D3.1 Overall architecture, system design and integration framework specification

WP3 DIANA service platform design and development

Stavros Tekes

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 130709.

Disclaimer

Any dissemination of results reflects only the author's view and the European Commission is not responsible for any use that may be made of the information it contains.

Copyright message

Document Information

Grant Agreement Number	130709	Acronym		DIANA
Full Title	Detection and Integrated Assessment of Non-authorised water Abstractions using EO			
Horizon 2020 Call	EO-1-2016: Downstream applications			
Type of Action	Innovation Action			
Start Date	1st January 2017	**Duration**		36 Months
Project URL	https://diana-h2020.eu/			
Document URL	-			
EU Project Officer	Iulia SIMON			
Project Coordinator	Polimachi Simeonidou, Anna Osann			
Deliverable	D3.1: Overall architecture, system design and integration framework specification			
Work Package	WP3 – DIANA service platform design and development			
Date of Delivery	**Contractual**	M13	**Actual**	M15
Nature	R – Report	**Dissemination Level**		CO - Confidential
Lead Beneficiary	AgroApps			
Lead Author	Stavros Tekes	**Email**	stavros@agroapps.gr	
	AgroApps	**Phone**	00302310253810	
Other authors	Apostolos Agrafiotis (AgroApps), Stelios Kotsopoulos (AgroApps)			
Reviewer(s)	Reviewers (Affiliation)			
Keywords	Architecture, System design, Integration, Specifications, Technical requirements			

Document History

Version	Issue Date	Stage	Changes	Contributor
0.1	8-1-2018	Draft	Initial structure	AGROAPPS
0.2	12-1-2018	Draft	Development methodology	AGROAPPS
0.3	17-1-2018	Draft	Mapping of UR, GR + first version of TR	AGROAPPS
0.4	18-1-2018	Draft	Revised version of TR	AGROAPPS
0.5	23-1-2018	Draft	First version of architecture	AGROAPPS
0.6	26-1-2018	Draft	Revised architecture, Added integration framework, Added wireframes	AGROAPPS
0.7	5-2-2018	Draft	Revised TR, architecture	AGROAPPS
0.8	12-2-2018	Draft	Finalized architecture	AGROAPPS
0.9	21-2-2018	Draft	Added revised wireframes	AGROAPPS
1.0	22-2-2018	Draft	Added mapping or UR+GR to TR	AGROAPPS
1.5	1-3-2018	Draft	Review feedback	AGROAPPS
2.0	9-3-2018	Final	Final version	AGROAPPS

Table of Figures

Table of Tables

Executive summary

This document presents deliverable *"D3.1: Overall architecture, system design and integration framework specification"* of the DIANA project. The aim is to report both the design of the overall system and the platform architecture. This deliverable provides detailed information about:

- an indicative analysis of features offered by competitor products/services,
- key functional and non-functional requirements along with their mapping to the user requirements that they originated from,
- the implementation approach that will be followed in DIANA, including the methodologies for software development, technical documentation management, source code repository management and deployment,
- the system architecture,
- the information flow that demonstrate the integration of components into the overall platform and
- wireframes that depict the envisioned functionalities described by the technical requirements

This deliverable is based on the aggregated outcomes of the co-creation workshops (Task 1.2) and on DIANA services definition (Task 1.3) that were held during M12 and it is essential to support the first version of DIANA service platform (Task 3.2). Moreover, this document is a living one, since minor adaptations to the DIANA system architecture and its components will be performed throughout the duration of the pilots, according to the users' feedback.

1. Development Methodology

Software development projects are resource intensive, requiring money and time in order for a completed final product to be delivered on a timely manner. A way of managing such projects is through the implementation of a software development methodology that would promote a disciplined project management to structure, plan and control the process of developing a system within reasonable timeframe and without extra effort and costs.

Several approaches have been presented and used to deliver a software product in order to reduce time and cost of its development, without reducing the product's quality[1]. Nevertheless, none of those is one solution that fits all. The most common software development methodologies are: Waterfall; Iterative and Agile. Each methodology has its own advantages and disadvantages[2].

Waterfall is the traditional method of software development[3]. Waterfall models are sequential models and follow a linear process. Key characteristic of Waterfall method is the phase separation; every stage starts only after the previous has been completed and the input of one phase is the result of the previous phase (Figure 1). Furthermore, Waterfall's rigid nature and linearity makes it easier to use and manage and allows a well-documented approach. However, the major disadvantage faced when using the method is the difficulty to handle changes in the middle of a development stage.

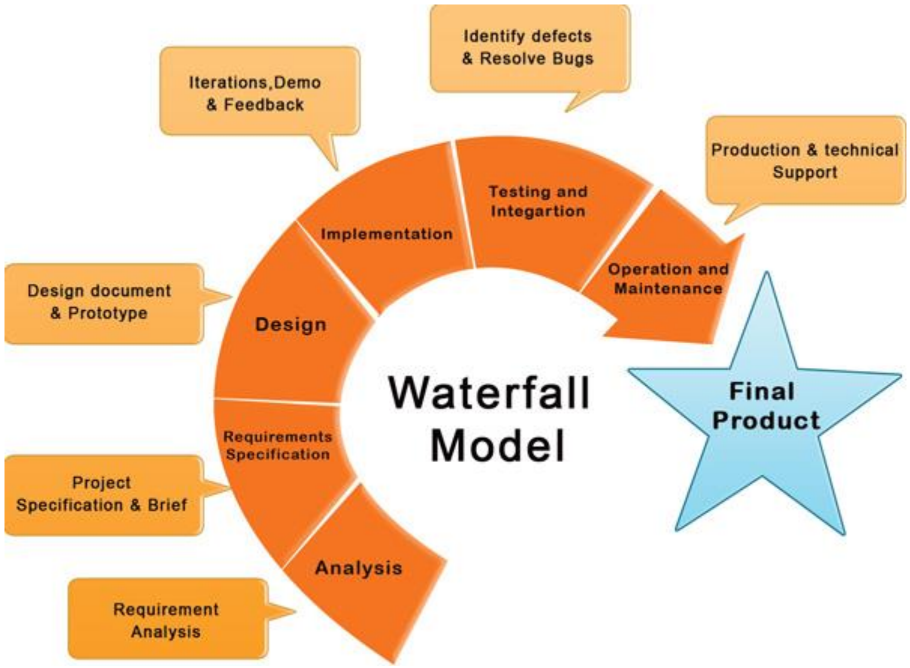

Figure 1: Waterfall software development process

[1] Elisio Maciel Simao, Comparison of Software Development Methodologies based on the SWEBOK, 2011

[2] Karl Wiegers and Joy Beatty, Best Practices, Software requirements, Third edition, 2013

[3] David C. Young, Software Development Methodologies, Alabama Supercomputer Center, 2013

Source: http://cyclosys.com/practices/methodologiesframework

On the other hand, Iterative methodology (Figure 2) is less risky than Waterfall. Iterative is a methodology that relies on building the software application one step at the time in the form of an expanding model[4] and introducing interactions between end-users and prototype versions of the software. These interactions aim to redesign the software in order to fully meet users' requirements. However, this approach also has disadvantages such as the fact that each phase is rigid with no overlaps. This means that issues may arise and be restrictive for the system architecture due to the lack of a full listing of requirements specification for the entire system.

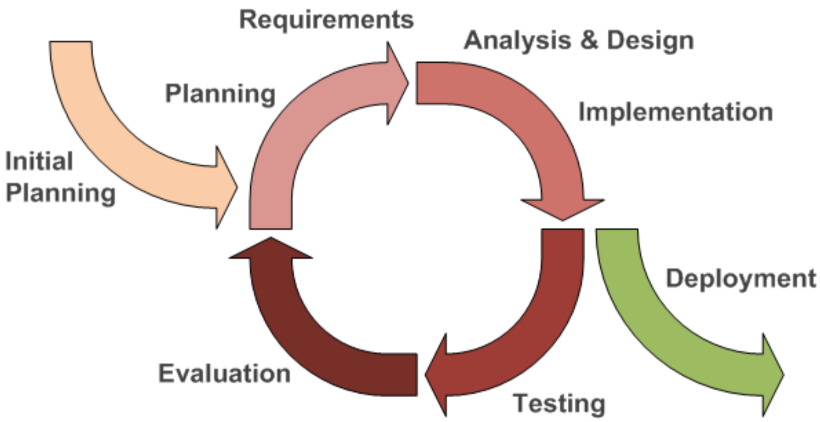

Figure 2: Iterative software development process

Source: http://cyclosys.com/practices/methodologiesframework

Agile methodology (Figure 3) surpasses the disadvantages of the previous two methodologies and it is an umbrella term that includes more agile methodologies (e.g. Scrum, XP, Crystal, FDD and DSDM)[5]. It is based on the combination of iterative and incremental approaches and it is open to changing requirements over time and encourages continuous feedback from the end-users. Agile methodology aims to shorten the time period between the decision making process and the feedback gained from the beta users. Therefore, Agile methods focus on flexibility, constant improvement and speed. However, it can be hard to establish a solid delivery date or the final product can be quite different from what was initially described.

[4] C. Larman, V. R. Basili, "Iterative and Incremental Development: A Brief History", Computer, vol. 36, no. 6, pg. 47- 56, 2003, doi:10.1109/MC.2003.1204375

[5] https://en.wikibooks.org/wiki/Introduction_to_Software_Engineering/Process/Agile_Model

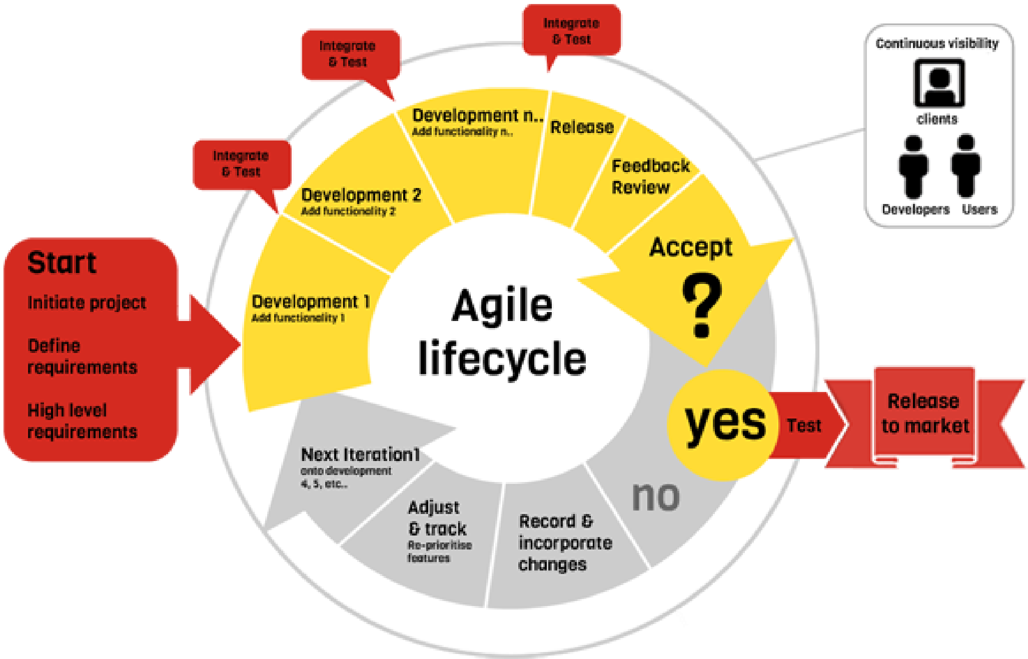

Figure 3: Agile software development process

Source: http://cyclosys.com/practices/methodologiesframework

The following table provides a helpful comparison between the three Software Development Methodologies in regard to several features.

Table 1: Comparison of Software Development Methods (Waterfall, Iterative, Agile)

Methodology/ Feature	Waterfall	Iterative	Agile
Specification of all the requirements in the beginning	Yes	Not all and frequently changed	Throughout the lifecycle
Long term project	Inappropriate	Appropriate	Appropriate
Complex project	Inappropriate	Appropriate	Appropriate
Frequently Changed Requirements	Inappropriate	Appropriate	Appropriate
Cost	Not costly	Costly	Not costly
Cost estimation	Easy to estimate	Difficult	
Flexibility	Not	Flexible	Very flexible
Simplicity	Simple	Intermediate	Simple
Supporting high risk projects	Inappropriate	Appropriate	Appropriate
Guarantee of success	Less	High	Very high
Customer involvement	Low	High, After each iteration	Actively involved
Testing	Late	After every iteration	Concurrent with development

Maintenance	Least maintainable	Maintainable	Maintainable
Ease of implementation	Easy	Easy	Easy
Detailed documentation	Necessary	Yes but not much	Not necessary

According to the 2011 CHAOS Report by the Standish Group, the projects that follow the Agile methodology are more successful than those that follow the Waterfall methodology. Agile methodology is mostly used to enhance collaboration and increase the level of software quality.

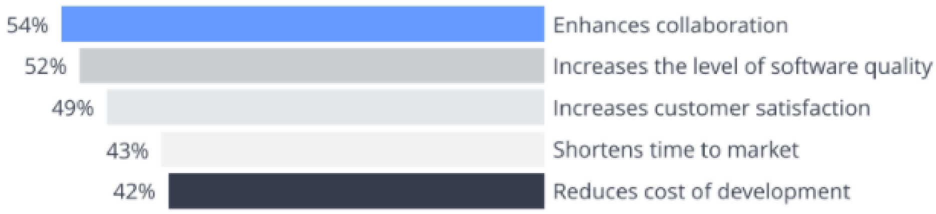

Figure 4: Agile implementation statistics.

Source: http://techbeacon.com/survey-agile-new-norm

Specifically, the report states that "The Agile process is the universal remedy for software development project failure. Software applications developed through the Agile process have three times the success rate of the traditional Waterfall method and a much lower percentage of time and cost overruns"[6]. A project can be characterized as successful based on time spend for development, budget spend and whether all planned features were delivered or not, according to the Standish Group. The following figure presents the results derived from projects that are in their database and conducted from 2002 through 2010.

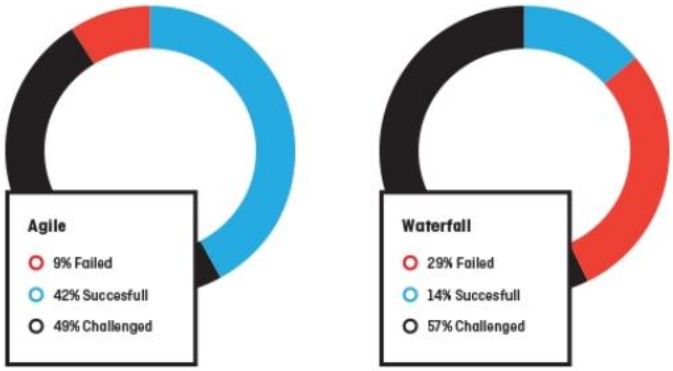

Figure 5: Comparison of Agile and non-Agile projects

Source: The CHAOS Manifesto, the Standish Group, 2012

[6] The Standish Group, The CHAOS Manifesto, 2012, page 25

2. Competitor Features Analysis

The competitor features analysis provided valuable information about the extent to which current systems satisfy the DIANA user needs and further analyzing revealed usability problems which served as an example when designing the DIANA user interface**Error! Bookmark not defined.**.

For the purpose of this deliverable, a detailed online research was conducted (based on competitors analysis from WP5) for identifying the supported featured offered by the DIANA competitor platforms. Table 2 contains the offered services and features of the competitive analysis in comparison to those that will be offered by DIANA platform.

Table 2: Competitors' offered services and features

	eleaf	IrriSAT	TOPS-SIMS	Irrisat	Spider	USDM	dms	NASA-GRACE	GADMFS	DIANA
Water auditing	x									x
Water accounting	x									
Water productivity	x									
Water Balance	x	x	x	x	x					x
Irrigation management	x	x	x							
Irrigation Scheduling	x	x								
Irrigated area mapping				x						x
Irrigation water requirement				x						x
Irrigation logs				x						
Irrigation fee recover				x						
Agroforestry decision making tool					x					
Drought classification						x	x	x		x
Drought Indicators						x	x	x	x	x
Drought monitoring									x	x
Drought forecast									x	x
Evapotranspiration	x	x	x	x	x	x	x	x	x	x
Crop monitoring	x				x					x
Crop management					x					
Crop Water Use		x								x
GIS Dashboard					x					
Agronomic Performance Indicators		x								

This project is co-funded by the European Union

Detection of non-authorized abstractions										x
Monitoring of non-authorized abstractions										x
Implementation of WFD										x
Monitoring of WFD										x

3. Technical Requirements

The aim is to make DIANA a successful solution that will empower water management authorities to optimize the identification and inspection of non-authorized water abstractions for irrigation as well as significantly improve the monitoring and assessment of their water management policies and practices, both in standard and special conditions such as in cases of drought. This can be achieved by capturing the user perspectives. DIANA solution's requirements elicitation process was faced as a combination of complementary approaches. For this reason, semi-structured interviews with key local actors were conducted with the usage of appropriate questionnaires. Additionally, the results of the interviews and workshops carried out in the context of Copernicus study were taken into consideration. Stakeholders and experts from 11 Member States expressed their need for a better knowledge of water abstractions and specifically on irrigation uses, irrigation infrastructures (channels, tanks), irrigated areas and abstraction volumes. Based on these approaches and in combination with the competitor's analysis (Annex I: Competitors' provided services and features), the following technical requirements were shaped which address the stakeholders' needs per service (Annex III: Requirements traceability matrix).

3.1. User roles

A basic process taking place during every software development stage, is the user requirements analysis. Understanding user requirements is an essential part of DIANA system and is crucial for the system's success.

The user requirements were collected in WP1 and were a part of deliverable *"D1.1 Users' and stakeholders' requirements analysis"* and for the readers' convenience, a matrix of the user and generic user requirements is included in Annex II: User requirements.

DIANAs' main stakeholders were identified from the very beginning of the project and are mainly public authorities (ministries, national-, basin-, regional and local authorities) and collective entities. Taking into consideration the DIANA services, specific customer segments can be distinguished such as:

(i) irrigation water managers (e.g. within local/ regional public authorities, associations of irrigators, etc.) responsible for monitoring and inspecting the abstraction of water irrigation;
(ii) authorities (national, regional or local) in charge of developing water/drought management plans and issuing relevant authorizations;
(iii) authorities that collect water fees.

Based on this segmentation, three types of users were identified:

- the Administrator (A)
- the Water Managers (WM) and
- the Inspectors (I).

One of the main responsibilities of the Administrator is to provide access to new users. Specifically, a user who is assigned as Administrator is able to approve or reject a new request for registration into the DIANA system. They have the power to create and manage users, assign them to organizations and departments or even make them inactive from the system. The Administrator is the user role that can perform the initialization of a system by setting up new organizations and adding departments to it.

The other two types of users are considered to be the core users of the DIANA platform. Both Water Manager and Inspectors, can make use of the information provided by the DIANA platform regarding their operational areas in an effective and simple way. They can access maps, graphs and data generated for the three provided services (Detection and Monitoring of non-authorized water abstractions, Drought Monitoring and Seasonal Drought Forecasting, Monitoring actions for the implementation of the WFD), generate reports, analyze and export graphs etc. However, Inspectors can use the mobile application during on-field inspections, having access to all the needed field-related data and the ability to upload time-stamped geo-tagged photos as proof of inspection or in order to report water meter indicators.

Water managers and Inspectors that belong to the same department, they can all have the same access and processing rights. That way users of the same department can upload or process any geospatial information files that defines the department's area of control and which is then used by DIANA, assuring that users only see information relevant to the areas they contributed to DIANA. An example can be seen in the diagram below where Dept1 and Dept2 belong both to the same department, but the areas defined (by uploading the corresponding shape files) for the first are different than the areas defined for the second.

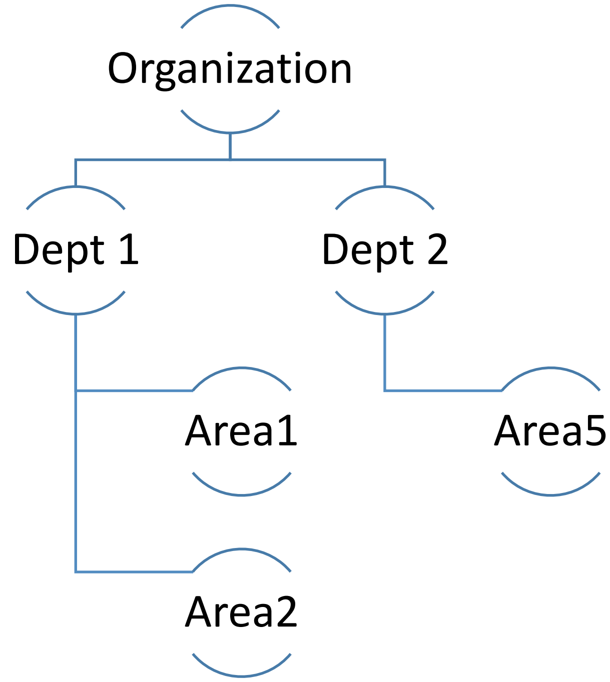

Figure 6: Organization & Department hierarchy

There are additional stakeholders which could be users of parts of the DIANA system but are not identified as main actors. However, DIANA kept also those users in mind as possible users of the core platform or some outputs of it as those were identified in WP1:

- Farmers, agricultural cooperatives and consultancies such as agribusiness professionals, advisors, innovation intermediaries, etc.
- Research and Academia such as academic institutions, non-university public research organizations, research and technology organizations, etc.
- Non-governmental organizations interested in sustainable water management in the EU and aimed at addressing relevant social challenges and needs.
- Policy and decision makers at EU level.

3.2. Web application

The web application will be the main DIANA interface, able to welcome the main actors (water managers and inspectors) of the system. The features and technical requirements (TR) for the web application for each user role are presented below:

3.2.1. Detection and Monitoring of non-authorized water abstraction

The detection and monitoring of non-authorized water abstractions service aims to detect non-authorized water abstractions either of Type-1[7] or Type-2[8]. This service will be available to water managers and inspectors.

DIANA will use a) geospatial reference data of water rights, land uses etc., b) spatial distributed crop water requirements and c) spatial distributed data of the maximum allowance of irrigation water consumption volumes. All these data will be used to produce the irrigation classification (irrigated-non-irrigated crops) map and the net irrigation water requirements map, to detect the Type-1 and Type-2 of non-authorized water abstractions. DIANA will also provide access to other types of geospatial data, such daily crop evapotranspiration, daily precipitation, crop growth biophysical parameters and EO derived vegetation indices.

The available features will be provided by this service, are presented in three main categories depending on the main visualization control that will be used: a) map view, b) charts and c) reports.

Map View

Map view will use maps to present the service results in a geospatial layer. Common map controls will be offered such as: zoom in/out, change from map to satellite view, parcels display, a time-slider control and additional controls will be mentioned in the following technical requirements below, where needed.

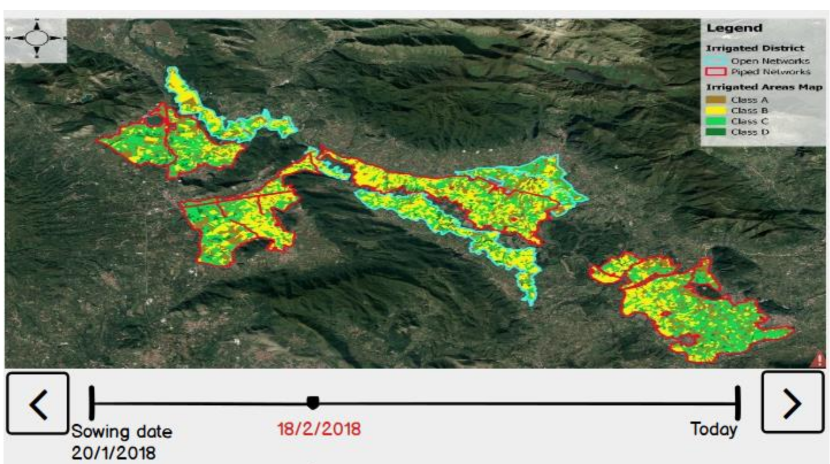

Figure 7: A map view with a slider time control

An example of such a control can be seen on Figure 7 where users can interact with the map through the slider and focus on a day/week/month/year of interest. Maps in combination with

---

[7] The Type-1 of non-authorized water abstractions refers to the identification of irrigated cropland in areas where irrigation is not allowed.

[8] The Type-2 refers to the non-authorized water over-abstraction of irrigated cropland in areas where irrigation rights exist, but the water management authority has set an upper threshold to the water volume that allowed to be used to irrigate each crop type cultivated in the area.

the time-slider will be used to display values ranging from the beginning to the end of the cultivation period.

Technical requirements of map controls offered in the detection and monitoring of non-authorized water abstraction service are presented below:

TR - 1. DIANA will offer a Crop Classification Map.

The Crop Classification Map will follow a parcel-based approach to classify and map agricultural land use. The Crop Classification Map will be a static map[9] that can be displayed on web and mobile devices, without the aid of a mapping library or API. The map will be accessible anytime, but it will be updated once at the end of the cultivation periods where all the data will be collected and analyzed.

TR - 2. DIANA will offer an Irrigation Classification Map.

The Irrigation Classification Map will provide information regarding the detection of which agricultural areas have been irrigated in the region of interest. The Irrigation Classification Map could be cross-checked with information about irrigable areas and/or registered official water rights of the region, to help verify the existence of type 1 non-authorized water abstractions for each specific location of irrigated land. The Irrigation Classification Map will be accessible anytime, but it will be provided once at the end of the irrigation season where all the data will be collected and analyzed.

TR - 3. DIANA will offer a Crop Coefficient Time Variant Map.

The estimation and parameterization of crop coefficient using remote-sensing data is critical for determining the water balance and planning the irrigation water use in the region of interest. The map will be provided in a weekly or bi-weekly time step during the cultivation period. A slider can be used in combination with the map, to assist filtering by date/time values during the cultivation period.

TR - 4. DIANA will offer a Net Irrigation Water Requirements Time Variant Map (crop water consumption).

The Net Irrigation Water Requirements Map will depict the quantity of water necessary for irrigation. The net irrigation water requirement map will be provided, in a weekly time step during the cultivation period. A slider can be used in combination with the map, to assist filtering by date/time values during the cultivation period.

[9] static map – refers to a map that is not updated frequently (once or twice a year) and therefore the information it represents, remain the same

TR - 5. DIANA will offer a Crop Evapotranspiration Time Variant Map.

The Crop Evapotranspiration Map will provide estimates of daily crop evapotranspiration during the cultivation period. The map will be updated in a daily time step during the cultivation period and a slider control will be used to select value ranges supporting both numerical values and date and time.

TR - 6. DIANA will offer a Reference Evapotranspiration Time Variant Map

The Reference Evapotranspiration Map will provide estimates of reference evapotranspiration during the cultivation period. The map will be updated in a daily time step during the cultivation period and a slider control will be used to select value ranges supporting both numerical values and date and time.

TR - 7. DIANA will offer a Precipitation Time Variant Map.

Precipitation data are needed to estimate the soil water balance to estimate the crop water requirements and thus to distinguish irrigated from non-irrigated croplands. This will be a daily map that will include precipitation analysis and forecast data.

TR - 8. DIANA will offer Earth Observation (EO) derived vegetation indices Time Variant Maps

DIANA will use high-resolution satellite imagery to produce EO derived vegetation indices in the area of interest. Frequent updates, every week, to existing information will be done offering continual and repeatable coverage. The offered EO maps will be:

- **Normalized Difference Vegetation Index (NDVI) Map:** DIANA will offer time series maps of NDVI that will provide all the information needed, pixel-by-pixel, parcel-to-parcel, that will be used for crop classification, to monitor crop growth and to provide the necessary information to estimate crop coefficient evolution.
- **Weighted Difference Vegetation Index (WDVI) Map:** DIANA will offer time series maps of WDVI that will support the detection of the irrigated areas during the irrigation period.
- **RGB Map:** DIANA will offer time series of RGB maps which will be used for crop classification.

TR - 9. DIANA will offer a Static Map with the Maximum Allowance of Irrigation Water Consumption Volumes

This map will present the legal volume of irrigation water for each specific location of irrigated land and it will be provided once at the beginning of the cultivation period.

TR - 10. DIANA will offer a Static Map with the differences between the Net Irrigation Water Requirement and the Maximum Allowance of Irrigation Water Consumption Volumes

This map will represent the differences between the Net Irrigation Water Requirements and the Maximum Allowance of Irrigation Water Consumption Volumes. Specifically, this map will depict the cases in which the volume of irrigation water exceeds the legal volume of water for each specific location of irrigated land. This map will be a static map and will be generated once at the end of the cultivation period.

TR - 11. DIANA will offer a Static map with flags in parcels where non-authorized abstractions occurred (Type-1)

The non-authorized water abstraction detection and monitoring service is one of the core services of the DIANA platform. DIANA will make use of the results of the aforementioned maps and will provide a static map depicting the areas where a non-authorized water abstraction occurs. These specific areas will be presented in the map with flags. The map will allow water managers or inspectors to right click on a field to queue it for inspection. This map will be released once at the end of the cultivation period.

TR - 12. DIANA will offer an over-abstractions map (Type-2)

The Type-2 refers to the non-authorized water over-abstraction of irrigated cropland in areas where irrigation rights exist, but the water management authority has set an upper threshold to the water volume that allowed to be used to irrigate each crop type cultivated in the area. The map will allow water managers or inspectors to right click on a field to queue it for inspection. The map will be released once at the end of the cultivation period.

TR - 13. DIANA will offer Irrigation Scheduling Time Variant Maps

These maps will provide information regarding irrigation scheduling based on the crop water needs. The map will be provided in a daily time step during the cultivation period.

TR - 14. DIANA will offer additional map layers according to the business needs

Two different layers on the main map in which the user would be able to view further information regarding the legal reference and the initial crop type.

Charts

Charts will be used to present time-series values which evolve with time. Charts will be combined with maps whenever possible, so when the user click on a pixel in the map, the chart gets populated with the time series of the visualized parameter in the map.

TR - 15. DIANA will present in a chart the Time Series of Net Irrigation Water Requirements

DIANA will offer weekly update of the crop net irrigation water requirements for the upcoming week.

TR - 16. DIANA will present in a chart the Time Series of Crop Growth Parameters (LAI, Crop Coefficient)

DIANA will offer historical time series of crop biophysical parameters.

TR - 17. DIANA will offer Time Series of EO parameters

DIANA will offer historical time series of NDVI, WDVI and RGB maps.

TR - 18. DIANA will offer the capability to export Water Auditing Reports

The user will be able to generate Water Auditing Reports through the DIANA platform. Those reports will include different types of data visualization such as maps, charts and statistics and the information will be presented in an easy and understandable way. These reports will be exported in appropriate formats such as pdf, csv and text.

3.2.2. Drought Monitoring and Seasonal Drought Forecasting

The Drought Monitoring and Seasonal Drought Forecasting service aims to assist the water managers (or inspectors) by providing them the ability to track the current drought conditions, and to foresee the probability of drought occurrence in the next six months. The system will be based on the operational use of a land surface model coupled with a routing channel-reservoir model in the AGRO APPS premises, which is fed by gridded meteorological fields (analysis and forecast fields), EO derived land surface parameters and auxiliary static geographical data of land-use-cover and topography.

The features that will be provided by this service are the following:

Drought Monitoring Maps

DIANA will use maps to present results of the service over geospatial layers. Common controls will be provided in the map visualizations such as: zoom in/out, change from map to satellite view, parcels display, and a time-slider control and additional controls will be mentioned in the following technical requirements below, where needed. DIANA drought monitoring maps will present measurements from the DIANA deployment date and up to 6 months ahead from the current day.

TR - 19. DIANA will offer Drought Time Variant Maps.

DIANA will offer a weekly Drought Map based on the following indices: Standardized Precipitation Index (SPI), Standardized Precipitation Evapotranspiration Index (SPEI), Palmer Drought Severity Index (PDSI), Surface Water Supply Index (SWSI), Effective Drought Index (EDI), Crop Specific Drought Index (CSDI), Soil Moisture Deficit Index (SMDI) and Evapotranspiration Deficit Index (ETDI). Based on the above, a number that indicates wet or drought conditions will be calculated and roughly correlate with drought severity. A slider bar will be used to define the weekly time step during the cultivation period that will be presented in the map.

TR - 20. DIANA will offer Drought Classification Time Variant Maps.

The Drought Classification Map will provide users with a visualization of drought in the area of interest, which will be classified into the following categories:

- **Meteorological drought:** The meteorological drought indicates the degree of dryness and the duration of the dry period due to meteorological conditions. It will be expressed on the basis of the degree of dryness, in comparison to the normal or climatologically expected rainfall over the area of interest on monthly, seasonal and annual time scale.
- **Hydrological drought:** The hydrological drought is defined as the situation of deficit rainfall and it follows the meteorological drought. Such droughts happen when actual water supply is below the minimum for normal operations. The frequency and severity of hydrological drought often occurs when the hydrological sources dry up and ground water level depletes.
- **Agricultural drought:** The agricultural droughts result due to the inadequate rainfall, when soil moisture falls to meet the water demands of the crop during growth. The agricultural droughts depend on the duration and intensity of drought, nature of crop, growth stage of the crop and on the soil characteristics.

These maps will be produced every week and they will cover the upcoming six months. A slider bar will be used to define the weekly time step during the cultivation period that will be presented in the map.

TR - 21. DIANA will offer Soil Moisture Deficit Time Variant Maps.

The Soil Moisture Deficit Maps will present the historical soil moisture deficit at the selected dates, the soil moisture deficit at the same time last year, the current soil moisture deficit and a six-month soil moisture deficit forecast. The drought monitoring and seasonal drought forecasting system will provide the soil moisture data. A slider bar will be used to define the daily time step during the cultivation period that will be presented in the map.

TR - 22. DIANA will offer Precipitation Deficit Time Variant Maps.

The precipitation deficit will be used as a potential drought indication based on the scarcity of rainfall in the area of interest. The map will present historical deficit at the selected date, the precipitation deficit at the same time last year, the current precipitation deficit and a six-month precipitation deficit forecast. A slider bar will be used to define the daily time step during the cultivation period that will be presented in the map.

TR - 23. DIANA will offer Time Variant Maps of Basic Meteorological Parameters.

The Maps of Basic Meteorological Parameters (e.g. precipitation, soil moisture, reference evapotranspiration, min/max and average temperature, solar radiation, relative humidity, wind speed and soil temperature) will present historical data of these meteorological parameters, current data and a six-month forecast. The produced map will be updated daily and combined with a slider bar that will be used to define the presented daily information.

TR - 24. DIANA will offer Time Variant Maps of Basic Hydrological Parameters

The Time Variant Maps of Basic Hydrological Parameters (e.g. soil moisture, surface runoff, stream and base flow and ground water table) will present historical data of these hydrological parameters, current data and a six-month forecast. The produced map will be updated daily and combined with a slider bar that will be used to define the presented daily information.

TR - 25. DIANA will offer Weekly Time Variant Drought Maps.

The drought maps are weekly updated maps that will present the location and intensity of areas currently experiencing abnormal dryness or drought across the areas of interest. Recent precipitation will be evaluated compared to long-term averages, and variables such as temperature, soil moisture, rainfall water, etc. The produced maps will be updated weekly and combined with a slider bar that will be used to define the presented weekly information.

TR - 26. DIANA will offer a Probability of Drought Occurrence Time Variant Map.

The Probability of Drought Occurrence Map will be based on the ensemble prediction of the drought indices. The map will provide six-month period forecasts of drought occurrence probability.

TR - 27. DIANA will offer Percentile Maps of Basic Meteorological Parameters.

The Percentile Maps will be used as support management tools to update existing regional or local drought management plans, enabling the authorities to take the needed actions to cope with the drought phenomena. These maps will present the percentage of weekly meteorological parameters for the all the years that DIANA will keep record, for which the parameters' value is equal to or below than the value recorded for a chosen week of the year (chosen by a slider). The meteorological parameters that the map will present are: precipitation, soil moisture, reference evapotranspiration and average temperature at 2m high.

TR - 28. DIANA will offer Percentile Maps of Soil Moisture

The Percentile Maps will present weekly analyses for each gridbox that will be computed by comparing the past seven days to the corresponding period in the percentile climatology.

Charts

TR - 29. DIANA will offer statistical plots.

Statistical plots will be used for better visualization of a set of data in a graphical way and can provide additional detail while allowing multiple sets of data to be displayed in the same graph. DIANA will offer the following statistical plots of the basic meteorological parameters (precipitation, soil moisture, reference evapotranspiration and temperature at 2m high).

- **Boxplots:** Boxplots will graphically depict groups of numerical data of meteorological parameters through their quartiles and indicate variability outside the upper and lower quartiles. Outliers will be plotted as individual points.
- **Distribution:** Distribution plots will visually assess the distribution of meteorological parameters data by comparing the empirical distribution of the data with the theoretical values expected from the specified distribution.
- **Ensemble time series:** Ensemble time series will be used for their predictive performance improvement, which combines multiple predictions to overcome accuracy of simple prediction.

Plots will be generating by clicking on a map pixel.

3.2.3. Monitoring actions for the implementation of the WFD

The Support of the Monitoring Actions for the Implementation of the Water Framework Directive (WFD) aims to offer hydrological data that are produced by the operational use of the other two DIANA services, to the water manager (or the inspectors) who is responsible for the monitoring actions of the implementation of the WFD.

This service will use map visualizations to present the results in a geospatial layer. Common controls will be offered in all the offered map such as: zoom in/out, change from map to satellite view, parcels display and additional controls.

TR - 30. DIANA will offer a total Reference Evapotranspiration Map

The map will present the total major irrigation water and precipitation use on the specific location of irrigated land and it will be produced once at the end of the cultivation period.

TR - 31. The DIANA will offer a total Precipitation Time Variant Map

The map will present the daily accumulated precipitation in daily time steps.

TR - 32. DIANA will offer a total Recorded Irrigation Water Time Variant Maps

These maps will present the total amount of water that is applied to a crop in order to calculate the amount of water the farmer has used per irrigation and record it against his/her crop and water source.

3.2.4. Inspection queues

This section covers the administration of inspections queued from the detection and monitoring of non-authorized water abstractions.

TR - 33. Water managers and inspectors can see the list of the unprocessed inspections

Water managers or inspectors can see the list of the queued inspections that belong to their department. They can see only inspections which are at the "queued", "in process" status. They can remove or change the status of an inspection and whenever a change of status takes place, the user needs to provide a comment to justify the change. The available status for inspections are "queued", "in process", "processed", and "canceled". The change of inspection status takes effect immediately without the need to notify any other user.

TR - 34. Water managers and inspectors can see the list of all processed inspections

The list should contain all the closed inspections (which have a status of "processed" and "canceled") and should allow the use to see details for each such as the history of status changes and documents provided from the inspectors via the mobile app. No actions are allowed from the user in this master-detail forms.

3.2.5. User actions

This section covers for generic user actions such as sign up/ sign in/edit profile etc.

TR - 35. Water managers and inspectors will be able to sign up to DIANA

Water managers or inspectors will need to enter their username, email, password, full name, date of birth, choose their organization and department, and enter their employee ID. Once they submit the data to DIANA they will receive an email to activate their account. Upon the account activation they receive a notification that their account is now forwarded to the administrator to activate and till then, they cannot connect to DIANA.

TR - 36. Water managers and inspectors will be able to sign in

Water managers or inspectors will need to enter their username and password to login to DIANA. In order for a user to login to DIANA he/she needs to have been activated by the administrator first in order to keep the access controlled to people working with the water authorities. Once a user is logged in he/she only has access to material defined for their organization/department.

TR - 37. Users can recover their account using their email

Users can also use the “forgot password” feature which forwards an email to the address they registered with, which contains a private link that will allow them to reset their password and enter a new one.

TR - 38. Water managers and inspectors can update their personal information at their profile page

They can also change their email address, but they will need to re-validate it via the link they receive by email. The administrator will **not** have to re-activate the user account in this case. However, if the user changes their organization/department/employee ID then their account is automatically deactivated and the administrator needs to re-activate it.

3.2.1. Administrative actions

TR - 39. Administrators will be able to sign in to the DIANA “admin area”

They will need to enter their username and password to login to DIANA “admin area”. If the user does not have the administrator role, he/she is not able to login to the “admin area” and their login attempt is registered in the system log.

TR - 40. Administrators can create/update users

DIANA administrators can create new users or update the information of the existing ones. Furthermore, users can be assigned to a role (administrator/water manager/inspector) and an organization/department.

TR - 41. Administrators can create/update organizations and departments

Each organization name needs to be unique. One organization can have many departments. A department cannot be deleted if it has users registered to it and an organization cannot be deleted if it has departments. For each department, the administrator can create a bounding box or define a polygon in a map that will be the limits that DIANA will use for users of this department.

3.3. Mobile Application

Only inspectors can access the mobile to login and see the available inspections which are open to their department.

3.3.1. User actions

This section covers for generic user actions such as sign in/edit profile etc.

TR - 42. Inspectors will be able to sign in to the mobile application

Inspectors will need to enter their username and password to login to DIANA mobile app. In order for a user to login to DIANA he/she needs to have been activated by the administrator first in order to keep the access controlled to people working with the water authorities. Once a user is logged in he/she only has access to material defined for their organization/department.

TR - 43. Users can recover their account using their email

Users can also use the “forgot password” feature which forwards an email to the address they registered with, which contains a private link that will allow them to reset their password and enter a new one.

TR - 44. Users can logout from the mobile application

3.3.2. Inspection queues

This section covers the inspection process from the inspector using the mobile app.

TR - 45. Inspectors can see the list of the unprocessed inspections

The list will contain all the open inspections that belong to the inspectors’ department. The inspector should see the results as a list or drawn over a map and they can choose a specific inspection to “process” which results in a change to the respective status (in process).

TR - 46. Inspectors can see the list of their active (in process) inspections

The list contains all inspections that they have turned to the “in process” status. The inspections should be presented as a list and drawn over a map. Inspectors can open a specific case to see the details and the history of status changes and the documents previously provided. They can add/remove documents and choose to close the inspections (status: ”processed”).

TR - 47. Inspectors can snap images from their mobile to upload in an inspection

When viewing an open inspection, the user can upload new images that will be acquired through the mobile devices’ camera. The image will be uploaded and correlated with the inspection. If the image is georeferenced, the information will be retained in the image since it might be used as a proof of the inspection. Photographs will need to be taken from the inspector to justify the finding of an inspection or as a proof that the inspector was in the field that given day.

TR - 48. Inspectors can provide a water meter indication for an active inspection

While at the in-field inspection the inspector can provide DIANA a water consumption reading from the irrigation source meter used by the inspected field. The inspector will also be advised to acquire the measurement with a photo of the measurement taken via the mobile device he/she carries.

3.4. Wireframes

3.4.1. Web Application

An indicative sitemap for the web application is provided in the figure below. The screens are analyzed in the following sections.

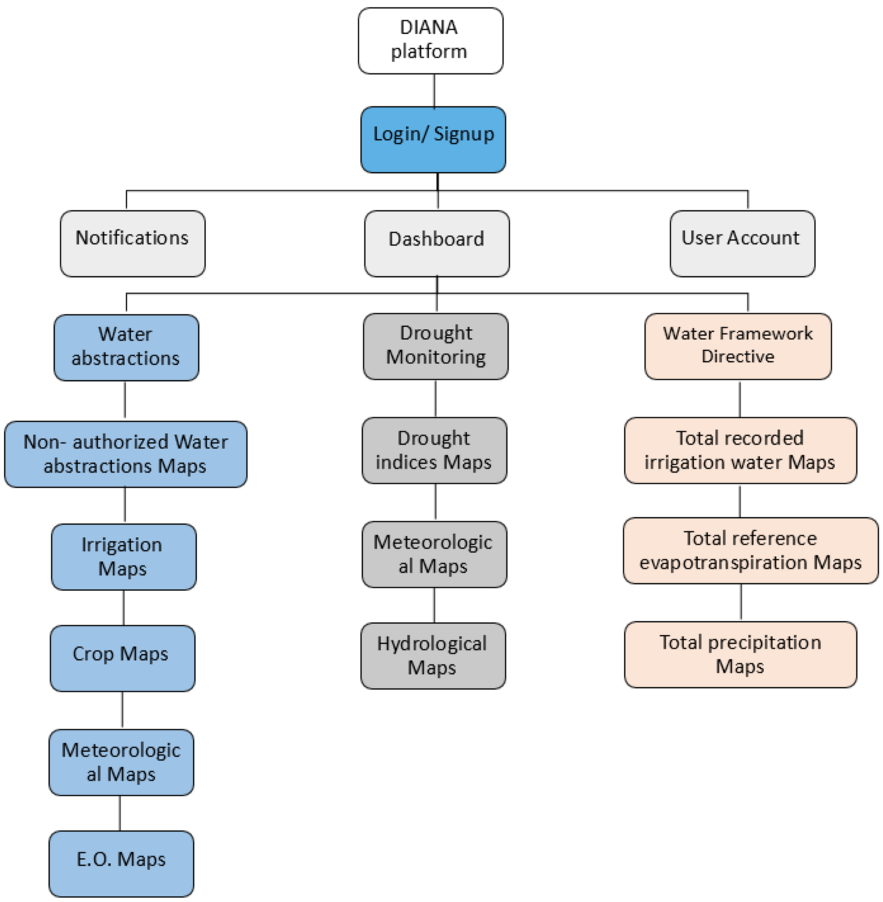

Figure 8: Web application sitemap

3.4.1.1. Login/Sign up

By accessing the DIANA platform, users see an initial screen where they can login (if they already have an account) or register.

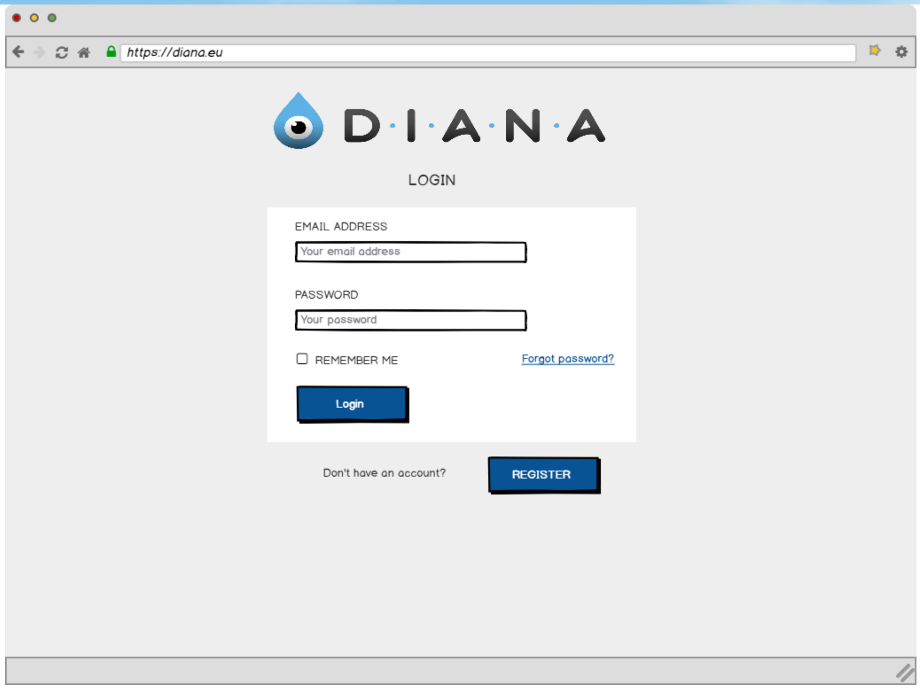

Figure 9: Sign in screen

In case the user does not have an account, they can create a new one by completing all the required information shown in the next image.

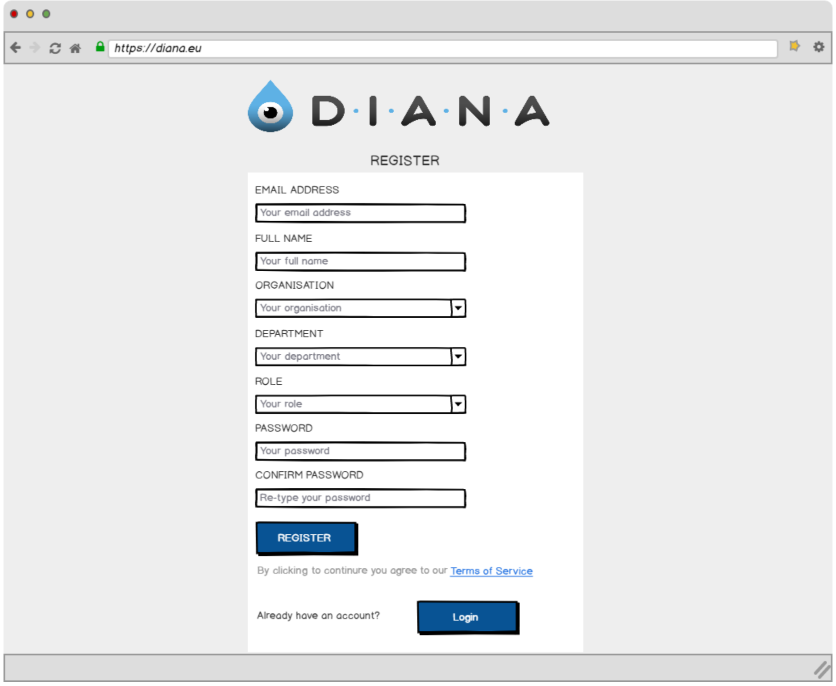

Figure 10: Signup screen

After completing the registration form, an email is sent to the user in the provided email address, in order to confirm the validity of the address. By clicking on the link, the users are informed that their account has been forwarded for activation to the DIANA administrators. This process aims to secure the sign-up process and protect access to data from unauthorized users. Once the administrator approves the new user, an email is sent to them informing that they can access DIANA providing also a link which (after logging in) lands them on their department's dashboard which is described in the following chapter.

3.4.1.2. Home page (dashboard)

For the first service, the Non-authorized Water abstraction, the initial dashboard provides the user with graphs regarding the total (legal and illegal) consumed water volumes. Specifically, it depicts two pie charts; one presenting the total water consumption based on crop type and another one presenting the total illegal consumed water volume based on crop type. Both graphs can be filtered for a specific month and year to allow the user to choose the reference period. Additionally, a line chart presents both measurements in the course of time from the beginning of the period till the given date. Button "More" on the bottom of the page allows the users to go to the detail page where they can see all the information in detail.

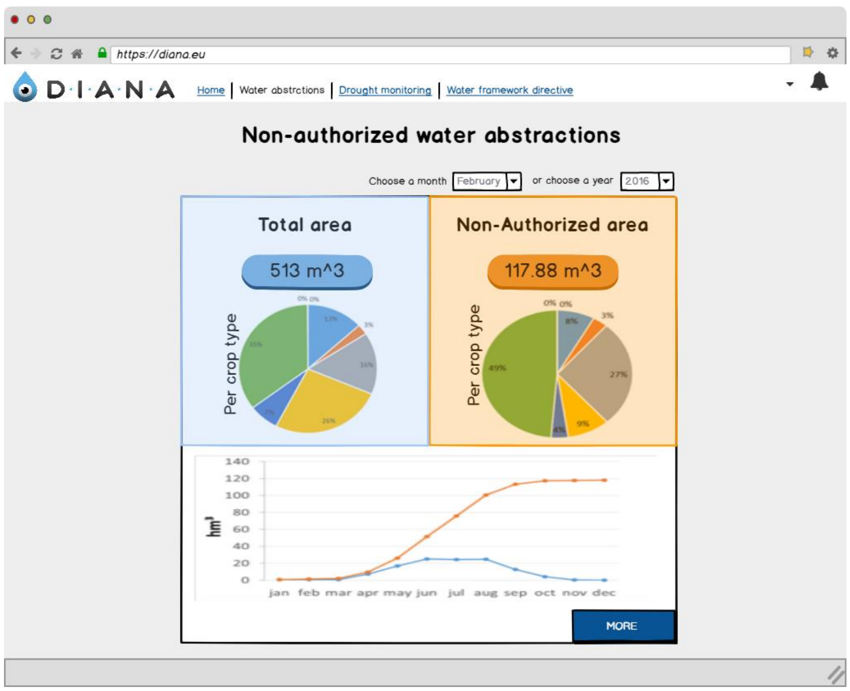

Figure 11: Non-authorized water abstraction initial screen

The dashboard page for Drought Monitoring and Seasonal Forecasting service, presents graphically the current drought condition based on specific drought indices (Figure 12). By clicking on the "More" button, the user goes to a more detailed view (Drought monitoring dashboard) that they can see maps and time-variant charts.

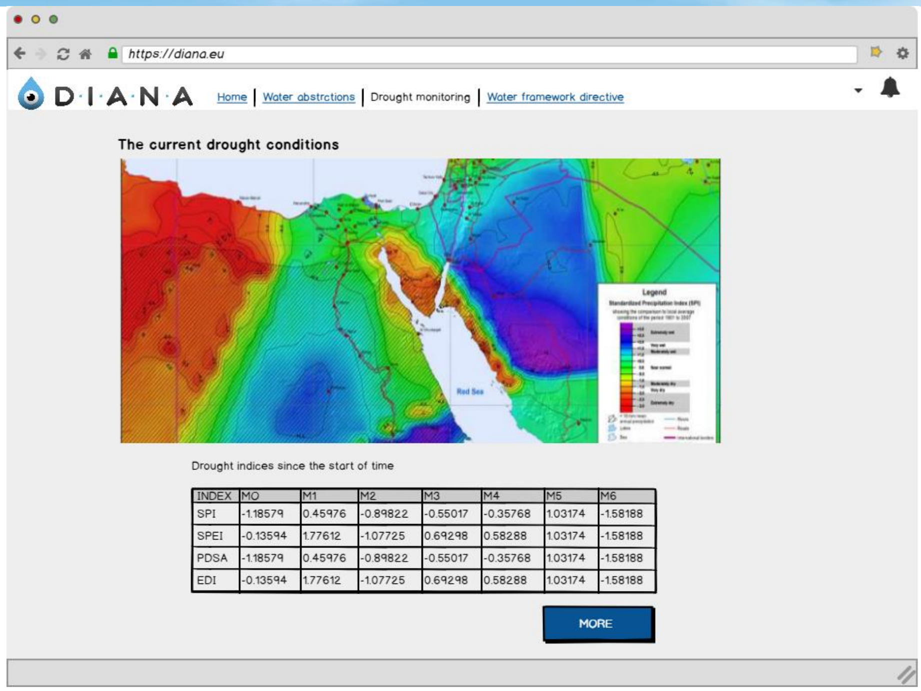

Figure 12: Drought Monitoring and Seasonal Forecasting initial screen

3.4.1.3. Water abstraction dashboard

The Water abstraction dashboard provides the user with maps for the better monitoring of non-authorized water abstractions. The categories for those maps are:

- Non-authorized water abstractions Maps
- Irrigation Maps
- Crop Maps
- Meteorological Maps
- E.O. Maps

The following figure illustrates the view of the recorded irrigation water map. Through the provided map the user can have an overview of the total recorded consumed water volume in the area of interest during the cultivation period. By selecting a day through the slider, the map is updated to present the information for the specific day. The user can click on a point on the map and view the evolution of the measurement over time for that specific location. The user can export the data from the graph as a CSV file. Moreover, the user can add a parcel in the inspection queue, if they notice any indication of breach, which is then passed to the inspectors via the mobile app.

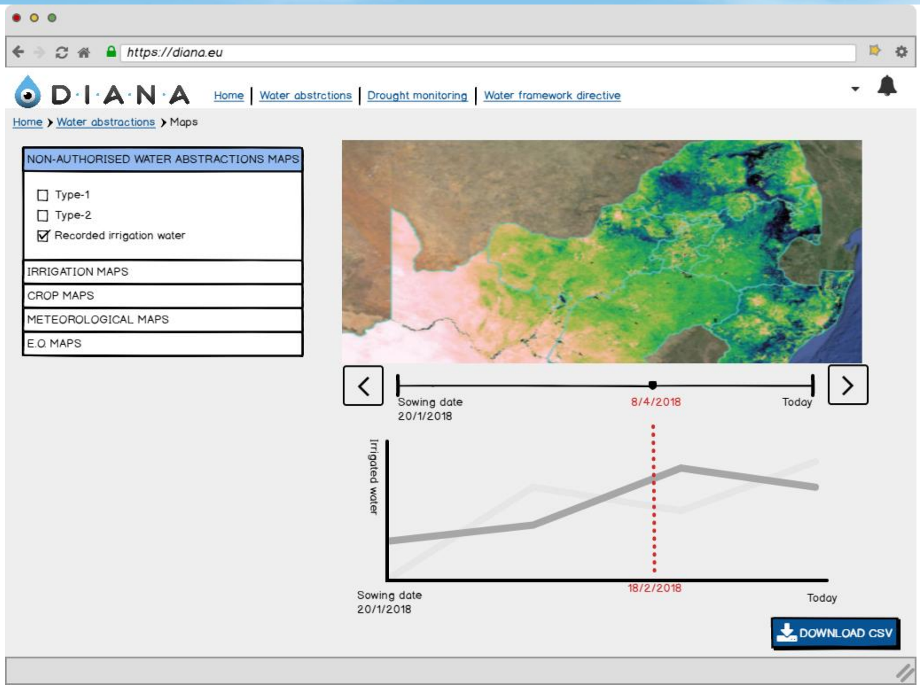

Figure 13: Recorded irrigation water map view for the monitoring of water abstractions

The aforementioned user interface describes the controls used to map variables that are dependent on time, however other parameters are also supported that involve one version of a map which is produced at the end of the season. The latter interface does not offer the slider or the chart control single it is not a time variant map. Table 3 presents all the maps offered by in the water abstraction service and define their generation frequency (as time variant or once per season).

Table 3. Water abstraction maps

Category Maps	Maps	Frequency
Non-authorised water abstractions	Type-1	Once per season
	Type-2	Once per season
	Recorded irrigation water	Daily (Time-Variant)
Irrigation	Irrigation Classification	Once per season
	Net Irrigation Water Requirements	Weekly (Time-Variant)
	Max Allowance of Irrigation Water Volumes	Once per season
	Legal Reference details	Once per season
	Irrigation Scheduling	Daily (Time-Variant)
Crops	Crop Classification	Once per season
	Crop Coefficient	Weekly (Time-Variant)

	Crop Evapotranspiration	Daily (Time-Variant)
	Initial Crop Type	Once per season
Meteorological	Precipitation	Daily (Time-Variant)
	Reference Evapotranspiration	Daily (Time-Variant)
E.O.	NDVI	Weekly (Time-Variant)
	WDVI	Weekly (Time-Variant)
	RGB	Weekly (Time-Variant)

3.4.1.4. Drought monitoring dashboard

The drought monitoring dashboard provides the user with maps for better visualizing drought in each departments area of interest, presenting measurements from the DIANA deployment date and up to 6 months ahead from the current day. The maps offered fall under the next categories:

- Drought indices maps
- Meteorological maps
- Hydrological maps

Using the maps, user will be able to monitor the drought in the area of interest (that their department is responsible) through the provided map based on specific indices which will be updated on weekly intervals. By selecting a week through the slider, the map is updated to present the information for the specific day. The user can click on a point on the map and view the evolution of the measurement over time for that specific location. The user can export the data from the graph as a CSV file. Moreover, the user can add a parcel (from the map) in the inspection queue, if they notice any indication of breach, which is then passed to the inspectors via the mobile app.

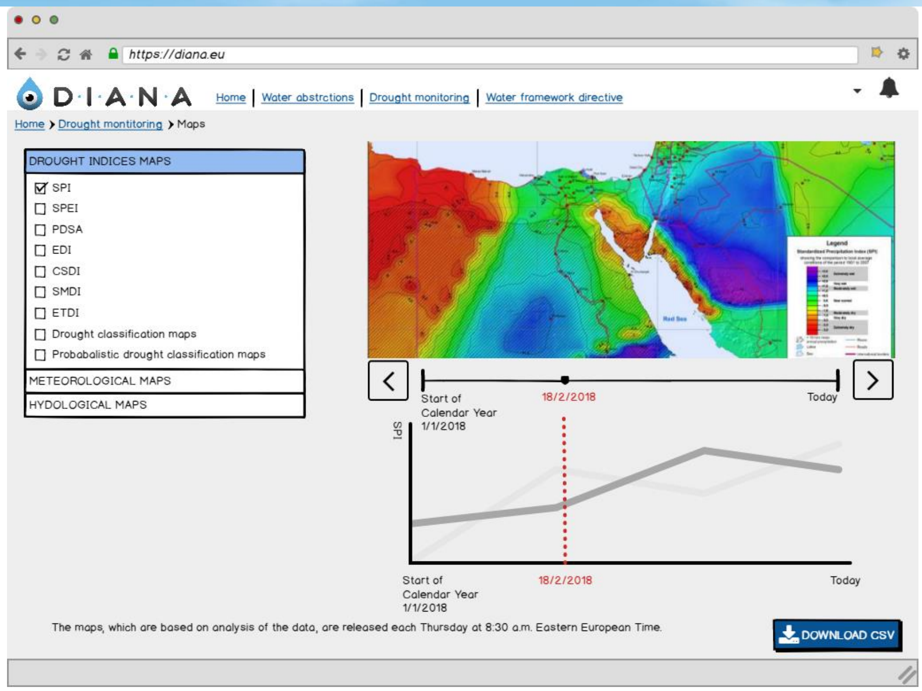

Figure 14: Drought Indices Map view (SPI)

The update frequency of the DIANA maps offered by in the drought forecasting service and define their generation frequency (as daily or weekly generated maps) is provided on the Table 4:

Table 4: Drought forecasting maps

Category Maps	Maps	Frequency
Drought Indices	SPI, SPEI, PDSA, EDI, CSDI, SMDI, ETDI	Weekly (Time-Variant)
	Drought Classification	Weekly (Time-Variant)
	Probabilistic Drought Classification	Weekly (Time-Variant)
Meteorological	Precipitation	Daily (Time-Variant)
	Evapotranspiration	Daily (Time-Variant)
	Maximum Temperature	Daily (Time-Variant)
	Minimum Temperature	Daily (Time-Variant)
	Average Temperature	Daily (Time-Variant)
	SOLR	Daily (Time-Variant)
	Relevant Humidity	Daily (Time-Variant)
	Wind Speed	Daily (Time-Variant)
	Soil Temperature	Daily (Time-Variant)

	Precipitation Deficit	Daily (Time-Variant)
	Percentile (Precipitation, Evapotranspiration, Average Temperature)	Daily (Time-Variant)
Hydrological	Soil moisture	Daily (Time-Variant)
	Surface runoff	Daily (Time-Variant)
	Streams flow	Daily (Time-Variant)
	Base flow	Daily (Time-Variant)
	Ground Water Table	Daily (Time-Variant)
	Percentile of Soil Moisture	Daily (Time-Variant)
	Soil Moisture Deficit	Daily (Time-Variant)

3.4.1.5. Water framework directive dashboard

The water framework directive dashboard provides the user with maps for better monitoring actions of the implementation of the WFD. These maps fall under the following categories:

- Total recorded irrigation water
- Total reference evapotranspiration
- Total precipitation

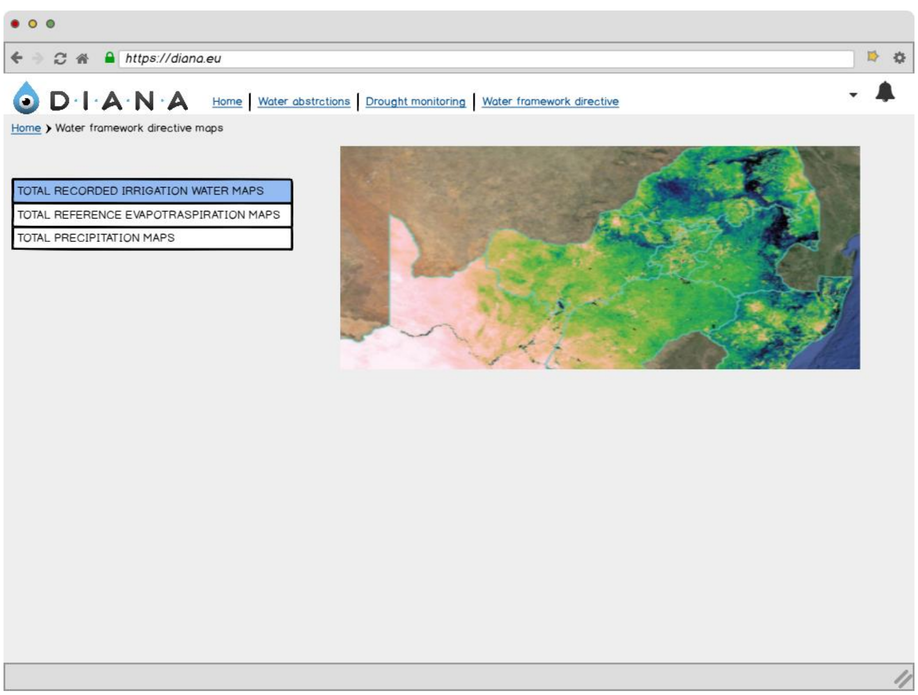

Figure 15: Total Recorded Irrigation Water map

The table below presents the update frequency of these maps.

Table 5: Water framework directive service maps

Category Maps	Frequency
Total Recorded Irrigation Water	Daily (Time-Variant)
Total Reference Evapotranspiration	Once per season
Total Precipitation	Daily (Time-Variant)

3.4.1.1. User's profile

A user's profile contains personal information (full name, email, profile picture) and information associated with the organization/ department the user belongs to (Figure 17). Additionally, the user's profile includes a set of parameters (Figure 16) which help to customize certain features for the user's needs e.g. define the sowing date per crop type and upload geographical files that define their departments' area of interest. User's profile are monitored and maintained by administrators.

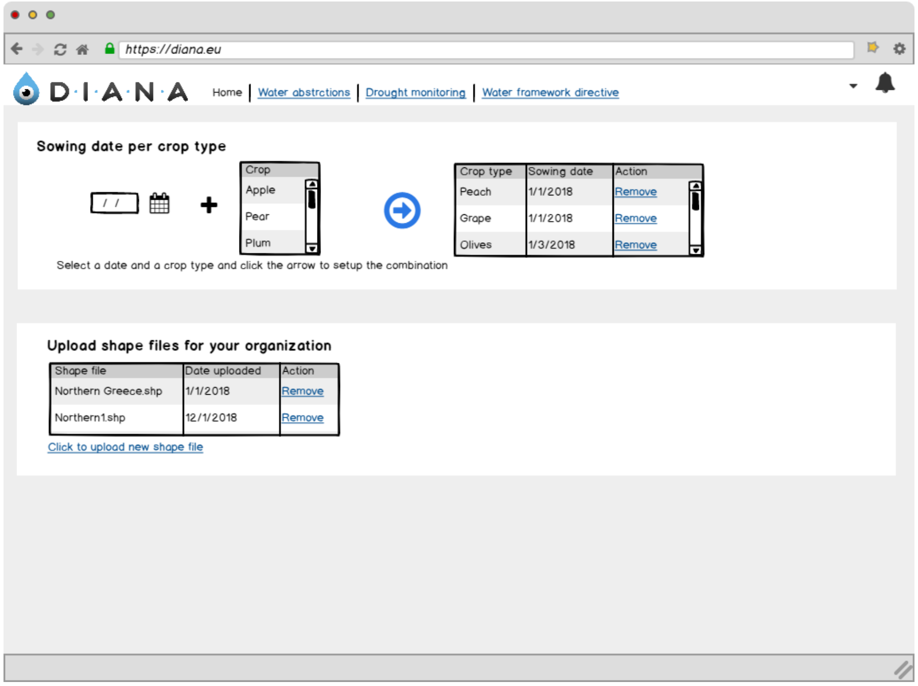

Figure 16: User's settings

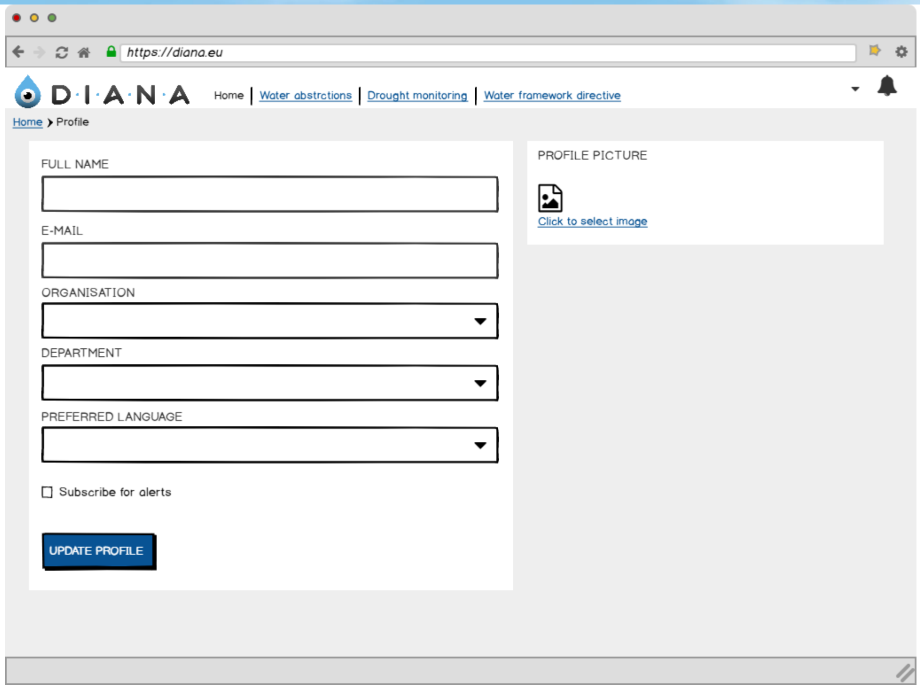

Figure 17: User's profile

3.4.1.2. Admin area

Figure 18 presents the Administrator's main screen. The administrator is the only responsible for managing organizations/departments and users in DIANA.

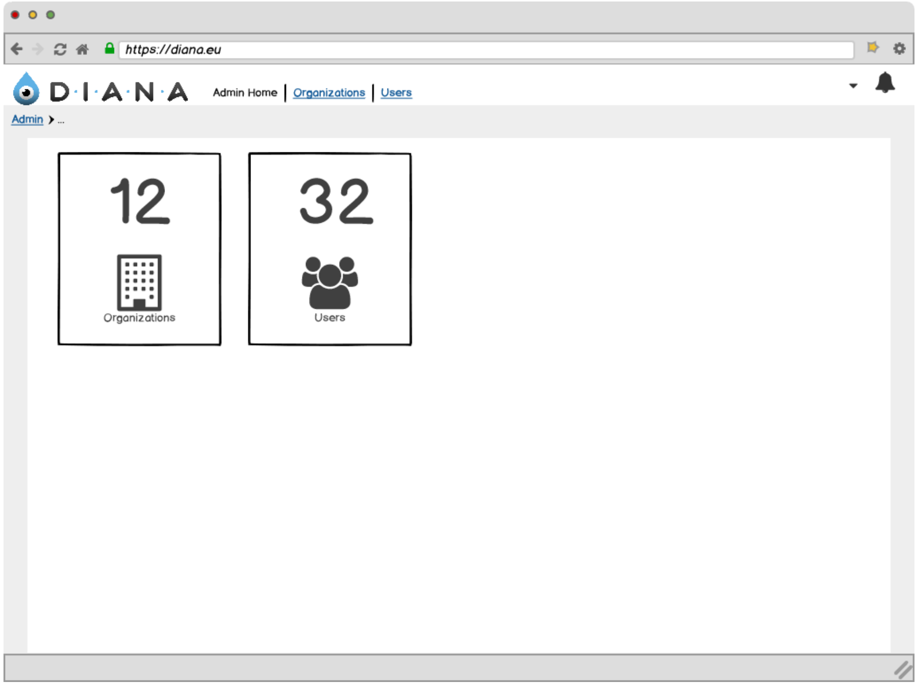

Figure 18: Admin home page

More specifically, the administrator can manage organizations and departments (Figure 19).

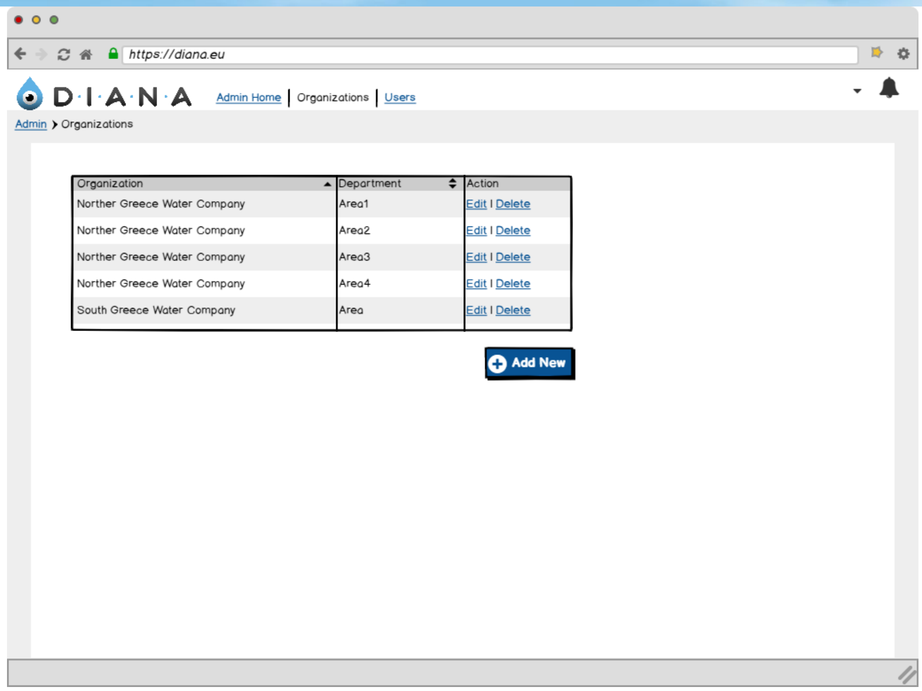

Figure 19: Organizations menu

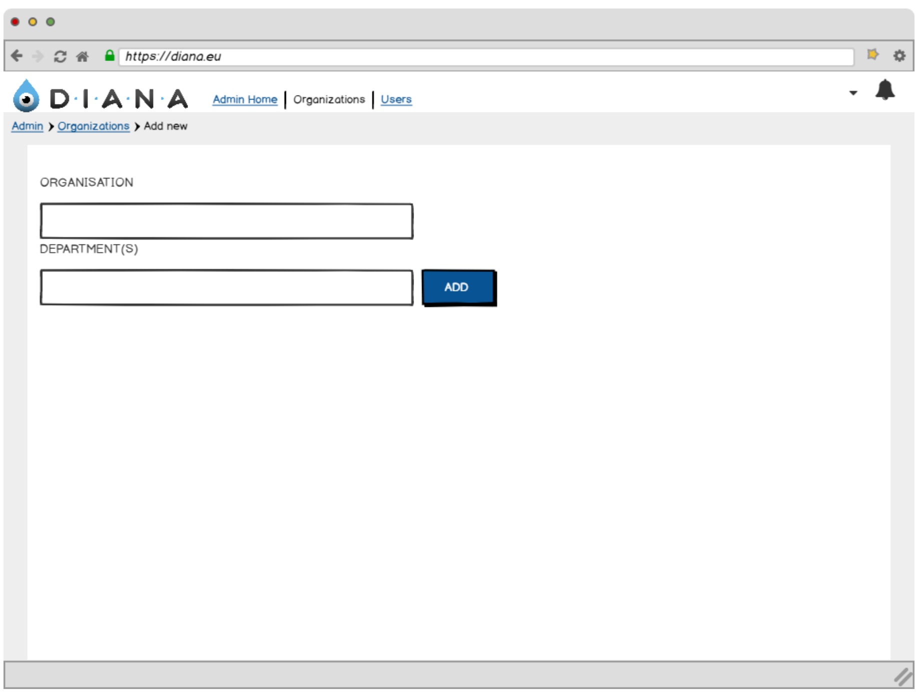

Figure 20: Creation of a new Organizations

Furthermore, the administrator is able to manage and activate users in the system. Every user that signs up in DIANA and after verifying their email address, they are "assigned" to the administrator to check if the user is indeed an employee of the water authority and then activate. Only then the user can login to DIANA. Alternatively, the administrator can create the user account and notify the user to login.

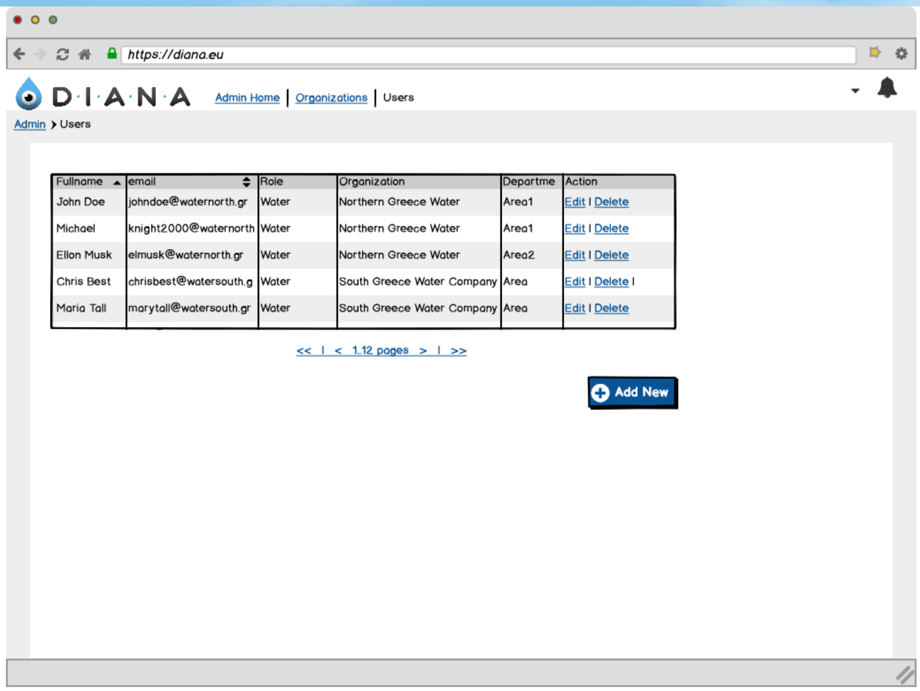

Figure 21: Users list

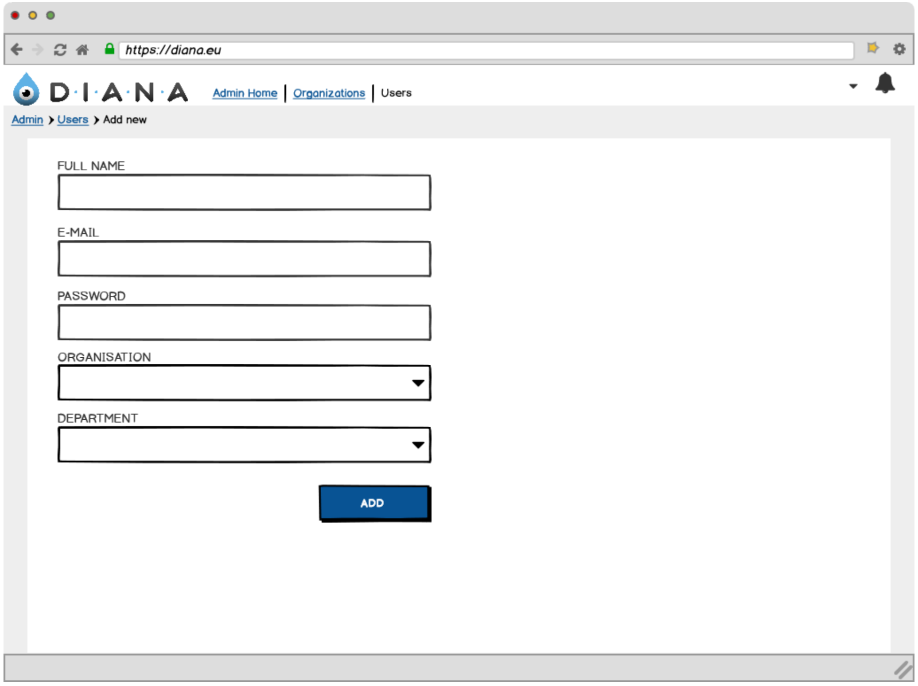

Figure 22: Create / update user

3.4.2. Mobile Application

The DIANA mobile application is targeted to be used by inspectors, to assist them during their on-fields inspection process. An indicative layout of the mobile application screens is provided in the figure below. The screens are analyzed in the following sections.

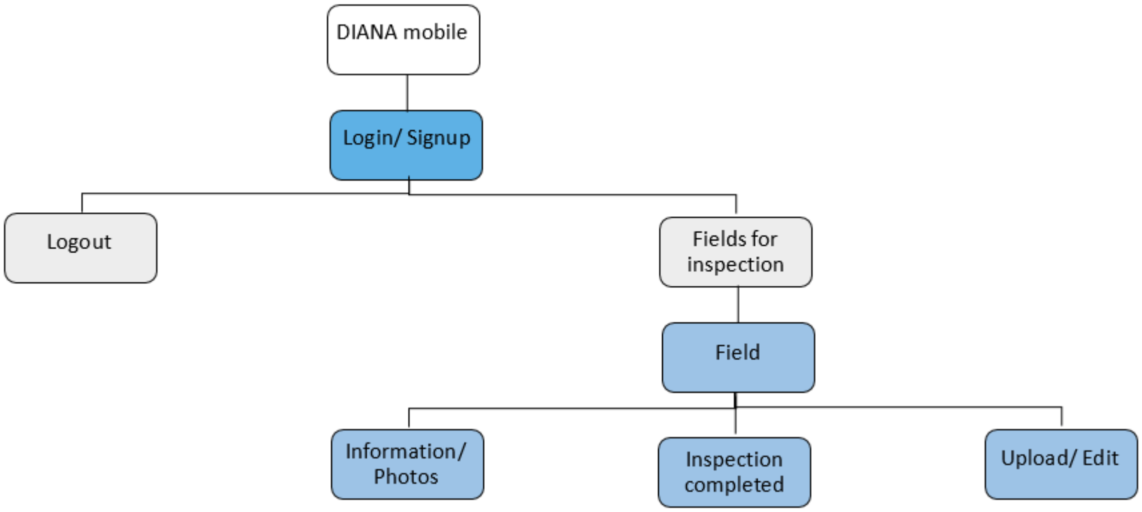

Figure 23: Mobile application sitemap

3.4.2.1. Login/ Signup

An inspector with an active account can login to the mobile application and have access to all the needed field-related data for the inspection.

Figure 24: Mobile login/signup

3.4.2.2. Home

The home screen of DIANA contains a list of the fields that have been assigned to the inspector. The inspector can tick the fields which indicates that the field has been inspected. The list can be sorted based on distance from the user's location. By clicking on the "See details" link, the inspector can see field-related information and snap photos related to the inspection process.

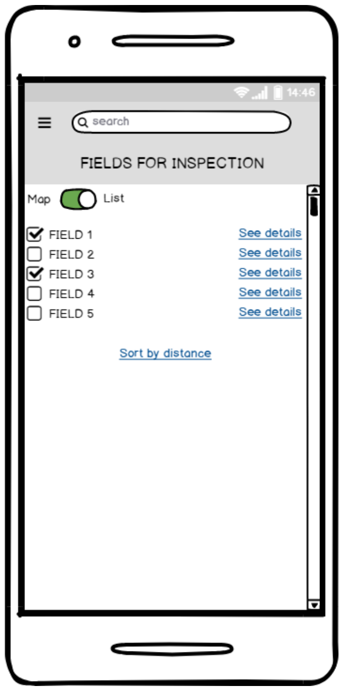

Figure 25: Home screen-inspection queue

3.4.2.3. Field's information and upload photos

The "field screen" contains information over a specific field as it can be seen in Figure 26. Upon completion of the inspection, the user can click on the button "Complete Inspection". Additional actions for this screen is the ability to upload photos/document.

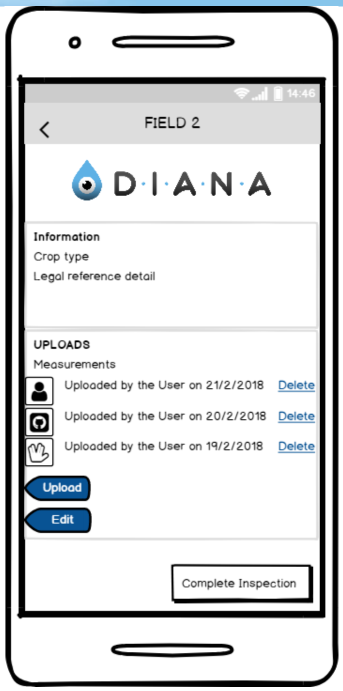

Figure 26: Field's information

The inspector is able to upload geo-tagged photos and submit water meter measurements from the inspected field. Both photos and measurements are available in the field page and can be removed/edited.

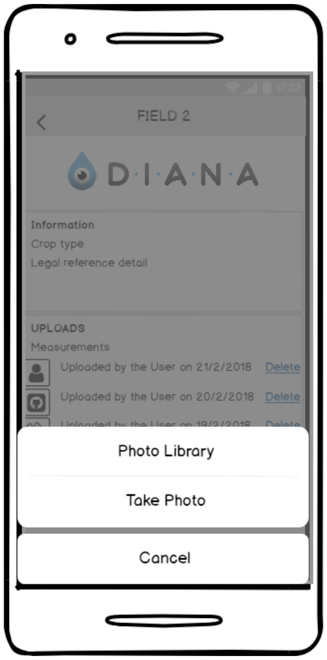

Figure 27: Upload photos

By clicking on the "Legal reference detail", the inspector receives a map view of the view along with essential information in a layer, regarding the legal ownership data of the field under inspection.

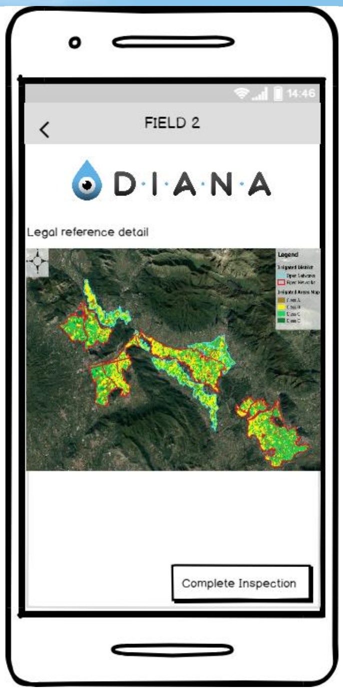

Figure 28: Field map view

3.5. Non-functional requirements

3.5.1. User Interface design

As far as the DIANA web app's UI is concerned, it will be designed following the common guidelines for usability, accessibility and efficiency. Furthermore, the web UI will follow the principles of Responsive Web Design (RWD), an approach to web design that suggests that design and development should respond to the user's behavior and environment based on screen size, platform and orientation. This approach provides an optimal viewing experience — ease of reading and navigation with a minimum of resizing, panning, and scrolling — across a wide range of devices (from desktop computer monitors to mobile phones).

3.5.2. Security

The purpose of this section is to define the security policies and rules that help ensure the security and availability of the platform and the confidentiality, integrity and availability of the data captured, stored and used in DIANA. The security policies and rules include the following:

- Authentication/Authorization. Only the authorized user can have access to specific information (for example the user profile can be viewed only by the person who owns the account).
- Cross-site scripting. Cross-Site Scripting (XSS) attacks are a type of injection, in which malicious scripts are injected into otherwise benign and trusted web sites. XSS attacks occur when an attacker uses a web application to send malicious code, generally in the form of a browser side script, to a different end user. The end user's browser has no way to know that the script should not be trusted and will execute the script. Because it thinks the script came from a trusted source, the malicious script can access any cookies, session tokens, or other sensitive information retained by the browser and used with that site. Our application will be using Laravel's XSS protection filters and middleware to filter html output.

4. DIANA architecture

The user specifications were analysed and using that information the team researched the potential tools/ technologies to be used in the DIANA platform. As a result of this work, the platform architecture was decided to follow a 3-layer approach that helps towards creating a scalable and high performance system.

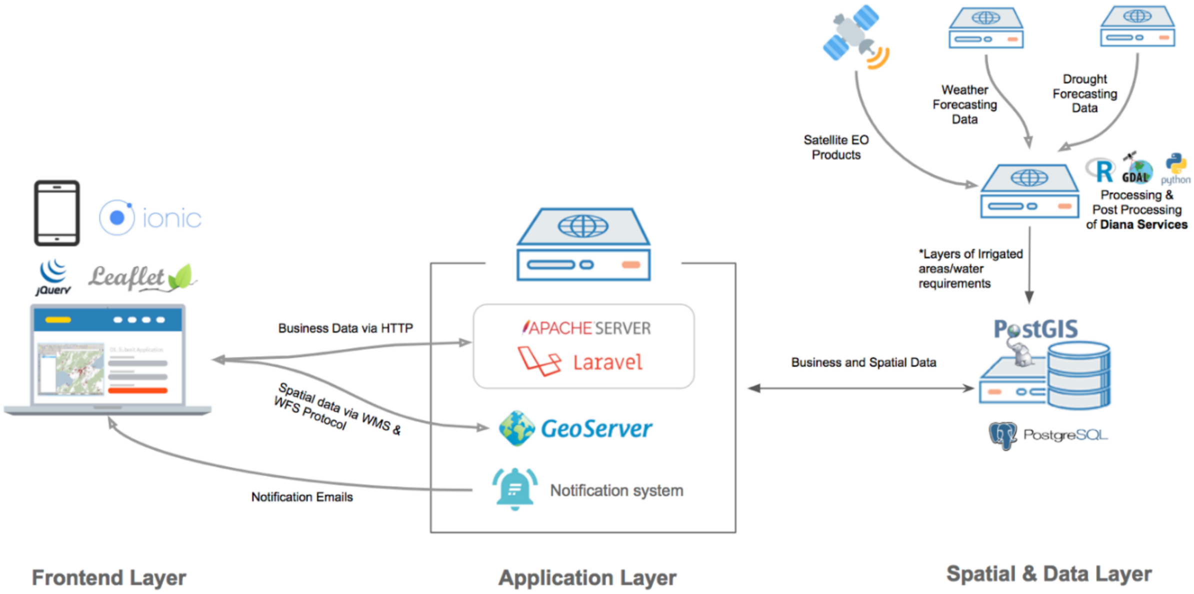

Figure 29: Architecture diagram

The 3 layers consist of:

1. **Spatial and data layer,** which collects data (e.g. weather and seasonal forecasts, meteorological observations, EO, relational data) from the different sources need to run the various DIANA services. The data layer includes the data persistence mechanisms that are responsible for storing and retrieving the data. It is mainly comprised of a database for storing the basic data entities and a spatial database responsible for all geospatial information which are accessible from Application layer.
2. **Application layer,** is responsible to execute all the logic defined for DIANA. It handles the requests and data coming from the frontend layer and spatial data layer, by applying the business logic rules and replying securely with proper content to the client applications (web and mobile applications). It contains several subsystems:
   - The database driven Core API of the platform is accessible by users through a Web server
   - A Map Server stack that is responsible to render spatial data as thematic maps to the Frontend layer
   - A notification system that is responsible to send out the appropriate messages to the end users based on their preferences

3. **Frontend layer,** hosts the DIANA user's interaction interface. It will be available to the web and mobile applications.

The technology stack will be chosen to serve the needs of the product and follow cutting edge technologies for building a modern product. The current understanding we have on the project results in the following choices.

1. A Restful API written in the Laravel framework in PHP, combined with a postgres/postGIS database for the **Webserver stack**,
2. GIS server software like Geoserver will be used for visualizing geospatial information coming from the models or other sources like postgres/postGIS.
3. The **front end** of the DIANA platform will be developed using jQuery, the technology behind most modern web platforms. Third party content and UI elements like basemaps, bootstrap or chart libraries are also included in this layer. The mobile application will be based on Ionic, which is built on top of AngularJS and Apache Cordova.
4. Python and R could be used for developing the models or for coordinating the numerous processes.

Several other decisions as the format of the files that are going to be send from each service in the spatial layer (Shapefiles, GeoTIFFs and CSVs), the OGC WMS/WFS standard for visualizing geospatial information to the front end etc.

5. DIANA integration plan (Inside Spatial & Data Layer)

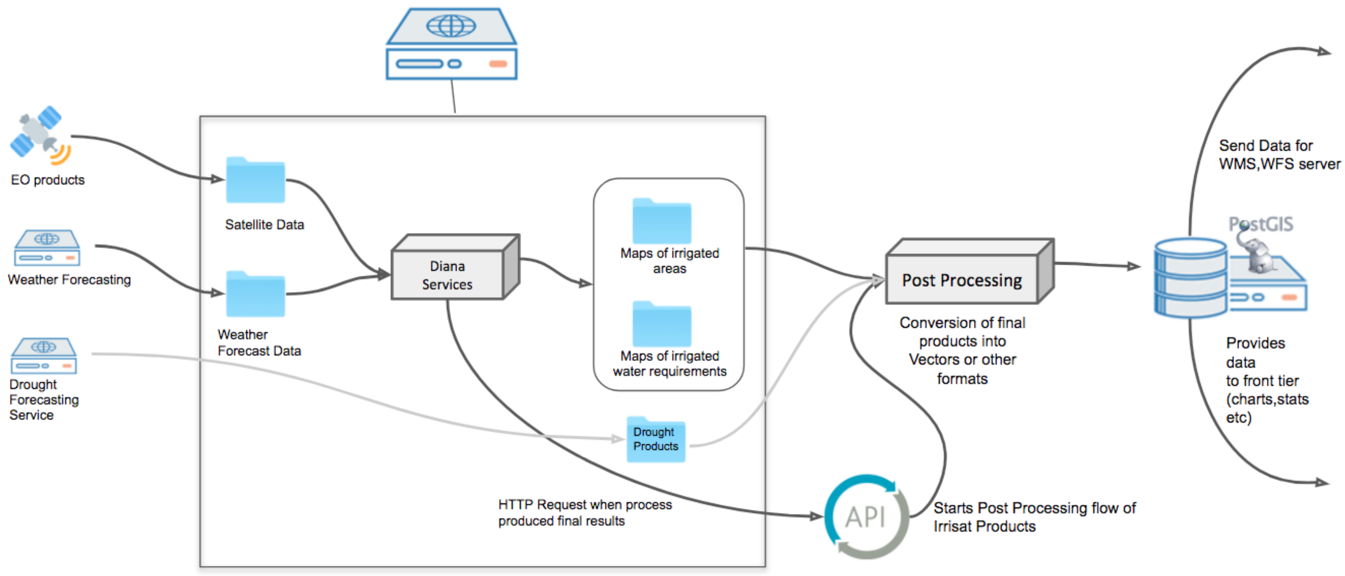

Figure 30: Integration diagram

"Spatial & Data" layer is the integration point between DIANA Core services and external data providers like weather and seasonal forecast services, meteorological observations and satellite data. This layer will expose endpoints based on common connectivity protocols (sftp, https, ssh) for data collection from external providers, into a well-organized file structure inside the server.

Once the needed inputs for the DIANA Services are collected and are ready for processing, the services are executed and produce the outputs which are saved into a well-organized file structure.

DIANA services will perform an HTTP request to a micro service endpoint to notify the existence of fresh data and trigger the post-processing stage. The main aim of the post processing stage is to prepare or convert the outputs based on PostGIS database schema and business requirements of the platform.

Finally, PostGIS will act as a data source for the map server and platform's API in order to guide the application layer of the system.

Annexes

5.1. Annex I: Competitors' provided services and features

Project/ Product	Service	Features
eleaf	• Water auditing • Water accounting • Water productivity • Irrigation management • Evapotranspiration data • Crop monitoring • Irrigation planner	• Field specific compliance auditing • Scans large areas regularly • Automatically flags non-compliance • Makes water flows comparable • Supports scenario setting • Optimized for large basins • Available in near real-time • Quantified in kg production/m^3 water • Available from field to continent • 5 day allocation needs forecast • Quantified water requirement in mm^3 • Water stress notifications • Available in near real-time • Quantified in mm/time step • Available from field to continent • Quantified crop production figures • Quantified crop water use figures • Easy identification of in-field production variations • Timely identification of underperforming areas • 5 day irrigation advice • Phone and email notifications • Field specific irrigation volumes
IrriSAT	• Decision support tool to assist irrigators with irrigation water management • Water Balance • Crop Water Use • Irrigation Scheduling • Agronomic Performance Indicators	• Tracking soil water deficit through time • Estimating reference evapotranspiration • Estimating the crop coefficient • Saturation • Field Capacity • Permanent Wilting Point • Readily Available Water • Soil Type • Rooting depth • Irrigation system type • Crop Water Use Index • Irrigation Water Use Index • Gross Production Water Use Index
TOPS-SIMS	• Satellite Irrigation Management Support	• ETcb • Basal crop coefficient (Kcb) • Fractional Cover (FC) • Vegetation Index (NDVI) gap-filled

		• NDVI
Irrisat	• Irrigated area mapping • Irrigation water requirement • Irrigation logs • Irrigation fee recover	• Mapping system for irrigated areas based on temporal variability of vegetative vigor • Classified map of the growth patterns • Registered cadastral parcels • Classified map of the growth patterns
Spider	• Participatory tool to aid decision making applied to improve agroforestry environments • Monitoring, control and agronomic management of crops and agroforestry areas • Main basic functions of a GIS • Tools are applied in synergy with advanced participatory methodology to achieve maximum transparency and active participation in agroforestry management	• ETc Adjusted Annual/ Monthly • ETo annual Annual/ Monthly • Precipitation Annual/ Monthly • Evapotranspiration Annual/ Monthly • NDVI • Kcb
USDM	• Drought Classification	• Maps for selected areas • Compare maps from two different weeks • Request custom map • Drought summary • Tabular data, time series, download datasets, data in GIS formats
dms	• Weekly map of drought conditions	• Integrated Drought Severity Index • Standardized Precipitation Index • Soil Moisture Index
NASA-GRACE	• Drought indicators	• Groundwater Percentile Maps • Root Zone Soil Moisture Percentile Maps • Surface Soil Moisture Percentile Maps
GADMFS	• Global Agricultural Drought Monitoring and Forecasting System	• Drought • VCI • NDVI

5.2. Annex II: User requirements

A/A	User requirement	Time and frequency	Data source	Priority
UR - 1.	Maps of irrigated areas (for non-authorized abstractions)	Once per season	Multi-temporal, multi-spectral satellite images with field calibration, jointly with other sources as orthophoto, ancillary information about crops, management, other cartography	High
UR - 2.	Maps of abstracted volumes	Once per season	Multi-temporal, multi-spectral satellite images with field calibration, jointly with other sources as orthophoto, ancillary information about crops, management, other cartography	High
UR - 3.	Maps of Crop inventory	Once per season	Multi-temporal, multi-spectral satellite images with field calibration, jointly with other sources as orthophoto, ancillary information about crops, management, other cartography	High
UR - 4.	Maps of prediction of crop water requirements	Weekly during the season, one week ahead	Multi-sensor, multi-spectral satellite images with field calibration & anchor station; Field station with crop phenology expert system; Combination of both	High
UR - 5.	Maps of actual crop water consumption	Weekly during the season, one week ahead	Multi-spectral satellite images (with field calibration & agromet station)	High
UR - 6.	Maps of total water consumption	Monthly/ or accumulated at the end of year	Multi-spectral satellite images (with field calibration & agromet station)	Medium
UR - 7.	Maps of water stress	Weekly during the season, one week ahead	Multi-spectral satellite images (with field calibration & agromet station)	High
UR - 8.	Maps of water use	Weekly during the season, one week ahead	Multi-spectral satellite images (with field calibration & agromet station)	High
UR - 9.	Maps of irrigation performance indicators	Monthly during the season	Multi-spectral satellite images (with field calibration & agromet station)	High

UR - 10.	Maps of Gridded water balance	Weekly to monthly	Multi-temporal, multi-spectral satellite images with field calibration, jointly with other sources as orthophoto, ancillary information about crops, management, other cartography	High
UR - 11.	Basin-wide maps of geo-, bio-, hydro-, agro-, eco-, climatic & social parameters/ indicators	Once per season	Multi-spectral satellite images (with field calibration & agromet station)	Medium
UR - 12.	Maps of ancillary information (soil maps of water retention capacity, land cover use maps)	Once per season	Public information sources	High
UR - 13.	Maps of waterlogged & salt-affected areas	Once per year	Multi-sensor, multi-spectral satellite images with field calibration	Small
UR - 14.	Maps of fertilizers & pesticide application	Monthly/ or accumulated at the end of year	Crop inventory plus ancillary information (average fertilizer or pesticide use per crop type)	Small
UR - 15.	Maps of water rights	Once a year	List and map of cadastral parcels with regular irrigation right. Water User Association archives. Available in some MS.	High
UR - 16.	Statistics and time-series analysis	Entire season	All the above	High

A/A	**General User Requirement**	**User Requirements**
GUR-1	The user should be provided with maps to monitor irrigated areas and abstracted volumes at least once a year.	UR - 1, UR - 2, UR - 3, UR - 4, UR - 5, UR - 6, UR - 8, UR - 9, UR - 10, UR - 12, UR - 15, UR - 16

GUR-2	Field inspections should be optimized through the use of maps detecting non-authorized abstractions at least once per season to ensure compliance with legal water allocation.	UR - 2, UR - 3, UR - 5, UR - 6, UR - 7, UR - 8, UR - 10, UR - 12, UR - 15, UR - 16
GUR-3	The reliability of self-declaration of water abstractions should be ensured at least once per season through the use of maps depicting abstracted volumes.	UR - 2, UR - 3, UR - 5, UR - 6, UR - 8, UR - 10, UR - 11, UR-12, UR - 15
GUR-4	The user should be provided with maps of water requirements at a weekly basis (one week ahead) during the seasonal period facilitating the drought management and ensuring compliance with the seasonal water restrictions.	UR - 3, UR - 4, UR - 5, UR - 6, UR - 7, UR - 8, UR - 9, UR - 10, UR - 11, UR - 12, UR - 15, UR - 16
GUR-5	The user should be provided with historical water rights in order to identify in a better way the water users.	UR - 3, UR - 5, UR - 6, UR - 8, UR - 9, UR - 11, UR - 13, UR - 12, UR - 14, UR - 15, UR - 16
GUR-6	Hydraulic works may be mapped.	UR - 1, UR - 2, UR - 8, UR - 10, UR - 12
GUR-7	The user should be provided with ex-post assessment on the implementation of water management systems, providing different time scales as a base for adopting future actions.	UR - 1, UR - 2, UR - 3, UR - 5, UR - 6, UR - 8, UR - 9, UR - 10, UR - 11, UR - 12, UR - 13, UR - 14, UR - 16
GUR-8	The user should be provided with information regarding the water abstraction volumes in order to adjust water prices and implement volume-based fee system.	UR - 2, UR - 10, UR - 12, UR - 15, UR - 16
GUR-9	Irrigation scheduling should be further supported with maps and statistical tools to increase the efficiency of water management systems.	UR - 1, UR - 2, UR - 3, UR - 4, UR - 7, UR - 8, UR - 9, UR - 10, UR - 11, UR - 12, UR - 15
GUR-10	All irrigated areas need to be identified and cross-checked with all available information/databases on irrigable areas (i.e. areas with a legal right to irrigate). Depending on national and/or regional legislation, the legal right to irrigate may be linked to the land, an abstraction point or a water source,	UR - 1, UR - 2, UR - 3, UR - 5, UR - 6, UR-7, UR - 8, UR - 9, UR - 10, UR - 12, UR - 15

	either permanently or for limited periods of time (e.g. seasonal restrictions).	
GUR-11	Irrigation water consumption should be monitored and cross-checked with regulated allocation and/or hydrological planning data on a monthly base or accumulated at the end of the year.	UR - 1, UR - 2, UR - 3, UR - 5, UR - 6, UR - 7, UR - 8, UR - 9, UR - 10, UR - 12, UR - 15

5.3. Annex III: Requirements traceability matrix

A/A	User requirement	A/A	Technical requirements
UR-1	Maps of irrigated areas (for non-authorized abstractions)	**TR - 2**	DIANA will offer an Irrigation Classification Map
		TR - 8	DIANA will offer Earth Observation (EO) Time Variant Maps
		TR - 11	DIANA will offer a Static map with flags in parcels where non-authorized abstractions occurred (Type-1)
		TR - 32	DIANA will offer a total Recorded Irrigation Water Time Variant Maps
UR-2	Maps of abstracted volumes	**TR - 4**	DIANA will offer a Net Irrigation Water Requirements Time Variant Map (crop water consumption)
		TR - 5	DIANA will offer a Crop Evapotranspiration Time Variant Map
		TR - 6	DIANA will offer a Reference Evapotranspiration Map
		TR - 7	DIANA will offer a Precipitation Time Variant Map
		TR - 8	DIANA will offer Earth Observation (EO) Time Variant Maps
		TR - 9	DIANA will offer a Static Map with the Maximum Allowance of Irrigation Water Consumption Volumes
		TR - 10	DIANA will offer a Static Map with the differences between the Net Irrigation Water Requirement
		TR - 11	DIANA will offer a Static map with flags in parcels where non-authorized abstractions occurred (Type-1)
		TR - 12	DIANA will offer a Static map to identify over-abstractions (Type-2)
		TR - 22	DIANA will offer Precipitation Deficit Time Variant Maps
		TR - 30	DIANA will offer a total Reference Evapotranspiration Map
		TR - 31	DIANA will offer a total Precipitation Time Variant Map
UR-3	Maps of Crop inventory	**TR - 1**	DIANA will offer a Crop Classification Map
		TR - 3	DIANA will offer a Crop Coefficient Time Variant Map

		TR - 5	DIANA will offer a Crop Evapotranspiration Time Variant Map
		TR - 6	DIANA ill offer a Crop Evapotranspiration Time Variant Map
		TR - 16	DIANA will present in a chart the Time Series of Crop Growth Parameters (LAI, Crop Coefficient)
		TR - 22	DIANA will offer Precipitation Deficit Time Variant Maps
		TR - 30	DIANA will offer a total Reference Evapotranspiration Map
		TR - 31	DIANA will offer a total Precipitation Time Variant Map
UR-4	Maps of prediction of water requirements	**TR - 3**	DIANA will offer a Crop Coefficient Time Variant Map
		TR - 4	DIANA will offer a Net Irrigation Water Requirements Time Variant Map (crop water consumption)
		TR - 5	DIANA will offer a Crop Evapotranspiration Time Variant Map
		TR - 6	DIANA will offer a Reference Evapotranspiration Map
		TR - 7	DIANA will offer a Precipitation Time Variant Map
		TR - 9	DIANA will offer a Static Map with the Maximum Allowance of Irrigation Water Consumption Volumes
		TR - 15	DIANA will present in a chart the Time Series of Net Irrigation Water Requirements
		TR - 22	DIANA will offer Precipitation Deficit Time Variant Maps
		TR - 30	DIANA will offer a total Reference Evapotranspiration Map
		TR - 31	DIANA will offer a total Precipitation Time Variant Map
		TR - 32	DIANA will offer a total Recorded Irrigation Water Time Variant Maps
UR-5	Maps of actual crop water consumption	**TR - 5**	DIANA will offer a Crop Evapotranspiration Time Variant Map
		TR - 6	DIANA will offer a Reference Evapotranspiration Map
		TR - 7	DIANA will offer a Precipitation Time Variant Map
		TR - 10	DIANA will offer a Static Map with the differences between the Net Irrigation Water Requirement
		TR - 22	DIANA will offer Precipitation Deficit Time Variant Maps
		TR - 30	DIANA will offer a total Reference Evapotranspiration Map
		TR - 31	DIANA will offer a total Precipitation Time Variant Map
		TR - 32	DIANA will offer a total Recorded Irrigation Water Time Variant Maps
UR-6	Maps of total water consumption	**TR - 5**	DIANA will offer a Crop Evapotranspiration Time Variant Map
		TR - 6	DIANA will offer a Reference Evapotranspiration Map
		TR - 7	DIANA will offer a Precipitation Time Variant Map
		TR - 10	DIANA will offer a Static Map with the differences between the Net Irrigation Water Requirement

		TR - 22	DIANA will offer Precipitation Deficit Time Variant Maps
		TR - 30	DIANA will offer a total Reference Evapotranspiration Map
		TR - 31	DIANA will offer a total Precipitation Time Variant Map
		TR - 32	DIANA will offer a total Recorded Irrigation Water Time Variant Maps
UR-7	Maps of water stress	**TR - 5**	DIANA will offer a Crop Evapotranspiration Time Variant Map
		TR - 6	DIANA will offer a Reference Evapotranspiration Map
		TR - 8	DIANA will offer Earth Observation (EO) Time Variant Maps
		TR - 22	DIANA will offer Precipitation Deficit Time Variant Maps
		TR - 30	DIANA will offer a total Reference Evapotranspiration Map
		TR - 31	DIANA will offer a total Precipitation Time Variant Map
UR-8	Maps of water use	**TR - 4**	DIANA will offer a Net Irrigation Water Requirements Time Variant Map (crop water consumption)
		TR - 5	DIANA will offer a Crop Evapotranspiration Time Variant Map
		TR - 6	DIANA will offer a Reference Evapotranspiration Map
		TR - 7	DIANA will offer a Precipitation Time Variant Map
		TR - 8	DIANA will offer Earth Observation (EO) Time Variant Maps
		TR - 9	DIANA will offer a Static Map with the Maximum Allowance of Irrigation Water Consumption Volumes
		TR - 12	DIANA will offer a Static map to identify over-abstractions (Type-2)
		TR - 22	DIANA will offer Precipitation Deficit Time Variant Maps
		TR - 30	DIANA will offer a total Reference Evapotranspiration Map
		TR - 31	DIANA will offer a total Precipitation Time Variant Map
		TR - 32	DIANA will offer a total Recorded Irrigation Water Time Variant Maps
UR-9	Maps of irrigation performance indicators	**TR - 8**	DIANA will offer Earth Observation (EO) Time Variant Maps
		TR - 27	DIANA will offer Percentile Maps of Basic Meteorological Parameters
UR-10	Maps of Gridded water balance	**TR - 4**	DIANA will offer a Net Irrigation Water Requirements Time Variant Map (crop water consumption)
		TR - 5	DIANA will offer a Crop Evapotranspiration Time Variant Map
		TR - 6	DIANA will offer a Reference Evapotranspiration Map
		TR - 7	DIANA will offer a Precipitation Time Variant Map
		TR - 9	DIANA will offer a Static Map with the Maximum Allowance of Irrigation Water Consumption Volumes
		TR - 22	DIANA will offer Precipitation Deficit Time Variant Maps
		TR - 23	DIANA will offer Time Variant Maps of Basic Meteorological Parameters
		TR - 30	DIANA will offer a total Reference Evapotranspiration Map
		TR - 31	DIANA will offer a total Precipitation Time Variant Map

UR-11	Basin-wide maps of geo-, bio-, hydro-, agro-, eco-, climatic & social parameters/ indicators	**TR - 8**	DIANA will offer Earth Observation (EO) Time Variant Maps
		TR - 27	DIANA will offer Percentile Maps of Basic Meteorological Parameters
UR-12	Maps of ancillary information (soil maps of water retention capacity, land cover use maps)		Use of open data from publicly available sources
UR-13	Maps of waterlogged & salt-affected areas	**TR - 8**	DIANA will offer Earth Observation (EO) Time Variant Maps
UR-14	Maps of fertilizers & pesticide application	**-**	-
UR-15	Maps of water rights	**TR - 14**	DIANA will offer additional map layers according to the business needs
UR-16	Statistics and time-series analysis	**TR - 17**	DIANA will offer Time Series of EO parameters
		TR - 18	DIANA will offer the capability to export Water Auditing Reports
		TR - 29	DIANA will offer statistical plots

This project is co-funded by the European Union