Deliverable D3.1: End-User requirements

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[1] Dissemination level: **PU** = Public, **PP** = Restricted to other programme participants (including the JU), **RE** = Restricted to a group specified by the consortium, **CO** = Confidential, only for members of the consortium

[2] Nature of the deliverable: **R** = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other

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Deliverable abstract

The objective of this deliverable is the reporting of the outcomes of the end-user requirement analysis, providing their identified needs for the overall project; in particular, the requirements they need with respect to models and Decision Support System (DSS).

First, a description of each pilot plot together with the technique to apply is made for every pilot site: Spain, Italy and Portugal. With this information, which is the basis of the requirements, and taking into account the models that will run and feed the DSS (meteorological, phenological, irrigation, etc.), the overall information flow of the system has been outlined.

The data managed by the DSS are in 3 macro categories: Initial User Inputs, Monitoring, and User Feedback, for which requirements have been compiled in Table 4, according to end-users needs.

Further, Monitoring data has been subdivided according to these categories: short term weather forecast, medium-term weather forecast, seasonal forecast, phenological and irrigation models. Initial User Inputs are used to set the initial conditions for the models, while User Feedbacks to validate their outcomes and fine-tune next iterations.

Finally, the use cases and end-user requirement, which have been co-created with and validated by the project end-users, are listed for the CS-DSS are listed in Tables 5 and 6, respectively.

[3] Creation, modification, final version for evaluation, revised version following evaluation, final.

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1. Document objectives

The objective of this deliverable, which is the output of Task 3.1 "End-user requirement definition", is to co-define the end-user's requirements from the analysis of the assets and needs of the end-users being part of the VISCA consortium. This task started in the Kick-Off meeting, where a special session for gathering end-user's requirements was organized (see Deliverable D1.1). The deliverable is structured as follows:

In Section 2, the context is given by detailing for each end-user the characteristic of the vineyard considered in VISCA, and the technique foreseen. In Section 3, the end-user requirements are defined starting from the high-level needs in terms of data to be handled and visualized by the system, and subsequently from the use-cases, which describes the interactions between the user and the system. This approach is compliant with the human-centred design methodology [RF1]. Finally, in Section 4 conclusions are drawn.

2. End-Users: description of fields and techniques

In this Section, the context of the project is described. For each consortium end-user, the description of the vineyard considered in VISCA together with the outline of the technique that will be applied are given.

2.1. CODORNIU: vineyard description

The wine cellar of Raimat (Codorniu, Spain) is located in a region called Costers del Segre (DO), in the southwest slope of Raimat hills. This location confers special and differentiated characteristics: higher sunlight exposure in the afternoon, which allows the grapes to accumulate more degree days, achieving an earlier ripening without losing acidity. These are well drained soils; the slight inclination of the fields confers a natural draining of the rain water. Being on the slope of the hill causes steady currents of air, which provides a natural cooling down, conferring a special microclimate.

The demo/experimental fields (two) are located in the middle of the Raimat vineyards.

The first one (41.6509º N, 0.5194º E), with a typical cultivar for red wines ("Tempranillo") has an area of 3,7 ha and the rows are oriented NE-SW, with a planting density of 2.5 m. x 1.7 m. The vineyard is

5 years old and conducted under a VSP (Vertical Shoot Position) system. The main goal of this grapes is to produce “High Quality Red Wines” and are harvested at 25º Brix and a pH of 5,5.

On an average year the level of stress reached in this plot is about -0.7 MPa (midday stem water potential) before veraison and about -1.1 MPa from veraison to harvest.

The second one (41.6626º N, 0.5076º E), with a typical cultivar for white wines and cava (“Chardonnay”) has an area of 3,5 ha and the rows are oriented N-S, with a planting density of 3 m. x 1.7 m. The vineyard is 16 years old and conducted under a VSP system. The main goal of this grapes is to produce “Cava” and are harvested at 20º Brix and a pH of 3,5.

On an average year the level of stress reached in this plot is about -0.7 MPa (midday stem water potential) before veraison and about –0.9 MPa from veraison to harvest.

Table 1: CODORNIU key vineyard information

Vineyard name:	Raïmat (Vineyards 41 and 13)
Area:	3,7 ha (V.41) & 3,5 ha (V.13)
Grape Variety:	Tempranillo (V.41) & Chardonnay (V.13)
Harvest maximum temperature:	Usual Harvest around the 1st week of August for Chardonnay, Night Harvest, Max Air Temp of 22ºC ; and the 3rd week of September for Tempranillo, with a daily Max Temp of 28ºC.
Sugar/acidity:	21.5 ºBrix (13 AD) for Chardonnay, and 24 ºBrix (14 AD) for Tempranillo.
Technique to apply:	Crop Forcing

2.2. CODORNIU: crop forcing description

From 1950 to 1999, the majority of the world’s highest quality wine-producing regions experienced growing season warming trends. The effect of the future warming could make progressively more difficult the ripening of balanced fruit required for existing varieties and wine styles. On this regard, Crop forcing is a new technique that has shown promise results in California, and it is based on moving the grape-ripening period from hot summer months to a cooler month later in the growing season. This is achieved by making an additional pruning (severe leaf removal), stopping the natural cycle of the plant and forcing the plant to restart its cycle later.

Crop forcing therefore produce a later budburst and harvesting, which means that the vineyard cycle is forced to be shorter and delayed on time, in order to achieve a ripening under cooler temperatures, resulting in wines with more bouquet. The main obstacle to this technique is to know with enough accuracy when to begin with the vineyard cycle and therefore when to apply the additional pruning in the absence of monthly, seasonal and sub-seasonal meteorological information. Accurate predictions of this meteorological data are therefore needed.

Crop forcing therefore produce a later budburst and harvesting, which means that the vineyard cycle is forced to be shorter and delayed on time, in order to achieve a ripening under cooler temperatures, resulting in wines with more bouquet. The main obstacle to this technique is to know with enough accuracy when to begin with the vineyard cycle and therefore when to apply the additional pruning in the absence of monthly, seasonal and sub-seasonal meteorological information. Hence, accurate predictions of this meteorological data is needed to successfully apply Crop Forcing.

In particular, Crop Forcing will be applied on fields located in Raimat (Codorniu, Spain) where the climate is dry and very warm, and thus it is foreseen that climate change will have an impact on the life cycle of the vineyard by rising the atmospheric temperature.

Raimat experience applying the crop forcing technique is based on the last two seasons (2015 and 2016) where in different locations of their vineyard crop forcing was applied to two different commercial vineyards (few rows in each year) and in potted young vines, evaluating different levels of cuttings. From this initial experience it also clearly emerged that accurate weather forecasting and well-adjusted phenological models are key in order to precisely define the time when to practice the cuttings to induce crop-forcing. **The results obtained on these initial experiments showed that the moment of applying the cuts is not the only critical issue: the management of the vineyard after the cuttings (included irrigation) is of primary importance for the final outcomes.**

2.3. SYMINGTON: vineyard description

The Douro Region has perhaps more diversity than any great wine growing area in the world being around 100 km from west to east and with vineyards from 90 meters up to 60meters on the hillsides. The region is the largest area of mountain vineyard in the world and is protected from the Atlantic maritime climate by the mighty 1,400-meter-high Serras do Marão and Montemuro to the west and the valley is primarily composed of the specific schistous soils that characterise the region.

One of the most remote vineyard areas is the Vilariça in the northern extremity of the Douro Superior. This valley follows the 'Falha de Vilariça', a significant geographically fault line formed by the tectonic movements that created the Iberian Peninsula millions of years ago. The Vilariça valley emerges from the most northerly point of a giant 12 km meander of the Douro River as it follows this major fault line until it meets one of its main tributaries, the Rio Sabor, where it then resumes its westerly route to the Atlantic Ocean.

Within the 81 hectares of vineyard at Quinta de Ataíde, besides the traditional schist, three distinct types of topsoil can be found: sandy loam, silt loam and in some places, clay loam with its propensity to retain water. The soil pH is neutral, in contrast to much of the Douro located to the west of the Valeira dam, where soils tend to be slightly acidic.

The Ataíde estate is situated at between 210 and 270 meters above sea level and has an average annual rainfall of 502 mm, compared to 640 mm at Pinhão and 849 mm at Régua. The 'Growing Season Average Temperature' is 16.0°C, which is comparable with other of the Douro's best regions, but colder winters and hotter summers are an integral part of this annual average.

With high summer temperatures and virtually no rainfall in July and August, dry farming of the Ataíde vineyard would be virtually impossible, but a judicious use of drip irrigation guarantees a protection of the vines from excessive hydric stress and prevents dehydration. Extreme care is taken to limit the amount of water introduced so that the average yield per vine is contained. A system of underground probes measures the soil humidity across different parts of the Quinta, allowing the viticulture team to supply drip irrigation only when strictly necessary, according a network of reference points to monitor the predawn water potential in the leaf, with values that varies between -0,40 MPa and -0,70 MPa. In the control blocks without irrigation, these values reach -1,20 – 1,40 MPa also in the predawn water potential in the driest years.

An experimental grape variety library was planted at Quinta do Ataíde vineyard in 2014. This new vineyard is made up of 53 distinct *Vitis vinifera* varieties of which 29 are red and 24 are white, comprised of indigenous varieties from ancient vineyards across the Douro as well as from other Portuguese wine regions and a handful from other countries as benchmarkers.

Two hundred vines of each variety have been planted in two contiguous vineyard parcels covering 2,25 hectares. The relatively large size of this plant population will enable important comparative studies to be made. The Symington´s viticulture team are establishing research protocols with various universities and their findings will be shared with other producers.

The demo/experimental fields (two) are in the middle of the Quinta do Ataíde vineyards with a typical cultivar for red wines (“Touriga Nacional”). The first one (Parcel TN60), has an area of 1,38 ha and the rows are oriented NNE-SSW, planted in 2011 (6 years old), and the second one (part TN of the Parcel MC100) has an area of 1,28 ha and the rows are oriented WSW-ENE, was planted in 2014 (4 years old). Both grafted in the 196-17C rootstock, with a planting density of 2.2 m. x 1.0 m and conducted under a VSP system. The main goal of this grapes is to produce “High Quality Red Wines” and are harvested at 25º Brix and a pH of 3,5.

Table 2: SYMINGTON key vineyard information

Vineyard name:	Quinta do Ataíde (parcel’s TN60 and MC100)
Area:	1,38 and 1,28 ha (both parcels with 1,000 m2 each for experimental design.
Grape Variety:	Touriga Nacional
Harvest maximum temperature:	Harvest on average at 2^{nd} week of September. The Normal maximum temperature is 30°C
Sugar/acidity:	24-25° Brix, 3,6-3,8 pH and 3,8-4,5 Total Acidity.
Technique to apply:	Crop forcing

2.4. SYMINGTON: crop forcing description

Crop forcing is a new technique that has shown promise results in California, and it is based on moving the grape-ripening period from hot summer months to a cooler month later in the growing season. This is achieved by making an additional pruning (severe leaf removal), stopping the natural cycle of the plant and forcing the plant to restarting its cycle later.

Crop forcing therefore produce a later budburst and harvesting, which means that the vineyard cycle is forced to be shorter and delayed on time, in order to achieve a ripening under cooler temperatures, resulting in wines with more bouquet. The main obstacle to this technique is to know with enough accuracy when to begin with the vineyard cycle and therefore when to apply the additional pruning in the absence of monthly, seasonal and sub-seasonal meteorological information. Accurate predictions of this meteorological predictions are needed.

Crop Forcing will be applied on fields located in Quinta do Ataíde (Symington, Portugal), where the climate is dry and very warm, and thus it is foreseen that climate change will have an impact on the life cycle of the vineyard by rising the atmospheric temperature.

2.1. MASTROBERADINO: vineyard description

The vineyard is located at Mirabella Eclano (Avellino, Italy; Latitude: 41° 3'41.94"N, Longitude: 14°58'52.93"E) at an altitude of 400 m a.s.l with a slope of 10% facing North. It is the main estate owned by the *Mastroberardino* family, in the heart of the *Taurasi DOCG* area. The epicentre of *Aglianico* production, research and experimentation, this estate is spread over several hills with different exposures and is dedicated to the production of red grapes on the slopes characterized by soils with a greater presence of organic matter and volcanic matrix, as well as white grape vines in areas where soils contain more limestone and clay.

In the vineyard dedicated to VISCA, the soil is deep with sandy loam texture, volcanic and clay presence in its depths and limestone throughout the profile, well drained. The vineyard is 0.8 hectares and was planted in 2004 in a North-South row orientation. Vines are Aglianico grapevines grafted onto K5BB rootstocks, trained to a bilateral spur cordon (with 8 spurs/vine), and spaced 1.0 × 2.5 m (corresponding to a planting density of 4000 vines/ha). The permanent cordon is located at 80 cm above the soil. There is no irrigation application.

The grapes harvested in this vineyard are generally used to produce premium wines according to the "Taurasi DOCG" production protocol[4]. Target berry composition at harvest corresponds to a soluble solids content of around 23°Brix and juice titratable acidity of about 7 g/L of tartaric acid. Weather conditions of the area are typical of a continental climate with cold and rainy winters and hot and dry summers. In the last decade, annual rainfall was on average 833 mm (50% occurring in the period between November and March). Total rainfall during July and August was on average 73 mm. The best wine vintages generally occur in the years when rainfall is relatively low during berry ripening (between August and September). In the last 20 years, the best vintages for the Taurasi wines occurred in 1997, 2004, 2007, 2008 (these years were characterized by a total rainfall from August to October of 54, 52, 41, 71 mm, respectively).

[4] https://en.wikipedia.org/wiki/Taurasi_DOCG

Table 3: MASTROBERARDINO key vineyards information

Vineyard name:	Morabianca
Area:	0,8 ha
Grape Variety:	Aglianico
Harvest maximum temperature:	Harvest on average at the end of October. The normal maximum temperature is 22°C
Sugar/acidity:	23-24 °Brix and 7-8 g/Ltotal acidity
Technique to apply:	Post-veraison shoot trimming

2.2. MASTROBERARDINO: canopy management description

All the management practices (disease control, nutrition) are carried out following the vineyard's standard production procedures. All vines (2.5 m x 1 m rows x vines, 4.000 vines/ha) are pruned with the bilateral spur cordon, 8 spurs/vine and 16 buds/vine. Usually in May, shoots thinning is applied to remove non-count shoots and cordon suckers. Summer canopy trimming is performed usually in mid-July. By the end of July, leaf removal is applied manually to remove the leaves and the lateral shoots located at the base of each shoot up to the distal cluster, which is typically present on the fourth or fifth node.

Late summer pruning strategy (canopy trimming) will be used to modulate sugar accumulation rate in the berries and to avoid the occurrence of the decoupling between the technological and phenolic maturity of the grapes. This undesired condition, often occurring in hot and dry years, is expected to be more frequent under future climate change scenarios, likely influencing negatively grape quality. Previous experimental experiences on the use of this canopy management tool have already demonstrated that post-veraison shoot trimming is a suitable summer pruning strategy to slow down sugar accumulation in the berries of Aglianico and to reach the desired full phenolic maturity of the grapes at harvest[5]. This aims to produce premium wines with moderate alcohol concentration. However, the vine response to shoot trimming depends on the climatic conditions (mainly air temperature and rainfall) occurring during berry ripening. **Therefore, medium-term climate forecasts**

[5] Caccavello G., Giaccone M., Scognamiglio P., Forlani M., Basile B., 2017. Influence of intensity of post-veraison defoliation or shoot trimming on vine physiology, yield components, berry and wine composition in Aglianico grapevines. Australian Journal of Grape and Wine Research, 23(2):226-239.

may be useful to decide the intensity of shoot trimming to apply in order to reach the desired wine alcohol concentration.

3. Definition of the end-user requirements

In this Section, the end-user requirements are defined following the approach outlined in Section 1.

3.1. Data Processing: main information flow

The basic model chain, where the input and output data of the weather and climate module of the DSS - according to user's requirements- is shown in Figure 1. The phenological models will need the output of meteorological forecasts (e.g., temperature, precipitation, radiation, etc.) at different temporal resolutions (days, months), so they can provide values of the phenological events such (e.g., bud break, bloom, veraison, harvest day, etc.), necessary for the demo sites to apply the different techniques on the vineyards. The information flow will be further analysed and detailed in Task 3.2 "Technical Requirement and architectural design".

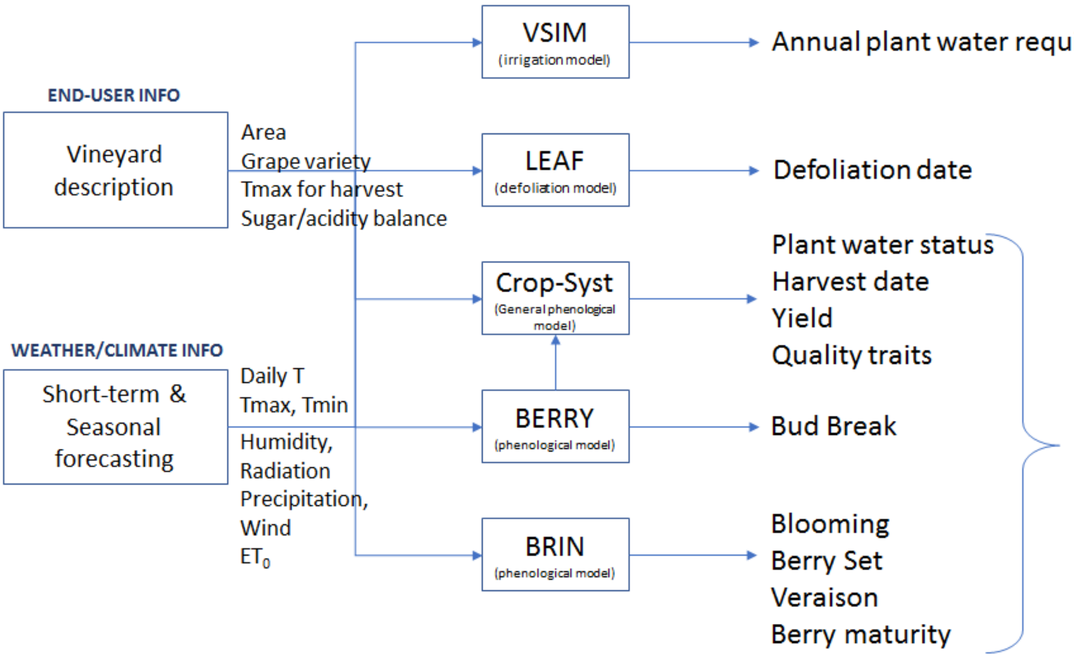

Figure 1. VISCA Information flow

The DSS to be developed in VISCA will implement a visualization dashboard containing selectable and actionable geospatial data layers, presenting the data in a dynamic and interactive map. The CS-DSS will implement the logic to couple the phenological data, end-user needs and constraints, and in-field geolocated feedbacks provided by end-users in order to suggest the most appropriate date to apply the actions on the vineyard (crop planning, canopy management).

The data managed by the DSS can be divided in the following categories:

1. **Initial User Inputs**, to which the information needed to initialize the system belongs. The end users will have to insert the information necessary for the models, according to the chosen conditions for the harvesting. Phenological models need these inputs to forecast best days for harvesting, according to the properties that the end-user wants for the grapes.
2. **Monitoring**, which represents all data that require monitoring because they are updated along the way. The end-user will be able to look up the information that is being produced by the different models (weather and climate, phenological and water management)
3. **User Feedback**, which are the in-field observation, including both phenological and weather data, which are provided by the users and by the in-situ weather stations. The end-users will be able to insert information corresponding to observed events and final harvest.

The summary of this classification is reported in Table 1.

Table 4: Main information to be handled by the system, divided into three categories

Initial User Inputs (targets)	Monitoring (Model Outputs)	Validation Data
Maximum temperature for harvesting	Predicted Weather+ risks (extreme events)	Must composition: Sugars (Brix) and Color. Seeds: Degree of maturation.
Desired sugar balance and acidity	Predicted seasonal climate variability	Wine quality parameters: Organoleptic profile from a panel taste.
Initial vineyards description	Predicted phenological events	Real Phenological dates
	Predicted water requirements	Observational weather data
	Suggested actions: canopy management and crop forcing	Final vineyards description

3.2. Data visualization needs

This subsection contains the list of information to be visualized, which are grouped according to their category, i.e., weather, climate, phenological & Irrigation, technique and user feedbacks:

Weather Forecast (Short-term: 1-3 days)
Extreme Events which may affect any vineyard activity:
Wind speed
Precipitation,

Weather Forecast (Medium-Short-term: 5-15 days)
Daily Temperature
Humidity
Wind speed
Precipitation,
ET_0

Climate Forecast (seasonal: 1-7 months)
Maximum temperature
Minimum temperature
Mean temperature
Precipitation

Phenological & Irrigation models
Defoliation
Bud break
Blooming, berry set, veraison, berry maturity
Harvest date , Yield, Quality traits
Water requirements: plant water status and annual requirements
Crop forcing: (day, number of stages to be removed)
Canopy management (day, percentage of leaf to be removed)

User Feedbacks to Validate Models and Forecasting
Real phenological dates: Bud break, Blooming, berry set, veraison, berry maturity
Harvest date, Yield, Quality
Irrigation done
Crop forcing: (day, number of stages to be removed)
Canopy management (day, percentage of leaf to be removed)
Observational weather data (Daily Temperature, Humidity, Wind speed, Precipitation)

3.3. Use Cases

The list of use cases, cooperatively created with all end-users involved in the project, is reported in Table 5.

Table 5: CS-DSS Use-case list

ID	Description	Category	Goal	Pre-conditions	Triggers	Success Post condition	Actors	Steps
UC1	The admin registers a User into the system	General	Create a new User profile into the system	Browser, Internet connectivity	Automatic for the end-Users involved in the project. Otherwise, if a User buys the VISCA solution	A link to finalize the registration is sent to the User via email, so that he/she can complete the registration and create the password	Admin User	1) logins with admin credential 2) access the VISCA web frontend at the registration page 3) insert the User data (name, surname, email, telephone) 4) confirm
UC2	A pre-registered User completes the registration	General	Complete the registration procedure	Pre-registration email received	The User is pre-registered into the system by an admin	the User can successfully login into the system	User	*) Click on the link received via email from, the VISCA system 1) complete the registration by creating the password 2) confirms the profile information
UC3	A registered User logins into the system	General	Login into the system	The User has completed the registration process	the User wants to login into the system	the User is logged into the system	User	1) the User access the VISCA home page 2) the User inserts its credentials (User, password)
UC4	A registered User modify/update the profile information	General	Change profile information	User logged	The User wants to update the profile information	The profile information are changed according to the User selection	User	1) the User access its profile 2) the User edits the profile information and updates it

UC5	A User adds/updates a vineyard into the system	Initial Inputs	Insert a new vineyard into the system	User logged	The User wants to use VISCA on a given vineyard or update its data	The vineyard is successfully inserted/updated into the VISCA system	User	1) the User selects to create/update a new vineyard 2) the User adds/updates a new vineyard providing all information and data required in case of a newly inserted vineyard or updating
UC6	The User adds/updates meteo data inside the system	Monitoring	Insert data from a meteorological station	User logged The data is provided according to an agreed standard	The User wants to insert meteo data from a given system	The time series of the meteo station is inserted into the system	User	1) the User opens a page dedicated to data import (file import) 2) the User uploads a new file together with appropriate metadata
UC7	The User visualizes phenological or irrigation or technology (crop forcing, canopy management) data on a selected vineyard	Monitoring	Visualize the outputs of phenological or irrigation or technology models on a given vineyard	User logged, vineyard selected	The User wants to see the outputs models The vineyard/parcel is already inserted into the system	The model outputs are show in the vineyard selected, together with the user feedbacks (real observations), if any	User	1) the User selects the parcel to visualize the results 2) The System shows the output. If spatialized it is shown as a map layer on top of the vineyard area. If user feedbacks are available, they as shown as well

UC8	The User visualizes meteo or climate forecasts data on a selected geographical area	Monitoring	Visualize the outputs of meteo and climate models on a given vineyard	User logged, geographical area selected on a map	The User wants to see the outputs of meteo or climate models	The selected model outputs are show in the selected geographical area	User	1) the User selects the meteo/climate data type to be visualized 2) the User selects the specific lead-time to be visualized 2) the data is shown by the system
UC9	The User gives a feedback about a state, action, result of a given vineyard (phenological state, irrigation, action done)	Feedback	Give a feedback to the system about a real state, action, or result related to a given vineyard	User logged, vineyard selected	User has updates regarding a state, action, or result and it wants to update the system	The new data is inserted into the system and can be visualized	User	1) the User selects the data type to be inserted/updated 2) the User insert the data

3.4. End-user requirement list

The list of end-user requirements that results from the analysis of the use-case is reported in Table 6, which has been validated by all the end-users of the VISCA consortium.

Table 6. list of end-user requirements

ID	Description	Priority	Use-case code	Comments
1	**Pre-registration** of a new User by an Administrator	Must	UC1	the registration need to be completed before to become effective (login capabilities)
2	**Login** via username and password for all registered users	Must	UCx	all use cases
3	**Confirmation e-mail** is sent after a user pre-registration	Must	UC1	
4	**Finalization of login** after the registration confirmation link is clicked	Must	UC2	
5	Update of the **profile information**	Must	UC2, UC4	
6	Add or update **vineyard information** (initial data)	Must	UC5	
7	**Add or update meteo** data from a **local station**	Must	UC6	pre-defined format and metadata to be defined
8	**Visualization** of latest predicted **phenological events** for each vineyard parcel	Must	UC7	
9	Visualize the dates predicted **irrigation needs** for each vineyard parcel	Must	UC7	
10	Visualization of the latest **short-term weather forecasts** on a selected geographical area from the map	Must	UC8	
11	Visualization of the latest **seasonal weather forecasts** on a selected geographical area from the map	Must	UC8	

12	Visualization of latest **climate change projections** on a selected geographical area from the map	Must	UC8	
13	**Visualize** the **predicted date** for applying the **technology** selected and the **amount of stages/leaves to be removed** for each of the parcels composing the plot	Must	UC7	
14	**Insert** an observed **phenological event** for a selected parcel	Must	UC9	
15	Insert irrigation done for a selected parcel	Must	UC9	
16	Insert harvest data (yield, quality)	Must	UC9	

5. Conclusions

The end-user needs in terms of data to be provided and use-cases has been analysed and summarized in a list of requirements, which does not point to any specific functionality requiring a mobile application.

All requested functionalities can be implemented within the CS-DSS web application, which will allow both the data visualization as well as the capability to provide feedbacks in terms of phenological dates, yields, quality.

The effort planned for the realization of the mobile application will be devoted to the implementation of the CS-DSS web application, which will have to be responsive to allow a correct visualization on all form factors and resolution, in order to be usable from mobile devices (smartphones, tablets, notebooks).

Similarly, also the data from the in-situ meteorological stations will be ingested by the CS-DSS, which will allow to upload them through a web page. Such data will have to be formatted according to a common standard that will be agreed by the partners within the activities of Task 3.2.