approach allows continuous monitoring, hotspot identification and targeted mitigation actions at field level .
Support to policy-making and land management strategies	Provision of authorities with reliable tools for monitoring emissions and SOC changes, enabling better design and evaluation of agricultural and climate policies. The system supports spatial planning, carbon management and implementation of mitigation strategies.
Development of certification and carbon footprinting frameworks	Introduction of a measurement-based certification scheme for agricultural products, linking real emissions data with product labelling and sustainability claims. This creates incentives for farmers to adopt low-emission practices.
Preparation for large-scale deployment and replication	Establishment the basis for scaling the system across the Mediterranean and the EU, including the development of monitoring networks, legislative proposals and replication roadmaps.

Methodology

The methodology is built around direct, in situ measurement of GHG using LiDAR devices installed in agricultural fields. These systems capture concentration gradients along a measurement path, enabling continuous monitoring of emissions and providing high-frequency datasets that reflect real field conditions.

Data collected from field devices are transmitted through a LoRa-based telemetry system to central databases. This ensures real-time data flow, system interoperability and the ability to monitor multiple sites simultaneously within a networked infrastructure.

The system integrates multiple data streams, including meteorological data, soil analyses, crop data and remote sensing (multispectral imaging). This allows a comprehensive characterization of the agro-ecosystem and supports more accurate modelling of emissions and SOC dynamics.

SOC changes are estimated through a hybrid methodology combining CO_2 and CH_4 emissions measured by the LIDAR devices, modeling approaches and remote sensing indicators. The methodology is calibrated using field measurements and evolves through iterative validation, reflecting its research-oriented nature and progressive maturity.

All data are processed within the CMM platform, which provides spatial visualization, data storage and analytical tools. The platform enables mapping of emissions, identification of hotspots and generation of indicators at different spatial scales. Standardized protocols were developed for measuring, processing and reporting GHG emissions and SOC changes, ensuring consistency, reproducibility and alignment with EU MRV requirements, forming the basis for higher-tier reporting systems.

The methodology does not stop at measurement but connects data with agronomic practices. By identifying emission patterns and hotspots, it supports the design of targeted mitigation strategies and improved land management.

All methodological components were tested in pilot fields representing Mediterranean crops and conditions, ensuring that the system is not theoretical but validated under real operational constraints, including environmental variability and management practices.

Finally, the methodology is embedded within a broader framework that includes legislative proposals, certification systems and replication strategies. This ensures that the outputs can be transferred from project level to national and EU implementation.

From Project to System

The LIFE ClimaMED project concluded having moved significantly beyond the stage of experimental demonstration and proof-of-concept development.

A key achievement of the project is that its core technological system, the LIDAR–LoRa–CMM architecture, has reached a level of operational maturity that allows its direct use beyond the project context.

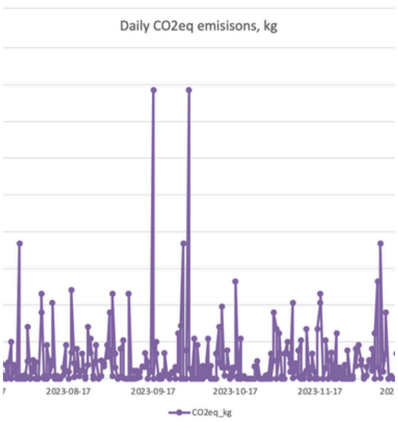
The system has been successfully deployed under real field conditions, generating consistent and high-quality datasets, and demonstrating robustness in measurement, transmission and processing workflows. This confirms that the outputs of the project are not temporary experimental tools but constitute operational assets capable of supporting long-term applications and policy use.

At the same time, the project has established a complete methodological framework for SOC estimation, supported by datasets and field validation. Although this component remains at an earlier stage of maturity, it provides a scientifically coherent basis for further development and scaling.

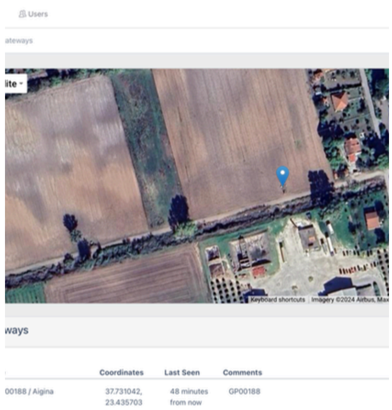
Importantly, the project has also produced a fully functional digital platform (CMM), a certification-oriented framework and a structured replication roadmap. Together, these elements form a coherent system that is ready to transition from a LIFE project into a long-term operational and policy-support tool.

Field practices

Real time measurement and data processing



CMM platform



The LIDAR device

The Institute of Electronic Structure and Laser of FORTH developed and adapted an advanced LiDAR (Light Detection and Ranging) system within the LIFE ClimaMED project for continuous GHG monitoring in agricultural fields. The system was designed to remotely detect and quantify atmospheric concentrations of CO_2, CH_4 and N_2O directly above cultivated land, supporting field-scale climate monitoring and agricultural emission assessment.

The LiDAR unit is installed at the edge of the field, approximately 3 meters above ground level, and performs continuous laser scanning across the cultivated area. Using LiDAR (DIAL) technology, the system emits laser beams at specific wavelengths absorbed by target gases and records the reflected signal from distant surfaces. By comparing absorbed and non-absorbed wavelengths, the system calculates GHG concentrations along the laser path in real time.

Unlike conventional point sensors, the LIFE ClimaMED LiDAR system measures emissions continuously over long distances, allowing the monitoring of spatial variability across agricultural fields and capturing the combined influence of soil processes, crop activity and farming practices. The methodology developed in the project also integrates meteorological parameters and dispersion modeling in order to estimate ground-level emissions and support the calculation of annual greenhouse gas emissions and soil carbon dynamics.

The LiDAR system is fully safe for humans, animals and the surrounding environment. The laser operates at wavelengths specifically selected for atmospheric gas detection and classified as non-hazardous for human exposure under normal operational conditions. The emitted radiation is of very low power and does not pose risks to human eyes, nearby residents, farmers, wildlife or birds crossing the monitored area. As the system performs remote and non-invasive measurements without emitting pollutants or disturbing the ecosystem, it constitutes an environmentally friendly monitoring technology fully compatible with agricultural and natural environments.

The technology represents one of the most innovative components of the LIFE ClimaMED monitoring framework, demonstrating the potential of laser-based remote sensing systems for future agricultural MRV (Monitoring, Reporting and Verification) applications and climate-oriented farming policies.

LIDAR devices were installed in different regions of Greece, including Crete, the Peloponnese, Central Greece and Northern Greece, covering a wide range of agricultural systems and cultivation types. The monitoring activities included olive groves, vineyards, cereal crops, vegetable cultivation fields and pistachio orchards, as well as a livestock farm for cattle breeding.



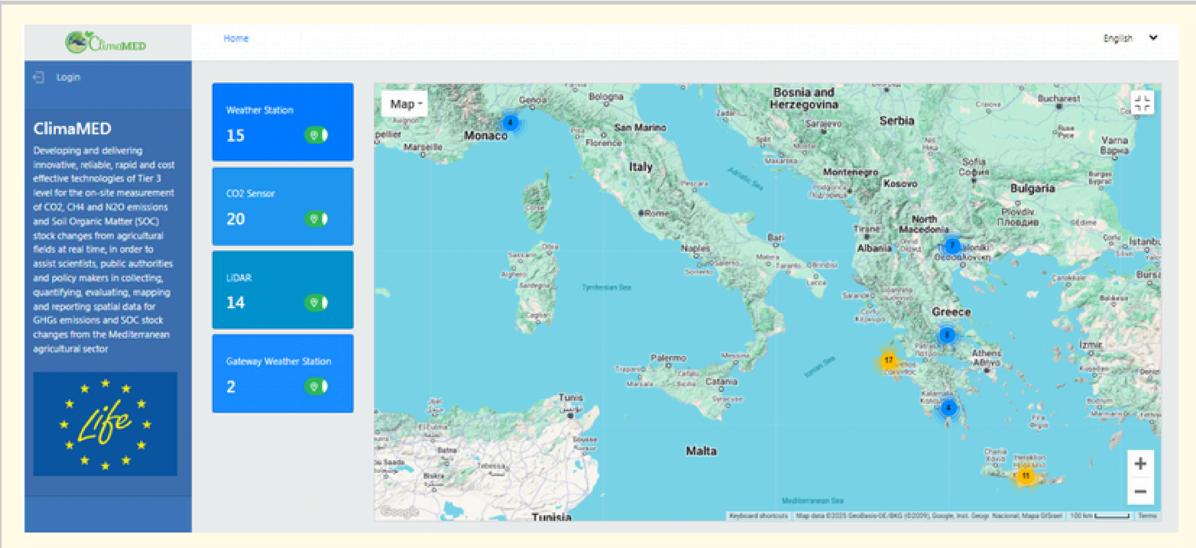






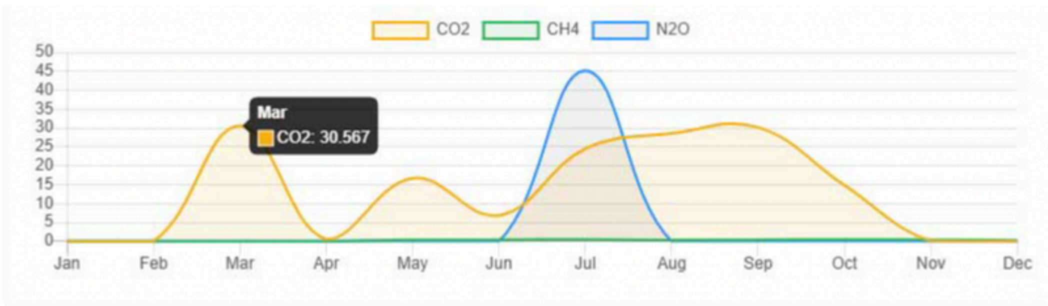
The CMM platform

The LIFE ClimaMED project developed the CMM (Center of GHGs Monitoring and Management) platform as an integrated digital tool for the monitoring, mapping and management of GHG emissions and SOC changes in agricultural systems. The platform was designed as an operational decision-support and policy-support instrument, capable of assisting national and regional authorities, farmer cooperatives and agricultural stakeholders in understanding the climate footprint of cultivated areas and supporting climate-oriented agricultural management.



The CMM platform combines geospatial information, telemetric infrastructure, LiDAR measurements, meteorological data and field management information into a single web-GIS environment. Through interactive maps and dashboards, users can monitor agricultural fields, visualize GHG emissions in real time and assess spatial and temporal trends across different regions. The platform allows the visualization of agricultural fields and monitoring points directly on a map interface, enabling users to identify monitored areas and associated LiDAR and sensor infrastructure.

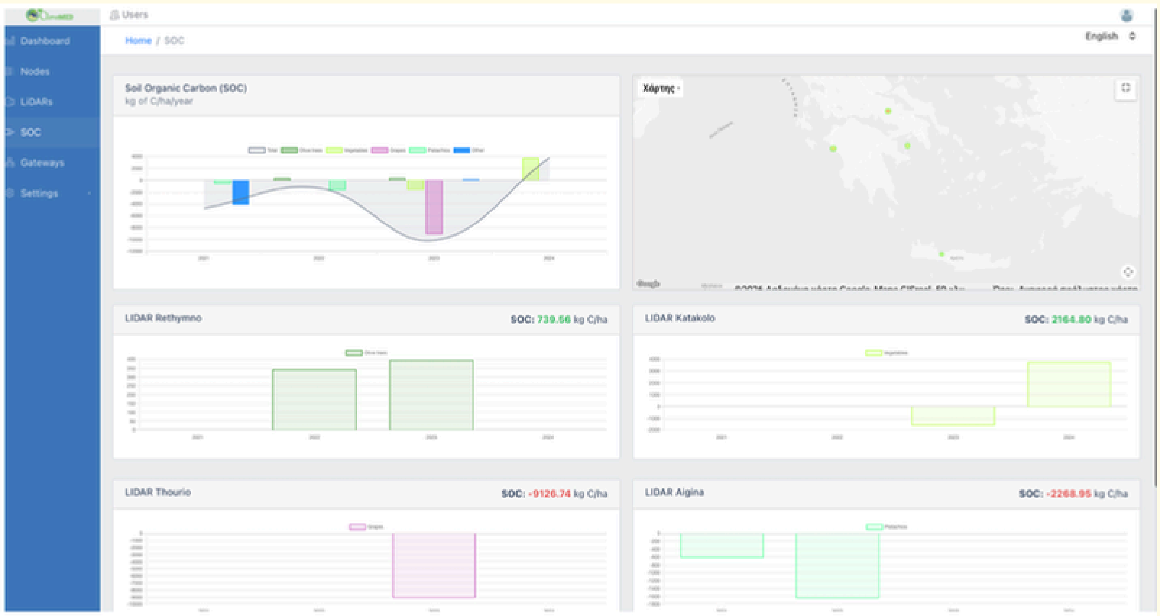
The system provides detailed information on CO_2, CH_4 and N_2O emissions per agricultural field, including temporal trends and comparative analyses between areas and cultivation periods. Interactive graphs allow users to examine how emissions evolve over time and to identify areas with higher or lower environmental impact.



In parallel, the platform incorporates information related to land parcels, crop types, cultivation periods and production data, allowing a direct connection between agricultural practices and environmental performance. This functionality transforms the CMM platform from a simple monitoring system into a broader agricultural management and climate-policy tool. Authorities and stakeholders can therefore use the platform not only to observe emissions, but also to evaluate management practices and support the design of mitigation strategies adapted to Mediterranean agricultural conditions.

The CMM platform has already demonstrated its operational value as a policy-support tool for the Greek Ministry of Rural Development and Food, which adopted it as a national platform for the monitoring, recording and management of GHG emissions from the Greek agricultural sector, within the framework of Law 5184/2025 and the relevant national legislative provisions introduced during and after the LIFE ClimaMED project. Through this institutional integration, the platform moved beyond the level of a pilot research application and became part of the broader national effort to support climate monitoring, agricultural sustainability and the gradual development of MRV-oriented procedures for the agricultural sector.

Visualization of SOC changes on CMM platform



By integrating GHG measurements, cultivation information and modelling methodologies developed during LIFE ClimaMED, the platform allows users to monitor carbon dynamics and evaluate the contribution of agricultural practices to carbon sequestration and soil health improvement. This functionality is particularly important in the context of future carbon farming schemes and European climate policies related to soil monitoring and carbon removals.

From pilot implementation to operational deployment

The continuation of LIFE ClimaMED after its completion is not conceptual but already embedded in concrete pathways defined during the project implementation.

Following the successful validation, the LiDAR systems demonstrated reliable performance under real-field conditions, producing datasets suitable for replication and policy use. Based on this performance, a clear post-LIFE continuation pathway has already been established, ensuring that the monitoring system will not be discontinued but will be directly reused and further deployed.

A particularly important development supporting this continuation is the progress achieved at national level in Greece, where a legislative framework for GHG monitoring in agriculture has being established (Law 5184/2025). Within this context, the infrastructure developed was directly integrated into the national implementation scheme.

The LiDAR devices developed during the project will be maintained and redeployed forming the first monitoring units of the national system.

This ensures continuity between the pilot phase and real-world policy implementation, effectively transforming the LIFE outputs into a component of a regulatory framework.

In addition, the entire supporting infrastructure, including the LoRa communication network, meteorological stations and autonomous power systems, will continue to operate as an integrated package. This guarantees not only the technical continuity of the system but also the consistency and reliability of long-term data collection.

This transition from project-based implementation to policy-driven deployment confirms that the project has produced mature, reusable and scalable results, capable of supporting regulatory monitoring, decision-making and climate policy implementation.

Replicability

The LIDAR-LoRa-CMM system

What?

An integrated monitoring system combining: open-path LIDAR measurements, LoRa communication infrastructure and the CMM digital platform for monitoring, processing and visualization of GHG emissions and environmental data.

Highest replication potential for Mediterranean agricultural regions: Orchards, vineyards, open-air livestock systems, composting facilities, semi-open land-management environments.

Conditional replication in Central and Northern Europe after recalibration and adaptation to humid and enclosed environments.

Who?

Potential replicators include: regional and national authorities, MRV operators, research institutes, farmer cooperatives, environmental agencies, technology providers and advisory services.

When?

Immediate replication potential in Mediterranean regions.

Progressive adaptation and expansion towards wider European deployment during the 2025–2035 period.

Replicability

The SOC change methodology

What?

A hybrid measurement-model methodology for estimating annual SOC stock changes using: in-field CO_2/CH_4 measurements, multispectral data, meteorological information, and agricultural management metadata.

Highest applicability for Mediterranean agro-ecosystems: orchards, vineyards, vegetables and cereal systems.

Broader European applicability: feasible in all EU regions, but requiring local calibration datasets and region-specific validation.

Who?

Replication may involve: soil research institutes, ministries and paying agencies, advisory organizations, soil-monitoring authorities, research infrastructures and carbon-farming initiatives.

When?

Pilot scientific replication can begin immediately.

Operational maturity expected progressively by 2030 in Mediterranean systems and later in non-Mediterranean regions following recalibration phases.

Replicability

Guidelines for GHG reduction and SOC enhancement

What?

A set of crop-specific and management-oriented guidelines for: reduction of GHG emissions, enhancement of SOC stocks, optimization of fertilization and residue management, compost application, cover cropping and improved agricultural practices.

Highest direct replicability: Greece, Spain, Italy, Cyprus, Malta, Portugal, southern France and comparable warm-temperate agricultural regions.

Partial/conditional replicability: temperate and northern regions for annual crops and cross-cutting soil-management practices.

Who?

Potential users include: farmers, cooperatives, advisory services, CAP eco-scheme actors, certification bodies and regional agricultural authorities.

When?

Immediate replication potential through advisory and agricultural-support mechanisms.

Progressive integration into CAP, soil-health and carbon-farming initiatives during the coming years.

Replicability

Certification framework and CMM-supported MRV approach

What?

A proposed framework for: certification of low-GHG agricultural products, integration of measured emissions into MRV systems and support of climate-related agricultural verification mechanisms through the CMM platform.

Most suitable initially in: Mediterranean agricultural systems for organized producer groups, cooperatives, and regions developing carbon-farming or sustainability-certification schemes.

Potential future expansion: wider EU implementation aligned with CRCF and soil-monitoring policies.

Who?

Potential replicators include: ministries, certification organizations, paying agencies, producer organizations, cooperatives and environmental governance bodies.

When?

Early replication possible through pilot certification schemes and voluntary initiatives.

Broader institutional uptake expected progressively alongside EU policy evolution related to CRCF, CAP eco-schemes and Soil Monitoring initiatives.

Transferability

The transferability of the LIFE ClimaMED components varies depending on their technological maturity, environmental sensitivity and institutional requirements. The highest transferability is observed in Mediterranean regions, where environmental and operational conditions closely match those of the pilot sites, while transfer to Central and Northern Europe requires targeted adaptation and calibration. The table below summarizes the transferability of outputs across countries and regions, distinguishing between validated applications and cases where pilot deployment, calibration or institutional alignment is required.

Transferable components and target countries

LIDAR–LoRa–CMM system	SOC methodology	Mitigation guidelines
Greece: Fully deployed and validated under real-field conditions (reference system).	Greece: Developed and tested using pilot field data and integrated measurements.	Greece: Directly applicable to Mediterranean crop systems.
Italy-Spain-Cyprus:High transfer potential, requiring pilot installation and local calibration.	Italy-Spain-Cyprus: Transferable with additional local calibration and data collection.	Italy-Spain-Cyprus: Transferable with minor adaptation to local practices.
Med-EU:Very high transfer potential in similar agro-climatic conditions, with baseline calibration.	Med-EU:High transfer potential with multi-site validation.	Med-EU:Transferable to similar crop systems with limited adjustment.
C-N-EU:Conditional transfer requiring significant adaptation to climate and system conditions.	C-N-EU:Conditional transfer requiring extensive recalibration and long-term datasets.	C-N-EU:Transferable to local crop systems with adaptation.

**C-N-EU: Central-North Europe*

Transferable components and target countries

Low-GHG certification system	CMM platform and digital workflows
Greece: Ready for implementation within national framework.	Greece: Operational platform for data processing and reporting.
Italy-Spain-Cyprus:Transferable following establishment of monitoring infrastructure and institutional setup.	Italy-Spain-Cyprus: Transferable with adaptation to national data systems.definition of data flows and user roles.
Med-EU:Medium-term transfer potential linked to MRV adoption.	Med-EU:Strong transfer potential as modular platform.
C-N-EU:Long-term transfer potential dependent on full MRV integration.	C-N-EU:Transferable with adaptation to national systems and regulations.

The table below presents the sectoral transferability of the LIFE ClimaMED system, focusing on the practical applicability of its components across different production and land-use environments. It highlights where the system can be directly applied and where specific constraints or adaptations must be considered, based on real demonstration activities and feasibility assessments carried out during the project.

Sectoral transferability, constrains and transferability potential

Sector	Transferable component	Constrains	Transferability level
Agriculture	Full system (LIDAR–LoRa–CMM + SOC)	Minor constraints related to local calibration and crop variability	High
Livestock farms	LIDAR–LoRa–CMM	Limitations in enclosed facilities and ventilation conditions	High (Med), Medium (EU)
Ports/industrial areas	LIDAR–LoRa–CMM	High humidity, corrosion, moving obstacles	Medium
Greenhouses	SOC methodology	Need for calibration under controlled environments	High
Forests/Natural areas	SOC methodology	Requires long-term monitoring and soil data availability	Medium
Waste/Composting /Land management	LIDAR + SOC methodology	Dust, heterogeneity, dynamic surfaces	High
Urban/Campuses	LIDAR–LoRa–CMM	Interference from infrastructure and human activity	Medium

The operational transfer mechanism foreseen for the LIDAR–LoRa–CMM system across different geographical contexts consists of 5 steps. The approach follows a progressive pathway, beginning with knowledge transfer and feasibility assessment and moving towards deployment preparation, operational integration and long-term institutional uptake. The mechanism reflects both the experience gained during the project implementation and the conditions identified in the Transferability Plan for future scaling and adoption of the system.

Transfer mechanism (How it actually happens)

Step 1	**Knowledge transfer and system demonstration**
Greece	Full-scale operation and demonstration under real-field conditions
Italy/Spain/Cyprus	Demonstration activities, technical exchanges, feasibility assessment and stakeholder engagement completed.
Med EU Countries	Transfer through replication guidelines, demonstrations and institutional networking.
Other EU counties	Awareness and technical dissemination targeting suitable sectors and environments.

Step 2	**Feasibility and readiness assessment**
Greece	Already completed through operational deployment.
Italy/Spain/Cyprus	Site suitability, environmental compatibility and institutional readiness assessed during project activities.
Med EU Countries	Preliminary assessment based on Mediterranean environmental compatibility and MRV readiness.
Other EU counties	Assessment focused on climatic constraints, enclosure conditions and regulatory compatibility.

Step 3	**Deployment preparation and enabling conditions**
Greece	Operational conditions already established.
Italy/Spain/Cyprus	Preparation for targeted installations through identification of pilot sites, calibration needs and governance requirements.
Med EU Countries	Preparation of baseline calibration and institutional integration pathways.
Other EU counties	Definition of adaptation requirements, recalibration needs and suitable operational environments.

Step 4	Operational integration pathway
Greece	System already integrated with monitoring workflows and policy-oriented actions.
Italy/Spain/Cyprus	Ready for operational deployment once pilot installations, institutional support and regulatory alignment are secured.
Med EU Countries	Scalable deployment pathway following initial demonstration and institutional uptake.
Other EU counties	Selective and conditional deployment limited to suitable open-system applications.

Step 5	Long-term institutional uptake
Greece	Integration into national monitoring and policy-support frameworks.
Italy/Spain/Cyprus	Potential integration into national MRV, CAP eco-schemes and certification systems.
Med EU Countries	Future integration into Mediterranean-scale monitoring and climate-policy actions.
Other EU counties	Long-term potential depending on adaptation success and MRV alignment.

Country readiness Expected uptake

In line with the transferability pathway presented above, the expected uptake of the LIFE ClimaMED LIDAR–LoRa–CMM varies depending on environmental compatibility, institutional readiness and the maturity of national MRV-related structures.

Greece represents the reference implementation environment of the LIDAR–LoRa–CMM system, since all calibration datasets, operational protocols and monitoring workflows were developed and validated under Greek conditions. The country demonstrates the highest level of readiness for long-term uptake, supported by the operational maturity of the system and the ongoing policy integration efforts linked to agricultural GHG monitoring and climate-related governance frameworks.

Italy, Spain and Cyprus demonstrate high transfer potential due to their strong agro-climatic similarity with the Greek pilot conditions, including comparable crop systems, vegetation structures, wind regimes and management practices. In all three countries, the project activities stuctured and confirmed a high level of technical and institutional readiness, supporting the transition towards future operational deployment once the appropriate enabling conditions and implementation mechanisms are established.

Other Mediterranean EU countries, particularly Portugal, Malta and Southern France, are also considered highly suitable environments for future transfer and scaling of the system. The similarity of environmental and agronomic conditions across Mediterranean regions significantly facilitates the applicability of the monitoring approach, requiring mainly baseline calibration and institutional adaptation steps.

Central and Northern European countries present a more complex transfer environment due to climatic and operational differences, including higher humidity, fog conditions, enclosed livestock systems and different atmospheric dispersion behavior. For these regions, transferability remains feasible but more conditional, requiring targeted adaptation, recalibration and careful selection of suitable operational environments before large-scale deployment can be considered.

Timeline for transferability and operational uptake

Based on the Transferability and Replicability Roadmap developed under Action C5 of the project, the scaling and operational uptake of the LIDAR–LoRa–CMM is expected to follow a progressive and phased pathway between 2025 and 2035, depending on the maturity of the technology, environmental compatibility and institutional readiness of each country group.

2025–2027: Institutional preparation and operational readiness

During the first phase, activities are expected to focus on institutional preparation, stakeholder mobilization and technical readiness.

In Greece, the legislative basis for the implementation of the LIDAR–LoRa–CMM system has already been established through Law 5184/2025, which legally integrate the ClimaMED system into the national agricultural GHG monitoring framework and assign responsibility to the Ministry of Rural Development and Food. The law also provides for the establishment and operation of the Operational Centre-CMM for agricultural GHG monitoring, creating the institutional framework for the future deployment and long-term operation of the system. The next implementation step is the issuance of the forthcoming Joint Ministerial Decision (JMD/KYA), which is expected to define the operational procedures, technical specifications, implementation conditions and support mechanisms for the large-scale deployment of the system at national level. Following the issuance of the

JMD, the system is expected to enter its first operational deployment phase, including installation of monitoring units, integration of the CMM platform with national agricultural structures and gradual scaling-up of the methodology across Greece.

For Italy, Spain and Cyprus, the priority will be the consolidation of the enabling conditions already established during the project through demonstration activities, technical exchanges, stakeholder engagement and the preparation of national draft legislative frameworks inspired by the ClimaMED approach. Particular emphasis will be placed on advancing these legislative initiatives, identifying suitable pilot areas, strengthening institutional coordination and preparing deployment-ready operational workflows for future implementation of the LIDAR–LoRa–CMM system.

For other Mediterranean countries, this phase will focus primarily on awareness-building, agro-ecological suitability assessment and alignment with national MRV and CAP-related structures.

In Central-Northern EU countries, the process is expected to remain at the level of scientific dialogue, feasibility assessment and research-oriented adaptation planning.

2027–2030: Pilot integration and regional expansion

The second phase is expected to mark the transition from readiness and feasibility assessment to structured operational integration. In Mediterranean countries, this period is foreseen as the main phase for calibration pilots, targeted deployments and integration of the system into advisory workflows, digital infrastructures and MRV-oriented applications.

The roadmap foresees that by 2030 the LIDAR–LoRa–CMM system could achieve stable operational deployment across Mediterranean agricultural and land-management sectors that share environmental and operational characteristics similar to those of the Greek pilot sites. These include orchards, livestock systems, composting units and semi-open land-management environments. At the same time, more complex sectors and non-Mediterranean regions are expected to undergo structured calibration and adaptation processes, including humidity-related adjustments, recalibration campaigns and development of sector-specific deployment protocols.

2030–2035: Institutionalization and large-scale scaling

The long-term phase foresees the gradual institutionalization and scaling-up of the system within broader national and European MRV frameworks.

In Greece, the roadmap foresees full national operational integration by 2030, while **Italy, Spain and Cyprus** are expected to move towards broader operational uptake and alignment with Carbon Removal Certification Framework (CRCF)-related and CAP-linked frameworks during the 2030–2035 period.

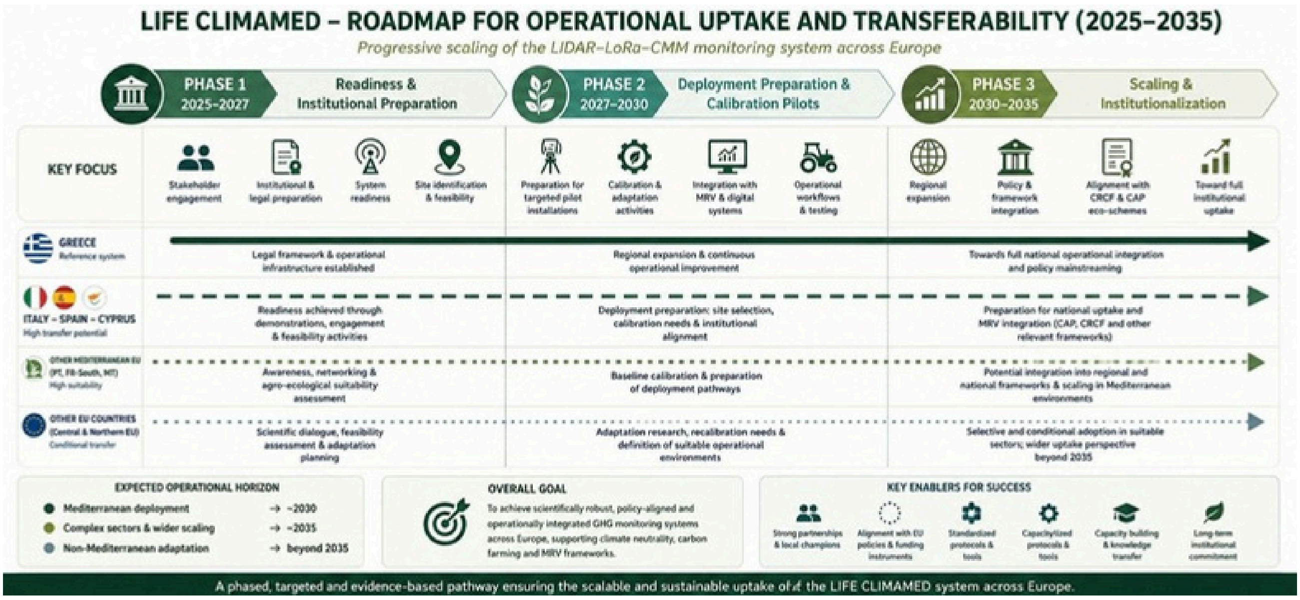
For other Mediterranean countries, the same period is expected to support wider legislative uptake, expansion of pilot installations and integration into carbon-farming and certification-oriented mechanisms.

In Central and Northern Europe, deployment is expected to remain more selective and adaptation-oriented, focusing on sectors and environments compatible with the operational requirements of the technology. According to the Roadmap, wider adoption in these regions is considered a longer-term perspective beyond 2035, following extensive recalibration and integration into national MRV systems.

Long-term perspective

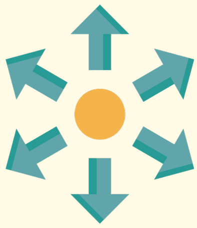
Overall, the roadmap developed within LIFE ClimaMED foresees a gradual transition from pilot-level demonstrations and operational readiness towards stable, institutionalized and policy-integrated deployment of the system across Mediterranean Europe and, progressively, to wider European contexts. The approach is based on phased scaling, scientific validation, institutional adaptation and alignment with emerging European frameworks related to MRV systems, CAP eco-schemes and the Carbon Removal Certification Framework (CRCF).

Progressive scaling and operational uptake roadmap of the LIDAR–LoRa–CMM system across Europe (2025–2035)



Actions for transferability

Greece, Italy, Spain, Cyprus



Beneficiary-led operational expansion

LIFE ClimaMED beneficiaries will act as the main transferability facilitators through the networks and expertise developed during the project.

- Collaboration with ministries, regional authorities, cooperatives, advisory bodies and technology actors will be strengthened to support operational deployment planning.
- National stakeholder groups will be promoted to support pilot preparation, calibration activities and institutional uptake.
- Further support the maturation of draft legislative initiatives and the future integration of the ClimaMED methodology into MRV and CAP-related frameworks.
- Bilateral agreements and MoUs with local actors will be promoted to facilitate the transition from informal cooperation to structured operational partnerships.

Med Countries

Expansion through strategic networks and institutional partnerships

- Development of regional strategic alliances with agricultural organizations, research institutions, technology providers and policy-support actors across Mediterranean countries.
- Collaboration with Mediterranean-wide networks and innovation platforms to accelerate regional uptake of the ClimaMED system: agricultural cooperatives, advisory networks, climate-related initiatives and cross-regional innovation ecosystems
- Promotion of the ClimaMED approach as a Mediterranean reference system for agricultural GHG monitoring and climate-oriented farm management.
- Support for regional calibration and adaptation activities through cooperation with research institutions and technical actors.
- Collaboration with cooperatives and advisory organizations for development of bundled climate-support and monitoring services.
- Engagement with governmental and policy actors for future integration into regional climate, MRV and agricultural strategies.
- Pursuit of new European and national funding opportunities to support pilot deployments and institutional validation activities in Mediterranean regions with similar agro-climatic conditions to the Greek reference sites.

Other EU countries

Selective transferability through research and innovation ecosystems

Focus on scientific collaboration, targeted adaptation and selective deployment scenarios in Central and Northern European regions.

- Cooperation with universities, environmental research centers, technology providers and innovation ecosystems to support: recalibration activities, methodological adaptation, validation under different climatic and operational conditions.
- Priority on research-oriented transferability actions rather than immediate large-scale deployment.

  * pilot research activities

  * interoperability testing

  * adaptation of LIDAR and atmospheric monitoring methodologies

  * participation in broader European MRV and climate-monitoring initiatives

- Gradual creation of the scientific and institutional basis for future uptake beyond the Mediterranean region.

The consortium foresees that, over time, the ClimaMED system could progressively evolve from a project-based demonstration activity into an operational Mediterranean monitoring and advisory ecosystem supporting GHG monitoring, MRV applications, climate-oriented agricultural advisory services, certification systems, carbon-related mechanisms and sustainability-oriented agricultural governance frameworks.

Sustainability

The long-term sustainability of LIFE ClimaMED is supported by the fact that the project did not produce isolated scientific outputs, but an integrated operational ecosystem combining legislation, digital infrastructure, measurement technologies, protocols, advisory logic and institutional workflows. Several continuation mechanisms are already in place or have been structurally prepared during the project implementation phase.

CMM institutional sustainability

The most important sustainability element is the continuation of the CMM platform and its integration into the operational environment of the Greek Ministry of Rural Development and Food (MINAGRIC). The platform has already been adopted at institutional level and connected with the wider monitoring and management logic developed during the project. This substantially reduces the risk commonly observed in projects where digital tools remain only pilot demonstrators.

The sustainability of the platform is supported through:

- hosting within operational governmental infrastructure,
- interoperability with Land Parcel Identification System (LPIS) and national agricultural registries,
- integration with future MRV and certification procedures,
- open API architecture allowing future expansion,
- existence of operational manuals, QA/QC procedures and training material already produced during the project.

The developed multimedia training tools and user-management structures, allowing future onboarding of new users without continuous dependence on project beneficiaries. The multimedia training centre will remain available through the project website and can support future users, advisors, cooperatives and institutional actors.

Sustainability through policy integration

A major sustainability driver is the connection of LIFE ClimaMED with national and European policy mechanisms. The legislative framework already adopted in Greece through Law A’34/2025, together with the forthcoming Joint Ministerial Decision (JMD), creates the institutional basis for the long-term operation of the system beyond the LIFE funding period.

The policy integration allows:

- future incorporation into CAP eco-schemes,
- linkage with CRCF-related MRV systems,
- integration into national GHG inventories,
- development of result-based support schemes for farmers,
- future integration into sustainability-certification and carbon-farming frameworks.

Because the system is aligned with future regulatory needs rather than temporary project priorities, its continuation is directly linked with evolving climate-monitoring obligations and agricultural policy requirements.

Monitoring system: Technical and operational sustainability

The sustainability of the LIDAR–LoRa–CMM system is based on a phased operational models, replicability plan and business strategy.

The continuation mechanism foresees:

- permanent coordination structures between the Greek Ministry of Rural Development and Food, the Operational Centre, and project consortium
- progressive deployment of additional devices,
- establishment of maintenance and recalibration routines,
- continuous cloud-based monitoring through the CMM,
- long-term technical support through specialized scientific and engineering partners.

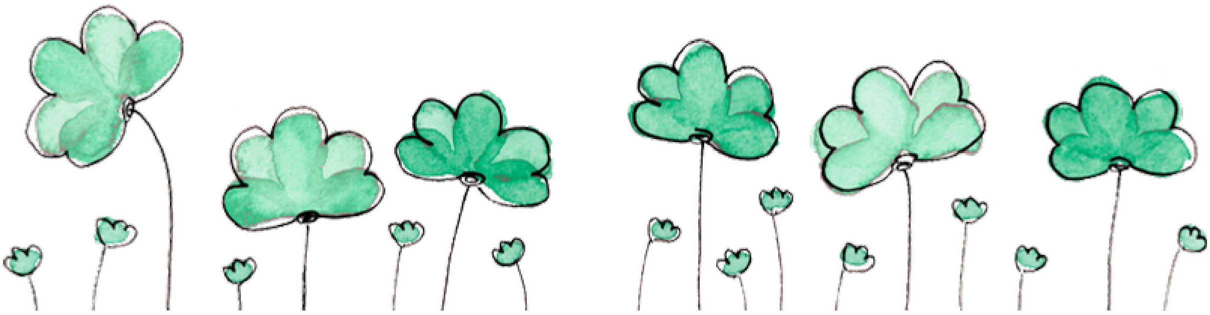
Following maintenance, recalibration and technical upgrading where required, the LiDAR units developed and validated during LIFE ClimaMED are expected to constitute the first operational monitoring units deployed under the future national implementation framework foreseen by Law 5184/2025 and the forthcoming and the relevant JMD. The devices are therefore expected to remain operational after the end of the project and to support the first implementation phase of the national GHG monitoring and certification system.

The project has already produced

- installation standards,
- calibration protocols,
- troubleshooting manuals,
- telemetry workflows,
- uncertainty-management procedures,
- interoperability documentation,
- operational deployment guidelines.

This significantly lowers future operational barriers and allows gradual expansion without redesigning the system architecture.

Economic sustainability and service-based continuation



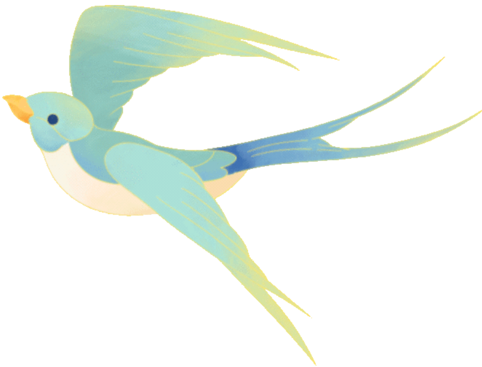
The project also developed a business-oriented continuation pathway through the Business Plan and Exploitation Strategy developed under Action C6.

The sustainability model is based on monitoring services, advisory services, certification-support services, technology transfer activities, deployment and maintenance services, and future operational deployment contracts.

The Business Plan identified potential exploitation pathways for: the LIDAR monitoring systems, the CMM platform, associated data-management services, and future certification and MRV-related activities.

The project also examined accreditation procedures and QA/QC structures for future providers involved in installation, operation and certification services associated with the ClimaMED methodologies.

Potential future funding streams include:



- CAP-related instruments and eco-schemes,
- Structural Funds,
- Recovery and Resilience Facility (RRF) investments,
- EIB-supported investments,
- carbon-farming initiatives,
- national climate programmes,
- result-based support mechanisms linked to GHG reduction,
- private sustainability-oriented investments.

At the same time, the modular architecture of the system allows gradual scaling according to available funding capacity, avoiding the need for immediate large-scale deployment.

Sustainability of the SOC methodology

The SOC stock-change methodology has lower technological maturity compared to the LIDAR system, but its sustainability is supported through its integration into the CMM platform and its connection with future soil-monitoring and carbon-farming frameworks.

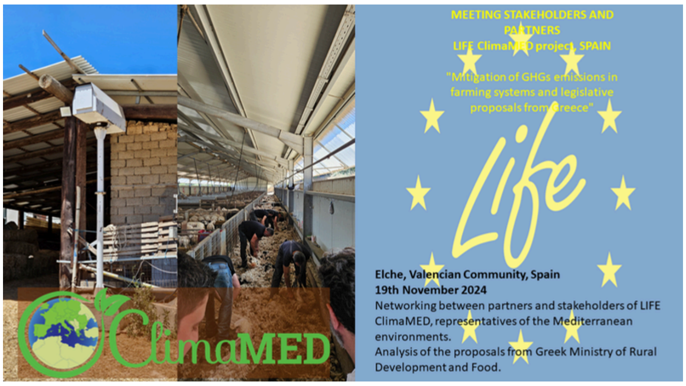
Continuation activities expected after the project include:

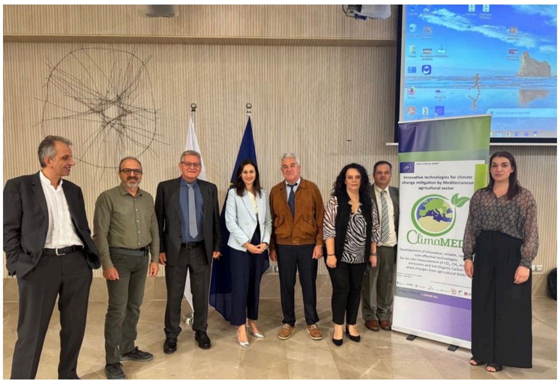
- expansion of calibration datasets,
- additional validation campaigns,
- incorporation of new crop systems,
- refinement of regional coefficients,
- progressive integration into CRCF-aligned monitoring approaches.

Student poster competition on soil protection organized by the LIFE ClimaMED project held in Rethymno, Crete, within the framework of the 2nd International Conference OpenEARTH 2024, promoting environmental awareness and sustainable soil management among the younger generation.

Sustainability through advisory systems-stakeholder networks

The project invested heavily in stakeholder engagement, which creates an important social and operational sustainability mechanism. During the project cooperation was established with cooperatives, regional authorities, advisors, farmers, ministries, certification-related actors, and scientific organizations and progressively integrated into the project ecosystem through workshops, consultations, demonstrations and pilot activities.





A Memorandum of Understanding (MoU) was adopted and signed between the project beneficiaries, stakeholders and policy makers from Greece, Spain, Italy and Cyprus, providing an institutional basis for continued cooperation after the end of LIFE funding.

Ceremony for the signing of the MoU between the project beneficiaries and stakeholders (Crete, June 2024)

This strong network supports continuation through advisory-system integration, dissemination of mitigation practices, local operational support, future pilot deployment activities and replication activities in additional Mediterranean regions.

Long-term sustainability

2030-2035

According to the project roadmap, the long-term vision extends progressively from pilot implementation towards full institutionalisation, through the pathways:

- expansion of regional deployment after 2027,
- integration into advisory and certification workflows,
- automated national-scale MRV functionality,
- creation of permanent operational structures,
- progressive scaling in Mediterranean regions,
- full integration into agricultural climate-monitoring systems by 2030–2035.

This phased approach increases sustainability because continuation does not depend on a single post-project funding source, but on gradual institutional embedding into existing agricultural, climate-governance and certification mechanisms.

Dissemination - Communication

Dissemination and communication activities are expected to continue after the end of LIFE funding through the project website, the CMM platform, the multimedia training environment and the scientific and institutional networks of the consortium partners.

The beneficiaries will continue dissemination through scientific publications, conferences and workshops, stakeholder meetings, policy-oriented discussions, advisory and training activities, participation in national and European initiatives related to MRV systems, climate-smart agriculture, carbon farming and soil-monitoring policies.

Following the adoption of Law 5184/2025 in Greece, the GHG monitoring system developed under LIFE ClimaMED was institutionally integrated into the operational framework of the Greek Ministry of Rural Development and Food. The operational centre (CMM) currently hosted by the Foundation for Research and Technology – Hellas is legally foreseen to be transferred and installed within the Ministry by 31 December 2029, ensuring the long-term operational continuity, maintenance and institutional exploitation of the ClimaMED infrastructure and associated digital services beyond the duration of LIFE funding.

In addition, the project website and core dissemination material are expected to remain accessible for at least five years after the end of the project, supporting future users, stakeholders and potential adopters of the ClimaMED methodologies.

Website: https://www.life-climamed.eu

Beneficiaries

- Benaki Phytopathological Institute - Greece
- Foundation for Research and Technology - Greece
- Technical University of Crete - Greece
- Ministry of Rural Development and Food - Greece
- Green Projects - Greece
- Miguel Hernández University of Elche - Spain
- Centro di Sperimentazione e Assistenza Agricola - Italy
- ENVITECH - Cyprus

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.