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

D8.3 - Integration and Operation with real-life Software Systems

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ACRONYMS LIST

BDG	BigDataGrapes
WP	Work Package
D	Deliverable
DSS	Decision Support System
REST API	Representational State Transfer Application Program Interface
SVIs	Spectral Vegetation Indices
Vit	Vitality
NDVI	Normalized Difference Vegetation Index
NDRE1	Normalized Difference Red Edge Index (v1)
NDRE2	Normalized Difference Red Edge Index (v2)
NDWI	Normalized Difference Water Index
SAVI	Soil Adjusted Vegetation Index
EVI2	Enhanced Vegetation Index 2
CI-RE	Chlorophyll Index - Red Edge
EO	Earth Observation
RGB	Red, Green, Blue
JSON	JavaScript Object Notation
API	Application Programming Interface
LAI	Leaf area
NIR	Near-infrared
VRT	Variable rate technology

EXECUTIVE SUMMARY

The deliverable (D8.3) focuses on the task **T8.3 Integration with existing real-life Software Systems:** this task focuses on the integration of the BigDataGrapes (BDG) software stack and data model into a market-ready Farm Management System produced by ABACO, SITI4Farmer, augmenting its functionalities to support the implementation of the envisaged Use Cases.

This deliverable aims to incorporate by prototyping onto SITI4Farmer, the relevant functionalities of the BDG software stack, further used in the piloting sessions.

Within the BDG scope, the farm management system integration refers to the integration of weather-soil-plant monitoring data via data exchange over Rest-APIs in JavaScript Object Notation (JSON) format. Another important integration domain is represented by the GEOCLEDIAN Satellite data and the related vegetation indices. The real-life software system allows to define (draw and edit) farming plans at field level on top of which time series of indices are calculated.

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1 INTRODUCTION

The deliverable D8.3 – Integration and Operations with real-life Software Systems, focuses on the integration of ABACO software SITI4farmer into BDG task.

The task focuses on the incorporation of the BDG software stack in an existing Farm Management System produced by ABACO, SITI4Farmer, augmenting functionalities required for the implementation of the envisaged Use Cases tanks to the cooperation with the technological partner of the project.

The exploited BDG technologies are related to satellite data from GEOCLEDIAN and data visualization improvements with the support of KU Leuven. As regards the next steps, specific data modelling tasks with ONTOTEXT are described.

Within the Big Data Grapes context, the current software SITI4Farmer is going to be updated with functionalities regarding satellite indices data storage and display, field sensors data storage and display, and with new data visualization widgets, the decision support system (DSS), calculated from both satellite and field sensors, that can be easily used by piloting farmers. In fact, SITI4Farmer, in its current version, provides valuable data, however the final decision must be taken by the user. The improvement in data visualization includes providing practical decision support in farming activities, such as suggesting water quantity to be supplied and so on.

The capabilities of the real-life software span from Precision Farming techniques and good agricultural practice capturing, in a corporate database, the information and data of the company and its daily activities. The system integrates this data with other information from heterogeneous sources.

The data feed is thoroughly geo-referenced into the corporate knowledgebase onto which a set of analysis algorithms are executed. These algorithms process information and indicators in order to support a smart management of the company.

SITI4farmer follows European Union's guidelines for Precision Agriculture, defined as a way to "apply the right treatment in the right place at the right time", a farming management concept based upon:

- observing
- measuring
- responding

In order to inter and intra-field variability in crops, or to aspects of animal rearing.

The goal is to define a DSS for whole farm management with the goal of optimizing returns on inputs whilst reducing environmental impacts.

This document is structured as follows: after a brief introduction, Chapter 2 focuses on the farm management pilot and the related data recorded. Chapter 3 is about datasets and their relationships with use case scenarios. Chapter 4 describes SITI4Farmer and how the BDG technologies are integrated into the system. The exploited BDG technologies are related to satellite data from GEOCLEDIAN and data visualization improvements with the support of KU Leuven. Finally, Chapter 5 describes the next steps, including specific data modelling tasks with ONTOTEXT.

2 FARM MANAGEMENT PILOT

2.1 INTRODUCTION & SPECIFIC GOALS

The ABACO and GEOCLEDIAN Farm Management Pilot is focused on developing a unique system that satisfies these needs:

- Farm Management System with all functionalities to support the farmer in his day-by-day activities and to help gathering field data
- Host data from various sources and provide tools and functionalities for comparisons and easy data management
- Data exchange: (a) a "day by day" data producer, to feed the generated data into the other BDG components and (b) a "data consumer" to use the 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 for farming activities.

Two wine makers were identified as actors in this pilot. They are involved in the pilot in two ways:

- They are supported in their work by the developed products and, apart from the farm management system itself, such products include sensors and other measurement techniques that provide decision support data.
- On the other hand, these actors help design the new system by providing feedback and know-how about their needs and activities. They can also give insights on how to disseminate results, approaches and ideas delivered by the BigDataGrapes Project.

2.2 SITE DESCRIPTION

The 2 wineries are located in Tuscany, Italy:

Figure 1 Tuscany region map and the position of the two piloting farms

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 2 Casato Prime Donne vineyards aerial image

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 3 IL Palazzo vineyards aerial image

2.3 EQUIPMENT USED

ABACO supplied a version of SITI4farmer readily accessible by the 2 winemakers and the project partners.

SITI4farmer is a web-based system that handles:

- Preparing of the graphical crop plan or farming plan;
- Managing farming practices and phenology phases;
- Analyzing indices;
- Providing dashboards to support decisions (agro-meteorology and vegetation);
- Keeping farm data organized and accessible;
- Recording field data with the SITI4land app;
- Printing and exporting data.

Furthermore, it is able to integrate weather data and services from different sources, and it can use open databases and local land registries made available by everyone that expose data through web services.

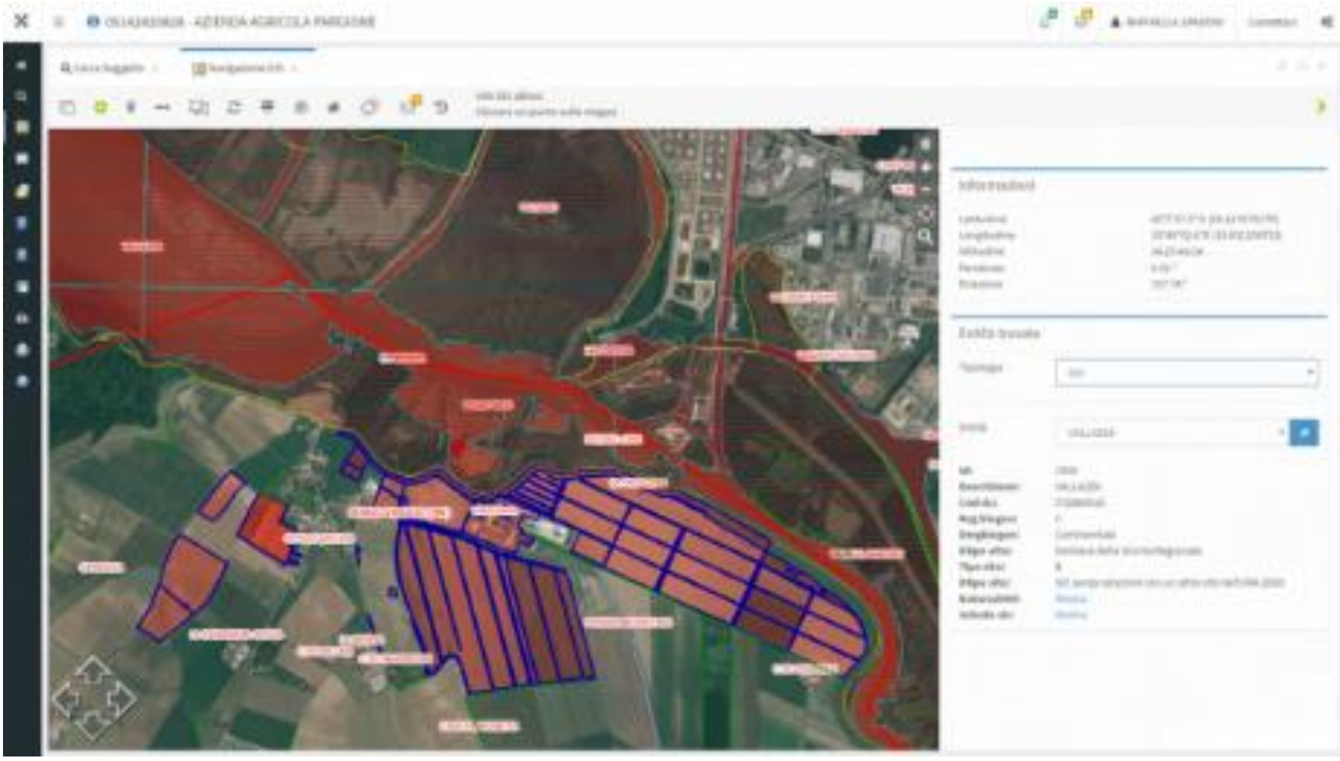

Figure 4. SITI4farmer screen view

In order to make full and comprehensive measurements in the fields, automatically as much as possible, ABACO acquired 2 Weather and sensor stations and integrated the data in their system. The Sensor Stations have been purchased directly by ABACO , and installed at the two farms, after a dedicated study with ABACO's experts, to find the right place and position in accordance with the expected measurement quality.

The weather stations have been set up with a data transmission via radio to a central server which transmits the data directly to SITI4farmer. They are equipped 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;
- Leaf Wetness Sensor Module with a 5-meter cable;
- Drill & Drop Sensors (Temperature and soil moisture sensors).

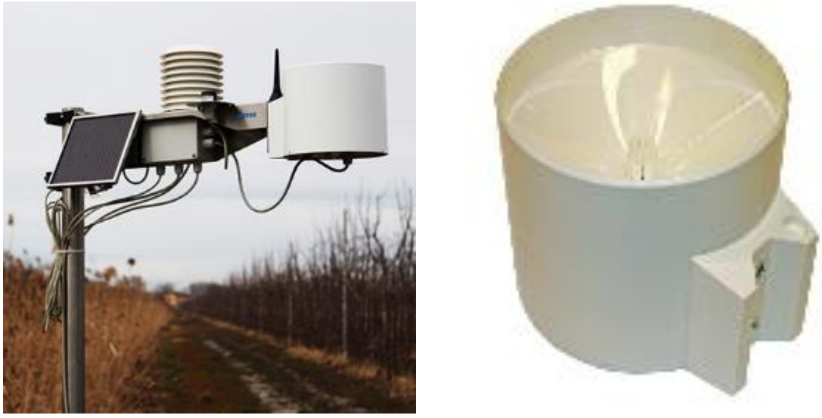

Figure 5: Sensor & Weather Station (left) and Rain Gauge Module (right)

GEOCLEDIAN is acquiring, processing and delivering Copernicus Sentinel-2 and USGS Landsat-8 images for all sites during the pilot run time directly to SITI4Farmer (more details in section 4.1).

2.4 TIMELINE

ABACO's main Tasks and Operations, that have been 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 interfaces and interoperability with the central system of the sensors stations;
- Measurements and monitoring of field activities;
- Integration with GEOCLEDIAN services;
- Improvement in data visualization with KU Leuven ;
- Data modelling improvements with ONTOTEXT.

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 their Processing platform Ag|knowledge and the data be provided to all project partners in near real-time. The following figure provides a rough overview of ABACO's and GEOCLEDIAN's main tasks:

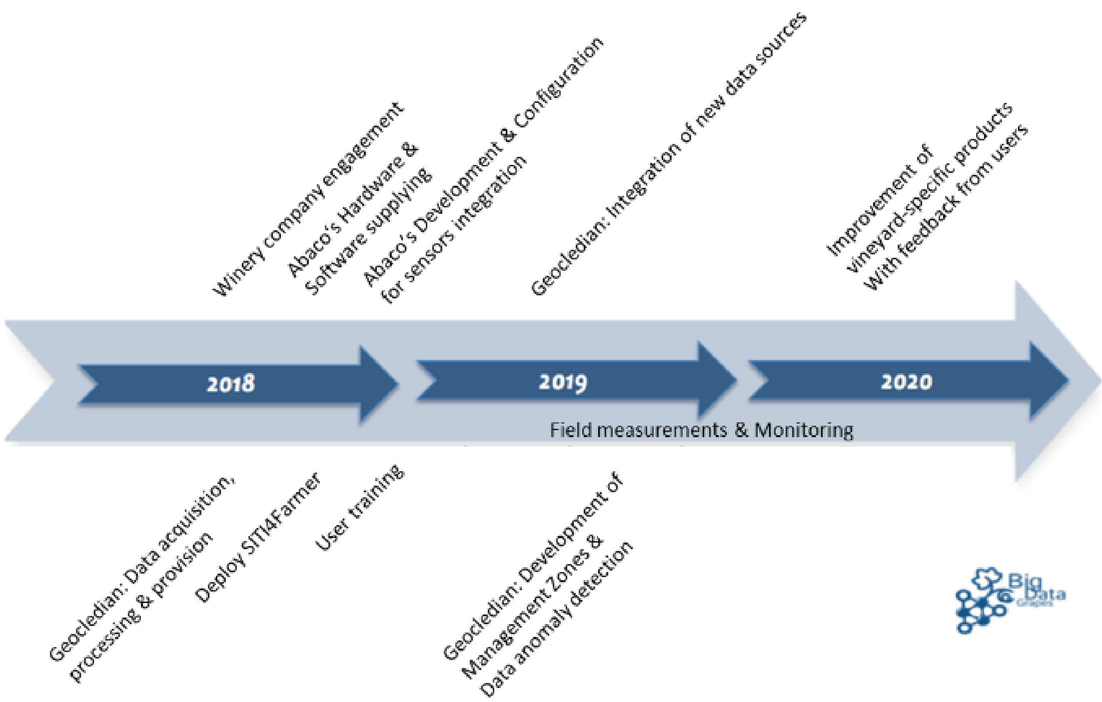

Figure 6 Timeline of Farm Management piloting plan

2.5 MEASUREMENTS

ABACO, with its SITI4farmer system, is engaged to provide the big picture of farm management data, bonding information from external environments, space and ground activities. This means to measure all environmental variables as presented in the previous paragraph, and in the following sections, together with all information coming from the farm activities, for example: treatments/fertilizing (when, what, how much), ground handling, or tasks related to the culture management; and with data from the position, shape, terrain, geographically localized. GEOCLEDIAN is delivering a variety of satellite data products via REST API to SITI4Farmer (see section 4.1 for details).

2.6 ENVISAGED OUTCOMES

The Farm Management Pilot is focused on developing SITI4Farmer further into 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;
- Semantic Data modelling by ONTOTEXT and integration by Rest-API standard.

In the frame of the pilot, GEOCLEDIAN is further developing their initial data processing platform Ag|knowledge into a Big Data Processing Platform that allows the scalable production, provision and analysis of large scale data sets of new vineyard-specific products for all test sites of the project so that they can be integrated into farm management systems, like ABACO’s SITI4Farmer. The combination of remote sensing with in situ field and weather data will enable the development of new Farm Management products. ABACO makes use of the output from GEOCLEDIAN, from sensors, and from the users of the system, in order to create knowledge maps and data systems to relate the crop quality with all the other variables. Finally, the system will integrate semantic data modelling by ONTOTEXT, including BDG dataset.

3 SITI4FARMER & USE CASES

The SITI4FARMER Portal, at the beginning of the project, consisted of few essential modules that mainly allowed data overview at different scales:

LAND DATA OVERVIEW

- Historical meteo;
- Meteo Forecast;
- Climatology;
- Pedology maps;
- Pedological survey;
- Ortophoto base map.

FARM DATA OVERVIEW

- Asset management;
- Warehouse and Stock.

FIELD DATA OVERVIEW

- Crop plan;
- Farming activities;
- Product management;
- Mandatory registries;
- Record activities on the field, with SITI4Info APP;
- Agrometeorological indices;
- Earth Observation.

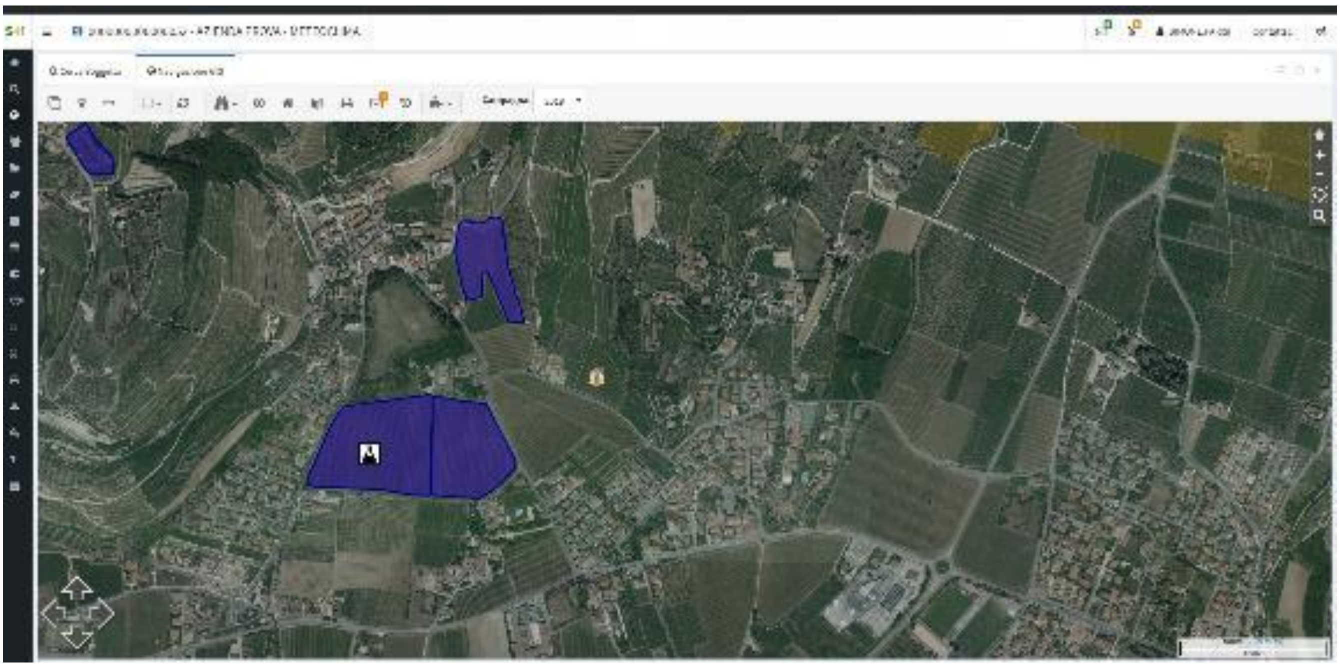

Figure 7 The GIS Navigation system in SITI4FARMER

Starting from the software prototype described above, the ABACO and GEOCLEDIAN activity in the 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 related to the farmer should be displayed in a way that provides an added value and new insights to the farmer for his activities giving precise suggestion for best practice activities.

In particular, precision farming features like the production of variable rate maps will represent a powerful instrument for improving quality and productivity in the vineyards.

The pilot's Use Case scenarios have been developed to describe the new capabilities that should be developed for SITI4FARMER. The work on two use case scenarios is planned:

The first scenario is on the Optimization of Farm Practices in the Vineyard. Management Practices such as irrigation, fertilization and phytochemicals are regularly over- or underestimated with respect to the real plant needs. Especially in the case of overestimation in quantities, there is a negative countereffect towards the plants. The fertilization or phytochemical spraying actions can be supported by satellite data and new precision agriculture practices are based on the evidence that there are interaction effects between weather, management practices and vegetation/fruit qualities. By means of the Precision Agriculture module in SITI4FARMER and in particular new data modelling features, variable rate best practices will be implemented and tested.

The second scenario is on Earth Observation Data Anomaly detection & classification. Earth Observation (EO) data can serve as a valuable source of information for precision farming. But in order to make efficient use of EO data for Farm Management applications, it is crucial to be able to differentiate between data issues and anomalies. Anomalies detection is possible through the detection of deviations between Expectation and Observation. Inputs that can support this are the Static Heterogeneity of the field (Management Zones) and typical patterns of expected crop development for the observed environmental conditions. Classification of anomalies should be able to differentiate between Data errors (clouds, shadows, atmospheric disturbances) and Farm Management related issues (Pests, diseases, vegetation stress through missing water or fertilizer or weather-related damage).

4 SITI4FARMER SYSTEM EVOLUTION

The SITI4Farmer prototype that existed at the beginning of the project is briefly described in section 3. The following sections will provide an overview on the system evolution during the project.

4.1 BIG DATA GRAPES DATA

SITI4Farmer acts as an input into the BDG data model. Moreover, SITI4Farmer also acts as an output from semantic data modelling by ONTOTEXT.
As regards to Big Data, an essential input is represented by Satellite data provided by GEOCLEDIAN with its analytics capabilities.

4.2 SATELLITE DATA

ABACO provides Landsat 8 and Sentinel 2 data from GEOCLEDIAN for each lot registered in the system SITI4Farmer. Every lot has an ID that is registered when a new lot geometry is saved. As the new ID / lot is generated, the downloading of satellite index time series referred to the campaign year in which the lot is registered starts.
In a few minutes, satellite indices based on Landsat 8 and Sentinel 2 data time series are calculated and cut on the lot geometry. All the image raster data and lot statistic on the vegetative indices are provided by means of Rest-API standard in JSON Format as well as geotiff/pngs. The JSON Format is then easily translated in table and plots displayed in the SITI4Farmer dashboard. In the next section, the work that has been done on the satellite image processing side is described.

GEOCLEDIAN has acquired, processed and delivered all available USGS Landsat 8 and Copernicus Sentinel 2 satellite images for 2013 – 2019 above a certain cloud cover threshold for all available parcels in this pilot. GEOCLEDIAN 's Cloud Processing Platform provides the field monitoring service ag|knowledge that allows the automatic crop monitoring for fields with multispectral products. Ag|knowledge provides a REST API allowing easy access and integration of satellite remote sensing data and analytics into agricultural applications. The API provides access to field monitoring products for registered parcels (i.e. fields or parts of land). The data for each parcel are immediately updated as soon as new measurements are available. For all of these products, time series and a full history of the last 5 years are available. Currently, these data products are available:

Table 1. The data products currently available in Ag|knowledge

Name	Description
Visible	A visible true colour image of the parcel (RGB).
Vitality	A simplified NDVI product optimized for vegetation vitality visualization.
Variations	A simplified relative NDVI product optimized for vegetation vitality variations visualization.
Normalized Difference Vegetation Index (**NDVI**)	NDVI is a quantitative vegetation monitoring tool used as indicator for the vitality of a crop in particular for the live green vegetation. NDVI correlates with the amount of leaf area (LAI) of active, healthy, green vegetation. Quantifies vegetation by measuring the difference between near-infrared (vegetation strongly reflects) and red light (vegetation absorbs). It is the most widely used vegetation index. Overall, NDVI is a standardized way to measure the amount of healthy vegetation, although it has the disadvantage to saturate at high leaf area

	levels and therefore shows limited variation in dense fields with high biomass. It minimizes topographic effects. Reference: Rouse et al. 1974
Normalized Difference Red Edge Index (v1) (**NDRE1**)	Substitution of NDVI's red band with NDRE's red edge band (730nm). The Red Edge Indices are designed to estimate chlorophyll content in the canopy. More sensitivity in vegetation with high LAI. Less sensitivity to open water. There are several different formulas for the NDRE index. Reference: Clevers & Gitelson 2013
Normalized Difference Red Edge Index (v2) (**NDRE2**)	Substitution of NDVI's red band with NDRE's red edge band (700nm). The Red Edge Indices are designed to estimate chlorophyll content in the canopy. More sensitivity in vegetation with high LAI. Less sensitivity to open water. There are several different formulas for the NDRE index. Reference: Clevers & Gitelson 2013
Normalized Difference Water Index (**NDWI**)	NDWI is less susceptible to atmospheric scattering than NDVI, but does not remove completely the background soil reflectance effects, similar to NDVI. Because the information about vegetation canopies contained in the SWIR channel is very different from that contained in the VIS channel, NDWI is considered as an independent vegetation index. It presents enhanced sensitivity to vegetation water content & water stress. There are also other "NDWI" indexes with different meaning. Reference: Gao 1996
Soil Adjusted Vegetation Index (**SAVI**)	The index minimizes soil brightness influences from spectral vegetation indices involving red and near-infrared (NIR) wavelengths. It is interesting in sparse vegetation canopies or early growing stages. Reference: Huete 1988
Enhanced Vegetation Index 2 (**EVI2**)	The enhanced vegetation index (EVI)2 is a vegetation index designed to enhance the vegetation signal with improved sensitivity in high biomass regions and improved vegetation monitoring through a de-coupling of the canopy background signal and a reduction in atmosphere influences. Reference: Jiang et al. 2008
Chlorophyll Index - Red Edge **(CI-RE)**	The index is used to calculate the total chlorophyll content of the leaves. The CIgreen and CIred-edge values are sensitive to small variations in the chlorophyll content and consistent across most species. Apart from the very high Chlorophyll content, it also presents Nitrogen sensitivity and thus canopy Chlorophyll and Nitrogen contents can be derived from this index. Reference: Clevers & Gitelson 2013

Throughout the pilot duration, GEOCLEDIAN acquires and processes the described satellite data of all sites. Visible images and Vegetation Index Maps are produced, and the data provided to all project partners in near real-time via REST API as JSON, png and Geotiff files. For every parcel geometry registered in our system, we deliver the time series of satellite images together with timeseries statistics on all the vegetation indexes. The data can be visualized with visualization components, e.g. a web widget that is already integrated in S4F.

After being downloaded to the Ag|knowledge platform, the data is preprocessed, atmospherically corrected, cloud masked and ready-to-use images are produced for every registered parcel. The full product overview is available here

The following figures show vegetation index time series for one parcel of the Tenuta il Palazzo vineyard:

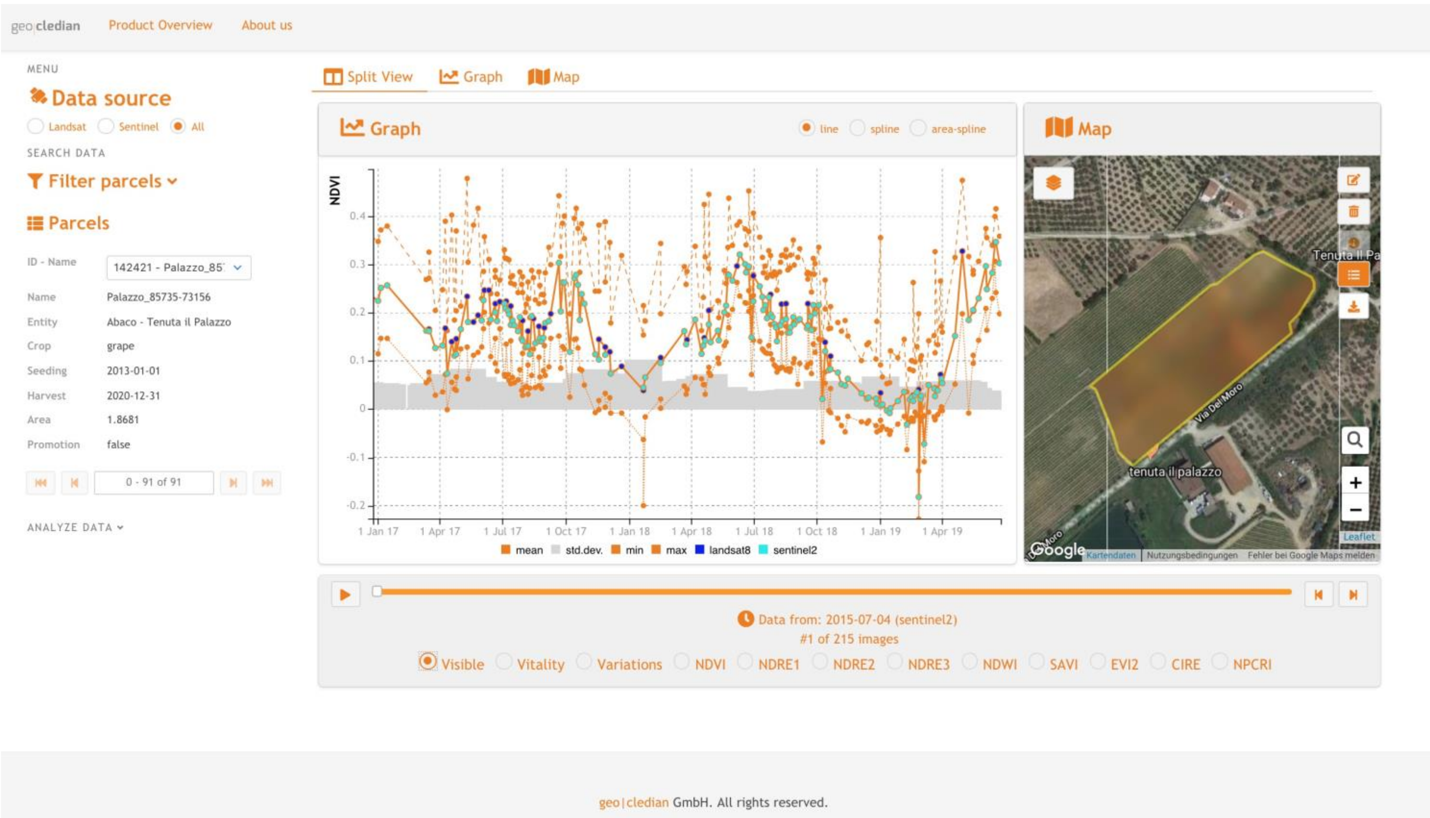

Figure 8. A Sentinel-2 RGB image for a parcel of the Tenuta il Palazzo vineyard, Italy. All available Landsat 8 and Sentinel-2 image acquisitions for 2017 – 2019 are also shown.

Figure 9. A Sentinel-2 NDVI time series for 2017 - 2019 for a parcel of the Tenuta il Palazzo vineyard, Italy.

Figure 10. A Sentinel-2 NDWI time series for 2017 - 2019 for a parcel of the Tenuta il Palazzo vineyard, Italy. This NDWI is known to be related to leaf water content.

Figure 11. A Sentinel-2 CI-RE time series for 2017 - 2019 for a parcel of the Tenuta il Palazzo vineyard, Italy. The Chlorophyll Index-Red Edge (CI-RE) is reported to be highly correlated with canopy Chlorophyll and Nitrogen contents.

At the start of the project, the first version of Ag|knowledge, a basic image delivery service based only on the first 3 products (Visible, Vitality, Variations), was integrated in SITI4Farmer allowing the user to see these products for his fields without any user interaction.

Extensive tests in the first project year have shown that Ag|knowledge at project initiation had bottlenecks concerning the data processing capacity and scalability, especially when large amounts of new parcels have been registered in the system. On top of that, certain features had to be improved in order to enable new data product generation and increase the product quality.

Therefore, a series of developments have been implemented and deployed successfully to improve data download and processing, performance monitoring, scalability and data visualization and to enable the delivery of the new data products and vegetation indexes that were developed for ABACO. In the frame of this project, the field monitoring service Ag|knowledge is further developed from a basic image delivery service into an Agricultural Big Data Processing Platform that allows the scalable production, provision and analysis of large-scale data.

More specifically these tasks have been carried out in the frame of the pilot so far:

Scalability

- Development and implementation of processing performance monitoring tools for Ag|knowledge;
- Performance analysis of certain Ag|knowledge components, e.g. the satellite scene or parcel processing;
- Architectural refactoring of the initial system into modular subsystems to enable scalability and processing optimizations;

- Development of scalable modules with CNR (ongoing work, technical details will be reported in WP4 deliverables);
- Increase the scalability of the user management of Ag|knowledge.

Data acquisition, processing & provision

- Development and implementation of extended data download and processing routines (e.g. Delivery of all 12 S2 spectral bands to enable the new vegetation indexes; Prepared Data Reprocessing campaign for all pilot sites to complete the data sets with these spectral bands);
- Acquisition and processing of all available Sentinel-2 data sets for all sites;
- Data quality improvements (e.g. work on improved cloud and cloud shadow detection algorithms & atmospheric corrections) (ongoing);
- Provision of these data sets to the project partners via API and visualization tools (ongoing).

Analytics

- Development and implementation of 7 new vegetation indexes and data products as requested by ABACO;
- Development and implementation of new API endpoints for data delivery;
- We started to develop a prototype for Data anomaly detection to detect features in the satellite data time series that are either related to data issues or potentially interesting farm management related issues (ongoing);
- We started to develop a prototype for the automatic generation of Farm Management Zones from EO data that could help ABACO and the other project partners to generate improved Management Zones products later (ongoing).

Data Visualization and analysis tools

- Development and implementation of data visualization tools for data review and analysis.

These components have been deployed successfully:

- 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.

To tackle the data processing optimization and scaling issues, GEOCLEDIAN started an intensive collaboration with CNR in the frame of the project. This ongoing activity comprises these tasks:

- performance monitoring and analysis of the system;
- identification and analysis of performance bottlenecks;
- architectural refactoring of the initial system into modular subsystems to enable scalability and processing optimizations;
- development of scalable platform components.

This activity will be reported in more detail in WP4 deliverables.

4.3 SATELLITE DATA MODULE EVOLUTION IN SITI4FARMER

In the meantime, SITI4Farmer, using services provided by GEOCLEDIAN which give Earth Observation (Open BIG DATA) capabilities, has included dashboard for satellite indices displaying.

Figure 12 Example of SITI4Farmer satellite data dashboard displaying year time series of SAVI index on selected parcel.

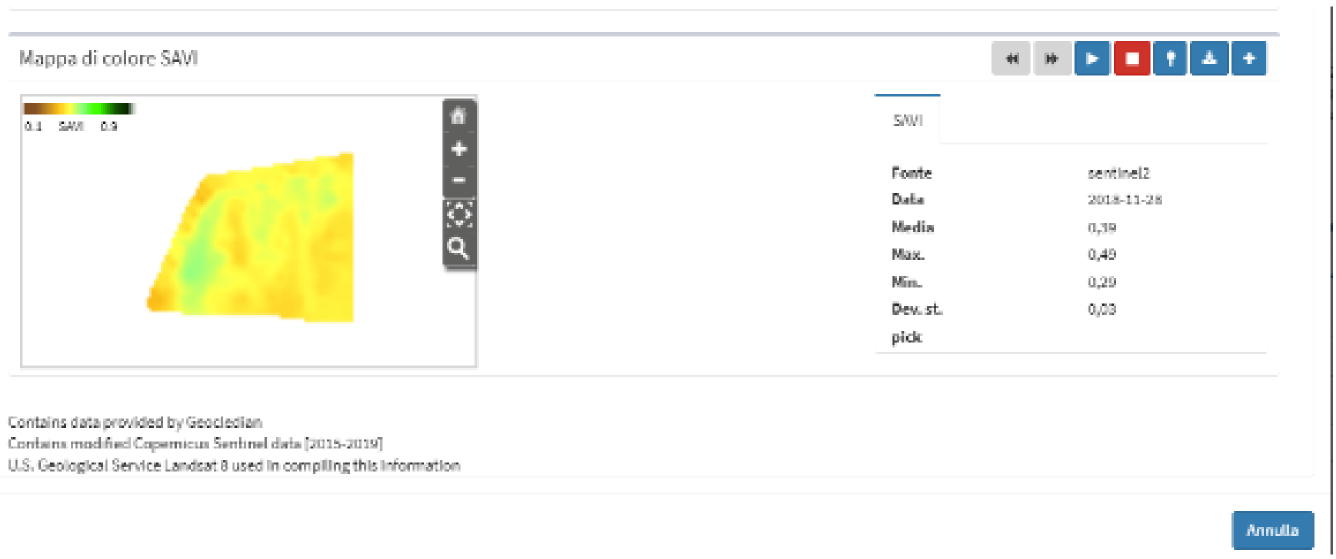

Figure 13 For a selected date in the Satellite indices time series the raster image of the parcel is displayed with statistics data.

In particular the following remote sensing indices are calculated from multi-spectrum images Landsat 8 and Sentinel 2 (Copernicus project).

- Normalized Difference Vegetation Index (NDVI);
- Normalized Difference Red Edge Index (v1) (NDRE1);
- Normalized Difference Red Edge Index (v2) (NDRE2);
- Normalized Difference Water Index (NDWI);

- Soil Adjusted Vegetation Index (SAVI);
- Enhanced Vegetation Index 2 (EVI2);
- Chlorophyll Index - Red Edge (CI-RE).

Each index is focused on different kind of support on plant stress detection. In detail, the NDWI index represents a very useful support for plant water stress alert, then NDRE indices are very well correlated to Nitrogen plant content and they are essential inputs for Prescription Maps for the fertilization (see Precision Farming Module).

Moreover, the above-mentioned indices, combined with atmosphere-plant-soil data (from PESSL stations), can provide Standard Alerts on:

- Soil temperature suitable for sowing;
- Insufficient quantity of ground water;
- Not uniform vegetative growth;
- Vegetative stage not in line with forecasts;
- Approaching critical temperatures;
- Accumulation of thermal and radiative insufficient resources to technological maturity / harvest.

For each type of ALERT, the user can define:

- the monitoring data sources;
- the alarm thresholds (defined by default, but modifiable);
- the number of standard ALERT.

4.4 PRECISION FARMING MODULE

Variable rate technology (VRT) of inputs is a key component of precision agriculture, providing economic benefits to growers in the form of reduced use of fertilizers, agrochemicals, and irrigation water, while having a positive environmental impact.

Thanks to improved satellite data, ABACO released a Precision Farming module in their GIS Navigator tool of the SITI4Farmer agriculture solution. The module enables users to manage variable rate input (of chemicals) and crop management practices taking into consideration various inputs.

The SITI4Farmer Precision Farming has the capability to rasterize, i.e. to provide a continuous data layer from scattered data, such as soil survey data all over lots and farm.

This rasterized data is one of the several inputs used to build a prescription map together with:

- GEOCLEDIAN Satellite vegetative indices;
- Drone raster maps;
- Yield maps;
- Soil surveys raster data.

The preparation and adjustment of prescription maps, also known as variable rate maps, is possible thanks to another component of SITI4Farmer called “Raster Calculator”.

Users can do the re-classification of a map, that means subdividing the output into different customizable classes, that can be managed by the variable rate machinery, such as a fertilizing trail. The export format to the variable rate machinery is currently done through a shapefile.

As regards to new implementations, the module will be improved so as to provide an even smarter and more intuitive navigation by the farmer. The command layout will allow precise and fast variable rate map editing and the visualized output will be also available in PDF format, to enable also a manual use of variable rate maps.

Big Data enables ABACO to further study and execute Data Modelling tasks. The data coming from Satellite datasets are valuable inputs for new data models that can run in the R or Python languages on the Raster Calculator platform inside SITI4Farmer.

Data modelling, in the framework of DSS, aims to calculate more precise, accurate, and differentiated doses of fertilizer, pesticides, water and other inputs by means of variable rate maps.

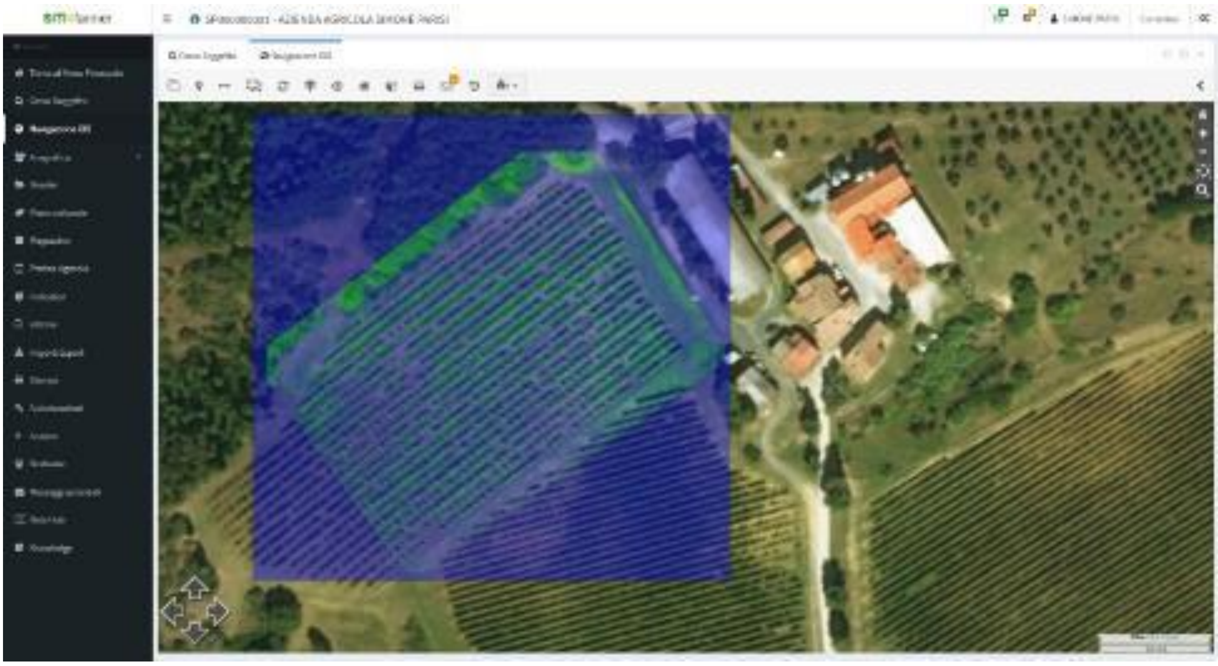

Figure 14 Import of Drone (UAV) raster data.

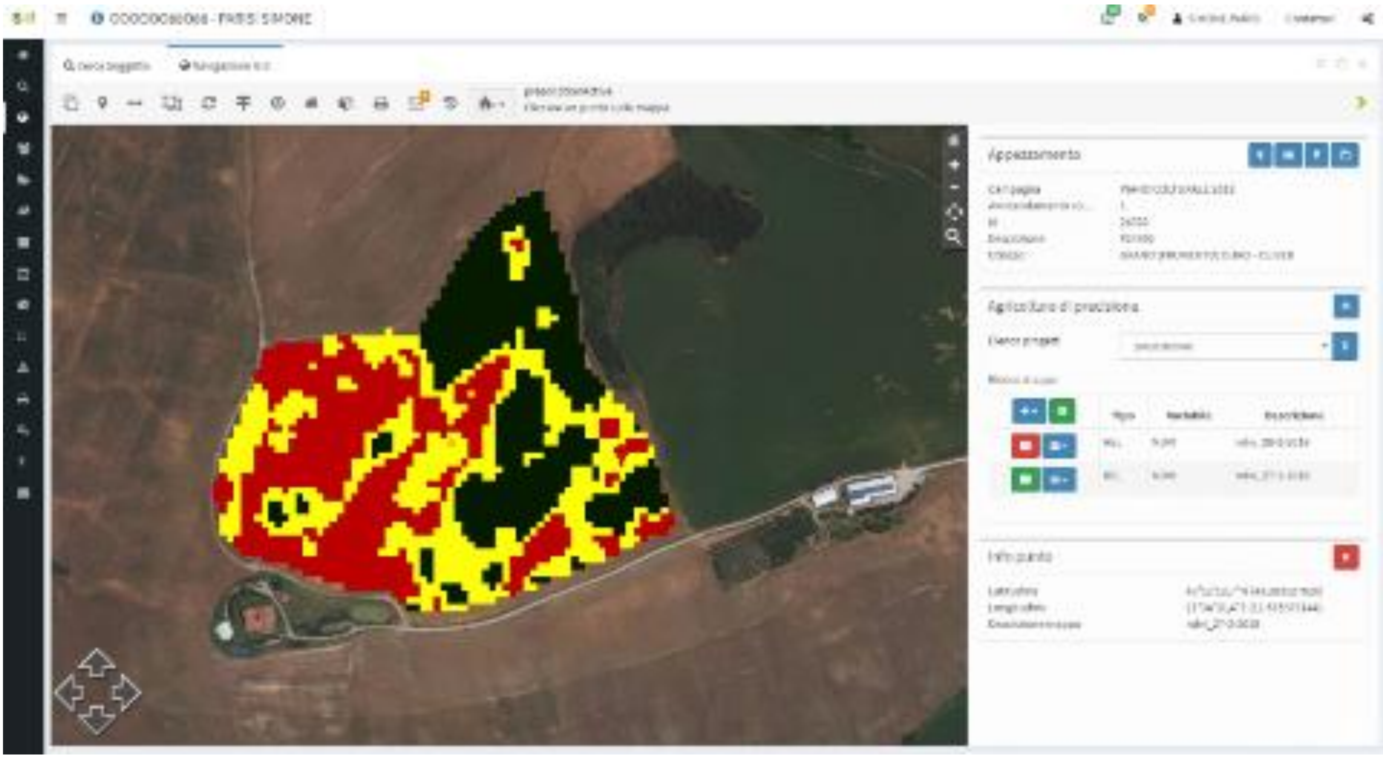

Figure 15 Reclassified Map from NDRE2 satellite data.

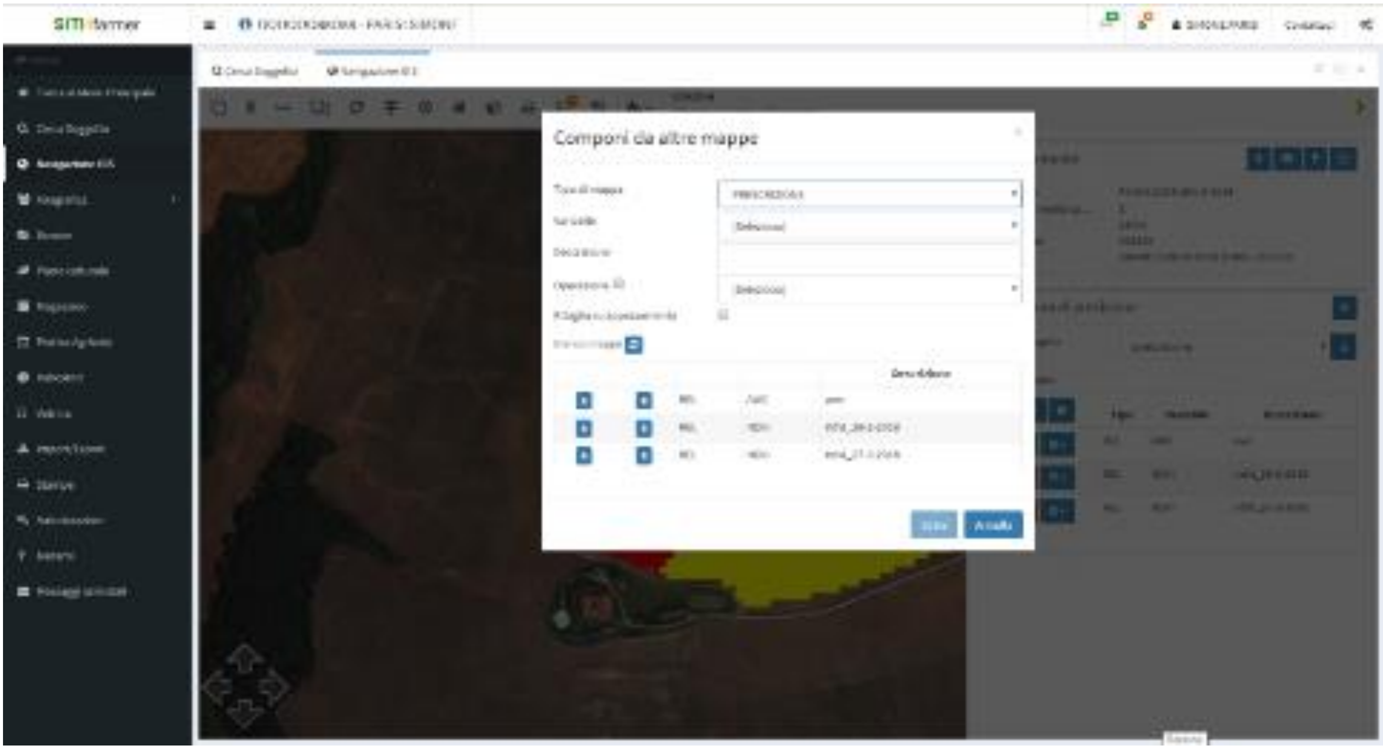

Figure 16 Raster calculator interface. Allows model run on different raster input data.

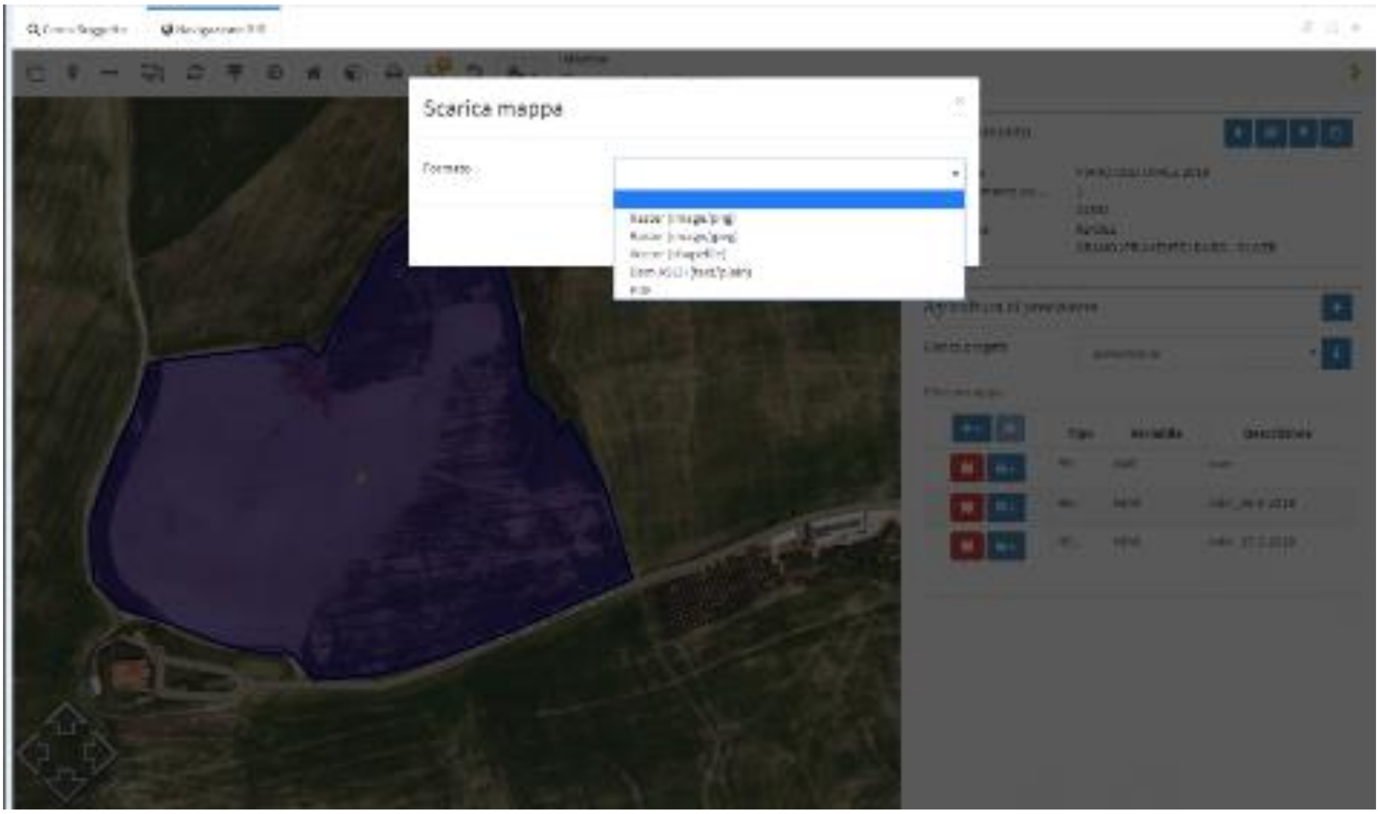

Figure 17 Map export on vectorial or raster formats.

Figure 18 Import of a prescription map on a Trimble VR computer.

4.5 SENSOR DATA CONNECTIVITY – THE SENSOR PROXY

Weather station data recorded in piloting farms are connected to the SITI4Farmer portal thanks to the development of The Sensor Proxy procession, enabling connectivity by API-REST protocol, where the data is disseminated by means of SITI4Farmer dashboards.

PESSL Instruments' sensors are connected to the SITI4Farmer portal by API-Rest in order to display data in a dedicated dashboard widget and to use such data for the DSS models.

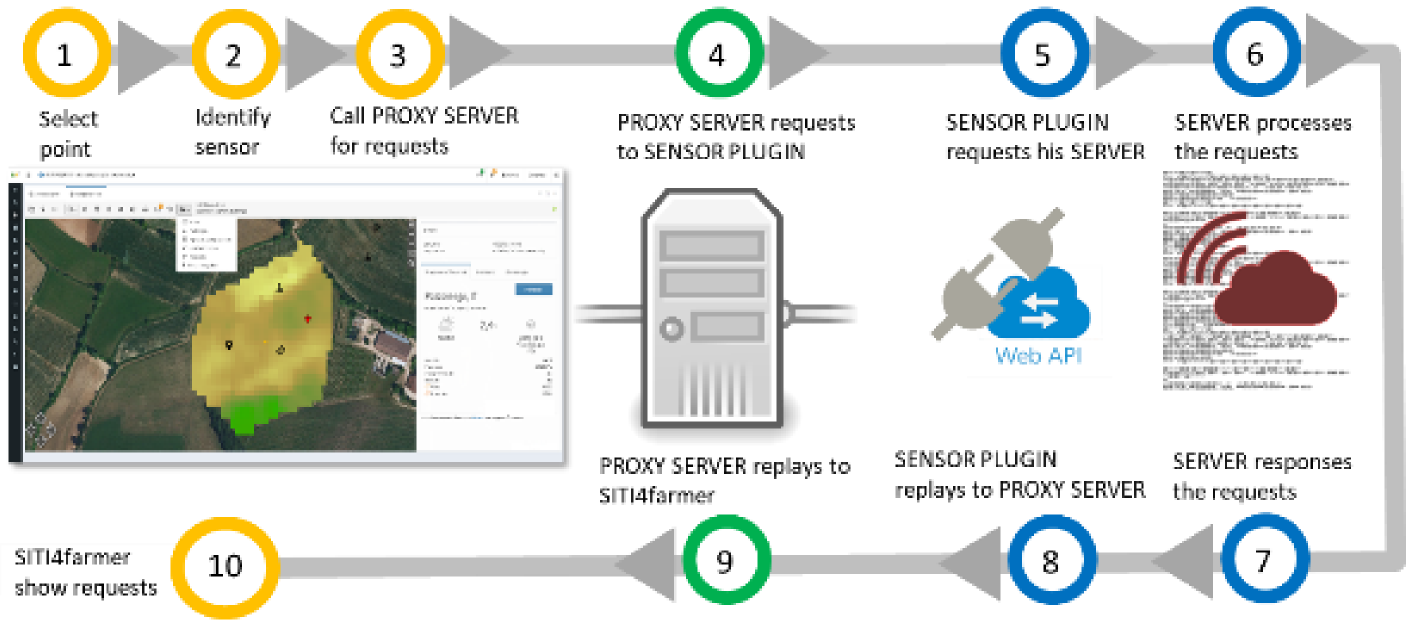

Figure 19 Sensor Proxy data fluxes scheme.

4.6 FUTURE IMPROVEMENT IN DATA VISUALIZATION

The DSS Widgets are focused on agro-meteorological indices. The interpretation of the data displayed must be read by agronomists or experts of the subject. The innovative step to be done for the pilots of BDG is the upgrade in the interpretation of data. The new widget will provide alerts and suggestions to the end user related to the best agricultural practice to follow. The collaboration with KU Leuven is focused on these subjects.

Several meetings were organized between GEOCLEDIAN and KU Leuven to introduce the available satellite data visualization components, of which one web widget has already been integrated in S4F. Potential satellite data visualization use cases were discussed.

Here follows a proposal on how to customize the monitoring systems for the Piloting farms.

Custom Decision Support System: monitoring data comes from internal data sources like satellite data, or also external sensors, such as PESSL sensors.

In the context of the DSS, The WATER BALANCE (which takes into account irrigation, evapotranspiration, soil texture, and root system of the different crop) is the one in which the final user gives more attention, since it determines, together with rain forecast, the level requested of IRRIGATION. In particular "how much to irrigate?" is the question, and by means of new data visualization instruments, we want to make it clearer.

The visualization of satellite indices will be also improved. If we consider the index standard deviation (when it exceeds a threshold value, for example, of 0.8), we will need to provide an evaluation parameter of the uneven of growth in the field, and therefore the need for irrigation or fertilization.

The automatic generation of alerts from satellite data, visualized in a smart way, will represent a great added value for the SITI4FARMER Portal.

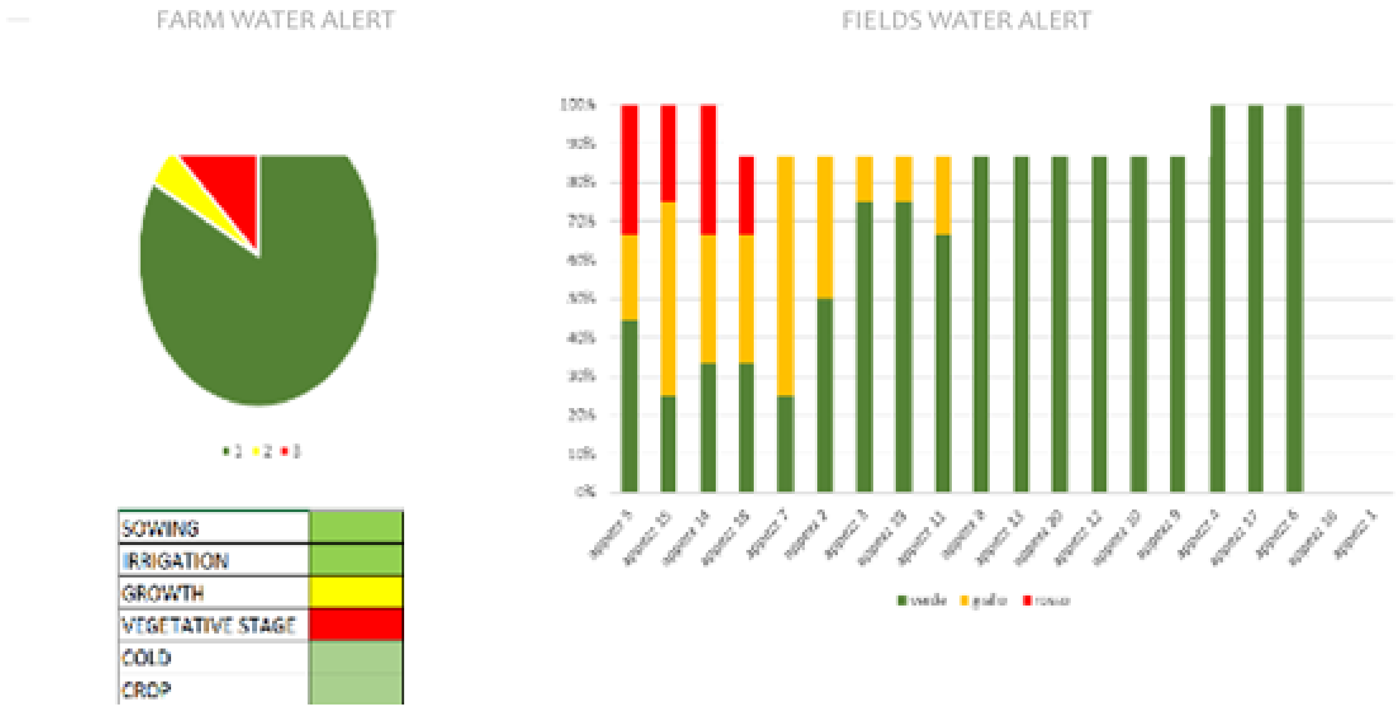

Figure 20 Farm water alert dashboard containing the summary of fields in water stress status.

The NDVI, and its deviation from the average value of a reference field, provide a parameter for the proper identification of phenological stages and the consequent need of agricultural treatments

Figure 21 Crop growth alert from satellite indices.

5 NEXT STEPS AND CONCLUSIONS

As seen in the previous chapters, the software SITI4Farmer is going to be updated with functionalities regarding satellite indices data storage and displaying, field sensors data storage and displaying, and finally the DSS improved by those satellite and field sensors data with a new data visualization, that can be easily readable by the farmers.

As regards to semantic data modelling performed by ONTOTEXT, it will be included in SITI4Farmer functionalities. The modelling output will be imported through REST-APIs in SITI4Farmer to enable its visualization. ONTOTEXT has already started communicating with the PESSL Weather stations and retrieving data for semantic modelling.

In the context of Precision Farming, it is essential to note that the BDG project aims to also demonstrate that this new technology suits small-medium farms and not only big ones like in the ones in USA-Canada: this will be possible through the software solution from ABACO. In fact, the most important obstacle for Precision Farming is the cost of machinery. Within BDG, we demonstrate that is not necessary, at first time, to procure new hi-tech equipment, since the farmer can simply take effective and precise decisions starting from the knowledge of plants-soil conditions.

Furthermore, in the context of BDG, it must be taken into consideration that vineyards require a specific agronomic management to satisfy the real needs of this crop, in relation to the spatial variability within the vineyard. The introduction of new technologies in order to support vineyard management allows the efficiency and quality of production to be improved and, at the same time, reduces the environmental impact.

Figure 22 Variable Rate map for fertilization in Viticulture. 3D parcels representation simulation.

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