



**Project Acronym:** LIFE GAIA Sense  
**Grant Agreement number:** LIFE17 ENV/GR/000220  
**Project Title:** LIFE GAIA Sense: Innovative Smart Farming services supporting Circular Economy in Agriculture

## DELIVERABLE

### Final technical testing and user validation report

<b>Type of Document</b>	Deliverable
<b>Contractual date of delivery</b>	12/2020
<b>Deliverable Leader</b>	NP
<b>Status – version, date</b>	Updated version – v.1.0, 30/12/2021
<b>Action</b>	B3

<b>Project co-funded by the European Commission within the LIFE 2014-2020 programme</b>		
<b>Dissemination Level</b>		
<b>P</b>	<b>Public</b>	<b>X</b>
<b>C</b>	<b>Confidential, only for members of the consortium and the Commission Services</b>	

This deliverable was produced under the co-finance of the European financial instrument for the Environment (LIFE) programme during the implementation of the project "LIFE GAIA Sense" (LIFE17 ENV/GR/000220).

The information in this document reflects only the author's views and the European Commission is not liable for any use that may be made of the information contained therein.



## Executive Summary

This document presents the technical testing and validation of GAIA Sense solution both from a technical and user perspective. As it is documented in Deliverable “Revised Smart Farming Application”, two applications have been developed:

- The **“gaiasense web-based application”** that provides access to detailed current and historic environmental information of selected parcels (fields) along with scientific based indications on the associated hazards with regards to irrigation and pest management.
- The **“gaiasense mobile application”** tailored to the needs of users that are on the move while performing various tasks (e.g. farmers visiting different fields and applying various cultivation practices) hence only crucial information summaries are presented to small-mobile devices.

Both applications are based on the gaiasense (<http://www.gaiasense.gr/en>) - cloud based - information management system that provides to both the web-based and mobile applications, access to the necessary data in support of their overall functionality.

The main objective of the work presented in this document is to evaluate the overall performance of the developed solutions in operational conditions to identify the respective weaknesses and proceed with the necessary improvements. The conducted evaluation is twofold, the realisation of technical testing and validation of GAIA Sense solution but also the user validation with respect to the overall usefulness and usability of the framework.

Role	Name (Organisation)
<b>Deliverable Leader:</b>	Nikos Kalatzis (NP)
<b>Contributors:</b>	Vasilis Pyrgiotis (NP), Thanasis Manos(NP), Nikos Marianos (NP)
<b>Reviewers:</b>	F.Bampas AUTH
<b>Approved by:</b>	Vasilis Pyrgiotis (NP)

Version	Date	Contributor(s)	Description
0.1	10/10/2020	N. Kalatzis, V. Pyrgiotis,	Initial version
0.2-0.9	10/12/2020	N. Kalatzis, V. Pyrgiotis, N Marianos	Draft versions for review
0.10	15/12/2020	F.Bampas AUTH	Reviewed version
1.0	30/12/2020	N. Kalatzis	Final version
1.1	30/12/2021	N. Kalatzis, Vasilis Pyrgiotis	Document updated with performance evaluation results.

## Table of Contents

<b>Executive Summary</b> .....	<b>2</b>
<b>Table of Contents</b> .....	<b>4</b>
<b>1. Introduction</b> .....	<b>7</b>
1.1. Project Summary .....	7
1.2. Document Scope .....	7
1.3. Document Structure .....	8
<b>2. GAIA Sense smart farming applications performance evaluation</b> .....	<b>9</b>
2.1. Evaluation approach .....	9
2.2. Gaiasense web-based application performance.....	11
2.3. Gaiasense mobile application performance .....	12
<b>3. IoT stations performance evaluation</b> .....	<b>15</b>
<b>4. User Validation process</b> .....	<b>16</b>
4.1. User Validation results .....	17
4.1.1. Age, Gender, Education level, Profession, Farm focus .....	17
4.1.2. Farm area .....	20
4.1.3. Do you already use the any kind of digital technologies/solutions to your farm? .....	20
4.1.4. Usefulness of the Farmer's Assistant Application .....	21
4.1.5. Most important features that you find beneficial for your farm or company of this solution	22
4.1.6. Three least interesting features of the solution .....	23
4.1.7. Ease of use.....	24
4.1.8. The three most important reasons for using the solution .....	27
4.1.9. The three most important reasons for NOT using the solution:.....	28
4.1.10. Issues hinder the use of this solution in your farm .....	28
4.1.11. Are you willing to pay for utilising this smart-farming solution? .....	30
4.2. User access statistics.....	30
<b>5. Conclusions</b> .....	<b>32</b>
<b>6. References</b> .....	<b>33</b>
<b>7. Annex A</b> .....	<b>34</b>

## Table of Figures

Figure 1. Gaiasense Web-based application performance- rendering one year of environmental recordings.....	11
Figure 2. Gaiasense Web-based application performance- rendering one year of pest infestation predictions.....	11
Figure 3. Gaiasense mobile application performance- rendering one year of environmental recordings. ....	12
Figure 4. Gaiasense mobile application performance- rendering one year of pest infestation predictions and famers calendar entries.....	13
Figure 5. Gaiasense application performance- rendering one month of pest infestation predictions and famers calendar entries.....	13
Figure 6. Main Dashboard of the IoT monitoring service .....	15
Figure 7. Alerts and notifications about events on IoT stations. ....	15
Figure 8 Ages of participants.....	17
Figure 9 Gender of participants .....	18
Figure 10 Education Level of participants .....	18
Figure 11 Main profession of participants .....	19
Figure 12 Farm Focus of participants .....	19
Figure 13 Farm Area .....	20
Figure 14 Any kind of digital technologies/solutions the participants already use to their farm.....	21
Figure 15 Usefulness of the Farmer’s Assistant Application.....	22
Figure 16 The most important features that you find beneficial for your farm or company of mobile application.....	22
Figure 17 Three least interesting features of the solution on the mobile application .....	23
Figure 18 Ease of use of mobile application.....	25
Figure 19 Ease of use of Gaiasense web-based application.....	27
Figure 20 Issues hinder the use of this solution in your farm .....	29
Figure 21 Issues hinder the use of this solution in your farm from Gaiasense web-based application questionnaire .....	30
Figure 22. Total number of logins per month to Gaiasense web-based application .....	31
Figure 23. Total number of logins per month to Gaiasense mobile application.....	31

## List of Tables

Table 1. Performance of Gaiasense web-based application when retrieving and rendering 12 month measurements for one parcel.....	12
Table 2. Performance of Gaiasense mobile application when retrieving and rendering 12 month measurements for one parcel.....	14
Table 3 Overall results of any kind of digital technologies/solutions the participants already use to their farm.....	20
Table 4 Overall results of Usefulness of the Farmer’s Assistant Application.....	21
Table 5 Overall results of Ease to use of the mobile application.....	24
Table 6 Overall results of ease to use of Gaiasense web-based application.....	26
Table 7 Overall results of issues hinder the use of this solution in your farm from Farmer’s assistant application questionnaire.....	28
Table 8 Overall results of issues hinder the use of this solution in your farm from Dashboard questionnaire.....	29

## Definitions, Acronyms and Abbreviations

Acronym	Title
<b>AB</b>	Advisory Board
<b>ALs</b>	Action Leaders
<b>CE</b>	Circular Economy
<b>M2M</b>	Machine2Machine
<b>NP</b>	NEUROPUBLIC AE PLIROFORIKIS & EPIKOINONION
<b>SF</b>	Smart Farming
<b>KPI</b>	Key Performance Indicator
<b>SF</b>	Smart Farming
<b>API</b>	Application programming interface
<b>REST</b>	Representational State Transfer
<b>NDVI</b>	Normalized difference vegetation index
<b>JSON</b>	JavaScript Object Notation
<b>IoT</b>	Internet of Things
<b>iCM</b>	Crop management system

## 1. Introduction

### 1.1. Project Summary

The main objective of the LIFE GAIA Sense project is to demonstrate Gaiasense, an innovative “Smart Farming” (SF) solution that aims at reducing the consumption of natural resources, as a way to protect the environment and support Circular Economy (CE) models.

More specifically, this project will launch 18 demonstrators across Greece, Spain and Portugal covering 9 crops (olives, peaches, cotton, pistachio, potatoes, table tomatoes, industrial tomatoes, grapes, kiwi) in various terrain and microclimatic conditions. They will demonstrate an innovative method, based on high-end technology, which is suitable for being replicated and will be accessible and affordable to Farmers either as individuals or collectively through Agricultural Cooperatives.

Moreover, LIFE GAIA Sense aims to promote resource efficiency practices in SMEs of the agricultural sector and eventually, contribute to the implementation of the Roadmap to a Resource Efficient Europe. This project will demonstrate a method on how the farmer will be able to decide either to use or avoid inputs (irrigation, fertilizers, pesticides etc.) in a most efficient way, without risking the annual production. The focus is on the resource consumption reduction side of CE, and the results will be both qualitatively and quantitatively, considering the resources’ efficiency in agricultural sector.

### 1.2. Document Scope

This document presents the technical testing and the user evaluation results of the core ICT solutions that have been developed for the needs of the LIFE GAIA Sense project. In this context, the following two Smart Farming (SF) applications that have been developed are evaluated in terms of overall usability and performance:

- The **“gaiasense web-based application”** that provides access to detailed current and historic environmental information of selected parcels (fields) along with scientific based indications on the associated hazards with regards to irrigation and pest management.
- The **“gaiasense mobile application”** tailored to the needs of users that are on the move while performing various tasks (e.g. farmers visiting different fields and applying various cultivation practices) hence only crucial information summaries are presented to small-mobile devices.

Performance evaluation is realised with the use of standardised metrics when performing intensive actions on the applications and measuring the response time. Overall usability evaluation is realised with the use of questionnaires.

This document presents the IoT stations monitoring and testing framework along with an engineering portal that has been developed for rendering in real time the overall performance and health status of the deployed equipment.

The documented updated on December 2021 with additional data on user access statistics and more details on IoT station performance.



### 1.3. Document Structure

This document is comprised of the following chapters:

**Chapter 1** is the introductory section of this document.

**Chapter 2** presents the methodology and the performance evaluation results of the web and mobile applications.

**Chapter 3** presents the IoT stations performance evaluation.

**Chapter 4** presents User Validation outcomes.

**Chapter 5** presents the overall conclusions

## 2. GAIA Sense smart farming applications performance evaluation

This section briefly presents the two application that have been developed for the needs of the project. Detailed analysis on these applications are presented in deliverable [1] but for reasons of completeness of this document these descriptions are also presented hereafter.

The **gaiasense web-based application** is tailored to the needs of the agronomists/advisors and is accessible through resource rich devices (e.g. desktop and laptop personal computers). This web-based application provides access to current and historic environmental conditions on the targeted parcels (fields) along with scientific based indications on the associated hazards with regards to irrigation and pest management. The user will be able to be informed about the potential pest or insect infestations through the scientific models that are integrated. This helps the user to enhance and optimize the process of making timely decisions and precision applications in the crop. In addition, the user has a complete overview on the field activities during a growing season though the necessary intuitive visualisations about irrigation and plant protection works carried out, the phenological stages of the plants, and harvest related info.

The **gaiasense mobile application** is tailored to the needs of the farmers and is optimised for utilisation through mobile devices (e.g. smart-phones, tablets). This category of users is expected to be on the move while performing various tasks (e.g. visiting different farms and applying various cultivation practices).

The application is “parcel” oriented meaning that the central information entity that the application is designed upon is the field that the farmer is cultivating. The application visualises only the information necessary to the farmer avoiding complicated details about the underlying scientific models. The focus is on the simplified and user friendly representation of the respective outcomes. This implies that a relative minimalistic approach is followed, especially when compared with the information richness of the “gaiasense web-based application”.

Both applications followed an incremental development approach where initially a set of core functional services are provided that are constantly improved according to user recommendations and feedback. Improvements are expected to both user-experience aspects of the service but also on the advanced knowledge extraction elements of the provided services.

### 2.1. Evaluation approach

One of the most important metric of software applications is response time especially when resource intensive requests are performed. In order to evaluate the response times of the developed applications a methodology that has been introduced by Google was utilised. The “Network Analysis Reference”<sup>1</sup> guide describes all the necessary concepts that support the analysis of web application pages loading process along with instructions on how to exploit Chrome DevTools network analysis features. For each call to the two web application that correspond to specific user actions the respective “Waterfall output” is utilised (and presented hereafter) with indicative performance measurements. A short explanation of each of the phases that are presented in a “Waterfall output” follows:

---

<sup>1</sup> <https://developers.google.com/web/tools/chrome-devtools/network/reference#timing-explanation>



**Queueing.** The browser queues requests when:

There are higher priority requests.

There are already six TCP connections open for this origin, which is the limit.

The browser is briefly allocating space in the disk cache

**Stalled.** The request could be stalled for any of the reasons described in Queueing.

DNS Lookup. The browser is resolving the request's IP address.

Proxy negotiation. The browser is negotiating the request with a proxy server.

**Request sent.** The request is being sent.

ServiceWorker Preparation. The browser is starting up the service worker.

Request to ServiceWorker. The request is being sent to the service worker.

**Waiting (TTFB).** The browser is waiting for the first byte of a response. TTFB stands for Time To First

Byte. This timing includes 1 round trip of latency and the time the server took to prepare the response.

**Content Download.** The browser is receiving the response.

Receiving Push. The browser is receiving data for this response via HTTP/2 Server Push.

The most resource intensive process of both applications is the retrieval and visualisation of large amounts of data that correspond to a long time period of recordings. To this end, two main indicative benchmarking processes were applied:

- a) Retrieving a history log of **environmental measurements** and rendering them through a graph
- b) Retrieving a history log of **calculated pest infestation risk values** and rendering them through a graph

Each benchmarking process has been realised for two type of network connection, WIFI for the **gaiasense web-based application** on desktop devices and 3G for the **gaiasense mobile application** on mobile devices. Figures 1-5 present screenshots/results of the two applications when requesting recorded data for a time period of 12 months for one of the LIFE GAIA sense parcels.

## 2.2. Gaiasense web-based application performance

In figure 1 the user has requested to the “Gaiasense web-based application” the retrieval and creation of a graph containing the Temperature recordings for the time period February 2020- February 2021. The system replies with a total of about (one record for each day hour)\* (365 days)= 8760 records.

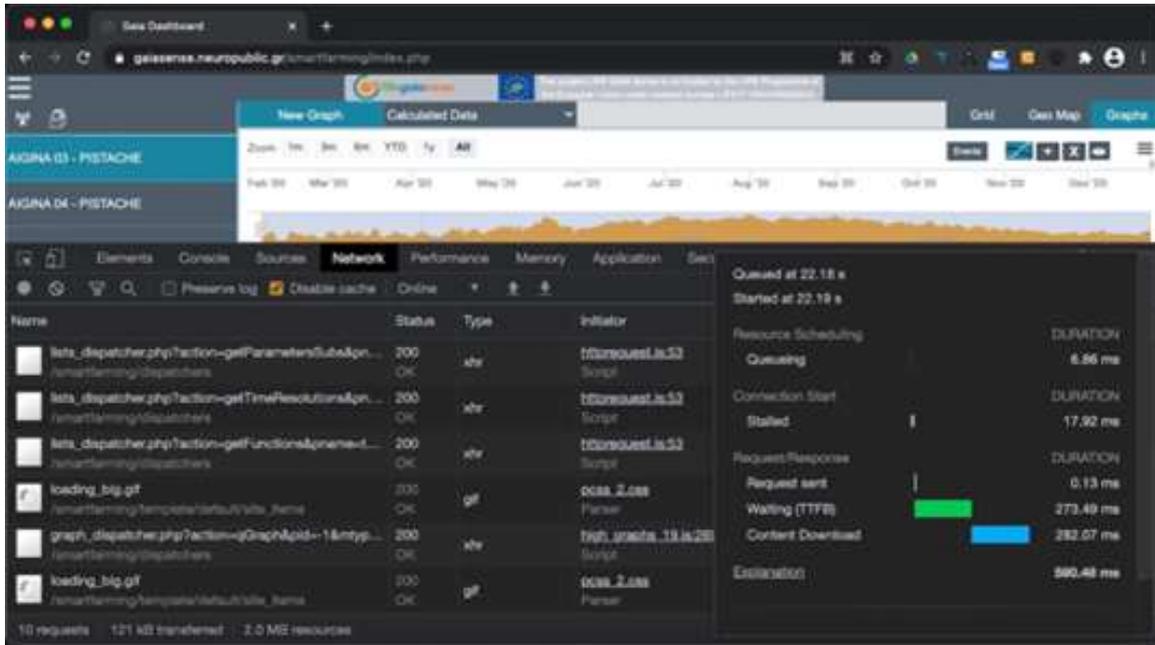


Figure 1. Gaiasense Web-based application performance- rendering one year of environmental recordings

In a similar manner figure 2 presents the calculated pest infestation risk index for the same time period and for the same parcels. It should be noted that at this graph are also rendered records of the farmer’s calendar e.g. growth stages, pesticides applications etc.

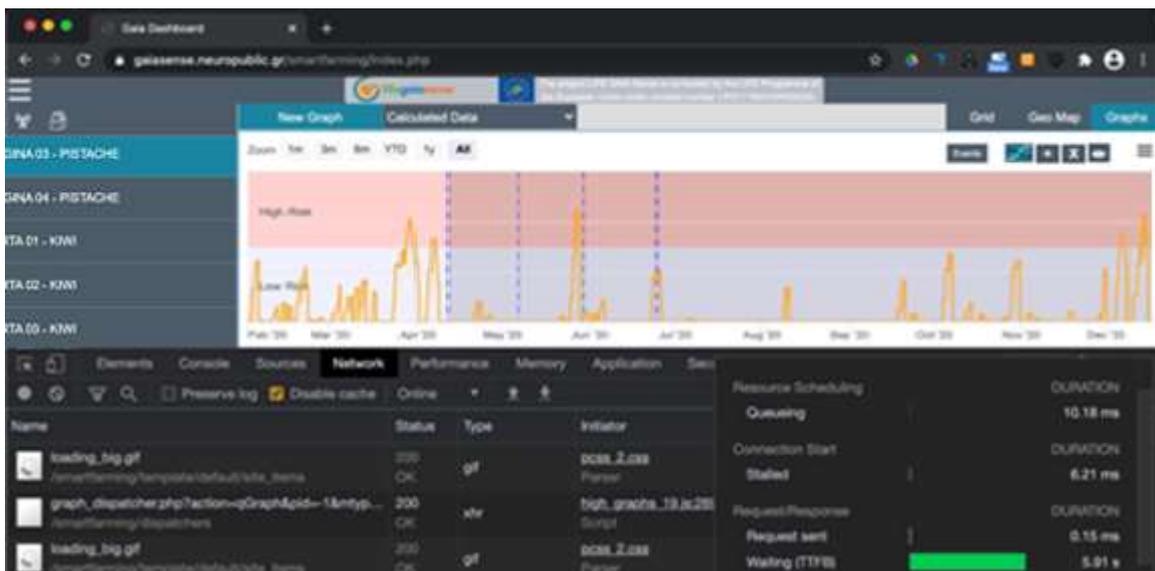


Figure 2. Gaiasense Web-based application performance- rendering one year of pest infestation predictions.

At the bottom of the previous graphs the “Chrome DevTools network analysis features” are visible where the overall time duration for the full cycle of the request is presented. The most important values that are also summarized in Table 2 are the “Request/Response” Duration which corresponds to the waiting from the time of the request until the rendering of the data.

Table 1. Performance of Gaiasense web-based application when retrieving and rendering 12 month measurements for one parcel.

WiFi connection	(Waiting - Downloading- Total)
History log of <b>environmental measurements</b>	273.49- 282.07 – 580.48 (msec)
History log of <b>calculated pest infestation risk</b>	5.91- 163.72- 6.09 (sec)

As it is evident, the total waiting time for simple environmental recordings is less than 0.6sec. The performance of the second example test is about 6sec. This increased time delay occurs mainly due to the fact that two different backend services are queried one for the IoT recordings and one for the farm calendar entries. However, this time duration corresponds to one year of data, which is a query that is not expected to be performed often. Obviously, requests for shorter time periods will be replied in even lower time frames.

### 2.3. Gaiasense mobile application performance

Similar tests have been performed for the gaiasense mobile application. The respective results are presented in figures 3-5.

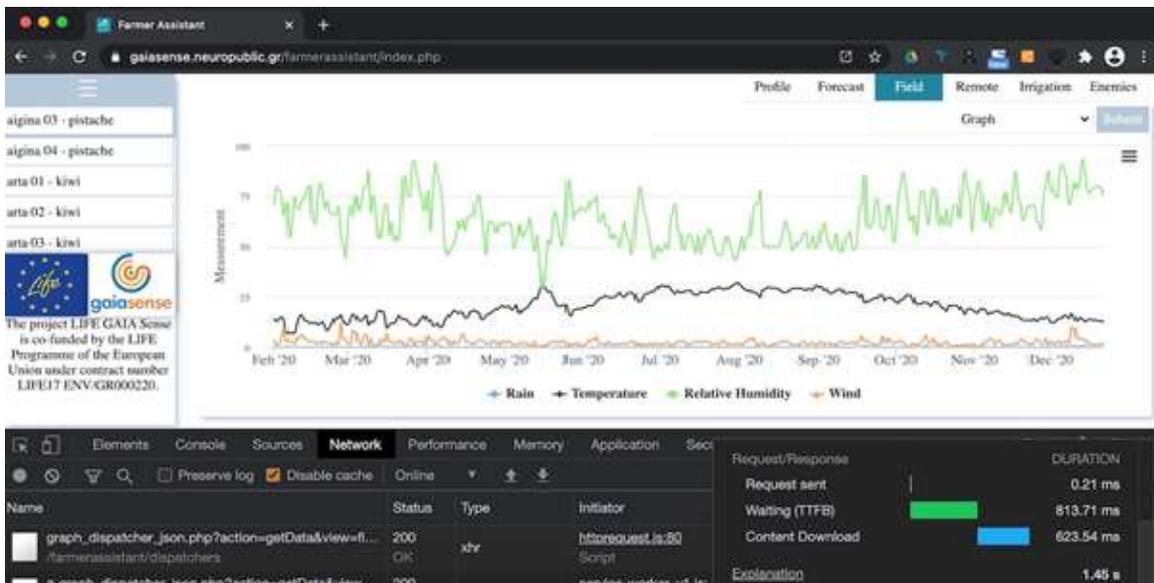


Figure 3. Gaiasense mobile application performance- rendering one year of environmental recordings.

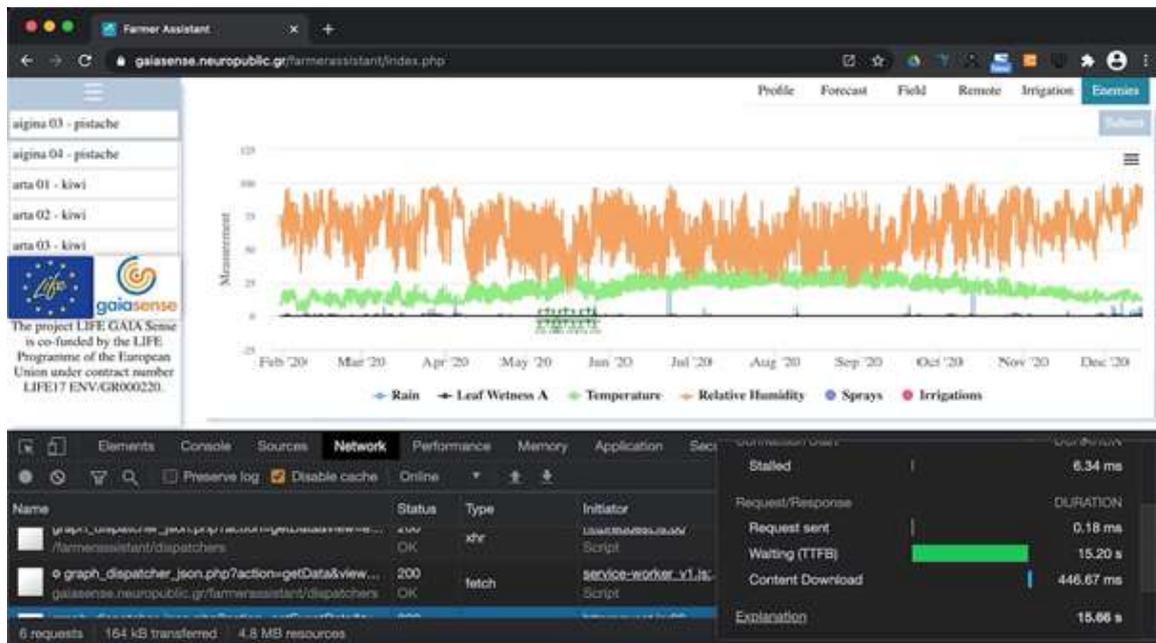


Figure 4. Gaiasense mobile application performance- rendering one year of pest infestation predictions and farmers calendar entries

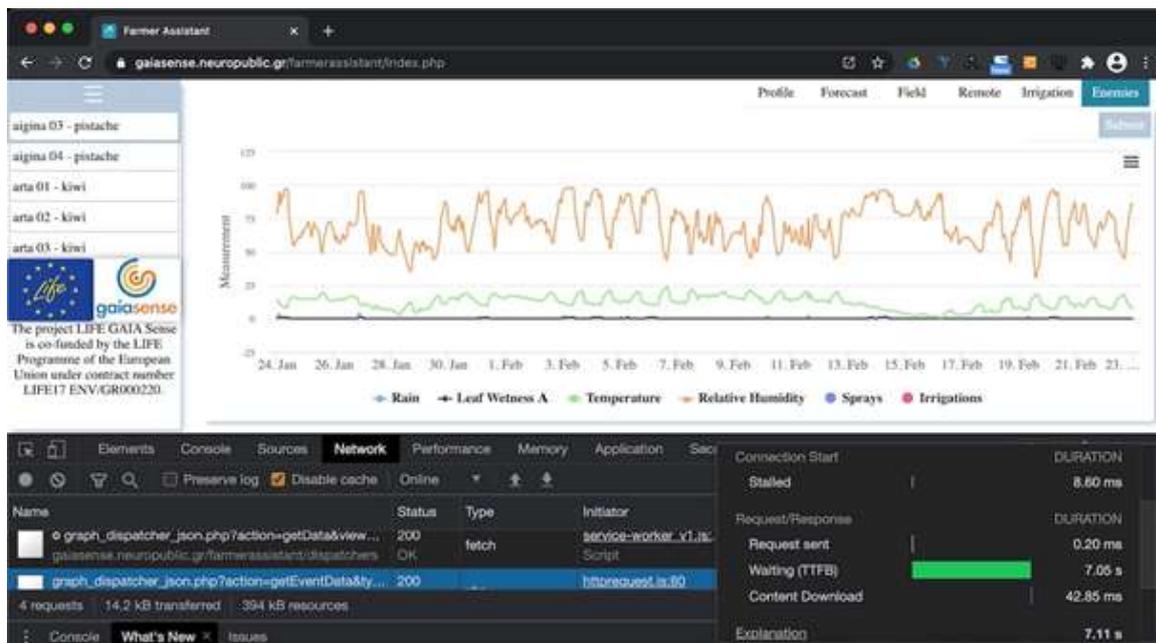


Figure 5. Gaiasense application performance- rendering one month of pest infestation predictions and farmers calendar entries

Similar with the previous set of results IoT related recordings are rendered in time duration of less than 1.5 seconds. With regards to pest infestation and farmers calendar entries the overall request-response-render time duration is significant higher and reaches even ~15sec for one year of recording. The increase time duration occurs because of the constraints of the mobile connection. However, retrieving one year of data is not a query that the user is expected to perform often through a mobile device. The preset-default time window for retrieving the pest infestation records is set to one week.

Table 2. Performance of Gaiasense mobile application when retrieving and rendering 12 month measurements for one parcel.

3G connection	(Waiting - Downloading- Total)
History log of <b>environmental measurements</b>	813.71 – 623.54 - 1450 (msec)
History log of <b>calculated pest infestation risk</b>	15.2 – 0.446 - 15.66 (sec)

### 3. IoT stations performance evaluation

In order to evaluate the overall performance and health status of the IoT stations deployed at the pilot fields a set of monitoring mechanisms have been developed and an engineering portal is utilized for the rendering of the results. As it is illustrated in figure 6 system administrators of the gaisense smart farming solution are able to have an overview of the data send and received by the IoT stations, to check the status of the stations (online, offline, last reset), and to check the status of the various sensors that are attached to each station.

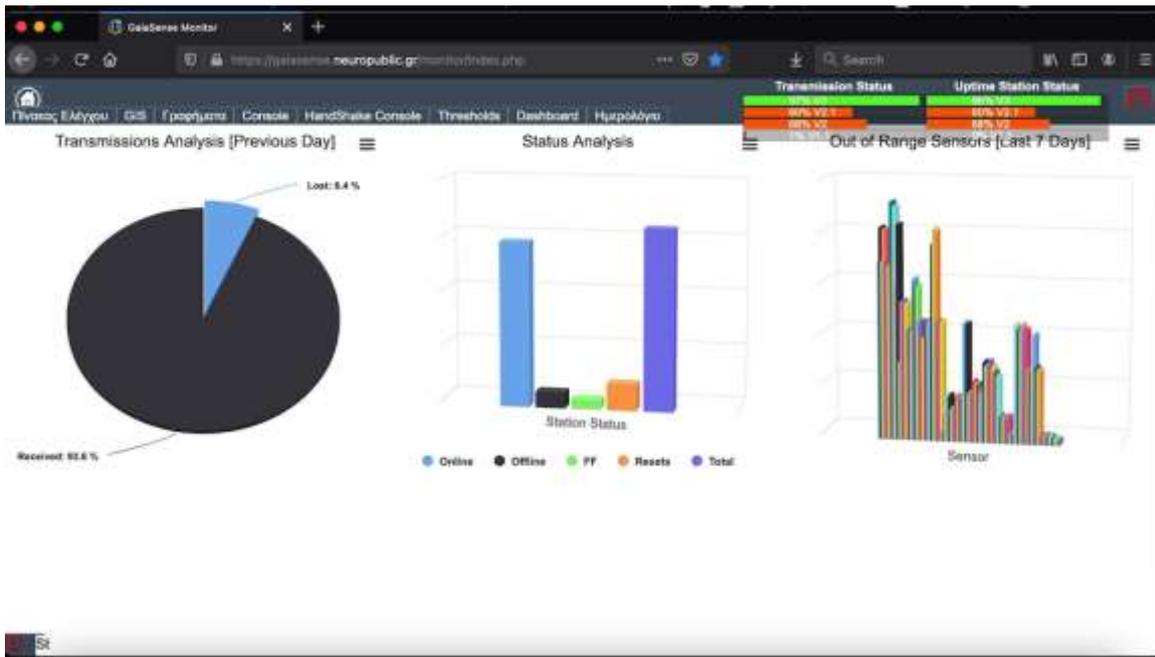


Figure 6. Main Dashboard of the IoT monitoring service

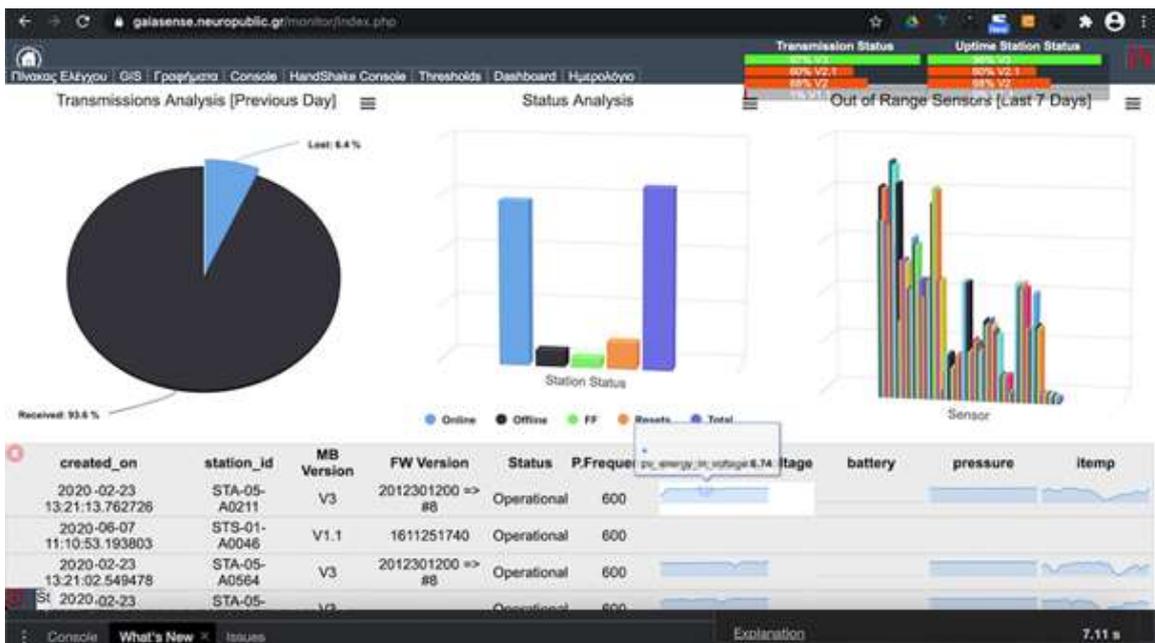


Figure 7. Alerts and notifications about events on IoT stations.

“Consider the environment before print”



In addition, an alerting system provides notifications on certain critical events related with the health of each IoT station (Figure 7) while preconfigure daily reports are send to through email. The engineering portal also supports the remote execution and monitoring of various actions on the IoT stations including the run of diagnostic procedures.

Besides the extended logging of the stations performance various additional mechanisms have been implemented in order to ensure the uninterrupted collection of sensed data.

In order not to lose any recordings when connectivity of the station with the back-end cloud data repository fails, data are stored locally and retransmitted in bulk when connection is restored. Data sanitization mechanism operating at the cloud ensure that missing data are correctly integrated on the main repository.

In case of a major failure of a specific IoT station additional mechanisms are activated in order to perform data collection from nearby stations. Triangulation methods are utilized in order to automatically identify and select the most appropriate IoT station and integrate the respective recordings.

#### 4. User Validation process

The evaluation of the developed applications from the user perspective was realized with the use of questionnaires. A total of number of 18 questionnaires were completed by the various end-users, although some of them were not completed by a single person, but reflect the collective responses of the whole team. From the total number of questionnaires 9 refer to the **gaiasense mobile application** and 9 refer to the **gaiasense web-based application**.

The questions mainly targeted to get partners feedback with regards to their overall -until today- experience with the gaiasense approach and more particularly about the installed IoT technologies and the developed LIFE GAIA Sense user interfaces for accessing the related information. The feedback was analysed in order to proceed with any appropriate improvements needed. The feedback from the various teams was mainly related with issues like the look and feel of the interface, the information items that are presented, the loading times of different pages, etc.

The user validation process took place during the growing seasons of 2020. During this period, the end-users tested the **Life Gaia** applications in real conditions and then they completed the questionnaires. A sample email follows, while the full survey is presented at the Annex of this document:

***“Dear Life Gaia sense partner,***

*This survey is a tool to support you increase user acceptance of smart-farming products and solutions. The survey offers a chance to receive feedback from the smart-farming solutions users itself and allows to identify acceptance problems during the development cycle. The results of the test can be used to adjust the product according to the users’ needs.*

*In order to have a better experience with this mobile application follow these steps:*

- 1. On your mobile device use a well-established browser (e.g. Chrome) and access the link <https://gaiasense.neuropublic.gr/smartfarming/views/login.php>*
- 2. Login with your credentials (username-password)*

*“Consider the environment before print”*

3. Click on browser's configuration parameters. In Chrome this option is available at the top of the page, beside the address bar.
4. Select the option "Install application". When this process finishes successfully, on the mobile's desktop the "Farmer's Assistant" icon will be visible.
5. Close the Internet Browser. From now on you can access the application through this icon.



We kindly ask you to fill-in this survey. The survey contains mainly multiple choice questions and takes approximately 5 minutes to complete. If you feel that a question is not applicable to you, feel free to skip it.

Thank you for your efforts and for sharing your opinion!"

## 4.1. User Validation results

The following sections presents an analysis of the collected answers

### 4.1.1. Age, Gender, Education level, Profession, Farm focus

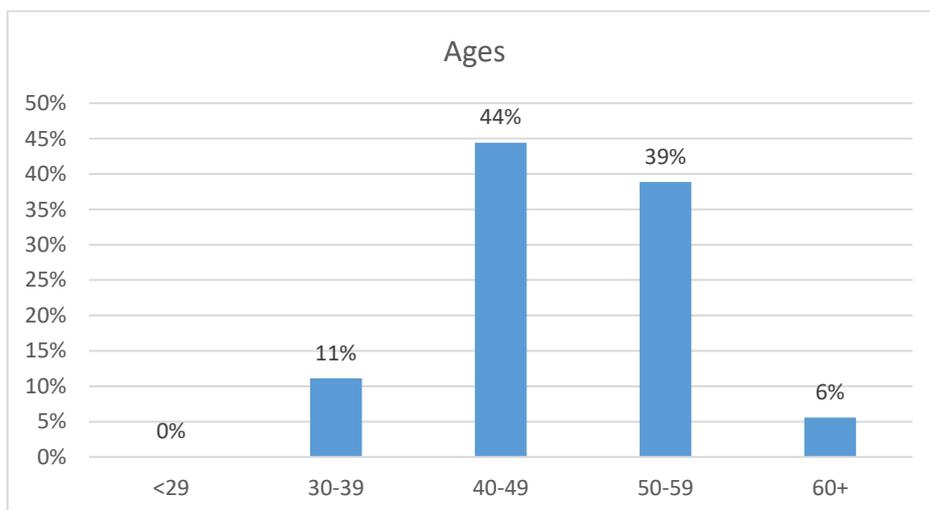


Figure 8 Ages of participants

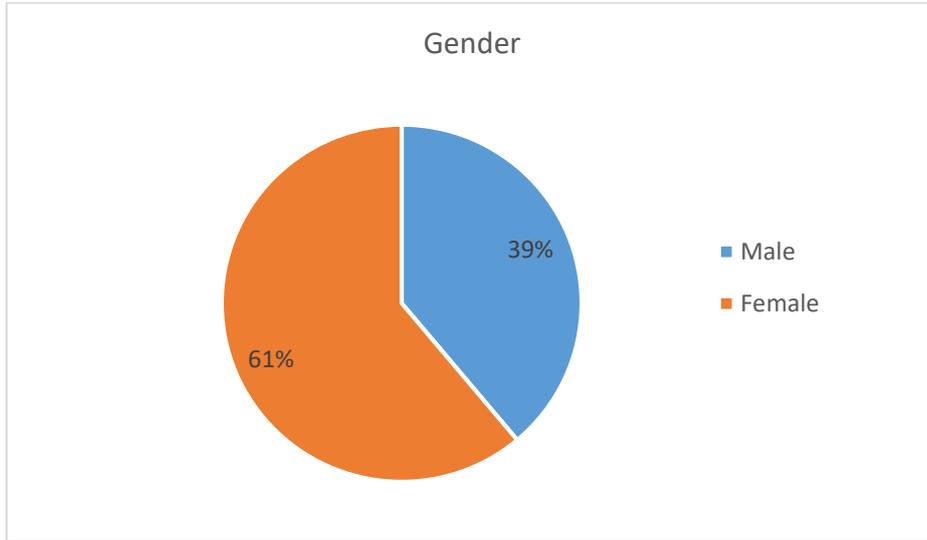


Figure 9 Gender of participants

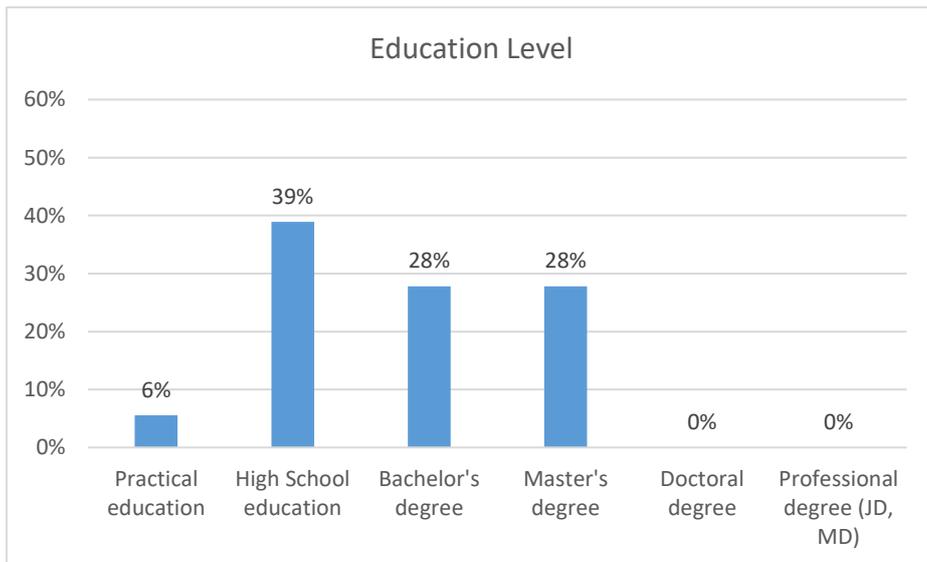


Figure 10 Education Level of participants

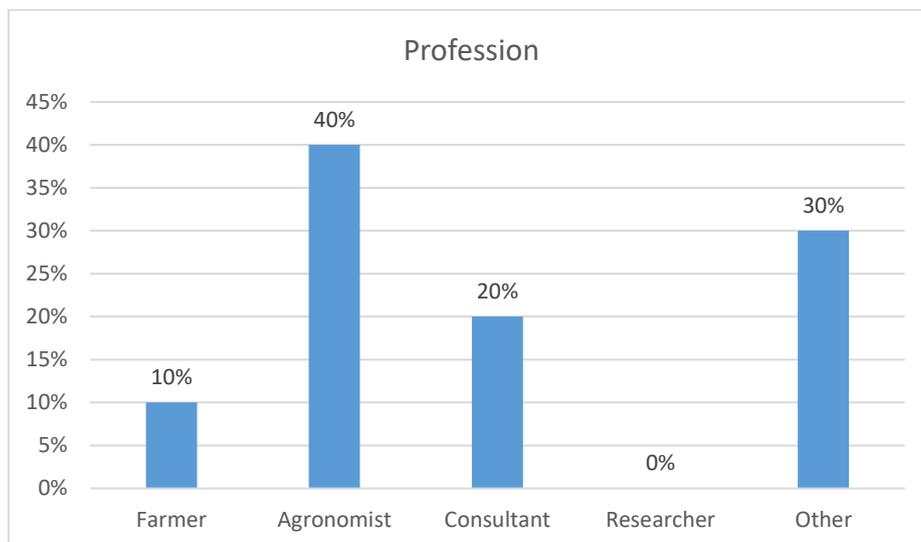


Figure 11 Main profession of participants

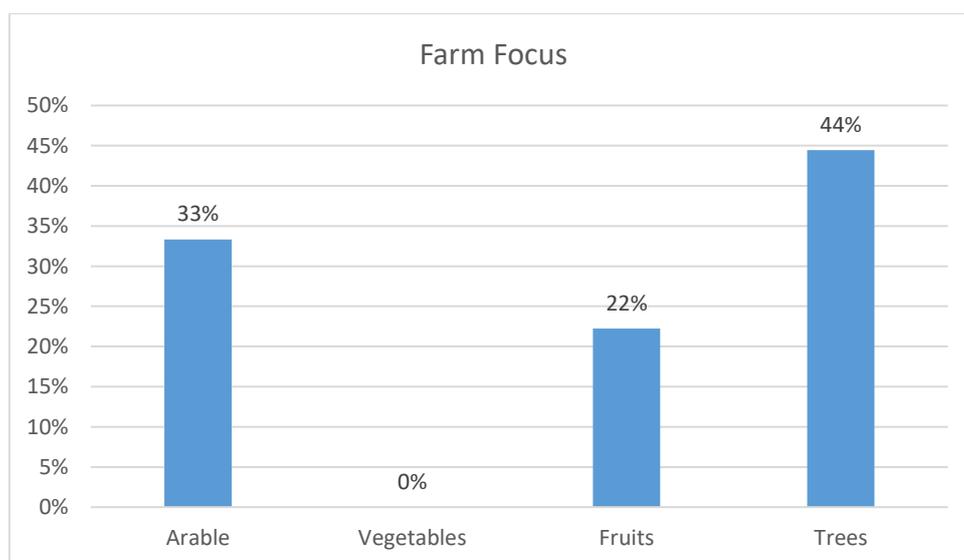


Figure 12 Farm Focus of participants

#### 4.1.2. Farm area

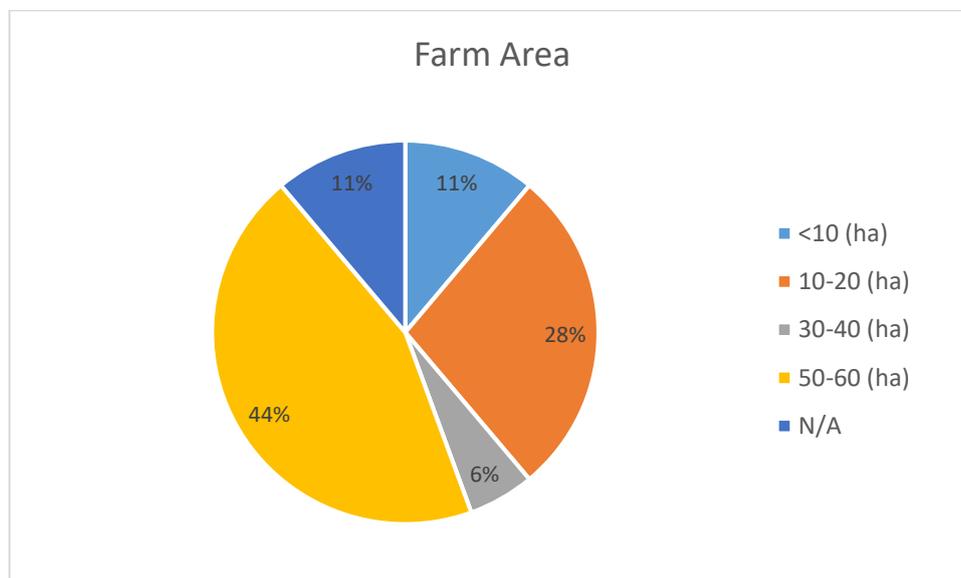


Figure 13 Farm Area

#### 4.1.3. Do you already use the any kind of digital technologies/solutions to your farm?

Table 3 Overall results of any kind of digital technologies/solutions the participants already use to their farm.

Do you already use the any kind of digital technologies/solutions to your farm?	
Yes, already applied in my farm	11
We plan to apply within a year	0
We are interested, but have no specific plans	4
No, but maybe later	0
Not at all	2

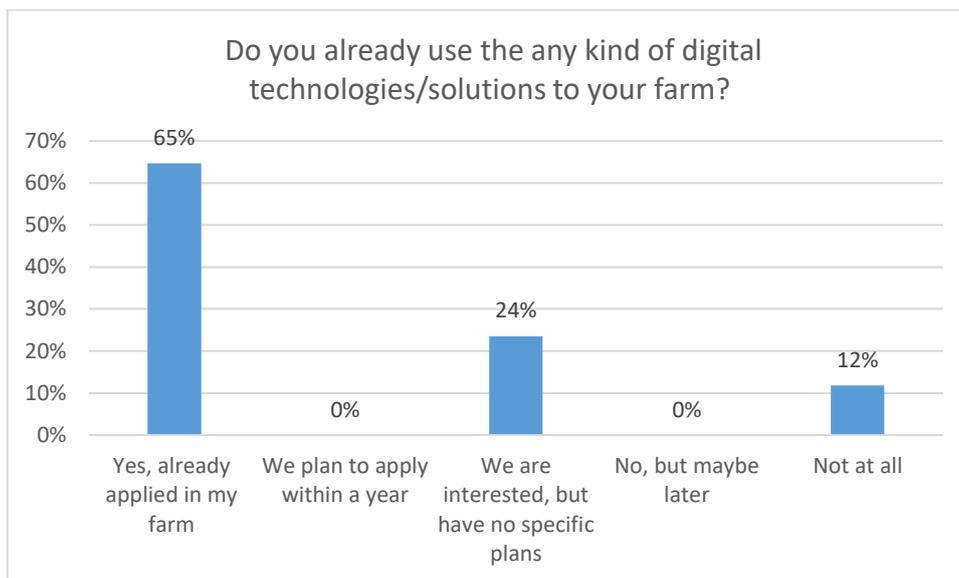


Figure 14 Any kind of digital technologies/solutions the participants already use to their farm

#### 4.1.4. Usefulness of the Farmer’s Assistant Application

Table 4 Overall results of Usefulness of the Farmer’s Assistant Application

Usefulness of the Farmer’s Assistant Application						
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	N/A
The additional benefit of the solution for the farm is clear.	10	8				
I believe that this solution reduces working time.	10	4	4			
This solution clearly supports more accurate decision making.	13	5				
I believe applying this smart farming solution contributes to realizing societal goals, such as making farming more environmentally friendly.	13	5				
I think that this smart farming solution offers me more benefits than current practice.	12	5	1			

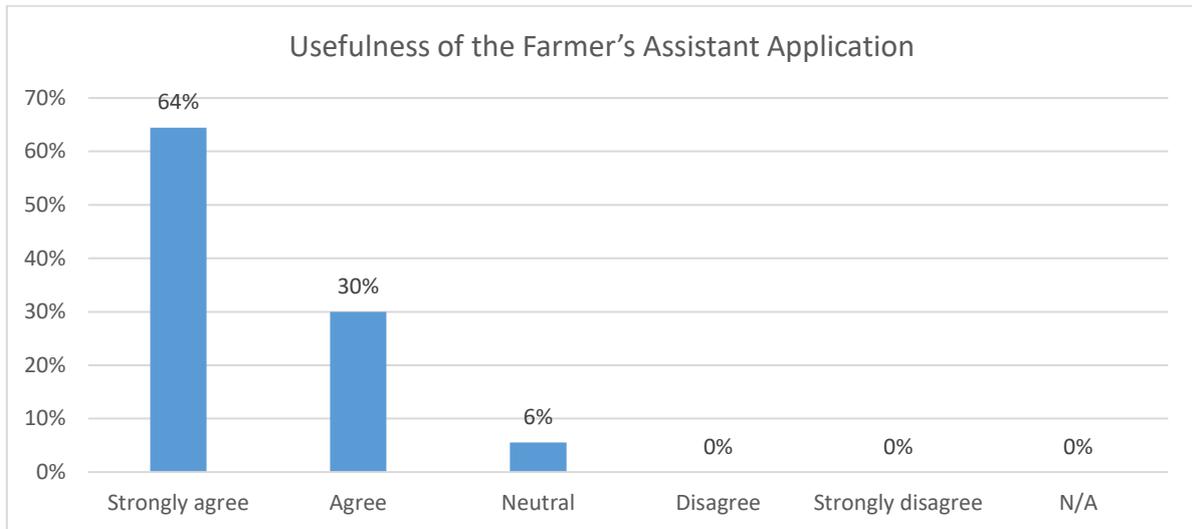


Figure 15 Usefulness of the Farmer's Assistant Application

**4.1.5. Most important features that you find beneficial for your farm or company of this solution**

This question is different when referring to the two application. The “Gaiasense mobile application” has predefined pages so users where asked to answer which of them are more useful. The results are presented here after (4.1.5.1).

**4.1.5.1. Gaiasense mobile application**

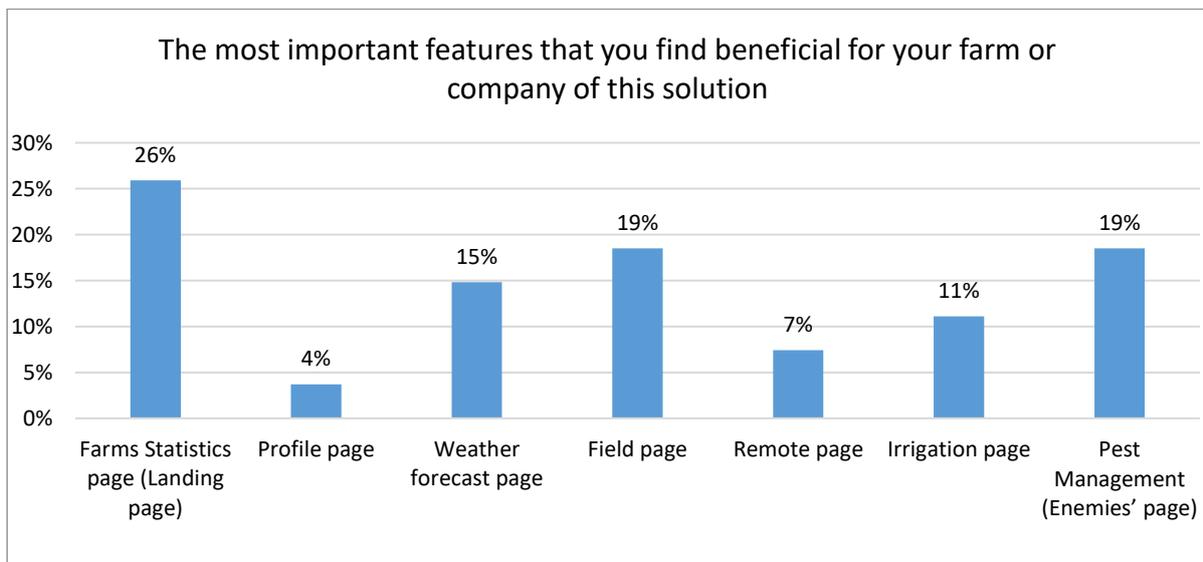


Figure 16 The most important features that you find beneficial for your farm or company of mobile application

#### 4.1.5.2. Gaiasense web-based application

The answers regarding the usefulness of the “Gaiasense web-based application” are based on free text descriptions which are presented below:

- The most important features that dashboard bring to me as agronomist and responsible of 50 ha. of own vineyards, and also near 400 ha. to advice, are:
  - Real information at real time of weather conditions. This is a key tool at this area because of strong and permanent positive conditions to suffer fungi diseases on vineyards.
  - Real information about climate conditions, very useful to understand after the harvest how the year was going and see in which areas we can improve. For example, the high temperatures we suffered 10 days before harvest with no leaf humidity and no temperature contrast between night and day were the main responsible of perhaps a loss of 7 – 12 % of grape weight.
  - Be used to have this tool to be in contact with new technologies and also incorporating them to the daily routine, being agriculture a very traditional sector with a strong inertia to changes.
- Temperature (7 answers)
- Rainfall (7 answers)
- Soil Moisture (4 answers)
- Relative Humidity(3 answers)
- Solar radiation (2 answers)
- Leaves Humidity (2 answers)

#### 4.1.6. Three least interesting features of the solution

##### 4.1.6.1. Gaiasense mobile application

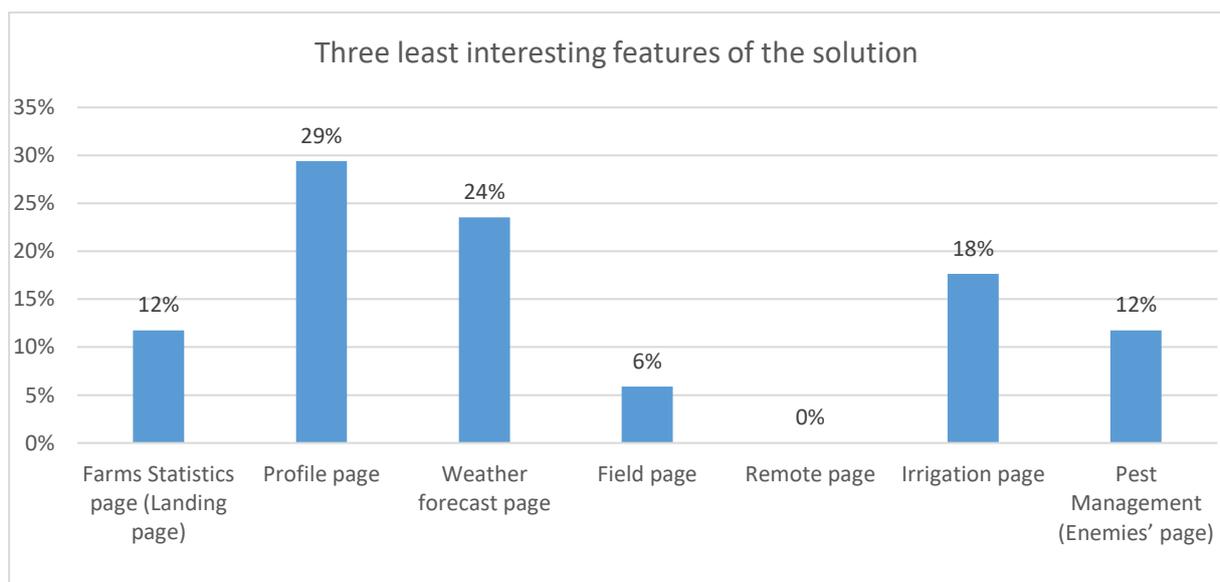


Figure 17 Three least interesting features of the solution on the mobile application

#### 4.1.6.2. Gaiasense web-based application

The results of the dashboard questionnaire are presented below,

- “The ability to have the information of the dash like temperatures, humidity, soil humidity, leaf temperature...  
 Also, the graphs, very useful and visual, For example, these days we have suffered very low temperatures that don’t affect the vines, but very illustrative to see all the period with temperatures below 0 ° C we had.”
- Leaves Humidity (4 answers)
- Solar Radiation (3 answers)
- Air pressure (3 answers)
- Soil Salinity, Electrical conductivity

#### 4.1.7. Ease of use

##### 4.1.7.1. Gaiasense mobile application

*Table 5 Overall results of Ease to use of the mobile application*

Ease of use						
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Not applicable
The smart-farming solution was easy to access.	5	1				
The design of the solution is easy to understand.	1	4	4			
The workflow of the solution is logically and delivers the result with few clicks.	1	7	1			
Accessing the solution on my mobile device works properly.	2	6			1	



The use of the product/solution of our use case needs special (ICT) expertise.		3	4	2		
The solution of our use case was easy to use and understand by all persons working with it.	1	6	2			
If not, which features where complex for your personnel to understand (open question).	"Not been able to install the app at mobile or tablet following the instructions."					
Waiting time for rendering the retrieved data is acceptable	3	5				1

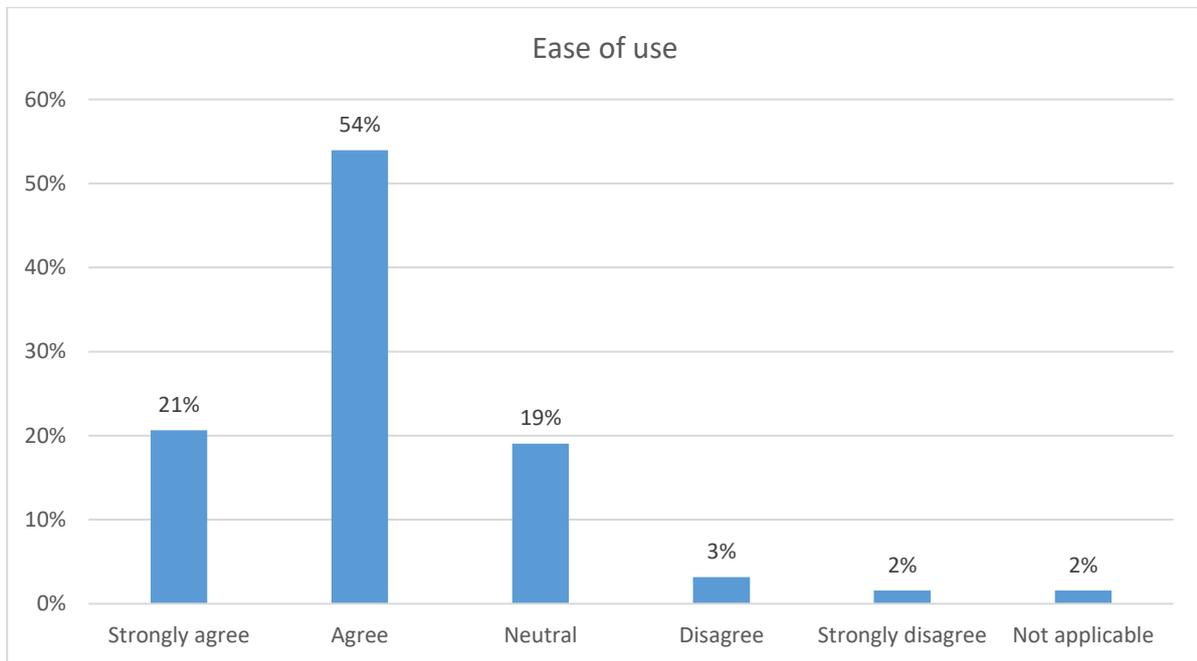


Figure 18 Ease of use of mobile application

#### 4.1.7.2. Gaiasense web-based application

Table 6 Overall results of ease to use of Gaiasense web-based application

Ease of use						
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Not applicable
The smart-farming solution was easy to access.	5	3	1			
The design of the solution is easy to understand.	3	5	1			
The workflow of the solution is logically and delivers the result with few clicks.	4	5				
The use of the product/solution of our use case needs special (ICT) expertise.	3	2	3	1		
The solution of our use case was easy to use and understand by all persons working with it.	3	4	2			
If not, which features were complex for your personnel to understand (open question).						
Waiting time for rendering the retrieved data is acceptable	6	3				

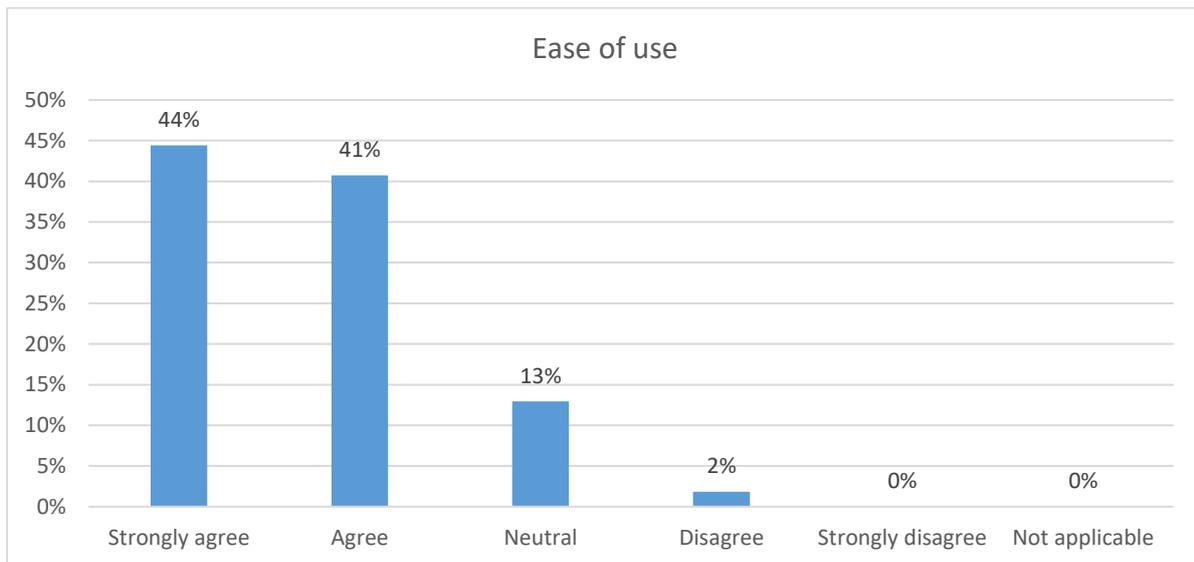


Figure 19 Ease of use of Gaiasense web-based application

#### 4.1.8. The three most important reasons for using the solution

- “The ability to have the information of the dash like temperatures, humidity, soil humidity, leaf temperature...”
- “Also, the graphs, very useful and visual, for example, these days we have suffered very low temperatures that don’t affect the vines, but very illustrative to see all the period with temperatures below 0 ° C we had.”
- “Also interesting the terms about irrigation; in terms of diseases, it has less interest for us, we have to be present at the vineyards to see if there are symptoms on leaves or fruits or other parts.”
- “It is a very nice tool to achieve smart farming and rational use of all items and issues to provide safe and natural products, because it brings us the data we need to avoid unnecessary chemical treatments or not useful agricultural practices.”
- “Also help us to develop and justify all the practices we have done during the year in order to accomplish the specific legislation.
- “As we are involved as part of LIFE GAIA SENSE Project, and also very commitment with smart farming and rational use of all items and issues to provide safe and natural products, this tool brings us the data we need to avoid unnecessary chemical treatments or not useful agricultural practices
- “Reduction of production costs.”
- “Targeted cultivation practices resulting in environmentally friendly farming”
- “Timely and accurate information on the state of the crop.”
- “Link data to development models and provide advice to farmers.”
- “Easy and overall reflect of the entire growing period”
- “Easy access to crop calendar”
- “Avoid unnecessary cultivation practices e.g. irrigations, pesticides”
- “Possibility to provide information and advices to the farmer”
- “Sufficient information on the conditions prevailing in the field”

#### 4.1.9. The three most important reasons for NOT using the solution:

- “Farmers are not familiar with digital technologies.”
- “Lack of technological tools (e.g. smartphones)”
- “The high annual subscription cost”
- “The solution may be a little bit difficult to use if you are not used to work with digital technologies; it also requires a good formation to extract all the potential information that bring you. And also it is a little bit difficult to use, in my own experience, in certain periods of the year that you are very focused on harvest time or pruning.”
- “Absence of Wi-Fi”
- “Difficulty in understanding of terminologies.”
- “There is no fertilization as an option & the simultaneous selection of fields”

#### 4.1.10. Issues hinder the use of this solution in your farm

##### 4.1.10.1. Gaiasense mobile application

Table 7 Overall results of issues hinder the use of this solution in your farm from Farmer’s assistant application questionnaire

Which of the following issues hinder the use of this solution in your farm?	
Absence of Wi-Fi	7
Absence of internet connection at all	4
Connection is at very low speed	3
Difficult to find suitable mobile connectivity provider	0
No access to mobile coverage	1
The smart farming solution is not secure	1
Other, please specify	0

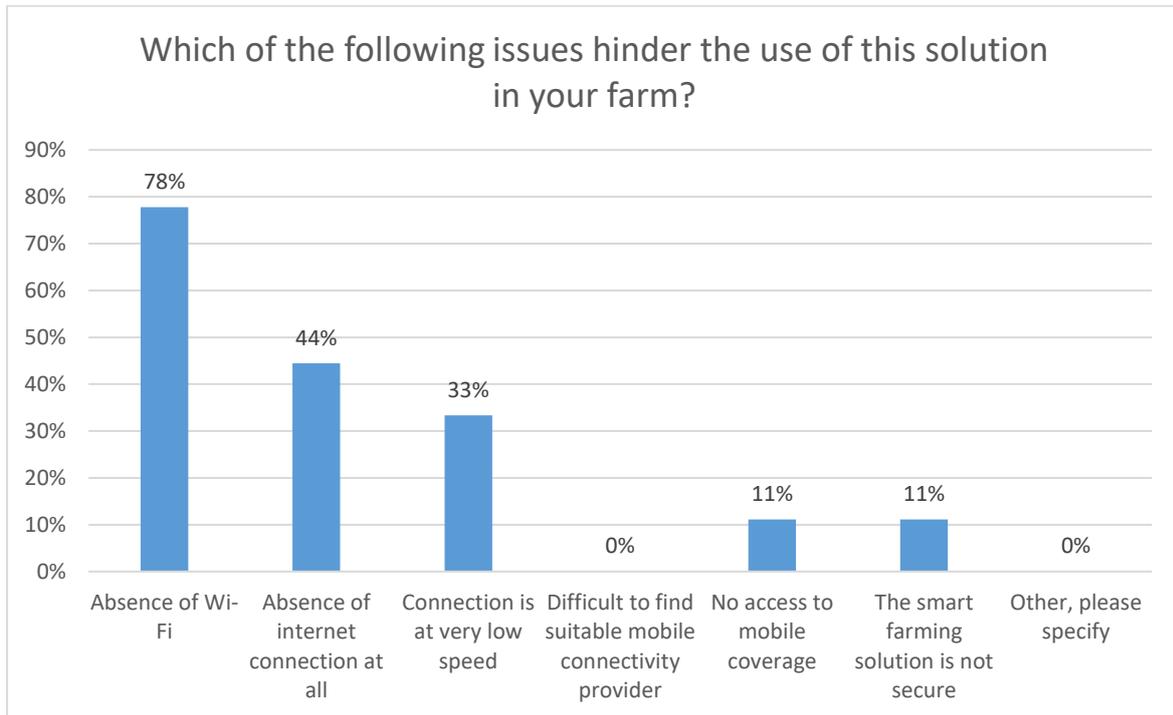


Figure 20 Issues hinder the use of this solution in your farm

#### 4.1.10.2. Gaiasense web-based application

Table 8 Overall results of issues hinder the use of this solution in your farm from Dashboard questionnaire

Which of the following issues hinder the use of this solution in your farm?	
Absence of Wi-Fi	5
Absence of internet connection at all	6
Connection is at very low speed	4
The smart farming solution is not secure	1
Other, please specify	0

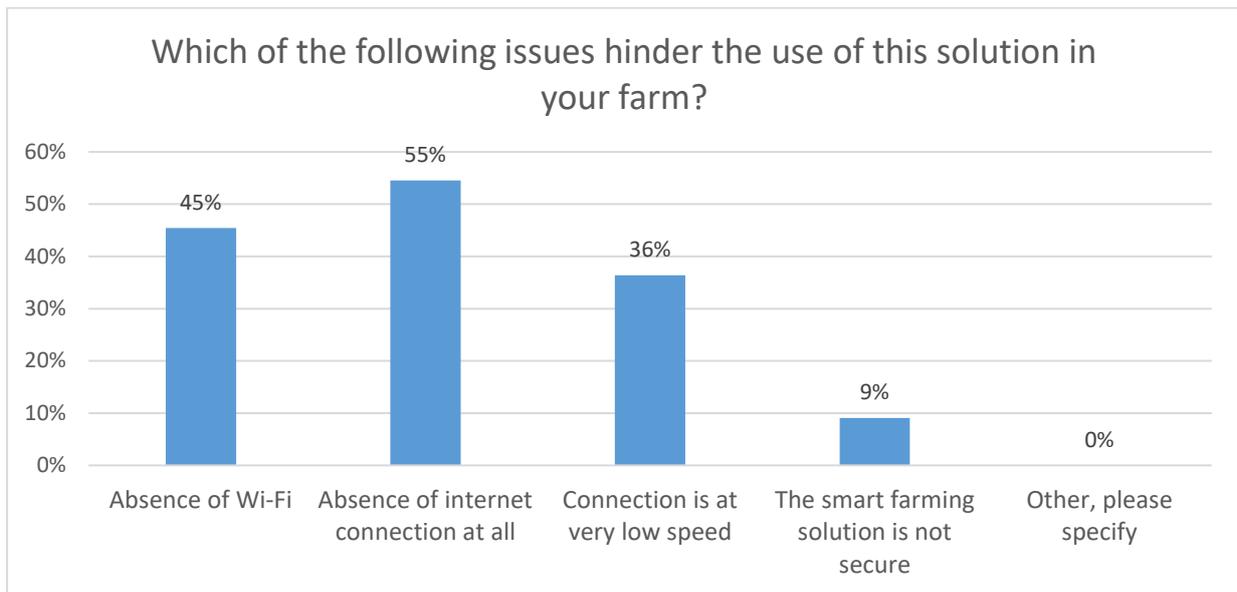


Figure 21 Issues hinder the use of this solution in your farm from Gaiasense web-based application questionnaire

**4.1.11. Are you willing to pay for utilising this smart-farming solution?**

The majority of participants declare that they are willing to pay for utilizing this smart - farming solution.

- “For sure. Once you have experience, and when it is part of your daily tools, it is a payless value to help to make the right decisions, for example at our area with so many fungi diseases with so much yield loss.”
- “Yes, although this was also linked to a responsible agronomist who would improve the data and would also have a physical presence on field.”
- “Yes, if farming was the main occupation.”
- “Yes, within a reasonable price framework and at the same time providing updates”
- “Yes, under conditions and with some improvements”

**4.2. User access statistics**

Overall there have been created accounts for 34 unique users for the Gaiasense web based dashboard and 26 accounts for the Gaiasense mobile application by 26 unique users. Figures 22 and 23 present the total number of logins performed to each application per month and per year from these accounts. The numbers in figures are not reflecting unique visitors but the total number of logins meaning that the user might have performed several logins per month while some other user may have performed only some visit. As it was expected there is more traffic during the Spring until Autumn period where the various cultivations are active. In addition, more users utilized the Web-based dashboard which was developed to mainly support the agricultural advisors.

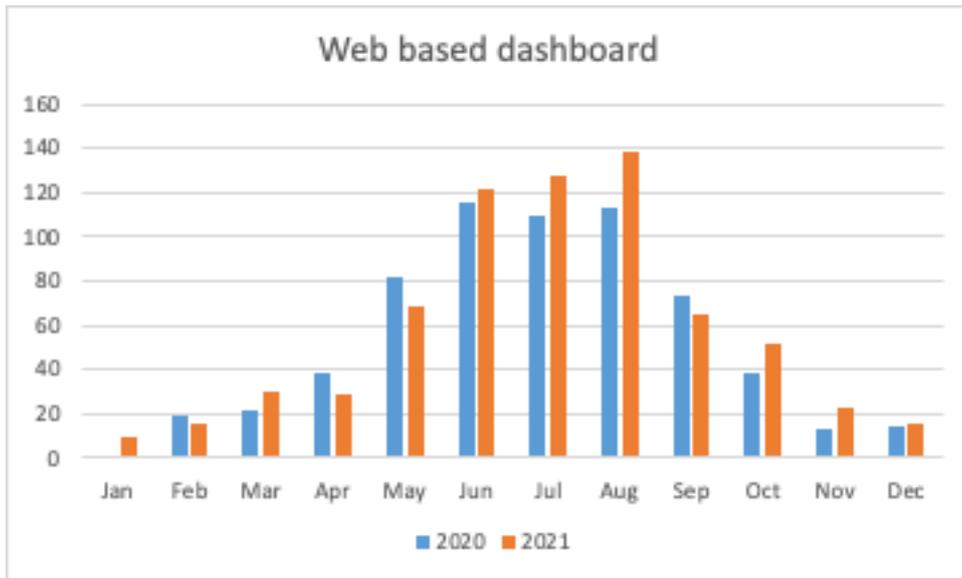


Figure 22. Total number of logins per month to Gaiasense web-based application

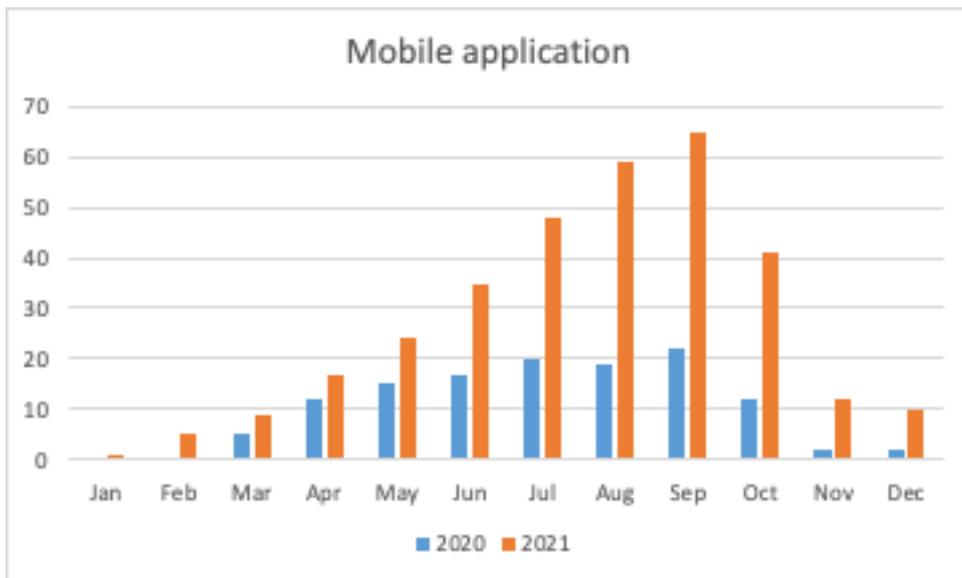


Figure 23. Total number of logins per month to Gaiasense mobile application



## 5. Conclusions

The main objective of the work presented in this document is to evaluate the overall performance of the developed solutions in operational conditions, to identify the respective weaknesses and proceed with the necessary improvements. The conducted evaluation is twofold, the realisation of technical testing and validation of GAIA Sense solution but also the user validation with respect to the overall usefulness and usability of the framework. Feedback from the users will be utilized by the development team in order to further improve and optimize the usability of the applications. Overall user responses are satisfactory especially with regards to the “ease of use” and “overall usefulness” which were among of the core objectives of the LIFE Gaia Sense project.



## 6. References

- [1] Deliverable: Revised Smart Farming Application, LIFE GAIA Sense project, 31/12/2019
- [2] Pautasso, Cesare; Wilde, Erik; Alarcon, Rosa (2014), REST: Advanced Research Topics and Practical Applications, Springer, ISBN 9781461492986
- [3] Clarke, Steven (2004). "Measuring API Usability". Dr. Dobb's. Retrieved 29 July 2016.

## 7. Annex A



"Innovative Smart Farming Services  
Supporting Circular Economy in Agriculture"  
LIFE17 ENV/GR/220  
<http://lifegaia sense.eu/>



### LIFE GAIA Sense Questionnaire

Farmer's Assistant Application v2.

#### Dear Life Gaia sense partner,

This survey is a tool to support you increase user acceptance of smart-farming products and solutions. The survey offers a chance to receive feedback from the smart-farming solutions users itself and allows to identify acceptance problems during the development cycle. The results of the test can be used to adjust the product according to the users' needs.

In order to have a better experience with this mobile application follow these steps:

1. On your mobile device use a well-established browser (e.g. Chrome) and access the link <https://gaisense.neuropublic.gr/smartfarming/views/login.php>
2. Login with your credentials (username-password)
3. Click on browser's configuration parameters. In Chrome this option is available at the top of the page, beside the address bar.
4. Select the option "Install application". When this process finishes successfully, on the mobile's desktop the "Farmer's Assistant" icon will be visible.
5. Close the Internet Browser. From now on you can access the application through this icon.



We kindly ask you to fill-in this survey. The survey contains mainly multiple choice questions and takes approximately 5 minutes to complete. If you feel that a question is not applicable to you, feel free to skip it.

Thank you for your efforts and for sharing your opinion!

The project LIFE GAIA Sense is co-funded by the LIFE Programme of the European Union under contract number LIFE17 ENV/GR000220

"Consider the environment before print"



"Innovative Smart Farming Services  
Supporting Circular Economy in Agriculture"  
LIFE17 ENV/GR/220  
<http://lifegaiasense.eu/>



## QUESTIONNAIRE

1. Age				
<29	30-39	40-49	50-59	60+

2. Gender	
Male	
Female	

3. Education level	
Practical education	
High School education	
Bachelor's degree	
Master's degree	
Doctoral degree	
Professional degree (JD, MD)	

4. Profession	
Farmer	
Agronomist	
Consultant	
Researcher	
Other	

The project LIFE GAIA Sense is co-funded by the LIFE Programme of the European Union under contract number LIFE17 ENV/GR000220

"Consider the environment before print"



"Innovative Smart Farming Services  
Supporting Circular Economy in Agriculture"  
LIFE17 ENV/GR/220  
<http://lifegaia sense.eu/>



5. Farm focus :	
<input type="checkbox"/>	Arable
<input type="checkbox"/>	Vegetables
<input type="checkbox"/>	Fruits
<input type="checkbox"/>	Trees

6. Farm area (ha)	
<input type="text"/>	

7. Do you already use the any kind of digital technologies/solutions to your farm?	
<input type="checkbox"/>	Yes, already applied in my farm
<input type="checkbox"/>	We plan to apply within a year
<input type="checkbox"/>	We are interested, but have no specific plans
<input type="checkbox"/>	No, but maybe later
<input type="checkbox"/>	Not at all



"Innovative Smart Farming Services  
 Supporting Circular Economy in Agriculture"  
 LIFE17 ENV/GR/220  
<http://lifegaiasense.eu/>



8. Usefulness of the Farmer's Assistant Application						
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	N/A
The additional benefit of the solution for the farm is clear.						
I believe that this solution reduces working time.						
This solution clearly supports more accurate decision making.						
I believe applying this smart farming solution contributes to realizing societal goals, such as making farming more environmentally friendly.						
I think that this smart farming solution offers me more benefits than current practice.						

9. Please select the three most important features that you find beneficial for your farm or company of this solution, if there are any:	
<i>Each option corresponds to one menu item (horizontal bar) of the application</i>	
Farms Statistics page (Landing page)	Remote page
Profile page	Irrigation page
Weather forecast page	Pest Management (Enemies' page)
Field page	

10. Please mention the three least interesting features of the solution, if there are any:	
<i>Each option corresponds to one menu item (horizontal bar) of the application</i>	
Farms Statistics page (Landing page)	Remote page
Profile page	Irrigation page
Weather forecast page	Pest Management (Enemies' page)
Field page	

The project LIFE GAIA Sense is co-funded by the LIFE Programme of the European Union under contract number LIFE17 ENV/GR000220

"Consider the environment before print"



"Innovative Smart Farming Services  
 Supporting Circular Economy in Agriculture"  
 LIFE17 ENV/GR/220  
<http://lifegaiasense.eu/>



11. Ease of use						
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Not applicable
The smart-farming solution was easy to access.						
The design of the solution is easy to understand.						
The workflow of the solution is logically and delivers the result with few clicks.						
Accessing the solution on my mobile device works properly.						
The use of the product/solution of our use case needs special (ICT) expertise.						
The solution of our use case was easy to use and understand by all persons working with it.						
If not, which features were complex for your personnel to understand (open question).						
Waiting time for rendering the retrieved data is acceptable						

12. Please mention the three most important reasons for using the solution:



"Innovative Smart Farming Services  
Supporting Circular Economy in Agriculture"  
LIFE17 ENV/GR/220  
<http://lifegaia sense.eu/>



13. Please mention the three most important reasons for NOT using the solution:

--

14. Which of the following issues hinder the use of this solution in your farm?  
(more than one answer is possible)

<input type="checkbox"/>	Absence of Wi-Fi
<input type="checkbox"/>	Absence of internet connection at all
<input type="checkbox"/>	Connection is at very low speed
<input type="checkbox"/>	Difficult to find suitable mobile connectivity provider
<input type="checkbox"/>	No access to mobile coverage
<input type="checkbox"/>	The smart farming solution is not secure
<input type="checkbox"/>	The solution of our use case cannot stand the (seasonal) hot or cold temperature at our region
<input type="checkbox"/>	Other, please specify

15. Are you willing to pay for utilising this smart-farming solution?

--



"Innovative Smart Farming Services  
Supporting Circular Economy in Agriculture"  
LIFE17 ENV/GR/220  
<http://lifegaiasense.eu/>



## LIFE GAIA Sense Questionnaire

SMARTFARMING MONITORING

DASHBOARD

**Dear Life Gaia Sense partner,**

This survey is a tool to support you increase user acceptance of smart-farming products and solutions. The survey offers a chance to receive feedback from the smart-farming solutions users itself and allows to identify acceptance problems during the development cycle. The results of the test can be used to adjust the product according to the users' needs.

We kindly ask you to fill-in this survey. The survey contains mainly multiple choice questions and takes approximately 5 minutes to complete. If you feel that a question is not applicable to you, feel free to skip it.

The application is available here:

<https://gaiasense.neuropublic.gr/smartfarming/index.php>

Thank you for your efforts and for sharing your opinion!

The project LIFE GAIA Sense is co-funded by the LIFE Programme of the European Union under contract number LIFE17 ENV/GR000220

*"Consider the environment before print"*



"Innovative Smart Farming Services  
Supporting Circular Economy in Agriculture"  
LIFE17 ENV/GR/220  
<http://lifegaiasense.eu/>



## QUESTIONNAIRE

1. Age				
<29	30-39	40-49	50-59	60+

2. Gender	
	Male
	Female

3. Education level	
	Practical education
	High School education
	Bachelor's degree
	Master's degree
	Doctoral degree
	Professional degree (JD, MD)

4. Profession	
	Farmer
	Agronomist
	Consultant
	Researcher
	Other

The project LIFE GAIA Sense is co-funded by the LIFE Programme of the European Union under contract number LIFE17 ENV/GR000220

"Consider the environment before print"



"Innovative Smart Farming Services  
Supporting Circular Economy in Agriculture"  
LIFE17 ENV/GR/220  
<http://lifegaia sense.eu/>



5. Farm focus	
	Arable
	Vegetables
	Fruits
	Trees

6. Farm area (ha)	

7. Do you already use the any kind of digital technologies/solutions to your farm?	
	Yes, already applied in my farm
	We plan to apply within a year
	We are interested, but have no specific plans
	No, but maybe later
	Not at all



"Innovative Smart Farming Services  
Supporting Circular Economy in Agriculture"  
LIFE17 ENV/GR/220  
<http://lifegaiasense.eu/>



8. Usefulness of the <b>Dashboard</b> Solution						
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	N/A
The additional benefit of the solution for the farm is clear.						
I believe that this solution reduces working time.						
This solution clearly supports more accurate decision making.						
I believe applying this smart farming solution contributes to realizing societal goals, such as making farming more environmentally friendly.						
I think that this smart farming solution offers me more benefits than current practice.						

9. Please select the three most important features that you find beneficial for your farm or company of this solution , if there are any:

10. Please mention the three least interesting features of the solution, if there are any:



"Innovative Smart Farming Services  
 Supporting Circular Economy in Agriculture"  
 LIFE17 ENV/GR/220  
<http://lifegaiasense.eu/>



11. Ease of use						
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Not applicable
The smart-farming solution was easy to access.						
The design of the solution is easy to understand.						
The workflow of the solution is logically and delivers the result with few clicks.						
The use of the product/solution of our use case needs special (ICT) expertise.						
The solution of our use case was easy to use and understand by all persons working with it.						
If not, which features were complex for your personnel to understand (open question).						
Waiting time for rendering the retrieved data is acceptable						

12. Please mention the three most important reasons for using the solution:



"Innovative Smart Farming Services  
Supporting Circular Economy in Agriculture"  
LIFE17 ENV/GR/220  
<http://lifegaia sense.eu/>



13. Please mention the three most important reasons for NOT using the solution:

--

14. Which of the following issues hinder the use of this solution in your farm (more than one answer is possible):

<input type="checkbox"/>	Absence of Wi-Fi
<input type="checkbox"/>	Absence of internet connection at all
<input type="checkbox"/>	Connection is at very low speed
<input type="checkbox"/>	The smart farming solution is not secure
<input type="checkbox"/>	Other, please specify

15. Are you willing to pay for utilising this smart-farming solution?

--