Innovation action
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Vineyard Innovative Tool based on the InteGration of Earth Observation Services and in-field Sensors

List of participants

Participant No	Participant organisation name	Country
1 (Coordinator)	FUNDACIO EURECAT	Spain
2	FONDAZIONE LINKS	Italy
3	eLEAF BV	Netherlands
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5	PriceWaterhouseCoopers	Portugal
6	UNIVERSITA DEGLI STUDI DI NAPOLI FEDERICO II	Italy
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1. Excellence

Sustainable agriculture aims at maximizing the net benefit for people by developing new farming practices **to meet current and future societal needs for food, ecosystem services and human health**.
The wine sector invests heavily in state-of-the-art technology due to their intrinsic quality requirements and maintenance of production under sustainable labels (e.g. organic). **Innovative solutions applied to this particular sector can be extended to other crops to respond to future challenges of the worldwide food industry**[1], which requires to **intensify the production within agro-food systems in a sustainable way**[2], mitigating the effects of climate change, reducing negative environmental externalities and promoting local **economic growth**.[3] Being that winemaking is the main economic activity of many regions in the South of Europe[4], t**he European Union is the world's biggest wine producer** (60% of the world wine production). Some studies have forecasted a decrease between 25% - 73% of major wine producing regions by 2050 due to the shifting patterns of agricultural production in response to climate change[5]. If the latter fulfils, **the direct effect on these regions will be catastrophic, from economic, social and cultural points of view** (massive losses of jobs and centuries-accumulated knowledge on regional viticulture, etc.).

The maturity of open Earth Observation (EO) services like GEOSS and Copernicus (free of charge, high-frequency and detailed information about the land surface), **allows for the deployment of specific added value products for the agriculture sector**, even at local level. The integration of Earth Observation data with other in-field data sources (available sensors and cameras) and the subsequent data assimilation through specific models provides a priceless opportunity to obtain **operational customised information on crop status in the form of agro-monitoring systems, aimed at delivering yield forecasting, early warnings and robust information for decision makers on different aspects such as irrigation, use of fertilizers & pesticides, early detection of diseases, timings of field operations, business management, etc**. The development of these applications represents a **major technological challenge**, as they require gathering of and integrating a huge amount of heterogeneous information and incorporating interoperability best practices.

VITIGEOSS will integrate existing solutions - VISCA & FruitLook - to couple **satellite imagery with in-field sensors** to **increase resolution and reliability of satellite information** applied to **all aspects of viticulture and specific wine-business operations.** Our application will **empower the usage of European open EO services** by the improvement of agriculture business operations at economic, environmental and social[6] level, and will ensure an **effective engagement with EuroGEOSS** by direct participation within its Action groups. **The presence of 3 end-users in the consortium will facilitate a successful penetration in the market through eLEAF, who will act as commercialization partner.**

1.1 Objectives

The main scope of the project is to **empower the potential of EO Systems by deploying an innovative commercial information application to optimize sustainable grapevine cultivation via decision support systems (DSS) on phenology, irrigation, fertilizer, disease and business operations management**. Satellites imagery will be combined with in-field measurements, models and best practices to build up an integrated but modular management tool covering the most critical operations of the business, **including sustainability aspects to align the outcomes with UN SDG´s**[7]**,** which will directly welfare population living in rural communities around wine producers locations. The realization of the aforementioned system is linked to the following specific objectives:

1. To deploy a **climate forecast intelligent service** exploring the frontiers of sub-seasonal climate predictions and their synthesis with weather forecast and seasonal climate predictions **to provide seamless forecast for decission making processes in the wine sector.** (WP2) (M13)
2. To deploy a **disease management service** capable of launching **warning alerts on the appearance of most important diseases based** on the symptoms and characteristics of each geographical area (and their climate conditions) and creating **contingency plans according to user's available tools**. (WP2) (M13)

[1] https://www.researchgate.net/publication/232862903_Climate_Change_Viticulture_and_Wine_Challenges_and_Opportunities
[2] http://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf
[3] A. Sarkar. Sustainable Solutions for Food Security (2019). Springer. ISBN: 3319778781, 9783319778785
[4] http://ec.europa.eu/agriculture/wine/statistics/market-situation-2014-07_en.pdf
[5] http://www.pnas.org/content/110/17/6907.full.pdf
[6] **By education of rural communities on sustainability based on lessons learnt**
[7] https://www.un.org/sustainabledevelopment/sustainable-development-goals/

3. Build a set of Copernicus and GEOSS downstream services **integrating satellite with in-situ data to optimize the crop management using the highest quality data.** Recent advancements on Artificial Neural Networks (a.k.a deep learning) and the availability of both EO and in-field imagery will be used to combine novel algorithms aimed to estimate key crop management indicators (leaf water potential, leaf area index, grapevine phenology stages) (WP3) (M18)
4. **Establish an integrated, modular management solution** for vineyard cultivation in 3 demo-sites of Portugal, Italy and Spain using Earth Observation Systems and field monitoring tools (WP4) (M15)
5. Quantification of **sustainable wine production indicators** (relative yield %, CFP[8], GHGI[9], erosion hazard, benefit–cost ratio, availability of farm labour, etc.) **via an integration of EO and field monitoring techniques** to empower decision makers in the wine sector with the necessary toolbox **to make wine production in Europe environmentally and commercially sustainable** (WP4) (M18)
6. **Business plan** for a successful market entry strategy, based on market analysis and stakeholder consultation (WP5) (M30)
7. **Realization of 2 workshops[10]** comprised of seminars and training courses **on data analysis, satellite data acquisition & probabilistic climate forecast for appropriate decision making** among technology developers and commercialization partners, supported with the presence of **relevant stakeholders of wine, agricultural sector and EuroGEOSS members** (WP6) (M36)

1.2 Relation to the work programme

TOPIC: SC5-16-2019. Development of commercial activities and services through the use of GEOSS and Copernicus data b)
Actions should deliver solutions addressing citizens' needs and contributing to the development of new markets of products and services through integrating EO data and information, e.g. from GEOSS and Copernicus, with other data sources
Coupling EO data from Copernicus with in-field measurements provides **a high quality and timely basis for the optimization of winery operations by having a reliable time window to make decisions related to phenology, fertilisation, disease control, sustainability and business operations. This has a significant** positive impact on local growers (e.g. timely and guaranteed delivery of grapes due to an improved predictability of yields will support rural communities close to wine producers). Sustainable practices will be **empowered with sustainability indicators** (see section 1.3.2) that will act **as a source of information to maintain and increase sustainability practices in the sector.** Other actors in the business (insurance companies, traders, large cooperatives and policy makers) are direct beneficiaries, since they can easily monitor agro-tendencies and policies through the analysis of the information provided. **Public authorities can adopt the use of VITIGEOSS to support small farmers, promoting digital innovation in this sector,** which presumably will lead to social development of rural communities. By innovating on image processing and deep learning applied to such a high-value added sector like wine, **VITIGEOSS will encourage the use of Copernicus and GEOSS among agriculture sectors, by making companies aware of the benefits that these services bring into their businesses.**
These products and services should incorporate assimilation techniques and interoperability best practices, automation, systemization and integrated web-based services, and be brought – at least – into pre-operational service provision, going beyond the demonstration phase
With a **track record of completed projects and running services in the wine production** sector in several countries, **the consortium brings the necessary knowledge to build a robust service for wine producers**. Several challenges facing the wine production sector in Europe are identified in cooperation with the end users represented in the consortium. The proposed services confront these challenges by integrating the latest technological developments within the Earth Observation, machine learning and related segments. **These improvements are presented as intelligent services which can be linked into commercial wine dashboard of the partner ELEAF**; this forms an integrated solution to achieve sustainable and resource efficient vineyard cultivation. **By including Symington[11], Mastroberardino[12] and Torres[13]** as partners in

[8] Product Carbon Footprint
[9] Greenhouse Gas Inventory
[10] Co-located in existing sectorial events like fairs or conferences to take advantage of the participating audiences
[11] https://www.symington.com/
[12] https://www.mastroberardino.com/
[13] https://www.torres.es/es/inicio

our consortium, we ensure that the established solutions fit the need of the sector and will be carried on after the project closes (the product has been co-design with them, following their priorities).

The services developed under this project will be **linked via interoperable APIs to a central platform**. **Automation of data production** using established technologies means t**he products produced are scalable and cost-efficient**. **Data is assimilated from various platforms, including Earth Observation, weather observations and predictions, in-field cameras and any other monitoring devices available to the farmer.** These data products form the basis for various automated advisory services which are developed through machine learning, to establish a service that is scalable and operationally available to the farmers.

Activities are expected to focus on Technology Readiness Levels (TRLs) 5 to 7 and to be developed in close coordination with EuroGEOSS.

VITIGEOS can contribute to EuroGEOSS by demonstrating the effective use of European EO resources (space, airborne, in-situ measurements and citizen observations) in an operational environmental (forecasting) application **for the wine industry**. The application is at the pre-operational readiness level 6 to 7 and as such can reinforce other EuroGEOSS initiatives. **VITIGEOSS already has strong connection with for example GEOGLAM -G4AW[14] (**GEO group on Earth Observations**)**, where the partner eLEAF participates in a number of project under the theme *Earth Observation for Food Security*. **VITIGEOS will explore the readiness level with different EuroGEOSS Coordination Groups** to ensure that it meets the EuroGEOSS requirements. **Connection with these action groups will be ensured with the presence of relevant members (CREAF, VITO, ECMFW) in the Advisory Board.**

CALL: Greening the economy in line with the Sustainable Development Goals (SDGs)

The services developed under this project aim at **the efficient use of the resources by the appropriate crop management actions at the right time on the right place,** so the vine can be managed more effectively during its growth and production of grapes. Consequently, our system will arouse **a decrease of the environmental impact (less use of fossil fuels, nitrogen and chemicals), empowering the sustainability within the wine companies**. The efficient use of resources by appropriate crop management actions will lead inevitably to a decrease of wastes, as well as reduction of CO_2 emissions due to optimization of tasks done in the field. If these practices were to be extrapolated to all sectors of agriculture, this would turn out in a **noticeable improvement of the worldwide welfare in terms of mitigation of climate change effects and development of more efficient agro-food systems**.

Thanks to the precise application of the recommendations generated by the VITIGEOSS services, the **optimization of resources used in the vineyards will enable to make the most of each available resource avoiding its misuse or overdosing**. The continuous monitoring of the vineyards by field sensors and Earth observations will also allow the **permanent control of the vineyard status, enabling the immediate decision making based on accurate data, refine predictive algorithms and forecasts in order to adapt the wineries strategies for optimal management**.

*VITIGEOSS directly aligns with SDG2 ”provide food for everyone”, SDG6 “avoid wasting water”, SDG8 “sustainable economic growth”, SDG12 “sustainable production” and SD13 “climate action”.

1.3 Concept and approach

1.3.1. Concept description

Being agriculture totally dependent on weather conditions, **high reliable meteorological information coupled with crop status measurements will be critical for the wineries** to be prepared for extreme scenarios. The immediate consequence that upward-move in seasonal temperature had on the wine sector has been the shift of the normal pattern of grapevine development toward an earlier onset of flowering, veraison, and harvest. With grapes accumulating high levels of sugar much sooner than they used to, **winemakers must have accurate information to decide on the optimum harvesting dates**.[15] There are other climate-driven impacts that are affecting the vineyards to a large extent, such as the increase in diseases. **Many regions that were out of climate range of certain pests are now suffering from infestation and contagion** (*Philloxera*, Downey mildew, Powdery mildew, etc.)[16]. Therefore, **another urgent need is the early identification of diseases in the plant, besides a continuous and thorough pest management**.

[14] https://cropmonitor.org/
[15] https://www.theguardian.com/food/2018/sep/16/climate-change-wine-industry-bordeaux-california
[16] M. R. Mozell and L. Thach. The impact of climate change on the global wine industry: Challenges & solutions. Wine Economics and Policy 3, 81-89 (2014).

A**griculture also plays an important role in climate change effects itself** (Agriculture is responsible for 24% of CO_2 emissions, which makes the agricultural sector the world's second-largest emitter, after the energy sector)[17]. Better prediction of the main grapevine phenological stages (beginning of shoot growth, blooming, fruit set, veraison, berries harvest-ripe, leaf fall, etc.) and scheduling of critical vineyard management practices (like summer and dormant pruning, pest management, fertilization, harvesting, etc.) help to improve the wineries resource and tasks planning, **reducing emissions of greenhouse gases** by optimization of operations that involve the use of fossil fuels and **reducing the amounts of chemicals and nitrogen used on fields.**

The richness of remote sensing data is of great help to obtain up-to-date information on farmland and agricultural processes. When coupled with in-field measurements from specific tools available to farmers through advanced deep learning algorithms **this information is used to assess the effectiveness of agricultural management steps**. However, in order to have a global crop monitoring system, **an effort is required to gather and integrate huge amounts of information derived from remote sensing, weather, in-field measurements and modelling data**. The use of Big Data technologies and of web-based architectures and APIs allows to parallelize data processing and storage, and to create modular and interoperable systems. These can be effectively exploited in commercial products and services, making data services accessible to third party systems and usable graphical interfaces and dashboards for decision supports that can be directly delivered in the hands of end-users. The information from these services are to be delivered to the end users in an understandable and user-friendly way.

To winegrowers, VITIGEOSS offers the opportunity to improve the efficiency and profitability of the vineyard thanks to **accurate mapping of each plot, image processing, algorithms and modelling, altogether combined with viticulture know-how operations** that makes possible to extract useful indicators for a better management of vineyards and the optimisation of agricultural practices.

1.3.1.1. Technology Readiness Level

At the end the project all main components will be ready and made available to the market, providing immediate uptake for the technical partners that build the consortium. VITIGEOSS will advance the technology to a minimum level of TRL7 (system prototype demonstration in operational environment), that will be validated during the demonstration pilots that will take place during 2 years.

1.3.1.2. National or international research and innovation activities linked with the project

Activity & Brief description	Outcomes that will feed the Project
VISCA **(LINKS, BSC, SYM, MBD, NAP):** Climate Service (CS) and Decision Support System (DSS) capable of handling weather, phenological and irrigation forecasts, and deliver them to end-users through a dashboard for decision support.	In cooperation with eLEAF, selected modules of the VISCA system will be chosen for improvement and adoption within VITIGEOSS so as to fully benefit from the existing solutions that have been implemented by the consortium partners and deliver a competitive solution that can be effectively exploited towards the wine industry and other cultivars.
FruitLook (**ELEAF**): The FruitLook pre-operational service demonstrates the benefits to wine farmers of integrated satellite technologies in their daily water and farm management in the Western Cape of South Africa. The FruitLook project makes the pre-operational service freely accessible to all potential farmers, who indicate improvements in water use efficiency of up to 30%.	The FruitLook platform consists of an advanced front- and back-end architecture that is at the operational level for its current applications, providing the proper infrastructure to combine data and applications emerged from VITIGEOSS partners to progress to the TRL7 level. The platform already serves a customer base and this allows for a quick scale-up to the market once VITIGEOSS is operational.
IoECrops (**EURECAT**) This projects works on the connection of agricultural machinery to several agronomic cloud services from different partners to improve the management of extensive crop farms. In addition a data analysis platform is developed to optimize the resources used.	The knowledge from the project will be easily adapted to other type of crops: A selection of standards used to enable the interoperability between clouds; the technology developed to connect the agricultural machinery to Internet; and the data analytics infrastructure and application used will allow the optimization of resources in wineries.
S2S4E (**BSC**): Innovative service to improve the management of renewable energy variability by	Comprehensive sub-seasonal and seasonal forecast quality assessment for climate variables that affect the agriculture sector (Temperature and precipitation).

[17] https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

combining seasonal and sub-seasonal climate predictions	
MED-GOLD (**BSC**): MED-GOLD will build pilot climate services focusing on three key crops of the Mediterranean area: grapes, olives and durum wheat.	Tailored services using seasonal climate predictions will be developed within the project and evaluated in terms of user impact.

1.3.2. Overall approach

VITIGEOSS will build an operational and modular ecosystem where a set of advanced models (smart services) **will deliver essential forecasts and estimations to wine makers** in order to optimize the crop management processes. Standard protocols, metadata, and data exchange formats will be used in order to make the **VITIGEOSS ecosystem fully interoperable with existing solutions** and allow its output data to be published in GEOSS/DIAS repositories, making them discoverable through such platforms. Specifically, the INSPIRE directive and OGC standards will be used for geospatial data, while W3C standards will be used for all web-based solutions. Also, ISO, ETSI and CEN/CENELEC standards will be followed for all processes and communication protocols. Our objective is the deployment of a platform that is able to create, manage and disseminate EO-derived data and services relevant for the wine industry.

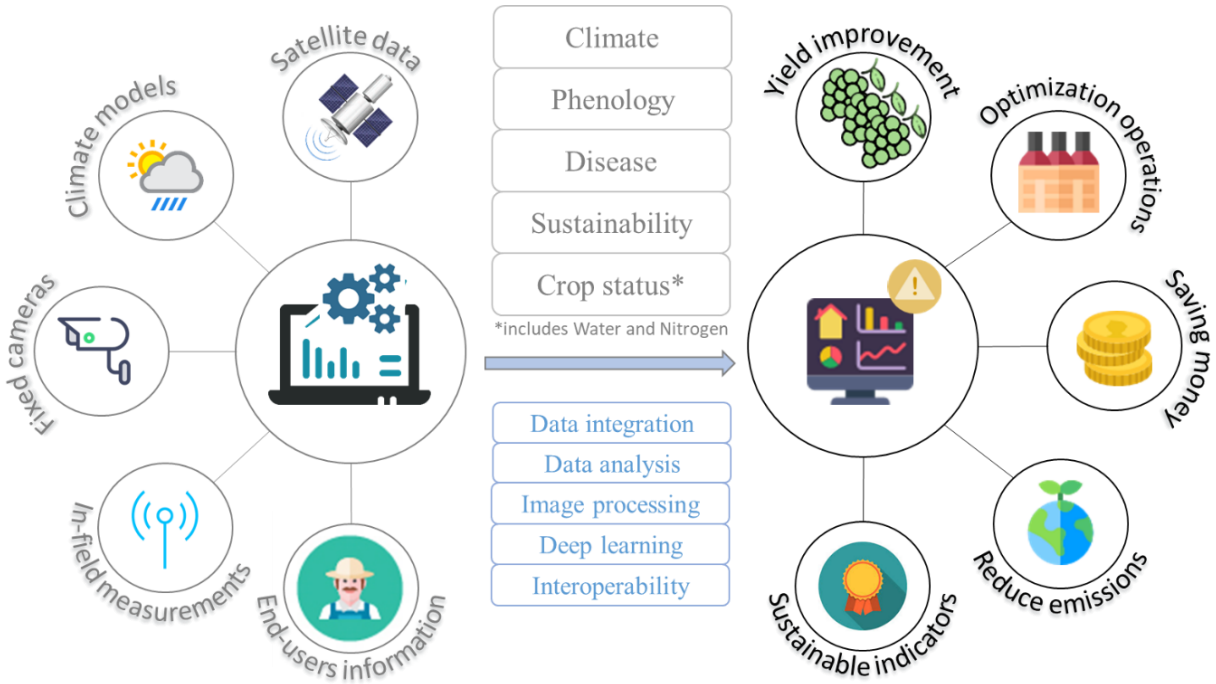

Figure 1. Input data used in the back-end (left), processed to feed the smart services (weather, phenology, crop status, disease, and sustainability), which will generate outcomes for the front-end (right).

VITIGEOSS will use free-of charge satellite imagery and EO products from the European Copernicus Programme (e.g. Sentinel-1/2A data, SPOT/VEGETATION - PROBA-V (GEOV1) LAI) and NASA (e.g. MODIS and OLI data), **coupling them with in-field data sources to give rise to 5 smart services:**

1. **Climate forecast**: Assessment and maximization of the performance of sub-seasonal and seasonal forecast systems and their synthesis with weather forecast. Climate predictions from COPERNICUS Climate Data Store (CDS) and the North American Multi-Model Ensemble will be post-processed and evaluated against observations for operational implementation.
2. **Phenological forecast:** Last generation fixed cameras installed on the field will be used to complement remote sensed imagery with in-situ observation to improve the accuracy of the phenological forecasting (beginning of shoot growth, veraison, harvest, and the end of the vegetative season) to provide well-founded information for decisions to be taken during the vineyards' agriculture cycles.
3. **Crop status:** Crop status will be assessed on a weekly basis using Sentinel-2 observations for the creation of vegetation health indicators and crop growth maps. Evapotranspiration maps will be created on a weekly basis describing the crop water consumption, which, complemented with leaf water potential estimation and weather forecasting will establish crop water demand for the upcoming week. These maps and other data (e.g. leaf area index, phenology stages, soil water content, etc.) derived from the coupled use of in-field measurements will be made available to farmers to detect growth problems timely and to make judgement

calls on production blocks supporting decision making on resource management. Satellite based information on leaf nitrogen levels integrated with in-field samples will ensure better insight into the actual crop need for nutrients, and better decisions on fertilizer application thus saving resources and reducing environmental strain.

4. **Disease management**: Early warning approach on the appearance of critical diseases (e.g. Downey mildew, Powdery mildew, black rot) in the vineyard lifecycle based on historical data (treatments applied, weather records, etc.) and tuning of algorithms to the specific field conditions. The resulting algorithm will be improved with near real time monitoring data from satellite data services, weather stations and in-field measurements to detect the conditions under which the disease can appear, **and spray beforehand to avoid irreversible situations**. This service will include a treatment schedule to prevent and control, considering disease characteristics and best practices.

5. **Business & Sustainability:** Overall output data from all services mentioned above will be used to (i) plan best timing for field operations e.g. summer pruning, harvesting, etc. (ii) improve predictability of production, (iii) calculate personnel resources needed (critical for the harvesting period), (iv) guarantee a better planning of resources (e.g. grapes from nearby local growers), (v) reduce usage of raw materials (pesticides, fertilizers, water, fossil fuels), (vi) automate "zonal delineation" for selective harvesting[18] and specific management to predict ideal production zones for different wine cultivars (based on slope, heat units, cold units, solar radiation, type of soils, etc), which will serve as input for (vii) evaluation of production standards based on the analysis of sustainability indicators on Productivity (fruit and water yield %), Environment (PCF, GHGI)[19], Protection (percentile 10 and 90 of wind and precipitation to predict erosion & flooding hazards) and Economic viability (benefit–cost ratio, availability of farm labour).

The services of the project and lessons learnt will be used for building capacity amongst rural communities on sustainability that will benefit the local economies (by ensuring productivity at long term, thus safeguarding creation of jobs in the region). The latter approach can be used by policy makers to monitor and map general irrigation and crop cultivation activities in their management area, both historic and in near real-time, which can support decision making processes on future sustainability strategies.

1.3.3. Methodology

The project will entail a total of 36 months, allowing for 2 years' demonstration. The lifetime of the project will be structured according to the following Work Packages (main participants mentioned after every WP):

WP1. Management of the Project. EURECAT
Entails communication, project planning, configuration management, reporting and administrative tasks.

WP2. Intelligent services on vineyard management. LINKS, BSC, ELEAF, EURECAT, all partners
WP2 will create a set of Intelligent Services for an integrated vineyard management and decision support. These services include the operational provision of sub-seasonal climate predictions, the monitoring of both phenological stages and crop key indicators, the alerting in case of high risk of disease, the suggestion of operational activities - together with the appropriate workforce required - and sustainability mapping. In-field measurements will be stored and used to downscale the models. In order to improve their marketability, all VITIGEOSS intelligent services will be designed and implemented so as to be interoperable through web-based APIs and standards and to be deployable as stand-alone applications that will be integrated in WP3.

WP3. Integrated Vineyard Management DSS. ELEAF, LINKS, EURECAT
WP3 deploys the DSS application dashboard. The dashboard will be co-created with the end-users, following Agile development cycles[20] and based on the FruitLook and VISCA technologies. A data visualization library will be implemented to allow interactive and dynamic visualization of geo-located data and maps. A System Test and Validation will be performed on the use cases supported by the application. Set up of the system will be done during the first year of the project, which implies the specification of all data formats and protocols for the information exchanges between the main VITIGEOSS services. From the 2nd year the system will run in operation mode.

WP4. Demonstration. NAP, SYM, MBD, TORRES, ELEAF, LINKS, EURECAT, BSC
VITIGEOSS will be validated with end-users on three demo sites belonging to **Symington, Mastroberardino and Miguel Torres**, who participate as full partners in the consortium. All sites will devote a pilot vineyard for the project. During the first year of the project, those vineyards will be used for the calibration of every services.

[18] different wine styles according to the quality and characteristics offered by the different areas
[19] http://www.viticolturasostenibile.org/EN/AirIndicator.aspx
[20] https://en.wikipedia.org/wiki/Agile_software_development

During the second year, the services will be validated, tested and deviations analysed for possible further corrections of models (included sub-seasonal predictions). Finally, the third year all services will run operationally and their finally accuracy will be evaluated as a parameter for success and to create uptake. Each demo site will receive the information through VITIGEOSS, and in return end users will feed the tool with field data. The latter, together with historical data, will be used by the software developers to improve the accuracy of the tool, by means of machine learning and by the validation of the models.

WP5. Commercial innovation and market penetration. PWC, ELEAF, all partners
This WP is focused on the market uptake of VITIGEOSS. eLEAF provides satellite based applications and data to optimise crop production and water management and has worked in more than 50 countries all over the world for a wide range of different clients, including the wine industry in South Africa. This partner will act as commercialization partner interested in adopting the latest innovations. The modular-based architecture will facilitate the market up-take according to the different clients' needs. A business plan will be developed by PriceWaterhouseCoopers for a rapid penetration of VITIGEOSS into international markets. This WP will likewise focus on networking with relevant initiatives, especially EuroGEOSS, as well as analysis of how complementary funding mechanisms can be mobilised.

WP6. Communication & Dissemination. BSC, EURECAT, all partners
This WP will ensure that the project objectives, activities and outcomes reach the relevant target groups (such as wine makers and agricultural communities, farmers, educational and training organizations and policy-makers, etc.) in and beyond the demo site countries. The latter will also include special sessions during the general assemblies (in every of the 3 different end user's premises) between local farmers and rural communities to educate on sustainable agricultural practices to improve productivity.
Lessons learned during the lifetime of the project will be used to advance EuroGEOSS objectives (spread use of EO services among agricultural sectors) through capacity building addressed to industrial partners and stakeholders by the realization of 2 workshops (see objective 7).

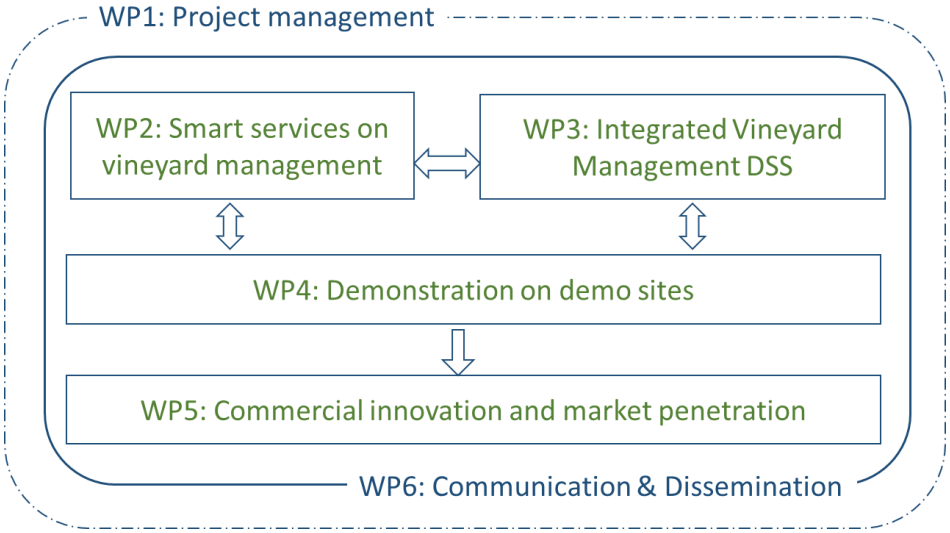

Figure 2. WP structure of VITIGEOSS

1.3.2.1. Sex and/or gender analysis

VITIGEOSS consortium will promote equal opportunities in the human resources acquisitions or collaborations arisen during the execution of the project, besides eensuring that any meeting, workshop or high profile presentation will be planned from a gender balance perspective. VITIGEOSS will endorse the principles of the *European Charter for Researchers and Code of Conduct for the Recruitment of Researchers*[21] regarding women recruitment.

1.4 Ambition

1.4.1. Advance beyond the State of the Art

1. **Crop status**: Substantial advancements will be achieved in the estimation of key measurements in order to optimize the crop management, e.g. leaf area index, the phenology stages and the bunch size. These

[21] https://euraxess.ec.europa.eu/jobs/charter

estimations will be achieved through the supervised machine learning approaches based artificial neural networks that will be trained starting from labelled satellite and in-field data.

2. **Climate forecast**: VITIGEOSS will develop state of the art techniques for forecasting temperature and precipitation in a weekly and monthly basis facilitating the adaptation of agriculture to climate variability. In addition, cutting-edge techniques for improving the accuracy of forecasts will be deployed to enhance model skill and forecasts reliability. Climate forecast (sub-seasonal and seasonal) will be merged with weather forecast to provide seamless predictions for the forthcoming days, weeks and months.
3. **Phenological forecast**: Phenological stages will be automatically detected using EO-derived indexes and in-field images acquired through fixed cameras. Also in this case, supervised machine learning approaches will be used.
4. **Disease management**: Our approach entails deep/machine learning models based on the analysis of most critical parameters (Tª, humidity, leaf area, phenology) and experience of end users that will determine if the conditions are given for an infection to happen. If so, the winegrowers have a window action to spray before the vines get infected, thus saving the vines from irreversible situations.
5. **Sustainability monitoring**: Via a combination of observation techniques VITIGEOSS will support farmers in better resource management while simultaneously providing them the tools to evaluate their production standards. This module is able to optimize the scheduling of tasks during a period of time considering all possible restrictions like, priority, needed/available resources, needed/available skills, average time needed, distances to place with problems. This service can be executed periodically and recalculate the scheduling providing always the suboptimal solution to better fit each scenario. This provides direct insight in the sustainability of the production from the field to the vineyard level.

1.4.2. Innovation potential

While there are several products in the market covering business management aspects of wineries (ERPagro, eVineyard, Vintrace, ISAGRI, Vintegrate, eCellar, eVit), high resolution weather forecasting (Customweather, Weather.com, agro-weather tool), and viticulture features (Climate FieldView™, Vintel®, e-Stratos, AGRICOLUS, Verde), there is not yet in the market a tool that integrates all aspects afore mentioned, interconnecting the outcomes from the different modules for an overall picture.

VITIGEOSS will be the first application offering integrated services for sub-seasonal and seasonal predictions, crop management, disease warnings, business operations and sustainability monitoring. **VITIGEOSS** will transform existing solutions from a local grower service to a regional platform that **not only provides support to growers, but will be a single access point for wine producers that aims to be sustainable and support a circular economy**. The addition of partner services that are at the demonstration level, will significantly boost its functionality without the need for research and development and will make the application unique. **There are no other existing applications combining fruit support, monitoring, disease management, water management and sustainability mapping, thus VITIGEOSS will not only showcase European capabilities, it will make them available to the European wine industry**.

2. Impact

2.1 Expected impacts

Effective engagement of the European commercial sector within EuroGEOSS
VITIGEOSS will interact with the European Commercial sector by submitting an Expressions of Intent to the next EuroGEOSS request of the EuroGEOSS action groups as a joint proposal, aiming to become part of the community. Connection with the action groups will be ensured with the presence of relevant members (CREAF, VITO, ECMFW) in the Advisory Board. Until this opportunity arrives, VITIGEOSS will actively approach member for commercial opportunities, such as by contacting EARSC[22] to explore synergies and find ways to interact with existing EuroGEOSS applications. *KPI_1: Submission Expression of Interest to EuroGEOSS to join the community and interact with their services.* *KPI_2: Association of VITIGEOSS with relevant Action Groups of EuroGEOSS to input into their activities.*
New commercial products and services using GEOSS and Copernicus data and services

[22] European Association of Remote Sensing Companies

Integration of weather forecasts with real-time observations enhance capabilities for efficient commercial wine farming. By doing so, farmers are better advised when to act and in which manner, both in-field and after harvest. GEOSS and Copernicus data and services are core inputs for the perceived service package. Integration and enrichment of this open-source base information leads to an all-round management package for wine producers in Europe which is scalable and affordable.

KPIs: at least 5 new downstream services using Copernicus/GEOSS deployed as standalone applications, plus one modular and interoperable platform for crop management and decision support.

Capacity building among current and potential developers of commercial products

VITIGEOSS will organise technical webinars on integration, homogenisation and standardisation of heterogeneous data sources (interoperability), applied analysis of geospatial data and time series (knowledge), decision support and real-time recommendations (architectures), all led to potential service providers within the wine sector and beyond (to foster the possibility of the exploitation of some particular components of the platform outside of the wine producers community). The latter will strengthen skills, competencies and abilities to advance the development of services and products based on the use of EO systems. Two participatory workshops will be delivered during the second half of the project to share lessons learnt, present the platform to the wine (producers) community and disseminate its main achievements with the focus on spreading the use of EO services among them.

KPI: Number of participants in webinars, workshops and other public events linked to the project (min.40).

Demonstrated capability and reliability of novel EO products and services through the whole value chain

The added value of VITIGEOSS will be demonstrated throughout the whole European wine industry:

1. Farmers, able to increase the yield of their cultivations by enhancing the productivity of existing cultivations and by exploiting new fields previously unproductive.
2. Downstream operators (chiefly Wine producers and Distributors) benefitting from a timely and guaranteed delivery of grapes due to an improved predictability of yields (in terms of both quantity and quality).
3. Upstream operators (e.g., Fertilizers producers), guaranteeing them a better planning of resources and the possibility of improving their products, being involved in the development and improvement of a cutting edge technological solution.
4. Other stakeholders (e.g., retailers, policy makers, environmental organizations, technological centres), all interested in the enhancement of the sustainable products for final customers and/or the eco-sustainability of their business.
5. Society as a whole: increase in food security, new jobs and economic value added to be created; minimise the production of waste & usage of raw materials and reduce gas emissions.

Since VITIGEOSS has already a commercial partner with connections to the wine industry, the penetration of the market in terms of commercialization is assured from the 1st day of the project. Therefore, the market analysis to be performed will be focused on acceptance of the application by wine and agriculture producers. PwC network has an extensive knowledge of wine and agriculture sector and our team has been engaged with several companies on strategic plans, market entry studies, market analyses and business plans in these sectors.

KPI: Business plan completed in draft version by month 18 and in final version by month 30

Mobilising the most dynamic actors of the European commercial sector, developing new EO-derived mass markets and increasing cross-domain exploitation of EO data

VITIGEOSS contributes to a responsible consumption and production of wine by ensuring a sustainable production of its raw material (grapes) minimising inputs as fertiliser and pesticides and by managing water resources. As such, VITIGEOS aims to become the reference for the European wine industry by a) supporting sustainable production of wine by providing a toolbox, and b) by providing unbiased sustainability information that clearly indicates how sustainable a winery is operating. This is a niche market that will mobilise the most dynamic actors of the wine industry supporting a new mass market for wineries, wine buyers, importers and purchase managers as well as investors and consumers who aim to have a sustainable circular lifestyle.

KPI: Production of sustainability mapping displayed in the DSS for the 3 sites