RE.CAP

Reinforcing CAP

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RE.CAP
Reinforcing CAP

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Glossary

API	Application programming interface
BBOX	Bounding Box
BPS	Basic Payment Scheme
BSM	Burnt Scar Mapping
CAP	Common Agricultural Policy
CC	Cross Compliance
DRF	Diango REST Framework
EO	Earth Observation
GAEC	Good Agricultural and Environmental Conditions
GIS	Geographical Information System
LPIS	Land Parcel Indentification System
NDVI	Normalised Difference Vegetation Index
PA	Paying agency
RGB	Red Green Blue colour model
RS	Remote Sensing
SDK	Software development kit
SMRs	Statutory Management Requirements
WMS	Web Map service

Executive Summary

This document aims to outline the steps that were followed and the decisions that were made in order to develop and deliver the final version of the RECAP web and mobile application. Furthermore, it documents the integration practices, functional and non-functional requirements and the development of a testing methodology in order to present the final release of the RECAP platform. "D3.4 1st version of product backlog and development report" was used as the basis for preparing the current deliverable.

Specifically, this deliverable aims at describing the progress made in WP3 during the duration of the work package. Moreover, it presents the final version of RECAP platform and its components; outlines the progress made by the development team since the previous deliverable; describes any changes that might have occurred in the workflows during the development period; and describes the integration between the components and the core platform. Finally, the document depicts an overview of the users registered into the RECAP platform and a list of recommendations for future enhancements and improvements.

The web platform can be found at: http://app.recap-h2020.eu

The mobile application can be downloaded from:
https://play.google.com/store/apps/details?id=io.cordova.myapp4a5807

The SDK can be found at: https://zenodo.org/record/1475193#.W9hjD5P7SM8

Specifically, the deliverable covers the following topics:

- **Chapter 1:** Progress towards RECAP platform
- **Chapter 2:** RECAP architecture
- **Chapter 3:** Difficulties faced & lessons learnt
- **Chapter 4:** References
- **Chapter 5:** Annexes

1 Progress towards RECAP platform

The RECAP platform builds on the use of open (public) and user generated datasets varying from open satellite and other spatial data to administrative data from public authorities and data generated by farmers and inspectors, providing information to the different functioning components of the platform. RECAP was aiming to develop a platform with a common interface and features for the delivery of public services. However, based on the results derived from the users' needs analysis and co-production of services in all pilot countries, presented in the "D2.2 Report of user requirements in relation to the RECAP platform", the RECAP platform was comprised of five different workflows (one for each pilot). All the above led to the development and release of the 1st version of the integrated and tested RECAP platform, as described in the "D3.4 1st version of product backlog and development report".

1.1 Development methodology

As it has already been described in D3.4, the Scrum[1] methodology was used for the development of the platform. All user stories from "D2.2 Report of user requirements in relation to the RECAP platform" were collected and placed on an online tool (PivotalTracker[2] and Trello[3]) to assist the easy monitoring of the development tasks (Figure 1).

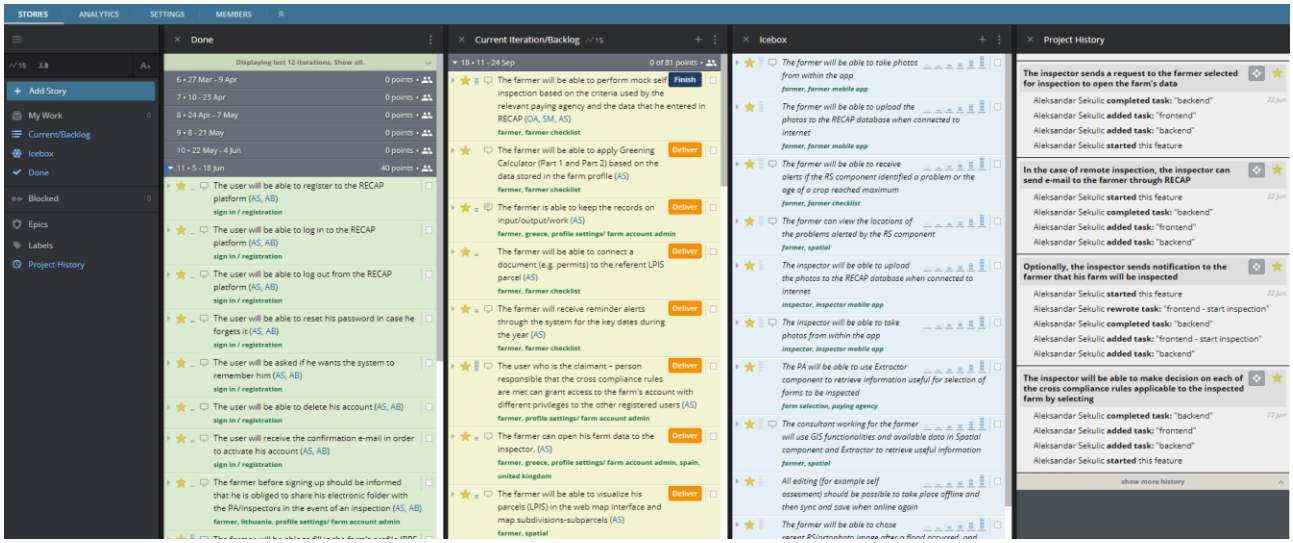


Figure 1: PivotalTracker for the specifications and managing of the development

Taiga[4] was used as an issue tracking system, where testers and RECAP partners were reporting issues tracked during their use of the application (Figure 2). More information is presented in the Section 1.5.

[1] https://en.wikipedia.org/wiki/Scrum_(software_development)
[2] https://www.pivotaltracker.com
[3] https://www.trello.com
[4] https://tree.taiga.io

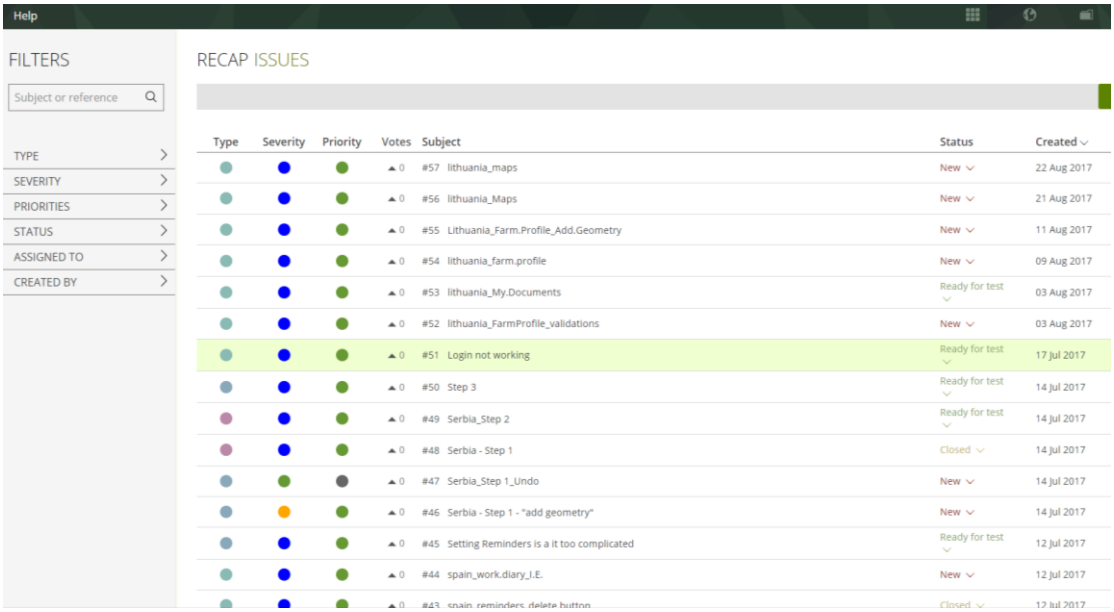


Figure 2: Taiga used as the issue tracking system

1.2 Pilot implementation

During March and October, the RECAP platform has been tested and validated in 5 pilots (within more than one operational environments – farmers, agricultural consultants, public authorities and inspectors), testing all different components and functionalities of the platform. The WP3 team actively participated in the pilot implementation phase, fixing a range of issues reported on TAIGA, guiding the pilot stakeholders on how to use platform's functionalities, when it was needed, and assisting on the platform demonstration to the pilot users. Moreover, the WP3 team was in close collaboration with the WP2 team, collecting and providing input with regards to the platform operability and modifications in order for the "D2.4 Report on co-production of services" to be developed.

1.3 Integration

1.3.1 Integration among the RECAP components

The integration plan was described in "D3.1 RECAP System Architecture" and covered the connection among the RECAP components to work under one common roof. Furthermore, "D3.3 Software components development" touched the development of the components and the integration plan between those and the web application (front end) was described. In "D3.4 1st version of product backlog and development report" was described in details the development of the 1st version of the integrated and tested RECAP platform, as well as the beta version of the mobile application was presented.

1.3.2 Integration among the Remote Sensing (RS) component

The biggest challenge was the integration with the Remote Sensing (RS) component due to the fact that it is hosted at NOA premises and it needed to trigger a lengthy process which involves the download and parsing of large satellite data chunks.

It was decided that the PAs will trigger a process on the RS servers and, when the results are ready, they will be passed to the RECAP API in order to be ingested in the database:

1. The registered and authorized user draws an Area Of Interest (AOI) in the map component of the RECAP platform.
2. The polygon, along with the farmers' declaration within the AOI are extracted from the RECAP database and passed to the Remote Sensing component through a POST call.
3. This POST action triggers the automatic remote sensing workflows relevant to cross-compliance and greening rules.
4. When the workflows are finished, the values of a set of alphanumeric variables are updated in the RS component internal database. Each parcel in the AOI is associated with this set of variables. The variables are shown in Table 1 have been agreed between NOA and DRAXIS.

Table 1: Remote Sensing variables used for cross-compliance and greening checks

Cross-compliance checks with RS and attributes per parcel		
Attribute code	**Attribute description**	**Attribute type**
Green1	Diversification of crops	Boolean (checked or not checked)
Green2	Maintenance of permanent grassland	Boolean (checked or not checked)
GAEC4	Minimum Soil Cover	Boolean (checked or not checked)
NDWI	Normalised Difference Water Index	Float
NDVI	Normalised Difference Vegetation Index	Float
PSRI	Plant senescence reflectance index	Float
SAVI	Soil-adjusted vegetative index	Float
SeasType	Seasonal Label Estimation	String (summer, winter, permanent)
FarmType	Crop Family Label Estimation	String
CropType	Lowest level of crop specificity	Integer (from lookup table)
GAEC6	Crop residue burning residues	Boolean (checked or not checked)
BurnPerc	Decision if the parcel is burnt or not	Int
BurnTimestamp	First Month of the year for which the burned area was mapped	Inte
SMR1	Water pollution risk assessment – Risk Indicator	Boolean (checked or not checked)
GAEC1	Comply with buffer zones	Boolean (checked or not checked)
GAEC5	Soil Erosion/ Poor tillage	Boolean (checked or not checked)
Slope	Average parcel slope angle	Float (decimal degrees)
Aspect	Average parcel aspect angle	Float (decimal degrees)
K-factor	Soil erosivity depended on the ground composition (clay, sandy, etc.)	Float

C-factor	Soil erosivity according to land/cover and tillage practices	Float
SoilErIndx	Product of K-factor and C-factor	Float
RUSLE	Revised Universal Soil Loss Equation	Float
WaterProx	Distance between parcel and closet watercourse	Float
Risk Index	Parcel risk assessment for water pollution	String (V. Low, Low, Medium, High, V. High)
Croptype_conf	Confidence of the estimated crop type decision	Int (1,2 3 or 4)
Season_conf	Confidence of the estimated season type decision	Int (1,2 3 or 4)

5. The values attributed to the different variables update then the corresponding parcels table in the RECAP database (via an API call), for further exploitation and decision making.
6. Finally, the satellite imagery that was used to generated the RS information, is being made available to RECAP users through a Mapserver WMS service available from NOA's RS server.
7. An automatic update process takes places every 15 days for the existing AOIs. Noa component is responsible for searching new cloudless images related to every AOI, generating new remote sensing results and finally updating the parcels table in the RECAP database along with the Maserver WMS service.

1.4 Development of components

The development of the components was covered extensively in "D3.3 Software components development". The components developed were: a) workflow, b) spatial, c) e-learning, and d) remote sensing. However, a rapid appraisal methodology for the identification of specific users' needs and objectives was followed in order to develop a Software Development Kit (SDK) with enhanced reliability and integrity.

1.4.1 Software Development Kit (SDK)

RECAP PHP SDK makes easy the integration of any PHP application, library or scripts with RECAP core functionalities. It provides a set of classes and methods generated by the API where developers can embed in their codebase in order to include or build features based on RECAP business logic.
The operations listed below are primarily supported through the core API, however below services are also exposed through the SDK:

- Authentication
  1. Login
  2. User Details
  3. Logout
- Documents Management
  1. List of documents
  2. Document's CRUD Operations
  3. Search Documents
  4. List of Tags
- Events
  1. Set Reminder options
  2. List of User's Reminders
  3. Notification's CRUD Operations
- Roles
  1. List of additional users
  2. Role's CRUD Operations
- Lithuanian Pilot
  1. List of crop codes
  2. List of parcels (ids, Crop types, Remote sensing results)
  3. Parcel's CRUD Operations
  4. Search Parcels
- UK Pilot
  1. List of crop codes
  2. List of parcels (ids, Crop types, Remote sensing results)
  3. Parcel's CRUD Operations
  4. Search Parcels
- Greek Pilot
  1. List of crop codes
  2. List of parcels (ids, Crop types, Remote sensing results)
  3. Parcel's CRUD Operations
  4. Search Parcels
- Spanish Pilot
  1. List of crop codes
  2. List of parcels (ids, Crop types, Remote sensing results)
  3. Parcel's CRUD Operations
  4. Search Parcels
  5. List of CAP use
  6. List of CAP declarations
  7. CRUD Operations of CAP declarations
- Serbian Pilot
  1. List of crop codes
  2. List of parcels (ids, Crop types, Remote sensing results)
  3. Parcel's CRUD Operations

4. Search Parcels

The installation of a new SDK client requires at least PHP 5.x , Composer Package Manager service and of course a set of valid credentials arguments where the user use in order to login into the web platform.
Any runtime script which uses the RECAP SDK must declare the autoload.php path of the Vendor package:

```
require_once(__DIR__ . '/vendor/autoload.php').
```

After that, an initialization of SDK object is required in order to gain access to the offered methods of SDK Classes:

```
$recapSDK = new Swagger\Client\Api\DefaultApi().
```

Finally, a call of login() method will use the user's credentials in order to establish an authenticated channel with RECAP core:

```
$user = $recapSDK->login();   // Login to ReCAP system
```

User's credentials must be declared into Configuration.php file according to the RECAP SDK manual.

1.5 Testing

During the testing procedure, the WP3 team developed the essential mechanisms to test and validate the platform's 13ehavior compared to the initial "vision" and the WP2 "user stories" for the RECAP platform established at the first stage of the development and reassure that the platform functions securely and reliably. Furthermore, during the testing period and the pilot implementation phase, the WP3 team established additional mechanisms (TAIGA) for the operability, improvement and stability of the RECAP platform that might be jeopardized by technical or non-technical malfunctions. TAIGA helped the team to keep track and resolve issues both in code-level but also in the logic of the event by prioritizing them based on type (bug, question, enhancement) and on severity (critical, important, normal, minor, wishlist).

Below some statistics are provided with regards to the issues registered and handled in the TAIGA based on type, severity, priorities, status and pilots.

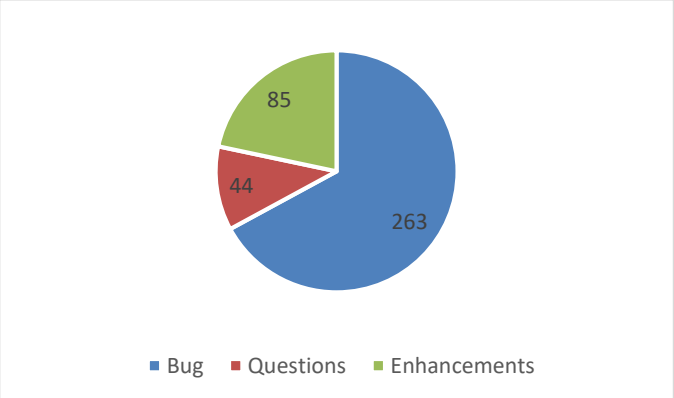


Figure 3: Pie chart presenting the type of issues reporting in TAIGA

The most common reported issues were bugs representing the 67% of the total issues (392). Since the 1st release of the RECAP platform was used for the testing phase, this number is quite logical. In the same line, the second popular type of reported issue was the Enhancements, representing the 22% of the total issues. Through TAIGA, pilot partners also posed questions in order to get information, support and guidance related to RECAP platform services. This specific section was quite useful for the WP2 team obtaining a holistic overview of the platform progress.

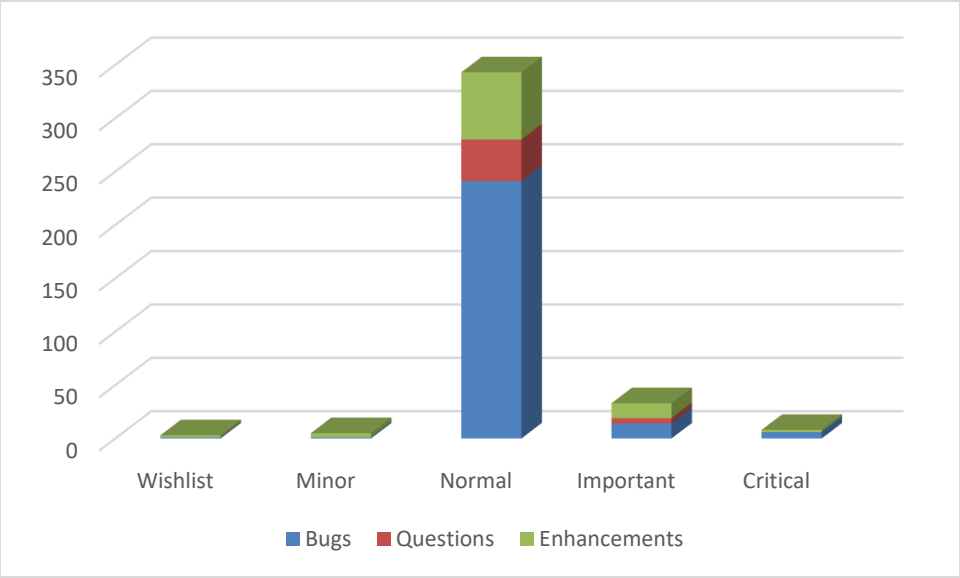


Figure 4: *Bar chart presenting the correlation between types and severity*

The majority of the reported issues were characterized with normal severity and only the 2% of them were reported as critical for the platform operation. Specifically, most of the issues reported as bugs were labelled with normal severity, representing the 91% of the total bugs.

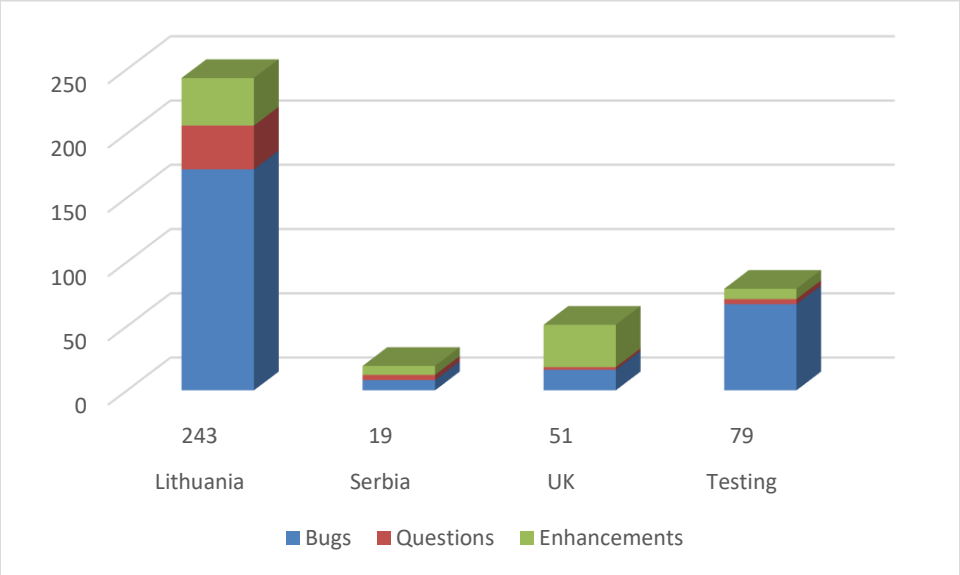


Figure 5: Bar chart presenting the correlation between types and pilots

The Lithuanian pilot used TAIGA through the entire process of the RECAP platform development. All communications with the technical team were performed through TAIGA. On the contrary, the Greek and UK cases preferred to organize a person-to-person meetings in order to address the platform issues. In the case of the Spanish pilot, no further requests were raised other than those identified in the user requirements' phase.

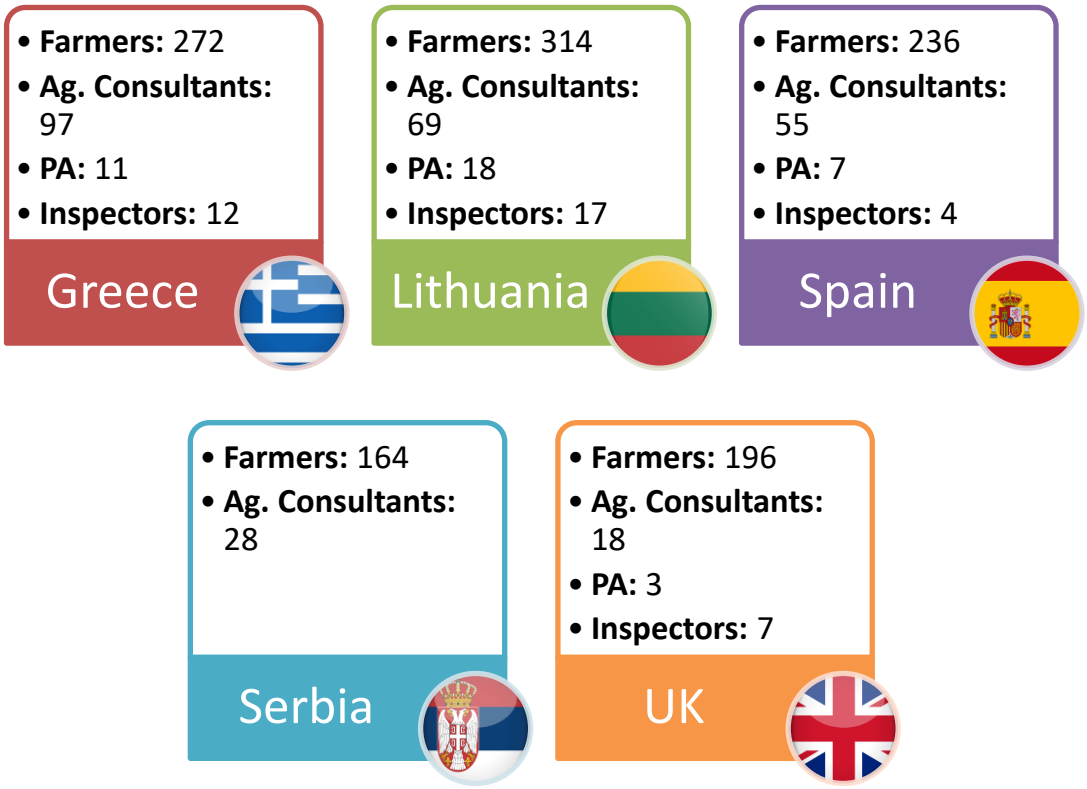
1.6 RECAP platform: An open approach

RECAP platform will be available by DRAXIS under the GNU General Public License (GNU GPL v3)[5] and it is accessible through Zenodo (DOI: 10.5281/zenodo.1451796).

The GNU General Public License is a free, copyleft license for software and other kinds of works. Everyone is permitted to copy and distribute verbatim copies of this license document, but changing is not allowed.

1.7 Platform users

The registered users in the RECAP platform per type and per pilot are presented below (3/10/2018):



1.8 Recommendations

A list of recommendations has been provided by the pilot users for enhancing the platform's operation. Since the RECAP platform is provided as an open source solution, these recommendations would be of great benefit to the users/ developers who would like to adapt the RECAP solution into their workflow.

[5] https://www.gnu.org/licenses/gpl-3.0.html

Inspections

- After inspectors submitting the final decision, the RECAP platform should not allow them to perform changes. If any additional action is needed, PA should provide them with access to the already submitted final decision.
- It would be useful for the inspectors and PA to see the status and progress of the assigned inpsections.

CC rules/ Checklist

- The CC rules section should be open and editable for the PA in order to update the description, the taskes and the obligations, when it is needed.

Layers

- An additional layer should be included into the map section. Through this layer the users will be able to see the difference (if there is any) between the delcared and identified crop.

2 RECAP Architecture

2.1 Revised Architecture (decisions, problems)

The RECAP architecture as it was presented in "D3.1 RECAP System Architecture" was followed without any major changes. There were minor ones and an update is introduced and documented below. The final architecture diagram is presented in Figure 6.

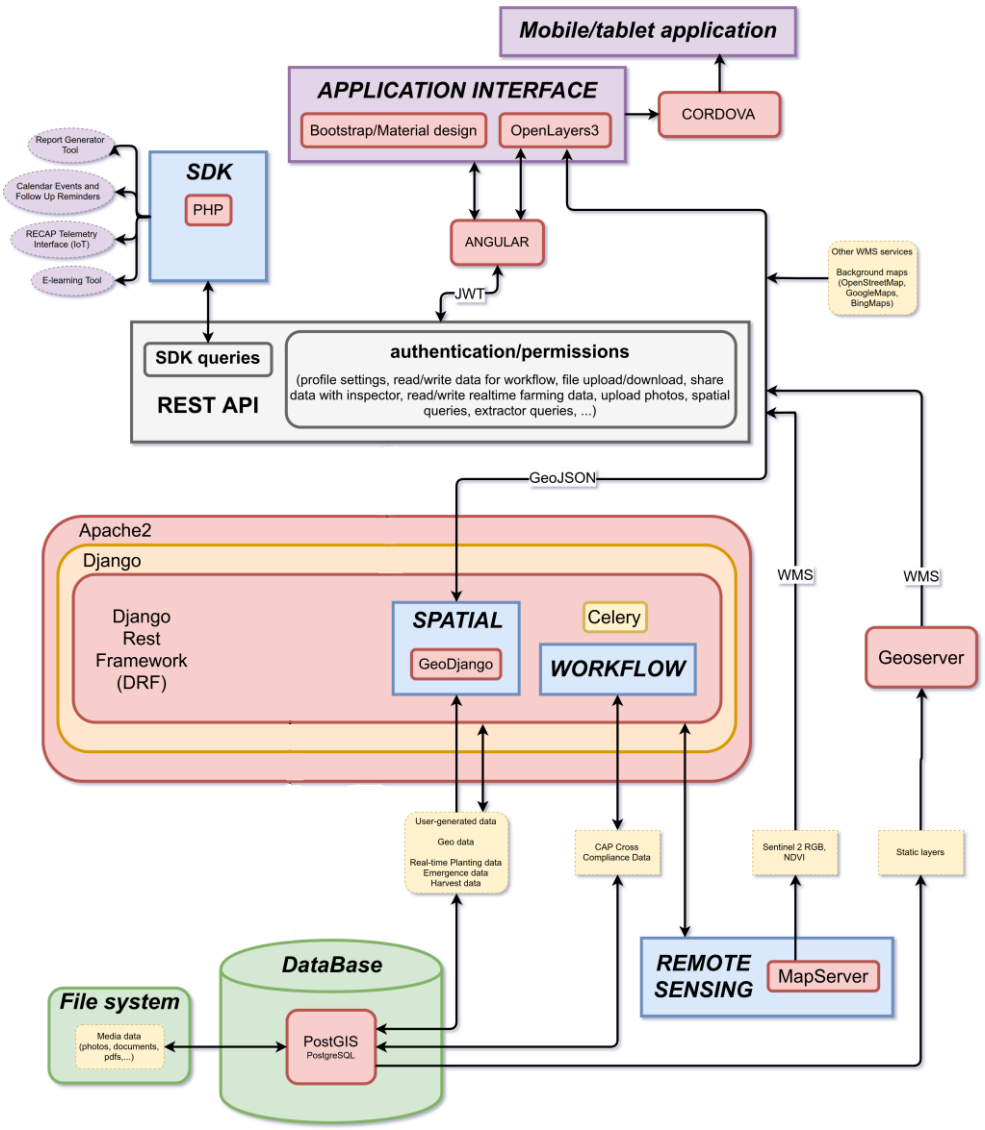


Figure 6: RECAP architecture

The most significant updates and decisions for the architecture compared to the one in "D3.1 RECAP System Architecture", "D3.3 Software components development" and "D3.4 1st version of product backlog and development report" are listed here:

Serving static layers

The initial approach was to use Geoserver[6] to serve static vector and raster data (etc. map layers, natura2000, land use, slope). The pilots' requested mostly vector data to show up on a map, so currently there were only a few raster data repository feeding Geoserver. Vector data are stored in a PostGIS[7] database which can efficiently render map segments and allows the possibility to perform spatial queries

[6] http://geoserver.org/
[7] http://postgis.net/

using parcel geometries. Raster data are stored in file system. Each pilot has its own Geoserver workspace, in order to facilitate the presentation of their specific static layers over the map.

Another change from the original plan concerns the storage of the remote sensing results. Initially the plan was for the results to be stored in the PostGIS database and be served through Georserver. A better approach that assists a potential scaling of the application was to host the results on the remote sensing server where all the work takes place. That reduced significantly the need to transfer data from one part of the application to another.

2.2 *Revised User Stories / Workflows*

All the user stories that remained in the backlog have been resolved. With regards to the ones recorded in the D3.4, each issue is presented below along with a description on how it was addressed:

- **User should be able to print the map**
  A button has been added in the map section in order for the user to be able to print the map (including the layers that may be displayed in the top of the map).
- **During farm creation user needs to be asked generic questions (e.g. do you have livestock and if yes, we need to hide related questions).**
  This user story does not apply to the needs of every pilot. Each pilot has provided the technical team with the forms based on which the farm profile has been developed. Wherever it was asked, this kind of questions were included in the last step (Questionnaire).
- **User needs to have a tool for drawing and measuring length and perform a spatial query on the Map**
  This was a common request and it was included in the map section for every pilot case.
- **User should be able to create reminders for activities**
  Apart from the reminders related to the CC rules actions, an additional type was added into the reminders section. The user is able to create a new reminder for their own activities or an inspector can add to the user's calendar a reminder with regards to an eminent inspection.
- **User should have access to his/her work diary**
  Users do have access to their work diary. However, due to privacy policy additional users (consultants, PA and inspectors) do not have access to such information, unless the users grant them with access.
- **User should be able to filter items from the log history**
  In order for the user to better find a performed action from the log history, a search engine was added. The user is able to filter the log history by entering an action type (created, updated, deleted).
- **PA admin user should be able to confirm who is an inspector or PA user & During registration, user should be able to choose their preferred user role: farmer, inspector or PA**
  During the registration, the users are able to select their preferred user role (farmer, agricultural consultant, PA and inspector). In order to avoid non-authorised actions with regards to inspections' results and farmers-related data handling, an additional user was added in order to be responsible for the registered users under the role of inspectors. The PA admin is responsible for confirming a user as inspector as well as manage and assign to them inspections to be performed.
- **Inspector should be able to filter farmers list by BPS ID**
  This was a common request and a search engine was added in the list of the assigned farmers for inspection.
- **Farmer user should be able to upload documents that will be available to the inspectors at all times**
  Farmers are able to upload documents and photos to their own repository. However, this kind of information is not available/ visible to the inspectors, since it is personal information. In order to address this request, RECAP team has developed a functionality that allows farmers to make this information visible to the inspectors. Furthermore, inspectors are able to request for access to this information at any given time.
- **User should be able to download all of the documents at once**

A "Click to select all documents" button was added in order for the user to download all the documents at once.

Furthermore, two workflows were revised. Specifically, the UK pilot expressed its need to revise the farmer's profile and the Greek one the inspector's profile. Three different meetings were held, two with the Greek pilot and one with the UK team, in Thessaloniki in order to discuss the raised issues. All the requirements were analysed, prioritized and categorized into two types, namely, High and Low priority. The Low Priority issues would be taken into consideration and they would be re-evaluated at a later stage and if there was enough time, these issues would be addressed.
The technical team has prepared the revised workflows and circulated to the respective partners and agreed on the content. All the proposed revisions, described in the new workflows, were successfully addressed. These documents were also shared with the WP2 team in order to be included in the D2.4.

3 Difficulties faced & lessons learnt

Throughout a project's life time, we learnt lessons and discovered opportunities for improvement. Thus, this chapter describes some difficulties that the development and technical team faced since the beginning of the project and the actions that were taken in order to address them. The aim of this description is to provide an opportunity for partners to be informed of the actions taken or things that might have been done differently, unintended outcomes and recommendations for others involved in similar future projects.
The first thing that should be mentioned, is the need to redesign some of the workflows that we used to describe the respective flows in each pilot country. After the completion of the identification and collection of user requirements, the development team drafted wireframes and presented them to the pilot partners. However, due to similarities of the main functionalities applied to all pilot cases, the development team did not prepare wireframes for all screens/parts of the platform. Consequently, after the release of the 1st version of the RECAP platform and during the testing phase, two of the pilot cases (UK and Greece) expressed the need of some profiles of the platform to be modified (Section 2.2). The logic of this adaptation lies not only in legistlation differentiations, but also in the specific needs of their organisations and their established business processes, as well as their vision of how they intend to exploit the platform to their target users, during and after the course of the project. The development team needed to spend additional effort on communicating with the respective partners, in order to ensure that the planned revision of the platform, will meet their needs, in order to avoid a similar situation for the second time.
Alongside with the 1st version of the RECAP platform, a beta version of the mobile application was also delivered. However, due to the modifications and changes that needed to be performed on the RECAP platform based on the feedback derived from the testing phase, the delivery of the final version of the mobile application was postponed. That was due to the fact that each change performed in the web application should have been reflected also in the mobile application. Adaptions such as the revision of specific workflows required additional effort and time for the mobile too. After the development team finalized the web application, ensuring that the platform could be used in all the pilots, the development of the final version of the mobile application continued from the place it was halted.
Difficulties were also faced with the development, utilization and credibility of the remote sensing component. Firstly, it should be mentioned that the CAP standards, as described in Statutory Management Requirements (SMRs), Greening and Good Agricultural and Environmental Conditions (GAECs), cannot be tackled in their entirety via means of earth observation. The system is founded on one basic pillar and that is the crop identification. The crop identification product constituted the greater part of the remote sensing

deliverables of the system and was combined with other geospatial products using Geographical Information System (GIS) techniques to provide solid qualitative information to answer the CAP requirements. Additionally, Burnt Scar Mapping (BSM) algorithms were adapted to locate parcels of burnt crop residue or stubble.

Secondly, the crop classification accuracy is dependent on three main parameters including the cloud coverage, the size of parcels and the truthfulness of declarations. In order to overcome the accuracy variability based on the area of application, but also in order to quantify the trustworthiness of each classification decision, we have introduced the concept of the traffic light system. The posterior probability for the classification of each parcel was used to divide the dataset into confidently and not confidently classified parcels. This way targeted on the spot inspections were possible. For example, in cases where the decision was confident and the classification results did not agree with the declaration, it was considered as a potential breach of compliance. Moreover, it was noted that in countries with extended cloud coverage, classification was more challenging, especially for classifications early in the year (i.e. late June when declarations are received). The development team decided to regularly update the classification results through the summer for progressively more accurate results.

The integration of the remote sensing component with the rest of the RECAP platform was based on a Restful API that was developed for this purpose. It proved to be an effective choice and its mission is to function not only on retrieving parcels data, but also on serving and linking data. An API endpoint was created from the remote sensing component side in order to serve the type and the date for each generated product. Although this strategy proved worth the effort, the team faced real-life problems mainly based on the linking time, especially for pilots with a high number of parcels, which required to establish a separate connection to the RECAP platform for each parcel. For those pilots, the development team analysed and processed the data to deliver the results offline and then linked them into the remote sensing component using a .shp file.

4 References

- D2.2 Report of user requirements in relation to the RECAP platform
  (Confidential deliverable not available on the web)
- D3.1 RECAP System Architecture
  https://www.recap-h2020.eu/wp-content/uploads/2017/03/d.3.1_system_architecture.pdf
- D3.3 Software components development
  https://www.recap-h2020.eu/wp-content/uploads/2017/09/d.3.3_Software_components_development.pdf
- D3.4 1st version of product backlog and development report
  https://www.recap-h2020.eu/wp-content/uploads/2018/04/d3_4_first_version_of_product_backlog_and_development_report.pdf

5 Annexes

5.1 Annex I - Manual

This ANNEX presents the last version of the RECAP platform that has been used, tested and validated during the pilot implementation. The users of the five pilot cases provided feedback and an evaluation of their satisfaction with the RECAP solution, which would be used for the completion of the "D4.4 Final Evaluation Report". Furthermore, through the pilot phase, it was provided a list of recommendations for enhancing the platform's operation.

There are five different user roles within the RECAP system:

- The farmer role
- The consultant role
- The inspector role
- The paying agency role
- The paying agency admin role

"D3.3 Software components development" described the various components of the RECAP platform and detailed how these were implemented as well as how they communicate with each other. "D3.4 1st version of product backlog and development report" presented the first version of the RECAP platform that would be used during the pilot operation. This deliverable includes a detailed description of the final version of the RECAP platform (some parts may be similarly presented as in the D3.4).

5.1.1 Web application

The initial screen of the RECAP platform allows the users either to log into the platform (if they have already been registered) or to create a new user based on a specific user type (farmer, consultant, paying agency and inspector) and Country (United Kingdom, Lithuania, Serbia, Greece and Spain). Moreover, this screen includes the "Personal Data Protection Policy", "Terms and Conditions" and the "Informed Consent Form" in order to inform the users on how RECAP collects, processes, discloses and protects their provided information.

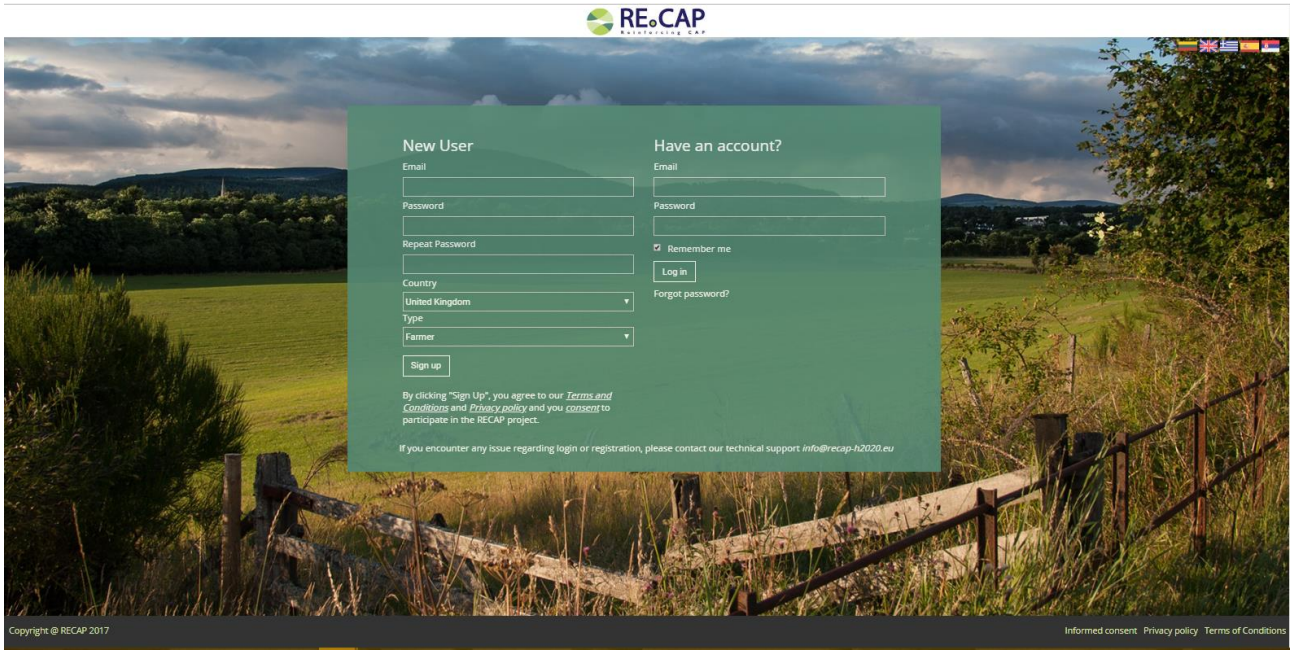


Figure 7: Log in and registration screen

5.1.1.1.1 Farmers

After completing the registration, the farmer lands on the dashboard in which they have to fill in the fields with all the needed farm-related data. These required data are the same data needed for the completion of the Basic Payment Scheme (BPS) application. Based on the farmer's input, the system decides which Cross Compliance (CC) rules apply to their fields. Figure 8 depicts the BPS form. In order to be more user-friendly and help user to keep up with no extremely long lists, the BPS form is split in steps.

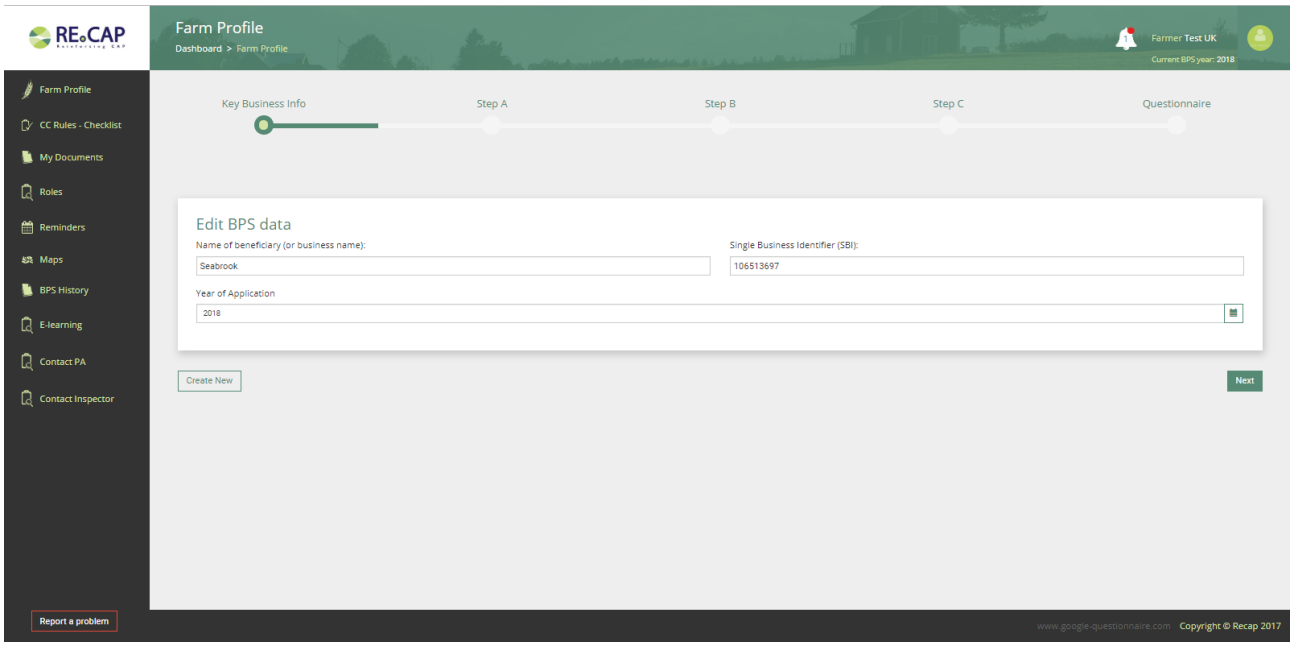


Figure 8: Filling in the farm profile

The farmer can add their parcels either by importing the .shp file or by drawing the boundaries within the RECAP platform. At any given point, the farmer can edit the parcel or even delete it.

Search and navigate to place
CLOSE
A1
A1M
Pinewood Drive
Pinewood Drive
Pinewood Drive

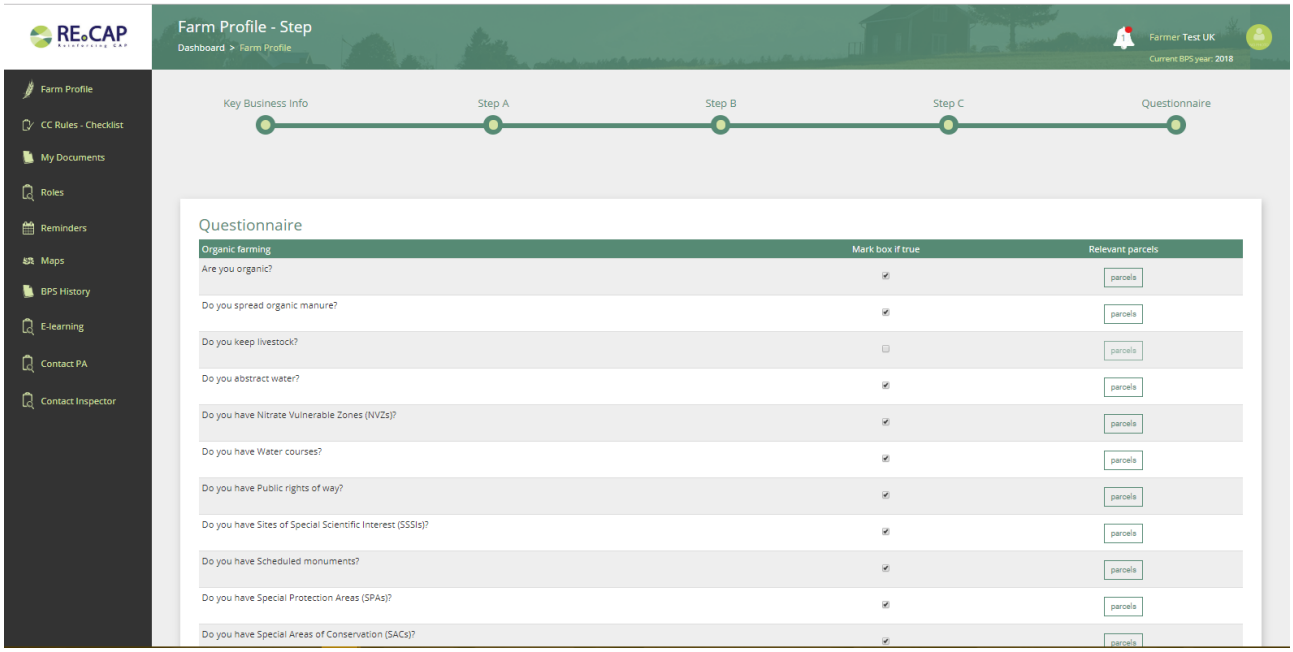


Figure 10: Correlation of parcels with CC rules

Through the parcel button the user is able to choose the parcels to which each rule applies.

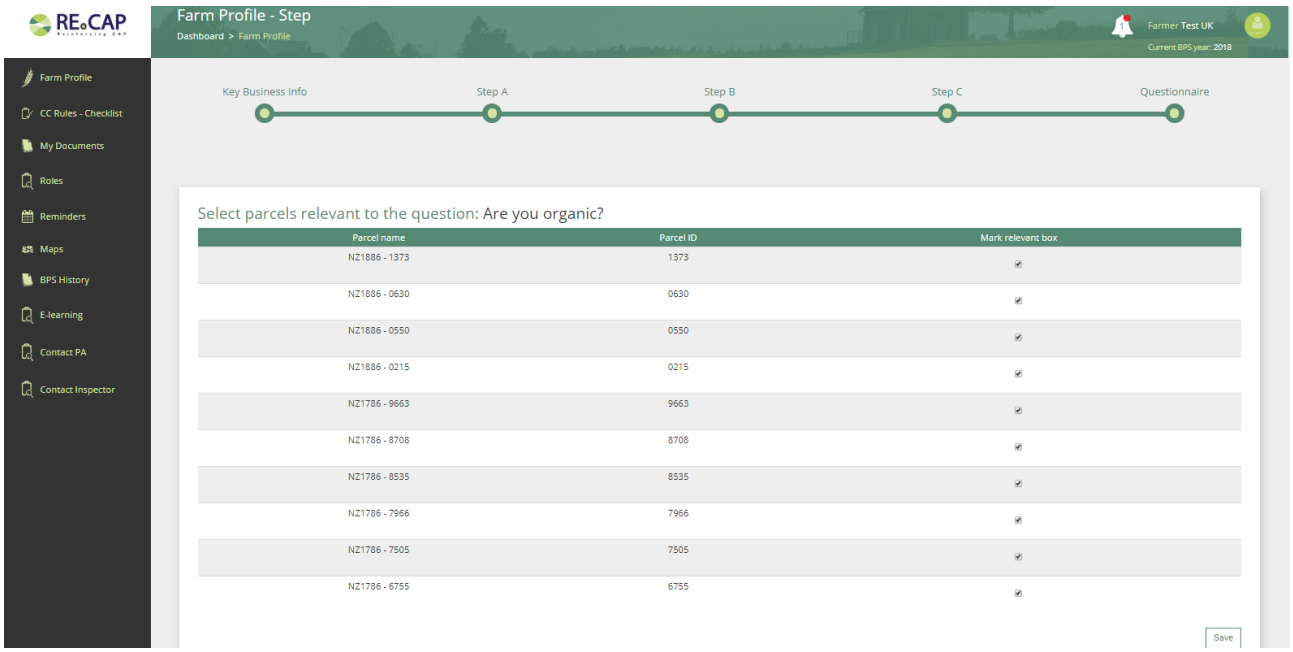


Figure 11: Selecting Parcels

Since the farm-related data are entered into the system, a list of all relevant rules is displayed to the end-user, in order to simplify the visualization and group the complex regulations that the user need to be compliant with.

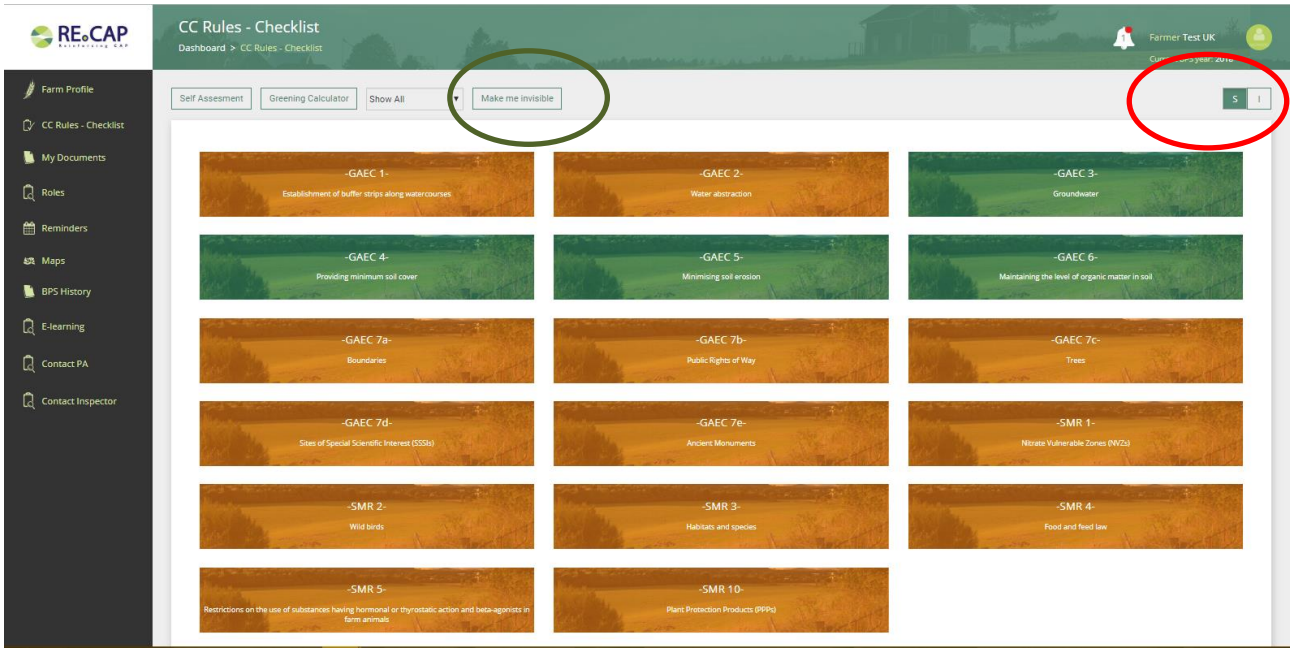


Figure 12: Cross Compliance (CC) checklist

In each rule, there are specific instructions explaining to the end-user what they have to do or not do in order to comply; and through a checklist the users can mark the completed instructions (Figure 13). Moreover, the users can attach relevant documents and photos to each of the rules in order to better showcase their compliance with the CC rule.

Based on farmer's answers, each rule applying to their farm, is marked on a colour-based code as completed or pending, facilitating the farmer to easily identify which are the rules the farmer must comply with and what action to perform. For instance, if the farmer has not performed any action, then the colour of the respective CC rule box is red, otherwise the colour is orange. Once the farmer has completed all the required actions described in the CC rules, the colour of the box turns into green (Figure 10).

Furthermore, through a drop-down list, the users are able to view the specific rules that apply to their declared parcels separately or as a whole.

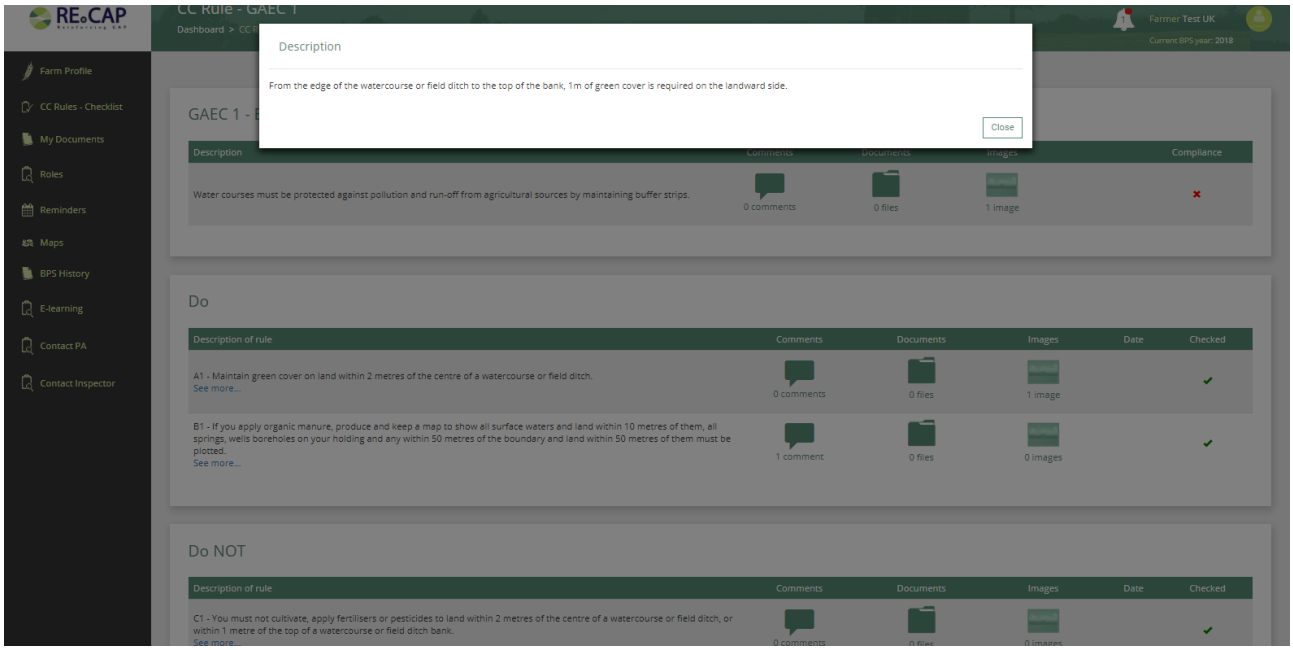


Figure 13: CC Rule description and checklist

During the inspection process, the user might be requested to open their information (documents, input/ output and work dairy records) to the inspector. By clicking on the button “Make me visible” (green marked circle at Figure 12**Error! Reference source not found.**) at the CC rules page, the user chooses to make themselves visible to the inspectors and grant them with access to their information. User data are maintained securely on the RECAP servers and always remain private to their owners, unless granted to be shared with the inspectors.

By selecting the “I” option at the top right of the CC rules page (red marked circle at Figure 12**Error! Reference source not found.**) the user can view the inspection results grouped per CC rule along with any supportive documents that the inspectors have uploaded.

In order to have an overview of their “obligations”, the user can click on the “Self-Assessment” button at the top left of the CC rules page and retrieve a total summary of what they should do and which documents are still missing. Moreover, the download functionality has been added in order for the user to download the report (in excel format).

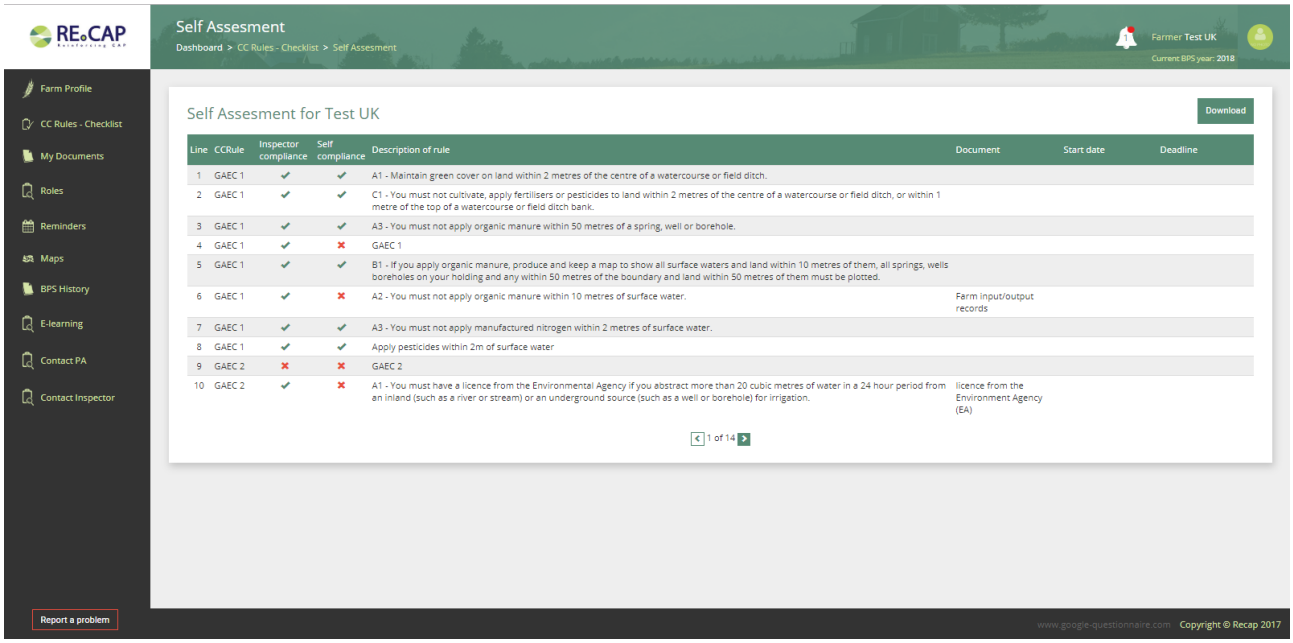


Figure 14: Cross Compliance rules overview

Moreover, the farmer can check if the declared sub parcels added via the spatial component are compliant with the greening rules through the Greening calculator at the top left of the CC rules page.

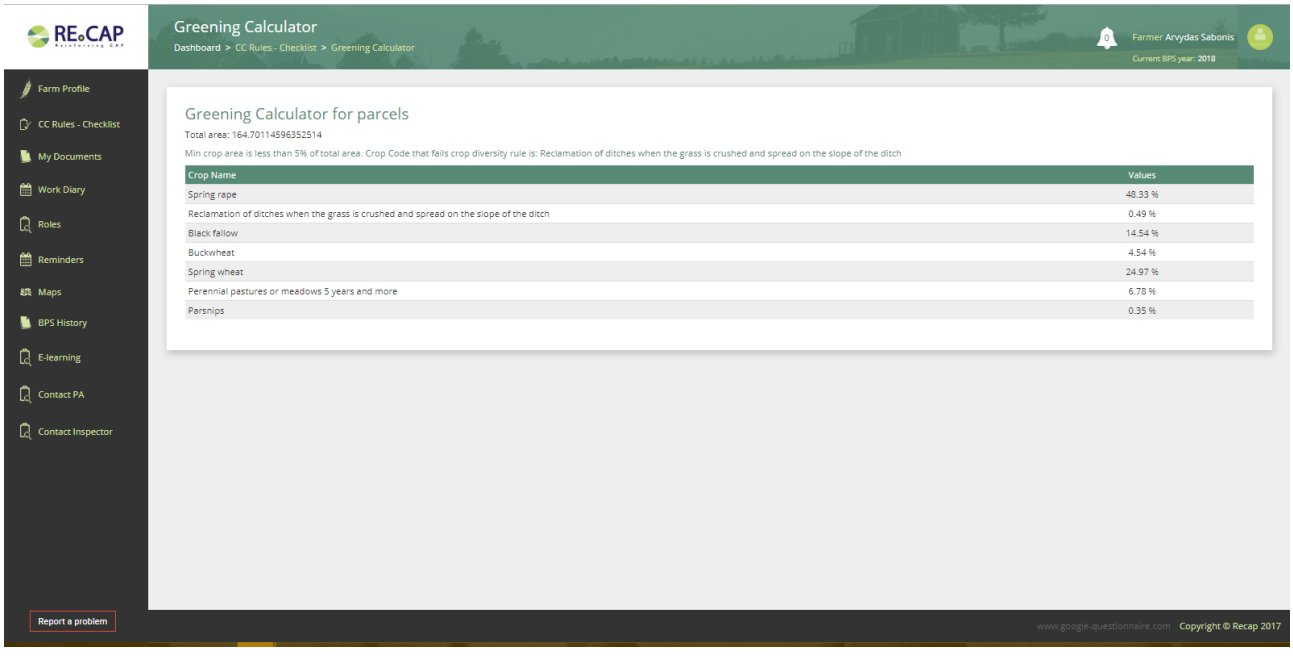


Figure 15: Greening Calculator

In order to assist users, either farmers or inspectors, during an imminent inspection, the RECAP platform offers to the farmers the option to maintain input/ output and work dairies records. This functionality helps farmer to retrieve notes and details from the practices that can be useful in case of an inspection.

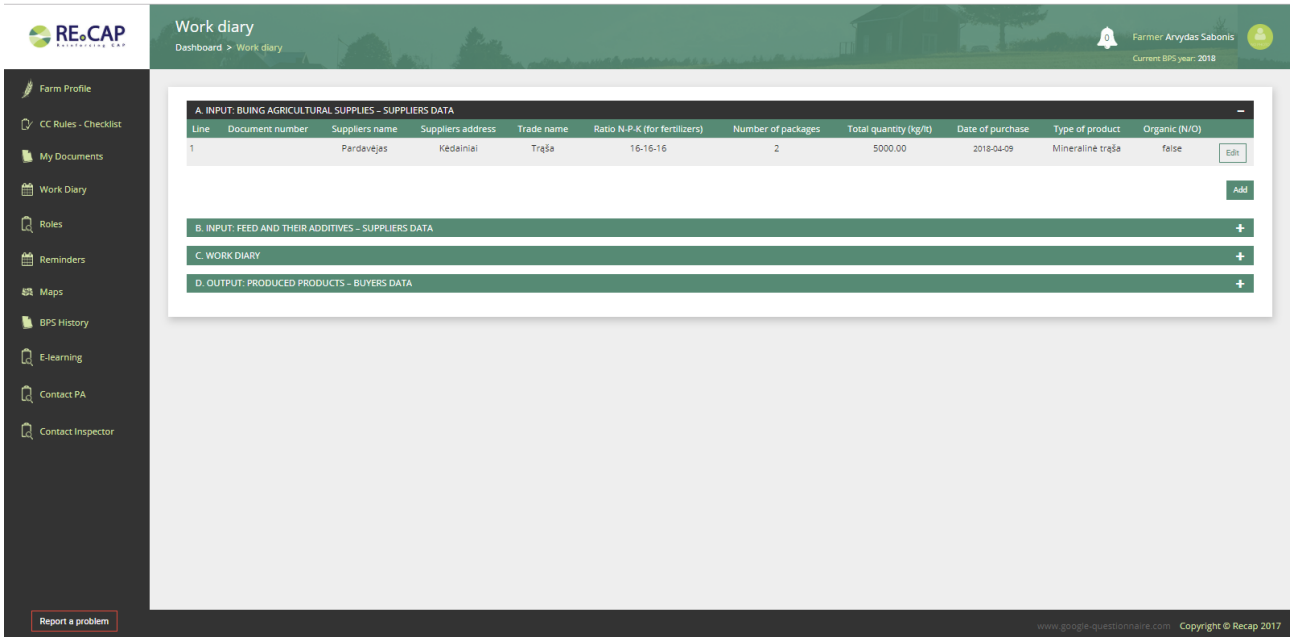


Figure 16: Farmer's Work Dairy

Reminders are also one of the most important functionalities of the RECAP platform and can be categorized in three different types:

- Reminders based on calendar key dates that the users must remember related to the CC rules obligations.
- Reminders created by the inspectors with regards to the imminent scheduled inspection.
- Users can create their own custom reminders that will be displayed either as a calendar, or as a list along with the calendar key dates reminders.

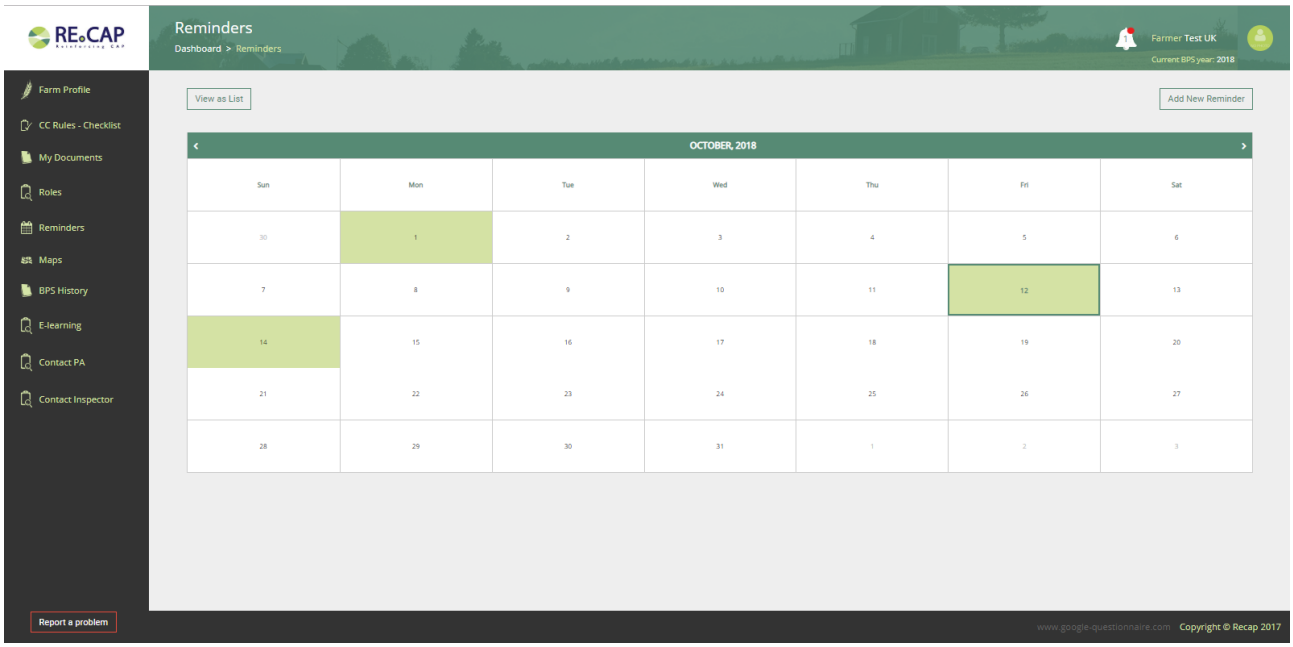


Figure 17: Reminders – View as a Calendar

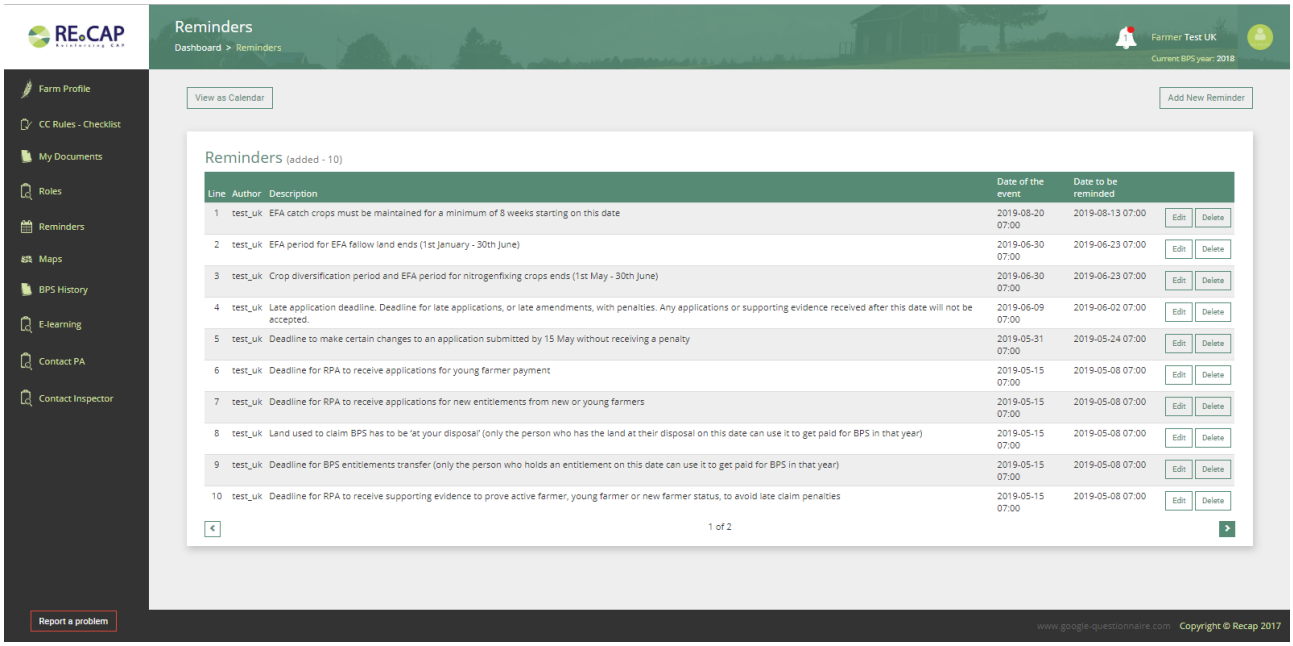


Figure 18: Reminders – View as a List

Other than farmers, agricultural consultants and farm stuff are able to have access to the RECAP platform and get the information of the farmers. Once the farmer grants access to their accounts, by defining role and access level, the agricultural consultant or the farm stuff is able to view farmer's profile. The

agricultural consultants can have a view of all their clients' fields and are able to select a specific farmer to view their fields and check if there are any new reminders.

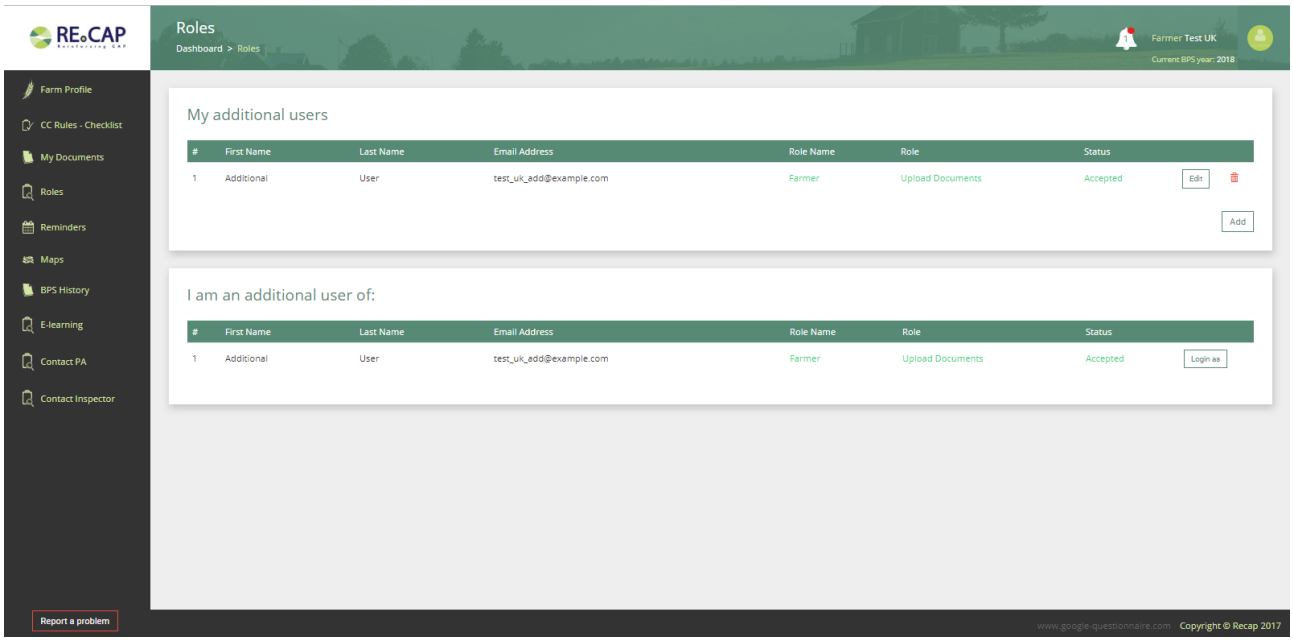


Figure 19: Roles – Additional users

Through the map section, the farmer can view the declared-parcels along with indices and results derived from the remote sensing component. The user is able to find a parcel by entering its ID into the search engine or through the parcel list.

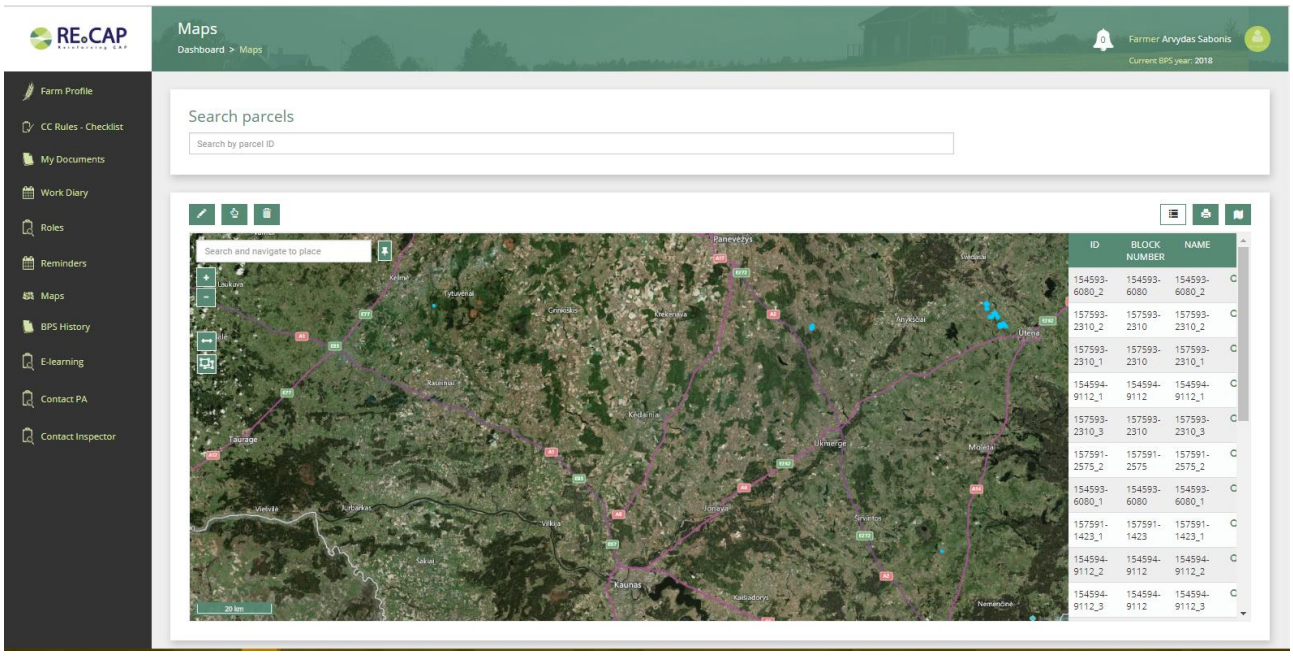


Figure 20: Search for a parcel

By clicking on a specific parcel, a floating menu appears at right containing parcel's information. This information is related to:

- crop type declaration,
- crop type estimation,
- confidence of the crop type estimation (green, yellow, red and unreliable),
- crop type family,
- crop type family estimation,
- confidence of crop type family estimation,
- area, burnt (No/Yes),
- burntimestamp (hidden, if burnt is no),
- GAECs rules
- Green 1 and Green 2 rules
- K Factor
- C Factor
- Rusle
- Water proximity
- SMR1
- Soil index
- Risk index (Exempted, no risk, low risk, medium risk, high risk, very high risk)
- NDVI, NDWI, PSRI and SAVI indices

In case of inability to calculate any of the above fields in case certain input values are missing for a specific parcel, value is labeled as "N/A".

Figure 21: Parcel Information

Moreover, based on the needs of each pilot case, various datasets are displayed as layers on the top of the map, such as:

- Time-series of Sentinel-2 background optical imagery for viewing only
- Time-series of Sentinel-2 derived vegetation indices (NDVI, PSRI, NDWI, SAVI) for viewing only
- Habitat
- Natura sites
- Nitrate Vulnerable Zones
- Botanical Heritage Sites
- Watercourse maps
- Slope map (or DEM)
- Administrative boundaries and settlements
- Land Use/ Land Cover Maps, as detailed as possible
- ILOT and sub-ILOT
- LPIS (WMS or shp)

Moreover, through the platform, PAs/ inspectors and farmers can communicate directly and the farmers can ask them specific questions and the PAs can reply. In like manner, inspectors can reach out to the farmer to request specific information before the inspection.
Farmers can keep former BPS and they can have access to the auxiliary and supportive material that the PA uploads through the e-learning section in order to be informed and updated.

5.1.1.2 Agricultural Consultants

The Agricultural Consultants' interface is similar to the farmers' one. Based on the user requirement needs, agricultural consultants should be able both to create their own farm profile (if they have parcels too) and to handle their clients' profile. However, in the RECAP database, these users are categorized differently from the farmers.

5.1.1.3 Paying Agencies

The PAs can select from a list an inspector and assign to them farmers that should be inspected. The selected inspectors have access to the farmers' BPS.

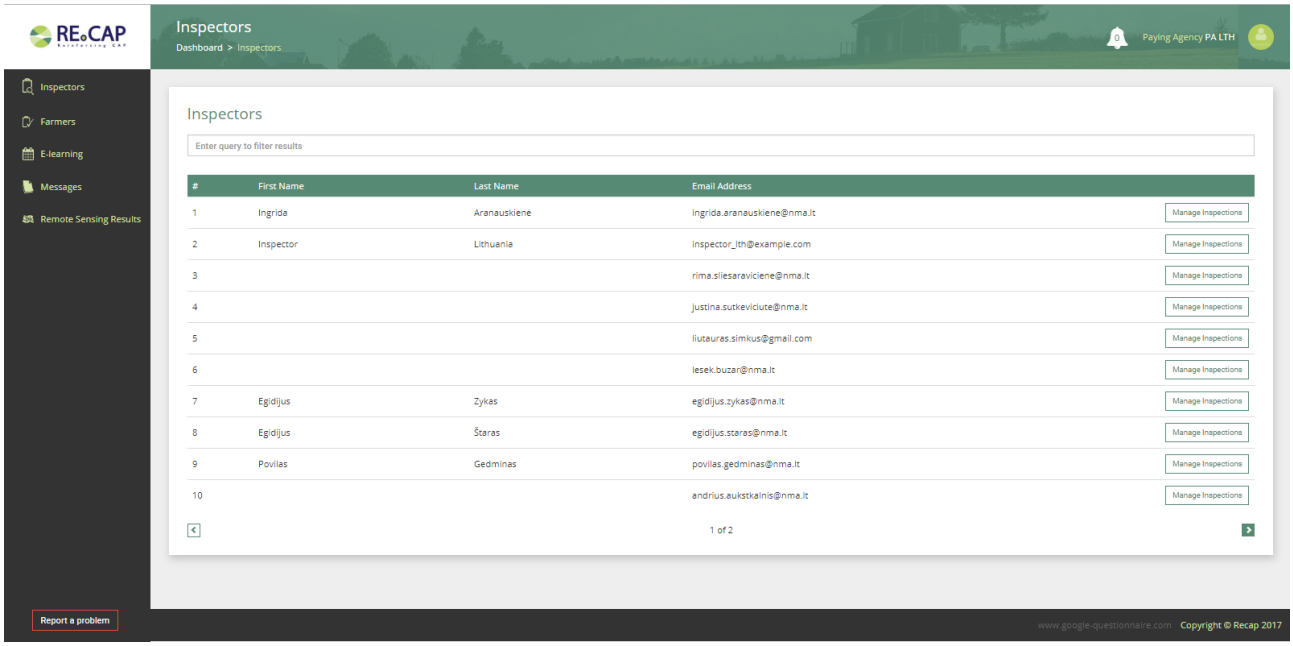


Figure 22: Inspectors management

Furthermore, the PA officers can view all the farmers registered in the RECAP platform and are under their jurisdiction. They are also able to view the farmers' details and the BPS history.

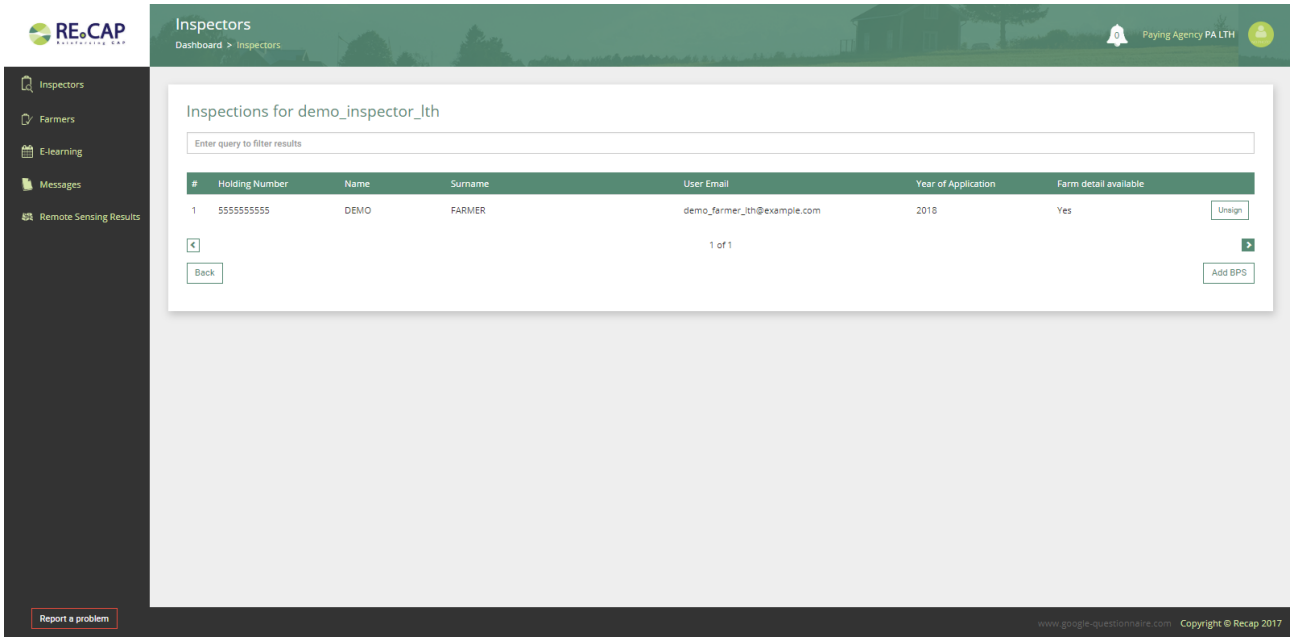


Figure 23: Farmer's details and BPS history

Another functionality of the final version of the RECAP platform is the e-learning tool. PAs in order to inform farmers about a new regulation and keep them updated, they are able to upload any auxiliary and supportive material in the e-learning section. These documents are visible from any user.

Furthermore, PAs can view the results and indices derived from the remote sensing component, such as image classification derivatives, risk estimation products and vegetation indices, as well as RGB satellite images, using a set of Sentinel-2 images. This information that is returned by the Remote Sensing component for each farmer's declared parcel, is combined with auxiliary data and used within the RECAP platform to provide indications about specific CC rules.

In addition, the Spatial component provides PA officers and inspectors access to the spatial information generated by the Remote Sensing component and external spatial data. With the use of maps the users are able to visualize information needed for the selection and inspection process.

The results from the Remote sensing component are also displayed in the form of map controls in the user interface. Moreover, the PAs are able to select a bounding box on the map from the area that they are interested in, which triggers the remote sensing processes and returns the results of the Remote sensing analysis.

This information is displayed in a larger scale than in farmer and inspector's profile. The PA officers can view the results for the entire area of interest.

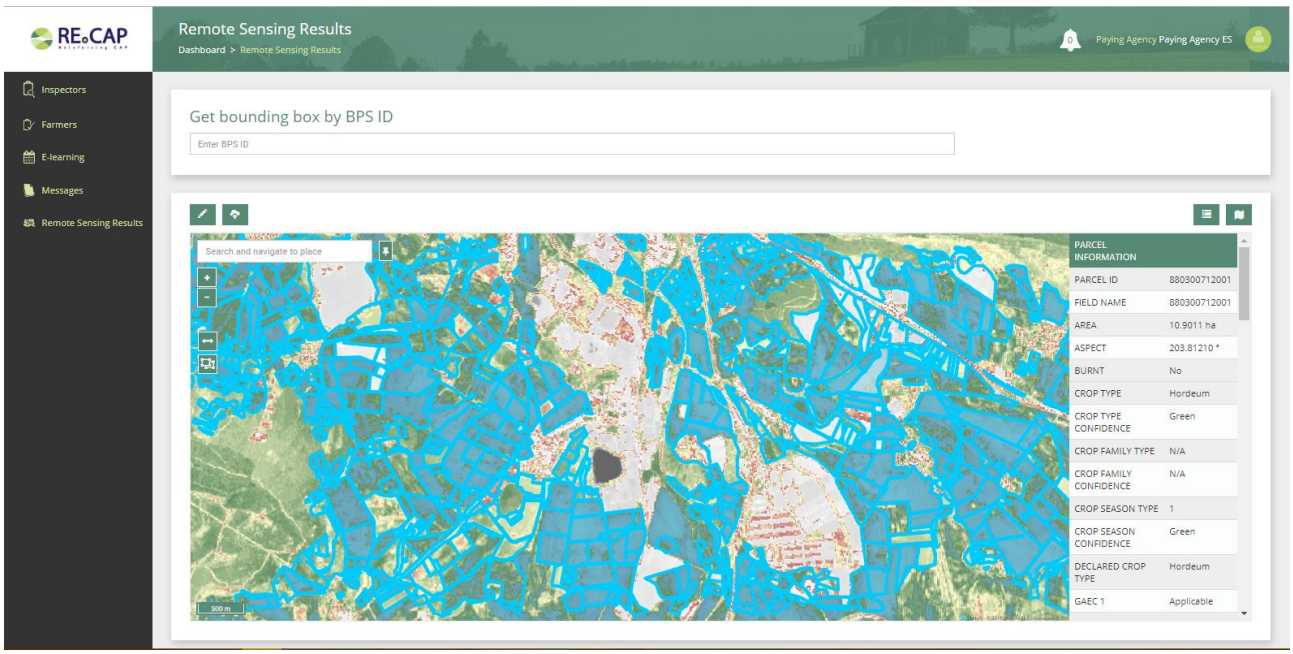


Figure 24: Remote sensing component view

5.1.1.4 Paying Agency Administrator

The Administrator has the same rights and functionalities with a PA officer. However, the administrator is responsible to make an inspector active and give them access to the RECAP platform.

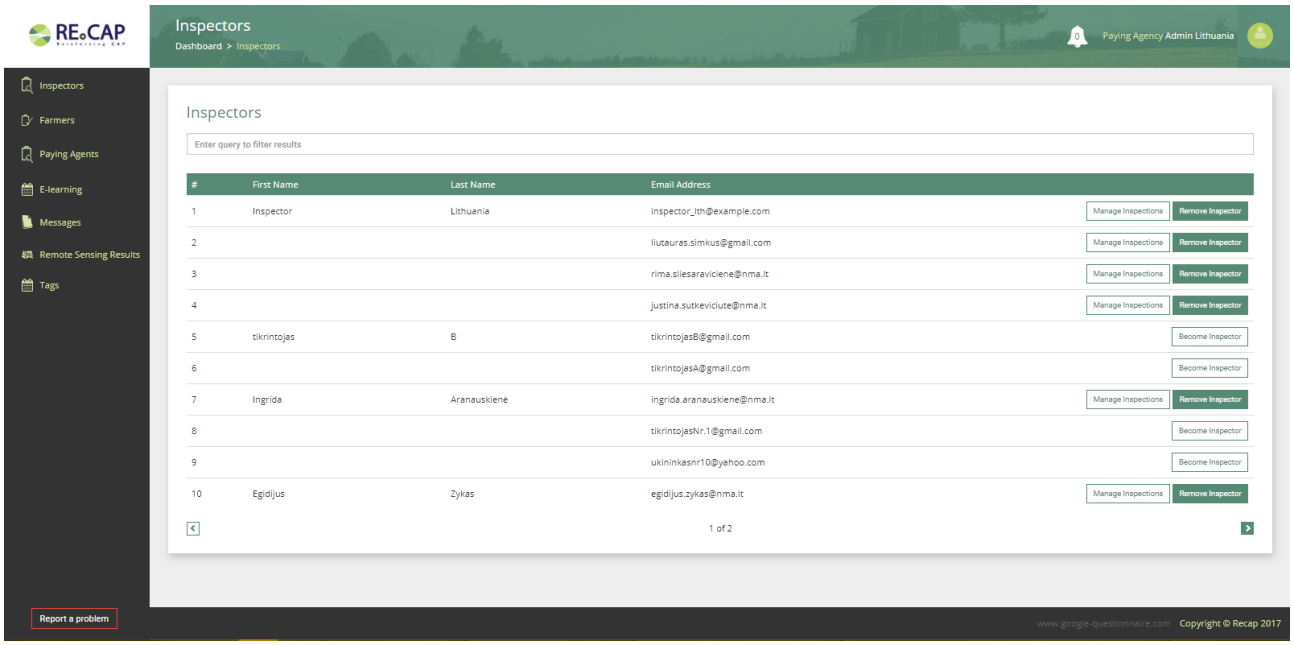


Figure 25: Manage inspectors

5.1.1.5 Inspectors

The inspectors are defined by the PA administrator and they are able to view all the relevant checklists and maps for the farmer that they inspect (if the farmer has made this information visible to them) in order to get ready for the inspection and help them decide if the inspected farmer is applicable/ compliant with the regulations or not.

The inspectors can view a list of the farmers that they have to inspect in the “Inspections menu” and select a farmer to open the inspection form.

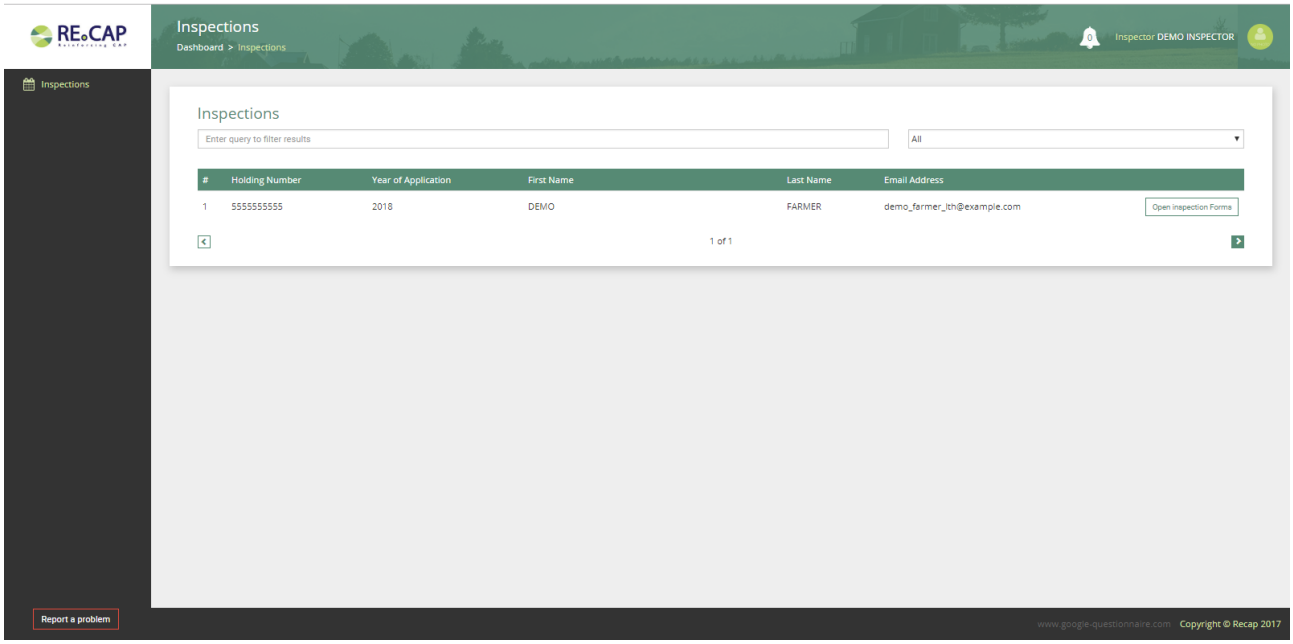


Figure 26: Inspections

Based on the farmer's BPS application, the respective checklists are displayed to the inspector. In addition, some of the checklist fields get prepopulated based on the information provided by the farmer, saving valuable time for the inspector and minimizing the possibility of entering wrong information.

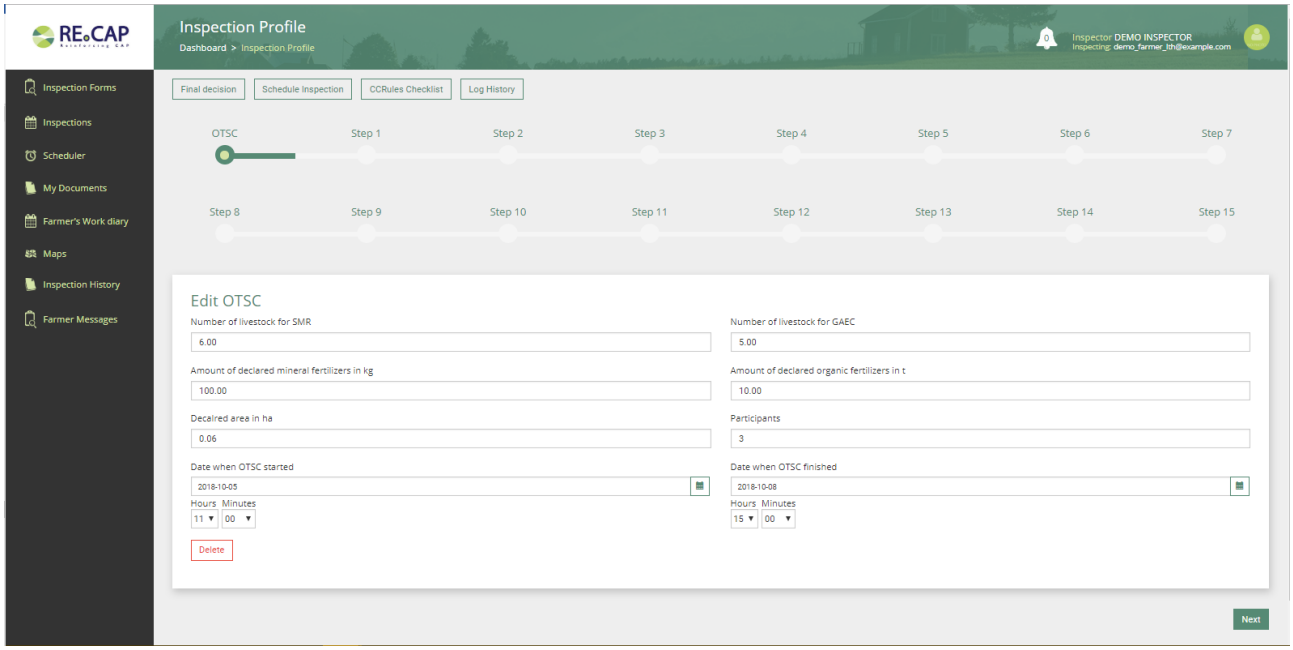


Figure 27: Inspection checklist

After the farmer's permission to give access to their information, inspectors can view which rules apply to the farmer and gain visibility to the farmer's documents, work diary and input/ outputs tables.

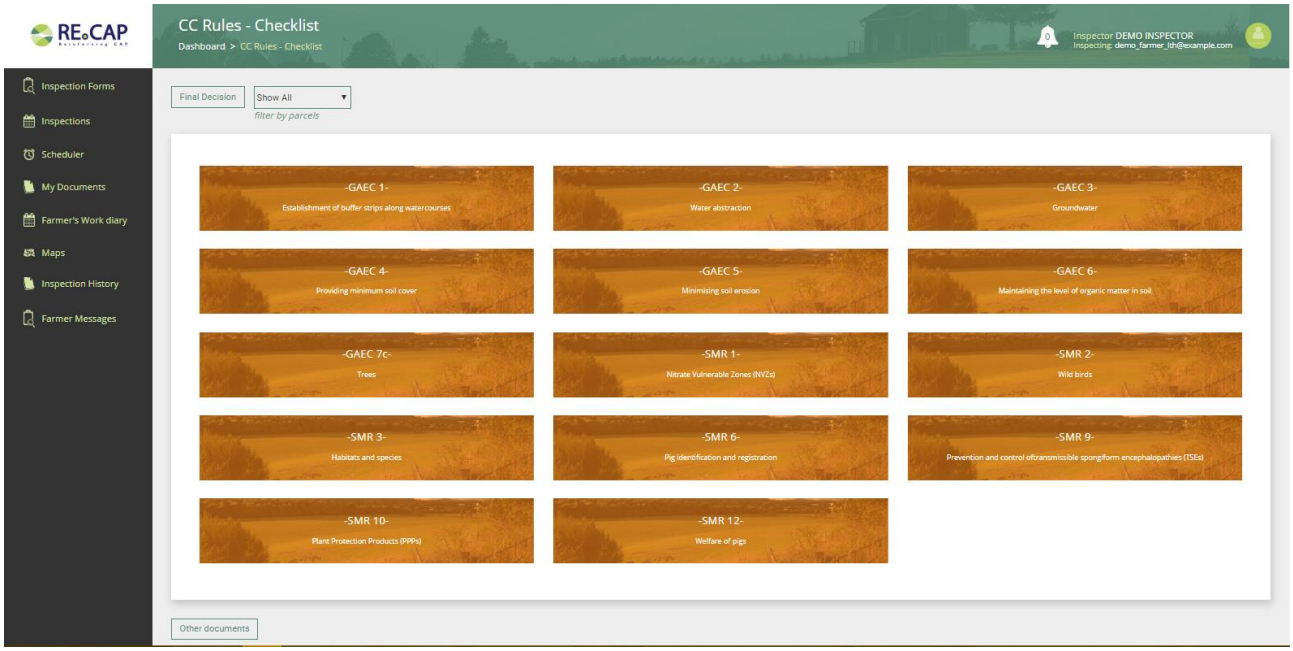


Figure 28: CC Rules checklists

Once the inspector fills in all the checklists with the relevant information, they can go to the "Final Decision" page. There they can define for each rule whether it is being followed by the farmer or not. When this task is finished, they can submit the final decision to the RECAP platform and a reporting email will be sent to the farmer and the PA.

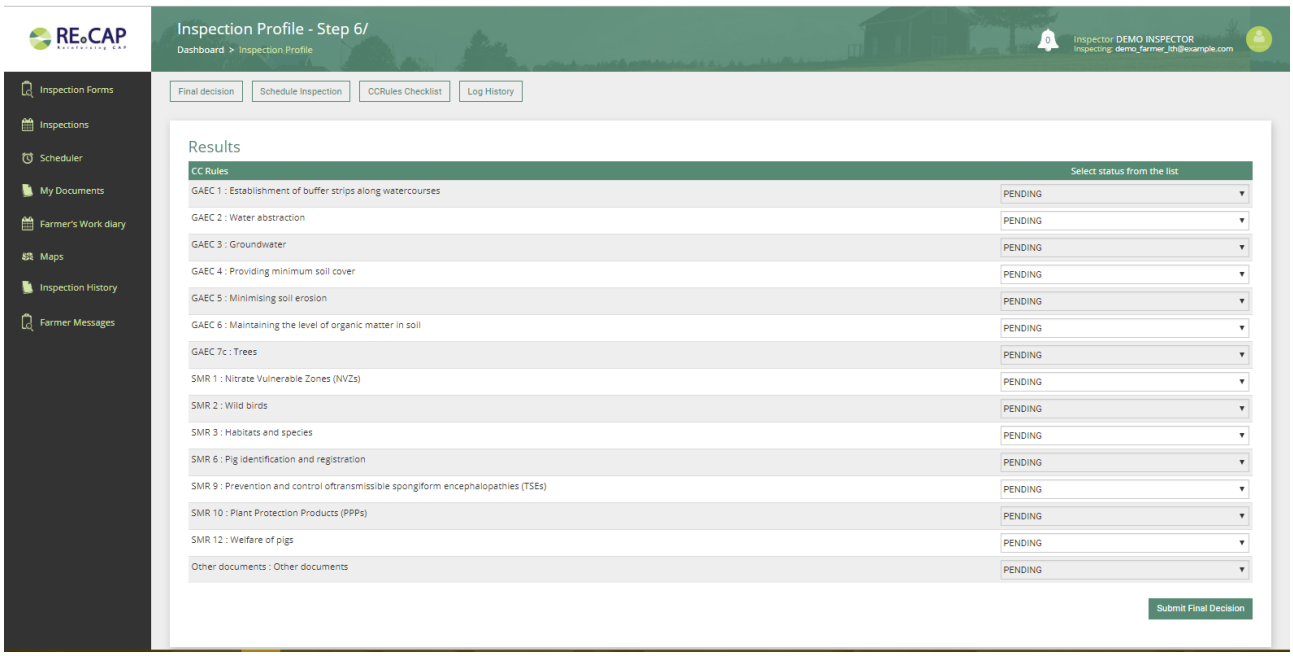


Figure 29: Final Decision

Furthermore, Scheduler allows inspectors to create and visualize inspection events. Inspectors can schedule an inspection and the farmer receives an email that contains the date that they will be notified about the coming inspection. A notification is also displayed within the farmer's application. Moreover, if the farmer has allowed access to their information, the inspector can view their scheduled events.

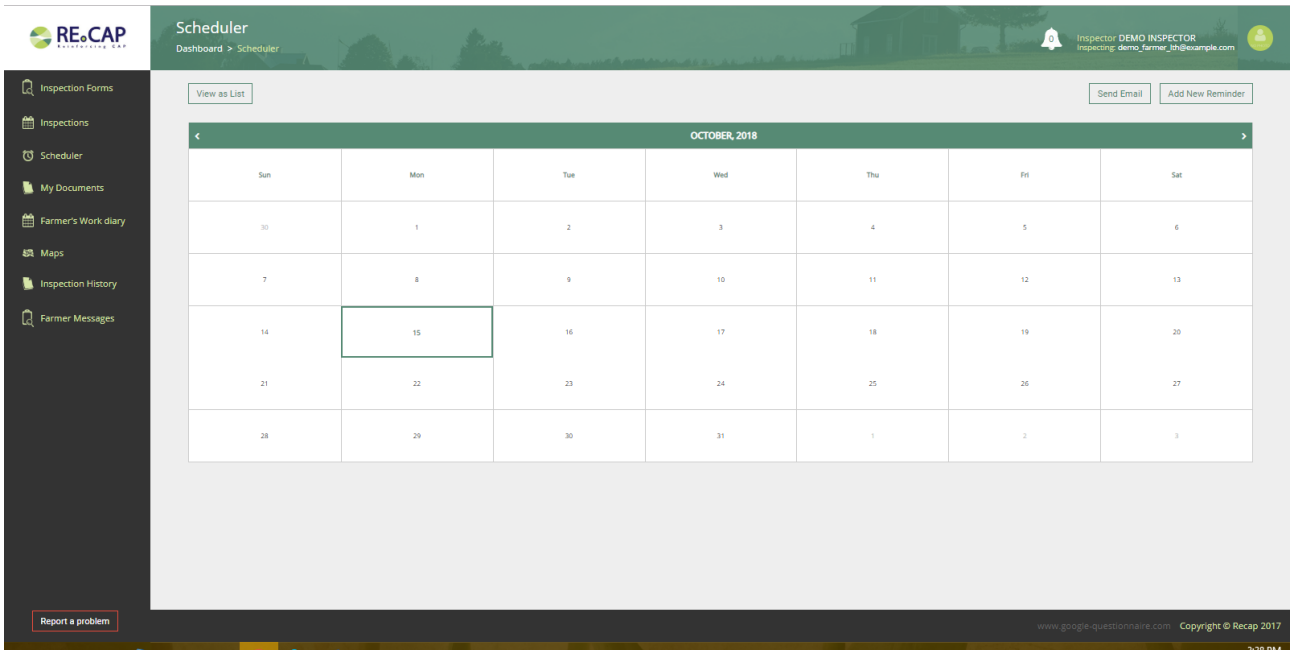


Figure 30: Scheduler

Finally, the inspector is able to view the results and the indices derived from the Remote Sensing component for the farmer's parcels.

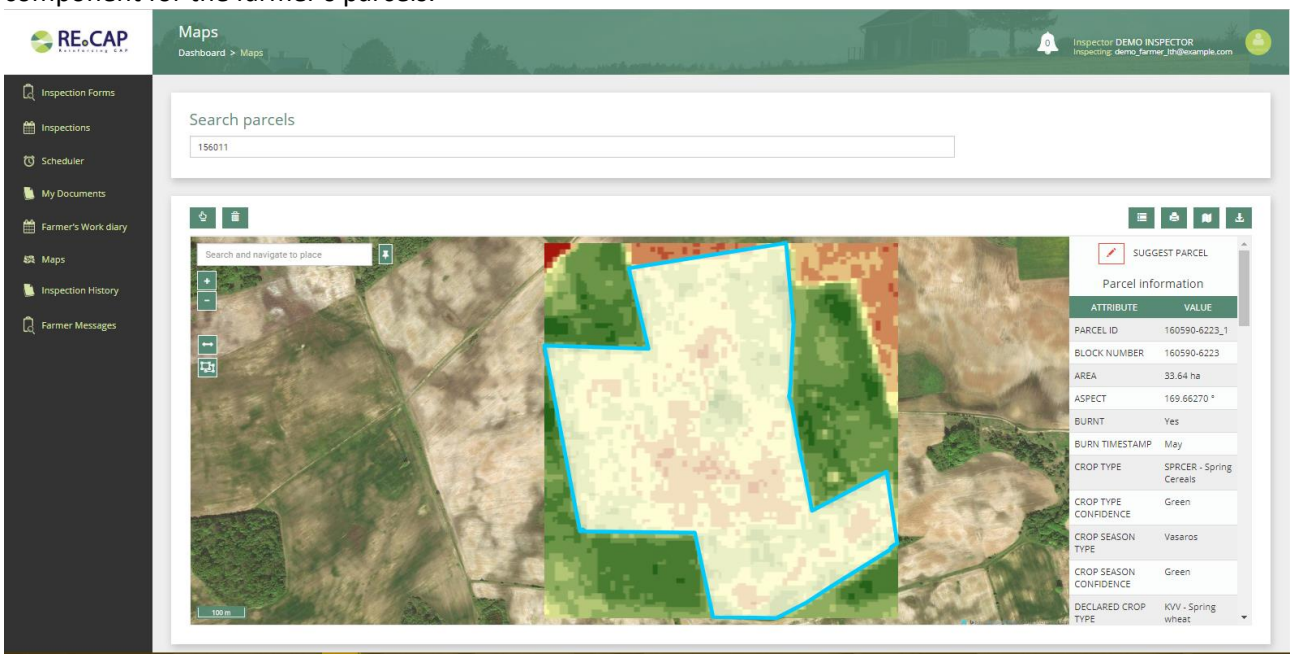


Figure 31: Remote sensing component view

5.1.2 Mobile Application

Two mobile applications were developed; a smartphone optimized application dedicated to the farmers' needs and another one focusing on the inspectors' needs. The mobile application is mainly for the data collection on the farmer's field either from the farmer or from the inspector for on-the-spot checks. Consequently, the mobile app is a secondary user environment as the main one is the web application.

5.1.2.1 Farmers

Using the mobile application, the farmers are able to view the CC Rules – Checklist based on the data they have entered through the web application and also view the tasks that they should perform in order to be compliant (Figure 32).

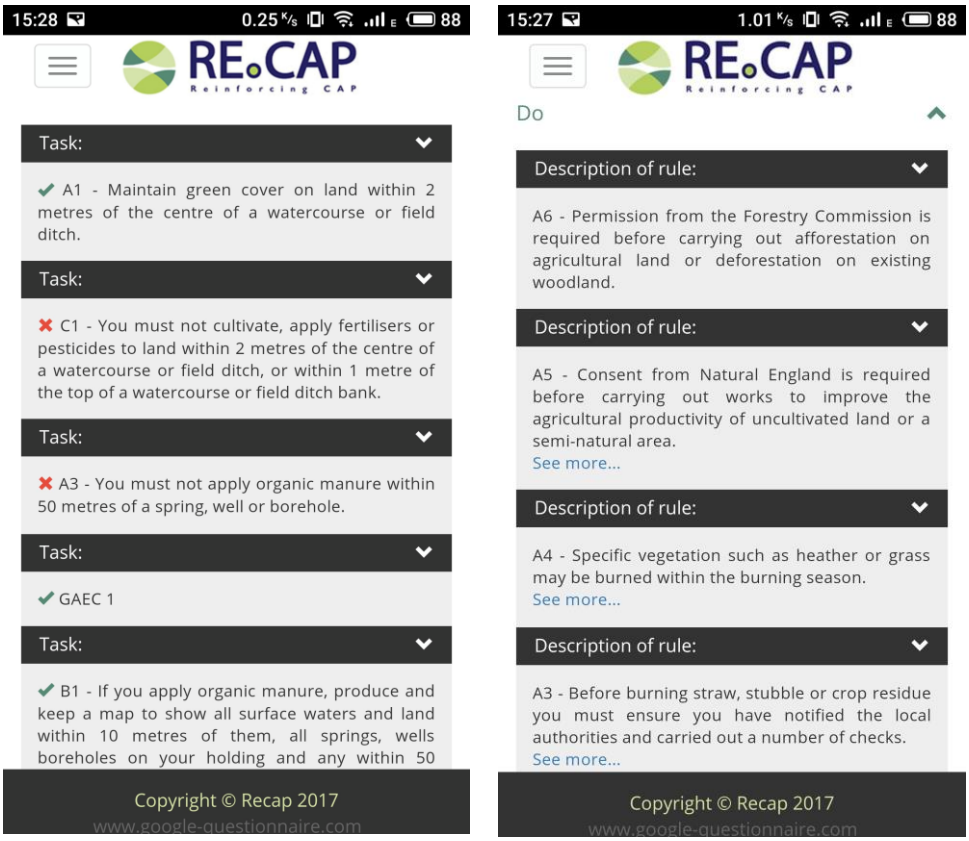


Figure 32: CC rules tasks

Furthermore, the farmers are able to collect and store timestamped and geotagged photos from their fields on the My Documents menu. Specifically, the farmer is able to take photos from within the mobile application and they can view/ upload/ delete/edit all the documents and/ or images uploaded to RECAP and apply filters based on type/ tags/ CC rules, etc.

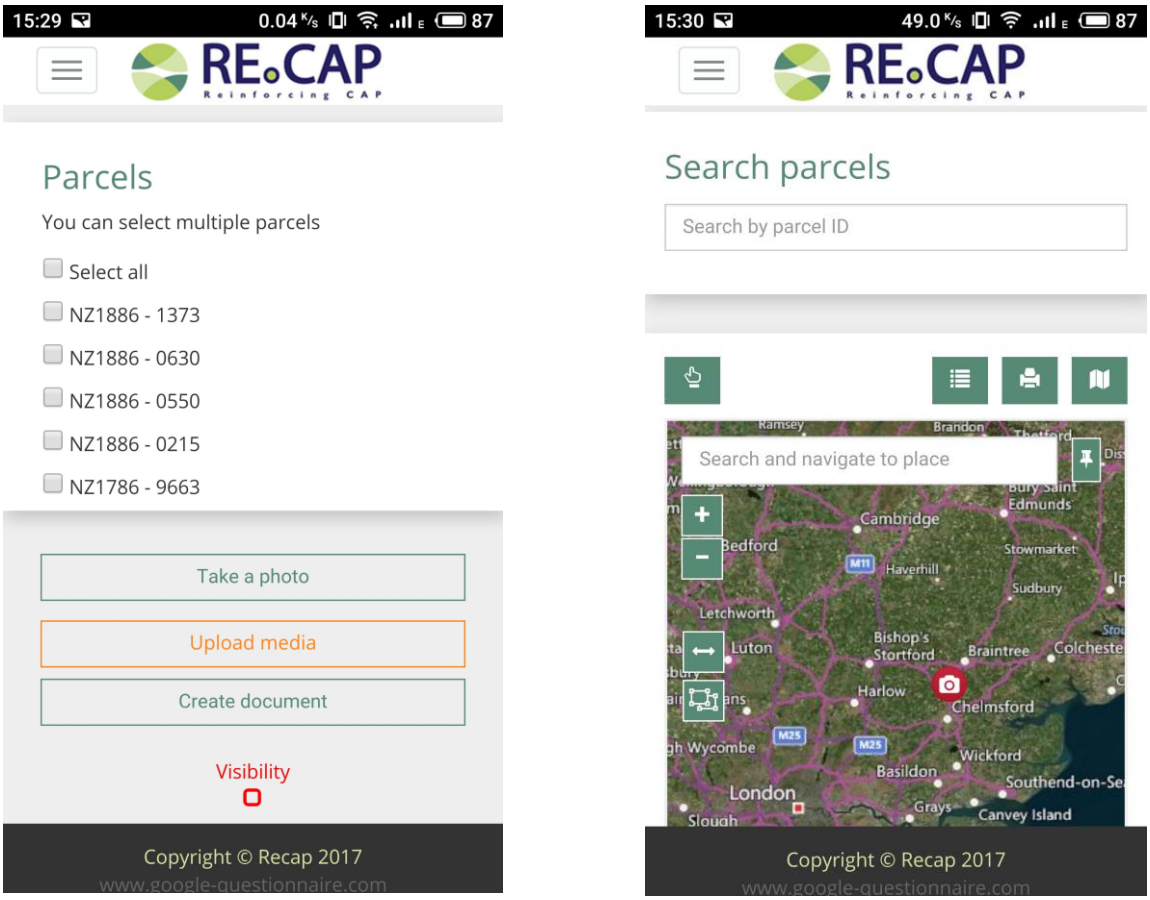


Figure 33: Upload of geotagged photo

Farmers are able to view their declared parcels along with various datasets displayed as layers on the top of the map and indices derived from the remote sensing component.

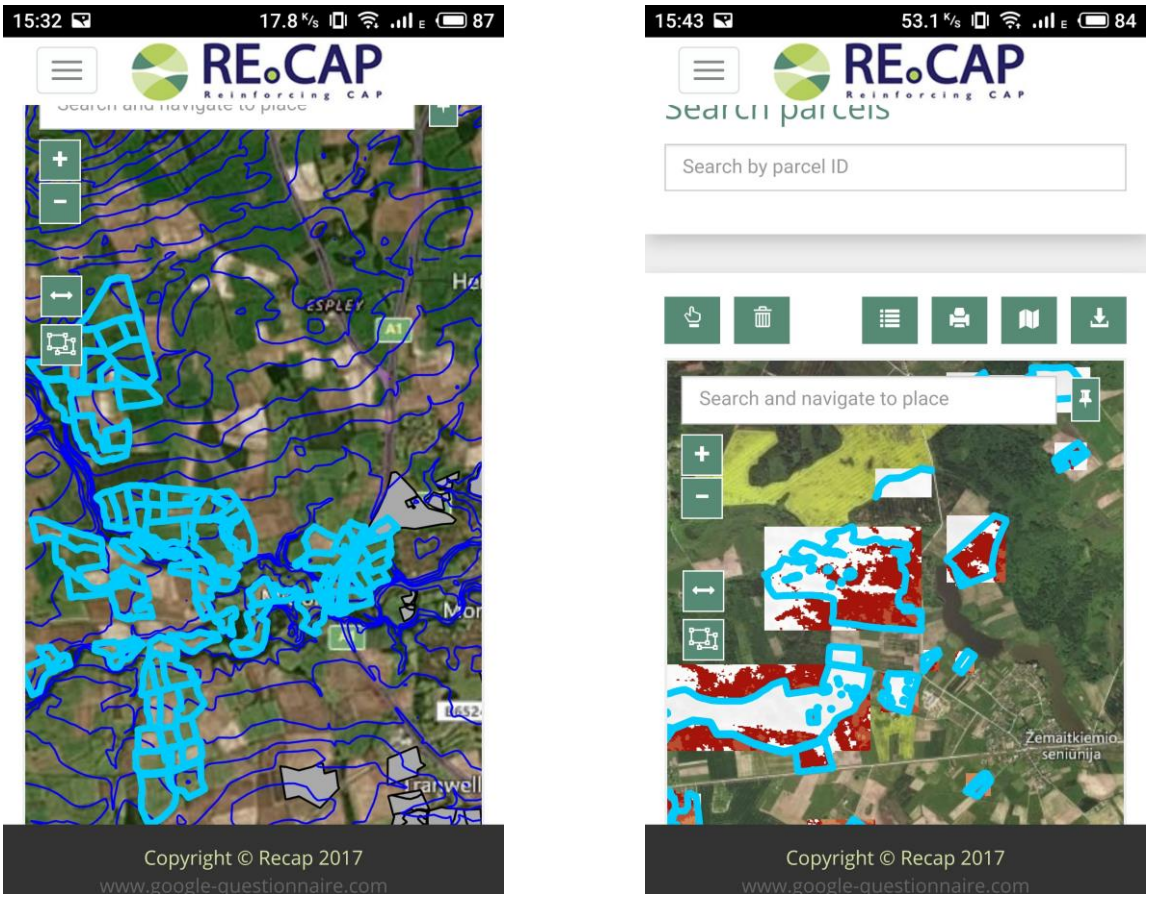


Figure 34: Spatial component view

5.1.2.2 Inspectors

The Inspectors are able to access the data related to the farm to be inspected either from the web application or from the mobile app. This is due to the necessity of having access to any data needed for OTSC.

The inspectors are able to fill in the inspection forms and view the CC Rules – checklists during the inspection process through their mobile phones and can also take photos from within the app and upload them to the RECAP database (Figure 35) when connected to internet (offline mode).

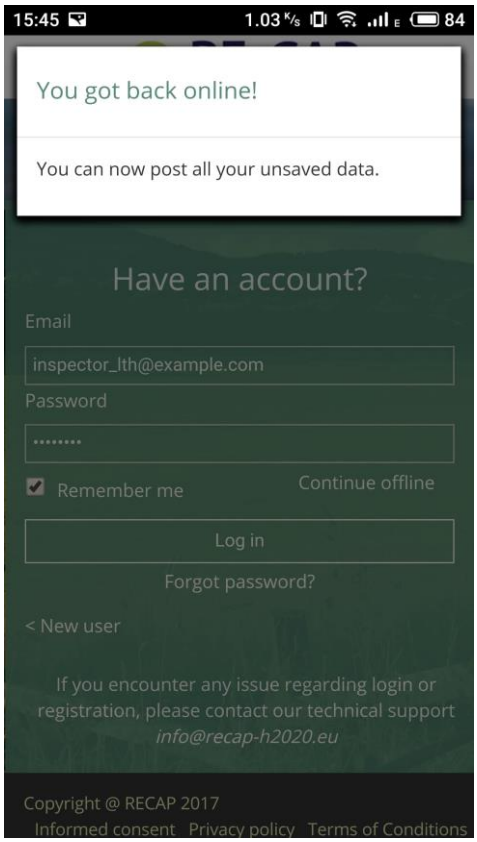


Figure 35: Offline mode

The inspectors are able to view all the declared parcels of the farmer as well as the results and indices derived from the Remote Sensing component.

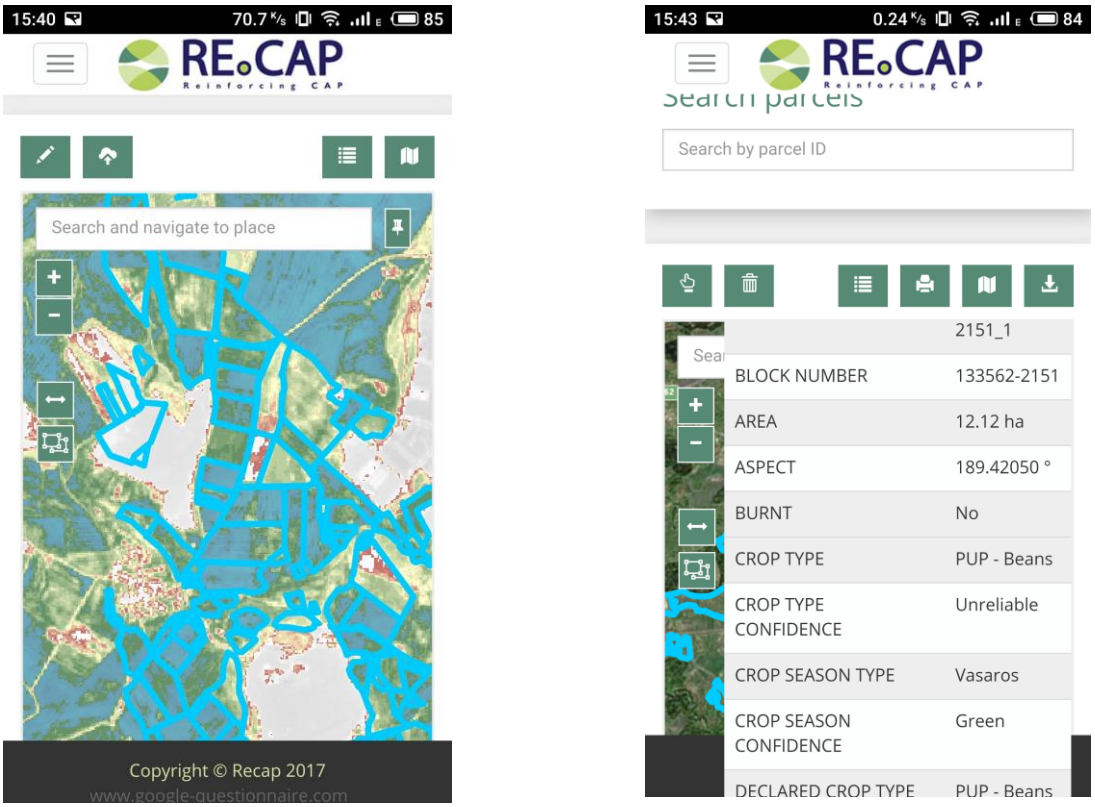


Figure 36: Remote Sensing component view

5.2 Annex II – Remote Sensing variables

5.2.1 Aspect

The field named 'Aspect' refers to the orientation of the primary slope of the parcel. The 'Aspect' values are given in degrees and can be translated in cardinal directions according to the following figure.

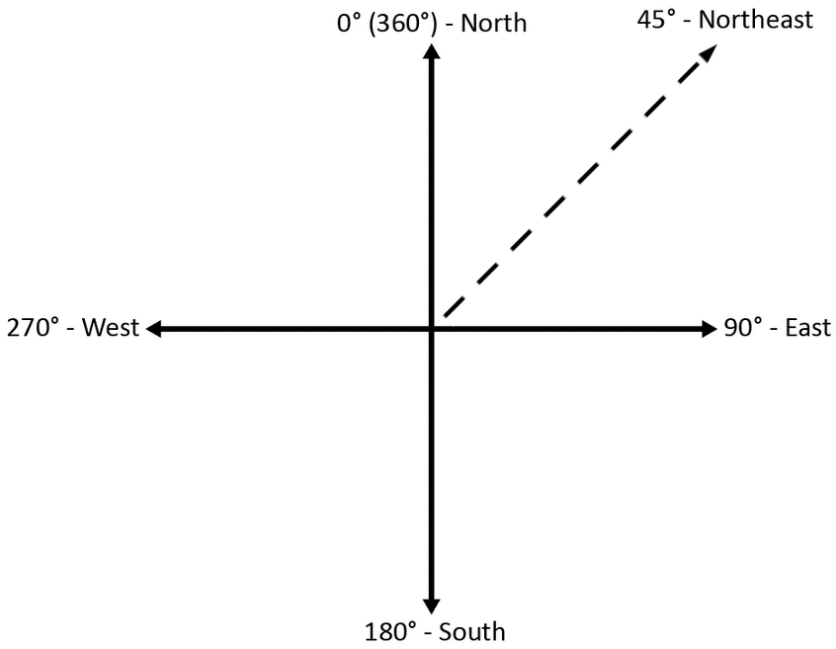


Figure 37: Aspect Values and cardinal directions

5.2.2 Burnt

The field 'Burnt' can take only two values and that is either 'No' or 'Yes', if stubble burning was not identified or if it was indeed identified, respectively.

5.2.3 Burn timestamp

The field named 'Burn timestamp' refers to the month that stubble burning was first identified (January-December). If stubble burning never occurred for the parcel in question, the value would be 'None'.

5.2.4 C factor

C is the cover-management factor. The C-factor is used to reflect the effect of cropping and management practices on erosion rates. It is the factor used most often to compare the relative impacts of management options on conservation plans. The C-factor indicates how the conservation plan will affect the average annual soil loss and how that soil-loss potential will be distributed in time during construction activities, crop rotations or other management schemes.
If a C factor of 0.15 represents the specified cropping management system, it signifies that the erosion will be reduced to 15 percent of the amount that would have occurred under continuous fallow conditions. The C factor in Michigan, for example, ranges from 0.005 for continuous low residue grass/hay to 0.50 for continuous row crops with low residue returned to the soil. C factors are also available for pastureland, wildlife land, idle land, and woodland uses.
As a rule of thumb values below 0.1 refer to very low erosion rates, based on the cropping practices that the cultivated crop type implies. In the same manner values 0.1-0.25 are considered as low-medium, 0.25-0.35 as medium-high and finally 0.35-0.5 as high.

5.2.5 Crop type/Crop family type/Seas type

The fields named 'Crop type', 'Crop family type' and 'Seas type' refer to the estimation of the cultivated crop type (e.g. soft wheat), the crop family (e.g. cereals) and the season of cultivation (e.g. winter), respectively. The estimation is based on a machine learning based supervised classification scheme. The crop type field is the lowest level of crop type description and can be used for the Greening 1 compliance checks.

5.2.6 Crop type/Crop family type/Seas type confidence

These fields describe the confidence of classification decision for each parcel and for each classification level (i.e. type, family, season). The possible values are green, yellow, red or unreliable. This is the so called traffic light system with green being an almost completely trustworthy decision, yellow a less reliable but still usable decision, and red and unreliable being decisions of low confidence (these should be used with caution). When the crop type classification for example is given with green confidence and does not agree with the declaration is an indication of potential wrongly declared crop type.

5.2.7 K factor

K factor is soil erodibility factor which represents both susceptibility of soil to erosion and the rate of runoff, as measured under the standard unit plot condition. Soils high in clay have low K values, about 0.05 to 0.15, because they resistant to detachment. Coarse textured soils, such as sandy soils, have low K values, about 0.05 to 0.2, because of low runoff even though these soils are easily detached. Medium textured soils, such as the silt loam soils, have a moderate K values, about 0.25 to 0.4, because they are moderately susceptible to detachment and they produce moderate runoff. Soils having high silt content are most erodible of all soils. They are easily detached; tend to crust and produce high rates of runoff. Values of K for these soils tend to be greater than 0.4.

5.2.8 Soil index

This is a soil erosion index that is the product of the K and C factor, indicating a combined effect on erodibility, based on the cropping practices, dependent on the cultivated crop type (C-factor), as well as the type of soil (K-factor). This field is used to identify parcels prone to soil erosion and can be used for an educated sampling of inspections for the GAEC 5 requirement that attempts to minimize soil erosion from cropping practices.

5.2.9 Rusle

This is the output of the Revised Universal Soil Loss Equation (RUSLE). The RUSLE was developed from erosion plot and rainfall simulator experiments. The USLE is composed of six factors to predict the long-term average annual soil loss (A). The equation includes the rainfall erosivity factor (R), the soil erodibility factor (K), the topographic factors (L and S) and the cropping management factors (C and P).

$A = R * K * LS * C * P$

K and C factors are introduced above, as they are given as separate products, but also as a combined factor. R is the rainfall-runoff erosivity factor. It is the average annual summation (EI) values in a normal year's rain. The erosion-index is a measure of the erosion force of specific rainfall. When other factors are constant, storm losses from rainfall are directly proportional to the product of the total kinetic energy of

the storm (E) times its maximum 30-minute intensity (I). Storms less than 0.5 inches are not included in the erosivity computations because these storms generally add little to the total R value. R factors represent the average storm EI values over a 22-year record. R is an indication of the two most important characteristics of a storm determining its erosivity: amount of rainfall and peak intensity sustained over an extended period. L is the slope length factor, representing the effect of slope length on erosion. It is the ratio of soil loss from the field slope length to that from a 72.6-foot (22.1-meter) length on the same soil type and gradient. Slope length is the distance from the origin of overland flow along its flow path to the location of either concentrated flow or deposition. Fortunately, computed soil loss values are not especially sensitive to slope length and differences in slope length of + or – 10% are not important on most slopes, especially flat landscapes. S is the slope steepness and represents the effect of slope steepness on erosion. Soil loss increases more rapidly with slope steepness than it does with slope length. It is the ratio of soil loss from the field gradient to that from a 9 percent slope under otherwise identical conditions. The relation of soil loss to gradient is influenced by density of vegetative cover and soil particle size. P is the support practice factor. The RUSLE P-factor reflects the impact of support practices on the average annual erosion rate. It is the ratio of soil loss with contouring and/or stripcropping to that with straight row farming up-and-down slope.
As a rule of thumb, low RUSLE values are between 0-4, medium values between 4-8, high values 9-15, very high values >15.

5.2.10 Water prox

This is the water proximity field. The value is calculated based on the average orientation of the primary slope of each parcel and the shortest distance from each parcel's vertex to the nearest watercourse. Then:

- Calculate the orientation of each proximity distance with respect to the North, so as to be comparable with the slope orientation measurements.
- Set an angle range of +-60 degrees and accept all proximity distances falling within this range as compared to the respective parcel's aspect.
- Record the lowest of the remaining proximity distances for each parcel
- All parcels without any nearby watercourses in the general orientation of their slope are exempted.

Therefore, the output value of 'water prox' is in meters and refers to the shortest distance to nearby watercourses, for watercourses that are in the same orientation as the parcel's slope. This product, together with 'Rusle' and 'Risk index' is for the monitoring of SMR1 and GAEC 1. According to those requirements the distance buffers of interest are 0-10 meters, 10-50 meters and larger than 50 meters.

5.2.11 Risk index

This field is a combination of the 'water prox' and 'Rusle' fields according to the following table. The values low, medium, high and extreme describe the risk of soil and/or water runoff to nearby watercourses and should be consulted for compliance for SMR1 over the nitrate vulnerable zones.

RISK INDEX	**RUSLE**			
	LOW 0-4	**MEDIUM** 4-8	**HIGH** 9-15	**VERY HIGH** >15

Proximity					
	NEGLIGIBLE > 50 meters	LOW (1)	LOW (2)	MEDIUM (5)	MEDIUM (6)
	MARGINAL 10-50 meters	LOW (4)	MEDIUM (6)	HIGH (8)	EXTREME (11)
	CRITICAL < 10 meters	HIGH (6)	HIGH (7)	HIGH (9)	EXTREME (12)

Table 2: Risk index combinations

5.2.12 Slope

This field refers to the average slope of the parcels in degrees.

5.2.13 NDVI, PSRI, NDWI, SAVI

These fields refer to the average value per parcel for the four vegetation indices, for all images.

NDVI (from -1 to 1)
This most known and used vegetation index is a simple, but effective VI for quantifying green vegetation. Low values of NDVI correspond to non-vegetation cover, which are colored from black to white in the layers tab. Black color shows water-related features. Transition to white color indicates cover such as snow, rock, wet soil and dry soil. Intermediate values of NDVI correspond to shrubs, grassland or arable land and are displayed with red to green color transition. High values of NDVI reveal dense vegetation or tropical rainforest or dense vegetation and are colored with shades of blue.

PSRI (from 0 to 1)
An increase in PSRI indicates increased canopy stress, the onset of canopy senescence, and plant fruit ripening. The PSRI is designed to maximize sensitivity of the index to the ratio of bulk carotenoids to chlorophyll.
High values of PSRI are marked as blue Intermediate values of PSRI are colored from green to red Low values of PSRI are mapped with black and white indicating no vegetation cover.

NDWI (from -1 to 1)
The Normalized Difference Water Index (NDWI) is a remote sensing derived index estimating the leaf water content at canopy level. The NDWI is an indicator sensitive to the change in the water content of leaves and is useful for drought monitoring.
High values of NDWI (in blue and dark blue) correspond to high vegetation water content and to high vegetation fraction cover. Intermediate NDWI values (red, orange and ending to blue) correspond to increasing vegetation water content and fraction cover. Low NDWI values (in black and white) correspond to low vegetation water content and low vegetation fraction cover. In period of water stress, NDWI will decrease.

SAVI (from -1.5 to 1.5)
The soil-adjusted vegetation index was developed as a modification of the Normalized Difference Vegetation Index to correct for the influence of soil brightness when vegetative cover is low.

High values of SAVI are related to dense vegetation or tropical rainforest and marked as blue. Intermediate values of SAVI are colored from red (rock, bare soil or buildings), light green (agriculture) and dark green (dense vegetation and forests). Low values of SAVI are mapped with black and white indicating water-related features.

5.3 Annex III – SDK Usage Scenarios

Scenario 1. Get List of Documents

```
require_once(__DIR__ . '/vendor/autoload.php');
$recapSDK = new Swagger\Client\Api\DefaultApi();

try {
    $user = $recapSDK->login();   // Login to ReCAP system
    $documents = $recapSDK->apiDocumentTypeListGET();

    foreach($documents as $document) {
        echo 'Id : '. $document->getId() .PHP_EOL;
        echo 'Label : '. $document->getLabel() .PHP_EOL;
        echo 'Url :' .$document->getUrl() . PHP_EOL;
        echo '-'.PHP_EOL;
    }

} catch (Exception $e) {
    echo 'Exception when calling DefaultApi->identityOauthTokenGet: ', $e->getMessage(), "\n";
}
```

Output Results

```
Id : 3
Label : Image
Url :https://app.recap-h2020.eu/backend/api/documents/document_types/3/
-
Id : 2
Label : Office document
Url :https://app.recap-h2020.eu/backend/api/documents/document_types/2/
-
Id : 1
Label : PDF document
Url :https://app.recap-h2020.eu/backend/api/documents/document_types/1/ -
```

Scenario 2. Get User's Reminders

```
$user = $recapSDK->login();   // Login to ReCAP system, Get User's details
$reminders = $recapSDK->apiUserReminderListAllRemindersGET($user->getPk());

 foreach($reminders as $rem) {
      echo 'Author Name : '. $rem->getAuthorName() .PHP_EOL;
      $reminder = json_decode($rem->getReminder());
      echo 'Reminder Description : '.$reminder->description.PHP_EOL;
      echo 'Reminder Date : '.$reminder->date;
      echo '-'.PHP_EOL;
  }
```

Output Results

```
Author Name : GEORGE LTH
Reminder Description : Farmer GEORGE LTH has sent you a message
Reminder Date : 2018-10-09T16:30:10+03:00
```