Big Data to Enable Global Disruption of the Grapevine-powered Industries

D8.2 - Experimental Protocols and Evaluation Methodology

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ACRONYMS LIST

BDG	BigDataGrapes
SVIs	Spectral vegetation indices
NDVI	Normalized Difference Vegetation Index
NDRE	Normalized Difference Red Edge Index
ECa	Electrical Conductivity
LAI	Leaf Area Index
UAV	Unmanned Aerial Vehicles
FRAP	Ferric Reducing Antioxidant Power
RH	Relative humidity

EXECUTIVE SUMMARY

The deliverable D8.2, “Experimental Protocols and Evaluation Methodology”, aims to define the experimental protocols and specify the evaluation methodologies that will be activated for each measurement during the execution of the application pilots. A report describing the experiments to be conducted and their parameters, along with the methodology for assessing the results of the experiments in accordance with the piloting plan. In conjunction with the activities of D8.1 “Piloting Plan”, the objective of this deliverable is to provide, in the first part, the experimental protocols to all the pilots, which will constitute instantiations of the use cases already been identified in WP2, and their evaluation methodologies.

Deliverable D8.2, “Experimental Protocols and Evaluation Methodology”, is based on the individual experimental protocols and evaluation methodologies of the following pilots: Table and Wine Grapes Pilot (AUA), Wine Making Pilot (INRA), Farm Management Pilot (ABACO & Geocledian), Natural Cosmetics Pilot (SYMBEEOSIS) and Food Protection Pilot (AGROKNOW). This document reports a detailed overview of the individual experimental protocols and evaluation methodologies for each of the five pilots. Information was directly provided by the pilot leaders to ensure the specificity of the guidelines, the smooth progress and evaluation of the measurements to be conducted.

This deliverable is to be periodically updated to take account of additional protocols and methodologies, measurements and data adopted during the project’s lifetime. This is the 2nd version of the deliverable D8.2.

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1 INTRODUCTION

From Day 1 and throughout the lifecycle of the project, BigDataGrapes will continuously collect and monitor data derived from all test sites owned or accessible by consortium members, bringing an expansive and diverse collection of datasets. These streams of data and datasets will serve as the basis for carrying out research and technical work and will be used as the testbed for enabling the implemented technical components to efficiently handle the volume and intricacies of these data, clearly acquired from realistic in-field conditions. The corporate and public organisations that are producing and harvesting these data assets will contribute them to a data marketplace demonstrator that will serve as the project's experimentation environment, an environment where the testing and adjustment of the proposed technical solutions can be carried out in a realistic setting. As the project progresses, the data pool will be continuously enriched in volume and range, in accordance with the needs and requirements of the covered use cases.

Moving from testing in laboratory conditions to testing in real-world settings, BigDataGrapes will design and execute application pilots, pertaining to the defined Use Cases, under WP8, "Grapevine-powered Industry Application Pilots". The work package will be responsible for the planning and preparation of the pilots, the definition of the experimental and evaluation protocols to be followed, the execution of the pilots and ultimately, the collection and evaluation of the pilot results and their assessment over indicators defined by the end users. A detailed piloting and evaluation plan will be produced and followed during the pilots' execution. In this context, this document provides the plan for developing, executing and evaluating the measurements taking place in the pilots during the BigDataGrapes project lifetime. In conjunction with the activities of T8.1, T8.2 "Evaluation Protocols" will specify the experimental and evaluation protocols that will be activated during the execution of the application pilots. The protocols will explicitly define the parameters of the experiments for each application scenario to be carried out, such as the number of participants, the number of testing subjects, the location and time plan, the factors to be examined and the indicators to be assessed. This document outlines how the experiments and measurements should be designed and deployed, what methodology will be adopted and what materials will be used and how to evaluate their successfulness. The aforementioned detailed experimental and evaluation plan will be produced and followed during pilot execution. The BigDataGrapes Piloting partners will run a set of human-centred assessment activities, organised in the following phases:

Formative phase, leading up to the "Use Case Definition & Assessment Planning" (M9): Industry-centred requirements and the concrete use cases where the BigDataGrapes solution will be applied and tested against these requirements will be defined through WP2 and WP8. During this phase, suitable data and processes for fulfilling the requirements of the specific use cases will be identified and relevant piloting activities will be defined.

Intermediate phase, leading up to "Functional Assessment Sessions" (M18): The first round of controlled pilot trials will implement a first version of the pilots using the first versions of newly developed BigDataGrapes components. These will be restricted piloting trials in terms of scale and complexity. The objectives of these trials are (a) to provide data for the assessment of early BigDataGrapes components and (b) to refine the pilots themselves into their subsequent iterations.

Summative phase, leading up to "Operational Assessment" (M36): The final phase entails the validation of the BigDataGrapes components in real-life conditions and with realistic complexity. The components will be used throughout the timespan, with developments in the technologies incorporated opaquely in the operational platform. A summary of the operation of the system and the respective pilot observations will be delivered, followed by a final evaluation report where the performance of the system will be assessed against the established evaluation criteria and the appropriate Key Performance Indicators.

Evaluation within this project is to be both formative and summative. The former is essentially self-assessment and will be carried out by the project's partners and will be followed in T8.2. The summative evaluation will involve external as well as internal evaluation and it will be used in T8.5 to complete the evaluation of the grapevine-powered industry application pilots. BigDataGrapes clearly distinguishes methodological and functional testing from real-world evaluation by actual users, with the two aspects of the BigDataGrapes solution complementing each other, so as to ensure that technical progress is directed towards improving realistic application of the technology. The implementation of the work plan follows a circular approach, where technical advancements go through experimental testing and are subsequently made available for the application pilots in real-world settings. The evaluation of the BigDataGrapes systems and components, organized in the aforementioned phases, will be centred on realistic, strictly defined experiments that reflect real-life operations of the related industries. Reports will include on-going evaluation of activities and their impact. It is anticipated that these areas will be based on data collected, not only from partners themselves but also from other organizations, in the particular Member States that are participating in the project activities. This approach recognizes that evaluation needs to be placed at the centre of the planning and development processes and also that not only is analysis of information collected for monitoring purposes important but also evaluation from partners and key stakeholders.

The document is structured as follows. Chapter 1 serves as an introduction to the deliverable whereas Chapter 2 provides an overview of the 'Individual Experimental Protocols' and processes to be employed, containing important information regarding the experiments and measurements to be realized by the five pilots. Each of these experimental protocols is separated in four sections: the introduction and the measurement's ultimate goal, the measurement's importance and specific goals, the activity description and the data gathered. The introduction describes the importance of each measurement proposed and contains information to clearly identify why the measurement is being conducted and what it is intended to accomplish, including its ultimate and specific goals, along with any assumptions being made. In the activity description section, the deployment site where the measurements will take place, the experimental procedures and equipment used, along and the expected timeline are included. Finally, the gathered data part constitutes a description of the collected data and datasets. Similarly, Chapter 3 provides the 'Individual Evaluation Methodologies' to evaluate the progress of each experiment/ measurement per pilot. The evaluation methodology includes two parts 1) the '*Measurement's Evaluation Summary*' and 2) the '*Status of implementation*'. In the '*Measurement Evaluation Summary*' pilot partners explained specific objectives, work plan progress, achievement and results, and problems and challenges per measurement for the certain reporting period. The '*Status of implementation*' includes information about the actors, equipment and methodology, gathered data and formats. Chapter 4 is an assessment of the measurements results including an overview of the Data and Datasets that are gathered or are expected to be gathered per measurement performed during the execution of each pilot and Chapter 5 contains the conclusions regarding the experimental protocols and evaluation methodologies.

2 INDIVIDUAL EXPERIMENTAL PROTOCOLS

Data-driven approaches have the potential to improve decision making in different industries and settings. All five Pilot partners (Table and Wine Grapes Pilot - AUA, Wine Making Pilot - INRA, Farm Management Pilot – ABACO & Geocledian, Natural Cosmetics Pilot - Symbeeosis, Food Protection Pilot - Agroknow) provided important information regarding the experimental protocols. These protocols will explicitly define the parameters of the experiments, such as the number of participants, the number of testing subjects, the location and time plan, the factors to be examined and the indicators to be assessed. The aforementioned detailed experimental plan will be produced and followed during pilot execution.

Each of these experimental protocols is separated in four sections: the introduction and the measurement's ultimate goal, the measurement's importance and specific goals, the activity description and the data gathered. The introduction describes the importance of each measurement proposed and contains information to clearly identify why the measurement is being conducted and what it is intended to accomplish, including its ultimate and specific goals, along with any assumptions being made. In the activity description section, the deployment site where the measurements will take place, the experimental procedures and equipment used, along with the expected timeline are included. Finally, the gathered data part constitutes a description of the collected data and datasets.

2.1 TABLE AND WINE GRAPES PILOT EXPERIMENTAL PROTOCOL (AUA)

2.1.1 Topographic Data and Elevation Maps

AUA's Experimental Protocol	Topographic data and Elevation maps
Hypothesis	Real-Time Kinematic positioning systems can record topographical data such as field boundary points and elevation data with millimetre-level positioning accuracy, enabling the creation of highly accurate topographic and elevation maps of the test sites. Topographic data and elevation maps can be used in the following hypothesis scenarios: Yield Prediction, Crop Quality Prediction for Optimizing Post Harvest Treatments of Table Grapes, Optimization of Farm Practices in the Vineyard, Management Zones Delineation for Vineyards.
Introduction & Specific Goals	The topographic elements represent yet another key factor that influences viticultural and oenological characteristics of a given region. Amongst the most important topographic elements for viticulture are elevation, slope degree and aspect/ exposure. Elevation can have a significant impact on vineyard temperatures, thus exerting a strong influence in site and varietal selection. The slope degree of the terrain impacts on canopy microclimate (e.g. through solar exposure), soil erosion, water drainage and viticultural management. The aspect refers to the compass direction to which the terrain faces (e.g. northern/southern exposure), influencing the surface net incoming solar radiation flux, thus being determinant for site selection. These elements further enhance the singularity of viticultural regions, since they influence cultural and management practices. Topographic and elevation measurements provided high accuracy topographical data of the test sites where the measurements will take place throughout the entire project.

Activity Description

Deployment Site
The experimental procedures take place in three test sites in the north-eastern part of Peloponnese, Greece: Palivou Estate, Kontogiannis Estate and Fasoulis Estate as presented in the Apparent Soil Electrical Conductivity (ECa) Experimental Protocol above.

Experimental Procedures
The system consists of two parts, a stable base and a mobile rover. The handheld rover with the GPS receiver on top is used to collect georeferenced points of the fields' boundaries as well as elevation data while the base acts as a reference point that minimizes positioning errors.

Figure 4: Topcon HiPer V RTK GPS

Tech Components
- HiPer V RTK GPS (Topcon Positioning Systems Inc., Livermore, CA, United States). Records topographical data, such as field boundary points, and elevation data (Kitchen et al., 2005; Pedersen & Lind, 2017). This includes: a HiPer V GNSS Rover Receiver, a HiPer V GNSS Base Receiver and a Topcon Controller used to configure and set up the receivers.

Time plan
This measurement is performed once throughout the course of the first season of the project, at the beginning of the table grapes pilot, prior to all other measurements.

Replications and Number of Seasons
This measurement will not be repeated since there is no temporal variability in positioning data of the test sites.

Gathered Data

- *Dataset Name:* Topographic data and elevation maps.
- *Data Description:* Spatial data (boundaries and elevation data).
- *Provenance:* Remote sensing.
- *Data Type Format:* csv, xls, xml. The final output can be a KML, KMZ file.
- *Data size:* MB.

	The data will be presented with maps that demonstrate the exact positions of the fields' boundaries and elevation maps.

2.1.2 Apparent Soil Electrical Conductivity (ECa)

AUA's Experimental Protocol	Apparent Soil Electrical Conductivity (ECa)
Hypothesis	Electrical Conductivity Maps are used for in-field variability observations and management zones delineation of the test sites. Apparent soil electrical conductivity data can be used in the following hypothesis scenarios: Yield Prediction, Crop Quality Prediction for Optimizing Post Harvest Treatments of Table Grapes, Optimization of Farm Practices in the Vineyard, Management Zones Delineation for Vineyards.
Introduction & Specific Goals	Soil electrical conductivity is a parameter that demonstrates high spatial variability. The fact that ECa is directly connected to several soil attributes of major importance such as soil structure, salinity and water content sets it as a reliable and the most widely used variable for management zones delineation. In viticulture it is used to estimate edaphic parameters that condition vineyard productivity. The most extensively studied application of the ECa measurement concerns the assessment of salinity of vineyards in grape (Bramley and Lanyon 2002; Bramley 2004; Bramley and Hamilton 2004), as well as long-term effects of irrigation (De Clercq and Van Meirvenne, 2005) and it has also been used to map soil texture in viticulture areas (Winkel et al. 1995, Hedley et al. 2004). The most extensive current applications are related to precision viticulture, as the ECa can estimate spatial patterns of grape yield (Bramley 2003). Spatial heterogeneity of yield creates a strong basis for developing site-specific practices, however, in viticulture quality parameters take precedence as well.
Activity Description	*Deployment Site* The experimental procedures take place in three test sites in the north-eastern part of Peloponnese, Greece: Palivou Estate, Kontogiannis Estate and Fasoulis Estate. Palivou Estate: is located in Nemea, planted with *Vitis vinifera* L. cv. 'Agiorgitiko' and 'Merlot' for winemaking. The row orientation is northeast-southwest, and the training/trellis system is VSP (vertical shoot positioned) - cane pruning, double Guyot.

Figure 1: Palivou Estate test site (Google Earth Pro)

Kontogiannis Estate: in Ancient Corinth having the same VSP -double Guyot or double Royat- training/trellis system planted with 'Roditis', 'Savatiano', 'Mavroudi' and 'Soultanina' for winemaking. Its row orientation is north to south.

Figure 2: Kontogiannis Estate test site (Google Earth Pro)

Fasoulis Estate: situated in Nemea, cultivated with 22 different table grape varieties, where each line has a different variety. The orientation is southeast to northwest.

Figure 3: Fasoulis Estate test site (Google Earth Pro)

Experimental Procedures
There exist a number of procedures for measuring soil ECa at the field scale. A primary method is the electromagnetic induction (McNeill 1980b). The most commonly used electromagnetic induction conductivity meter for agricultural purposes is the EM38 (Geonics Limited, Mississauga, Ontario, Canada) because of ease of use and a functional measurement depth (Corwin and Lesch 2005). The EM38 can be placed in the horizontal coil configuration, where its effective signal detection is from 0.75 m, or in the vertical coil configuration with an effective signal detection depth of 1.5 m. These depths generally correspond well with the depth of the grape-rooting zone.

Measurements of soil ECa were collected using an EM38 soil electrical conductivity meter. The EM38 is used, positioning the instrument in both the horizontal and vertical modes of dipole orientation for the estimation of soil ECa. The EM38 instrument is calibrated before each measurement following Geonics Limited (1999) instructions. The sensor is placed in a wooden sleigh with a plastic base, which is then fastened with a 2 meters long rope to the tractor. Soil electrical conductivity measurements were taken by placing the EM38 in the center of the alley and taking readings. The sensor collects data while the tractor cruises across the field and stores it to the Archer Data Logger from which is then retrieved when the entire field has successfully been scanned.

Figure 4: EM38-MK2 and Archer Data logger

Figure 5: EM38-MK2 placed on its sleigh

Tech Components

- EM38-MK2 probe (Geonics LTD, Mississauga, ON, Canada). The EM38 measures apparent soil electrical conductivity (ECa) in millisiemens per metre (mS/m) in the root zone at 0.5 and 1.0 m depth and the in-phase ratio of the secondary to primary magnetic field in parts per

	thousand (ppt) (Kitchen et al., 2005; Anastasiou at al., 2017; Balafoutis et al., 2017). - The georeferenced data collection is supported by the DAS70-AR Data Acquisition System (Archer Data logger). - The sleigh that is made of wooden and plastic materials in order to avoid interference to the accuracy of the measurements from metallic objects. *Time plan* This measurement was performed once at the beginning of the first season of the project (May 2018), the beginning of the table and wine grapes pilot, prior to all other measurements. *Replications and Number of Seasons* This measurement will be performed once at the beginning of each season, to study the temporal variability and annual changes of Soil Electrical Conductivity. In total three (3) EM38 campaigns will be undertaken at the beginning of the growing season each year of the project's lifetime (May 2018, April 2019, April 2020).
Gathered Data	- *Dataset Name:* ECa sensing. - *Data Description:* Geo-referenced soil electrical conductivity data. - *Provenance:* Proximal sensors. - *Data Type Format:* csv, xls. - *Data size:* MB. The data will be presented with maps that demonstrate the spatial variability of the test sites' ECa.

2.1.3 Canopy Sensing and Vegetation Indices

AUA's Experimental Protocol	Canopy sensing and vegetation indices
Hypothesis	Combination of canopy reflectance values in different spectrums can create indices that represent plant health, stress, vigour etc. Crop monitoring during different phenological growing stages can provide data throughout the entire growing season and act as an indicator of anomalies. Canopy sensing and vegetation indices can be used in the following hypothesis scenarios: Yield Prediction, Crop Quality Prediction for Optimizing Post Harvest Treatments of Table Grapes, Optimization of Farm Practices in the Vineyard, Management Zones Delineation for Vineyards.
Introduction & Specific Goals	Non-destructive methods, such as proximal sensing, are widely used to estimate crop yield and quality characteristics, and spectral vegetation indices (SVIs) are commonly used to present site-specific information. Georeferenced data from sensors that measure the reflectance of the plants can generate maps that indicate the overall condition of the crops, potential stresses, pest infestations and disease outbreaks in different zones of the field. The most well-known SVI is the Normalized Difference

Vegetation Index (NDVI). NDVI has been correlated with crop parameters, such as wet biomass, leaf area index, plant height and grain yield. Based on the NDVI, more indices have been generated that present equal or better performances in the estimation of crop-related parameters and are based on the same or different bands of the electromagnetic spectrum, such as the Normalized Difference Red Edge Index (NDRE).

Activity Description

Deployment Site

The experimental procedures take place in three test sites in the north-eastern part of Peloponnese, Greece: Palivou Estate, Kontogiannis Estate and Fasoulis Estate as presented in the Apparent Soil Electrical Conductivity (ECa) Experimental Protocol above.

Experimental Procedures

Proximal sensing is based on the usage of ground-based moving vehicles carrying various types of sensors that are suitable for continuous measurements of soil or canopy parameters. Two different canopy reflectance sensors, Crop Circle ACS-470 (ACS-470, Holland Scientific Inc., Lincoln, NE, USA) and SpectroSense2+ GPS (Skye Instruments Ltd, Landrindod Wells, UK) are mounted on a tractor in a way that the spectral sensors face the canopy of the vines (Figure 8). Vegetative indices measurements are done in two different canopy parts, by the side and at upper canopy of the vines, by fitting the equipment to a winegrowing tractor. The proximal canopy sensors are located at a height of 1.5 m from the soil surface and 1.2 m horizontally from the vines is used to scan the side canopy area in order to assess crop vigour from proximal sensing. As the tractor cruises across the field, georeferenced data are collected and stored in an external memory card (Crop Circle ACS-470) or within the system (Spectrosense2+).

Three lenses with different band absorptions are used to calculate the above SVIs with the Crop Circle canopy sensor (550 nm—GREEN, 670 nm—RED and 760 nm—NIR). The reason for choosing the NIR wavelength was its high reflection in healthy leaves due to its relationship with many leaf structural features (Vescovo et al., 2012). The red wavelength region was chosen because it presents strong absorption peaks for assessing the chlorophyll content (Wu et al., 2008) and some researchers have found that higher absorption in the green wavelength region increases the efficiency of plant photosynthetic activity compared to the red wavelength region (Tereshima et al., 2009).

Additionally, in cases when tractors could not enter the vineyards at the time/date of the measurements (i.e. recent rainfall resulting to high water content), the sensors were used as handheld units to collect data, along with a Crop Circle RapidScan CS-45 hand held sensor. The CS-45 can also measure canopy reflectance in the bands of Near Infra-Red, Red and RedEdge, while georeferenced data is stored within the unit.

Tech Components

- Crop Circle ACS-470 (Holland Scientific Inc., Lincoln, NE, United States) (Figure 5). This remote sensing tool is measuring the radioactive transfer and the biophysical characteristics of plant canopies. It is an active crop canopy sensor that provides basic reflectance information from plant canopies and soil as well as classic spectral vegetative index data (NDVI, NDRE etc.).

Figure 6: Crop Circle ACS-470

- SpectroSense2+ GPS (Skye Instruments Ltd, Landrindod Wells, UK) (Figure 6). Used to estimate LAI (Leaf Area Index) and NDVI vegetation indices.

Figure 7: SpectroSense2+ GPS

- Crop Circle RapidSCAN CS-45 (Holland Scientific Inc., Lincoln, NE, United States) (Figure 7). Used to estimate vegetation indices such as NDVI and NDRE indices.

Figure 8: Crop Circle CS-45

- Software such as Surfer 11 (Golden Software), ArcGIS (ESRI, Redlands, CA, USA), Global Mapper for the generation of thematic maps Crop Circle ACS-470 sensor.
- Metallic structure that allows the sensors to be mounted on the tractor (Figure 8).

Figure 9: Both canopy sensors mounted on a tractor

Time plan

Six (6) measurements per season will be performed each summer, to record in the most precise way the phenological development of the grapevine, which is divided into 9 principal growth stages. The data is used to estimate Leaf Area Index (LAI) and vegetation indices (NDVI and NDRE) and produce spatial variability maps.

	Replications and Number of Seasons This measurement will be repeated a total of eighteen (18) times over the three (3) years period of the project's lifetime.
Gathered Data	- *Dataset Name:* Canopy sensing and vegetation indices. - *Data Description:* Canopy sensing data. - *Provenance:* Proximal sensors. - *Data Type Format:* csv, xls. - *Data size:* MB. The data will be presented with maps that demonstrate the temporal and spatial variability of the test sites in vegetation indices.

2.1.4 Drone Imagery

AUA's Experimental Protocol	Drone Imagery
Hypothesis	Unmanned Aerial Vehicles (UAV), or simply Drones, are small nimble remote-controlled aircrafts that, if equipped with multispectral or thermal cameras, can swiftly generate large amount of high-quality data and enable the scan of large fields in only a few minutes. Drone imagery can be used in the following hypothesis scenarios: Yield Prediction, Crop Quality Prediction for Optimizing Post Harvest Treatments of Table Grapes, Optimization of Farm Practices in the Vineyard, Management Zones Delineation for Vineyards.
Introduction & Specific Goals	Georeferenced imagery data from multispectral cameras are used to monitor the overall health and condition of the crops, while thermal cameras can provide information about the water status variability and water needs of the crops in different zones of the field and the optimal irrigation timing.
Activity Description	*Deployment Site* The experimental procedures take place in three test sites in the north-eastern part of Peloponnese, Greece: Palivou Estate, Kontogiannis Estate and Fasoulis Estate as presented in the Apparent Soil Electrical Conductivity (ECa) Experimental Protocol above. *Experimental Procedures* A defined set of waypoints can be pre-programmed to form a set flight path. Flight planning software calculates the spacing and layout of waypoints to acquire data over the region of interest at a nominated image scale. Imagery is typically acquired at the maximum rate allowed on the device, thereby providing redundancy to account for elimination of imagery with excessive tilt, motion blur or bad exposure. *Tech Components* - Two Phantom 4 Pro drones (Dà-Jiāng Innovations, Shenzhen, Guangdong, China) (Figure 9). - Parrot Sequoia+ Multispectral sensor (Parrot SA, Paris, France).

- FLIR Vue Pro thermal infrared sensor (FLIR Systems Inc., Wilsonville, Oregon, United States) to estimate water activity among others.

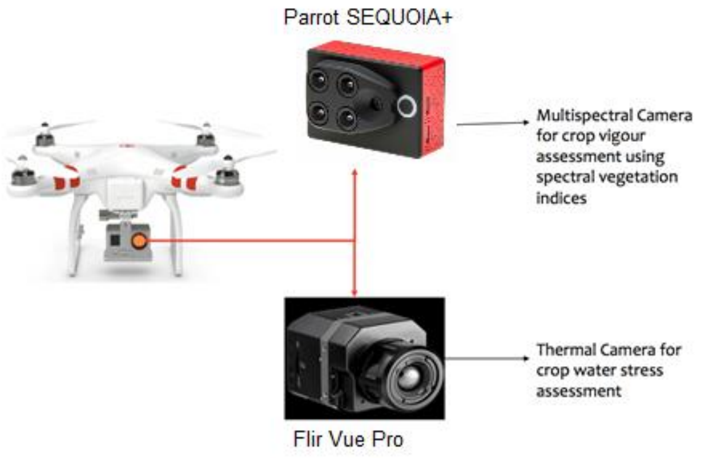


Figure 10: Phantom 4 Pro drone equipped with multispectral or thermal camera

Time plan
Similarly, to the measurements for the canopy characteristics, drone imagery with thermal and multispectral cameras will be collected during the same periods. Six (6) measurements per season will be performed each summer, to record in the most precise way the phenological development of the grapevine, which is divided into 9 principal growth stages.

Replications and Number of Seasons
This measurement will be introduced during the 2019 season and will be repeated a total of twelve (12) times over the three (3) years period of the project's lifetime.

Gathered Data	- *Dataset Name: Drone Multispectral and Thermal Imagery.* - *Data Description: Drone Images.* - *Provenance: Aerial Sensing.* - *Data Type Format: Georeferenced .TIF and .JPG.* - *Data Size: GB.*

2.1.5 IoT Stationary

AUA's Experimental Protocol	IoT Stationary
Hypothesis	Weather and soil data can be used in the following hypothesis scenarios: Yield Prediction, Crop Quality Prediction for Optimizing Post Harvest Treatments of Table Grapes, Optimization of Farm Practices in the Vineyard, Management Zones Delineation for Vineyards.
Introduction & Specific Goals	Climate, also an important component of the terroir, is widely acknowledged as one of the most important factors for grapevine development and growth. During the growing season (April–October in the Northern Hemisphere), climatic conditions exert a significant influence

	on vine physiological processes. It has been shown that the timings and duration of the grapevine phenological stages are deeply tied to the prevailing atmospheric conditions, which also contribute to variability in grapevine yield, wine production and quality. All these climatic factors limit the geographic distribution of grapevine, being also key factors in determining the suitability of a given region for specific varieties and wine types.
Activity Description	*Deployment Site* The experimental procedures take place in three test sites in the north-eastern part of Peloponnese, Greece: Palivou Estate, Kontogiannis Estate and Fasoulis Estate as presented in the Apparent Soil Electrical Conductivity (ECa) Experimental Protocol above. *Experimental Procedures* The automatic weather stations were installed inside the vineyard. Weather information is being recorded in real-time throughout the growing season. Similarly, the soil moisture sensors are continuously recording the humidity and temperature of the soil. *Tech Components* - Two Vantage Pro 2 weather stations (Davis Instruments Corp., Hayward, CA, United States) (Figure 10) with rain sensor, to detect rainfall, anemometer to measure wind speed and direction, air temperature sensor, air humidity sensor, barometer to monitor atmospheric pressure. The basic equipment can be supplemented with sensors for UV and solar radiation. - Four Decagon EC-5 soil moisture sensors (METER Group, Inc., Pullman, WA, USA) recording the humidity and temperature of the soil.  **Figure 11: Vantage Pro2 Weather Station (left) and Decagon EC-5 soil moisture sensor (right)** *Time plan* Weather and soil information will be continuously collected in real-time throughout the growing season, starting on Day 1 of the project.
Gathered Data	- *Dataset Name: IoT Stationary data.* - *Data Description: Soil moisture and meteorological parameters.* - *Provenance: IoT data.* - *Data Type Format:* csv, xls. - *Data Size: MB.*

2.1.6 Yield Mapping

AUA's Experimental Protocol	Yield Mapping
Hypothesis	Yield mapping can be used in the following hypothesis scenarios: Yield Prediction, Crop Quality Prediction for Optimizing Post Harvest Treatments of Table Grapes, Optimization of Farm Practices in the Vineyard, Management Zones Delineation for Vineyards.
Introduction & Specific Goals	Ever since the first adoptions of precision viticulture, the need of accurate yield predictions has become obvious. Yield estimations can help the growers optimize variable rate applications, the timing of harvest operations, as well as storage and shipping of their production.
Activity Description	*Deployment Site* The yield estimation takes place at the Palivou Estate, as presented in the Apparent Soil Electrical Conductivity (ECa) Experimental Protocol above. A regular grid of 100 cells (6.6 m x 2.2 m per cell) was set up to facilitate field sampling in order to assess crop vigour, yield and grape quality covering the total area. *Experimental Procedures* The grapes are hand harvested in late August – middle September. The actual yield is estimated during the harvest period by measuring the total number of bins per cell and multiplying it with the average bin weight of the harvested grapes. *Tech Components* - To estimate the weight of the bins field with grapes a hand-held scale is used. *Time plan* The yield mapping is being estimated once per year. The grapes are hand harvested in late August – middle September.
Gathered Data	- *Dataset Name: Yield Mapping.* - *Data Description: Yield data.* - *Provenance: Laboratory equipment.* - *Data Type Format:* csv, xls. - *Data Size: MB.*

2.1.7 Qualitative and Quantitative Characters

AUA's Experimental Protocol	Qualitative and quantitative characters
Hypothesis	In order to perform more accurate yield and crop quality predictions of table and wine grapes as well as the post-harvest treatments of table grapes, it is important to monitor the maturation of the grapes. At harvest and according to the technological maturity, grapes are characterized by specific qualitative and quantitative characters. If these data coming

	directly from the grapes are correlated with data coming from the field (like sensor data, etc.), more accurate predictions will be made.
Introduction & Specific Goals	Qualitative and quantitative data are important in order to make yield and crop quality predictions of the grapes and the post-harvest treatments depending on their use (table grapes or wine grapes) and according to the consumers' trends.
Activity Description	*Deployment Site* The experimental procedures take place in the Laboratory of Viticulture (Vitis Lab), Agricultural University of Athens. Grapes collected from the three test sites in the north-eastern part of Peloponnese, Greece (namely Palivou Estate, Kontogiannis Estate and Fasoulis Estate) will be transferred to the Vitis Lab where all measurements and analyses will take place. *Experimental Procedures* The samples collected undergo preparation in Vitis Lab, according to the protocols and methodologies that will be followed. *Tech Components* - UV/ Vis spectrophotometer (Perkin Elmer, Lambda 25, Beaconsfield, Bucks, U.K.). - HPLC Shimadzu Nexera comprising a gradient pump Shimadzu Nexera X2, a ProStar model 410 AutoSampler, and a ProStar model 330 Photodiode Array Detector on a reversed-phase Waters C18 x select (250 mm x 4.6 mm, 5 mm) column. - ATAGO N1-a refractometer with a 0-32 Brix measurement range at 0.28 Brix increments. *Time plan* The measurements will be repeated every year. Some of the qualitative and quantitative characters of the grapevines, such as pH, soluble solids, total titratable acidity, antioxidant capacity by DPPH, FRAP assay, and aminoacids, will be tested and assessed at the end of each season, when harvesting. The grape and berry mechanical properties (weight, length, width, density etc.), berry deformation, berry detachment, density, grape volume, berries diameter, berries weight for table grapes will be measured at post-harvest. *Replications and Number of Seasons* The measurements will be repeated every year at various growth stages according to the maturity of the grapes over the three (3) years period of the project's experiments.
Gathered Data	- *Dataset Name:* Qualitative and quantitative characters. - *Data Description:* Qualitative and quantitative data. - *Provenance:* laboratory analyses. - *Data Type Format:* csv, xls. - *Data size:* MB.

2.2 WINE MAKING PILOT EXPERIMENTAL PROTOCOL (INRA)

2.2.1 Viticulture and Grapes Quality

<table>
<tr><th>INRA's Experimental Protocol</th><th>Viticulture and Grapes Quality</th></tr>
<tr><td>Hypothesis</td><td>Crop Quality prediction for optimizing winemaking.</td></tr>
<tr><td>Introduction & Specific Goals</td><td>The INRA's experimental unit of Pech Rouge (UEPR) is dedicated to research in the fields of viticulture and oenology with an integrated point of view that allows a transversal approach from the vineyard to the packaged final product. The unit conducts research and technological experiments on:
- Viticulture and the ecophysiology of the vine, with as a main issue a better knowledge and better control of grape quality.
- Enology with, as major research axes, the expression of quality potential existing in the grapes and wines and the on-line monitoring and control of the alcoholic fermentation.
- Technological processes with the aim to propose and study innovative technologies applicable to various steps of winemaking.
- The valuation of coproducts, extraction of molecules and environmental impacts.</td></tr>
<tr><td>Activity Description</td><td>Deployment Site
The INRA Pech Rouge Experimental Unit is located N43°08'47', E03°07'19' WGS84, in the Occitanie region (Aude department) of France. The landfield of Pech Rouge includes a total area of 170 ha of land planted with 38 hectares of vines, distributed in three areas. The INRA Pech Rouge Experimental Unit also contains analytical laboratories, technological tools and finally a Sensory Analysis Laboratory, which enables the tasting of different wines.


Figure 12: Landfield of Pech Rouge (INRA, France) (Google Maps)</td></tr>
</table>

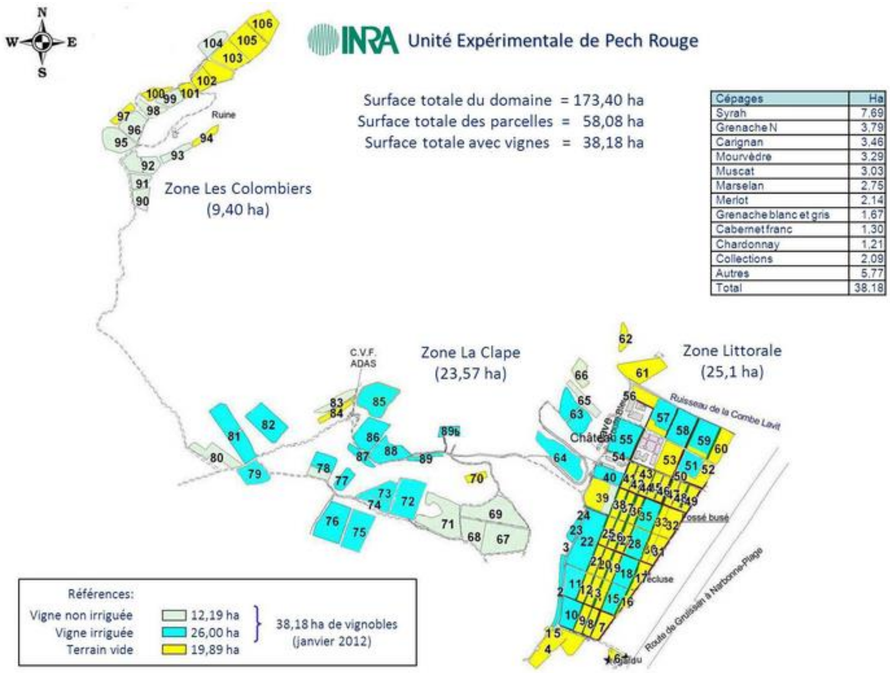


Figure 13: INRA Pech Rouge Experimental Unit

Experimental Procedures

In function of project goals, diverse variables were measured, and diverse protocols have been conducted.

Research topics are mainly related to the agro-climatic and social context of the South of France. It can be summarised as follows: hot climate, dryness, climate change, pH and K+ elevation, grapes and wine acidity diminution, irrigation, varieties selection, vineyard cultural practices, diversification, sensors.

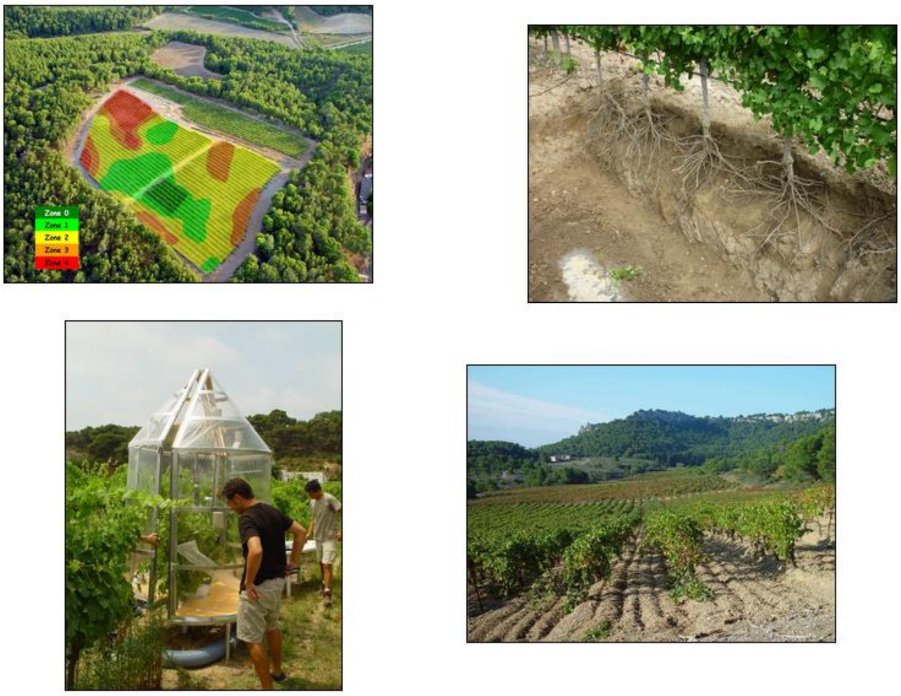


Figure 14: Experiments at Pech Rouge Team Viticulture / Quality Grapes

Tech Components

- Climatic data

Climatic data are monitored by a weather station. These climatic data are used to compute the reference evapotranspiration (ETo) according to Allen et al. (1998).

- Field data / Grapes data / Measures at different scales

The landfield of Pech Rouge includes a total area of 170 ha of land planted with 38 hectares of vines, distributed in three areas.

Time plan

The following figure (14) shows chronology of measurements at Pech Rouge:

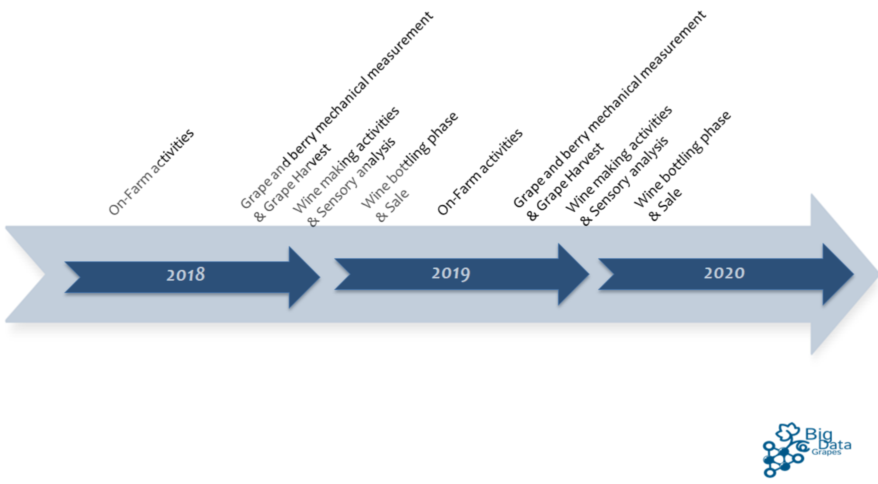


Figure 15: Timeline of Wine Making piloting plan

	Replications and Number of Seasons
	Number of seasons depends on the project. For example, data from one of our datasets were measured for three years, from 2012 to 2014, and measurements were repeated for each grapevine lifecycle.
	
	Example of measurements - Operations:
	- Installation of specific devices (sensors…)
	- Harvest
	- Sampling and analysis
	- Phenological stages (Budding, flowering and veraison)
	  • Sampling: 15 grapevine per repetition
	  • Frequency: 2 dates per stages
	- Maturity (weight of 200 berries, sugar, total acidity, pH, assimilable nitrogen, anthocyanins, polyphenols)
	  • Sampling: 200 berries per treatment + 200 berries for anthocyanins and polyphenols
	  • Frequency: 14 days before harvest, 7 days before harvest and at harvest
	- Aroma precursors
	  • Sampling: 20 bunch of grape/treatment
	- Yield
	  • Sampling: 15 grapevines / repetition at harvest
	- LAI (leaf area index)
	  • Sampling: 4 transepts per treatment

Gathered Data	*Climatic Data* - *Dataset Name: AGROCLIM.* - *Data Description (Operation): Data measured with sensors assessing variables related to climate, environment.* - *Provenance: CLIMATIK web tool which gather data from sensors.* - *Data Type Format: xls.* - *Data size: MB.* *INRA workers have access to CLIMATIK database, which is online. With a map, relevant sensors can be chosen to collect data.* *Field and Grapes Data / Farm practices* - *Dataset Name Silex VitiOeno.* - *Data Description (Operation): data related to field and grapes at Pech Rouge or collected for projects with INRA involved.* - *Provenance: Vinnotec.* - *Data Type Format: xls.* - *Data size MB.* *INRA workers have access to Vinnotec database which is online. The request can be done with the year of interest, varieties, fields and all data related to the request are listed. Then, variables can be extracted and for each variable, the study scale is written (grapevine, aera...).* *Phenotypic Data* - *Dataset Name: PHIS.*

	- *Data Description (Operation): several pictures are taken every day for each plant + data from sensors.* - *Provenance: PHIS - Inra unit called LEPSE, phenotypic platform: high speed data gathering.* - *Data Type Format: csv + images.* - *Data size MB.* *Genetic Data* - *Dataset Name: French Network of Grapevine Repositories "Réseau Français des Conservatoires de Vigne".* - *Data Description (Operation): grapevine genetic resources.* - *Provenance: bioweb supagro.* - *Data Type Format: csv.* - *Data size: MB.* This database contains huge information on grapevine genetic resources. Information are presented in several tables such as: details, aptitudes, accessions, location in collections, morphological description or genetic profile.

2.2.2 Winemaking And Wine Quality

INRA's Experimental Protocol	Winemaking and Wine Quality
Hypothesis	Crop Quality prediction for optimizing winemaking.
Introduction & Specific Goals	The INRA's experimental unit of Pech Rouge (UEPR) is dedicated to research in the fields of viticulture and oenology with an integrated point of view that allows a transversal approach from the vineyard to the packaged final product. The unit conducts research and technological experiments on: - Viticulture and the ecophysiology of the vine, with as a main issue a better knowledge and better control of grape quality. - Enology with, as major research axes, the expression of quality potential existing in the grapes and wines and the on-line monitoring and control of the alcoholic fermentation. - Technological processes with the aim to propose and study innovative technologies applicable to various steps of winemaking. - The valuation of coproducts, extraction of molecules and environmental impacts.
Activity Description	*Deployment Site* The deployment site is INRA's Pech Rouge Experimental Unit as described in the Viticulture and Grape Quality Experimental Protocol above. *Experimental Procedures* First, information related to harvest are recorded. Then, different operations are monitored during the winemaking process. For example, some observational data are done concerning the different product features and also observational results of some attributes for a particular

product stage such as grape, initial must, must after alcoholic fermentation, and finished wine (such as sensorial analysis achieved by judges).

Here, Figure (15), is an example of the different steps of winemaking done at Pech Rouge for red wines.

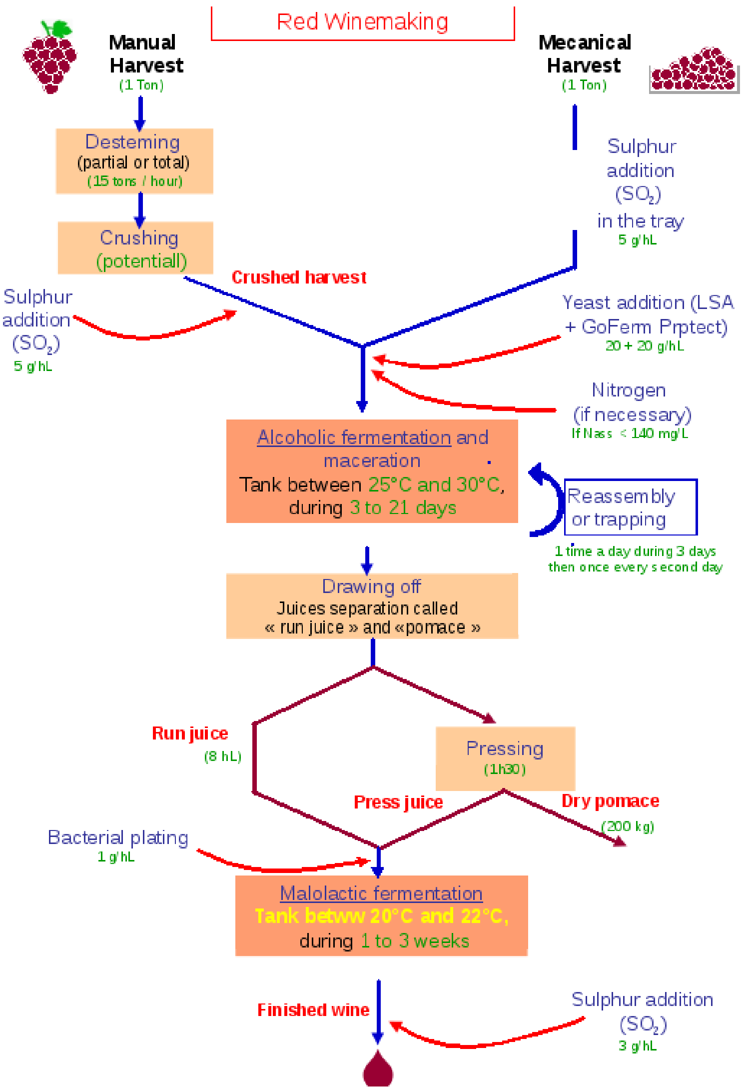


Figure 16: Steps for winemaking taking place in Pech Rouge

Tech Components

The experimental unit possess 5000 m² of buildings representing experimental facilities and different installations (winemaking unit, microbiology, delayed fermentation, extraction and separation techniques, ageing, etc.) - covering a total of nearly 5000 m².

- Experimental technological facilities:
    - A technological facility dedicated to grape extraction, grape processing and winemaking for experimental work scales from 100 kg to 5 tonnes. This winery is equipped with various facilities:

desteammer, juicer, pressing units, flash release equipment, centrifuges, tangential filters, earth filters, various tanks, etc.

- A technological facility for delayed fermentations allowing alcoholic fermentations under controlled conditions with on-line acquisition of fermentation kinetics (16 100L-fermenters and 4 10L-fermenters). This facility is equipped with a plate pasteurizer and a storage room for storage of stabilized musts under aseptic conditions (at 2 °C) with a total capacity of 210 hl. In addition, it has new online monitoring equipment for the determination of volatile compounds in fermentation gases on 4 fermenters.

Figure 17: INRA Technological Facilities – Delayed Fermentations

- A technological facility dedicated to the technologies of separation/ fractionation (electro-membrane and membrane processes, distillation processes and membrane contactors).
- Winery (a winery with traditional concrete tanks with a total volume of 1200 hl, and a more recent technological winery with stainless steel vats and tanks for a total capacity of 1500 hl).
- Packaging facility (two bottling lines for wine lots ranging from 20 L to 100 hl with control of dissolved gases (oxygen and carbon dioxide).
- Barrel cellar (Chai) with a capacity of 60 oak barrels (15 to 17 ° C, with humidity control).

Figure 18: Oak Barrel Cellar

- Wine bar: for the storage of all experimental wines up to a 4 years period.

Laboratory Analysis:
Neutral sugar amount is calculated relative to the allose (Albersheim et al., 1967). Polyphenol monomers are analyzed by HPLC-DAD according to the procedure described in Ducasse et al. (2010). Tannins are analyzed by HPLC after acid-catalyzed depolymerization reaction in the presence of a nucleophilic agent. The acid-catalyzed cleavage are carried out in the presence of excess 2-mercaptoethanol, according to the protocol developed by Roumeas, Aouf, Dubreucq, and Fulcrand (2013).

The performance of spectrophotometric measurements was applied using UVmc2 spectrophotometer (Figure 18).

Figure 19: SAFAS UV-mc² Spectrophotometer

Sensorial Analysis:
During sensory analysis sessions, the wine samples (40 mL) are served in black glasses following a monadic order (Latin square) in order to minimize carry-over effects (Macfie, Bratchell, & Greenhoff, 1989). The samples are identified by a set of three digits random codes, which are different for each judge and each sample. The wine analysis is intended to be purely olfactory. In this purpose; the glasses were covered with a lid. The terms listed by the judges are grouped together into term families in accordance with the Pearson correlation, the Wine Aroma Wheel (Noble et al., 1987).

Figure 20: Sensorial Analysis Platform

Time plan

The following figure (20) shows chronology of measurements at Pech Rouge:

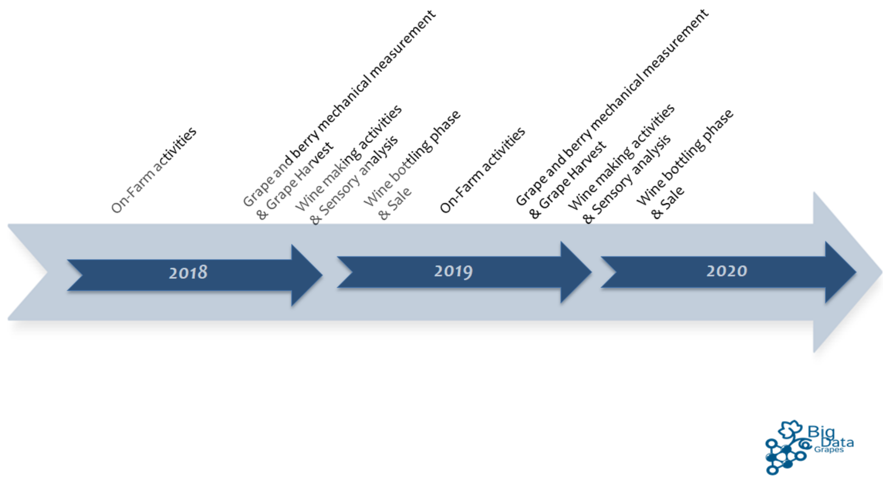


Figure 21: Timeline of Wine Making piloting plan

Replications and Number of Seasons

Number of seasons depends on the project. Measurements are repeated for each grapevine lifecycle in function of projects goals.

Gathered Data

Winemaking activities

- *Dataset Name: Winemaking Activities.*
- *Data Description (Operation): Bioconversion of sugar into ethanol and CO2, monitoring of alcoholic fermentation and sugar content, yeast characteristics, monitoring of winemaking process.*
- *Provenance: laboratory equipments/ ALFIS.*
- *Data Type Format: xls and hand-written.*
- *Data size: MB.*

Laboratory analysis

- *Dataset Name: chemical and physical analysis.*
- *Data Description: chemical and physical analysis of must and wine.*
- *Provenance: laboratories from Pech Rouge.*
- *Data Type Format: xls.*
- *Data size: MB.*

Sensory analysis

- *Dataset Name: Sensory Analysis.*
- *Data Description (Operation):* Expert panel of tasters' sensory analysis (wine bitterness, astringency, phenol content, aroma etc.).
- *Provenance: experts' analysis.*
- *Data Type Format: xls.*
- *Data size: MB.*

Alcoholic fermentation

- *Dataset Name: ALFIS.*

	- *Data Description (Operation): Expert panel of tasters' sensory analysis. (wine bitterness, astringency, phenol content, aroma etc.).* - *Provenance: fermenters from Pech Rouge and another unit "SPO". Sciences for oenology.* - *Data Type Format: csv.* - *Data size: MB.*

2.3 FARM MANAGEMENT PILOT EXPERIMENTAL PROTOCOL (ABACO – GEOCLEDIAN)

2.3.1 Farm Management

Abaco – Geocledian Experimental Protocol	Farm Management
Hypothesis	Earth Observation Data Anomaly Detection & Classification, Optimization of Farm Practices in the Vineyard, Management Zones Delineation for Vineyards.
Introduction & Specific Goals	The ABACO and Geocledian Farm Management Pilot is focused on developing a unique system that satisfies these needs: - Farm Management with all the functionalities to support the farmer in his day by day activities and gather data from the field. - Hosting data from different sources with proper tools and functionalities for comparisons and easy data management. - Data exchange. A "day by day" data producer, to feed the generated data into the other BDG components and make use of the incoming information from the other BDG components. - Data visualization. The data relevant for the farmer should be displayed in a way that provides an added value and new insights to the farmer for his activities. Two wine makers were identified as actors in this pilot. They will be involved in the pilot in two ways: - They will be supported in their work by making the developed products and systems available to them. In addition to the farm management system itself, this includes sensors and measurements that will provide data as basis for decision support. - On the other hand, these actors can help in designing the new system by providing input and knowhow about their needs and activities. They can also give insights on how to disseminate results, approach and ideas of the BigDataGrapes Project.
Activity Description	*Deployment Site* The approach expects to involve 2 wineries, making them an active part of the project, collecting data from the field, in automatic and manual manners, and therefore contribute to the results. Company Name: CASATO PRIME DONNE CIRCA Address: Località Casato – Montalcino, Tuscany, IT GPS Coordinates: 43.088196° N 11.464319° E

Internet Site: www.cinellicolombini.it
12 HA of wineyards of Brunello of Montalcino

Figure 22: 12 HA of wineyards of Brunello of Montalcino

Company Name: CANTINA IL PALAZZO
Address: Loc. Antria, Arezzo, Tuscany, IT
GPS Coordinates: 43.502773, 11.904402
Internet Site: www.tenutailpalazzo.it
35 HA of Wineyards of CHIANTI D.O.C.

Figure 23: 35 HA of Wineyards of CHIANTI D.O.C.

Geocledian plans to acquire satellite data of one additional test site with pergola cultivation to compare the spectral behaviour of different vineyard cultivation types.

Tech Components

- Abaco is going to release a version of its product, SITI4farmer (Figure 23) ready to be used in the field, by the 2 different winemakers, and all the project partners.

  SITI4farmer is able to (with just an internet connection trough browser):
  - Preparation of the graphical crop plan.
  - Managing farming practices and phenology phases.
  - Analyze indices and dashboards to support decisions (agro-meteorology and vegetation).
  - Keeping farm data organized and accessible.
  - Recording field data with the SITI4land app.

- Printing and export data.

Furthermore, it's able to integrate weather data and services from different sources, also, it can use open databases and local land registries made available by everyone that has an exposed service.

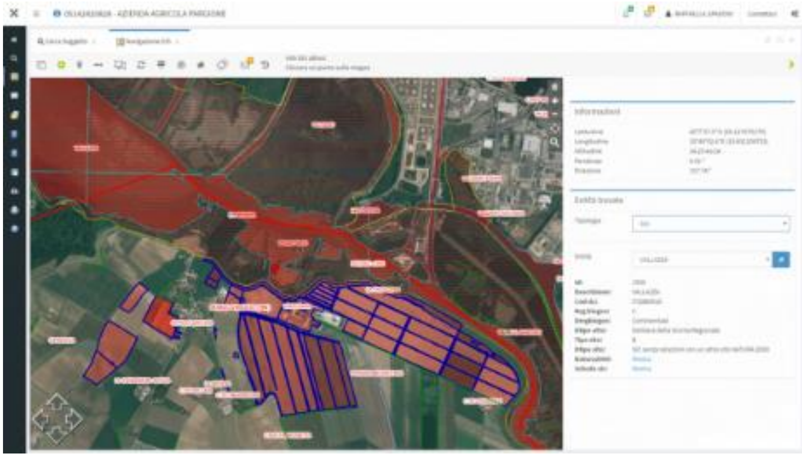


Figure 24: SITI4farmer screen view

- In order to make full and comprehensive measurements in the fields, automatizing as much as possible, Abaco is going to finance the acquirement and the integration within the system of 2 sensors stations dedicated to this purpose. Sensor Stations will be purchased directly from Abaco, and installed within two farms, after a deep study with Abaco's experts, to find the right place, right position in according with quality measurements expected from the project (that's will be discuss from project partners).

Sensors and weather station (Figure 24) are going to set for working via radio with a central server, and then transmit data directly to SITI4farmer.

They will be equipped (for example) with:

- Modem, aerial, battery, solar panel.
- Rain Gauge Module.
- Temperature and humidity sensors.
- Wind direction system.
- Wind speed measurement sensors.
- Solar Radiation sensor.
- Single Leaf Temperature Sensor.
- Infrared Temperature Module.
- IR Temperature sensor.
- Instruments Leaf Wetness Sensor Module with 5 meter of cable.
- Drill & Drop Sensor (Temperature and soil moisture sensors).

Figure 25: Sensor & Weather Station

Figure 26: Rain Gauge Module

- Geocledian will acquire and process Copernicus Sentinel-2 and USGS Landsat-8 images for all sites during the pilot run time.
- Geocledian's Processing Platform provides the existing service ag|knowledge that allows the automatic crop monitoring for fields with basic products like visible images and NDVI (based on 4 spectral bands). In the frame of the pilot Geocledian will develop the current data processing platform further into a Big Data Processing Platform as described below.

Time plan
Abaco's main Tasks and Operations, that will be performed to achieve the goals of the pilot are:
- Formal Engagement of the winery companies.
- Collecting information of fields, terrain, product quality.
- Analysis for the sensors set up on the right spot and configuration.
- Deployment of the system SITI4farmer for the 2 companies.
- Development of the system sensors station interfacing.
- Measurements and monitoring of field activities.

Piloting activating (in particular the last one) will be part of the entire project and is going to be considered as an activity in continuous improvement, where data and results will be presented to the other partners regularly.

Table 1: Timeline of the Farm Management Pilot Macro Activities

Macro Activity	Time
Geocledian: Data acquisition, processing & provision	Q3-Q4.2018
Winery Company formal engagement	Q3.2018
Abaco's Hardware & Software supplying	Q3.2018
Deploying of SITI4farmer	Q4.2018
Abaco's Development & Configuration for sensors integration	Q4.2018
Training of user on the system	Q4.2018
Geocledian: Integration of new data sources	Q1-Q2.2019
Field Measurements & monitoring	Q1.2019 to Q4.2020
Geocledian: Development of Management Zones & data anomaly detection	Q1-Q4.2019
Geocledian: Improvement of vineyard specific products with feedback from users	Q1-Q4.2020

Throughout the pilot duration, Geocledian will acquire and process the described satellite data of all sites. Visible images and Vegetation Index Maps will be produced in our Processing platform and the data will be provided to all project partners in near real-time.

Gathered Data

Abaco, with its SITI4farmer system, is engaged to make a big picture of farm data on multiple views:

- *Chemical and physical info on grapes.*
- *Day by Day Activities in term of treatments, fertilization, field operation.*
- *Plot and Fields information georeferenced.*
- *Weather and soil main parameters measurements (Figures 26 and 27).*

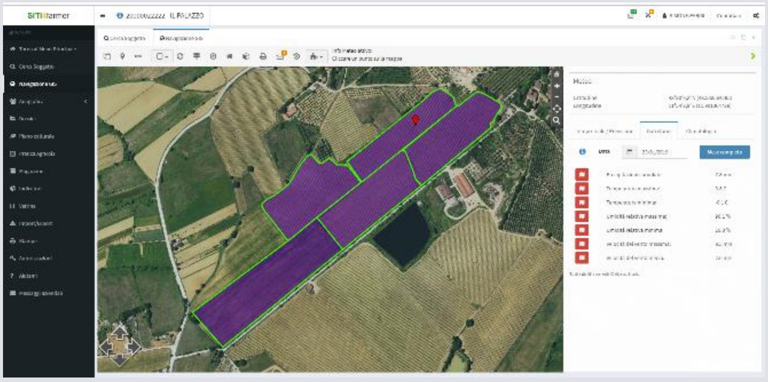
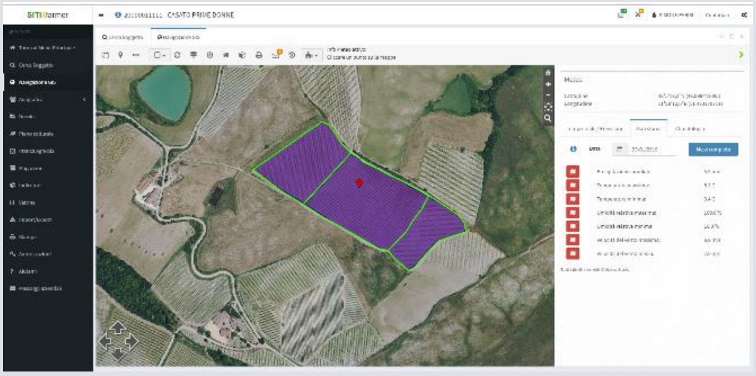


Figure 27: "Il Palazzo" farm GIS plot and related historical meteorological data display example

	 **Figure 28: "Casato Prime Donne" farm GIS plot and related historical meteorological data display example** - *Geocledian will acquire and process all Sentinel-2 data sets available (until a certain cloud cover threshold) for all sites during the pilot run time (max. every 2/3 days). Visible images and Vegetation indexes will be produced and the data be provided to all project partners.* - *Geocledian will acquire and process all Landsat-8 data sets available (until a certain cloud cover threshold) for all sites during the pilot run time (max. every 16 days). Visible images and Vegetation indexes will be produced and the data be provided to all project partners.*

2.4 NATURAL COSMETICS PILOT EXPERIMENTAL PROTOCOL (Symbeeosis)

2.4.1 Biological Efficacy

Symbeeosis' Experimental Protocol	Measurements of Biological Efficacy
Hypothesis	Predicting Biological Efficacy.
Introduction & Specific Goals	There is a need in extracting the most out of pharmaceutical plants for both economic and environmental reasons. A real challenge is to add high value to by-products. Wine making produces a lot of by-products that may have a significant biological value if there are adequate data concerning farm management. These data can lead to decisions concerning the processing of by-products in order to produce high added value active ingredients for cosmetics and food supplements. The goal of the pilot is to prove the correlation between data from the field and the quality of extracts developed from vine materials. The main purpose is to find how we can link crop location and weather conditions to the biological quality of the products. This scenario hypothesis is aiming to create a predictive model that will correlate parameters concerning weather conditions and parameters linked with biological efficacy.

In particular, the pilot intends to gather samples of vineyard by-products across the Greek territory and more specifically vine leaves of two different grape varieties (Agiorgitiko and Mandilaria) and test their phytochemical profile and biological value after extraction.

S Specific tests that will be conducted include:

- *pH*
- *Refractive index*: Measurement of Brix%.
- *Total microbial count*: Measurement of TPC with classic development of micro-organisms in Petri-dishes.
- *Yeasts and moulds*: Measurement of Y&M with classic development of micro-organisms in Petri dishes.
- *Antioxidant activity*: Spectrophotometric measurement of antioxidant capacity of extracts using DPPH & ABTS assay.
- *Total phenolic content*: Spectrophotometric measurement of the phenolic content in the extracts using TPC assay.
- *Total flavonoids content*: Spectrophotometric measurement of the flavonoids content in the extract using $AlCl_3$ assay.
- *Toxicity on skin cells*: Cell viability assessment using MTT assay.
- *Gene expression on skin cells*: Target SIRT1 mRNA transcripts using real time PCR.

Activity Description

Deployment Site

As a first stage, for the first year of the project, sixteen regions (Figure 28) of the Greek territory have been chosen for sample collection, i.e. dried vine leaves of two different varieties.

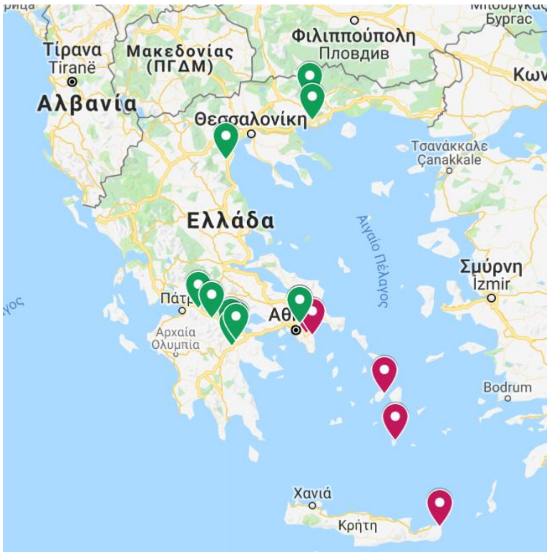


Figure 29: Dispersion of samples across the Greek territory

The preparation of vine leaf extracts with the two different extraction methods and the testing of biological efficacy of each sample will take place at the laboratory of collaborating Company APIVITA S.A. – Natural Cosmetics, located in Industrial Park of Markopoulo Mesogaias in Greece.

- *Experimental Procedures pH*

Procedure: Turn on ("ON") or turn off ("OFF") the ph meter by the switch (power-button), which is on the red cover of the instrument. Turn on the pH meter and wait until the display shows the measurement mode "pH". Mix thoroughly the measured solution before the measurement. Dip the electrode into the test solution (the electrode immersion depth approximately 4 cm) and wait until the value on the display stabilizes. Read the measured pH value on the display. The electrode must be dipped in the solution only for necessary period of time. It is necessary to rinse the electrode with distilled water after each measurement. If pH measurements are not performed immediately after each other, it is necessary to keep the electrode between measurements in a test tube with the storage solution (electrode must not dry out). After the measurement rinse carefully the electrode with distilled water and dip it back into the storage solution. Turn off the pH meter.

- *Refractive index*: Measurement of Brix%

Procedure: Verify the instrument has been calibrated before taking measurements. Wipe off prism surface located at the bottom of the sample well. Using plastic pipettes, drip sample onto the prism surface. Fill the well completely. (Note: If the temperature of the sample differs significantly from the temperature of the instrument, wait approximately 1 minute to allow thermal equilibration). Press the READ key. Measurement is displayed in units of % BRIX. (Note: The ATC tag blinks and automatic temperature compensation is disabled if the temperature is outside the 10-40 °C/ 50-104 °F ranges). Remove sample from the sample well by absorbing with a soft tissue. Using plastic pipettes, rinse prism and sample well with distilled or de-ionized water. Wipe dry. The instrument is ready for the next sample.

- *Total microbial count*

Procedure: Measurement of TPC with classic development of micro-organisms in Petri-dishes.

- *Yeasts and moulds*

Procedure: Measurement of Y&M with classic development of micro-organisms in Petri dishes.

- *Antioxidant activity*

Procedures:

- DPPH assay: The DPPH assay is a spectrophotometric method done according to the method of Brand-Williams et al. (1995) with some modifications.

- ABTS assay: The ABTS assay is a spectrophotometric method, done according to the method of Arnao et al. (2001) with some modifications.

- *Total phenolic content*

Procedure: TPC assay is a spectrophotometric method using the Folin–Ciocalteu reaction (Singleton et al., 1999), with gallic acid as the standard.

- *Total flavonoids content*

Procedure: TFC is a spectrophotometric method using the aluminum chloride colorimetric assay as described by Chang et al. (2002) with slight modifications.

- *Toxicity on skin cells*

Procedure: Cell viability assessment using MTT assay as developed by Mossman (1983).

- *Gene expression on skin cells*

Procedure: Target SIRT1 mRNA transcripts using real time PCR.

Tech Components

- The measurement of pH will be conducted with a seven compact pH meter, METTLER-TOLEDO (Figure 29).

Figure 30: pHmeter, METTLER-TOLEDO.

- The measurement of refractive index will be conducted with a Digital Refractometer RX-a- series ATAGO (Figure 30).

Figure 31: Digital Refractometer ATAGO.

- A NUVE Incubator and a Laminar Telstar BIO-II-A will be used for the measurement of total microbial count with classic development of microorganisms in Petri-dishes (Figure 31).

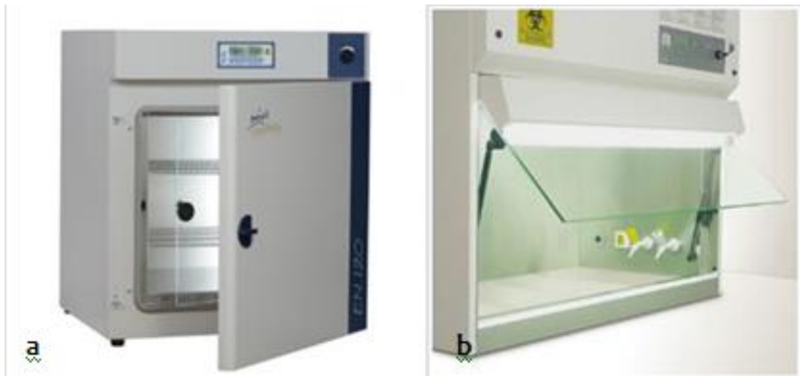


Figure 32: (a) NUVE Incubator, (b) Laminar Telstar BO-II-A.

- A Memmert Universal oven will be used for the measurement of yeasts and moulds with classic development of microorganisms in Petri dishes (Figure 32).

Figure 33: Memmert Universal Oven 055 UN/UNm.

- A UV 1800 SPECTROPHOTOMETER, SHIMADZU EUROPA will be used for the measurement of antioxidant activity (DPPH & ABTS assay), total phenolic content and total flavonoid content (Figure 33).

Figure 34: UV Spectrophotometer.

- A Nanoquant, infinite M200 Pro, TECAN will be used for the measurement of toxicity on skin cells (MTT assay) (Figure 34).

Figure 35: Nanoquant, infinite M_{200} Pro.

- A CFX connect Real time System, BIO-RAD will be used for the measurement of gene expression on skin cells (Target SIRT1 mRNA transcripts using real time PCR) (Figure 35).

Figure 36: CFX connect Real time System.

Time plan
Measurements related to the Natural Cosmetics pilot will take place during the whole duration of the project. The collection of samples from the chosen vineyards will be repeated every year in the summer, following extraction using two different methods and measurements of biological efficacy of developed extracts.

Replications and Number of Seasons
The sample collection, extraction and the measurements will be repeated once every season of the project (3 seasons). Each measurement will take place 3 times.

Gathered Data	Datasets: - Land-based Weather Data: National Centers for Environmental Information (NCEI), Open source data, a tool will be developed that will exploit open source data and extract information regarding the weather conditions on the location and altitude of each crop. - SVIs Data: Satellite Vegetation Indexes of Visible & NIR Bands from LandSat-8 OLI (USGC, NASA) and Sentinel-2A/B MSI (Copernicus EO Programme, ESA) are collected for the sampled vineyards with the assistance of BDG Partner GEOCLEDIAN, json, geotiff and png format, TB, Confidential. - Vine Leaf Variety 1 – Extraction Method 1 Data: Data related to sample's biological activity, xls files, MB, Confidential. - Vine Leaf Variety 1 – Extraction Method 2 Data: Data related to sample's biological activity, xls files, MB, Confidential. - Vine Leaf Variety 2 – Extraction Method 1 Data: Data related to sample's biological activity, xls files, MB, Confidential. - Vine Leaf Variety 2 – Extraction Method 2 Data: Data related to sample's biological activity, xls files, MB, Confidential. The data can be presented as a map or a diagram that shows the variance of biological efficacy per region.

2.5 FOOD PROTECTION PILOT EXPERIMENTAL PROTOCOL (AGROKNOW)

2.5.1 Food Protection

Agroknow Experimental Protocol	Food Protection
Hypothesis	Supply Chain Risk Prediction Dashboard, Price Prediction Dashboard, Price & Fraud Correlation Dashboard, Marketing Automation Dashboard
Introduction & Specific Goals	Food protection, including safety and fraud, is one of the most critical parameters in food production highly affecting the food companies from the financial and brand point of view. Agroknow is providing a digital solution for the food industry that delivers trends and risk estimation for raw materials, ingredients and finished products. The solution is helping the Quality Assurance (QA) and Food Safety (FS) experts working in the food industry to identify risk in their supply chain. The current solution is limited to alarms, statistics, simple trends and search mechanisms. During the first two years of the project, Agroknow has performed a series of focused group and consultation meetings with several companies of the food industry, such as Gallo Winery, Conagra, Campbell, Pepsico, Hershey and Lamb Weston. The meetings were held during large food safety events like the GMA Science Forum. During these meetings Agroknow team validated the need for new FOODAKAI extensions that will enable risk predictions in the supply chain.

Thus, the main objective of this pilot is to enhance the current digital solution with new modules that will address further needs of the grape and wine supply chain. The enhancement will mainly focus on the further development of Agroknow's Big Data platform with new software modules that will enable advanced data analysis and risk prediction using machine learning and deep learning methods.

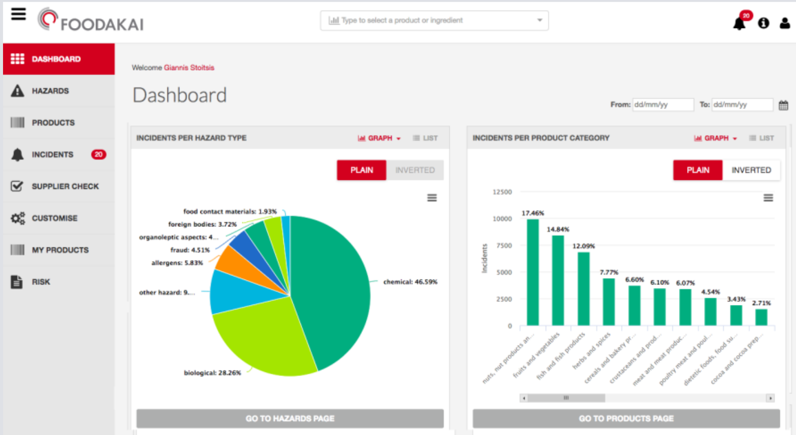


Figure 36: Food Protection dashboard of FOODAKAI system

The specific goals of the food protection pilot are:

- To develop a software module that will be able to predict emerging and increasing risks for chemical hazards in the grapes and wines supply chain;
- To develop a price prediction dashboard that will include algorithms able to predict the prices of agricultural products, including grapes;
- To develop a food fraud dashboard that will help experts working in the food industry to perform an effective vulnerability assessment for products;
- To develop a marketing automation module that will facilitate the exploitation of the food safety and fraud solutions that will be developed by Agroknow in the context of the project.

Activity Description

A. Big Data Collection & Processing

We identify all the datasets that are needed to develop the prediction services. The following data types are explored and integrated into the Big Data Platform:

- **Food recalls and border rejections** that include incidents for hazards and fraud identified in raw materials, ingredients and food products;
- **Pricing data** for the agricultural products;
- **Surveillance studies data** about hazards and fraud in food products on the market;
- **Laboratory testing data** of the food companies and producers;
- **Country risk and corruption index data.**

After collecting the data, we apply big data processing techniques available at the BDG software stack to filter, classify and enrich the data. Enrichment includes the automatic annotation with terms from multilingual semantic vocabularies for products and hazards.

B. Big Data Analysis

Based on the real industry scenarios we define which are the main parameters that need to be predicted. Based on these findings we test several machine learning and deep learning algorithms to predict parameters like the chemical risk, pricing and fraud. The goal is to combine different datasets to achieve the optimum performance for the prediction of the risk in raw materials (e.g. grapes) and finished products (wine).

C. Prediction Dashboards

Sessions with the end users from industry are organized to verify the digital services that are developed and integrated in the FOODAKAI system. Mockups of the final services are developed and validated with the end users. Based on the final version of the mockups, Agroknow develops the functionalities and the user interface. The risk, price and fraud prediction dashboards are tested by end users and further improved.

D. Marketing automation

By applying the BDG technologies we produce food safety and fraud insights that can be used to develop powerful marketing content. We focus on the development of two processes:

a) A process to enable the semi-automatic creation of data reports for specific product categories e.g. grapes-based products;
b) A process for personalized marketing messages that are based on the data reports and on the target prospect profile.

The two processes are part of a generic marketing workflow that takes into account the profile of the end user. Algorithms that classify the targeting users in specific categories are defined and developed. Automated mechanisms for sending the data-powered emails are designed and developed.

Gathered Data	A large number of different data sources and data types has been used to enable the predictions. We used textual information and numerical data. Textual information includes mainly announcements about food recalls and border rejections whereas numerical data includes lab test results and pricing data. The main source of our datasets is the open data published by the governments and the private data for lab testing that will be provided by the companies.

3 INDIVIDUAL EVALUATION METHODOLOGY

All five Pilot partners (Table and Wine Grapes Pilot- AUA, Wine Making Pilot- INRA, Farm Management Pilot- ABACO- Geocledian, Natural Cosmetics Pilot- Symbeeosis, Food Protection Pilot- Agroknow) provided the 'Individual Evaluation Methodologies' to evaluate the progress of each experiment/ measurement per pilot and eventually specify the evaluation protocols that will be activated during the execution of the application pilots. Based on the "Piloting Plan" deliverable and the experimental protocols described above, partners provided input that will be used to explicitly define the methodology for assessing the results of the experiments in accordance with the piloting plan - the factors to be examined, the indicators to be assessed, etc.

The evaluation methodology includes two parts 1) the '*Measurement's Evaluation Summary*' and 2) the '*Status of implementation*'. In the '*Measurement Evaluation Summary*' pilot partners explained specific objectives, work plan progress, achievement and results, and problems and challenges per measurement for the certain reporting period. The '*Status of implementation*' includes information about the actors, equipment and methodology, gathered data and formats.

3.1 TABLE AND WINE GRAPES PILOT EVALUATION SUMMARY AND STATUS OF IMPLEMENTATION (AUA)

3.1.1 Topographic Data and Elevation Maps

AUA Evaluation Protocol	Topographic data and Elevation maps Evaluation Summary
Hypothesis	Real-Time Kinematic positioning system is used to collect topographical data, such as field boundary points and elevation data with millimetre-level positioning accuracy.
Specific Objectives	The topographic elements represent yet another key factor that influences viticultural and oenological characteristics of a given region. Amongst the most important topographic elements for viticulture are elevation, slope degree and aspect/exposure. Topcon HiPer V RTK GPS is used to collect high accuracy topographical data of the test. The data is used to create millimetre-level accuracy topographic and elevation maps.
Work Plan Progress	- The measurement takes place a single time throughout the entire project, before the start of the experiments and is not repeated again. - The measurements are performed by AUA. The owners of the test sites (Palivou Estate, Kontogiannis Estate and Fasoulis Estate) provided information and gave AUA access to their vineyards in order for the measurements to be performed. - The goal of this measurement is to create topographic and elevation maps of the test sites. The system consists of two parts, a stable base and a mobile rover. The handheld rover with the GPS receiver on top is used to collect georeferenced points of the fields' boundaries as well as elevation data while the base acts as a reference point that minimizes positioning errors. The positioning and elevation data is then used to create topographic and elevation maps of the test sites.

Achievements/Results	High quality topographic data have been collected from all three (3) test sites and topographic and elevation maps have effectively been generated.
Problems/Challenges	No problems were encountered in this measurement.

AUA Evaluation Protocol	Topographic data and Elevation maps Status of Implementation
Actors Involved	AUA
Methodology	The system consists of two parts, a stable base and a mobile rover. The handheld rover with the GPS receiver on top is used to collect georeferenced points of the fields' boundaries as well as elevation data while the base acts as a reference point that minimizes positioning errors.
Deployed Components	- Name of the deployed technology: Real Time Kinematics GPS / GNSS. - Supplier (brand) name and model: Topcon Positioning Systems Inc., United States, HiPer V RTK GPS. - Number of units used per site: A single HiPer V RTK GPS sensor is used. - Deployment site(s) name in the reporting period: Topographic data have been collected from all three (3) test sites and topographic and elevation maps have effectively been generated.
Gathered Data and Formats	- Gathered data using this measurement technique: Coordinates of the test sites' boundaries (northing and easting) and elevation data (m). - Defined frequency of data collection: A single measurement prior to all other measurements (no repetition). - Data model/format: .xls files that contain the coordinates and the elevation of the sites. - Data size in the reporting period: MB.

3.1.2 Apparent Soil Electrical Conductivity (ECa)

AUA Evaluation Protocol	ECa Sensing Evaluation Summary
Hypothesis	The delineation of the test sites into management zones using ECa georeferenced data.
Specific Objectives	The fact that ECa it is directly connected to several soil attributes of major importance such as soil structure, salinity and water content sets it as a reliable and the most widely used variable for management zones delineation. The EM38-MK2 sensor is used to collect georeferenced ECa data from the entire test site. The data is then used to create ECa spatial variability maps that work as a base for the sites to be divided into management zones.
Work Plan Progress	- The measurement takes place once every year during the last weeks of spring (April – May). - The measurements are performed by AUA. The owners of the test sites (Palivou Estate, Kontogiannis Estate and Fasoulis Estate)

	provided information and gave AUA access to their vineyards in order for the measurements to be performed. - The goal of this measurement is to create ECa spatial variability maps of the test sites. Measurements of soil ECa were collected using an EM38 soil electrical conductivity meter. The EM38 is used, positioning the instrument in both the horizontal and vertical modes of dipole orientation for the estimation of soil ECa. The sensor is placed in a wooden sleigh with a plastic base, which is then fastened with a 2 meters long rope to the tractor. The sensor collects data while the tractor cruises across the field and stores it to the Archer Data Logger from which is then retrieved when the entire field has successfully been scanned. The georeferenced ECa data is finally used to create maps that demonstrate the spatial variability of the test sites.
Achievements/Results	Georeferenced ECa data has been collected from two (2) test sites (Kontogiannis Estate and Palivou Estate) and could effectively be divided into management zones.
Problems/Challenges	It has recently been reported that trellis systems can cause substantial interference with EM38 measurements when metal stakes are used with a full complement of foliage and drip irrigation support wires, and the EM38 is positioned close to it. Due to the fact that Fasoulis Estate is an experimental greenhouse-type vineyard, the metallic foundations, support pillars and foliage support wires did not allow for accurate ECa measurements with the sensor.

AUA Evaluation Protocol	ECa Sensing Status of Implementation
Actors Involved	AUA and the three test sites' owners, Palivou Estate, Fasoulis Estate and Kontogiannis Estate.
Methodology	Measurements of soil ECa were collected using an EM38 soil electrical conductivity meter. The EM38 is used; positioning the instrument in both the horizontal and vertical modes of dipole orientation for the estimation of soil ECa. The EM38-MK2 sensor is placed in a wooden sleigh with a plastic base, which is then fastened with a 2 meters long rope to the tractor. The sensor collects data while the tractor cruises across the field and stores it to the Archer Data Logger from which it is then retrieved when the entire field segment has successfully been scanned.
Deployed Components	- Name of the deployed technology: Quad-phase measurement with electromagnetic induction sensors. - Supplier (brand) name and model: Geonics Ltd, Canada, EM38-MK2 sensor. - Number of units used per site: A single EM38-MK2 sensor is used. - Deployment site(s) name in the reporting period: ECa data have effectively been collected from Palivou and Kontogiannis Estate. However, due to excessive noise from metallic materials encountered in Fasoulis Estate, no accurate ECa measurements could be made for this site.

Gathered Data and Formats	- Gathered data using this measurement technique: Georeferenced ECa data in millisiemens per meter (mS/m). - Defined frequency of data collection: A single measurement each year, during the last weeks of spring (April – May). - Data model/format: The raw files from the sensor (.n38), which are converted into .xls files that contains the georeferenced ECa data. - Data size in the reporting period: MB.

3.1.3 Canopy Sensing and Vegetation Indices

AUA Evaluation Protocol	Canopy sensing and vegetation indices Evaluation Summary
Hypothesis	Remotely sensed vegetation indices can deliver information on plant health and potential stresses. Georeferenced data from the vineyards collected by active crop canopy sensors that measure crop reflectance at bands near the Near Infrared wavelengths can generate vegetation indices-based maps that act as indicators of crop status and overall health.
Specific Objectives	Spectral sensors that measure the light reflectance of the crops in specific spectra (Near Infrared and Visible/Red) can provide data on the overall health of the plants as well as the growing conditions and stages of the grapevines. The objective of these measurements is to provide a frequent data stream providing information on the phenological growth, conditions and possible variations of the grapevines.
Work Plan Progress	- The measurements are performed six (6) times each year during the summer. - The measurements are performed by AUA. The owners of the test sites (Palivou Estate, Kontogiannis Estate and Fasoulis Estate) provided information and gave AUA access to their vineyards in order for the measurements to be performed. - The goal of this measurement is to create vegetation index-based maps of the test sites during different phenological growth stages of the grapevines. Two different canopy reflectance sensors, Crop Circle ACS-470 and SpectroSense2+ GPS are mounted on a tractor in a way that the spectral sensors face the canopy of the vines. As the tractor cruises across the field, georeferenced data is collected and stored in an external memory card (Crop Circle) or within the system itself (Spectrosense2+). The data is then used to create spatial variability vegetation indices-based maps. Additionally, in cases when tractors could not enter the vineyards at the time/date of the measurements (i.e. recent rainfall resulting to high water content), the sensors were used as handheld units to collect data, along with a Crop Circle RapidScan CS-45 hand held sensor. The CS-45 can also measure canopy reflectance in the bands of Near Infra-Red, Red and RedEdge, while georeferenced data is stored within the unit.
Achievements/Results	Vegetation Indices-based maps have been generated from all six measurements and the different phenological growth stages of grapevines have been successfully monitored for the first season.

Problems/Challenges	Some problems were encountered using all three lenses on the Crop Circle ACS-470.

AUA Evaluation Protocol	Canopy sensing and vegetation indices Status of Implementation
Actors Involved	AUA and the three test sites' owners, Palivou Estate, Fasoulis Estate and Kontogiannis Estate.
Methodology	Two different canopy reflectance sensors, Crop Circle ACS-470 and SpectroSense2+ GPS are mounted on a tractor in a way that the spectral sensors face the canopy of the vines. As the tractor cruises across the field, georeferenced reflectance data is collected and stored in an external memory card (Crop Circle) or within the system itself (Spectrosense2+). The data is then used to create maps that demonstrate the spatial variability of the test sites in NDVI and LAI values. Additionally, in cases when tractors could not enter the vineyards at the time/date of the measurements (i.e. recent rainfall resulting to high water content), the sensors were used as handheld units to collect data, along with a Crop Circle RapidScan CS-45 hand held sensor.
Deployed Components	- Name of the deployed technology: Canopy Reflectance sensors. - Supplier (brand) name and model: Holland Scientific Inc., United States, Crop Circle ACS-470 and Crop Circle RapidScan CS-45 and Skye Instruments Ltd, UK, SpectroSense2+ GPS. - Number of units used per site: A single unit of each sensor is used. - Deployment site(s) name in the reporting period: Vegetation indices data have been collected from all three (3) test sites.
Gathered Data and Formats	- Gathered data using this measurement technique: Georeferenced reflection data of the grapevines in the Near-Infrared and visible/Red spectral bands. - Defined frequency of data collection: A total of six (6) measurements prior each year during summer. - Data model/format: .xls files that contain georeferenced data of the grapevines' reflectance and the indices calculated from these values. - Data size in the reporting period: MB.

3.1.4 Drone Imagery

AUA's Evaluation Protocol	Drone Imagery Evaluation Summary
Hypothesis	Drone imagery will be used for the collection of georeferenced imagery data from multispectral and thermal cameras.
Specific Objectives	Georeferenced imagery data from multispectral cameras are used to monitor the overall health and condition of the crops, while thermal cameras can provide information about the water status variability and water needs of the crops in different zones of the field and the optimal irrigation timing.

Work Plan Progress	- Similarly, to the measurements for the canopy characteristics, drone imagery with thermal and multispectral cameras will be collected during the same periods. Six (6) measurements per season will be performed each summer, Partners involved, third parties involved (organization names). - The goal of this measurement is to record georeferenced imagery data from multispectral and thermal cameras in order to monitor the overall health and condition of the crops and their water status variability. A defined set of waypoints can be pre-programmed to form a set flight path. Flight planning software calculates the spacing and layout of waypoints to acquire data over the region of interest at a nominated image scale. Imagery is typically acquired at the maximum rate allowed on the device, thereby providing redundancy to account for elimination of imagery with excessive tilt, motion blur or bad exposure.
Achievements/Results	For this reporting period there are no achievements/results available regarding the drone imagery.
Problems/Challenges	The equipment was purchased after the end of the first season. Thus, drone imagery data were not collected during the first year of the project's lifetime.

Since drone imagery data have not yet been collected the 'Status of Implementation' for this measurement will be included in the next version of D8.2.

3.1.5 IoT Stationary

AUA's Evaluation Protocol	IoT Stationary Evaluation Summary
Hypothesis	Weather and soil data will be continuously recorded.
Specific Objectives	The automatic weather stations were installed inside the vineyard. Weather information is being recorded in real-time throughout the growing season. Similarly, the soil moisture sensors are continuously recording the humidity and temperature of the soil.
Work Plan Progress	- Weather and soil information will be continuously collected in real-time throughout the growing season. - Two Vantage Pro 2 weather stations, with rain sensor, to detect rainfall, anemometer to measure wind speed and direction, air temperature sensor, air humidity sensor, barometer to monitor atmospheric pressure, were installed inside the vineyard. Weather information is being recorded in real-time throughout the growing season. Similarly, the soil moisture sensors are continuously recording the humidity and temperature of the soil.
Achievements/Results	- Weather and soil data have been recorded effectively since the installation of the equipment on field.

Problems/Challenges	Weather stations and soil humidity sensors were installed at the end of the first season. Thus, data have been collected starting on Month 9 of the project's lifetime.

AUA's Evaluation Protocol	IoT Stationary Status of Implementation
Actors Involved	AUA and the three test sites' owners, Palivou Estate, Fasoulis Estate and Kontogiannis Estate.
Methodology	Weather and soil information will be continuously collected in real-time throughout the growing season. Two Vantage Pro 2 weather stations, with rain sensor, to detect rainfall, anemometer to measure wind speed and direction, air temperature sensor, air humidity sensor, barometer to monitor atmospheric pressure, were installed inside the vineyard. Weather information is being recorded in real-time throughout the growing season. Similarly, the soil moisture sensors are continuously recording the humidity and temperature of the soil.
Deployed Components	- Name of the deployed technology: Weather and soil humidity sensors. - Supplier (brand) name and model: Davis Instruments Corp., Hayward, CA, United States, Vantage Pro 2 weather station, METER Group, Inc., Pullman, WA, USA, Decagon EC-5 soil moisture sensors. - Number of units used per site: Two weather stations and four soil moisture sensors are used. - Deployment site(s) name in the reporting period: IoT stationary data have been collected from Kontogiannis Estate and Palivou Estate.
Gathered Data and Formats	- Gathered data using this measurement technique: Weather and soil moisture data. - Defined frequency of data collection: continuously collected in real-time throughout the growing season. - Data model/format: .csv, .xls files. - Data size in the reporting period: MB.

3.1.6 Yield Mapping

[Partner's Name] Evaluation Protocol	Yield Mapping Evaluation Summary
Hypothesis	The ultimate goal that this measurement serves is the estimation of yield.
Specific Objectives	Yield estimations can help the growers optimize variable rate applications, the timing of harvest operations, as well as storage and shipping of their production. Yield mapping can be used in the following hypothesis scenarios: Yield Prediction, Crop Quality Prediction for Optimizing Post Harvest Treatments of Table Grapes, Optimization of Farm Practices in the Vineyard, Management Zones Delineation for Vineyards.

Work Plan Progress	- The yield mapping is being estimated once per year. The grapes are hand harvested in late August – middle September. - The measurements are performed by AUA. The owner of Palivou Estate provided help when harvesting and gave AUA access to their vineyards in order for the measurements to be performed. - The goal of this measurement is the estimation of yield. The grapes are hand harvested in late August – middle September. The actual yield is estimated during the harvest period by measuring the total number of bins per cell and multiplying it with the average bin weight of the harvested grapes.
Achievements/Results	Yield data have been collected for the first harvesting period.
Problems/Challenges	No problems were encountered in this measurement.

AUA's Evaluation Protocol	Yield Mapping Status of Implementation
Actors Involved	AUA and the three test sites' owners, Palivou Estate, Fasoulis Estate and Kontogiannis Estate.
Methodology	The grapes are hand harvested in late August – middle September. The actual yield is estimated during the harvest period by measuring the total number of bins per cell and multiplying it with the average bin weight of the harvested grapes.
Deployed Components	- Name of the deployed technology: Hand-held scale - Number of units used per site: Two hand-held scales are used. - Deployment site(s) name in the reporting period: Yield data have been collected from Palivou Estate.
Gathered Data and Formats	- Gathered data using this measurement technique: Yield data. - Defined frequency of data collection: The yield mapping is being estimated once per year, when grapes are harvested in late August – middle September. - Data model/format: .csv, .xls files. - Data size in the reporting period: MB.

3.1.7 Qualitative and Quantitative Characters

AUA Evaluation Protocol	Qualitative and quantitative characters' measurements Evaluation Summary
Hypothesis	Qualitative and quantitative data can provide useful information regarding the yield prediction as well as the crop quality prediction after post-harvest treatments.
Specific Objectives	The objective of these measurements is to give a full profile of the samples studied providing information on the phenological growth,

	maturation process and possible variations of the grapevines and correlate them with data coming from the field (sensors etc.).
Work Plan Progress	- The measurements are performed each year during the summer at harvest and post-harvest and total PM. - The measurements are performed by AUA. The owners of the test sites (Palivou Estate, Kontogiannis Estate and Fasoulis Estate) provided information and gave AUA access to their vineyards in order for the collection of the grapes which are transferred to the laboratory for further measurement and analyses. - The goal of these measurements is to provide the full profiles of the samples and varieties during different phenological growth stages of the grapevines as well as the maturation process.
Achievements/Results	Qualitative and quantitative data have been gathered from all three sites which will be further statistically analysed and correlated with the data coming from the field for the first season.
Problems/Challenges	No problems were encountered in this measurement.

AUA Evaluation Protocol	Qualitative and quantitative characters' measurements Status of Implementation
Actors Involved	AUA and the three test sites' owners, Palivou Estate, Fasoulis Estate and Kontogiannis Estate.
Methodology	Samples collected from the three (3) test sites were transferred to the Laboratory of Viticulture, Agricultural University of Athens for further measurements and analyses following the respective protocols and methodologies.
Deployed Components	- Name of the deployed technology: UV/Vis spectrophotometer. - Supplier (brand) name and model: Perkin Elmer, Lambda 25, Beaconsfield, Bucks, U.K.). - Number of units used per site: A single unit of each equipment is used. - Deployment site(s) name in the reporting period: Qualitative and quantitative characters' measurements have been performed on samples collected from all three (3) test sites. - Name of the deployed technology: HPLC Shimadzu Nexera. - Supplier (brand) name and model: HPLC Shimadzu Nexera comprising a gradient pump Shimadzu Nexera X2, a ProStar model 410 AutoSampler, and a ProStar model 330 Photodiode Array Detector on a reversed-phase Waters C18 x select (250 mm x 4.6 mm, 5 mm) column. - Number of units used per site: A single unit of each equipment is used. - Deployment site(s) name in the reporting period: Qualitative and quantitative characters' measurements have been performed on samples collected from all three (3) test sites.

Gathered Data and Formats	- Gathered data using this measurement technique: Qualitative and quantitative characters of the grapes. - Defined frequency of data collection: Different measurements according to phenological growth stage of the vines each year during summer and at post-harvest. - Data model/format: .xls files that contain data of the grapevines' Qualitative and quantitative characters. - Data size in the reporting period: MB.

3.2 WINE MAKING PILOT EVALUATION SUMMARY AND STATUS OF IMPLEMENTATION (INRA)

3.2.1 Viticulture and Grapes Quality - Winemaking And Wine Quality

INRA's Evaluation Protocol	Viticulture and Grapes Quality - Winemaking and Wine Quality Evaluation Summary
Hypothesis	Crop Quality prediction for optimizing winemaking.
Specific Objectives	- Viticulture and the ecophysiology of the vine, with as a main issue a better knowledge and better control of grape quality. - Enology with, as major research axes, the expression of quality potential existing in the grapes and wines and the on-line monitoring and control of the alcoholic fermentation. - Technological processes with the aim to propose and study innovative technologies applicable to various steps of winemaking. - The valuation of coproducts, extraction of molecules and environmental impacts.
Work Plan Progress	Data are coming from diverse sources. The main data sources identified are: *Climatik database* - Climatic data available from 1989 to 2018. - Partners involved: INRA. - The goal is to connect environmental or climatic data to information related to the winemaking process or vines. *French Network of Grapevine Repositories* - The French Network of Grapevine Repositories (RFCV) includes 36 regional partners involved in the preservation of grapevine genetic resources and selection. More than 180 repositories are distributed to the grape producing regions in France. - The network partners are the regional stakeholders involved in grapevine conservation and selection in France. They play a pivotal role in the conservation and valorisation of our viticultural heritage. *PHIS*

	- Three experiments have been achieved on the phenotypic platform in 2012, 2013 and 2014 (the PhenoArch phenotyping platform). - Partners involved: the researches at the LEPSE unit (INRA). - Measurement goal: context of water scarcity and global climate changes, the researches at the LEPSE aim at analysing and modelling the responses of plants to drought and high temperatures as well as their genetic variability at the intra- and inter-specific levels. *SilexVitioeno* - SilexVitioeno Pech Rouge is an information system filled by people from Pech Rouge and about plots, vine stock, and berries all along grapevine lifecycle. - Partners involved: INRA, experimental unit of PechRouge. - The measurement goal is to characterize vines and their environment to optimize crop management. *Monitoring of winemaking operations* - The monitoring of winemaking operations is obtained with a form filled after harvest to record all information linked with the must studied. - Partners involved: Workers from Pech Rouge. - The goal of this monitoring is the traceability to compare and follow every steps of the winemaking process. *ALFIS* - Alfis is a SQL database started in 2004, this is an automatic monitoring connected to an information system. - Partners involved: INRA unit called Science for Oenology ("SPO"). - The goal is to make fermentations under controlled conditions with an online acquisition of fermentation kinetics to understand must and yeast behaviour and optimise the process of alcoholic fermentation. *Laboratory analysis* - Laboratory analysis is done on each sample of must and wine. - Partners involved: experimental unit of Pech Rouge and another INRA unit "Science for oenology" SPO. - The purpose is to have chemical and physical analysis of must and wine and look at their evolution. *Sensory analysis* - Sensory analysis is done by wine experts on some wine samples before and after bottling. - Partners involved: Science for Oenology unit. - Measurement goal: to obtain wine flavour profiles. All this data gathered will help us to build hypothesis and create semantic models. All data are recorded but they still need to put in order and adapted to the Big Data Grapes project.
Achievements/Results	*Climatik database*

	- Results: precipitation, water height, evapotranspiration, humidity, insolation, wind. *French Network of Grapevine Repositories* - Results: morphological description, genetic profile, accessions, location, aptitudes, details. *PHIS* - Results: leaf area, plant height, biomass, plant width and images/ plant trait extractions. *SilexVitioeno* - Results: soil characteristics, vineyards, plots, sub-plots, grapevines, different treatments of experiment, cropping management, grape/ berry properties, yield, observations regarding the grape characteristics during the growing season. *Monitoring of winemaking operations* - Different stages of the winemaking process, duration of winemaking steps, dates etc. *ALFIS* - Alcoholic fermentation kinetics. *Laboratory analysis* - Chemical and physical analysis of must and wine: pH, alcohol, total acidity, volatile acidity, residual sugars, etc. *Sensory analysis* - Wine flavour profiles, scores regarding aromas presence.
Problems/Challenges	*Data linkability:* The main challenge is related to traceability from field to wine. Indeed, diverse persons are involved in data collection at different scales and it is not always easy to make links between all operations (especially between winemaking and field data). Moreover, data are not always in our information system. Our challenge is to make connections between all data to be able to have a transversal approach from the vineyard to the final product.

INRA's Evaluation Protocol	Viticulture and Grapes Quality Status of Implementation
Actors Involved	Pech Rouge: Nicolas Saurin (Team leader), Team Viticulture / Quality Grapes.
Methodology	Research topics are mainly related to the agro-climatic and social context of the South of France. It can be summarised as follows: hot climate, dryness, climate change, pH and K+ elevation, grapes and wine acidity diminution, irrigation, varieties selection, vineyard cultural practices,

	diversification, sensors. Here is an example of several steps for vineyard experiments: - Maturity: sample of 200 berries with berry weight analysis, refractometric indexes (sugar content), total acidity, pH, assimilable nitrogen, and for red wines anthocyanins and total polyphenol index. 3 sampling dates (at 2 or 3 dates and at harvest). - Yield components: bunch number, weight per grapevine at harvest. - Harvest management information such as harvest weight, equipment…
Deployed Components	The land field of Pech Rouge includes a total area of 170 ha of land planted with 38 hectares of vines, distributed in three areas. The INRA Pech Rouge Experimental Unit also contains analytical laboratories, technological tools.
Gathered Data and Formats	- The gathered data using this measurement technique: climatic data, genetic data, information about vineyards, plots, sub-plots, grapevines, different treatments of experiment. - Defined frequency of data collection: every years but variables assessed depend on projects goals. - Database: SilexVitiOeno, CLIMATIK, PHIS, French Network of Grapevine Repositories, format: xls/ csv, size: MB.

INRA's Evaluation Protocol	Winemaking and Wine Quality Status of Implementation
Actors Involved	Pech Rouge: Jean-Michel, Alain Samson (Team leader) - Team Innovative Technology/ Oenology.
Methodology	First, information related to harvest is recorded. Then, different operations are monitored during the winemaking process. For example, some observational data are done concerning the different product features and also observational results of some attributes for a particular product stage such as grape, initial must, must after alcoholic fermentation, and finished wine (such as sensorial analysis achieved by judges). Here, Figure (36), is an example of the different steps of winemaking done at Pech Rouge for red wines.

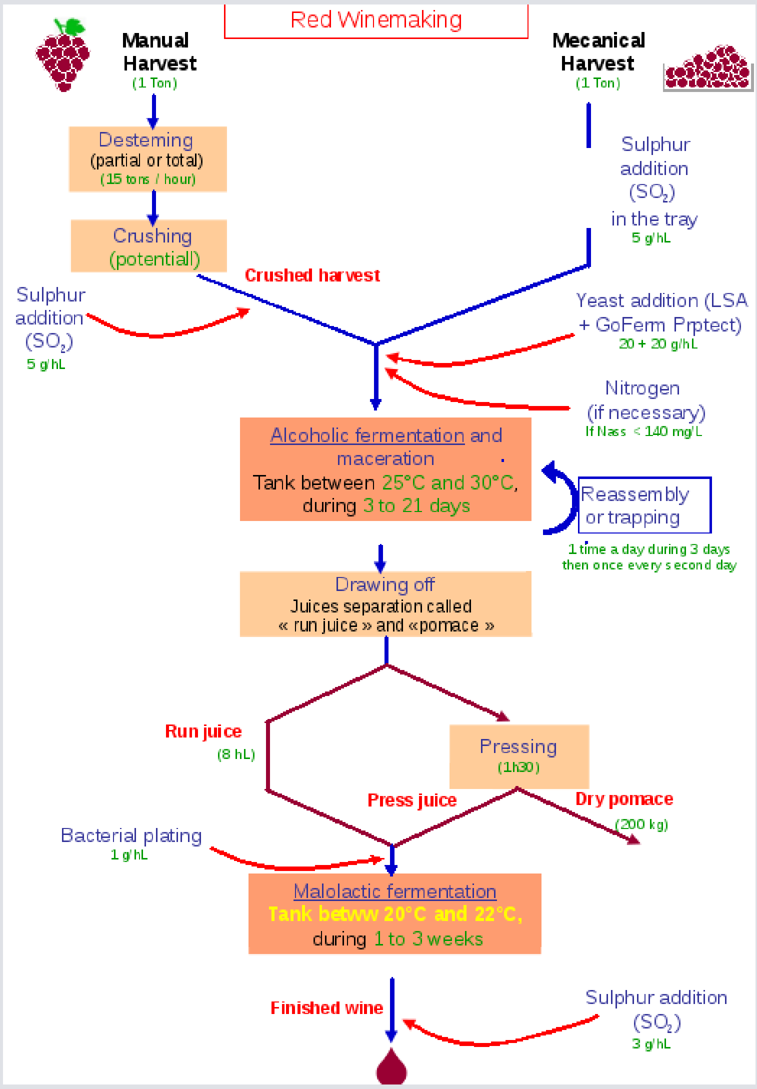


Figure 37: Steps for winemaking taking place in Pech Rouge

The land field of Pech Rouge includes a total area of 170 ha of land planted with 38 hectares of vines, distributed in three areas. The INRA Pech Rouge Experimental Unit also contains analytical laboratories, technological tools and finally a Sensory Analysis Laboratory, which enables the tasting of different wines.

Deployed Components

- Laboratory equipment
- Expert analysis
  - Experimental technological facilities: A technological facility dedicated to grape extraction, grape processing and winemaking. A technological facility for delayed fermentations allowing alcoholic fermentations under controlled conditions with on-line acquisition of fermentation kinetics.
- Winery
- Packaging facility
- Barrel cellar

	- Wine bar - Laboratory analysis - Sensorial analysis
Gathered Data and Formats	- The gathered data using this measurement techniques: different operations during the winemaking process: recorded observational data concerning the different product features. Observational results of some attributes for a particular product stage such as grape, initial must, must after alcoholic fermentation, and finished wine. - Defined frequency of data collection: every years but variables assessed depend on projects goals. - Database: files coming from Pech Rouge experimenters/ laboratories science for oenology unit, Alfis. - Format: xls, hand-written, size: MB. - Maturity (weight of 200 berries, sugar, total acidity, pH, assimilable nitrogen, anthocyanins, polyphenols). • Sampling: 200 berries per treatment + 200 berries for anthocyanins and polyphenols. • Frequency: 14 days before harvest, 7 days before harvest and at harvest. - Yield • Sampling: 15 grapevines / repetition at harvest. - Harvest management information such as harvest weight, equipment…

3.3 FARM MANAGEMENT PILOT EVALUATION SUMMARY AND STATUS OF IMPLEMENTATION (ABACO – GEOCLEDIAN)

3.3.1 Weather & Soil Data

ABACO Evaluation Protocol	Weather & Soil Data Evaluation Summary
Specific Objectives	Gather information on weather and soil parameter in the vineyard.
Work Plan Progress	Details provision on the conducted tasks in the reporting period - October 2018 till December 2020. - Partner involved: Geocledian. - Weather and soil data measures.
Achievements/Results	Winery companies engaged and instruments installed on field.
Problems/Challenges	Installation area definition in order to not interfere with farm management operations.

ABACO Evaluation Protocol	Weather & Soil Data Status of Implementation

Actors Involved	Pessl Instruments AG.
Methodology	The weather and soil stations are not already installed because of harvesting period not already closed.
Deployed Components	Weather and Soil sensors- API for data gathering into SITI4Farmer portal.
Gathered Data and Formats	- Weather and Soil data gathered in JSON format and exposed in SITI4Farmer portal. - Best Practices data of the 2018 season (pest management and fertilization) acquired in excel format and imported in Best Practices module of SITI4Farmer.

3.3.2 Sentinel-2 Data

Geocledian Evaluation Protocol	Sentinel-2 data Evaluation Summary
Specific Objectives	Geocledian will acquire and process all Sentinel-2 data sets available (until a certain cloud cover threshold) for all sites during the pilot run time. Visible images and Vegetation indexes will be produced and the data be provided to the project partners.
Work Plan Progress	These evaluation tasks have been conducted in the reporting period: - Acquisition of all available Sentinel-2 data sets for all sites. - Processing of these data sets. - Development & Implementation of new vegetation indexes and data products and related software components for data processing, delivery (API & visualization) and scalability. - Technical evaluation of software components and products. - Provision of these data sets to the project partners. - Qualitative data review of new vegetation indexes and data products. - Atmospheric correction procedures have been evaluated. - Data processing performance has been evaluated.
Achievements/Results	A series of developments has been implemented and deployed successfully to improve data download, processing, performance monitoring, scalability, visualization and to enable the delivery of the new data products and vegetation indexes. The Sentinel-2 data sets are available to the project partners in various formats (tif, png) and have been inspected in first qualitative checks with positive results. In addition to the reflectance values for each spectral band, new vegetation indexes are available (NDVI, NDRE1, NDRE2, NDWI, CI-RE, SAVI, EVI2) together with time series statistics.
Problems/Challenges	Cloud masking is still a challenge and it has to be evaluated if the cloud masking algorithms applied are sufficient or have to be improved further. Atmospheric correction procedures also need further evaluation. Data processing performance needs also further evaluation and possibly improvement.

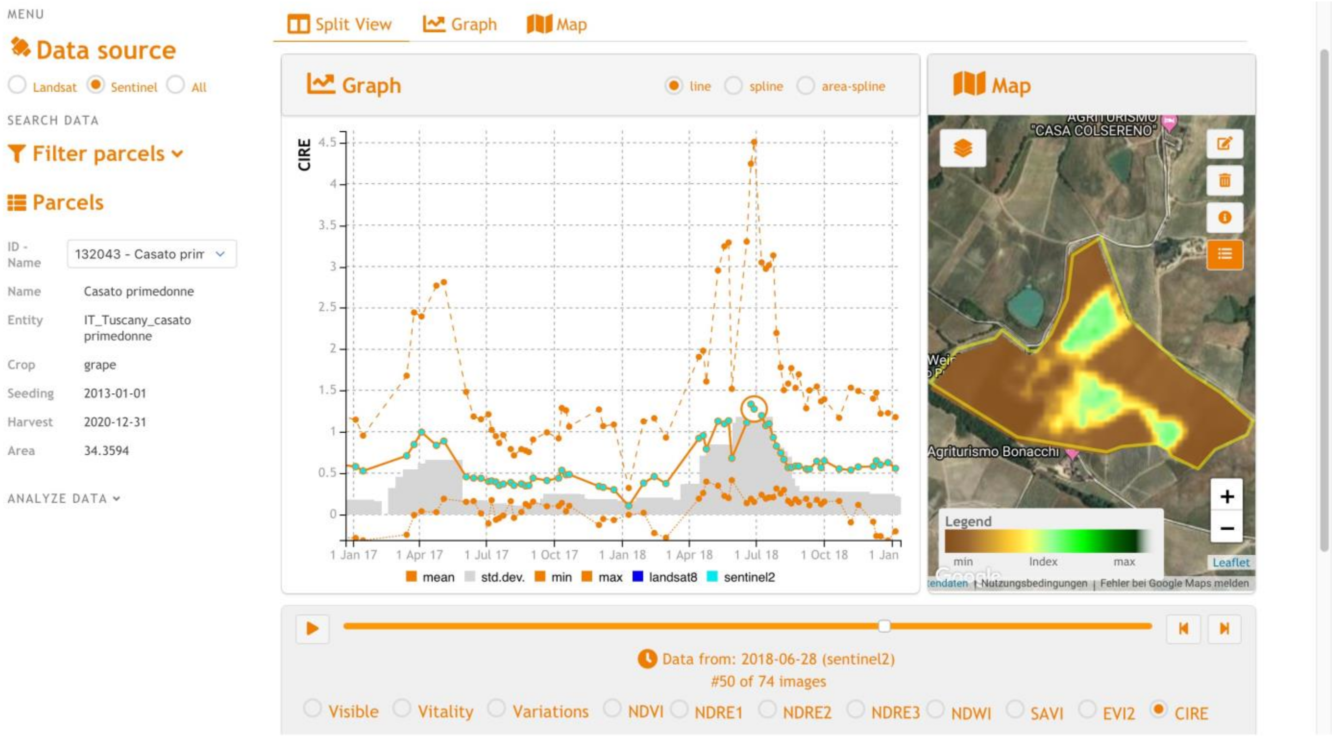


Figure 38: A Sentinel-2 Chlorophyll Index Red Edge (CI-RE) time series for 2017 & 2018 over parts of the Casato Prime donne site in Tuscany, visualized in a data analysis and review client.

Geocledian Evaluation Protocol	Sentinel-2 data Status of Implementation
Actors Involved	Data providers are: ESA, AWS, Google.
Methodology	These tasks have been conducted in the reporting period: - Development and implementation of extended data download & processing routines. - Acquisition & processing of all available Sentinel-2 data sets for all sites. - Development and implementation of processing performance monitoring tools. - Development & Implementation of new vegetation indexes and data products. - Development & Implementation of new API endpoints for data delivery. - Development & Implementation of data visualization tools for data review and analysis. - Provision of these data sets to the project partners via API (ongoing) and visualization tools.
Deployed Components	- Extended data download and processing components. - New processing performance monitoring tools. - New vegetation indexes and data products component. - New API endpoints for data delivery. - New data visualization tools for data review and analysis.
Gathered Data and Formats	All available Sentinel-2 data sets for all sites up to a cloud cover threshold of 50%.

3.3.3 Landsat-8 Data

Geocledian Evaluation Protocol	Landsat-8 data Evaluation Summary
Specific Objectives	Geocledian will acquire and process all Landsat-8 data sets available (until a certain cloud cover threshold) for all sites during the pilot run time. Visible images and Vegetation indexes will be produced and the data be provided to the project partners.
Work Plan Progress	These evaluation tasks have been conducted in the reporting period: - Acquisition of all available Landsat-8 data sets for all sites. - Processing of these data sets. - Development & Implementation of new data products and related software components for data processing, delivery (API & visualization) and scalability. - Technical evaluation of software components and products. - Provision of these data sets to the project partners. - Qualitative data review of new data products. - Data processing performance has been evaluated.
Achievements/Results	A series of developments has been implemented and deployed successfully to improve data download, processing, performance monitoring, scalability, visualization and to enable the delivery of the new data products. The Landsat-8 data sets are available to the project partners in various formats (tif, png) and have been inspected in first qualitative checks with positive results. In addition to the reflectance values for each spectral band, NDVI values are available together with time series statistics.
Problems/Challenges	Atmospheric correction procedures need further evaluation. Data processing performance needs also further evaluation and possibly improvement.

Geocledian Evaluation Protocol	Landsat-8 data Status of Implementation
Actors Involved	Data providers are: USGS, AWS.
Methodology	These tasks have been conducted in the reporting period: - Development and implementation of extended data download & processing routines. - Acquisition & processing of all available Landsat-8 data sets for all sites. - Development and implementation of processing performance monitoring tools. - Development & Implementation of new data products. - Development & Implementation of new API endpoints for data delivery. - Development & Implementation of data visualization tools for data review and analysis.

	- Provision of these data sets to the project partners via API (ongoing) and visualization tools.
Deployed Components	- Extended data download and processing components. - New processing performance monitoring tools. - New data products component. - New API endpoints for data delivery. - New data visualization tools for data review and analysis.
Gathered Data and Formats	All available Landsat-8 data sets for all sites up to a cloud cover threshold of 50%.

3.4 NATURAL COSMETICS PILOT EVALUATION SUMMARY AND STATUS OF IMPLEMENTATION (Symbeeosis)

3.4.1 Biological Efficacy

Symbeeosis Evaluation Protocol	Biological Efficacy Evaluation Summary
Specific Objectives	We want to examine how the biological efficacy (in terms of the parameters described above) depends on the location of the vineyard, the weather conditions, the extraction method used and the variety of the grape. As a final goal, we want to create a predictive tool of the biological efficacy based on the location and weather of a certain vineyard.
Work Plan Progress	During summer (May-July), the samples of vine leaves have been collected. Following extractions of gathered samples have been performed and also measurements on the value of developed samples (July-Oct). The partners involved besides the company (Symbeeosis) and Geocledian (for SVIs data gathering and processing) are the following vineyards chosen for sample collection.

	Vineyard	Grape Variety	Region	City
1	Semeli Wines	Agiorgitiko	Peloponnese	Nemea
2	Pavlidis Estate	Agiorgitiko	Northern Greece	Drama
3	RIRA Vineyards	Agiorgitiko	Peloponnese	Aigio
4	Vassaltis Vineyards	Mandilaria	Aegean	Santorini
5	Strofilia Estate Winery	Agiorgitiko	Peloponnese	Stimfalia
6	Papagiannoulis Winery	Agiorgitiko	Northern Greece	Katerini
7	Tetramythos Wines	Agiorgitiko	Peloponnese	Ano Diakopto
8	Skouras Domaine	Agiorgitiko	Peloponnese	Argos
9	Moraitis Winery	Mandilaria	Aegean	Paros
10	Toplou Winery	Mandilaria	Crete	Sitia
11	Aoton Winery	Mandilaria	Attica	Peania
12	Biblia Chora Estate	Agiorgitiko	Northern Greece	Kavala
13	Papagiannakos Domaine	Mandilaria	Attica	Markopoulo

14	Hellenic Agricultural Organization "DIMITRA"	Mandilaria	Attica	Lykovrisi
15	Hellenic Agricultural Organization "DIMITRA"	Agiorgitiko	Attica	Lykovrisi
16	Agricultural University of Athens	Agiorgitiko	Peloponnese	Nemea

Achievements/Results	We have concluded the extractions under two different methods and the following measurements of biological activity: pH, Refractive index, TPC, TFC, Total Microbial Count, Yeasts & Moulds, DPPH & ABTS assay. The correspondent file has been shared with the BigDataGrapes partners.
Problems/Challenges	The main challenge of the pilot is the need to coordinate all partners involved in sample gathering, meaning the vineyards chosen for collection, in order to have acceptable dispersion of samples across the country and a notable total number of samples. Also, the weather variability is another serious challenge that the pilot is facing. . Finally, during the present season the pending analyses of MTT assay and Real time PCR will be accomplished and new data on weather (apart of SVIs data) will be incorporated to the correlation analysis.

Symbeeosis Evaluation Protocol	Biological Efficacy Status of Implementation
Actors Involved	Agroknow and Symbeeosis.
Methodology	The measurements remaining to be finalized are: toxicity on skin cells, gene expression on skin cells. At the moment, we are in the process of transforming xls files to rdf files in collaboration with Agroknow, in order for them to be useful for other partners too.
Deployed Components	- A Nanoquant, infinite M200 Pro, TECAN will be used for the measurement of toxicity on skin cells (MTT assay) (Figure 38).  **Figure 39: Nanoquant, infinite M200 Pro.** - A CFX connect Real time System, BIO-RAD will be used for the measurement of gene expression on skin cells (Target SIRT1 mRNA transcripts using real time PCR) (Figure 39).

	 Figure 40: CFX connect Real time System.
Gathered Data and Formats	- The gathered data using this measurement technique: Results of biological efficacy have been shared with the BigDataGrapes partners. - Defined frequency of data collection: Once every season. - Associated data model/ format: xls files that will be transformed to rdf files. - Data size in the reporting period: MB.

3.5 FOOD PROTECTION PILOT EVALUATION SUMMARY AND STATUS OF IMPLEMENTATION (AGROKNOW)

3.5.1 Lab testing data

Agroknow Evaluation Protocol	Lab testing data Evaluation Summary
Specific Objectives	The main objective of using the lab testing data in the food protection pilot is to explore how this type of data can be used to get critical insights for chemical contamination in agricultural products and ingredients including grapes and raisins.
Work Plan Progress	Pesticides monitoring data (Laboratory analysis results) from 34 countries have been collected and processed by the Agroknow Data Platform.
Achievements/Results	• **54.729.584** lab testing data were collected and processed. The data are currently available by the Data Platform API; • Module for the processing and enrichment of lab testing data was deployed on the Agroknow Big Data Platform; • A dashboard for the Lab Data was developed and deployed in the FOODAKAI system. The lab data dashboard was presented to **4** companies of the agrifood industry
Problems/Challenges	• The collected lab testing datasets were highly heterogeneous. More than 500 excel files were combined to integrate the data in Agroknow Data Platform; • The data published by the national authorities in Europe cover only 2 years, namely 2016 and 2017;

	• The datasets followed a different hazards and products taxonomy than the FOODAKAI system; • It's difficult to convince food companies to share internal data for processing.

Agroknow Evaluation Protocol	Lab testing data Status of Implementation
Actors Involved	Agroknow, food manufacturers like Galo Winery and Conagra, retailers like AB Vasilopoulos, Agrochemical companies like Syngenta.
Methodology	The following methodology was used to evaluate the use of the lab testing data 1. We collected the data from the pesticides monitoring programs that are published by 34 countries in EU and America; 2. We processed and enriched the heterogenous data. The enrichment was focused on the alignment of the data with the hazards and products taxonomies; 3. The lab testing data was published through the data API of Agroknow Big Data Platform; 4. We developed a new module in the FOODAKAI system for the lab analysis data dashboard; 5. The new module was presented to Quality Assurance and Food Safety Experts working in food companies and retailers and feedback was collected; 6. The new module was tested by a control group of end users; 7. An iterative approach for implementing the improvements was followed
Deployed Components	• A new module fort the collection and processing of lab testing data was developed and deployed in the Agroknow Data Platform; • A lab data analysis dashboard has been developed and currently is tested by a control group of end-users; • The new module is available in the sandbox of the FOODAKAI product; • The Lab data analysis module was presented to food companies like Galo Winery, Conagra and AB Vasilopoulos.
Gathered Data and Formats	Data from Laboratory testing performed by the national Authorities was collected. More than **500 spreadsheets** that are published by EFSA and United States were processed. The data covers: • Lab data published by **34 countries**; • **2002 to 2018**; • **54.729.584** lab analysis results; • **170 countries** of origin.

3.5.2 Pricing data

Agroknow Evaluation Protocol	Pricing data Evaluation Summary

Specific Objectives	The main objective of using the pricing data for agricultural products is to explore if this type of data can be used for the fraud and hazards prediction.
Work Plan Progress	Prices data have been collected and processed by the Agroknow Data Platform. Deep and Machine Learning algorithms have been tested in order to find the best one.
Achievements/Results	Daily harvesting of prices from three data sources that is the Food and Agriculture Organization of the United Nations, the European Commission and the Greek Food market. • More than 352.590 pricing data • These datasets have been cleaned, prepared and stored in Agroknow' s Big Data Platform. • Have been tested six different algorithms
Problems/Challenges	The collected pricing datasets were highly heterogeneous. There are: • irrelevant column names, • outliers / unexpected data values • duplicates • missing data • columns that need to be processed

Agroknow Evaluation Protocol	Pricing data Status of Implementation
Actors Involved	Agroknow
Methodology	The following methodology was used for the price prediction experiments 1. We collected the data form the Food and Agriculture Organization of the United Nations, the European Commission and the Greek market 2. These datasets have been cleaned, prepared and stored in Agroknow's Big Data Platform 3. Deep and Machine learning algorithms have been applied to pricing data in order to predict the future price for several agricultural products. Have been tested 6 algorithms in order to find the best one. These algorithms are Moving Average, K-Nearest Neighbors, Linear Regression (Machine learning) and Arima, Prophet, Long Short-Term Memory (Deep Learning). 4. For each algorithm, the data were modified appropriately to fit the requirements of each algorithm and separated into train and test data. The train data was used to train the model and the test data to evaluate algorithms results 5. Algorithm evaluation 6. Repeat steps 3 to 5 until the best prediction is found

Deployed Components	• **Clean and ready to use pricing dataset stored in Agroknow Big Data Platform** • Automated data harvesting from three data sources • Full algorithm comparison • Implementation of a Deep learning algorithm that predicts future prices for over 800 products for the next 30 days
Gathered Data and Formats	Pricing Data performed by the national Authorities was collected. Prices for more than 800 products were processed. The data covers: • More than 352.590 pricing data for more than 800 products • Data sources are the Food and Agriculture Organization of the United Nations, the European Commission and the Greek Food market. • European Commission Weekly: 174972 • European Commission Monthly: 133864 • Hellenic Food Market Daily: 39852 • FAO Yearly: 2142 • European Commission Yearly: 1760 More than 30 countries of origin

4 ASSESS MEASUREMENTS RESULTS

All five Pilot partners (Table and Wine Grapes Pilot- AUA, Wine Making Pilot- INRA, Farm Management Pilot- ABACO- Geocledian, Natural Cosmetics Pilot- Symbeeosis, Food Protection Pilot- Agroknow) provided an overview of the Data and the Datasets that will be gathered per measurement performed.

4.1.1 Data and Datasets

Table 2: Table and Wine Grapes Pilot Data and Datasets

Name	DataSet Description	Priority	Provenance	Data Type Format	Data size
Yield Mapping	Yield data	Essential	Laboratory equipment	csv, xls	MB
Grape and berry mechanical properties	Measurements	Essential	Laboratory equipment	csv, xls	MB
Classical analytical techniques (HPLC)	Phenolic composition data	Essential	Laboratory equipment	csv, xls	MB
Topographic da ta and elevation maps	Spatial data (boundaries and elevation data)	Essential	Remote sensing	csv, xls, xml	MB
Canopy sensing and vegetation indices	Canopy sensing data	Essential	Proximal sensors	csv, xls	MB
IoT stationary data	Soil moisture data, meteorological parameters	Essential	IoT data	csv, xls	MB
Drone imagery	Drone images	Essential	Multispectral and thermal cameras	GEOTIFF	GB
Eca sensing	Geo-referenced soil electrical conductivity data	Essential	Proximal sensors	csv, xls	MB

Table 3: Wine Making Pilot Data and Datasets

Name	DataSet Description	Priority	Provenance	Data Type Format	Data size
Genetic Data	Genetic profile, Morphological description, origin, etc.	Essential	French Network of Grapevine Repositories (Database of the collections)	csv or api	MB
Phenotypic data	Images of grapevines under diverse water stress	Essential	PhenoArch phenotyping platform (PHYS)	json files (and jpeg for images)	GB
Soil characteristics	Texture, pH etc.	Essential	Field measurement	xls	KB
Plot management	Treatments/fertilizing (when, what, how much), ground handling, or tasks related to the culture management, pest control, water status, yield etc	Essential	Field measurement	Pdf,doc, xls	MB
Climatic data	Rainfall, temperature, radiation etc.	Essential	Field measurement	xls	MB
Grape and berry mechanical and chemical properties	Anthocyanin content, weight, length, width, density etc.	Essential	Field measurement	xls	MB
Qualitative and quantitative characteristics of must	Sugar content, alcohol, pH etc.	Essential	Laboratory equipment		MB
Winemaking activities	Bioconversion of sugar into ethanol and CO2, Monitoring of alcoholic fermentation and sugar content, yeast	Essential	Laboratory equipment	xls, pdf	MB

	characteristics etc.				
Sensory analysis	Expert panel of tasters' sensory analysis (wine bitterness, astringency, phenol content, aroma etc.)	Essential	Expert analysis	xls	MB
Wine commercial information	Number of bottles produced; number of bottles sold	Additional Data	Selling point	xls	MB

Table 4: Farm Management Pilot Data and Datasets

Name	DataSet Description	Priority	Provenance	Data Type Format	Data size
Sentinel-2	Sentinel-2A/B MSI visible & NIR bands, NDVI time series & advanced products	Essential	Copernicus EO Programme, ESA	JSON, GEOTIFF, PNG	150 GB/year*site
Landsat-8	Landsat-8 OLI visible & NIR bands & advanced products	Essential	USGS, NASA	JSON, GEOTIFF, PNG	6 GB/year*site
Chemical and physical info on grapes	Antocyanins, Ph, Brix values during maturation	Additional	Excel table file	XLS	TBD
Day by Day Activities in term of treatments, fertilization, field operation	Diary where farmer or operators can record and /or plan all the activities on their fields	Essential	SITI4farmer	Text file	TBD
Plot and Fields information georeferenced	Information of Plots position, shaping, cultures, type of	Essential	Form the field through SITI4farmer	Test files	TBD

	seed, dates, and everything related on the culture and the farm itself (form official and not official point of view)				
Relative Humidity	Relative humidity (RH) is the ratio of the partial pressure of water vapor to the equilibrium vapor pressure of water at a given temperature	Essential	Field Sensors	Decimal Data	TBD
Air Temperature		Essential	Field Sensors	Decimal Data	TBD
Global Solar Radiation	It's the power per unit area received from the Sun in the form of electromagnetic radiation in the wavelength range of the measuring instrument	Additional	Field Sensors	Decimal Data	TBD
Wind Speed and Direction		Essential	Field Sensors	Decimal Data	TBD
Soil Temperature		Additional	Field Sensors	Decimal Data	TBD
Soil Moisture	Measurement of the water in the large and intermediate size pores that can move about in the soil and be easily used by plants	Essential	Field Sensors	Decimal Data	TBD

Precipitation	Rainfall measurements	Essential	Field Sensors	Decimal Data	TBD
Infrared Surface Temperature	Temperature Surface calculated with infrared measurements	Essential	Field Sensors	Decimal Data	TBD

Table 5: Natural Cosmetics Pilot Data and Datasets

Name	DataSet Description	Priority	Provenance	Data Type Format	Data size
Sentinel-2	Sentinel-2A/B MSI visible & NIR bands, NDVI time series & advanced products	Essential	Copernicus EO Programme, ESA	JSON, GEOTIFF, PNG	TB
Landsat-8	Landsat-8 OLI visible & NIR bands & advanced products	Essential	USGS, NASA	JSON, GEOTIFF, PNG	TB
Agiorgitiko Samples UAE (11 samples)	Data on biological efficacy of samples of Agiorgitiko dried vine leaves, developed with Ultrasound Assisted Extraction	Essential	Laboratory testing	csv, xls	MB
Agiorgitiko Samples MAC (11 samples)	Data on biological efficacy of samples of Agiorgitiko dried vine leaves, developed with Maceration	Essential	Laboratory testing	csv, xls	MB
Mandilaria Samples UAE (5 samples)	Data on biological efficacy of samples of Mandilaria dried vine leaves, developed with Ultrasound Assisted Extraction	Essential	Laboratory testing	csv, xls	MB
Mandilaria Samples MAC (5 samples)	Data on biological efficacy of samples of Mandilaria dried vine leaves, developed with Maceration	Essential	Laboratory testing	csv, xls	MB

Weather Data	Weather data on the regions selected for sample gathering	Essential	Open source data	csv, xls	MB

Table 6. Food Protection Pilot Data and Datasets

Name	DataSet Description	Priority	Provenance	Data Type Format	Data size
Lab testing data	Results of the laboratory testing that the food companies perform to identify the presence of hazards	Essential	Laboratory testing	xsl, csv	GB
Pricing data	Pricing data published by Statistical Authorities both at local and global level	Essential	Open Data published by Authorities	xsl, csv, API	GB
UK Food Standards Agency	Food recalls published by the UK Food Standards Agency	Essential	Open Data published by Authorities	Html	MB
RASFF – Rapid Alert System for Food and Feed	Food recalls and border rejections information published by EU	Essential	Open Data published by Authorities	XML, Html	MB
Food Standards Australia New Zealand	Food recalls and border rejections information published by the Asutralian Gov	Essential	Open Data published by Authorities	Html	MB
FDA Recalls, Market Withdrawals, & Safety Alerts, warning letters, import refusals and inspection citations	Food recalls and border rejections information published by the United States Gov	Essential	Open Data published by Authorities	OpenFDA Food API, html, xsl, json, xml	GB
EFET - Hellenic Food Safety Authority	Food recalls published by the National Food Safety Authority of UK	Essential	Open Data published by Authorities	Pdf, Html	MB
Japanese Imported Foods Inspection Services	Food recalls and border rejections information published by the Japanese Gov	Essential	Open Data published by Authorities	Html, xsl	MB
Czech Agriculture and Food Inspection Authority	Food recalls published by the National Food Safety Authority of Czech Republic	Essential	Open Data published by Authorities	Html	MB

Healthy Canadians food alert information website	Food recalls published by the Canadian National Food Safety Authority	Essential	Open Data published by Authorities	Html	MB
Food Safety Authority of Ireland	Food recalls published by the Irish National Food Safety Authority	Essential	Open Data published by Authorities	Html	MB
German Food Safety: warnings and information to the public	Food recalls published by the German National Food Safety Authority	Essential	Open Data published by Authorities	Html	MB
Hong-Kong-Center for Food Safety	Food recalls published by the Irish National Food Safety Authority	Essential	Open Data published by Authorities	Html	MB
Open Food Facts	Crowd sourced open data about food products and their composition	Essential	Open Data published by Companies	Html	MB
ProMED-mail	Dataset about foodborne outbreaks, animal and plant diseases with global coverage	Essential	Open Data published by ProMED-email	Html	MB

5 SUMMARY

This deliverable, the "Experimental Protocols and Evaluation Methodology", belongs to WP8 "Grapevine-powered Industry Application Pilots". This work package is responsible for the planning and preparation of the pilots, the definition of the experimental and evaluation protocols to be followed, the execution of the pilots and ultimately, the collection and evaluation of the pilot results and their assessment over indicators defined by the end users. The purpose of this deliverable is to define the experimental protocols and specify the evaluation methodologies that will be activated for each measurement during the execution of the application pilots. A report describing the experiments to be conducted and their parameters, along with the methodology for assessing the results of the experiments in accordance with the piloting plan.

This document reports a detailed overview of the individual experimental protocols and evaluation methodologies for each of the five pilots. This deliverable is based on the individual experimental protocols and evaluation methodologies of the following pilots: Table and Wine Grapes Pilot (AUA), Wine Making Pilot (INRA), Farm Management Pilot (ABACO & Geocledian), Natural Cosmetics Pilot (Symbeeosis) and Food Protection Pilot (Agroknow). As further contributions, we have provided the updated tables containing all Data and Datasets related to the five pilots and their experiments/ measurements. These tables will be updated as needed in the future.

The project's Experimental Protocols and Evaluation Methodology presented in this report is a constantly updating roadmap to an efficient execution of the pilots of the project and it is aligned with the project vision and objectives.

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