H2020-SC5-01-2017

MED-GOLD

Turning climate-related information into added value for traditional **MED**iterranean **G**rape, **OL**ive and **D**urum wheat food systems

D4.6

First Feedback report from users on durum wheat pilot service development

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Disclaimer

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EXECUTIVE SUMMARY

This document reports the outcomes of the first user feedback workshop on the prototype climate service for durum wheat that can be integrated in the granoduro.net platform.

The workshop was held in Parma at the Barilla premises, and of an internal (WP4) follow-up meeting in Bologna. During the workshop with the users, graphical example were provided showing results of the proposed climate indexes computed on seasonal forecasts on three target locations identified and discussed in deliverable D4.1.

The seasonal forecasts are uploaded on the ICT web platform and an open R script (RAGROCLIM) has been developed to compute the relevant indexes during the relevant phenological stages of the crop. The computation can be performed assuming prescribed or dynamical phenology, calibrated according with JRC data. JRC meteorological data are uploaded as well on the ICT web platform in order to allow the bias correction on the full seasonal forecast ensemble (51 members).

HORTA srl has provided the sample visualization strategies that have been shown during the workshops and proposed to the participant. Their feedbacks were collected during the workshop to define the final list of climate indicators that are presented in this document and to finalize the visualization approach.

Participants were also asked to provide answers to questionnaires that were collected after the workshops. The questionnaires outcomes is quantitatively summarized in this document.

In addition to the general appreciation of the proposed prototype for practical purposes as agronomic decisions, varietal choice, future investments, etc. most of the users recognized an unexpected values of the prototype, which potentially ease a sustainable use of fertilizers and pesticides, preserving also the natural environment where durum wheat cultivation are embedded.

A further feedback is provided by Barilla on the DELPHI yield and biomass seasonal forecasts, following the same questionnaire. This document provides details of the DELPHI implementation driven by seasonal forecasts as well as the feedback provided by Barilla.

With this deliverable, the project has contributed to the achievement of the following objectives (DOA, PartB Table1.1):

No.	Objective	Yes
1	To co-design, co-develop, test, and assess the added value of proof-of-concept climate services for olive, grape, and durum wheat	X
2	To refine, validate, and upscale the three pilot services with the wider European and global user communities for olive, grape, and durum wheat	
3	To ensure replicability of MED-GOLD climate services in other crops/climates (e.g., coffee) and to establish links to policy making globally	
4	To implement a comprehensive communication and commercialization plan for MED-GOLD climate services to enhance market uptake	X
5	To build better informed and connected end-user communities for the global olive oil, wine, and pasta food systems and related policy making	X

1. INTRODUCTION

A previous deliverable (4.1) set several pillars for the development of MEdGOLD-WP4: specific locations were selected to test the pilot prototype, characterize by the availability of meteorological observations over long periods of time. These observation were analysed and compared with the JRC gridded meteorological dataset that will be used to correct the seasonal forecasts over the entire area.

Meanwhile, relevant data was uploaded on the ICT web platform. A replicable R script (RAGROCLIM) computing durum wheat crop phenology and a preliminary set of relevant climate indicators was developed. Example computations performed with RAGROCLIM on a seasonal forecasts ensemble (Copernicus Data Store - 51 ensemble for 6 months of forecast – started in November and February) was integrated into the HORTA granoduro.net framework. The seasonal forecasts are not bias corrected yet. Therefore, at this stage it was possible to present the conceptual idea founding the proposed pilot rather than actual quantitative results.

On 2nd and 3rd of April a MED-GOLD-WP4 workshop was help in Parma, at the Barilla premises, to show the first proposal of prototype climate service for durum wheat to selected granoduro.net users and relevant stakeholders / policy makers. The prototype consisted on a list of climatic indexes computed of seasonal forecasts that were discussed with the participants and the presentation of a graphical interface to illustrate results. A questionnaire was provided to the attendants and collected after the workshop.

On an independent line, the CNR developed a benchmark of the Delphi system for yield and biomass using the weather data provided by Copernicus Data Store released in October 2017 (51 ensemble for 6 months of forecast).

Results were compared with the results of the current Delphi System by feeding the model with synthetic weather scenarios based on historical observations (dry, average, wet scenario).

1.1. PURPOSE

This report summarizes the feedbacks on: 1) the first prototype proposed to granoduro.net users and policy makers during the workshop help in Parma on 2nd and 3rd of April as well as the internal discussion within WP4 during a follow-up meeting in Bologna on 14th of May, and 2) the Delphi prototype proposed to Barilla

1.2. SCOPE

This report frames the details of the current development of the climate service prototype for durum wheat that will be implemented in the next stages of the project.

2. GRANODURO.NET USER FEEDBACK AND NEXT STEPS

2.1. SUMMARY OF THE MEETING IN PARMA

The afternoon of the 2nd of April was organised among the Italian WP4 partners (Barilla, CNR, ENEA, HORTA, JRC) and was devoted to the fine-tuning of the presentations and questionnaires for the stakeholder workshop of the day after. On the workshop of the 3rd of April, selected participants of the scoping workshops held in 2018 (D4.1) were invited to provide their feedbacks of the first stages of the development of the climate service prototype. (the meeting agenda with participant list is attached, ANNEX B). The attendees of the workshop were durum wheat farmers, producers' association and elevators technicians users of Horta's Decision Support System (DSS) granoduro.net®, for the management of durum wheat crop and Barilla suppliers; representatives of local political institutions, breeding companies and stocks exchange markets.

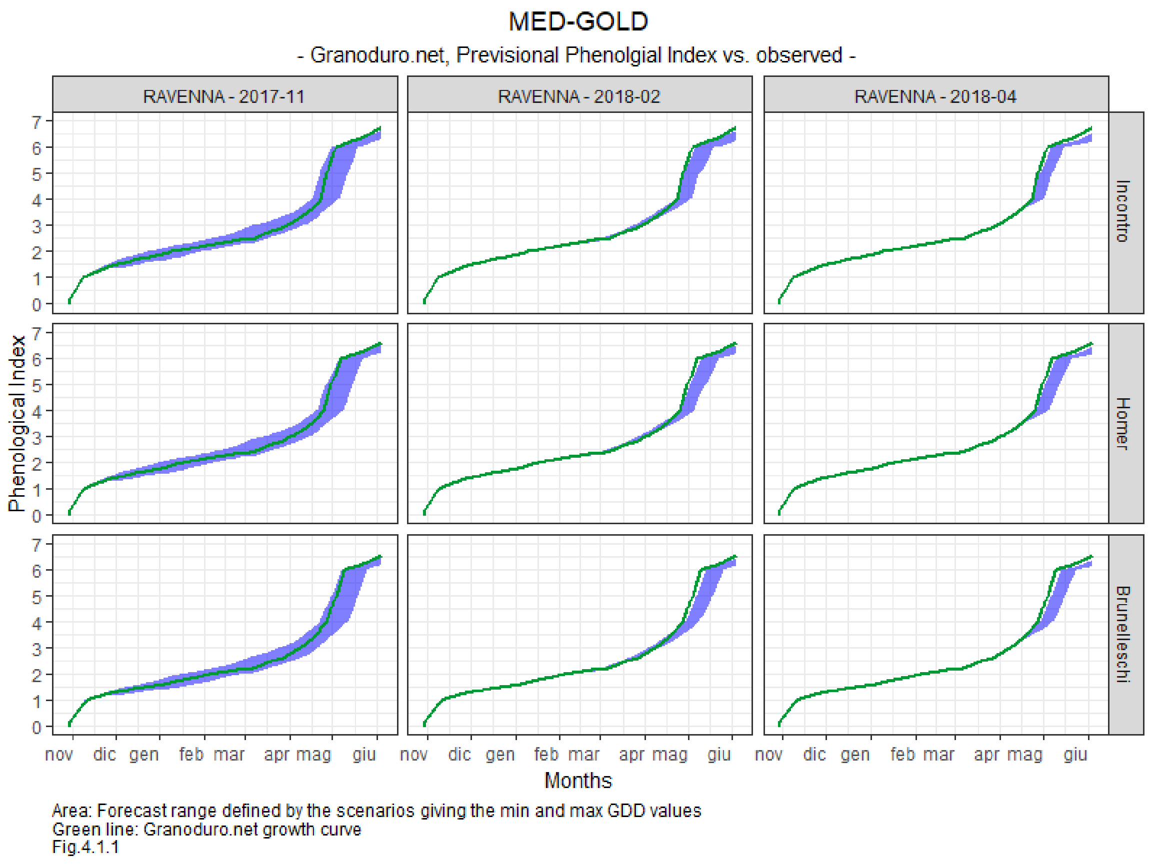

Figure 2-1: Example of computation of phenological stages on the seasonal forecasts ensemble (not corrected for the bias) according the granoduro.net mode, which depends on the sowing date and mean daily temperature, providing the occurrence of the 7 relevant phenological stages of durum wheat.

The workshop was organized as follows:

- Sandro Calmanti presentation on the MED-GOLD project, climate information time scales and predictability of the climate system
- Tiziano Bettati has shown the prototype user interface of the climate indicators agreed among partners to be included in the granoduro.net decision support system on the basis of an initial list of indexes defined on the basis of users needs identified in the previous workshop (D4.1) and coded in R scripts provided by Andrej Ceglar and Andrea Toreti. The computational flow of granoduro.net is not yet dynamically linked to the operational seasonal forecasts, nor yet bias

corrected. Therefore, this was a pure proof of concept of the visual impact of the developed graphical user interface. Figure 2-1 provides an example of computation of the granoduro.net phenological model for durum wheat of the seasonal forecasts ensemble (not yet corrected for the bias). Figure 2-2 provides a visual example of time-series computed on observed data for one of the selected indexes (i.e. drought from flowering to harvesting) over one of the target locations (Foggia). This kind of visualization computed of the hind-cast simulations, together with the next season forecasts, is one of the preferred graphical interfaces by the workshop participants (see outcome of questionnaires). Figure 3-3 shows the proposed graphical interface of the group of drought indexes for the virtual current growing season in the granoduro.net interface.

- Andrea Toreti and Matteo Zampieri have shown results of dynamical and statistical modelling of wheat yield projections in the Mediterranean area. This presentation demonstrated the need of climate adaptation projects such as MED-GOLD and demonstrated the skills of some of the indicators proposed in forecasting future yield losses. This presentation also included the results of a recent paper by Ceglar et al. demonstrating the skill of improved seasonal forecasts on maize yield in Europe, in order to provide an order of magnitude of the accuracy that can be potentially reached by the crop yield seasonal forecasts in the Euro-Mediterranean area.
- Andrej Ceglar has presented the detail of the R script automatically computing a number of temperature and precipitation based indicators during the relevant phenological phases of the wheat crop. These periods can be either prescribed a-priori or determined automatically by a dynamical phenological model implemented within the script.

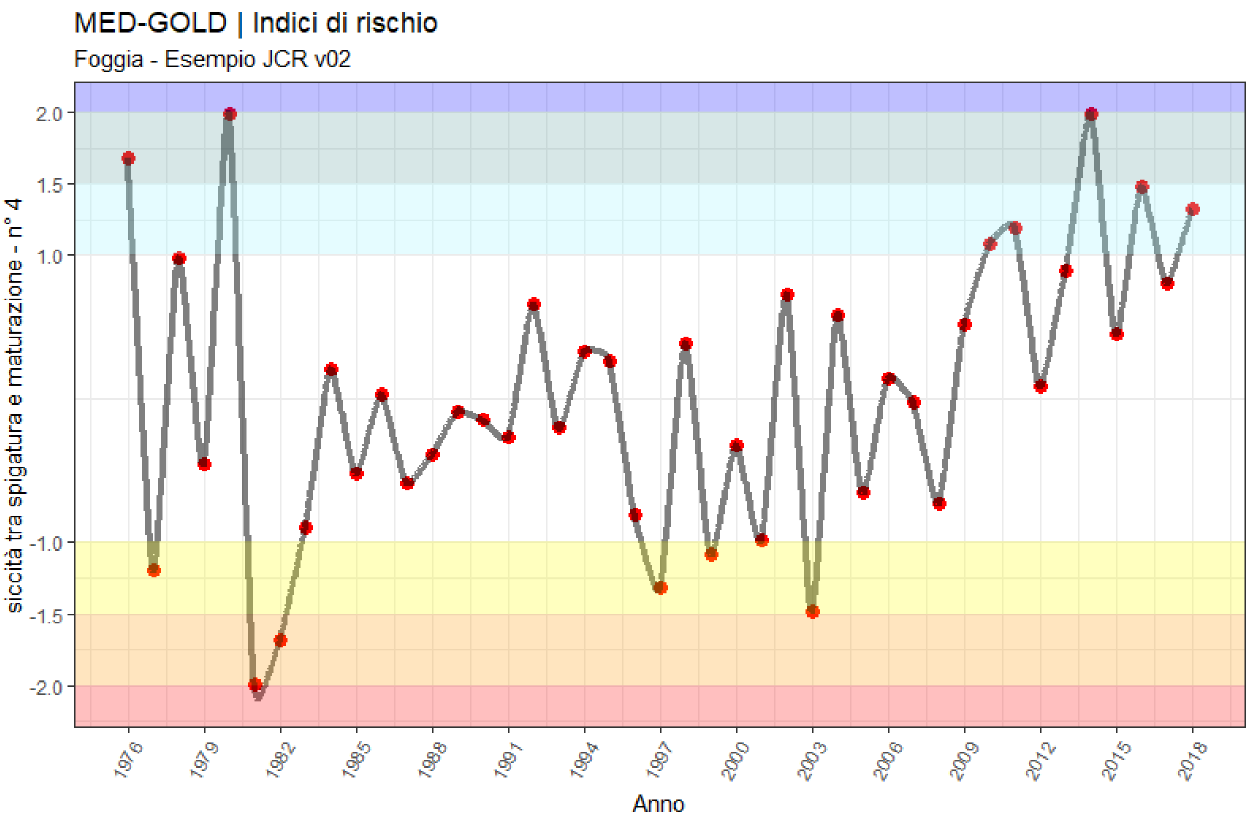

Figure 2-2: Example of time series for a selected index (i.e. drought between flowering and harvesting) for one of the target locations (Foggia), computed on observed data.

The discussion with the invited users and stakeholder provided useful comments and feedbacks. The general development that was proposed was well appreciated. However, an additional series of indicators was demanded, mostly supporting practical field operations during the growing season. Thus, the next steps will include the dynamical computation of the JRC R script of bias corrected outputs of the seasonal forecasts systems of the MED-GOLD ICT platform and on the HORTA granoduro.net platform, as well as the definition of the optimal indicators to provide useful information to improve the quality of the grains, minimizing fertilizer and pesticides use.

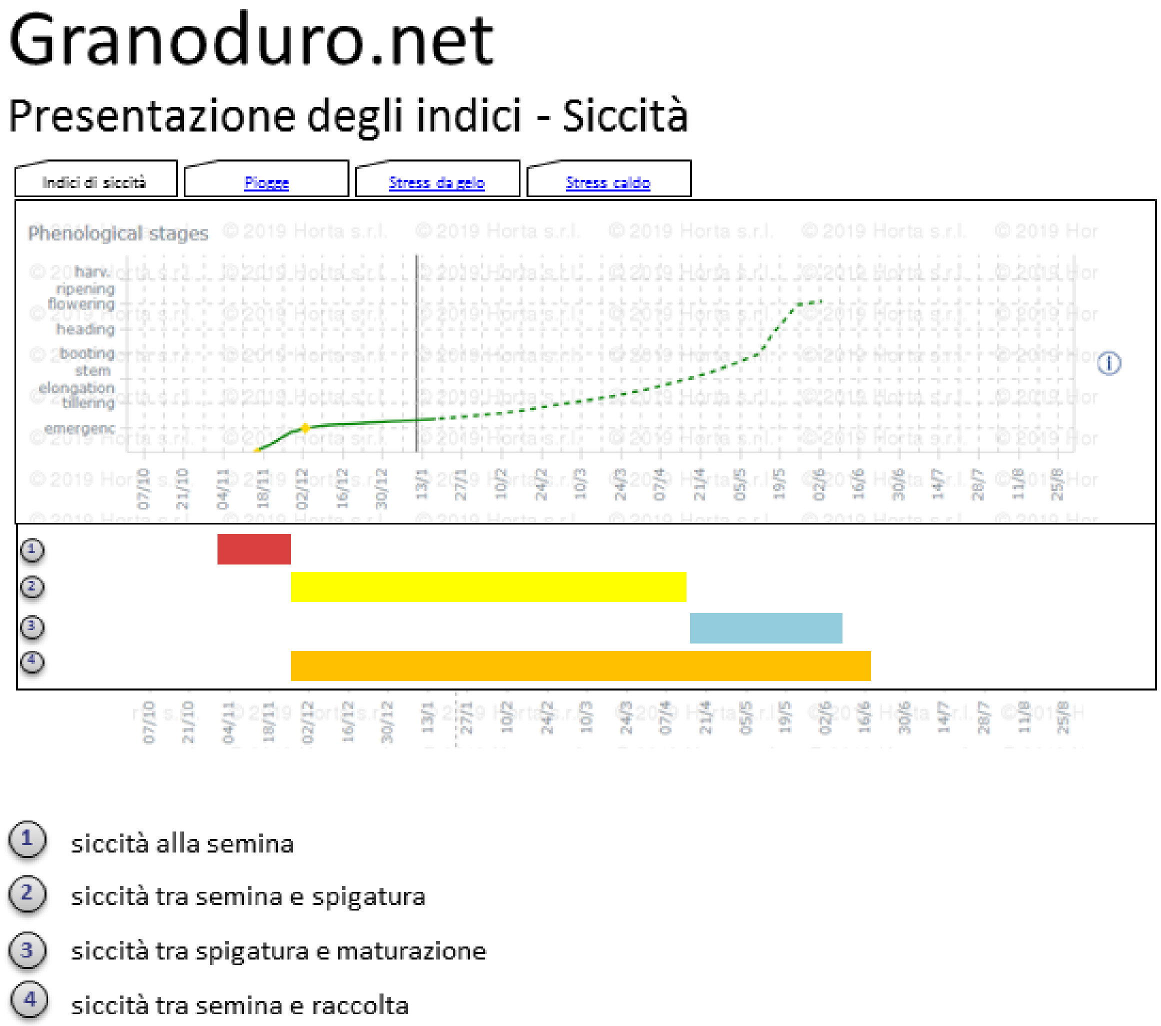

Figure 2-3: Proposed integration of the group of drought indexes for the growing season in the granoduro.net interface. The plot on top highlights the phenological development at a particular timing of the growing season, representing the virtual timing of consultation (in this example 31st of January). Data on the left of the vertical black line are computed from observations, data for the future are computed on the seasonal forecast ensemble. The bars on the bottom represent the drought indexes computed over four relevant periods during the growing season. The colours represent the water balance, with a colour code related to actual drought, normal conditions or too wet conditions. The consultation is eased by an online help.

2.2. FINAL LIST OF INDICATORS FROM THE FOLLOW UP MEETING

The outcome of the Parma workshop were discussed in Bologna on the 14th on May by Matteo Zampieri (JRC), Andrej Ceglar (JRC), Chiara Monotti (BARILLA), Marco Silvestri (BARILLA), Piero Toscano (CNR), Tiziano Bettati(HORTA), Valentina Manstretta (HORTA), Pierluigi Meriggi (HORTA), Sandro Calmanti (ENEA), Massimiliano Pasqui (CNR, remote).

The proposed list of indices was updated based on the output of the workshops. A set of total 16 indicators have been prepared divided into three main categories:

1. Hydrological balance indicators. All indices are based on SPEI but focusing on different periods.
2. Rainfall indicators including: rainfall before sowing, number of days with rainfall above 10mm during tillering

3. Temperature stress indicators.

Table 1 and 2 (see Annex A) describe the final list of indexes discussed with the users during the workshop. These indexes are going to be computed automatically with the R script developed by the JRC (RAGROCLIM) under two alternative configuration: one employing fixed calendar i.e. prescribed phenological phases; the other computing the phenological phases dynamically i.e. according to the climatic anomalies produced by the seasonal forecasts, according to the JRC phenological model for durum wheat. For running in the granoduro.net DSS, the HORTA phenological model for durum wheat will be used, which is calibrated for several durum wheat varieties.

During the Follow up meeting in Bologna, Andrej Ceglar presented preliminary results of the skill analysis (correlation, Equitable threat score, Brier Skill Score) performed on the selected indexes computed on the first 6 months of the re-forecasts issued in November compared to the observations after a simple bias correction (i.e. correcting the mean).

All indicators have been calculated based on fixed time windows as well as on time windows based on output of phenological phases.

For hydrological balance indicators the only big difference is for the index that describes the sowing conditions: for fixed period the time window is 2 months; for phenological based periods, the length of the time window can change a lot, depending on temperature. For the other variables values are very similar, especially the extremes. Rainfall indicators usually have lower values when calculated over phenological periods. Same happens for temperature stress indicators.

This analyses highlighted the need of more sophisticated bias correct method such as, for instance, quantile mapping, and suggested the possibility to consider an alternative strategy for downscaling seasonal forecasts i.e. using statistical downscaling employing circulation patterns as regressors. These strategies will be evaluated during the next stages of the project.

2.3. OUTCOMES FROM QUESTIONNAIRES

The questionnaires proposed to the invited participants of the user feedback workshop where filled and sent back after the workshop. Hereafter, we summarize the outcome of the questionnaire for each question, grouped in three main branches: technical aspects, usability of the prototype, and future development.

2.3.1. TECHNICAL ASPECTS OF THE INDICATORS PROPOSED FOR THE PROTOTYPE

- *Question 1: Which are the indexes / useful information for you work?*

Here the seven invited participants (users and stakeholders) identified short term meteorological (4/7) forecasts, based on previous experience, but appreciated the indexes proposed during the workshop, especially those for drought (5/7), precipitation (6/7) and heat waves (5/7), but also frosk risk (1/7), wind (2/7) and their anomalies compared to the climatology and trend. Some doubt has been raised on the accuracy of the seasonal forecasts. The users are interested in the comparison of the indexes computed with the next season and the same computed for the hindcasts (historical time-series, 1/7, see Figure 2-2). Such times-series will actually be one of the main graphical products offered by the prototype. Policy maker were more interested in decadal predictions, especially to face climate change impacts (2/7). The same holds for breeders and varietal developers (1/7), that were especially interested to drought in different phenological phases, frost risk and heat stress at flowering.

- *Question 2: What are the indexes / information that are NOT useful for your work?*

Some users did not show interest to information on the long term, longer than one year (2/7). However, most participants (4/7) declared that each of the indexes in the final list is relevant for their work. One participant (1/7) did not show interested in wind data.

- *Question 3: Is the proposed graphical interface easy to read?*

Most participants consider the proposed approach easy to pickup (4/7). Others think some time is needed to get used to the proposed interface (2/7). One prefer to wait for the final version to judge.

- *Question 4: The delivered information is easy to interpret?*

Most participants (5/7) think the interpretation is straightforward, and they appreciate this feature.

- *Question 5: Suggestions for improvement?*

Put in relationship the indexes with the actual impact on the crop and yield quality (2/7). Organized the information at the local scale (1/7) as well at the larger geographical areas (1/7). Remark the suggestion for the improvement already identified during the workshop (1/7). Some did not answer (2/7). One would like the information being provided with a reliability assessment (1/7).

- *Question 6: Can you identify particular "good" or "bad" years to check the indexes performance?*

2010 (1/7) and 2016 (1/7) were a bad year for the presence of DON (deoxynivalenol, mycotoxin) in the final product. 2014 (1/7) was bad for quality (low protein in yield). 2018 (1/7) and 2019 (1/7) were relatively good (however, during the workshop it was reported a hot and dry wind in the 3rd decades of April 2018 in the south area, which inhibited wheat heading; regarding 2019, up to the date of the workshop, the seasonal tends to be dry) In general, having the forecasts of the proposed indexes would have been quite useful on good and bad year to improve the planning and possibly avoid some of the negative impacts. Reliable seasonal forecasts started in November could have been used of the varietal choice at sowing. Some participant did not answer (1/7), or did not identify specific years (4/7).

2.3.2. USABILITY OF THE PROTOTYPE INDICATORS

- *Question 1: The proposed tool is helping in taking decisions? If so, how? If not, why?*

Most participant consider it useful (6/7), both for long-term planning, varietal choice and development (5/7), and to improve crop management i.e. plan fertilization and pests control (6/7). One stated that there is no clear link between the proposed indicators and field decisions (1/7).

- *Question 2: For which decisions could it be useful?*

It is considered useful (7/7), especially to plan field operation (3/7), weed control (2/7), fertilization (3/7) and crop protection (3/7) on a regular basis. Longer term decisions involve field preparation and varieties (2/7), sowing time (1/7) as well and economical and technical decisions (1/7).

- *Question 3: would you use this tool if it were available in the future?*

All participants answered absolutely positively (7/7).

- *Question 4: would the proposed tool bring benefits to your activity / business?*

All participants answered positively (7/7). Most of them (4/7) also identified the usefulness for environmental purposes i.e. the usefulness in reducing waste and pollution, other than just bringing a mere economical benefit.

2.3.3. FUTURE DEVELOPMENT ENVISAGED FOR THE PROPOSED PROTOTYPE

- *Question 1: would you like to continue being involved in this development and being informed of the feedback?*

All participants gladly answered positively (7/7).

- *Question 2: if so, how (online questionnaire, video call, meeting)?*

Almost all participants prefer meetings (6/7), if the frequency is not too high (2/7), otherwise other forms of communication are accepted as well (3/7). One (1/7) also suggests spreading the information gathered during this activity publicly, to a wider audience. One did not answer (1/7).

- *Question 3: which would be your preferred frequency for providing feedbacks? Are there particular timings during the season that you wish to identify?*

Most of the participants would devote the winter and the timing between two growing seasons for this feedback activity (4/7). Others would also like to meet at some particular stages of the growing season (2/7). One has no time constrains (1/7).

- *Question 4: would you be interested to test the final version of the tool using a real seasonal forecast for the next season?*

All participants answered positively (7/7).

3. DELPHI PROTOTYPE, BARILLA'S FEEDBACK AND NEXT STEPS

3.1. DELPHI PROTOTYPE

Delphi system for yield and biomass was run using the weather data provided by Copernicus Data Store released in October 2017 (51 ensemble for 6 months of forecast).

Results were compared with the results of the current Delphi System by feeding the model with synthetic weather scenarios based on historical observations (dry, average, wet scenario).

For each simulation the input weather files were built as indicated in Figure 3-1

Figure 3-1: Schematics of Delphi implementation driver data. Seasonal forecast are driving the Delphi simulations in the period indicated by yellow colour.

Delphi simulations were conducted for the three selected locations (Jesi, Ravenna, Foggia), described in D4.1. Yield and biomass predictions were calculated at a monthly time step starting from October 1st. For each case with all the ensembles and the Dry-Average-Wet scenarios results and charts with average, percentiles 25-75 for all ensembles predictions were proposed to Barilla as prototype climate service.

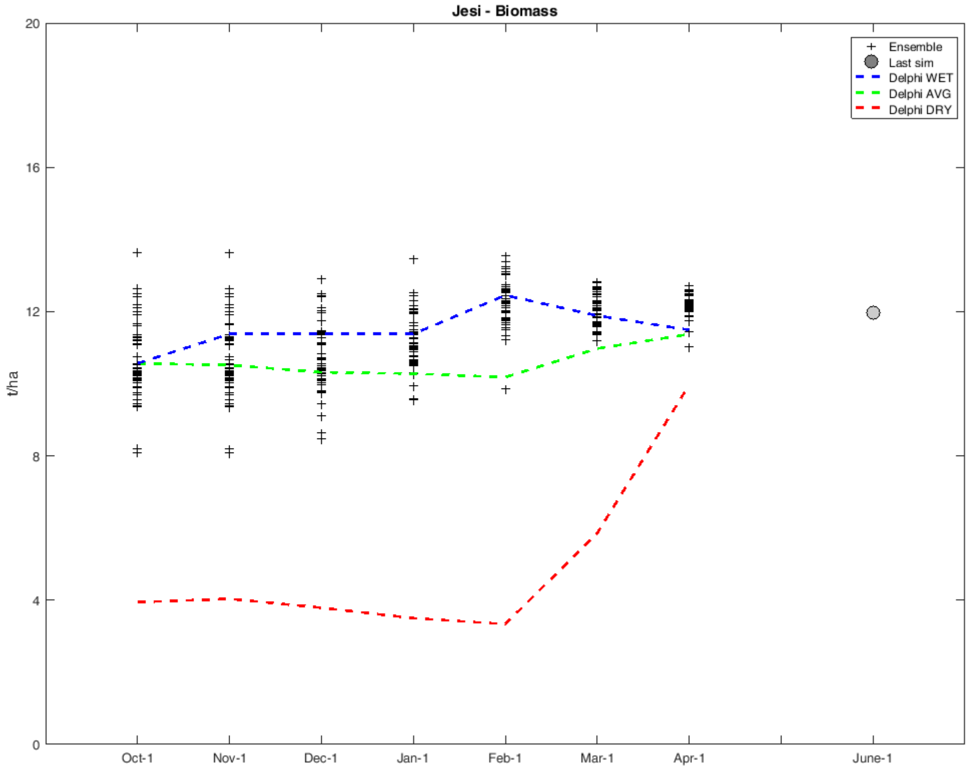

Figure 3-2: Example biomass simulation by Delphi computed for Jesi.

Figure 3-2 shows an example of simulation for one of the target locations discussed in D4.1. In general, seasonal forecast scenario range is narrower than that provided by the Dry-Average-Wet scenario. The results show a better performance for the predictions provided with seasonal forecast.

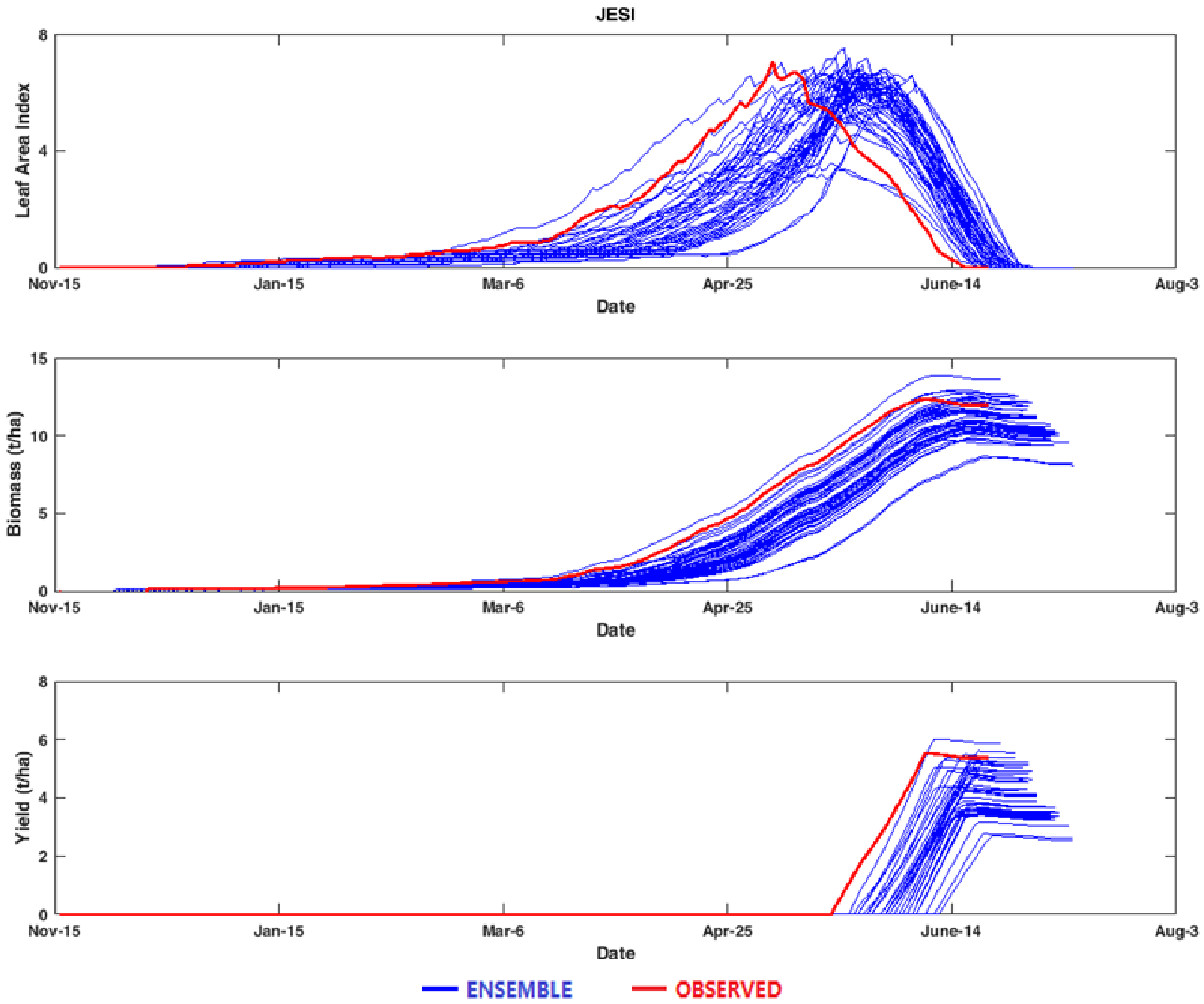

Figure 3-3: Example daily leaf area index (LAI), biomass and yield, simulated by Delphi. This simulation is drive by seasonal forecasts from 1st October to 30th April.

Benchmark of the Delphi system was provided also for daily Leaf Area Index, biomass, and yield (Figure 3-3). Results were compared with the results of the current Delphi System by feeding the model with observed weather data. It is worth noting that the seasonal forecasts driving this simulation is not bias corrected yet. Results show a clear tendency to postpone LAI, biomass and yield accumulation.

Delphi results were analysed also considering two extreme situations for each target location: 2010 for Ravenna; 2007 for Foggia and Ancona were analysed as representatives of “bad year” (i.e. low yield); 2012 for Ravenna; 2016 for Foggia and Ancona were analysed as representatives of “good years” (i.e. high yields).

3.2. BARILLA’S FEEDBACK

3.2.1. TECHNICAL ASPECTS OF THE INDICATORS PROPOSED FOR THE PROTOTYPE

- *Question 1: Which are the indexes / useful information for you work?*

Biomass and yield, as is from the basic service provided.

- *Question 2: What are the indexes / information that are NOT useful for your work?*

There are no indexes in Delphi service.

- *Question 3: Is the proposed graphical interface easy to read?*

Yes because it's similar to the current one.

- *Question 4: The delivered information is easy to interpret?*

Yes.

- *Question 5: Suggestions for improvement?*

Improve performances of the seasonal forecasts, as all results follow in cascade.

- *Question 6: Can you identify particular "good" or "bad" years to check the indexes performance?*

If the predictions were accurate, they could have driven market decisions.

3.2.2. USABILITY OF THE PROTOTYPE INDICATORS

- *Question 1: The proposed tool is helping in taking decisions? If so, how? If not, why?*

It helps planning the provisioning buys anticipating the market effect

- *Question 2: For which decisions could it be useful?*

It is useful to orient periodically the buying decisions.

- *Question 3: would you use this tool if it were available in the future?*

Yes.

- *Question 4: would the proposed tool bring benefits to your activity / business?*

Yes, if it is reliable.

3.2.3. FUTURE DEVELOPMENT ENVISAGED FOR THE PROPOSED PROTOTYPE

- *Question 1: would you like to continue being involved in this development and being informed of the feedback?*

Yes.

- *Question 2: if so, how (online questionnaire, video call, meeting)?*

F2F, questionnaires by email, video-call.

- *Question 3: which would be your preferred frequency for providing feedbacks? Are there particular timings during the season that you wish to identify?*

Any time of the year is good.

- *Question 4: would you be interested to test the final version of the tool using a real seasonal forecast for the next season?*

Yes.

4. CONCLUSIONS

This report is assessing the state of the project at a crucial step when the first prototypes of climate service for durum wheat are presented to decision support systems' users and policy makers, their feedbacks are collected and decisions are taken as a consequence.

Two categories of users are involved in this exercise: granoduro.net users, which are providers of the Barilla supply chain, and Barilla itself as user of the Delphi system. In both cases, users are quite interested and sometimes enthusiastic of the proposed solutions, but they raise concerns on the reliability of the seasonal forecasts (which were not bias-corrected yet).

It is worth noting that at every meeting and workshops a considerable amount of time was devoted in clarifying the validity and the necessity of a probabilistic interpretation of the seasonal forecasts results. This is still subject of internal discussion within WP4. During the last meeting in Bologna, on the 14th of May, the user feedbacks was discussed and we reached a final list of climate indicators that are relevant for decision making for the granoduro.net users, both for agro-management practices during the season and for variety selection and field preparations before on the longer term.

These indicators are computed with an open R-package developed by the JRC and available of the ICT platform, for replicability. The JRC provided a preliminary assessment of the seasonal forecasts results over the three target locations selected and discussed in deliverable D4.1. A simple bias correction was applied. These results triggered a discussion on the most suitable skill score to be accounted for, as well as the possibility of implementing alternative statistical downscaling to extract the information of atmospheric circulation regimes predicted by the seasonal forecast simulation ensembles, or a better suited bias correction methods.

At the time this report is being written, bias corrected data for the three selected locations in deliverable D4.1. are provided using quantile mapping method and will be soon available on the ICT platform. Future plans include:

- the entire reforecast dataset available on the ICT platform after bias correction (July 2019),
- new questionnaires for the participants to the next user feedback workshop (October 2019),
- updated results and questionnaires sent to the users (November 2019) and the organization of another users feedback workshop, tentatively in Bologna, with presentation of the latest available forecast product (December 2019).

These dates are chosen accordingly to the users preferences (see sections 3.3.3 and 4.2.3 of this deliverable).

ANNEX A. ANNEX

Table A-1 Explanation of indicators calculated based on phenological stages of durum wheat. All indicators have been introduced based on literature review and MED-GOLD WP4workshops' participants recommendations

Type of indicator	Description	Phenological period - beginning (BBCH)	Phenological period - end (BBCH)	Neutral value (no impact)	Risk associated value
1	hydrological balance during pre-sowing period (September and October)	September	October	[-1,1]	**[-1.5,-1] (moderate drought)** **[-2,-1.5] (severe drought)** **(< -2] (extreme drought)** [1,1.5] (moderate wet) [1.5,2] (severe wet) [2 >) (extreme wet)
2	hydrological balance between sowing and emergence	0	9	[-1,1]	**[-1.5,-1] (moderate drought)** **[-2,-1.5] (severe drought)** **(< -2] (extreme drought)** [1,1.5] (moderate wet) [1.5,2] (severe wet) [2 >) (extreme wet)
3	hydrological balance during tillering	20	29	[-1,1]	**[-1.5,-1] (moderate drought)** **[-2,-1.5] (severe drought)** **(< -2] (extreme drought)** [1,1.5] (moderate wet) [1.5,2] (severe wet) [2 >) (extreme wet)
4	hydrological balance between beginning of stem elongation period and end of booting	30	49	[-1,1]	**[-1.5,-1] (moderate drought)** **[-2,-1.5] (severe drought)** **(< -2] (extreme drought)** [1,1.5] (moderate wet)

					[1.5,2] (severe wet) [2 >) (extreme wet)
5	hydrological balance between beginning of heading period and full maturity	50	89	[-1,1]	**[-1.5,-1] (moderate drought)** **[-2,-1.5] (severe drought)** **(< -2] (extreme drought)** [1,1.5] (moderate wet) [1.5,2] (severe wet) [2 >) (extreme wet)
6	hydrological balance between sowing and full maturity	0	89	[-1,1]	[-1.5,-1] (moderate drought) [-2,-1.5] (severe drought) (< -2] (extreme drought) **[1,1.5] (moderate wet)** **[1.5,2] (severe wet)** **[2 >) (extreme wet)**
7	rainfall amount during pre-sowing period	September	October	Depends on soil type	>100 mm
8	number of days with rain above 10 mm during tillering period	20	29	0	>0*
9	number of days with rain above 40 mm during tillering	20	29	0	>0*
10	number of days with rain above 5 mm between beginning of heading and full maturity	51	89	0	>0*
11	number of days with rain above 40 mm between beginning of heading and full maturity	51	89	0	>0*

12	maximum number of consecutive days with rain above 5 mm between beginning of heading and end of end of flowering	51	69	0	>0*
13	maximum number of consecutive days with rain above 5 mm between end of flowering and full maturity	69	89	0	>0*
14	Number of days with minimum daily temperature below 2 deg. C between booting and flowering	41	69	0	>0*
15	Number of hot days with maximum daily temperature above 28 deg. C between end of stem elongation and end of flowering	39	69	0	>0*
16	Number of hot days with maximum daily temperature above 28 deg. C between during grain filling period	69	89	0	>0*

* - severity of impact is determined by the magnitude of the value calculated – higher the value, more severe the impact. In order to better characterize the impact of crop growth, an assessment using field data is necessary.

Table A-2 Explanation of indicators calculated based on fixed dates for durum wheat

Type of indicator	Description	Phenological period - beginning	Phenological period - end (month)	Neutral value (no impact)	Risk associated value

		(month)			
1	hydrological balance during pre-sowing period (September and October)	September	October	[-1,1]	**[-1.5,-1] (moderate drought)** **[-2,-1.5] (severe drought)** **(< -2] (extreme drought)** [1,1.5] (moderate wet) [1.5,2] (severe wet) [2 >) (extreme wet)
2	hydrological balance between sowing and emergence	October	November	[-1,1]	**[-1.5,-1] (moderate drought)** **[-2,-1.5] (severe drought)** **(< -2] (extreme drought)** [1,1.5] (moderate wet) [1.5,2] (severe wet) [2 >) (extreme wet)
3	hydrological balance during tillering	December	March	[-1,1]	**[-1.5,-1] (moderate drought)** **[-2,-1.5] (severe drought)** **(< -2] (extreme drought)** [1,1.5] (moderate wet) [1.5,2] (severe wet) [2 >) (extreme wet)
4	hydrological balance between beginning of stem elongation period and end of booting	April	April	[-1,1]	**[-1.5,-1] (moderate drought)** **[-2,-1.5] (severe drought)** **(< -2] (extreme drought)** [1,1.5] (moderate wet) [1.5,2] (severe wet) [2 >) (extreme wet)

5	hydrological balance between beginning of heading period and full maturity	May	June	[-1,1]	**[-1.5,-1] (moderate drought)** **[-2,-1.5] (severe drought)** **(< -2] (extreme drought)** [1,1.5] (moderate wet) [1.5,2] (severe wet) [2 >) (extreme wet)
6	hydrological balance between sowing and full maturity	November	June	[-1,1]	[-1.5,-1] (moderate drought) [-2,-1.5] (severe drought) (< -2] (extreme drought) **[1,1.5] (moderate wet)** **[1.5,2] (severe wet)** **[2 >) (extreme wet)**
7	rainfall amount during pre-sowing period	September	October	Depends on soil type	>100 mm
8	number of days with rain above 10 mm during tillering period	December	March	0	>0*
9	number of days with rain above 40 mm during tillering	December	March	0	>0*
10	number of days with rain above 5 mm between beginning of heading and full maturity	April	June	0	>0*
11	number of days with rain above 40 mm between beginning of heading and full maturity	April	June	0	>0*
12	maximum number of consecutive days with rain above 5 mm between beginning of heading and end of end of flowering	April	May	0	>0*

13	maximum number of consecutive days with rain above 5 mm between end of flowering and full maturity	May	June	0	>0*
14	Number of days with minimum daily temperature below 2 deg. C between booting and flowering	April	May	0	>0*
15	Number of hot days with maximum daily temperature above 28 deg. C between end of stem elongation and end of flowering	March	May	0	>0*
16	Number of hot days with maximum daily temperature above 28 deg. C between during grain filling period	May	June	0	>0*

ANNEX B. FIRST USER FEEDBACK MEETING AND WORKSHOP AGENDA

MedGOLD-WP4 First Feedback workshop

2-3 April Barilla G&R fli, via Mantova 166, Parma

Agenda

2 April

15.30-18 WP4 meeting to prepare the workshop and discuss feedback on the official comments on D1.4

3 April

From 09.00 to 13.00, farmers and elevators
09.00 – 09.15 Welcome, attendance signature
09.15 – 10.45

- Workshop May18 results
- Climatic Model explanations
- Pilot presentation

10.45 – 11.00 Coffee break
11.00 – 12.45 Open discussion on users' feedback
12.45 – 13.00 Conclusions
13.00 – 14.00 Lunch at Barilla canteen

From 14.30 to 18.00, institutional attendees
14.30 – 14.40 Welcome, attendance signature, bluejeans connection
14.40 – 16.00

- Workshop May18 results
- Climatic Model explanations
- Pilot presentation

16.00 – 16.15 Coffee Break
16.15 – 17.45 Open discussion on users' feedback
17.45 – 18.00 Conclusions

Meeting and workshop participants from MED-GOLD: Chiara Menotti (Barilla), Cesare Ronchi (Barilla), Andrea Toreti (JRC), Matteo Zampieri (JRC), Andrej Ceglar (JRC), Valentina Manstretta (HORTA), Tiziano Bettati (HORTA), Pier Luigi Meriggi (HORTA), Sandro Calmanti (ENEA), Massimiliano Pasqui (CNR). Invited users and stakeholders: Diego Scudellari (GRANDI COLTURE ITALIANE SCA), Enrico Bambi (ANB COOP), Daniele Govi (REGIONE EMILIA ROMAGNA), Carlo Maresca (MARESCA), Giovanni Maresca (MARESCA), Diego Marini (G.A.I.A Sociata Cooperativa), Oriana Porfiri (CGS SEMENTI SPA)

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