(Projects funded under the Call 2014 onwards must use this format)

LIFE Project Number

LIFE19-ENV_IT_000339

Final Report

Covering the project activities from 01/09/2020[1] to 31/10/2023

Reporting Date[2]

31/01/2024

LIFE PROJECT NAME or Acronym

LIFE WINEgROVER

Data Project

Project location:	IT/ITI/ITI2/ITI22 - ES/ES6/ES61/ES617
Project start date:	01/09/2020
Project end date:	31/10/2023
Total budget:	€ 2,188,137.00
EU contribution:	€ 1,203,475.00
(%) of eligible costs:	55.00%

Data Beneficiary

Name Beneficiary:	Università degli Studi della Tuscia – DIBAF
Contact person:	Mr Giuseppe SCARASCIA MUGNOZZA
Postal address:	Via de Lellis, snc, 01100, Viterbo, Italy
Telephone:	+39-0761-357395
E-mail:	gscaras@unitus.it
Project Website:	https://winegrover.eu/

[1] Project start date

[2] Include the reporting date as foreseen in part C2 of Annex II of the Grant Agreement

This table comprises an essential part of the report and should be filled in before submission

Please note that the evaluation of your report may only commence if the package complies with all the elements in this receivability check. The evaluation will be stopped if any obligatory elements are missing.

Package completeness and correctness check	
Obligatory elements	**✓ or N/A**
Technical report	
The correct latest template for the type of project (e.g. traditional) has been followed and all sections have been filled in, in English *In electronic version only*	✓
Index of deliverables with short description annexed, in English *In electronic version only*	✓
Mid-term report: Deliverables due in the reporting period (from project start) annexed Final report: Deliverables not already submitted with the MTR annexed including the Layman's report and after-LIFE plan Deliverables in language(s) other than English include a summary in English *In electronic version only*	✓
Financial report	
The reporting period in the financial report (consolidated financial statement **and** financial statement of each Individual Beneficiary) is the same as in the technical report with the exception of any terminated beneficiary for which the end period should be the date of the termination.	✓
Consolidated Financial Statement with all 5 forms duly filled in and signed and dated *Electronically Q-signed or if paper submission signed and dated originals* and in electronic version (pdfs of signed sheets + full Excel file)*	✓
Financial Statement(s) of the Coordinating Beneficiary, of each Associated Beneficiary and of each affiliate (if involved), with all forms duly filled in (signed and dated). The Financial Statement(s) of Beneficiaries with affiliate(s) include the total cost of each affiliate in 1 line per cost category. *In electronic version (pdfs of signed sheets + full Excel files) + in the case of the Final report the overall summary forms of each beneficiary electronically Q-signed or if paper submission, signed and dated originals**	✓
Amounts, names and other data (e.g. bank account) are correct and consistent with the Grant Agreement / across the different forms (e.g. figures from the individual statements are the same as those reported in the consolidated statement)	✓
Mid-term report (for all projects except IPs): the threshold for the second pre-financing payment has been reached	**N/A**
Beneficiary's certificate for Durable Goods included (if required, i.e. beneficiaries claiming 100% cost for durable goods) *Electronically Q-signed or if paper submission signed and dated originals* and in electronic version (pdfs of signed sheets)*	**N/A**
Certificate on financial statements (if required, i.e. for beneficiaries with EU contribution ≥750,000 € in the budget) *Electronically Q-signed or if paper submission signed original and in electronic version (pdf)*	✓
Other checks	
Additional information / clarifications and supporting documents requested in previous letters from the Agency (unless already submitted or not yet due) *In electronic version only*	✓
This table, page 2 of the Mid-term / Final report, is completed - each tick box is filled in *In electronic version only*	✓

**signature by a legal or statutory representative of the beneficiary / affiliate concerned*

1. Table of contents

2. List of key-words and abbreviations

Keywords
Proximal sensing, Remote sensing, Resilience, Sustainable intensification, Vitis vinifera L.

Abbreviations
C2M: Close to Market
CAGR: Compound annual growth rate
CAP: Common Agricultural Policy
CC: Climate Changes
CTF: Controlled Traffic Farming
ELR: Early Leaf Removal
ES: Ecosystem Services
EU: European Union
GNSS: Global Navigation Satellite System
GPS: Global Position System
GSP: Ground Sensors Platform
IoT: Internet of things
KPI: Key Project Indicators
LAI: Leaf Area Index
LCA: Life Cycle Assessment
LF: Leaf Nutrition
OIV: The International Organisation of Vine and Wine
OMN: Organo Mineral Nutrition
PV: Precision Viticulture
SRC: Soil Respiration Chamber
UAV: Unmanned Aerial Vehicles
UGV: Unmanned Ground Vehicle
VIs: Vegetational Indices

3. Executive Summary (maximum 2 pages)

The LIFE WINEgROVER project mainly focuses on reducing the environmental impact of viticulture, with an emphasis on preserving natural capital such as soil, water, and air. Additionally, the project aims to enhance human health by minimizing the use of pesticides. This is achieved through the sustainable intensification of viticulture, especially considering the challenges posed by global warming and environmental emergencies.

In these contexts, the LIFE WINEgROVER project has the following objectives:

- Producing grapes that protect and ensure the health and safety of consumers, producers, and production staff.
- Developing agronomic strategies to enhance plant resilience to new climatic conditions, thereby reducing the reliance on chemical inputs and promoting the provision of more ecosystem services (ES).
- Promoting sustainable viticulture from environmental, ecological, and economic perspectives by minimizing the use of inputs and energy.
- Preserving and protecting ecosystem services associated with vineyard systems.

These objectives can be achieved through the utilization of new technologies that assist winegrowers in the decision-making process, enabling the adaptation of agronomic practices in vineyards. This involves the integration of new devices such as sensors, robots, and drones, along with digital techniques to monitor and optimize viticulture production processes. The LIFE WINEgROVER project aims to implement an innovative prototype system, optimize the methodology of data collection and analysis for precision viticulture (PV), and validate its effectiveness in two environmentally sensitive grape-growing regions in the Mediterranean basin: Italy and Spain.

In this context, the primary deliverables have included the technical description of the construction and the definition of operational protocols for the collection, analysis, and fusion of data acquired by the prototype system, which consists of five components:

1. AERIAL DRONE - An unmanned aerial vehicle (UAV) equipped with global positioning systems (GPS) and two different types of sensors.
2. TERRESTRIAL ROVER - An innovative autonomous terrestrial electric rover designed to traverse vineyards, equipped with multi-sensor instrumentation for proximal sensing.
3. GROUND STATION - A ground control station responsible for Rover management during mission preparation and execution, as well as data acquisition.
4. SENSORS PLATFORMS - A ground-based sensor platform for real-time data and ground monitoring of key microclimatic parameters.
5. IoT PLATFORM and SOFTWARE: An IoT management platform and advanced data analytics, processing, and visualization software

The prototype system was designed to adapt to the specific environmental context of the selected grape-growing areas in Italy and Spain. The deliverables include the identification and characterization of test areas within the pilot vineyards. This characterization encompasses the climate, soil conditions (edaphic factors), and the varieties of vines present. Based on this information, experimental designs have been defined and described in the deliverables for both pilot vineyards. These designs include not only the specific areas to be tested but also the management practices that will be applied. Additionally, the deliverables outline the methodology for data acquisition by the prototype system, ensuring a comprehensive approach to monitoring and optimizing viticulture production in the given environmental contexts.

Through all these prototype components, the LIFE WINEgROVER project aims to verify and demonstrate the effective potential of precision viticulture (PV) techniques in terms of reducing inputs in two environmentally sensitive grape-growing areas in the Mediterranean basin. Furthermore, the integration of these technologies with the data analysis workflow developed by the project seeks to optimize external inputs while minimizing environmental impacts.

The project's impacts have been identified through key performance indicators (KPIs) defined at the project's outset on the LIFE portal, as well as through life cycle assessment (LCA) and the assessment of socio-economic indicators. Regular monitoring and evaluation of KPIs will be conducted in alignment with the multiannual work program of the LIFE WINEgROVER project. Moreover, the LIFE WINEgROVER project aspires to promote precision viticulture as a holistic farm management approach utilizing information technology, remote sensing, and proximal data gathering. The dissemination plan targets stakeholders to communicate the advantages of employing precision viticulture technologies, emphasizing that profitability is not the sole driver for investing in new machinery. Decisions may also be influenced by environmental or ecological regulations.

The primary outputs of the LIFE WINEgROVER project include the formulation of a management and data acquisition methodology capable of accurately determining the plant vigor, physiological status, and stressors associated with strategic management practices in vineyards. This methodology aims to reduce the overall impact on the environment and consumer health. The project's findings have been disseminated through a communication plan outlined in the deliverable dedicated, targeting stakeholders to underscore the benefits of utilizing these technologies. To disseminate the applied methodologies, guidelines, and informative documentation on precision agriculture and viticulture, the LIFE WINEgROVER project has produced a range of materials. This includes comprehensive guidelines that offer practical insights into implementing precision agriculture techniques in viticulture. Additionally, informative documentation has been created to provide accessible information to a broader audience interested in the project's methodologies.

Moreover, scientific articles derived from the analysis of the collected data have been generated. These articles serve as a valuable contribution to the scientific community, sharing insights, methodologies, and outcomes of the project. This dual approach, combining practical guidelines and scientific publications, ensures that the project's knowledge is shared not only with practitioners in the field but also with the broader scientific and agricultural communities. This approach seeks to showcase the advantages of the project's results and how they contribute to informed decision-making in viticulture, aligning with broader goals of sustainability and responsible agricultural practices.

As per the project timeline, the activities scheduled for the first growing season were successfully executed, despite challenges posed by the ongoing global pandemic caused by COVID-19. Due to the pandemic, all meetings were conducted remotely, and the kick-off event was held in a mixed mode with only Italian partners present. Notably, the initial visit by Italian partners to the Spanish vineyard, originally planned for October - November 2020, was rescheduled to June 2021.

The pandemic situation, compounded by the chip shortage crisis, difficulties in procuring components from China, and challenges in logistics leading to significant delays in material delivery, necessitated continuous adaptation of project activities. Despite these challenges and owing to the collaborative efforts of all project partners, activities were carried out successfully, and the project achieved the milestones defined in the project timeline.

As scheduled, the main activities conducted during the project encompassed:

- Implementation of Two Prototype Systems: The development of the initial system prototype for the Italian pilot vineyard (Famiglia Cotarella - Falesco Vineyard and Winery) and a second prototype for the Spanish pilot vineyard (Botega Conrad).
- Pedological to Meso-climate Characterization: A thorough characterization of the soil and meso-climate in the selected grape-growing areas in both Italy and Spain.
- Experimental Design Definition: The formulation of the experimental design for both the Italian and Spanish pilot vineyards, providing a structured plan for research and data collection and process.
- Field Surveys Data Collection: Conducting field surveys to gather data and assess the physiological effects of agronomical practices on vine performances, in accordance with the experimental design.
- Life Cycle Assessment (LCA) Data Analysis: The collection and processing of data for calculating the Life Cycle Assessment (LCA) for grape production, contributing to a comprehensive understanding of the environmental impact.
- Impact Indicators Definition: Defining environmental, economic, and social impact indicators associated with the project's actions, aiding in the assessment of the broader implications.

Additionally, a notable accomplishment of the LIFE WINEgROVER project is the planned go-to-market strategy for a component of the prototype system, specifically the terrestrial rover. With support from the C2M team of the LIFE program and the LUISS partner within the project, the SETEL company is working towards production. This involves integrating key components such as the IoT platform, the Ground station, and the multi-sensors head. This strategic move represents a tangible outcome in translating project innovations into market-ready solutions. In particular, the elaborated Business Plan delves into aspects related to the use of the Terrestrial Rover, as this product has been deemed closer to the introduction phase in the market.

4. Introduction (maximum 2 pages)

Environmental problem/issue addressed

Climate change trends do not affect the entire globe uniformly but vary according to the location, with rapid temperature changes, shifts in rainfall patterns, and an increased frequency and intensity of extreme climate events (natural or man-made disasters). Climate strongly influences vine growth, canopy microclimate, yield, and berry composition, as well as the occurrence of pests and diseases. Essentially, it can compromise the income of the wine sector and the preservation of natural capital. The adoption of climate-smart agronomic and canopy management practices could buffer future extreme weather effects on vine performance, such as lower water use, reduced cluster compactness and skin-to-pulp ratio in berries, reduced vigor, or, more generally, for a better vine balance (crop load). This could increase vine resilience and efficiency, leading to sustainable transitions in this pivotal and widely spread agri-food sector. To achieve these goals, detailed information is needed, such as how strategic canopy management can impact vine responses, for example, on the photosynthetic machinery. This would promote site-specific and vintage-based solutions to achieve greater yields even under stressed environments and safeguard berry quality.

A great deal of information can be derived directly from the survey of field parameters of crops, especially using proximal sensing linked to remote sensing measurements from unmanned aerial vehicles (UAVs), unmanned ground vehicles (UGVs), or satellites. These technologies provide near real-time monitoring at the vine level and enable informed management decisions to preserve crop production, implement vineyard-based applications, and foster a sustainable and competitive wine sector that can contribute significantly to the European Green Deal. For this, strong support has to be provided for small and medium-sized farms, which are less likely to adapt and introduce changes in their operations than specialized farms (source: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/eco_background_final_en.pdf). These farms are crucial stewards of biodiversity and fundamental in providing ecosystem services for nature sustainability, mediating social outcomes relevant to sustainable development (Ricciardi et al., 2021, source: https://www.nature.com/articles/s41893-021-00699-2), as well as for the ecological transition and intensification of agriculture.

On this issue, in 2004, the OIV focused on the sustainable intensification of viticulture and defined it as a 'global strategy on the scale of grape production and processing systems.' This strategy incorporates, at the same time, the economic sustainability of structures and territories, the production of quality products, consideration of precision in sustainable viticulture, environmental risks, product safety, consumer health, and the valuation of heritage, historical, cultural, ecological, and aesthetic aspects.

In this context, the objectives of the LIFE WINEgROVER project aim to produce grapes while protecting the health and ensuring the safety of consumers, producers, and staff associated with production. The project also aims to promote the use of mechanisms of natural regulation according to the implemented management strategies, minimize environmental impacts linked to viticulture through the monitoring of indicators, promote sustainable viticulture from an environmental, ecological, and economic standpoint, minimize the use of inputs and energy, as well as preserve and develop viticultural landscapes.

Outline the hypothesis to be demonstrated / verified by the project

The project aims to demonstrate hypotheses within the pilot vineyard, verifying how different agronomic strategies, defined in the experimental design according to the local context, can improve the quality and quantity of production while decreasing environmental impacts and enhancing social and economic conditions. In the project, we aim to demonstrate how the application of the site-specific concept of precision viticulture (PV) and the zoning derived from the prototype system can assist winegrowers in making optimal decisions for vineyard management and the judicious use of fertilizers only in the areas where the plants need them.

The project will illustrate how vegetation indices (VI) maps, derived from both proximal and remote sensing systems, along with non-destructive field surveys, can define the zoning of the field and indicate where actions or corrections are needed for a given parameter.

Description of the technical / methodological solution

The LIFE WINEgROVER project aims to demonstrate the technical performance and economic efficiencies of a new precision viticulture (PV) technology in two pilot vineyards in Italy and Spain, presenting an integrated solution. The prototype is conceived as a unified system comprising five distinct technologies interconnected for data acquisition and validation. The five components are:

1. Aerial Drone Prototype (UAV): Designed for optimizing surveys, data type acquisition, and data quality, the UAV is a purpose-built system with a commercial flight platform and telemetry system. It features two sensors—a Hyperspectral Sensor and a High-Resolution Real-Time 3D Lidar Sensor—integrated into a gimbal, allowing simultaneous acquisition of hyperspectral and lidar data during flight missions.
2. Terrestrial Rover: The rover provides precision agronomic information, encompassing image acquisition, data extraction, and analysis. Electrically operated with a low center of gravity, it has minimal impact on the crop. Equipped with infrared, NIR, and RGB sensors, the rover also offers sufficient space, load capacity, and energy reserve to host heavy-duty processing units for the rapid analysis of parameters obtained from the ground sensor platform to extract vegetative indices.
3. Ground Station: Responsible for remote rover management during mission preparation and execution, the ground station utilizes Commercial Off-The-Shelf components connected to the rover via an IP network. It includes a notebook, monitor, and joystick for controlling rover movement.
4. Ground Sensor Platforms**:** Prototypes developed for the LIFE WINEgROVER project, these platforms are based on small single-board computers (SBCs) and various sensors employed for monitoring vineyard parameters.
5. IoT Platform and Software: The data management technology of the LIFE WINEgROVER project is grounded in the FIWARE IoT Stack for the acquisition and connection layer. Additionally, it incorporates WTG's AMAIA technology, providing a Big Data infrastructure encompassing database storage (SQL/NoSQL), data sources integration module, processing engines (Calculations, Correlation, CEP, Machine learning), advanced data analytics (Streaming Real-time Data), as well as business intelligence (ETL Batch processing) and visualization tools (Dashboard and KPI construction).

In addition, field data in the pilot vineyards has been gathered using non-destructive tools—portable, battery-powered, and user-friendly devices designed to study various physiological parameters. These parameters include photosynthetic activity, stress detection (e.g., stomatal conductance), precise measurement of chlorophyll levels, and assessment of vine vigor through the leaf area index (LAI). These instruments play a crucial role in validating remote sensing data related to vine performance.

Expected results and environmental benefits

All initiatives implemented in LIFE WINEgROVER aim to reduce the environmental impact of viticulture on natural capital and enhance the resilience of vines to biotic stressors. Specifically, the management strategies implemented in the pilot vineyards can influence and regulate foliar pigment dynamics and the timing of their decline. These effects are observable through vegetation index maps derived from the new technologies introduced in the project. These technologies contribute to mapping the behavior of grape cultivars throughout the annual biological cycle, including the assessment of photosynthetic activity and the quantification of the potential carbon storage in vine organs, thereby contributing to climate targets with a reduction of 25% in kgCO_2 eq/ton of grapes. Furthermore, this analytical methodology can identify and modulate the impacts of abiotic stress factors, such as drought, on vine performance and water status. This approach aims to preserve leaf area, yield, berry components, and bud fertility, ultimately reducing water consumption for irrigation through precision vine water status mapping and precise dripping foliar. Moreover, the strategic agronomic practices will also contribute to altering certain morphological traits of clusters, such as the number of berries per bunch. As a consequence, this alteration improves the microclimate of the bunch by reducing humidity and contributes to a reduction in the use of pesticides and fungicides, aligning with the principles promoted by the EU CAP eco-scheme.

Expected longer term results

The longer-term outcomes of the LIFE WINEgROVER project align closely with EU policies on Climate Change, Environmental and Landscape Care, and Food, as promoted and adopted in 2019 through the EU Green Deal and related strategies. Notably, the strategic agronomic practices and precision agriculture implemented in LIFE WINEgROVER are integral to eco-schemes—the new instrument for applying the Common Agricultural Policy (CAP) strategic plans. These schemes support the transition towards a sustainable food system and reinforce the efforts of European farmers to contribute to the EU's climate objectives and environmental protection.

The replicability and transferability of the new precision viticulture (PV) technology developed in the project will be promoted at both local and EU levels through targeted dissemination actions aimed at relevant stakeholders and the public. These efforts will include fostering networking opportunities with grape producers and other farmers. Importantly, the system's applicability extends beyond viticulture and could be adapted for use in other crops as included in the project's replicability and transferability plan.

The one-day technical workshops were designed to provide practical training for grape growers, winemakers, and associated personnel. These workshops focused on environmental sustainability themes, LIFE WINEgROVER results, and their application and replication in vine sectors. Additionally, the training covered the potential adaptation of these practices to other intensive cropping systems, including olive groves, kiwis, and cotton.

Participation in the project is creating market opportunities for the partner SETEL through the introduction of a new competitive product—the terrestrial rover. This involvement not only promotes and exports EU technology but also establishes an early leadership position in vineyards, with plans to scale to other crops such as olive groves and kiwis. Initial market and economic analyses were conducted in the project's first phase and have been refined in subsequent stages. The business model is centered on a well-defined market with customers demonstrating a proven willingness to pay. The primary target customers include farms, crop consultants, and agricultural equipment industries. The product comprises proprietary hardware and software for monitoring crop health. Customers have the option to purchase hardware, accessories, and software licenses (in trial, base, and full versions), or alternatively, they can choose to rent a complete system for a specific campaign period. Complete systems, available in different versions, will be sold within the price range of 25,000 to 35,000 euros. Additionally, the option to rent the system for an entire season will be offered. An economic analysis has been conducted and updated during the project, aligning with achieved results and with support from the C2M Team. According to this preliminary study, Europe boasts 2.4 million holdings covering an area of 3.2 million hectares for grape production, presenting a substantial market for potential business profitability. The Global Precision Agriculture (PA) Market, valued at USD 3.3 billion in 2017, is anticipated to reach an estimated USD 4.6 billion in 2020, growing at a CAGR of 12%. The market strategy will initially target the niche market of Precision Viticulture. The business plan, spearheaded by LUISS Business School during the project, has been undergo refinement through competitor analysis and market adaptation based on test results, dissemination activities, and stakeholder interest. Specifically, in the first phase its activity will be focused on collaborations with various research centers in order to test and further improve the rover; gradually it will enter the market segment of companies identified in the BP (Large farms and Consortia of medium and small farms; Companies also of medium and small size but producing very high-quality wine).

5. Administrative part

The administrative management of the project encompasses key elements such as the project management process, the working methodology employed, challenges encountered, insights into partnerships and their added value, and comments on any noteworthy deviations from the original work plan.

6. Technical part (maximum 25 pages)

6.1. Technical progress, per Action

Action A - Preparatory actions
Action A1 - Definition of Technical Protocols

Foreseen start date: 1st September 2020 — Actual start date: 1st September 2020
Foreseen end date: 31st October 2020 — Actual end date: 31st October 2020

Action	Deliverable Number	Deliverable name	Foreseen Deadline	Actual Deadline	ANNEX
A1	D1	Technical document on protocols	oct-20	oct-20	Enclosed with the mid-term report.
A1	D2	Land lease Contracts	oct-20	oct-20	Enclosed with the mid-term report.

Action A1 was initiated at the beginning of the project to define the technical protocols for implementing the prototype system for use within the two pilot vineyards outlined in the project proposal. Specifically, as detailed in the deliverable "D1 - Technical Documents on Protocols," we described the Italian and Spanish pilot sites, taking into account climate and vegetation characteristics, along with the precise positioning of the sample plot within the 1-hectare vineyard. The technical protocol for monitoring Key Project-level Indicators (KPIs) was defined, considering vineyard management strategies, CO_2 emissions, and other greenhouse gases, precision management of diseases and pests, reduction of pesticide and fungicide use, water conservation, and life cycle assessment evaluation.

Additionally, the technical protocols for implementing communication and data exchange between prototypes were established. This included descriptions of the aerial drone, terrestrial rover, ground station, ground sensor platforms, IoT platforms, and software, as well as the rules and regulations for aerial drone usage in Europe, Italy, and Spain.

CREA has been in charge of overseeing the action. Wellness Telecom and Setel actively contributed to the development of deliverable D1, focusing on the description of communications between the components of the prototype system and the terrestrial rover, respectively. UNITUS took charge of outlining the aerial drone activities, while the descriptions of the vineyards were a collaborative effort involving UNITUS, CREA, and SCC. The formulation of Key Project-level Indicators (KPIs) and Life Cycle Assessment (LCA) details was conducted jointly by UNITUS and CREA. UNITUS and SCC will play active roles in the formulation of rental contracts.

Action A1 was executed in accordance with the project schedule, successfully reaching milestone “M1 - Technical Protocols for Implementing the System and Defined Measurements.” This achievement has had a positive impact on the seamless execution of subsequent actions within the project. The development of technical work protocols and operational diagrams for the prototype system, detailing each component, has laid the groundwork for forthcoming actions, particularly those falling under Action B.

Owing to the COVID-19 pandemic, the preliminary visit to the vineyard in Spain could not take place as initially anticipated by the project. Consequently, both the general and detailed descriptions have been incorporated into "D4 - Technical Document on Characterization of the Spanish Pilot Site”, related to Action B.1: Vineyards Characterization and Optimization (Task B1.2 Spanish Vineyard - deadline December 2021).

TASK	**ACTIVITIES UNDERTAKEN**	**OUTPUTS ACHIEVED**	**TECHNICAL DETAILS** (DELIVERABLE)
Definition of Technical Protocols	General Description of Italian Pilot site	Climate analysis at the large scale based on long time-series (1995–2015) functional also to B1 action – vineyard characterization.	D1
		Classification of local climate regimes as ‘hot–very hot’ useful to detect the agronomical and cultural strategies for vineyard sustainable management.	D1
		Baseline agro-phenological trends (1995–2015) for the white grapevine variety selected: Chardonnay (CH) to detect the effect of abiotic factors (climate variables) on biotic pressure (number of phytosanitary treatments for powdery (*Erysiphe necator*) and downy mildew (*Plasmopara viticola*).	D1
	General Description of Spanish Pilot site	Postponed in 2021 - preliminary visit to vineries has been not possible for COVID-19 pandemic	D1

		restrictions and it has been done in spring 2021.	
	Technical protocol for monitoring the KPI	Definition of agronomic strategies for vineyard sustainable management to reduce external inputs and increase vineyard sustainability.	D1
		Selection of environmental and climate parameters to define performance and quantify KPI: CO_2 emissions and other GHGs; identification diseases and pest precision management; reduction of the use of pesticides and fungicides; water reduction.	D1
		LCA parameters selected following the guidelines of the International Organization for Standardization (ISO), and identification of functional unit (FU): 0.75 l or 1kg of grape.	D1
	Technical protocols for data exchange between prototypes	Implementing of communication and data exchange between prototypes (aerial drone, terrestrial rover, ground station, ground sensors platforms, IoT platforms and software)	D1
Land area contracts	Definition land contract for the areas	Contact with the owners of the vineyards to define the contract for the use of the sample plot.	D2

Action B - Implementation Action
Action B1 - Vineyard Characterization and Optimization

Task B1.1 - Italian Vineyard

Foreseen start date: 1st November 2020
Foreseen end date: 31st March 2021

Actual start date: 1st November 2020
Actual end date: 31st March 2021

Task B1.2 - Spanish Vineyard

Foreseen start date: 1st November 2020
Foreseen end date: 31st March 2021

Actual start date: 1st November 2020
Actual end date: 31st March 2021

Foreseen start date: 1st October 2021
Foreseen end date: 31st December 2021

Actual start date: 1st October 2021
Actual end date: 31st December 2021

Action	Deliverable Number	Deliverable name	Foreseen Deadline	Actual Deadline	ANNEX
B1	D3	Technical document on characterization of the Italian pilot site	apr-21	apr-21	Enclosed with the mid-term report.
B1	D4	Technical document on characterization of the Spanish pilot site	dec-21	dec-21	Enclosed with the mid-term report.

Action B1 started in accordance with the project timetable in M3 (November 2020), with the first phase concluded in M7 (March 2021) for task B1.1. During this period, the microclimate characterization of the Italian pilot vineyard was conducted based on ground station sensors installed in the vineyard and historical climate data. Experimental design has been applied in the field according to the project timetable and it allowed the application of the three agronomic strategies promoted by the project in the first growing season.

A pedological survey, involving soil profile pits in the vineyard, along with the installation of soil respiration chambers, provided crucial data for the application of Life Cycle Assessment and allowed monitoring of carbon storage in the soil. Additionally, the experimental protocol for leaf pressure monitoring, based on the Scholander methodology, was implemented to assess plant water status, and define water stress. All pertinent information from these activities is documented in the deliverable "D3 - Technical Document on Characterization of the Italian Pilot Site".

The second task, Action B1 – Task B1.2, involving the characterization of the Spanish vineyard, commenced with a preliminary visit in June 2021 to Bodega Conrad in Ronda. Originally scheduled for October-November 2020, the visit was postponed due to the COVID-19 emergency and eventually took place in June 2021. This delay was in line with travel restrictions implemented to mitigate the spread of the coronavirus, prioritizing the health and well-being of all Europeans. On October 13, 2020, EU Member States adopted a Council Recommendation outlining a coordinated approach to restricting free movement in response to the pandemic. This Recommendation was subsequently updated on February 1 and June 14, 2021. Permission to travel to Spain was granted only in the first ten days of June, facilitated by the issuance of a green pass for researchers from the University of Tuscia (coordinator) and CREA (partner). The visit to the Spanish vineyard proved pivotal in determining the choice of vine cultivars (Pinot and Tempranillo) and identifying the sampling area within the vineyard. It also served as an opportunity for a face-to-face meeting between Italian (UNITUS, CREA) and Spanish partners (WELLNESS, SCC) to review the project's progress and outline future actions. Additionally, soil profiles were created and examined to characterize the soil type within the sample rows of the vineyard, and various physiological parameters (chlorophyll content and stomatal conductance) were measured to assess the plant vigor status.

The coordination of deliverables within this action was overseen by the UNITUS partner. CREA actively participated in the characterization of the vineyards in Italy and Spain. Moreover, CREA, Wellness Telecom, and Setel contributed to defining communications between the components of the prototype system in the field, participating in both on-site activities and remote meetings throughout this project phase. Additionally, Smart City Cluster was actively involved in this action.

Action B1 was executed in accordance with the project schedule, successfully achieving milestones "M2 - Italian Pilot Site Characterized" and "M3 - Spanish Pilot Site Characterized." This accomplishment has had a positive impact on the seamless execution of subsequent actions within the project.

The visit to the Spanish vineyard provided valuable insights into the current edaphic and vegetational conditions, facilitated by meetings with the agronomist responsible for managing

CONRAD's vineyards and conducting relevant surveys. This activity served as a preparatory step for actions B2 and B3, specifically regarding the installation of ground sensor platforms and the measurement campaign in Spain, planned for the growing season in 2022.

TASK	ACTIVITIES UNDERTAKEN	OUTPUTS ACHIEVED	TECHNICAL DETAILS (DELIVERABLE)
B1.1 ITALIAN VINEYARD	Ground sensors platforms installation in vineyard.	Activation of Ground Sensors Platforms in the three agronomic strategies and the control. Starting to storage seasonal micro-climate data.	D3
	Microclimate zonation based on the historical climate data and the ground sensors platforms	Trend of micro-climate variability (GDD, RCU, distribution of rainfall).	D3
	Definition of the experimental design	Identification in field of three rows for each agronomic strategy and the control row, definition the buffer areas in the row to avoid 'marginal effects', and identification of the three core areas of 10 vines (total of 30 vines) where place the Ground Sensors platform	D3
	Pedological survey	Soil profile pits were opened to characterize the soil composition in each of the three agronomic strategies and in the control row.	D3
	Soil Respiration Chamber (SRC) installation in vineyard.	Activation of CO2 monitoring in the soil and starting to store the data. Useful data to assess LCA.	D3
B1.2 SPANISCH VINEYARD	Climate zonation based on the data of weather stations of the Andalusian Agroclimatic Information Network (RIA).	Trend of climate variability for temperature and relative humidity of the air, the speed and direction of the wind, solar radiation, and precipitation in the form of rain.	D4
	Definition of the experimental design	Identification of the cvs tempranillo and pinot and definition in field the rows sample for each variety considering the buffer areas in the row to avoid marginal effects.	D4
	Pedological survey	Opening the soil profile pits to characterize the soil composition in each of the two variety chosen.	D4

Action B2 - Design and Construction of the Prototypes and Sensors Installation

Task B2.1 - Design of ground monitoring prototype and proximal sensors installation

Foreseen start date: 1st November 2020 Actual start date: 1st November 2020
Foreseen end date: 30th September 2021 Actual end date: 30th September 2021

Foreseen start date: 1st January 2022 Actual start date: 1st January 2022
Foreseen end date: 31st December 2022 Actual end date: 31st December 2022

Task B2.2 - Design and construction of the system prototypes

Foreseen start date: 1st November 2020 Actual start date: 1st November 2020
Foreseen end date: 31st December 2022 Actual end date: 31st December 2022

Action	Deliverable Number	Deliverable name	Foreseen Deadline	Actual Deadline	ANNEX
B2	D4	Technical drawings of AERIAL DRONE prototype design	dec-20	dec-20	Enclosed with the mid-term report.
B2	D5	Technical drawings of TERRESTRIAL ROVER prototype design	dec-20	dec-20	Enclosed with the mid-term report.
B2	D6	Technical drawings of GROUND STATION prototype design	dec-20	dec-20	Enclosed with the mid-term report.
B2	D7	Technical drawings of SENSORS PLATFORM prototype design	dec-20	dec-20	Enclosed with the mid-term report.
B2	D8	Technical drawings of IoT PLATFORM prototype design	dec-20	dec-20	Enclosed with the mid-term report.
B2	D9	Specification of the SOFTWARE prototype	dec-20	dec-20	Enclosed with the mid-term report.

Action B2, task B2.1, was initiated according to the project timetable in M3 (November 2020), and its initial phase concluded in M13 (September 2021). During this period, all technical activities necessary to transition from theory to practice were defined, with a focus on implementing prototypes and installing sensors in the Italian pilot site. Various components of the prototypes were fine-tuned to determine the optimal solution for integrating all parts, ensuring effective communication, source acquisition, and connectivity. This encompassed considerations for data acquisition and control, interconnection capacity, pre-processing of data, and facilitating data analysis. As detailed in "D7 - Technical drawings of SENSORS PLATFORM prototype design" ground sensor platforms were designed and deployed at the beginning of 2021 and installed in the Italian pilot site at the beginning of the growing season. These platforms were strategically placed to monitor key climatic and soil parameters for the three agronomic strategies and "control rows" as reported in "D3". The implementation of LoRa protocols facilitated data transmission for real-time monitoring and storage, connecting seamlessly with the terrestrial rover.

Action B2, task B2.1 was resumed according to the project timetable in M17 (January 2022) and concluded in M28 (December 2022). This second phase involved the installation of ground sensor platforms at the Spanish pilot site, following the experimental design outlined in "D14".

For both study sites (Italy-Spain), ground sensor platforms were installed at each project year (2021-2022-2023) at the beginning of the growing season. Subsequently, at the end of each growing season, the platforms were removed from the field for a technical inspection of the sensors and platform operations at the UNITUS laboratory. As outlined in the project plan, data was collected over three growing seasons (2021-2022-2023) at the Italian pilot site, while at the Spanish pilot site, data was acquired for two growing seasons (2022-2023).

Simultaneously, in task B2.2, the setup of the aerial drone was completed, including the implementation of self-guidance and signal reception systems, as detailed in "D4 - Technical drawings of AERIAL DRONE prototype design". In line with Action B3, flights of the aerial drone were conducted during the main phases of plant growth to validate the physiological data collected on the ground using non-destructive instruments. Hyperspectral and lidar data from the rows identified in the three agronomic strategies and the control row in the Italian pilot site were collected according to the protocol defined in "D10" as part of Action B3. As for the Spanish pilot site, multispectral data were acquired following the experimental design and protocol outlined in "D14" as part of Action B3.

Within this action, in task B2.2, the terrestrial rover was also implemented, as described technically in "D5 - Technical drawings of TERRESTRIAL ROVER prototype design". The hardware and firmware were specifically designed for the rover prototype, including the propulsion system. The terrestrial rover was utilized at the Italian pilot site in 2021,2022 and 2023 seasons during the main phases of plant growth for actively monitoring physiological parameters related to the three agronomic strategies and the control row according to "D3". In 2022, an additional terrestrial rover was put into operation at the Spanish pilot site, collecting data in line with the technical protocol outlined in D14 for the 2022 and 2023 seasons.
During the survey phase in July 2021, the multispectral sensor experienced a breakdown. The partner SETEL, responsible for this activity, promptly activated the warranty and maintenance services for the sensor. Unfortunately, due to the multispectral sensor's breakdown, acquiring multispectral data for subsequent surveys in the growing season became impossible. However, other planned data were successfully acquired. Due to logistical and transportation challenges arising from the COVID-19 pandemic, the sensor was still undergoing maintenance in February 2022. However, in May 2022, the sensor returned from maintenance and resumed acquiring data for the 2022 season and 2023.

Together with the terrestrial rover, its ground station was defined, as described in "D6 - Technical drawings of GROUND STATION prototype design"'. The ground station comprises several devices, including a monitor, notebook, and joystick, tasked with managing the rover during data acquisition missions and controlling the rover's parameters, as well as certain functions of the transported sensors.

The entire prototype system is interconnected through the implementation of software that manages connections and data flow, as outlined in "D9 - Specification of the SOFTWARE prototype". In this framework, the data management technology of the WINEgROVER prototype is established as a Big Data infrastructure, encompassing all data database storages, a data sources integration module, processing engines, advanced data analytics, as well as business intelligence and visualization tools, as detailed in the deliverable "D8 - Technical drawings of IoT PLATFORM prototype design".

Action B2 was carried out in accordance with the project schedule, reaching milestone "M4 - Prototype of the AERIAL DRONE built and ready to be used on the vineyards", "M5 - First Prototype of the TERRESTRIAL ROVER ready to be used in the Italian pilot", "M6 - First Prototype of the GROUND STATION ready to be used in the Italian pilot", "M7 - First Prototype of the SENSORS PLATFORM installed in the Italian pilot", "M8 - First Prototype of the IoT PLATFORM ready to be used in the Italian pilot", and "M9 - Prototype of the SOFTWARE ready to be used in the Italian pilot", “M10 - second Prototype of the TERRESTRIALROVER ready to be used in the Spanish pilot”, “M11 - Second Prototype of the GROUND STATION ready to be used in the Spanish pilot”, and “M12 - Second Prototype of the SENSORS PLATFORM installed in the Spanish pilot”.

The Setel partner coordinated this action with UNITUS and Wellness, and collectively, they contributed to the construction of the prototype system. CREA played a crucial role in realizing soil chambers for CO_2 analysis as reported in “D10”. The successful achievement of milestones and the completion of all components of the prototype system within the project timeline allowed for the timely execution of subsequent actions, particularly B3, which commenced with the measurement campaign at the Italian pilot site and successively in the Spanish pilot site.

TASK	ACTIVITIES UNDERTAKEN	OUTPUTS ACHIEVED	TECHNICAL DETAILS (DELIVERABLE)
B2.1 Design of ground monitoring prototype and proximal sensors installation	Design of Ground Sensors Platforms	Definition and technical description of the sensors and the design of the ground sensors platforms for monitoring microclimate in canopy, bunches, and soil.	D7
B2.2 Design and construction of the system prototypes	Design of aerial drone prototype system	Technical design and characterization of the aircraft, the sensors and the gimbal, flight and telemetry control, software and platform for acquisition, storage and analysis of spectral image data collected.	D4
	Design Terrestrial rover prototype	Technical Development Report: technical characteristic, main elements of the rover design, description of main elements and sensors, some drawings	D5
	Design Ground station prototype	Technical drawings of ground station prototype design: definition of ground station components connected to the Rover by means of an IP network, fine-tuning interfaces available to the pilot for driving prototype.	D6
	Design Technical of IoT PLATFORM prototype	IoT PLATFORM prototype design report: definition of architecture of IoT platform in layers: source acquisition and connectivity, data acquisition and control, interconnection capacity, pre-processing of data, facilitating the data analysis.	D8
	SOFTWARE prototype	Design of the platform using to integrate and perform all big data derived from the system prototype of the LIFE WINEgROVER project	D9

<u>Action B3 - Prototype's measurement on vines performances</u>

<u>Task B3.1 - Prototype's measurement on vines performances</u>

Foreseen start date: 1st April 2021 Actual start date: 1st April 2021
Foreseen end date: 30 September 2022 Actual end date: 30 September 2022

Foreseen start date: 1st January 2022 Actual start date: 1st January 2022
Foreseen end date: 30 September 2023 Actual end date: 30 September 2023

Task B3.2 - Prototype’s campaign, modelling, data fusion

Foreseen start date: 1st April 2021 Actual start date: 1st April 2021
Foreseen end date: 30 September 2022 Actual end date: 30 September 2022

Foreseen start date: 1st January 2022 Actual start date: 1st January 2022
Foreseen end date: 30 September 2023 Actual end date: 30 September

Action	Deliverable Number	Deliverable name	Foreseen Deadline	Actual Deadline	ANNEX
B3	D10	Operation report on measurements on the Italian Pilot	sep-21	sep-21	Enclosed with the mid-term report.
B3	D11	Operation report on data fusion	oct-21	sep-23	Enclosed with the mid-term report and final report
B3	D12	Analysis and modelling of the results – Report Italian Pilot Season 1	dec-21	dec-21	Enclosed with the mid-term report.
B3	D13	Analysis and modelling of the results – Report Italian Pilot Season 2	dec-22	dec-22	Enclosed with the final report.
B3	D14	Operation report on measurements on the Spanish Pilot Season2	sep-22	sep-22	Enclosed with the final report.
B3	D15	Analysis and modelling of the results – Report Spanish Pilot Season 2	dec-22	dec-22	Enclosed with the final report.

Action B3 started as scheduled on M7 (April 2021) at the Italian pilot site, utilizing the prototype system developed in Action B2. The focus was on detecting vegetative parameters during the first growing season to determine the state of plant vigor and gather data for Life Cycle Assessment (LCA) and Key Performance Indicators (KPIs) estimation. The action continued in the 2022 and 2023 growing seasons up to M36 (August 2023), involving both the Italian and Spanish pilot sites. In the Spanish site, the second prototype envisaged by the project and developed in Action B2 was used.

In the Italian pilot site, the measurements conducted by the prototype system covered the area with the three agronomic strategies and the control row as reported in D3. These measurements were carried out simultaneously at different phenological stages (Flowering - BBCH 065; Fruit set - BBCH 071; Bunch closure - BBCH 079; Softening of berries - BBCH 085; Ripening - BBCH 089) for both remote sensing acquisition and the survey of vegetative parameters. For remote sensing data, following technical protocols derived from actions A, B1, and B2, the rover with RGB, Thermal, and multispectral sensors moved between rows, while the aerial drone, equipped with hyperspectral and Lidar sensors, executed predetermined flight missions above the vineyard. Regarding the vegetation survey, parameters such as leaf chlorophyll concentration, stomatal conductance, Leaf area index (LAI), and fluorescence were measured in plants defined in D10 within the vineyard.

The same survey protocol, as outlined in D4 – Action B1 and D14, was employed at the Spanish pilot site for the 2022 and 2023 growing seasons, following the experimental design.

In the Italian pilot site, the ground sensor platforms defined in D7, completed, and installed in May 2021, were utilized to characterize microclimate conditions (canopy, bunches, soil temperature, and humidity) for the three agronomic strategies and the control row as reported in D3. Soil chambers were employed to collect soil respiration data in the two strategies, Ordinary Management (C) and Mineral-Organic Fertilization (OMF), as defined in D3. In the

Spanish pilot site, the ground sensor platforms were installed at the beginning of the 2022 vegetative season, following the experimental design outlined in D4 – Action B1. These platforms detected the same microclimatic parameters as defined for the platforms in the Italian pilot site as reported in D10 and D14.

The results derived from remote acquisition, ground sensor platforms, and field surveys with non-destructive instruments for the first growing season are reported in D12. The results for the second growing season are detailed in D13 for the Italian pilot site and in D15 for the Spanish pilot site, respectively.

Various types of sensors and various types of data were strategically placed within the vineyard and various types of data were collected necessitating the development of data fusion protocols. Data fusion was a crucial process in information integration, where disparate data from multiple sources were amalgamated to produce a comprehensive and accurate representation of reality. The primary aim of data fusion has been to enhance the overall quality and reliability of information by leveraging the strengths of diverse data sets. By combining data from various sensors, or modalities, such as drone imagery, sensor networks, and ground-truth data, data fusion seeks to mitigate the limitations and uncertainties inherent in individual datasets. The output of the data fusion process was a consolidated and refined dataset that provides a more holistic view of the target phenomena. This refined output often exhibits improved accuracy, completeness, and reliability compared to the original, disparate data sources. Data fusion involves the integrated use of data from multiple sensors, as opposed to analysing data from each sensor individually, to produce a high-quality visible representation.

In this context, data fusion aims to integrate information acquired with different spatial and spectral resolutions from sensors to create fused data, correlating them with field surveys.

The analysis of pre-processing data, the overall data flow, and the system architecture, including the calculation of the final score used to define the state of the plants at each point in the vineyard, has been outlined in D11. In the data fusion process, we considered images processed by an aerial drone with a vegetation index map, images acquired by a terrestrial rover with a map of the same vegetation index from the aerial drone, values of data collected on the ground, and bioclimatic indices derived from the ground sensor platforms. Each dataset was assigned a score based on a predefined range of values. The final score was determined by summing the points from each individual dataset. This approach resulted in a map where each point was color-coded based on the set values within a variation range. Red indicated plant stress conditions, green represented good vigor, and orange signified an equilibrium situation. The prescription maps thus obtained are then used as inputs for subsequent analyses, helping to define points where intervention is necessary or not.

As described in Action B2, during the first growing season (2021) we encountered some problems during the survey phase of the prototype system for the reception of images from the terrestrial rover, however, the monitoring activities through non-destructive instruments and the ground sensors platforms were continued throughout the growing season 2021. For the subsequent growing seasons (2022-2023), no problems were encountered in data acquisition in both pilot sites.

The two tasks (3.1 and 3.2) within Action B3 were carried out in parallel as Prototype's campaign strategy incorporates advanced modelling techniques, prototype's measurement of vine performance, and data fusion to optimize its efforts.

Action B3 was carried out in accordance with the project schedule, reaching milestone "M14 - Complete System operating in Italian site" and “M15 – Complete System operating on the Spanish site”.

The Wellness partner coordinated this action with UNITUS, Setel, and CREA, and together, they contributed to the measurements in the Italian pilot site and the Spanish pilot site. The achievement of milestones and the completion of measurements in both pilot vineyards have been crucial for defining the monitoring activity described in Action C.

TASK	ACTIVITIES UNDERTAKEN	OUTPUTS ACHIEVED	TECHNICAL DETAILS (DELIVERABLE)
B3.1 Prototype's measurement on vines performances	Application of canopy and soil management strategies in Italian pilot site.	Three strategic agronomic strategies were adopted (ELR, FN, OMN) to reduce abiotic stressor, to increase viticulture resilience and environmental sustainability. Operational description of strategies	D10
	Ground monitoring of microclimatic parameters by Ground sensors platforms in Italian pilot site	Several microclimate variables have been monitored to assess effects on vine eco-physiological process – such as leaf gas exchanges (CO_2 and H_2O)– and on soil carbon storage (quantification of CO_2 fluxes by prototype respiration chambers). Data are pivotal also for Life Cycle Assessment (LCA) assessment.	D10
	Vine performance in the field in Italian pilot site	Data collected by field survey through non-destructive tools (vegetative and productive data) useful to assess the influence of the three strategies on vines performance. The data are useful as input parameters for Life Cycle Assessment (LCA).	D10
	Mission Planning and data acquired by UAV in Italian pilot site	Reports on the operations to be performed for planning the UAV's flight missions automatically and acquiring data. Sensors calibration.	D10
	Mission Planning and data acquired by terrestrial rover in Italian pilot site	Definition the sensors head, definition of the connection with the ground station and operation report for planning the mission and acquisition of the data.	D10
	Application of management strategies in Spanish pilot vineyard.	Two cultivars (cv) have been selected. For each cv, one row was selected the first half of it was used as control (C) while on the other half the treatment (FN) was applied.	D14
	Ground monitoring of microclimatic parameters by Ground sensors platforms in Spanish pilot site	Several microclimate variables have been monitored to assess effects on vine eco-physiological process.	D14

	Vine performance in the field in Spanish pilot site	Data collected by field survey through non-destructive tools (vegetative and productive data) useful to assess the influence of the strategy on vines performance in the two cv. The data are useful as input parameters for Life Cycle Assessment (LCA).	D14
	Mission Planning and data acquired by UAV in Spanish pilot site	Reports on the operations to be performed for planning the UAV's flight missions automatically and acquiring data with a DJI Phantom 4 multispectral drone.	D14
	Mission Planning and data acquired by terrestrial rover in Spanish pilot site	Definition the sensors head, definition of the connection with the ground station and operation report for planning the mission and acquisition of the data.	D14
B3.2 Prototype's campaign, modelling, data fusion	Operation report on data fusion	The process of integrating data obtained from multiple sources was implemented for studying the same vineyard for defining the maps and the physiological needs of the plant	D11
	Analysis and modelling of the results – Report Italian Pilot Season 1	The data acquired in the first growing season were analyzed and obtained the first results for the strategies implemented in the vineyard.	D12
	Analysis and modelling of the results – Report Italian Pilot Season 2	The data acquired in the second growing season were analyzed and obtained the results for the strategies implemented in the vineyard.	D13
	Analysis and modelling of the results – Report Spanish Pilot Season 2	The data acquired in the first growing season were analyzed and obtained the first results for the strategy implemented in the vineyard in the two cv.	D15

Action B4.- Replication and Transferability Plan

Task B4.1 - Design and Replicability of Business Models

Foreseen start date: 1st January 2022 Actual start date: 1st January 2022
Foreseen end date: 31st October 2023 Actual end date: 31st October 2023

Task B4.2 - Replication Plan

Foreseen start date: 1st January 2022 Actual start date: 1st January 2022
Foreseen end date: 31st October 2023 Actual end date: 31st October 2023

Task B4.3 - Contribution and synergies with strategies of other Union Policies

Foreseen start date: 1st January 2022 Actual start date: 1st January 2022
Foreseen end date: 31st October 2023 Actual end date: 31st October 2023

Action	Deliverable Number	Deliverable name	Foreseen Deadline	Actual Deadline	ANNEX
B4	D16	Technical Replication and Transferability Report	apr-23	apr-23	Enclosed with the final report.
B4	D17	Replication Plan	Jun-23	Jun-23	Enclosed with the final report.
B4	D18	Report on the synergies with other EU policies	Jul-23	Jul-23	Enclosed with the final report.
B4	D19	Business Plan	oct-23	oct-23	Enclosed with the final report.

All tasks (B4.1, B4.2 and B4.3) in Action B4 started as planned in M17 (January 2022) and concluded in M38 (October 2023) with the completion of all three tasks.

In the initial phase, for task B4.1, the LUISS partner, serving as the coordinator of the action, along with Setel and UNITUS, conducted several conference call meetings to plan the business models and the C2M planning of the terrestrial rover. The 'Close 2 Market' action involves strategic initiatives aimed at expeditiously bringing a product, service, or innovation to the market. This strategy typically includes streamlining production processes, optimizing supply chains, and implementing agile marketing campaigns. By embracing this approach, LUISS and Setel, with the support of close-to-market LIFE projects, began collaborating to develop the business plan and model for the terrestrial rover.

The business model of a terrestrial rover involves a multifaceted approach centered around the design, manufacturing, and deployment of robotic vehicles for precision agriculture but also for exploration, surveillance, or other applications on Earth's surface. This terrestrial rover is equipped with advanced sensors, cameras, and mobility systems to navigate various terrains and collect valuable data. Crafting an effective business model has been essential for Setel to navigate the complexities of the market, establish a competitive advantage, and achieve long-term sustainability. The business plan is reported in D19.

Within this action, for task B4.2, an important part was dedicated to the replication and transferability plan as reported in D16 and D17. The replication plan is a strategic document that outlines the systematic process of reproducing and implementing the prototype system in a different context or setting. This plan is crucial for ensuring the successful transfer of knowledge, methodologies, and outcomes from the original endeavour to a new environment. The replication plan includes detailed steps for duplicating the component parts of the prototype system key elements of the LIFE project and adapting the approach and methodologies to fit the specific nuances of the new context. This can involve considerations such as ground sensors platforms locations, personnel training, and adjustments to account for variations in environmental and management factors. A well-crafted replication plan is instrumental in fostering scalability, sustainability, and the widespread adoption of successful practices, promoting efficiency and consistency across diverse settings.

The replication activities of the project were developed in the following vineyards:

- ARSIAL experimental vineyard, Velletri, Italy -3.5 ha
- Vigneto Italia – botanical garden in Rome, Italy - 0.4 ha
- PNRR Vineyards – Agritech, Ventotene, Italy - 1ha
- Cotarella Company Vineyards (Vermentino, Cabernet sauvignon, Merlot), Montecchio (TR) - Italy - 3ha
- AgricolliBio Srl Company – Latina (Soreli), Italy, 3ha

At the same time, the transferability plan was carried out. The transferability plan was designed to facilitate the smooth transition and application of the prototype system, developed in this project, from one context to another. Specifically, the seamless integration and adoption of precision agriculture practices tested in this project across diverse agricultural contexts. This plan is essential for sharing and implementing successful precision agriculture technologies, methodologies, and insights in different farming environments.

The transferability activities of the project were developed in the following area:

- AgricolliBio Srl Company – Latina, Italy (Kiwi) - 4ha
- CREA Company – Agriculture Environment Rutigliano (Bari), Italy - 1 ha cotton and 1 ha cotton and peach trees

For task B4.3 within this action, the members of the international advisory board (IAB), coordinated by UNITUS, were identified during the kick-off phase. The IAB comprising a experts and leaders with international experience, plays a pivotal role in providing strategic guidance, expertise, and insights to navigate the complexities of the global landscape in the precision agricolture. Members of the board brough a wealth of knowledge in the fields such as business, policy, and network of stakeholders. During the project, the international advisory board offered valuable counsel to ensure that the project objectives and aims remains adaptive and responsive to the dynamic challenges inherent in an international context. The IAB members with their expertises are reported in the web site of the project (https://winegrover.eu/index.php/iab/). The International Advisory Board played a crucial role in shaping and influencing the project through its diverse expertise and global perspectives. Engaged from the project's inception, the board members contributed strategic insights, drawing from their rich and varied experiences across international domains. Their involvement extended to providing guidance on market trends, considerations on technologies applied in the vineyard, and feedback on the results carry out by the strategies applied in the vineyards that have been integral to the project's success. Through regular consultations, the board offered critical feedback, helping refine strategies, identify potential challenges, and optimize decision-making processes.

To contribute in a synergistic way to national strategies on precision agriculture and other Union policies, the project has produced various documents, including:

- Report on the State of the Art of PA Technologies: explores emerging trends, challenges, and potential future developments in the field. By synthesizing information from research studies, industry reports, and practical applications, the Report on the State of the Art of PA Technologies serves as a valuable resource for stakeholders, policymakers, and practitioners seeking to understand the cutting-edge technologies shaping the future of agriculture and sustainable food production.
- State of the Art of PA: provides a comprehensive and up-to-date overview of the current landscape in agricultural technology. This document meticulously assesses the latest advancements in PA, considering innovations in areas such as remote sensing, data analytics, automation, and sensor technologies. The report delves into the integration of precision agriculture tools, including GPS-guided machinery, drones, and IoT devices, offering insights into their applications and benefits for farm management.

The documents are available in the web-site (https://winegrover.eu/index.php/documents/)

Thanks to the creation of these two documents, are reported in D18, the CREA the Italian research organization supervised by the Ministry of Agriculture, Food Sovereignty and Forests (Masaf), will serve as a reference for the realization of the National Guidelines being CREA the organization in charge of updating the National Guidelines for the Development of Precision Agriculture in Italy. At the same time, Thanks to its widespread network in the Andalusian region, the partner Smart City Cluster will try to spread through the stakeholders these documents.

For the dissemination of these technologies and the results obtained, as reported in D24, D25 and D30 in action D1, the project partnership participated in numerous events, with the main ones being:

- Presentation to farmers:
    - May 24, 2021 – Montecchio (TR) - Italy
    - June 25, 2021 – Arezzo - Italy
    - October 21, 2021 – Montecchio (TR) - Italy
    - November 26, 2021 – Velletri (Roma) - Italy
    - May 13, 2022 - Ronda
    - June 26, 2022 – Madrid - Spain
    - September 29, 2022 – Malaga – Spain
    - November 23-24, 2022 – Abruzzo - Italy
    - June 6, 2023 – Santarem – Portugal
    - October 17, 2023 – Velletri, Italy
- international and national conferences:
    - November 21, 2021 – Trento – Italy
    - July 1-2, 2021 – Sassari – Italy
    - May 25-26, 2022 - Cosenza, Italy
    - June 7-8, 2022 - Trento, Italy
    - July 12-13, 2022 – Fisciano– Italy
    - October 25-26, 2022 - Roma - Italy
    - November 21-23, 2022 - Roma, Italy
    - May 29-31, 2023 - Milano, Italy
    - June 23, 2023 – Torino – Italy
    - October 4-10, 2023 - Valletta Campus - Malta
- International Fairs
    - November 16-18, 2022 – Barcelona - Spain
    - September 29-30, 2022 – Malaga - Spain
    - March 31, April 1-2, 2023 – Perugia - Italy
    - May 3-5, 2023 – Rimini - Italy
- main events on precision agriculture:
    - September 29, 2022 – Malaga - Spain
    - June 6, 2023 – Santarem - Portugal
    - October 17, 2023 – Velletri, Italy

Action B4 was carried out in accordance with the project schedule, reaching milestone “M15- Tool Completed” (as reported in Action D), “M16 – Guidelines completed”, “M17 - Replication and transferability strategy developed”, and “M18 - Replicability tests concluded”.

The LUISS partner coordinated this action with UNITUS, Setel, Wellness and CREA. The task B4.3 was coordinated by CREA.

TASK	ACTIVITIES UNDERTAKEN	OUTPUTS ACHIEVED	TECHNICAL DETAILS (DELIVERABLE)
B4.1 Design and Replicability of Business Models	Market analysis	Market analysis thorough examination of industry trends, target customer demographics, competitive landscape, and potential opportunities, providing a strategic foundation for informed decision-making and successful market entry.	D19

	Go-to go-market	The go-to-market product strategy outlines the plan for introducing and delivering the product to the target audience, encompassing key elements such as marketing, distribution, and sales channels.	D19
	SWOT analysis	SWOT analysis involves evaluating the business's Strengths, Weaknesses, Opportunities, and Threats to make informed strategic decisions and enhance overall performance.	D19
B4.2 Replication Plan	Operation report on replication and transferability actions	The operation report provides a detailed assessment of the processes involved in replicating and transferring a project or initiative to different contexts, offering insights into challenges, successes, and strategic adjustments for wider implementation.	D16
	Replication Plan	The replication plan in precision agriculture delineates the systematic approach for duplicating successful technological implementations, such as sensor-based monitoring, across diverse agricultural settings, ensuring effective knowledge transfer and consistent adoption of precision farming practices	D17
B4.3 Contribution and synergies with strategies of other Union Policies	Relation with the policy makers and stakeholders	establishing robust relationships with policymakers and stakeholders for ensuring the alignment of technological advancements with regulatory frameworks, fostering informed decision-making, and promoting sustainable practices that benefit both the farming community.	D18

<u>Action C - Monitoring of the impact of the project actions</u>

<u>Task C1 - Monitoring of the Project Impact</u>

Foreseen start date: 1st March 2021
Foreseen end date: 31st October 2023

Actual start date: 1st March 2021
Actual end date: 31st October 2023

Action	Deliverable Number	Deliverable name	Foreseen Deadline	Actual Deadline	ANNEX
C1	D20	Life Cycle Analysis	mag-22	oct-23	Enclosed with the mid-term report and final report
C1	D21	Environmental and socio-economic impacts 1st report. Progress report	oct-21	ott-21	Enclosed with the final report.
C1	D22	Environmental and socio-economic impacts 2nd report. Progress report	dec-22	dec-22	Enclosed with the final report.
C1	D23	Environmental and socio-economic impacts Final report	oct-23	oct-23	Enclosed with the final report.
C1	D39	Extract of the project data from the KPI webtool	may-21	oct-23	Enclosed with the final report.

All tasks (C1.1 and C1.2) in Action C1 started as planned in M7 (March 2021) and concluded in M38 (October 2023) with the completion of both tasks.

Impact monitoring actions in this project involved systematic processes to assess and evaluate the outcomes and consequences of technological interventions on management practices applied in the vineyards. Impact monitoring actions include the establishment of LIFE Key Performance Indicators (KPIs), LCA study, and assessment of social and economic impacts resulting from project implementation.

The LIFE KPIs have been defined in the LIFE web tool and specified in D39 and reported in D21, D22 and D23, indicating baseline values, values at the end of the project, and values three years after the end of the LIFE WINEgROVER project. For each indicator, the unit of measurement and the methodology for defining the indicator have been established. The same deliverable includes information on social and economic impacts. In addition to those defined in the KPIs, additional project indicators on external stakeholders and economic efficiency have been defined. A list of potential stakeholders to be considered for the project has also been compiled to facilitate the application of these indicators, as reported in D31, Action D1.

Impact monitoring not only measures the success of the project's objectives but also provides valuable insights for continuous improvement, enabling stakeholders to refine precision agriculture practices, address challenges, and optimize overall agricultural sustainability.

In Task C1.1, this project analyzed environmental impacts associated with all stages of the process in the vineyard, comparing them across different vineyard management strategies in the Italian and Spanish pilot sites through the Life Cycle Analysis (LCA) . Utilizing the SimaPro software enhanced the precision and efficiency of this analysis. SimaPro is a powerful tool that facilitates comprehensive LCA by allowing users to input detailed data on resource consumption, emissions, and other environmental factors at each stage of a product's life cycle. The software then calculates the environmental footprint, considering aspects such as raw material extraction, production, transportation, use, and disposal. Through SimaPro's robust capabilities, has been performed scenario analyses, identify hotspots in the life cycle, and make informed decisions to minimize environmental impacts. This integrated approach not only supports sustainability initiatives but also enables business to optimize processes and products based on a thorough understanding of their life cycle environmental performance. As reported in D20, the results of the LCA highlight that in the hottest and driest years, the sustainability of viticultural production is better when basalt flour and organo-mineral fertilization are applied. ELR improves the quality of the berry.

The socio-economic impact of the project extends beyond traditional metrics, encompassing a multifaceted assessment of how the project can be influences the well-being of workers and communities involved. By comprehensively analyzing the socio-economic impact, stakeholders can gain insights into the project's contributions to local economies, poverty alleviation, and social equity. This holistic approach ensures that the project not only achieves its primary objectives but also fosters positive and sustainable changes that resonate

throughout the social fabric, ultimately creating a meaningful and lasting impact on the communities it serves. The indicators and the descriptions D21, D22 and D23.
With this aim, a questionnaire was created which can be highlighted:

- among the main benefits expected from the application of precision agriculture techniques are the following: containing the environmental impact; reduce production costs; limit the use of pesticides and improve the lives of workers in natural environments with "hostile" conditions.
- the "contextual" phenomena indicated as most relevant for the coming years are: the digitalisation of organisational, production and distribution processes; increase in environmental risks; increase in the intensity of competition; increased regulatory complexity and the need to comply with EU standards.
- among the main problems related to the application of precision agriculture techniques, the following have been indicated: the costs relating to the purchase of new high-tech vehicles, considering the small size of the agricultural companies; the age of farmers and level of studies; the lack of infrastructure (internet) and the need to acquire new professional skills also to encourage the reskilling of workers and mitigate the fear - also expressed by the respondents to the questionnaire - of losing their jobs.

Action C1 was carried out in accordance with the project schedule, reaching milestone “M19 – LCA Completed”, “M20- Final indicators collected and quantification of environmental and project impact”, "M21 - Monitoring methodology developed", M22- Initial indicators collected. Establishment of the baseline”, and “M23 - Socio-economic impact assessment developed”.

The CREA partner has coordinated this action with the entire partnership, and together, they have contributed to defining the environmental, social, and economic indicators, as well as the parameters to be measured, as defined in Action B.

TASK	ACTIVITIES UNDERTAKEN	OUTPUTS ACHIEVED	TECHNICAL DETAILS (DELIVERABLE)
C.1 Monitoring of the Project Impact	Implementation LCA in the vineyard	the report evaluates the environmental implications of grape cultivation, examining inputs such as water usage, energy consumption, and chemical application to offer insights into the overall sustainability of grape production.	D20
	The definition and monitoring of the main LIFE key project indicators KPI	The Key Project-level Indicators (KPI) for monitoring and evaluation in the multiannual work-program were identified and inserted in the KPI webtool.	D21
	The monitoring of the socio-economic impact of the project considering the subsequent exploitation plan of the technology implemented and demonstrated during the project	The socio-economic impact assessment of the project was carried out through the social indicators selected based on literature and legislation data.	D21

	The monitoring of the socio-economic impact of the project - progress	The socio-economic impact assessment of the project was monitored in the progress of the project.	D22
	The monitoring of the socio-economic impact of the project – final report	The socio-economic impact assessment of the project was evaluated in the final stage of the project.	D23
	Data from the KPI webtool	The data from the KPI web tool have been extracted and defined for evaluation during the progress of the project.	D39

<u>Action D - Public awareness and dissemination of results</u>

<u>Task D1.1 - Networking with other projects</u>

Foreseen start date: 1st November 2020 Actual start date: 1st November 2020
Foreseen end date: 31st October 2023 Actual end date: 31st October 2023

<u>Task D1.2 - Dissemination planning and development of the dissemination plan</u>

Foreseen start date: 1st November 2020 Actual start date: 1st November 2020
Foreseen end date: 31st October 2023 Actual end date: 31st October 2023

.ction	Deliverable Number	Deliverable name	Foreseen Deadline	Actual Deadline	ANNEX
D1	D24	Dossier of the communication activities and impact achieved. Progress report	dec-22	dec-22	Enclosed with the final report.
D1	D25	Dossier of the communication activities and impact achieved. Final Report	Jan-24	Jan-24	Enclosed with the final report.
D1	D26	Networking report including final event and meetings with outcomes presentation of the initiatives in relation with LIFE WINEgROVER project	jan-24	jan-24	Enclosed with the final report.
D1	D27	LIFE WINEgROVER website	feb-21	feb-21	Enclosed with the mid-term report.
D1	D28	Notice boards	jul-21	jul-21	Enclosed with the mid-term report.
D1	D29	Layman’s report	jan-23	Jan-23	Enclosed with the final report.
D1	D30	Communication plan	jun-21	jun-21	Enclosed with the mid-term report.
D1	D31	Database with the information of projects/initiatives/experts related to LIFE WINEgROVER project	dec-21	dec-21	Enclosed with the mid-term report.

The dissemination and project networking actions (tasks D1.1 and D1.2) started in M3 (November 2021) as per the project schedule and concluded in M38 (October 2023).

Regarding task D1.1, networking with other projects has emerged as a dynamic and collaborative initiative throughout the project period. This project has successfully fostered connections, both within and outside its domain, creating a vibrant ecosystem of knowledge exchange and mutual support. Through strategic partnerships and alliances, Networking with other projects has not only expanded its reach but has also played a pivotal role in cultivating innovation and cross-disciplinary synergies beyond the scope of precision agriculture. As reported in D26, and in the reports developed in Action B4, precision agriculture continues to evolve with cutting-edge technologies, machine-learning algorithms, and increasingly widespread use of drone and terrestrial rover imagery. This project has facilitated vital connections among various projects, enabling the seamless integration of data, methodologies, and insights. By bringing together experts, researchers, and stakeholders from diverse fields such as agronomy, data science, and technology development, Networking with Other Projects has paved the way for innovative solutions in optimizing crop yields, resource utilization, and sustainable farming practices.

The network formed during the project activities involved various projects with different themes. The involved projects are listed on the project's website (https://winegrover.eu/index.php/networking/) and include:

1. LIFE MEDINET—MEDITERRANEAN NETWORK FOR REPORTING EMISSIONS AND REMOVALS IN CROPLAND AND GRASSLAND (LIFE15 PRE/IT/000001). The collaboration with this project is attributed to the results achieved by the project in enhancing our understanding of SOC (Soil Organic Carbon) data for at least the top 30 cm of mineral soil across various crops and management types in Mediterranean countries.
2. DIVERFAMING - CROP DIVERSIFICATION AND LOW-INPUT FARMING CROSS EUROPE: FROM PRACTITIONERS' ENGAGEMENT AND ECOSYSTEMS SERVICES TO INCREASED REVENUES AND VALUE CHAIN ORGANISATION (H2020 728003). The collaboration with this project is due to the results obtained in low input management practices with reduced use of external fertilizers, pesticides, machinery, energy, and water while maintaining productivity and crop quality.
3. OENOMED—QUALIFICATION ET PROMOTION DES FILIÈRES VITIVINICOLES DES AIRES PROTÉGÉES DE LA MÉDITERRANÉE" PROGRAMME EUROPÈEN: ENI -CBC- MED 2014/2020 /IEV-CTS-MED 2014/2020. The collaboration with this project is due to the methodologies applied in OENOMED, that is 1- the study of new protocols and new zoning of viticulture to increase the environmental sustainability and the quality of production; 2- the proposal of new quality marks within the sector's regulations and of wine-eco-tourism packages to promote the protected areas and the producing companies; 3- the commercial promotion of quality viticulture-winemaking in the protected areas during national and international events.
4. MICOVIT 'BIOTECH APPLICATE ALLA MICORRIZZAZIONE DELLA VITE IN VIVAIO E SISTEMI DI RILEVAMENTO DELLA PERFORMANCE DI PIANTE MICORRIZATE IN VIGNETO SU BASE GEOMATICA' POR FESR LAZIO 2014 – 2020. The collaboration with this project is due to the methodologies applied in MICOVIT for the improvement of the viticulture supply chain, and in particular at the level of production of plant material, with i) biotechnological intervention of mycorrhization (starting from selected indigenous forms in a model vineyard) from the nursery to the vineyard; ii) monitoring of mycorrhization quality in the post-transplant phase; iii) site-specific monitoring of vine performance in the post-transplant phase and a model vineyard with a prototype system of proximal sensing technology (non-destructive) integrated with remote sensing technology (terrestrial rover).
5. GREENLIGHTPLUS – Política Agrícola Comum: Apoiando a Agricultura e Desenvolvimento Rural em Portugal. The GreenlightPlus Visa project helps inform and clarify the charter of the Common Agricultural Policy (CAP), encouraging different

groups to learn more about the CAP and its benefits at different levels, including economic, social and environmental.

6. Green My Way (Regio Call for Proposals grant agreement No 2020CE16BAT137). The project is a European project created in Janeiro in 2021 that aims to build a national platform, which could boost the circular economy as a resource, encouraging cooperation between different entities, public and private, national and international.
7. LIFE BIODIVEST (LIFE20 IPE/FR/000019). strategiche e concrete in materia di biodiversità. LIFE Biodiv'Est is the developer, author of numerous actors, of strategic and concrete actions regarding biodiversity.

In this project, building and maintaining partnerships and networking the projects involved a dynamic combination of electronic and field meetings. The initial stages of this activity have been frequently initiated electronically, leveraging digital platforms and communication tools. Virtual meetings, video conferences, and emails facilitate the exchange of ideas, proposals, and preliminary discussions, allowing potential partners to establish a foundation for collaboration. However, the field workshops during the COVID-19 pandemic have been organized for dissemination and networking activities.

An essential networking event for our project involved participation in the "Mettiamoci in RIGA Project - Strengthening Integrated Environmental Governance." This initiative was coordinated by the Ministry of the Environment and Energy Security, and details can be found at https://tiamociinriga.mite.gov.it/en/. The project, a part of the LQS - KNOWLEDGE PLATFORM - EXPERIENCES CAPITALIZATION AND DISSEMINATION OF RESULTS FOR GOOD PRACTICES' REPLICABILITY IN ENVIRONMENTAL AND CLIMATE FIELD (https://tiamociinriga.mite.gov.it/en/capitalize-on-experiences-and-disseminate-results-for-good-practices-replicability-and-climate/lqs), aimed to present project activities and outcomes to regional administrative representatives and coordinators of other projects.

Key highlights of our participation include:

Event Details:

- Project: Mettiamoci in RIGA Project - Strengthening Integrated Environmental Governance.
- Coordination: Ministry of the Environment and Energy Security.
- Platform: LQS - Knowledge Platform - Experiences Capitalization and Dissemination of Results for Good Practices' Replicability in Environmental and Climate Field.

Presentations and Discussions:

- October 2022: Meetings conducted via conference call mode.
- June 2023: Face-to-face meetings for more in-depth discussions.

Objectives:

- Presentation of our project activities and achieved results.
- Interaction with regional administrative representatives.
- Collaboration with coordinators of other projects within the knowledge platform.

Participating in these events allowed us to share our experiences, gain insights from others in the field, and contribute to the collective effort of strengthening integrated environmental governance. The platform provides a valuable space for capitalizing on experiences and disseminating results for the replicability of good practices in the environmental and climate domain.

Other significant networking events, as highlighted in Action B4, D24, D25, and D30 within Action D1, were the major gatherings on precision agriculture organized in Italy, Spain, and Portugal. These events played a crucial role in fostering collaboration and knowledge exchange in the field of precision agriculture. They provided a platform for stakeholders to share insights, innovations, and best practices. Here's a brief overview of these events:

Precision Agriculture Event in Italy:

- Date: October 2023
- Overview: The event in Italy focused on the results and vineyard management activity carried out in the project. Participants had the opportunity to discuss and learn about the latest technologies and strategies in the precision viticulture sector.

Precision Agriculture Event in Spain:

- Date: September 2022
- Overview: The precision agriculture events in Spain were significant for bringing together experts, practitioners, and stakeholders interested in optimizing vineyard practices management through technological advancements. The discussions likely covered topics such as sensor technologies, data analytics, and precision viticulture techniques.

Precision Agriculture Event in Portugal:

- Date: June 2023
- Overview: Portugal's precision agriculture events aimed to gather professionals and stakeholders involved in improving sustainable viticulture through precision techniques. The events provided a moment to explore the latest trends and share experiences in the field.

Participating in these events allowed our project to establish connections, exchange ideas, and stay abreast of the cutting-edge developments in precision agriculture across these countries. The networking activities undertaken during these events contribute to the collaborative efforts in advancing sustainable and technologically enhanced agricultural practices.

As regards the activities for Task D1.2, a communication plan (D30) has been prepared to outline the strategic approach for disseminating information, engaging stakeholders, and promoting the project. The communication plan served as a roadmap to ensure effective and targeted communication throughout the project.

Key elements of the communication plan (D30) included:

Objectives:

- Clearly defined communication objectives aligned with the project goals.
- Identification of target audiences, including stakeholders, partners, and the general public.

Messaging:

- Development of key messages that convey the project's purpose, achievements, and impact.
- Tailoring messages to resonate with different audience segments.

Communication Channels:

- Selection of appropriate communication channels, such as websites, social media, and press releases.
- Integration of traditional and digital platforms to reach a diverse audience.

Events and Activities:

- Planning and promotion of events, workshops, and conferences related to the project.
- Coordination of participation in relevant industry events for increased visibility.

Media Relations:

- Strategy for engaging with media outlets to secure coverage and maximize outreach.

- Preparation of press releases

Timeline:

- Development of a communication timeline to guide the release of information at key project milestones.
- Regular updates and adjustments to the plan based on project progress.

The communication plan (D30) was a vital tool for ensuring that project information is communicated clearly, consistently, and to the right audience.

The first phase of the project entailed developing a website (https://winegrover.eu/) (D27) along with a unique logo.

In line with the project plan, following the kick-off (D32), project profiles were established on X (Twitter), LinkedIn, and Facebook (D30), and the project brochure and notice board (D28) were developed.

As the end of the project approaches, the partnership has dedicated efforts to create accessible and engaging materials to communicate its outcomes to a broader audience. A Layman's report, written in clear and simple language, was created and uploaded to the website. This report serves as a bridge between the technical details of the project and the general public, ensuring that the broader community can comprehend the significance and impact of the work. In addition, a project video has been produced, providing a visual narrative that captures the key milestones, challenges, and successes. Together, Layman's report and project video serve as vital tools for effective knowledge dissemination and public engagement after the project.

To disseminate the project's findings and contribute to the broader scientific community, a series of informative and scientific articles have been crafted. These articles deepen the objectives of the project, presenting comprehensive analyses, methodologies, and results. The informative articles are designed to reach a wider audience, including stakeholders, policymakers, and the general public, providing accessible insights into the project's purpose, methodologies, technologies, and potential implications. Simultaneously, the scientific articles adhere to rigorous academic standards, contributing valuable knowledge to specialized fields. By publishing in reputable journals and platforms, the project aims to foster dialogue, share best practices, and contribute to the collective advancement of knowledge in relevant domains. This dual approach ensures that the project's impact is not only scientifically significant but also widely understood and appreciated across diverse audiences (D24-D25-D26).

At the events organized by the project, actively involving local media played a crucial role in the project's communication strategy. This approach facilitated effective outreach to the community, disseminated project updates, and nurtured a sense of local awareness and involvement. An illustrative example was Canalsur Radio y Televisión, based in Andalucía, which aired a report on the regional news, covering the project's activities at the Conrad winery in Ronda (https://www.canalsur.es/noticias/andalucia/malaga/tecnologia-punta-al-servicio-de-la-agricultura-en-ronda/1961551.html).

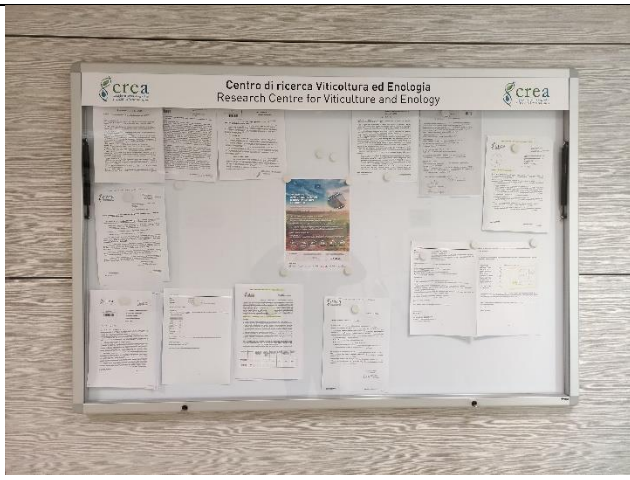
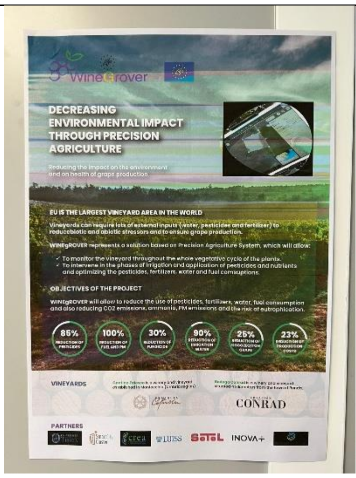
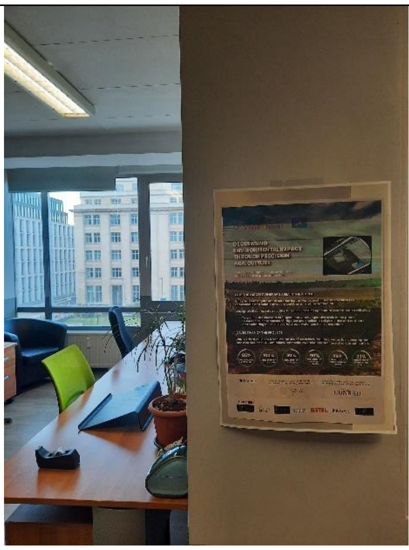
In addition to events directly organized by the partnership, the project has been showcased in various scientific and dissemination contexts at both the national and international levels participating in Congress, Workshops, fairs, and meetings.

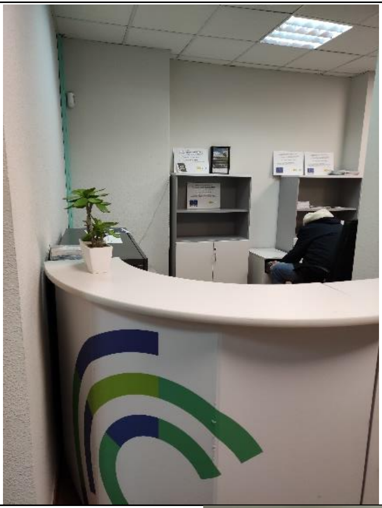
Thanks also to the project activities, the Conrad winery received the award from the Opinión de Málaga y Prensa Ibérica presenting the XIII edition of the Enterprise 4.0 Awards in the agri-food category with the following reasoning: Using a drone and a robot that moves across the rows you can achieve the most efficient vegetative development (https://mas.laopiniondemalaga.es/premios-enterprise/2023/).

The Smart City Cluster, in co-leadership with Inova+, coordinated this initiative, but all partners contributed collectively to the dissemination and networking of the project, too. As outlined in the project and in D28, all partners have installed notice boards in strategically accessible locations for public viewing within their facilities.

Action D1, in tasks D1.1 and D1.2, was carried out by the project schedule, reaching milestones "M24- Communication plan developed", "M25 – Project website available", "M26- Layman's report developed" and "M27 – Notice board installed".

Photo of the noticeboard installed at the partners' offices	
UNITUS	
SETEL	 

CREA	
SCC	 
INOVA+	

WELLNESS TELECOM	 
LUISS BS	

TASK	ACTIVITIES UNDERTAKEN	OUTPUTS ACHIEVED	TECHNICAL DETAILS (DELIVERABLE)
D1 – Public awareness and dissemination of results	Development of communication activities	The dossier of communication activities documents and analyzes the various strategies, channels, and outcomes implemented throughout the project, providing valuable insights for future planning and refinement	D24
	Development of communication activities	The dossier of communication activities documents and analyzes the various strategies, channels, and outcomes implemented in the project.	D25
	Networking report	the networking report offers a detailed overview of the project's collaborative efforts, outlining key partnerships, interactions, and outcomes to provide a comprehensive understanding of the network's impact and potential for future development.	D26

	LIFE WINEgROVER website has been created	LIFE WINEgROVER website was created and inserted all information about the project. Instructions and passwords for accessing the site have been distributed to all partners.	D27
	Notice boards	A LIFE information notice board reporting a compact description of project objectives has been elaborated. The partners have placed notice boards with LIFE and project logos at the entrances of their offices. Currently, all notice boards have been exposed by partners.	D28
	Layman’s Report	the Layman's Report is a user-friendly document designed to communicate the essence of the project in clear and accessible language, catering to a broader audience and facilitating a widespread understanding of its goals and achievements.	D29
	Communication plan	The activity describe is a general roadmap for all LIFE WINEGROVER related communication and dissemination activities. It presents LIFE WINEGROVER overall communication and dissemination strategy; analyses the project’s target actors; presents a set of core communication messages; analyses the communication resources available to the project; describes the project’s own communication channels and dissemination materials produced by the project; lists external dissemination opportunities and sets evaluation targets for project lifespan.	D30
	Database creation with the stakeholders list	All partner have filled in the database with the stakeholders contacted and involve in the LIFE WINEgRover project.	D31

Action E - Project management

Task E1.1 - Project management

Foreseen start date: 1st September 2020 | Actual start date: 1st September 2020
Foreseen end date: 31st October 2023 | Actual end date: 31st October 2023

Task E1.2 - After-LIFE plan

Foreseen start date: 1st January 2023 Actual start date: 1st January 2023
Foreseen end date: 31st October 2023 Actual end date: 31st October 2023

Action	Deliverable Number	Deliverable name	Foreseen Deadline	Actual Deadline	ANNEX
E1	D32	Minutes of the Kick-off meeting	sep-20	sep-20	Enclosed with the mid-term report.
E1	D33	1st Progress report	sep-21	sep-21	Enclosed with the mid-term report.
E1	D34	Minutes of 1st progress meeting	oct-21	oct-21	Enclosed with the mid-term report.
E1	D36	Minutes of the 2nd progress meeting	nov-22	nov-22	Enclosed with the final report.
E1	D37	2nd Progress report	dec-22	dec-22	Enclosed with the final report.
E1	D38	Minutes of final meeting	sep-23	oct-23	Enclosed with the final report.
E1	D40	Green Procurement and Ecolabel	sep-23	sep-23	Enclosed with the final report.
E1	D41	After-LIFE plan	may-23	may-23	Enclosed with the final report.

The project management activities (tasks E1.1, E1.2 and E.1.3) started in M1 (September 2020) according to the project schedule and were completed by M38 (October 2023).

The project entailed a multitude of project management activities to ensure its successful execution. The project management activities in the LIFE project encompass the entire project lifecycle, from initiation to completion. During the initiation phase, careful planning and goal setting have taken place, defining the project scope, objectives, and key stakeholders to be involved in this project. In this context, several meetings in the conference call, due to the COVID-19 pandemic, have been planned where the partnership articulated and clarified the specific goals and milestones to be achieved within the project.

The planning phase involved establishing distinct working groups with clear focuses and defined tasks to address specific issues, working towards achieving the project's objectives.
At the Kick-off meeting (D32), the project manager, in collaboration with the partners, defined both the working groups and the activities' coordinators. The following coordinators and working groups were delineated:

- Financial and Administrative Coordinator (FAC): the FAC oversaw and managed financial operations and administrative tasks within the project, ensuring efficient financial management and smooth day-to-day administrative functions. Daniele Iannotta (CURSA).
- Dissemination and communication coordinator (DCC): The DCC was responsible for developing and implementing strategies to effectively communicate project-related information to various stakeholders and the public, ensuring widespread awareness and understanding of the project's goals and outcomes. Clara Pata Rios and Veronica Ramirez del Valle (SCC) and Chiara Frencia (INOVA+).
- Project Management Board (PMB): The PMB provided oversight, strategic direction, and decision-making authority for the project, ensuring alignment with organizational goals and successful project implementation.
- Project Technical Committee (PTC): The PTC was the specialized group responsible for evaluating the technical aspects of the project, ensuring that it aligns with standards, technological requirements, and best practices defined in Actions B and C.
- International Advisory Board (IAB): The IAB functioned as a consultative body, offering valuable insights, expertise, and strategic guidance to ensure that the project was aligned with global perspectives and meets international standards.

Effective communication and collaboration among partners have been throughout the project, fostering a cohesive working environment.

On September 9, 2020, the project activities and organizational structure were presented to all partners during the project kick-off. The event took place in person for Italian partners at the LUISS headquarters (Via Nomentana, 216, 00162 Roma, Italy) and remotely for all other partners due to challenges posed by the COVID-19 pandemic (D32).

The project management was set up not only during the first year (of the COVID-19 pandemic situation) but also throughout the entire project, with the organization of numerous remote meetings with all partners both from a technical and financial perspective. Additionally, several on-site meetings were conducted with Italian partners in the Italian pilot vineyard to optimize the implementation of the project's prototype system. While visiting the Spanish pilot site, as outlined in Action B1, a meeting took place at the Conrad Winery on June 10, 2021, involving the Spanish project partners (A-366, 29400 Ronda, Málaga, Spain).

As part of the project management activities for the dissemination and replicability phase in the afterlife plan of the LIFE WINEGROVER project, the coordinating unit, the University of Tuscia - UNITUS, established an agreement with the University of Yantai through various meetings within the International Urban Cooperation (IUC) program of the European Union - Asia. The agreement aims to expand and promote mutual interests, fostering academic cooperation in agricultural, forestry, food science, landscape, and urban environment sectors. This collaboration is particularly focused on advancing the goals of the LIFE WINEGROVER project.

In Task E.13, we conducted an analysis (D40) of green procurement and ecolabel practices to understand how environmentally friendly purchasing is implemented. Green procurement initiatives involve strategically sourcing products and services that adhere to eco-friendly criteria, with the goal of minimizing the ecological footprint and promoting sustainability throughout the procurement process.

Action E1 was carried out in accordance with the project schedule, reaching milestones “M28 - Positive final Progress (final meeting), “M29 - After-LIFE Strategy defined”, “M30 - Positive Final Technical and Financial Report”, "M31 - Kick-off meeting", "M32 - positive 1st progress", and “M33 - Positive 2nd Progress (2nd midterm meeting)”.

The UNITUS partner coordinated this action with the entire partnership, and collectively, they all contributed to achieving the milestones.

TASK	ACTIVITIES UNDERTAKEN	OUTPUTS ACHIEVED	TECHNICAL DETAILS (DELIVERABLE)
E1 - Project management	Minutes of the Kick-off meeting	Minutes of the project kick-off held at the beginning of the project at the LUISS Business school in person for the Italian partners and remotely for the Spanish and Portuguese partners.	D32
	1st Progress report	At the end of the first year of the project, the first progress report on the activities carried out for the various actions of the project was implemented, including the main activities and criticalities encountered by the entire partnership, lists external dissemination opportunities, and	D33

		sets evaluation targets for project lifespan.	
	1st progress meeting	On December 16, 2021, the meeting with all project partners was carried out, initially planned in presence, it was then carried out on remote with all partners due to COVID-19 emergency.	D34
	2nd progress meeting	The second meeting, held on April 27, 2022, served as a crucial forum for project stakeholders to discuss progress, address challenges, and strategize further actions toward the successful realization of project goals	D36
	2nd Progress report	After the second year of the project, we carried out the second progress report, summarizing the activities undertaken across various project actions.	D37
	Final Meeting	The final meeting, conducted on October 18, marked the culmination of the project, providing an opportunity for stakeholders to reflect on achievements, discuss outcomes, and plan for any remaining tasks before project closure.	D38
	Green Procurement and Ecolabel	The analysis on Green Procurement and Ecolabel involves adherence to eco-friendly criteria, and determining the effectiveness of incorporating ecolabels in procurement processes to promote sustainability and reduce ecological footprints.	D40
	After life plan	The after-life plan outlines the post-project strategies, responsibilities, and measures to sustain the project's outcomes, ensuring a smooth transition, continued impact, and long-term success beyond the project's completion	D41

6.2.Main deviations, problems and corrective actions implemented.

During the project, several deviations and challenges were encountered, necessitating prompt corrective actions to ensure the project's successful completion. One notable deviation stemmed from unexpected changes in the project due to the COVID-19 pandemic, requiring a revaluation of the initial scope and subsequent adjustments to the project plan. To address these deviations and problems, a proactive approach was adopted, involving regular communication and collaboration among partner members. This facilitated the implementation of mitigating strategies to maintain project timelines and deliverables.

The project activities were conducted following the project schedule. In the initial phase of the project, the most significant challenges were encountered due to the global COVID-19 pandemic. This situation has led to:

- In order to start Actions B and E, most of the meetings were conducted remotely through the ZOOM platform. During the initial stage of the project, meetings between partners were exclusively held through remote means, except for the kick-off meeting and the monitoring visits, which took place in person for the Italian partners and remotely for the other partners. Despite these challenges, all actions and project activities were executed according to the schedule, and all deliverables were produced on time.
- The visit to the Spanish pilot site, originally scheduled for October 2020, has been postponed to June 2021. However, the description of the Spanish site, as well as the characterization and the signing of the vineyard lease, were completed on schedule.
- The field measurements and surveys were conducted by the Italian partners on schedule in both pilot sites. They adhered to the required safety standards amid the ongoing pandemic.
- As outlined in Action B2, the multispectral sensor of the rover experienced a breakdown and is repaired. Despite this setback, system measurements and field measurements were successfully conducted.
- Dissemination activities were conducted in an open field setting to prioritize personal safety and minimize complications, in the initial stage of the project. Different field workshops were organized and when the rules of the COVID-19 pandemic permitted, in-person events were organized to disseminate the project in Italy, Spain, and Portugal.

6.3. Evaluation of Project Implementation

Precision Viticulture (PV) is a cutting-edge methodology that revolutionizes traditional grape cultivation by leveraging advanced technologies and data analytics to optimize vineyard management. At its core, PV employs a data-driven approach to viticulture, utilizing various technologies such as GNSS, drone and terrestrial rover, remote sensing data, and sensor networks to collect detailed information about soil conditions, climate, and vine health. By analyzing these diverse data sets, viticulturists can make informed decisions to precisely tailor their practices to the specific needs of individual vineyard blocks or even individual vines. This level of precision enables resource optimization, enhances grape quality, and minimizes environmental impact.

The LIFE WINEGROVER project stands at the forefront of innovation in viticulture by seamlessly integrating precision viticulture technologies into its framework. Recognizing the transformative potential of these cutting-edge tools, the project leveraged state-of-the-art technologies to develop an integrated prototype system to enhance management practices in vineyards. By incorporating precision viticulture, LIFE WINEgROVER aimed to optimize resource utilization, minimize environmental impact and improve overall grape quality. The LIFE WINEGROVER project serves as a pioneering example of how precision viticulture technologies can be harnessed to propel viticulture into a new era of precision, sustainability, and quality.

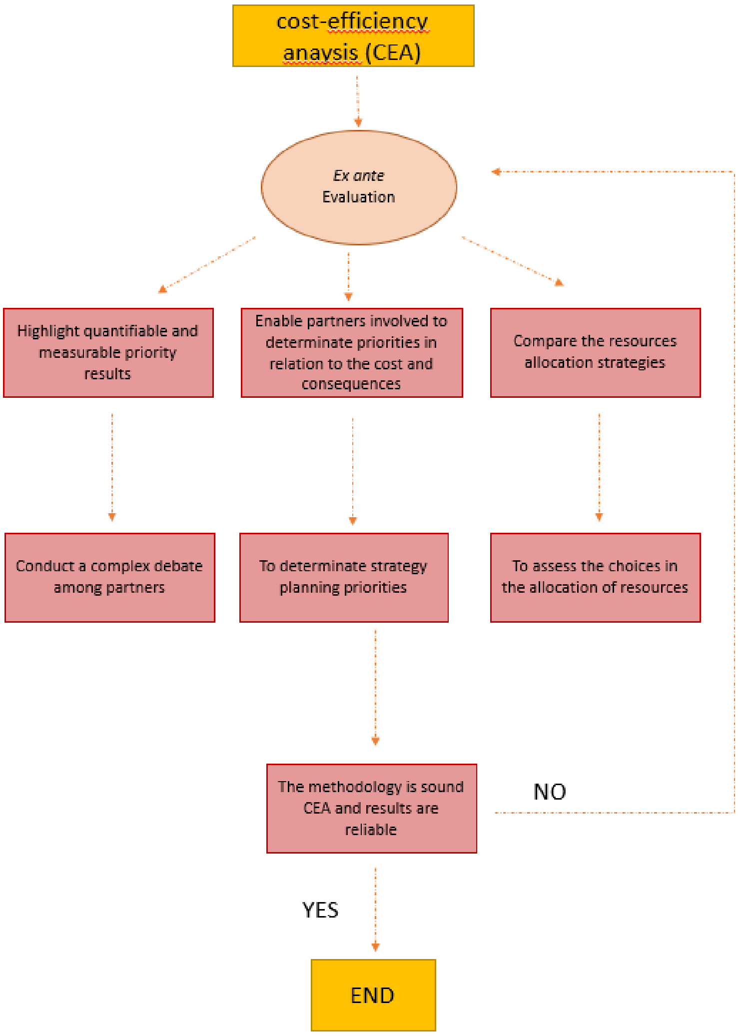
The Precision Viticulture (PV) approach applied in the LIFE WINEgROVER project utilized proximal sensing technology and spatial-temporal data analysis. This method aimed to characterize local variations in plant vigor, stressors, and health status over time through the assessment of vegetational indices. The primary objective and main challenge of the project involved testing a methodology that incorporates multi-temporal and multi-spatial data from prototype systems, including UAV and ROVER drones, as well as ground sensor platforms. The ultimate goal was to identify the effects of various agricultural strategies applied in vineyards.

The LIFE WINEgROVER project incorporates big data in its production through extensive data collection from precision viticulture technologies, followed by sophisticated analysis and processing methodologies to extract valuable insights for optimizing vineyard management practices. Moreover, the LIFE WINEgROVER project employed advanced data fusion techniques to integrate and harmonize the diverse datasets acquired, ensuring a comprehensive and cohesive understanding of vineyard conditions for more informed decision-making. In the pursuit of advancing precision viticulture, the LIFE WINEGROVER project has conducted a series of targeted actions aimed at optimizing vineyard management practices. These actions encompass the implementation of cutting-edge technologies in PV and a comprehensive business plan outlining strategic goals, financial projections, and risk management, ensuring a systematic and sustainable approach to the integration of precision viticulture technologies for long-term success.

In addition, the Life cycle assessment (LCA) methodology was applied in the LIFE WINEgROVER project to increase the economic and environmental sustainability of grape production. LCA is a powerful tool that allows evaluation of the environmental performances considering the whole or a part of the life cycle of the grape. In the LCA, the viticulture phase is the main wine hotspot mainly due to fuel, fertilizer, and pesticide consumption used during the growing season. This is based on ISO 14040 and 14044 standards that help us to define a general methodology but are not designed to define the details for each vineyard in which the method is used, and its application to the wine sector is still in a developing phase. For this reason, during the project, UNITUS and CREA spent a lot of time collecting data for LCA assessment regarding the viticulture phase (grape production and harvesting) for using the data in SIMAPRO software. Simapro is a widely used life cycle assessment (LCA) software that facilitates the quantitative analysis of environmental impacts associated with products and processes, helping organizations make informed decisions toward sustainability.

Regarding the cost-efficiency analysis, ex-ante evaluations have been conducted to support decision-making and provide guidance for choices to be made. During the project, for each milestone, the results achieved by each partner were utilized to enhance the effectiveness of activities. Depending on the specific cases, these results served the following purposes:

- To stimulate discussions among partners before making decisions.
- To underscore the preferences of partners involved in actions where interventions are planned.



Action	Foreseen in the revised proposal	Achieved	Evaluation
A1. **Definition of Technical Protocols**	**Objectives**: Define technical protocols for implementing the prototype system, customized to the specific characteristics of the two selected vineyards. Develop a protocol for determining the type of data to be acquired in both pilot sites, aimed at assessing the applied strategies and quantifying the environmental impacts resulting from the strategies employed in both locations. **Expected results**: Technical protocols for	Yes The action was completed and delivered within the deadline	Technical documents have been drafted based on preliminary data, serving as a reference baseline. These data were collected by UNITUS during preparatory work on the experimental vineyard in Italy, as well as preliminary information regarding environmental, climate and viticultural issues in Spain.

	implementing the system and for measurement defined.		
B.1: **Vineyard Characterization and Optimization**	**Objectives:** Characterization of the vineyard involved assessing specific performance indicators and parameters related to the vines (such as vigor, crop load, yield, etc.) and examining soil traits (including texture, water content, etc.) for both pilot sites. **Expected results:** A permanent monitoring system has been established for the vineyards, aligning with the strategies implemented in vineyards. Target vines have been geo-referenced (with an accuracy of < 0.05 m after post-processing) and their parameters have continually monitored over time in the field.	Yes The action was completed and delivered within the deadline	The vineyard pilot sites were undergoes meticulous characterization, encompassing detailed assessments of soil composition, climate conditions, vegetation characterization and topographical features to tailor precision viticulture practices for optimal grape cultivation. The gathered data proved valuable for analyzing vine performance at a detailed level, enabling the adoption of targeted management strategies to optimize the use of water, as well as the use of machinery and labor for management operations of vineyard. Reports characterizing both the Italian and Spanish pilot vineyard were generated.
B.2: **Design and Construction of the Prototypes and Sensors Installation**	**Objectives**: The design and production of the prototype system with developing the constituent devices and installing ground sensor platforms in the vineyards. **Expected results:** Two similar prototypes were assembled and customized to suit the characteristics of the two pilot vineyards, aligning with the overall architecture of the IoT WINEGROVER platform prototype.	Yes The action was completed and delivered within the deadline	The initial prototypes have been designed, encompassing technical drawings for the terrestrial rover, aerial drone, and ground station. These prototypes have been successfully installed in the Italian pilot vineyard, alongside the design of sensors. Subsequently, the second set of prototypes has been both designed and produced specifically for deployment in the Spanish pilot vineyard. This progressive approach ensures the adaptation of the technology to the unique characteristics of each vineyard, optimizing the application of precision viticulture methodologies in diverse environments.

B.3: **Measurements Campaign, Modelling, Data Fusion**	**Objectives**: The prototype's measurement on vine performance involved employing advanced sensors and data collection techniques to assess key parameters such as stomatical condutance, water stress, vegetation index, and overall plants health, providing valuable insights for precision viticulture management strategies applied. **Expected results**: Report on measurements and analysis and modelling of the results on the Italian and Spanish Pilot vineyard, report on data fusion.	Yes The action was completed and delivered within the deadline	The initial measurement season commenced in the Italian pilot vineyard. From the second growing season onward, both sites participated in the vineyard measurement campaign. Data were systematically collected and analyzed to assess the impact of diverse agronomic management practices on vine performance, carbon sink functionality, Life Cycle Assessment (LCA), and integration into data fusion processes.
B.4: **Replication and Transferability Plan**	**Objectives**: The action plan includes follow-up mechanisms to ensure and sustain the long-term implementation of the project. Data results will be utilized for formulating a replication plan, facilitating the transfer of project outcomes to other wineries and farmers within the European Union. **Expected results:** Protocols were developed to enhance the management strategies of the tested system and leverage the results of LIFE WINEgROVER. This includes the formulation of a replication plan, a comprehensive market study, and a business development plan. These measures aim to maximize the impact of LIFE WINEgROVER and facilitate its successful integration into broader markets.	Yes The action was completed and delivered within the deadline	The International Advisory Board (IAB) has been established as part of our project initiatives. Our partners actively participated in both international and national meetings to disseminate the technology and share the project's results. Additionally, we have published scientific and technical papers to contribute to the broader knowledge base. As of December 2021, we have completed the guideline, and we are initiating market monitoring along with a think-tank exercise to evaluate the project's outcomes. This will guide the development of a comprehensive Exploitation Strategy.

C.1: **Monitoring of the Project Impact**	**Objectives**: Define the impact of project results on the environmental and socio-economic aspects. **Expected results:** This action encompasses three crucial components: LIFE Key Project Level Indicators: These indicators serve as benchmarks to gauge the overall success and progress of the project. They provide a standardized framework for evaluating key aspects such as environmental sustainability, resource efficiency, and overall project effectiveness. Environmental Impact Assessment through Life Cycle Analysis (LCA): The project incorporates a comprehensive Life Cycle Analysis (LCA) to assess its environmental impact. This analysis considers the entire life cycle of the technology, from development to implementation and eventual decommissioning. It helps identify and mitigate environmental hotspots, ensuring a thorough understanding of the project's ecological footprint. Socio-economic Impact Evaluation: The project's socio-economic impact is evaluated by considering an exploitation plan for the LIFE WINEgROVER technology. This entails assessing how the technology's adoption contributes to economic development, job creation, and overall community well-being.	Yes The action was completed and delivered within the deadline	The project results have a profound impact on both environmental and socio-economic aspects. From an environmental perspective, the implementation of advanced precision viticulture technologies and practices introduced by the project contributes to sustainable vineyard management. By optimizing resource utilization through precise application of water, fertilizers, and other inputs, the project helps reduce environmental footprints associated with traditional viticulture methods. Additionally, the incorporation of data-driven decision-making aids in minimizing unnecessary chemical applications, contributing to overall environmental conservation. On the socio-economic front, the project's outcomes offer significant benefits to vineyard operators and local communities. The adoption of precision viticulture enhances the efficiency of vineyard management, leading to improved yields and product quality. This, in turn, positively impacts the economic viability of vineyards, supporting the livelihoods of those involved in the wine industry. Furthermore, the transferability of the project results to other wineries and farmers can stimulate economic growth and promote sustainable agricultural practices across various regions. In summary, the project's impact extends beyond technological advancements, influencing environmental sustainability and socio-economic well-being within the viticulture sector

	By integrating these three components, the project aims to provide a holistic assessment of its impact, addressing environmental sustainability, socio-economic considerations, and adherence to the key indicators outlined by the LIFE program.		
D.1: **Dissemination Planning and Execution**	**Objectives**: To carry out an exchange of knowledge, experiences, methodologies, and best practices with the other projects (LIFE and other European projects) and actions to disseminate the project activities and results. **Expected results:** Networking with other projects, Dissemination planning and development of the dissemination plan, notice boards, project video LIFE WINEgROVER website, printed and digital media; technical publications and scientific papers. By incorporating these diverse dissemination strategies, the project aimed to effectively communicate its progress and outcomes, reaching a wide range of stakeholders across various platforms and media types.	Yes The action was completed and delivered within the deadline	The project involved a collaborative exchange of knowledge, experiences, methodologies, and best practices with other initiatives, both within the LIFE program and other European projects. This exchange is integral to fostering a collective learning environment and maximizing the impact of shared insights. Key elements of this collaboration include: Knowledge Sharing: Actively participating in fairs, workshops, and conferences organized by the LIFE program and other relevant European projects to share project-specific knowledge, challenges, and innovative solutions. Experience Exchange: Facilitating dialogues and engagement opportunities where project teams can exchange their experiences, lessons learned, and effective strategies. This promotes cross-pollination of ideas and helps avoid potential pitfalls by leveraging the collective experience of diverse projects. Methodology Collaboration: Collaborating on methodologies related to precision viticulture, environmental impact assessment, and other relevant aspects. This ensures a harmonized and standardized approach within the broader context of similar projects. Best Practice Identification: Identifying and adopting best practices from other projects that align with the goals and objectives of the

			WINEgROVER project. This helps enhance project efficiency and effectiveness by leveraging successful approaches utilized by peers. Networking and Partnerships: Building and nurturing collaborative networks and partnerships with other LIFE projects and European initiatives. This facilitates ongoing communication and collaboration, fostering a sense of community within the broader scope of sustainable and innovative projects. Overall, this exchange of knowledge and collaboration with other projects contributed to a more comprehensive understanding of common challenges and opportunities, fostering a supportive environment for mutual growth and success.
E.1: **Project Management**	**Objectives:** coordination activities and definition of the Project Organizational Structure. **Expected results:** The scientific and technical monitoring of the project involved the implementation of a management strategy defined in accordance with the roles and responsibilities of various key figures or personnel within the project structure. Here's an outline of these roles: • Financial and Administrative Coordinator (FAC) • Dissemination and Communication Coordinator (DCC). • Project Management Board (PMB) • Project Technical Committee (PTC): • International Advisory Board (IAB):	Yes The action was completed and delivered within the deadline	The coordination activities and definition of the Project Organizational Structure are essential components in ensuring the smooth execution of the project. Here's a breakdown of these key elements: • Coordination Activities: Regular Meetings: Establishing a schedule for regular project meetings to discuss progress, challenges, and upcoming tasks. This includes both internal team meetings and coordination with external stakeholders. Communication Plan: Developing a clear communication plan outlining the methods and frequency of communication among project team members and stakeholders. Task Assignment: Clearly defining roles and responsibilities for each team member, ensuring everyone understands their

	The activities within the project are closely monitored to ensure alignment with the schedule, and coordination of activities was maintained through the partnership. Regular meetings, progress reports, and effective communication channels were essential to fostering collaboration and addressing any issues that may arise during the project's execution. The roles outlined above contributed to a well-organized and efficiently managed project structure.		specific contributions to the project. Issue Resolution: Implementing mechanisms for identifying and addressing issues promptly to prevent delays or disruptions in the project timeline. Progress Tracking: Utilizing project management tools to track and monitor progress against milestones and objectives. • Project Organizational Structure: Project Manager: The project Manager is responsible for overall project coordination, planning, and execution. Stakeholder Engagement: Identifying and categorizing project stakeholders, both internal and external, and defining strategies for effective engagement and communication. International Advisory Board: Establishing an Advisory Board consisting of experts and stakeholders to provide guidance, insights, and feedback throughout the project. Reporting Structure: Defining a reporting structure that ensures transparent communication within the project team and with external stakeholders. By carefully coordinating activities and defining a robust organizational structure, the project enhanced collaboration, streamlined decision-making processes, and optimized overall project performance.

All results have been meticulously documented and reported in the deliverables, showcasing the comprehensive outcomes achieved throughout the project's duration. Summarizing the immediate, visible deliverables:

- <u>Climate and Vegetational Characterization:</u>

Detailed reports on the climate and vegetational characteristics of both Italian and Spanish pilot sites, providing valuable insights into the environmental conditions influencing the vineyards.

- Field Survey and Data Analysis Protocols:
  Developed protocols outlining systematic approaches for conducting field surveys and comprehensive data analysis. These protocols serve as a guide for maintaining consistency and accuracy in data collection and interpretation.
- Prototype Components:
  Successfully designed and implemented prototype components including the Ground Sensor System (GSS), Drone, Rover Prototype, and integrated platforms. These prototypes represent crucial technological advancements within the project.
- Maps and Data for Three Seasons:
  Comprehensive maps and data obtained for the three seasons (2021-2022-2023) were analyzed in both the Italian and Spanish pilot vineyards. These datasets contribute to the project's understanding of the different strategies for management and trends over time.
- Dissemination Activities:
  Documentation and reports on various dissemination activities, such as scientific articles, seminars, technical days, and the project website. These efforts have effectively communicated project progress and outcomes to diverse audiences.

These deliverables not only showcase the progress made within the project but also lay the foundation for future phases and the broader dissemination of knowledge to relevant stakeholders.

During the project, while a prototype of the system continued to operate and collect data in the first pilot (Italian vineyard), a second prototype was constructed and deployed in the Spanish vineyard from the second year onward. This action can be deemed a pre-replication activity, building on the results obtained in Italy and executed during the project. It proved essential for the subsequent replication activities in other vineyards and facilitated the transfer of the technology to different types of crops.

The replication efforts yielded promising results, indicating a successful implementation of the precision viticulture methodologies across multiple vineyard sites, and other crops. Through careful adherence to the established protocols and integration of advanced technologies, the project achieved consistent and reproducible outcomes in various replication sites. The success of these efforts underscores the scalability and adaptability of the precision viticulture approach developed in the LIFE WINEgROVER project, demonstrating its potential for widespread adoption within the viticulture sector and beyond. These replicable outcomes not only validate the effectiveness of the project's methodologies but also contribute valuable insights for broader applications and the advancement of sustainable and efficient viticultural practices.

All dissemination activities have been spearheaded by the Dissemination and Communication Coordinator (DCC) and the Project Coordinator (PC). Their collaboration aimed to effectively reach the project's targeted audience and formulate an After-LIFE Strategy.

The challenge posed by organizing indoor events during the COVID-19 pandemic has evolved into a distinctive opportunity for the project. The imperative to avoid indoor gatherings led to the shift towards hosting outdoor events, providing an optimal setting to showcase the prototypes' functionality in the field. This transition not only alleviated the risks associated with confined spaces during the pandemic but also presented a tangible opportunity to demonstrate the effectiveness of precision viticulture methods. Outdoor events allowed stakeholders to directly witness the prototypes in action, emphasizing their capacity to enhance vineyard management. This adaptability to challenging circumstances illustrated the project's resilience in addressing emerging challenges and leveraging opportunities to advance innovative solutions in the wine sector.

The dissemination campaigns in the LIFE WINEgROVER were initiated in 2021 through the organization of two field workshops held in the Italian pilot vineyard. These workshops featured speech presentations, exhibitions, and demonstrations of the technology adopted in the LIFE WINEgROVER project and its benefits for the wine sector. The field workshops provided a unique opportunity for participants to observe the functionality of the platforms and served as a valuable networking opportunity for individuals interested in agricultural technology and Precision Viticulture. Notably, technicians and farmers from Falesco Winery who attended these workshops underwent training in comparing PV with traditional practices and understanding the advantages of adopting innovative technologies. Due to the success of these meetings, it was decided to continue organizing such events even after the COVID-19 restrictions were lifted.

In parallel with the field demonstration events, the project placed a strong emphasis on disseminating its findings through the production of numerous research articles and divulgation publications. These articles serve as an important act in communicating the project's data, methodologies, and outcomes to the scientific community. By documenting the research process, key insights, and experimental results, the project contributes valuable knowledge to the wider academic discourse on precision viticulture. The dissemination of these articles not only enhances the project's visibility but also establishes a foundation for future research endeavors in viticulture, ensuring that the advancements and lessons learned are shared with researchers, practitioners, and stakeholders alike. This dual approach of practical field demonstrations and scholarly publications underscores the project's commitment to both hands-on applicability and rigorous scientific inquiry in advancing the field of viticulture.

Participation in national and international trade fairs, as well as conferences, played a pivotal role in effectively disseminating the project and its outcomes. These forums provided invaluable platforms for showcasing the advancements and innovations in precision viticulture, allowing project representatives to engage with a diverse audience of industry professionals, researchers, and stakeholders. The interactive nature of trade fairs facilitated hands-on demonstrations, offering a tangible experience of the project's methodologies and prototypes. Concurrently, participation in conferences enabled the project team to present detailed insights and research findings, fostering knowledge exchange within the global scientific community. These events not only heightened the project's visibility but also established crucial connections, encouraging collaboration and furthering the integration of precision viticulture practices on a broader scale. Overall, active engagement in national and international forums played a vital role in amplifying the impact of the project and disseminating its achievements across varied audiences.

The project could have a significant policy impact within the viticulture context, particularly in the realm of the Common Agricultural Policy (CAP). By demonstrating the efficacy of precision viticulture methodologies, the project could influence policy discussions related to sustainable agriculture and technological innovation. This impact extends to considerations within the CAP, where the project's success in optimizing resource use, improving grape quality, and minimizing environmental impact aligns with broader goals of sustainability and efficiency. As a result, the project's findings have the potential to shape future policy frameworks, encouraging the integration of precision viticulture practices into agricultural policies that prioritize environmental stewardship, economic viability, and the overall resilience of the viticulture sector.

However, PV technology can collect and generate a wide range of data on soil characteristics, weather-related indices, and crop status at the land parcel level. These geo-referenced data are increasingly demanded for policy monitoring (regulatory mechanisms and control), environmental impact assessments of farm practices, or traceability requirements for agricultural products.

Below is a preliminary list of potential applications:

- Crowdsourcing farm data collection, understood as outsourcing tasks or data collection by a large group of non-professionals, is increasingly employed in scientific research and operational applications. The widespread adoption of Precision Agriculture (PA) within the EU territory would enable the possibility to solicit contributions from numerous farms and annually organize, through a common methodology, the production of 'big data' derived from recorded and produced data by these farms. Some researchers argue that "higher-quality information can be derived from vast amounts of low-quality data," which is related to the so-called "big data" paradigm. We have identified crowdsourcing of farmers' data as an alternative method for obtaining field observations to conduct yield gap analysis. Alongside remote sensing and sensor network applications in agriculture, crowdsourcing can not only provide inputs that meet the needs of agricultural researchers but also help close the knowledge dissemination loop between researchers and practitioners and foster farmer-to-farmer interactions. Therefore, there are significant opportunities for scientists and practitioners in developing crowdsourcing applications in agriculture.
- Improvement of crop models: Data collected and shared from Precision Agriculture (PA) may constitute a new information source on the spatial variability of crop performance, contributing to a better understanding of the impacts of soil properties, fertilizer/pesticide efficiency, topography, climate, and other factors. These elements would enhance the understanding or fine-tuning of crop yield components, subsequently improving yield forecasting models. Additionally, data from PA farms could contribute to enhancing the crop yield forecast system on a broader scale (Europe) by providing 'real-time' adjustments to the model throughout the crop cycle (e.g., soil status, crop status). Initiating crowdsourcing as a first step may lead to the establishment of a more formal representative set of farms. The Crop Growth Monitoring System (CGMS) currently used by the Joint Research Centre (JRC) in support of DG AGRI to provide reliable and timely spatial information about crop status in Europe could benefit from these real-time calibrations.
- Geo-traceability: Through Precision Agriculture (PA), almost all (if not all) data and activities are digitally geo-referenced. Consequently, ensuring the geo-traceability of farm products (e.g., farm to fork) can be rather straightforward, guaranteeing quick and accurate trace-back and recall when necessary or providing information on the provenance of agricultural products to the public. This is a growing requirement from food safety agencies, certification bodies, and the European consumer. Clear traceability offers additional assurance against false information or fraud, particularly in sectors like organic food or for consumers choosing products from short supply food chains (locally produced food labeling in shops). The 'added value' of geo-traceability that PA can provide may spark considerable interest for many companies and farms involved in certification processes.

Food systems lie at the core of the European Green Deal, the EU's strategy for sustainable and inclusive growth, emphasizing the importance of promoting healthy individuals, robust societies, and a thriving planet through sustainable food production.

Commencing on January 1, 2023, the new Common Agricultural Policy (CAP) aims to transition towards a sustainable agriculture and food system. This shift is anticipated to deliver environmental, health, and social benefits while promoting fair economic gains.

In Italy, the Common Agricultural Policy (CAP) initiative aligns with the recommendations of the technical-scientific Committee, comprising numerous experts from CREA – Council for Agricultural Research, a partner in the LIFE WINEgROVER project. CREA is the leading Italian research organization dedicated to agri-food supply chains. CREA centers are under the supervision of the Ministry of Agriculture, Food Sovereignty, and Forests (Masaf). Their activities involve scrutinizing documents, formulating technical opinions, attending meetings at Masaf or other relevant departments, and participating in meetings or activities at international institutions.

Furthermore, personnel from UNITUS and CREA are integral members of the expert team responsible for overseeing the eco-schemes. These schemes aim to provide stronger incentives for climate- and environment-friendly agricultural practices and can be promoted through rural development programs.

In the LIFE WINEgROVER project, various agronomical techniques were implemented in two vulnerable grape-growing areas to mitigate abiotic stressors. The goal was to identify strategic practices that could assist farmers in qualifying for the green direct payment outlined in the new Common Agricultural Policy (CAP). This payment is contingent upon compliance with three mandatory practices that specifically benefit the environment—focusing on soil, water, and biodiversity. Additionally, the project aimed to contribute insights to legislation, guiding potential agricultural practices that eco-schemes, for instance, could support. Within this legislative framework, the findings also assist winegrowers in adopting site-specific crop management. This approach involves observing, measuring, and responding to inter and intra-field variability in crops, adhering to the principle of 'the right treatment in the right place at the right time.' Furthermore, the project seeks to quantify the environmental footprint (EF) of grapes, utilizing the methodology proposed by the EU and life cycle assessment (LCA).

The project has played a crucial role in catalyzing the increased adoption of precision viticulture technologies across Italy, Spain, and Portugal. By showcasing the tangible benefits and operational efficiency of these advanced methodologies through field demonstrations, research articles, and active participation in national and international events, the project has contributed to a paradigm shift in viticultural practices. This influence extends to policy considerations, as the project's success aligns with broader goals of sustainability and innovation within the viticulture sector. The increased use of precision viticulture technologies in these prominent wine-producing regions not only enhances the overall productivity and quality of grape cultivation but also positions the industry at the forefront of technological advancements. As a result, Italy, Spain, and Portugal are poised to leverage the project's insights to further establish themselves as global leaders in the adoption and integration of precision viticulture practices.

To promote the adoption of Precision Viticulture technologies in the participating countries, the partners initiated the development of a report on Precision Viticulture Technologies with recommendations specifically tailored for Italy, Spain, and Portugal.

6.4. Analysis of benefits

Environmental benefits - a. Direct / quantitative environmental benefits

LIFE WINEgROVER activities had a positive impact on selected environmental and climate indicators. Among the measurable results of the environmental and climate action, LIFE WINEgROVER improved the trend of water consumption per unit of product up to 45%

at the end of the project and 76% in the following three years. Some agronomic strategies and innovations in vine performance monitoring permitted a reduction in the area subjected to soil pressure or threats enabling the improvement of soil functions in terms of soil organic matter (topsoil organic carbon content). The same actions concurred also to reduce pest and disease and therefore the amount of chemicals released from 3 to 17 per cent.

Carbon sequestration practices implemented in pilot vineyards, along with site precision characterization, microclimate analysis, and remote monitoring of vegetation, contributed to substantial and long-term reductions in greenhouse gas (GHG) emissions from grape production. The precision viticulture approach enables spatial and temporal mapping of vine performances, considering soil quality and microclimate stressors. This information assists farmers in managing the crop system for improved food quality and health.

Regarding climate change mitigation, the activities promoted by LIFE WINEgROVER improve the carbon sink function of plants under different management practices. On average in the 2022 season, one hectare of vineyard absorbed 6,80T CO_2 eq. /ha/year in the 2021 7,10 T CO_2 eq. /ha/year. The average value used at the end is therefore 7 T CO_2 eq. /ha/year, as the mean from the two observed seasons. Following the same criterion, the average value used at the beginning is 6.5 TCO_2 eq. /ha/year. This results in lower CO_2 emissions of the entire vineyard system determined according to LCA principles from a reduction of 13% at the end of the project to -19% after three years. The results of the LCA analysis show that, when compared to the same production year and concerning the same functional unit, the environmental performance of the experimental systems involving early defoliation and organo-mineral fertilization is generally worse than that of the control system. The use of basalt meal, on the other hand, led to an increase in harvested biomass, with a lowering of the overall impact, particularly in 2022.

Environmental benefits – b. - Qualitative environmental benefits

The project has demonstrated significant environmental benefits through the implementation of precision viticulture practices. By harnessing advanced technologies such as GNSS, remote sensing, and sensor networks, the project has enabled precise and targeted management of vineyards. Additionally, the project's focus on resource optimization has resulted in potential reduced water consumption and improved irrigation efficiency. The application of precision viticulture not only enhances the sustainability of grape cultivation but also contributes to broader environmental conservation goals by mitigating the potential negative effects associated with traditional, less precise viticultural practices. As a result, the project exemplifies how technology-driven precision in viticulture can lead to environmentally responsible practices, aligning the wine industry with sustainable and eco-friendly agricultural approaches.

The incorporation of terrestrial rover and remote sensing technologies in precision viticulture could bring substantial reductions in emissions, along with notable energy and resource savings. Traditional vineyard monitoring methods often involve manual labor, vehicular transport, and resource-intensive practices. However, by deploying terrestrial and aerial drones equipped with sensors (RGB, Multispectral, thermal, and hyperspectral) and leveraging remote sensing technologies, the project has streamlined data collection processes. This has significantly reduced the need for frequent on-site field collected data, minimizing the carbon footprint associated with travel and machinery use. Furthermore, the precise data acquired through these technologies allows for targeted interventions, optimizing resource utilization such as water. The resulting energy and resource savings not only contribute to cost efficiency but also exemplify the project's commitment to sustainable viticulture practices, demonstrating the positive environmental impact achievable through the strategic integration of cutting-edge technologies and strategies of vineyard management in the wine industry.

The combination of remote sensing technologies and the digitalization of field data, as implemented in the LIFE WINEGROVER project, makes it possible for growers, with the guidance of expert agronomists, to formulate detailed farming strategies. These strategies not only lead to high environmental benefits with lower impacts but also enable the application of the most effective techniques for each vine based on its health, water, and physiological status.

Life Cycle Assessment (LCA) is a widely utilized tool and was the first method applied for accounting resource and energy efficiency, pollution, and environmental impact in agricultural activities. Today, it has evolved into a standardized method that provides scientifically sound information on environmental sustainability. LCA holds a central role in the ongoing development of the European Union's policy on product environmental footprint, which is expected to significantly influence eco-labelling, trade, and consumer choices, including those related to agriculture. However, the reliability of results from LCA studies is strongly dependent on meeting data quality requirements. Gathering functional parameters for LCA assessment requires substantial time spent in the field and laboratory. Key considerations include time-related coverage (selected year), geographical coverage (study area), and technology coverage (technology used in the process stages). The LIFE WINEgROVER project aims to enhance the reliability of LCA results by integrating remote sensing and utilizing high spatial and temporal resolution data. This integration aims to quantify the environmental impacts of grape production and improve the overall accuracy of the results

Economic benefits

Beyond environmental benefits, the application of PA also yields economic advantages, including improved grape quality and increased profitability in agricultural operations. This enables growers to reduce costs by optimizing inputs.

The application of integrated approaches promoted by LIFE WINEgROVER brings about significant and long-term economic benefits, particularly in the realm of eco-innovation and the adoption of sustainable practices. For farmers, eco-innovation serves as a positive response within a context marked by the imperative search for sustainability, green innovation, or "eco-innovation," playing a crucial role in addressing challenges related to resource scarcity and environmental degradation. As market, reputational, and regulatory pressures continue to rise, eco-innovation provides a business approach that effectively tackles these strategic, long-term issues. It can offer win-win solutions by facilitating a more radical, systemic transformation to enhance business sustainability and improve economic competitiveness. Estimating the production cost of a bottle of wine is a crucial element in winery management, serving as the foundation for sound managerial strategies and efficiency checks across various production phases. However, many vine farms, especially those in most Mediterranean countries, have yet to adopt adequate systems for monitoring production costs. This situation is primarily attributed to structural and cultural barriers prevalent in sectors characterized by old production traditions, small farm sizes, and family-run businesses. Among the most significant costs for farms are those associated with fuels, chemical inputs, and water used in vineyards to mitigate pests and pathogens, counteract abiotic stressors, and increase yield and income. In LIFE WINEgROVER, site-specific monitoring of soil, vines, and microclimate aids in quantifying the needs of vines, ensuring the application of appropriate treatments to preserve production and the environment, and reducing costs in terms of the number of treatments, the number of external inputs, and fuels.

LIFE WINEgROVER also increased the number of full-time equivalents (FTE) and created job opportunities. At the end: FTE (2.16) has been determined by the total number of additional staff days (1,426), considering 8 hours for the full working day, 220 full working days per year worked by an employee, and 3 years of project duration (total 11,409.37 total working hours recorded by the end of the project). To continue the planned replication activities during the after-LIFE, 2 FTEs are foreseen and will be paid with beneficiaries' funds and/or funds from other international, national, and regional projects.

LIFE WINEgROVER project had a positive impact on jobs and economic growth, either in the short or long term. Regarding the budget for continuation/replication/transfer activities after the project, national, regional and international funds have been quantified as 408,000 € in the after-LIFE plan and derived by current public and private agreements financed: the experimental area 15.000€ ARSIAL (2022-2023); the experimental area PNRR Agritech: 141,133,33€ (14 months from 1 September 2022 to the end of the project Oct. 2023); the experimental area 'Vigneto Italia' in the Botanical Garden of Rome (20,000€) (2022-2023). Funds will also ensure entry into new sectors where the project technology would be replicated/transferred, such as on Kiwi fruit, Lentils, greenhouse and field-scale vegetables, and in different Countries such as Portugal, where technologies could be proposed and used by other entities, on in Italy where the rover could be used as an amphibious vehicle in internal and marine water.

Social benefits

The expectation is for a positive impact on job creation and increased social awareness through the understanding of the benefits of using Precision Viticulture (PV) to reduce the environmental impact of the wine sector at the field scale on natural capital. The LIFE WINEgROVER project extends its impact beyond the vineyards, offering a range of social benefits that positively influence various aspects of the community. Notably, the adoption of advanced technologies can lead to increased employment opportunities, particularly in fields related to data analysis, sensor technology maintenance, and precision agriculture consultancy. This infusion of skilled jobs contributes to economic growth and empowers local communities. Moreover, the project's emphasis on sustainable viticulture practices aligns with broader health and environmental concerns. By minimizing the use of agrochemicals and optimizing resource management, the project promotes healthier ecosystems and potentially reduces health risks associated with conventional farming practices. In essence, the social benefits extend beyond the immediate viticultural context, positively impacting the overall socio-economic fabric of the communities involved in the project.

The LIFE WINEgROVER project had positive societal impacts in terms of the main objective of governance projects. The dissemination activities promoted by the project partners have allowed for the involvement of lots of stakeholders during project activities, such as demonstration days, living labs, and/or contacts made at fairs and conferences. But also, other tools have been promoted for reaching/raising awareness of the public such as posters, information boards, newspaper and magazine articles, number of events/exhibitions organised, distinct media products (videos), and number of different publications made in scientific journals and conference papers, networking and synergies with other projects/initiatives.

Replicability, transferability, cooperation

The LIFE WINEgROVER project aimed to evaluate various management approaches in pilot vineyards, encompassing best practices (organ-mineral nutrition), innovative solutions (application of basalt flour and early leaf removal), and cutting-edge technologies (remote and proximal sensing monitoring). These approaches were designed to be replicable, transferable, or mainstreamed to address environmental challenges in viticulture. The goal is to understand how viticulture can contribute to reducing greenhouse gas emissions while preserving natural resources such as soil fertility and soil water content.

The attained results, detailed in dedicated deliverables, encompass the analysis of vegetative indices for each strategy deployed in the vineyard, a pedological characterization of the vineyard, and the establishment of data fusion incorporating diverse collected data and strategies applied. The findings from the LIFE WINEgROVER project not only contributed to determining the effectiveness of the strategies but also guided the optimization of the detection system. This included identifying main points for remote sensing data collection both in the field and through the platforms system. Furthermore, the definition of the prototype system marked the commencement of the Continual-to-Market (C2M) process for the ground rover, involving meetings with the LIFE team and project partners. This initiative aims to present the system to the market at the project's conclusion, with the development of a comprehensive business plan.

The application of the project is clear from both a commercial and technical perspective. The engineering solution can be employed in various sites or cropping systems, enabling its broad implementation. In terms of commercial application, it can be stated that revenues can be increased both through the correct use of vineyard practices capable of reducing vine stressors and preserving vine and berry quality and health and through savings in external inputs management/raw material costs.

The Replication strategy comprises three stages: short-term, mid-term, and long-term steps to enable different replications of the solution at the end of the project and transferability in other contexts after 3 years from the project's completion. Potential replication sites include vineyards and other crops in Italy and Spain. The new sites have been identified and defined within Action B4.

- Short term: Replication to other vineyards in Italy and Spain. After testing the effectiveness of the technologies proposed during the project in the pilot vineyards, the prototypes will remain available at the estates of the two winemakers, who will be able to use them in larger areas in the years following the end of the project.
- Midterm: Transfer to other regions and other crops in Spain and Italy, where partners already have a presence (Italy, Spain, and Portugal). A series of Italian and Spanish farms have already been selected. Dissemination actions will facilitate an exchange of knowledge, experiences, methodologies, and best practices with other projects (LIFE and other European projects) to integrate results and enhance the implementation of the LIFE WINEgROVER project, optimizing its replicability and promoting result transfer.
- Long term: Replication to non-EU markets. For example, UNITUS signed a Memorandum of Understanding with Yantai University (YTU) in China to engage in cooperative education and research activities for the mutual benefits of both institutions.

The cooperation agreement originates from several introductory sessions realised by the European Union’s International Urban Cooperation (IUC) project. YTU and UNITUS intend to expand and promote their mutual interests to establish also academic cooperation for the purpose of promoting educational and scientific exchange in the agricultural, forestry, food science, landscape and urban environment sectors. Cooperation between YTU and UNITUS will be developed in the following fields:

- joint curricular activities in education and teaching, such as summer/winter schools;
- collaboration on Doctoral student exchange and on co-supervised Doctoral thesis;
- collaborative research projects and studies;
- collaborative academic and scientific publications;
- exchange of undergraduate and graduate students;
- exchange of research and teaching staff;
- exchange of academic publications and scholarly documents;
- collaboration in the WINEgROVER project (LIFE19 ENV/IT/000339) (DIBAF, Tuscia University Coordination) an EU funded LIFE Environment and Resource Efficiency project (https://www.iuc-asia.eu/2020/10/virtual-signing-ceremony-of-mou-between-yantai-china-and-tuscia-italy-universities/).

Best Practice lessons

The results obtained from the LIFE WINEGROVER project analyzed the variability in production across the vineyard. In fact, in the same vineyard, there can be significant variations in grape yield, and quality, as well as water inputs to the soil. The Precision viticulture concepts applied in this project empower growers to define specific qualities and needs of individual vines, achieving accuracy at the level of individual plants. This allows for the customization of the best possible production techniques for each vine.

The project aims to develop a "best practice" in the medium to long term and intends to disseminate it in other national contexts, European, and international settings. The best practices identified in WINEgROVER encompass various topics, which can be categorized into different actions:

- Technological Action: The development and deployment of prototypes for the precision monitoring of vine status.
- Vineyard Management Action: implementation of strategic agronomical practices to counteract environmental emergencies and reduce chemical and practical inputs.
- Stakeholder Dialogue Action: Establishing a continuous dialogue with stakeholders, including the public, through channels such as websites, forums, and media engagement. This involves providing information about the project's progress, technical advancements, and relevant news. This aligns closely with the dissemination and networking actions undertaken in Action D.

The proactive engagement with stakeholders and the ongoing dissemination of information contribute to the project's transparency, knowledge sharing, and the adoption of best practices in viticulture. This approach ensures that the benefits and lessons learned from the project can be applied in various contexts, fostering sustainable practices in the wine industry on a broader scale. In simple terms, the precision viticulture project introduced and perfected a groundbreaking approach to grape farming that can be likened to using a tailored suit for each vine. This "best practice" involves leveraging high-tech tools like GPS and special sensors to understand exactly what each vine needs—whether it's more water, specific nutrients, or protection from pests. It's like giving personalized attention to every grapevine, ensuring they thrive and produce the best-quality grapes possible. Doing this, not only improves the health of the vines and the grapes they yield, but it also helps farmers use resources like water and fertilizers more efficiently. In a way, it's like upgrading traditional farming to a more sophisticated and eco-friendlier version, ensuring each grape gets the VIP treatment for a better and more sustainable harvest. The layman's report highlights the best practices derived from the LIFE WINEgROVER project, explaining how using advanced technologies is akin to giving each grapevine personalized attention, optimizing resources, and ensuring a top-quality harvest.

Continuing efforts in the After-Life phase to consolidate best practices and advocate environmental measures is crucial. This sustained focus on sharing experiences will form a solid foundation for further enhancing environmental performance, especially in the domains of vineyard precision management, ecological production, and resource conservation.

The development of innovative vineyard management and precision monitoring of vine status, as pursued by LIFE WINEgROVER, is positioned as a catalyst for sustainable development and a solution to contemporary environmental challenges.

Innovation and demonstration value

Numerous goals were successfully achieved in alignment with the project timeline. The most prominent outcome is the establishment of the prototype system, developed in the first year of activity and operational in both pilot sites from the second year of the project. Each partner responsible for individual prototypes within the prototype system completed their tasks on schedule and implemented operations in the vineyards through coordinated efforts in field surveys.

Precision farming, as advocated by the project, embodies a farming management paradigm that leverages digital techniques for monitoring and optimizing viticultural production processes. This approach is designed to empower farming decisions, ensuring the judicious use of inputs at the right location and time, thereby enhancing efficiency and minimizing environmental impact.

Furthermore, the adoption of appropriate agricultural data management and precision agriculture is posited to facilitate the effective implementation of EU regulations. This pertains particularly to areas such as the Common Agricultural Policy and other interconnected policies, including those related to the environment and food traceability. By aligning with these policies, precision viticulture contributes to the overarching goals of sustainability, compliance, and responsible agricultural practices.

Policy implications

The project assessed direct environmental benefits by quantifying emission reductions in terms of carbon sequestration, utilizing Life Cycle Assessment (LCA) for vine organs and topsoil in vineyards under different agronomical practices. Applying LCA to the management approaches adopted in the field can assist farmers and landholders in quantifying their 'carbon credits,' validating emission reduction or carbon sequestration practices. It also contributes to the implementation, updating, and development of EU environmental policy and legislation, including the integration of the environment into other policies, such as the link between environment and health, thereby promoting sustainable development. Furthermore, this methodology seeks to enhance environmental issues from two perspectives: the strategic management of soil and canopy, and the precision in predicting vine conditions, berries development, and stressor drivers. This translates into an improvement in natural resources utilization, and through the synergies of the project with other initiatives, engages winegrowers and technical personnel to increase their awareness of strategic viticultural practices. These practices aim to reduce carbon footprints and preserve production against environmental emergencies.

Among the obstacles to spreading the LIFE WINEgROVER project to consider are legislative challenges, such as restrictions on flying aerial drones in some countries/sites. Technical challenges also exist, particularly in marginal and rural areas that are mainly suitable for agricultural activities but lack essential services and infrastructure. Connectivity is crucial in agriculture and rural development, and although rural areas have historically been underserved with broadband internet access, the advent of 5G networks promises to address these challenges by enabling the interconnection of smart devices, supporting remote monitoring, real-time control, and facilitating machine-to-machine (M2M) services and Internet of Things (IoT) applications linked to agriculture.

In the agricultural domain, location-related information plays a pivotal role, and regular monitoring through sensor networks is imperative for collecting the evidence and data required by various pieces of EU agricultural legislation. This is crucial for managing aid to farmers and promoting agricultural practices that are beneficial for the climate and environment, aligning with the greening objectives of the Common Agricultural Policy (CAP).

The geo-spatial information generated by LIFE WINEgROVER holds the potential to become a defining factor in the implementation of policies across multiple sectors, including but not limited to:

AGRI – Agriculture and Rural Development
EMPL – Employment and Social Affairs
ENVI – Environment, Public Health, and Food Safety

IMCO – Internal Market and Consumer Protection
ITRE – Industry, Research, and Energy
JURI – Legal Affairs
LIBE – Civil Liberties, Justice, and Home Affairs
REGI – Regional Development
TRAN – Transport and Tourism

By providing accurate and location-specific data, the project contributes to informed decision-making and policy implementation across a spectrum of relevant areas.

The aforementioned list of European Parliament committees aligns with legislative acts that may require revisitation, particularly in light of the forthcoming communication on the future of the Common Agricultural Policy (CAP). The CAP encompasses diverse dimensions of agricultural policy and related fields, including environmental considerations, health, and climate change. This highlights potential areas within EU law that might necessitate adjustments or revisions, considering the multifaceted impacts associated with precision agriculture.

Moreover, the study offers comprehensive recommendations that EU stakeholders may find valuable when addressing precision agriculture. These recommendations likely serve as guidelines for navigating the legal and regulatory landscape to ensure the effective incorporation of precision farming practices within the broader agricultural policy framework.

7. Key Project-level Indicators

Key Performance Indicators (KPIs) in a project are specific, measurable metrics designed to assess and gauge the project's performance, progress, and success. These indicators serve as benchmarks that align with the project's objectives, allowing stakeholders to track and evaluate key aspects such as efficiency, effectiveness, and goal attainment.

In the LIFE WINEgROVER project the Key Performance Indicators (KPIs) have been defined within the project framework, accompanied by their corresponding target values. The table below reports the KPI defined within the project and the values at the beginning, at the end of the project and and three years after the end of the project.

The project proposal was largely confirmed by KPIs. An updated table of the Project Specific Indicators has been included in D39, which reflects the environmental, economic, and social benefits reported in the preceding section. UNITUS has taken the responsibility of reporting project outputs through the web KPI platform. They have worked with project partners to draft a new version of project KPIs and determine the data that needed to be collected. The KPIs have been actively monitored throughout the project, and various activities have been conducted to assess the impact of the technological innovation and ecological transition introduced by the project. The environmental KPIs have been updated based on the data collected under specific actions, and data on dissemination activities have been recorded on a three-monthly basis. The project is also required to report on mandatory indicators related to the project outcomes. The values of the KPIs demonstrate the impact of the project activities on the environment, climate action, and society. The project has shown positive impacts on various environmental and climate indicators, such as water consumption, soil functions, and the reduction of pests and diseases. In terms of climate change mitigation, the project has improved the carbon sink function of plants. The project has also had positive societal impacts, particularly in terms of governance. Additionally, the project is expected to indicate its impact on job creation and revenues, as well as its catalytic potential in terms of investment, transfer of project methods/tools/approach, and replication in different geographical areas.

Indicator 1.5 Project area/length

	Indicator	Descriptor	Begin Value	End Value	Beyond 3 years value	Unit	Comment
IT	1.5. Project area/length	Area of environmental/climate implementation actions (e.g. development, testing, demonstration, application of best practices/innovations).	0	13,9	19,9	ha	The value at the end of project is the total experimental area (in Italy + Spain). After 3 years, we expect to enlarge the area up to 13 ha thanks to the planned replication activities.
ES	1.5. Project area/length	Area of environmental/climate implementation actions (e.g. development, testing, demonstration, application of best	0	2	3	ha	

Indicator: 1.6. Humans (to be) influenced by the project

	Indicator	Descriptor	Begin Value	End Value	Beyond 3 years value	Unit
ES	1.6. Humans (to be) influenced by the project	Persons whose lives were directly, positively impacted by MAIN envir. actions of project - see Guide	0	2	2	Number of residents within or near the project area
ES		Persons who changed their behaviour or practices due to the project actions	0	15	30	Number of non-resident persons regularly present within or near the project area (e.g. employees)
IT	1.6. Humans (to be) influenced by the project	Persons whose lives were directly, positively impacted by MAIN envir. actions of project - see Guide	0	6	7	Number of residents within or near the project area
IT		Persons who changed their behaviour or practices due to the project actions	0	60	120	Number of non-resident persons regularly present within or near the project area (e.g. employees)

Indicator: 2.3.5.3. Water consumption for production

Indicator	Descriptor	Begin Value	End Value	Beyond 3 years value	Unit
2.3.5.3. Water consumption for production	The project's environmental or climate action outcomes linked to its main objective	19900	19900	19900	number of units produced or measure of services provided/year
	The project's environmental or climate action outcomes linked to its main objective	20	11	4.75	m3/unit produced

Indicator: 4. Resource efficiency (including soil, forests and green circular economy)

	Indicator		Descriptor	Begin Value	End Value	Beyond 3 years value	Unit
IT	4. Resource efficiency (including soil, forests and green circular economy)	4.3. Resource efficiency - soil	Soil Organic matter	19,9	6	0	ha
ES	4. Resource efficiency (including soil, forests and green circular economy)	4.3. Resource efficiency - soil	Soil Organic matter	3	1	0	ha

Indicator: 5. Environment and health (including chemicals and noise).

Indicator		Descriptor	Begin Value	End Value	Beyond 3 years value	Unit
5. Environment and health (including chemicals and noise)	5.1.1. Chemicals released	ECHA list of registered substances (include EC number/name in comment box)	124972	120809	103679	g/year released

Indicator: 8.1 Climate Change Mitigation
8.2 Carbon sequestration

Indicator		Descriptor	Begin Value	End Value	Beyond 3 years value	Unit
8. Climate Change Mitigation	8.1.1. CO2	Agriculture	31,203.20	27,158.30	25,412.30	KG of CO2 /year
		Agriculture	0.16	0.14	0.13	kg CO2/kg produced (Agriculture)
	8.2. Carbon sequestration	Carbon capture and	5630	7000	7000	kg/ha/year
8. Climate Change Mitigation	8.1.1. CO2	Agriculture	4327	4327	6597	KG of CO2 /year
		Agriculture	0,34	0,32	0,3	kg CO2/kg produced (Agriculture)
	8.2. Carbon sequestration	Carbon capture and				kg/ha/year

Indicator: 9.1. Adaptation area

	Indicator		Descriptor	Begin Value	End Value	Beyond 3 years value	Unit
IT	9. Climate Change	9.1.	Adaptation	0	13.9	19.9	ha
ES	9. Climate Change	9.1.	Adaptation	0	2	3	ha

Indicator: 10. Governance

Indicator		Descriptor	Begin Value	End Value	Beyond 3 years value	Unit
10. Governance	10.2. Involvement of non-governmental organisations (NGOs) and other stakeholders in project activities	Private for profit	0	35	45	number of stakeholders involved due to the project

Indicator: 11.1 website

Indicator	Descriptor	Begin Value	End Value	Beyond 3 years value	Unit
11.1 website mandatory	No. of unique visits	0	34396	50000	Number of unique website visits

Indicator: 11.2. Other tools for reaching/raising awareness of the general public

Indicator		Descriptor	Begin Value	End Value	Beyond 3 years value	Unit
11. Information and awareness raising to the general public	11.2. Other tools for reaching/raising awareness of the general public	Number of different displayed information created (posters, information boards)	0	13	15	Number of outcomes (e.g. nr of reports, events, etc)
		Number of articles in print media (e.g. newspaper and magazine articles)	0	6	8	Number of outcomes (e.g. nr of reports, events, etc)
		Number of events/exhibitions organised	0	5	9	Number of outcomes (e.g. nr of reports, events, etc)
		Other distinct media products created (e.g. different videos/broadcast/leaflets)	0	1	1	Number of outcomes (e.g. nr of reports, events, etc)
		Number of different publications made (Journal/conference)	0	1	4	Number of outcomes (e.g. nr of reports, events, etc)

Indicator: 12.1. Networking (mandatory)

Indicator		Descriptor	Begin Value	End Value	Beyond 3 years value	Unit
12. Capacity building	12.1. Networking (mandatory)	Professionals - experts in the field	0	240	300	No. of individuals

Indicator: 13. Job

Indicator	Descriptor	Begin Value	End Value	Beyond 3 years value	Unit
13. Jobs	Jobs	0	2,16	2	No. of FTE

Indicator 14. Contribution to Economic growth

Indicator		Descriptor	Begin Value	End Value	Beyond 3 years value	Unit
14. Contribution to Economic growth	14.1. Running cost/operating costs during the project and expected in case of continuation/replication/transfer after the project	Running cost/operating costs during the project and expected in case of continuation/replication/transfer	0	2.222.813,88 €	**2.630.813,88 €**	€
	14.2.2. Operating expenses expected in case of continuation/replication/transfer after the project period	Operating expenses expected in case of continuation/replication/transfer after the project period		2.222.813,88 €	408.000,00 €	€
	14.3. Future funding	EU Structural Funds (ESIF)			408.000,00 €	€
	14.4. Continuation/replication/transfer after the project period	14.4.1. Entry into new entities/projects			408.000,00 €	€
	14.4. Continuation/replication/transfer after the project period	14.4.2. Entry into new sectors			408.000,00 €	€
	14.4. Continuation/replication/transfer after the project period	14.4.3. Entry into new geographic areas				Portugal

(Projects funded under the Call 2014 onwards must use this format)

8. Comments on the financial report

Complete the following table to show the project costs incurred compared to the approved budget and comment on each of the cost categories focussing particularly on discrepancies compared to the allowed flexibility of the 20% limit (cf. Article II.22 of the General Conditions).

8.1. Summary of Costs Incurred

(Projects funded under the Call 2014 onwards must use this format)