D6.2: User Profile & Personalised nudging engine mid-term

NAIADES

Greening the economy in line with the sustainable development goals

Project Title:

A holistic water ecosystem for digitisation of urban water sector

SC5-11-2018

Digital solutions for water: linking the physical and digital world for water solutions

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0.5	13/08/2020	ICCS	Overview of systems analysis
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1.0	30/11/2020	ICCS	Final version for submission

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Summary

One of the main objectives of NAIADES (Objective 5) is to enhance water end-users' as well as related stakeholders', such as managers of water companies and public officials, awareness on water consumption and promote user engagement in water conservation activities. WP6 "Water Consumers Awareness and Behavioural Change Support" is set to address this objective with the design and development of a set of services that rely on information personalization and persuasive technologies in order to guide water end-users towards efficient decisions and actions. This deliverable, the second of WP6, describes the NAIADES services for awareness and user engagement in water conservation which are the outcome of the work performed in tasks T6.2, T6.3 and T6.4. The implemented services focus on the following set of use cases:

1. **Water consumption awareness for water management companies and public officials**. This use case shows how to make use of the NAIADES data aggregation middleware and optimally present water consumption data and related contextual parameters such as the time of consumption, weather conditions etc., to interested stakeholders in order to allow them to monitor and understand how water is consumed in a specific area or consumption point. Decisions on water consumption mitigation measures can rely on such information and such measures can be monitored after their implementation.

2. **Water consumption awareness for public employees**. This use case shows how to make use of watering data and AI services for watering predictions in order to inform public employees decisions related to plants watering tasks. Plants' watering is performed in nearly every municipality and public building, and commonly leads to unnecessary water consumption and waste of human resources. The NAIADES approach aims to inform watering decisions for timely watering actions and water savings.

3. **Behavioural change support for inducing sustainable water use behaviours among water consumers**. This use case shows how ICT solutions can be used in order to change consumers' perceptions and actions towards water conservation. In NAIADES we focus on school students, a group of consumers that can provide a channel for generating great impact as students i) will evolve to the responsible citizens of tomorrow and ii) they can transfer the knowledge, attitudes and behaviours they shape to their families, leading to a cascading effect of the NAIADES impact.

The NAIADES applications described in the following are designed and developed in order to address the aforementioned use cases and include:

- The Consumption Awareness Dashboard for Water Management Companies & Public officials
- The Water Consumption Awareness Dashboard for Public Employees
- The Water Consumers Awareness Dashboard

1 Introduction

A main objective of NAIADES (Objective 5) is to enhance the awareness of water end-users on water consumption and promote user engagement in water conservation activities. In addition to water end-users this objective also applies to other related stakeholders, such as managers of water companies and public officials. WP6 "Water Consumers Awareness and Behavioural Change Support" aims to address this objective with the design and development of a set of services that rely on information personalization and persuasive technologies in order to guide water end-users towards efficient decisions and actions. This deliverable, the second of WP6, describes the NAIADES services for awareness and user engagement in water conservation which are the outcome of the work performed in tasks T6.2, T6.3 and T6.4.

Task T6.2 focuses on the definition of an elaborate user profile that is used to describe water consumers in the NAIADES platform. The user profile is employed in order to store, mine, and extract the required user information from the NAIADES data sources (e.g. data on water flows and metered consumption) as well as from observed end-user interactions with the NAIDES applications. It also captures routine water consumption behaviour, user and school characteristics which may influence water consumption with the aim to support the provision of recommendations and feedback, facilitating enhanced awareness on water consumption and usage savings.

Task 6.3 designs and implements methods and tools for information personalization and recommendation that filter and select appropriate information to be displayed to water consumers aiming to nudge them towards efficient water usage. The information includes suggestions for efficient water use coupled with visual representations of behavioural change strategies such as social comparison and self-monitoring. The algorithms make use of recommendation techniques and decision theory methods while considering the persuasive strategies and user model developed in task T6.1. The main goal of the recommendation services is to support long term behavioural change and sustainability-oriented decisions. The personalization and persuasive recommendation services extract context from the NAIADES system by leveraging information from various sources and sensors and subsequently aggregate and utilize it in recommendation and awareness raising processes.

The main goal of T6.4 is the development of web-based applications, also accessible via smartphones and tablets which assist users in their daily routines towards achieving awareness and behavioural change for efficient water usage. The provided apps consider users' water consumption profiles, their water consumption needs, best practices followed by similar peers as well as environmental and water system states. With the use of the NAIADES apps for water consumption awareness, end-users know how much water is consumed, they receive recommendations of action plans for water conservation, along with an estimation of their impact on water use and are, ultimately, nudged towards water conservation-related behavioural change. The applications provide a holistic view of the water consumption through intuitive user interfaces, while data captured from smart meters/sensors and user's feedback feed visualization of information.

1.1 Overview of use cases addressed

NAIADES aims at providing a set of innovative services that will enhance public awareness on water consumption and usage savings, promote user engagement and enhance user participation in water conservation activities. These include awareness services that present detailed information about water consumption and behavioural change support services that leverage the power of behavioural change support and persuasive strategies and features such as social proof, tailoring, self-monitoring, goal setting/commitment and rewards. The goal is to change the attitude and practices towards water conservation by enhancing public awareness on water consumption and usage savings, promoting user engagement and enhancing user participation in water conservation activities. These services make use of the data middleware and AI services which are part of the NAIADES solution. More specifically the

NAIADES awareness services and behavioural change support services focus on the following set of use cases:

1. **Water consumption awareness for water management companies and public officials**. This use case shows how to make use of the NAIADES data aggregation middleware and optimally present water consumption data and related contextual parameters such as the time of consumption, weather conditions etc., to interested stakeholders in order to allow them to monitor and understand how water is consumed in a specific area or consumption point. Decisions on water consumption mitigation measures can rely on such information and such measures can be monitored after their implementation.
2. **Water consumption awareness for public employees**. This use case shows how to make use of watering data and AI services for watering predictions in order to inform public employees decisions related to plants watering tasks. Plants' watering is performed in nearly every municipality and public building, and commonly leads to unnecessary water consumption and waste of human resources. The NAIADES approach aims to inform watering decisions for timely watering actions and water savings.
3. **Behavioural change support for inducing sustainable water use behaviours among water consumers**. This use case shows how ICT solutions can be used in order to change consumers' perceptions and actions towards water conservation. In NAIADES we focus on school students, a group of consumers that can provide a channel for generating great impact as students i) will evolve to the responsible citizens of tomorrow and ii) they can transfer the knowledge, attitudes and behaviours they shape to their families, leading to a cascading effect of the NAIADES impact.

1.2 Structure of the deliverable

The remainder of this deliverable proceeds as follows:

- Section 2 provides a summary of the NAIADES Consumer Awareness and Behavioural Change Support Framework already defined in D6.1 and shows the position of the services developed in WP6 within the overall NAIADES architecture.
- Section 3 focuses on the water consumption awareness for water management companies and public officials use case. It presents an overview of the NAIADES water consumption dashboard for cities along with its technical implementation details.
- Section 4 focuses on the water consumption awareness for public employees use case. It presents the NAIADES Watering application, while it describes its implementations details.
- Section 5 focuses on the water management companies & public officials use case. It presents the water consumers' awareness dashboard, and its implementations details.
- The deliverable concludes in Section 6 with final remarks and the next steps for the coming period.

2 The NAIADES Awareness and Behavioural Change Support Framework

The NAIADES Awareness and Behavioural Change Support applications aim to address the requirements of two use cases of the project namely those of the water utility in Alicante, Spain and the municipality of Carouge, Switzerland. The water utility in Alicante is transforming its water supply network with smart sensors that measure consumption at different levels. There is an abundance of water consumption data that remain unexploited and which can be used to raise water consumption awareness in different stakeholder levels as well as target consumer groups and support sustainable water use and reduced consumption. The provision of solutions for awareness and behavioural change support is a common need among many water utilities across Europe and NAIADES aims at providing an innovative approach showcasing the benefits of such solutions. The Carouge case focuses on the problem of efficient watering of plants in municipalities. The aim is to leverage AI supported solutions for plants' watering predictions and couple them with awareness technologies targeted to personnel responsible for watering. This is also a common need among municipalities across Europe and the Carouge case provides the opportunity to deploy and demonstrate a solution which can be adopted by other stakeholders.

Deliverable D6.1 described the NAIADES conceptual framework for water consumption awareness and positive behavioral changes in citizens nudging them to opt for more sustainable water consumption choices. The framework aims to address the requirements of the NAIADES use cases and is shown in Figure 1. It consists of three main layers offering different functionalities. The layers align with the work performed in tasks T6.2, T6.3 and T6.4 of WP6 and drove the development of the related applications that are described in this deliverable. Moreover, Figure 1 shows the interactions of the framework with the NAIADES services developed in WP5 and WP3.

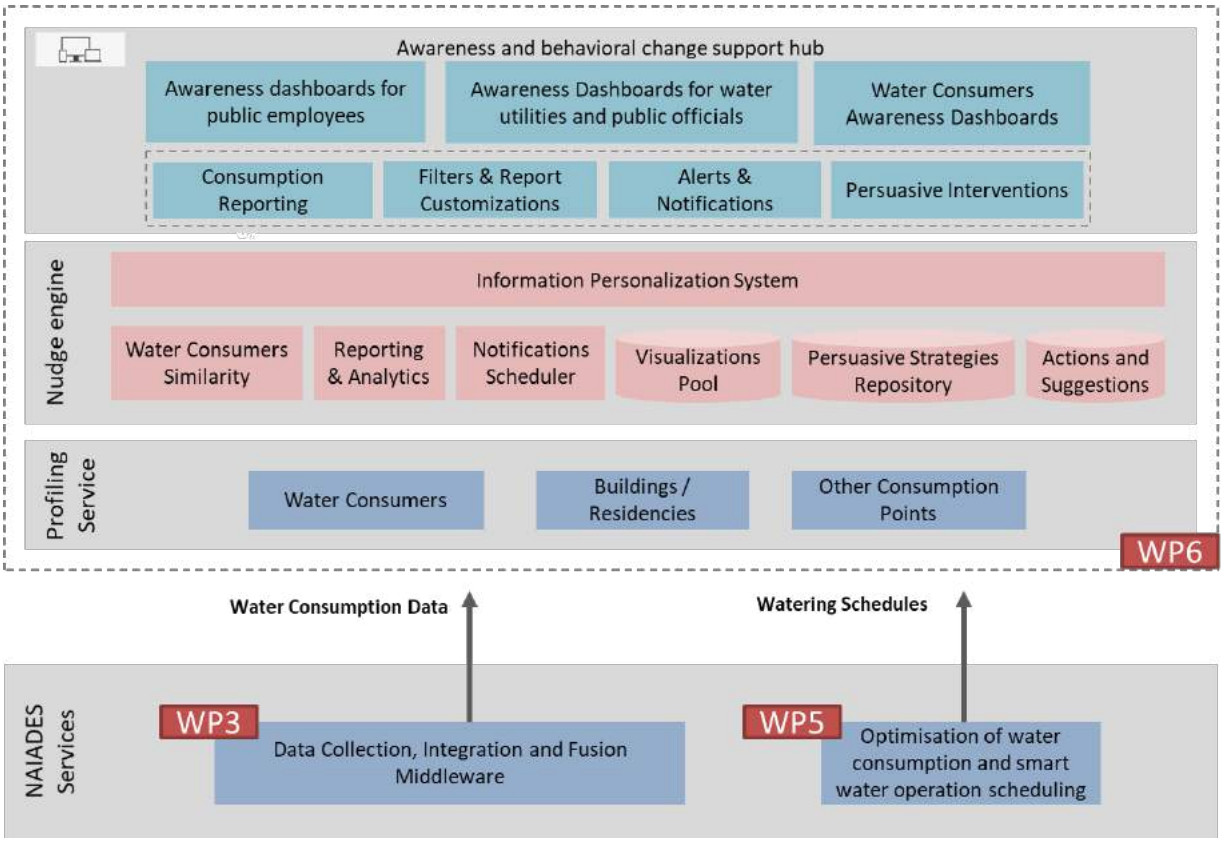


Figure 1: The Naiades Conceptual Framework for Water Consumption Awareness and Behavioural Change Support.

The Profiling Service, displayed in the bottom layer, describes water consumers, such as buildings and watering points (e.g. fountains) in the NAIADES platform. Related information is captured for public

buildings and consumption points such as schools, sport facilities, gardens, with characteristics such as location, type, size, consumption type, number of students, etc. and water end users in public buildings. The characteristics of the consumption points include:

- Type of consumption point such as public buildings, schools, sport facilities, gardens
- Location
- Size
- Historical water consumption
- Frequency and type of measurements (automated or manual)

A special case refers to schools' interventions, where extra information is considered and includes: school class size, school hours and socioeconomic information of the area, the existence of garden, pool and other water consuming facilities.

The nudge engine layer provides functionalities that enable filtering and selecting appropriate information to be displayed to end-users aiming to raise water consumption awareness and nudge them towards efficient water usage.

- The **Reporting and Analytics** module handles water consumption data stored in related repositories and serves these data for the generation of reports in different time scales. Moreover, it performs data normalizations where needed, for better data understanding.
- The **Water Consumers Similarity** module generates a similarity score between the different consumption points stored in the database. The similarity score should be based on the characteristics of the consumption point and historical consumption measurements.
- The **Notifications Scheduler** is responsible for delivering notifications (such as watering actions) at proper times while considering contextual parameters such as the time of day and past consumption trends. The goal is to carefully select the timing of the notifications in order to be noticed and considered by the end-users.
- The **Visualizations Pool** is a repository of smart visualizations that can be used to visualize water consumption. Such visualizations may include different kinds of graphs (e.g. time-series, bar charts, pie charts etc.) as well as playful designs that communicate water consumption in different ways, such as a tree that grows more when the user conserved water.
- The **behavioural change support strategies repository** provides the details for implementing different strategies. In NAIADES we consider the most relevant to be self-monitoring and feedback, social comparison, rewards and suggestion for implementing public awareness and behavioural strategies within water management.
- The **repository of Actions and Suggestions** contains informative messages and tips which can be displayed to end-users and nudge them towards actions for sustainable water use.
- The **information personalization system** consists of tailoring the behavioural change interventions, suggestions, alerts and reports, to accommodate specific groups or segments of individuals (employees, consumers, schools, etc.).

The awareness and behavioural change support hub includes the presentation layer and functionalities that enable water consumption awareness and assist water consumers in their daily routines towards behavioural changes for efficient water usage.

More specifically, the awareness and behavioural change support hub consists of three dashboards: the awareness dashboard for water companies and city officials, the water consumers' awareness dashboard and the awareness dashboards for public employees. The awareness dashboard for water companies and city officials is addressed to stakeholders who want to make sense of water consumption data, such as Alicante. The water consumers' awareness dashboard is addressed to water consumers. In NAIADES these are the

students and school teachers in Alicante. The awareness dashboard for public employees is addressed to city workers responsible for irrigation of public spaces, such as the Carouge employees. The awareness and behavioural change support hub facilitates water end-users to know how much water is consumed, to get recommendations of action plans for water conservation along with an estimation of their impact and to be nudged towards water conservation-related behavioural change interventions provided by the nudge engine.

The dashboards that are developed integrate the following functionalities:

- Consumption reporting. Different types of reports should be provided, including reporting of consumption by time, reporting of consumption by point type and comparisons of different periods and consumption points.
- Filtering and report customizations refer to functionalities that allow users to select subsets of data to be reported and generate customized reports based on the selected data.
- The Alerts and Notifications functionality is used to display in the user interface alerts, tips and other notifications generated by the notifications' scheduler. Placeholders or notification pop-ups should be created in the dashboards to present the relevant data.
- The behavioural change interventions refer to specific views in the dashboards that instantiate behavioural change strategies. These include consumption feedback and self-monitoring views, consumption rankings that allow social comparisons and related discussion forums that enable communication among consumers.

Note that in order to ensure the adherence to user requirements, the awareness and behavioural change support dashboards are developed incrementally in an agile and iterative manner based on the requirements of the relevanant pilot stakeholders. In this context, user interface prototypes (usually known as mockups or wireframes), have proven to boost efficiency when capturing requirements of Web Applications (Reggio et l., 2018). One of their advantages is that they are technically valuable for developers and, at the same time, fully understandable by end-users (Gamito and da Silva, 2020). To this end, we have used digital UI mockup tools to rapidly draft the app's user interfaces and the developed mockups/prototypes have been used to help in discussing UI specifications with end-users, and also to discover and define non-UI requirements in a language that is more familiar to them, as opposed to plain textual specifications (Kaindl, 2019). In addition, such UI mockups worked not only as requirements artifacts, but also as general requirements elicitation helpers (Kumar and Krishnamurthi, 2016), allowing to capture and register fluid requirements (Pacheco et al., 2018) – those that are usually expressed orally or informally and are an implicit (and usually lost) part of the elicitation process.

With respect to NAIADES' technical architecture which is described in detail in deliverable D2.9, the awareness and behavioural change support services presented in this deliverable are positioned as shown in Figure 2.

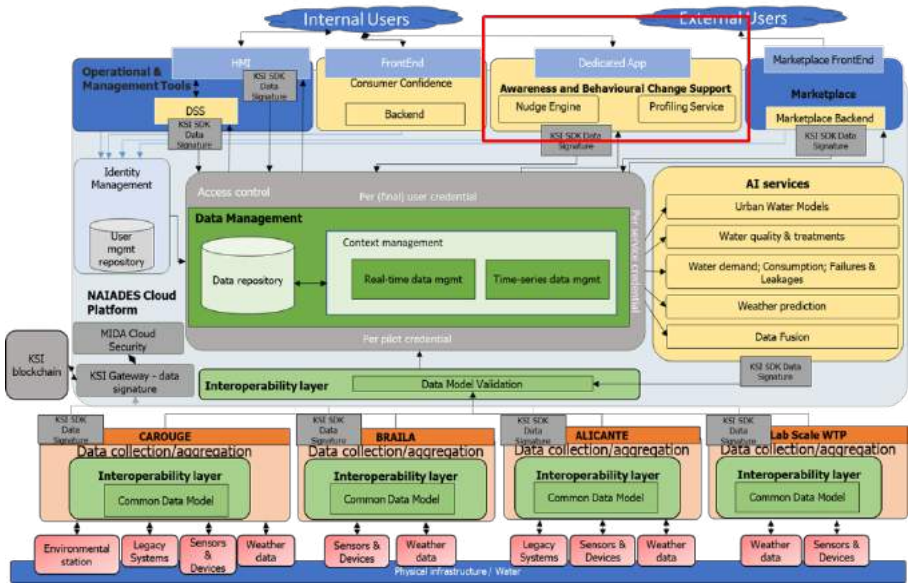


Figure 2: Position of the awareness and behavioural change support services within the NAIADES technical architecture. The services are marked with a red rectangular.

The awareness and behavioural change support services make use of the NAIADES AI services outputs as well as the information generated by the NAIADES sensors networks through the data management framework and the NAIADES context management component (see D3.9) in order to deliver intelligent functionalities.

Moreover, users are authenticated through the Identity Management services and have access to different functionalities based on their assigned role. As the various NAIADES water consumption awareness applications can be accessed by different users with varying interests regarding the functionalities and information stored in the platform they need to be aware of the access level of users and allow access to the functionalities and information relevant for the particular user. Authentication and authorization is managed through FIWARE services and tools, offering to users the possibility to log in to the applications using their FIWARE Accounts. This is performed with the OAuth2 protocol and Keyrock[1], the Identity Manager component of FIWARE. In the same way that users usually log in to some services using their Twitter or Facebook account, they can use their FIWARE accounts to access the NAIADES applications.

A Role-based access control (RBAC) approach is followed in order to differentiate user permissions based on roles. The RBAC model allows NAIADES administrators to create roles for various job functions and assign permissions to perform certain operations to specific roles. Members or staff (or other system users) are assigned particular roles, and through those role assignments acquire the permissions needed to perform particular system functions. With RBAC users are not assigned permissions directly, but acquire them through their role (or roles), which means that the management of individual user rights becomes a matter of simply assigning appropriate roles to the user's account; this simplifies common operations, such as adding a user, or changing a user's department. Users are not permitted to change the level of access control that has been assigned to their role. It should be noted that the mid-term prototypes of the NAIADES awareness and behavioural change support apps presented at this deliverable the RBAC model is not fully integrate and all the screens are available to all roles.

The remainder of the deliverable provides a detailed description of the implemented applications.

[1] https://fiware-idm.readthedocs.io/en/latest/

3 Water Consumption Awareness Dashboard for Water Management Companies & Public officials

3.1 Overview

Water management companies & public officials need water consumption awareness tools and mechanisms to better understand available consumption data. In order to cover their needs, we developed a holistic water consumption awareness dashboard that supports public officials to: (i) monitor and understand how water is consumed in a specific area or consumption point (including schools, sport facilities, gardens, other buildings) in the course of time, leveraging the available consumption metering information from smart meters or from manual readings (e.g. Aguas de Alicante's Customer Management System includes manual readings on a monthly and quarterly basis); (ii) compare consumption across various dimensions, including per groups of consumers, areas, types of consumption points and time periods. Stakeholders are able to create comparisons using filtering functionalities and become aware of the consumption across the different dimensions; (iii) take decisions regarding water consumption mitigation measures based on such information and (iv) monitor the impact of consumption mitigation measures after their implementation by comparing consumption pre- and post- interventions. In the following we present the main functionalities of the NAIADES water consumption awareness dashboard.

3.2 Information Architecture

The design of the NAIADES apps, including the Water Consumption Awareness Dashboard relied on an Information architecture (IA) approach (https://www.usability.gov/what-and-why/information-architecture.html). This kind of approach focuses on organizing, structuring, and labeling content in an effective and sustainable way so that users can effectively find information, easily complete information identification tasks and take decisions based on the identified information. The IA approach provides the means to understand how the information pieces of a user facing application pieces fit together to create the larger picture, how items relate to each other within the system. Figure 3 provides an overview of the information architecture of the NAIADES water consumption awareness dashboard for Water management companies & Public officials.

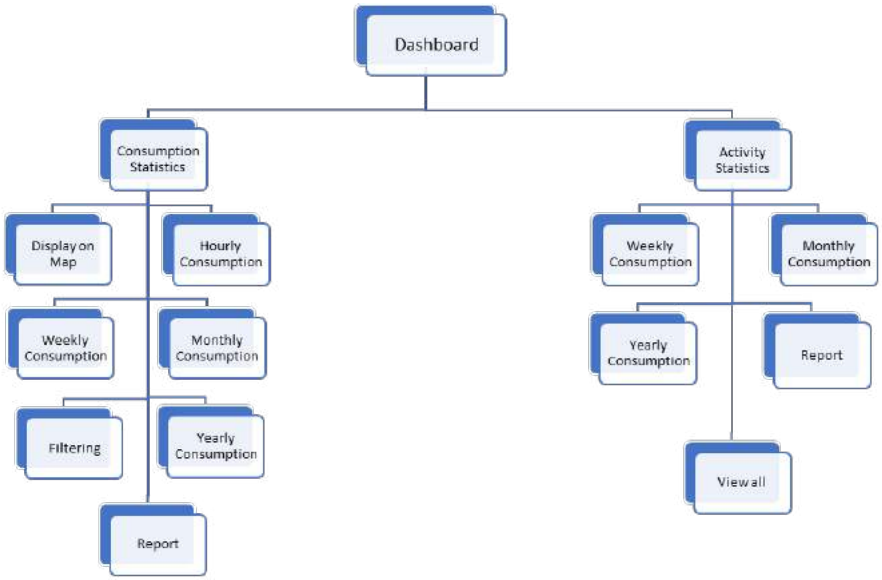


Figure 3: NAIADES Consumption Awareness Dashboard Information Architecture

The approach was defined in close collaboration with the pilot users from Aguas de Alicante in an agile an iterative manner. Throughout the dashboard development period a series of workshops were held with the end users, in which the structure of the dashboard information and related functionalities were presented

and comments and remarks were noted which were implemented in the application. In total 4 workshops were held which allowed us to align the dashboard to user needs and address the corresponding requirements. The following sections describe in details the implemented functionalities.

3.3 Consumption points statistics

In the main page of the dashboard (Figure 5) public officials can see all the watering consumption points in a map. Figure 5 provides an indicative view of the related consumption points in Alicante. The consumption points are presented with different colours ranging from green to light green, yellow, orange and red, based on the level of their water consumption over the last week. The consumption points with the lowest water consumption are annotated with green colour, those with the highest consumption are annotated with red colour, while those lying in between are annotated with a gradient between green and red. Figure 4 depicts the scale used. The exact color of each consumption point in this scale is calculated using the following formula that indicates normalised consumption:

$$\frac{consumption - min}{max - min} \in [0,1] \rightarrow [green, red]$$

where *consumption* is the weekly water consumption of the specific consumption point, *min* is the minimum consumption among all consumption points this week and *max* is the maximum consumption among all consumption points this week. In case all consumption points have the same consumption, i.e. *min* equals *max*, the orange color in the middle of the scale is used.

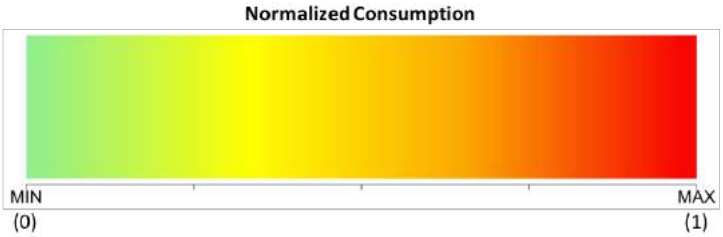


Figure 4: Color Bar used to indicate the relative level of water consumption for the various points

Users can also see the average daily water consumption for all consumption points on a graph view as shown in Figure 4 over the last year. In addition, the dashboard presents the yearly water consumption in cubic meters, segregated for the different uses (schools, public gardens, municipal offices etc.) along with the respective percentages, as well as the water consumption change per consumption type over the last year. Note that percentile changes in the consumption are denoted with different colours (red/green) depending on whether they correspond to an increase or a decrease, respectively, while a steady consumption is indicated with an orange colour.

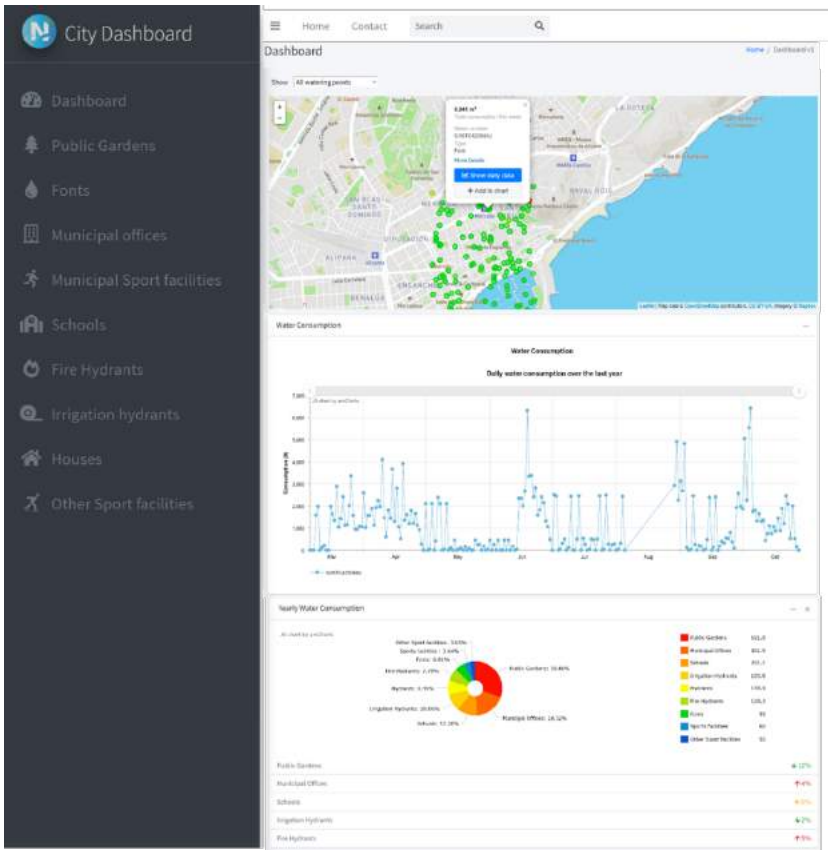


Figure 5: Main (landing) page of the Consumption Awareness Dashboard.

Users can also filter the depicted consumption points on the map based on their type. The consumption points types have been defined after analysing those available at the city of Alicante and include the following: public gardens, fonts, municipal offices, municipal sport facilities, schools, fire hydrants, irrigation hydrants, houses and other sport facilities. In case a filter for a specific type of consumption has been applied, both the map and the graph depicting the average daily water consumption include information for the consumption points of that type only (see Figure 6).

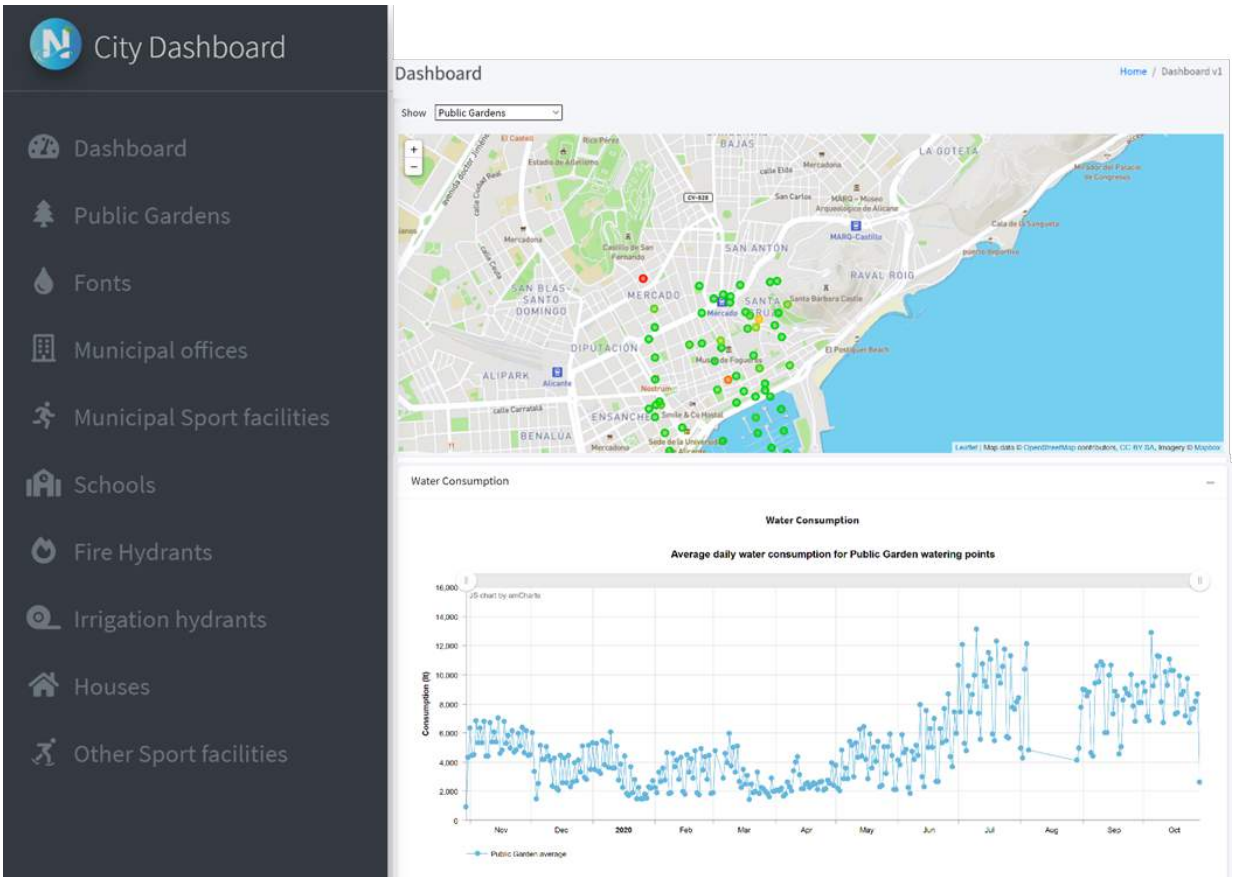


Figure 6: Indicative view of the Consumption Awareness Dashboard when the user has selected one type of consumption point. In this view the dashboard shows information for public gardens.

Users can access the water consumption details of each point by clicking on the consumption point marker in the map (displayed with a green or red color). When the user clicks on a marker, a window pops up showing the corresponding meter id, type and weekly water consumption of the selected point (Figure 7).

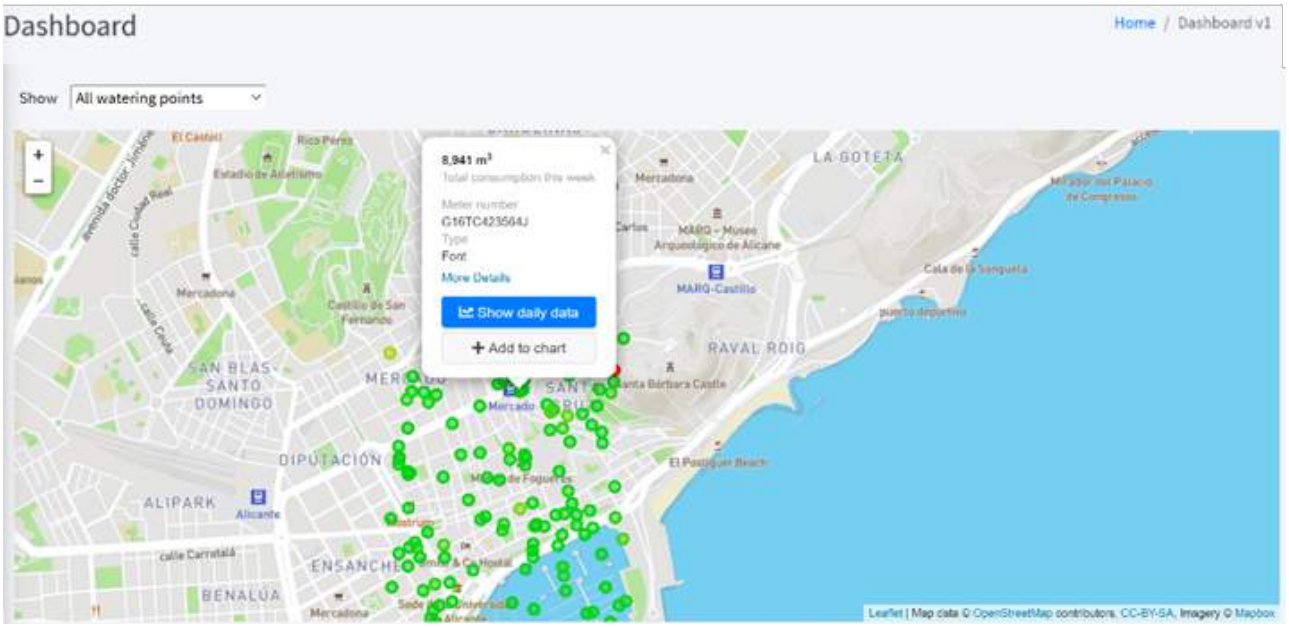


Figure 7: Detailed information for a consumption point can be viewed on the map by clicking the marker of the point. A popup window displays the corresponding meter id, type and weekly water consumption.

When the user clicks on the button "Show daily data" in the popup window, the chart below the map is filled in with the consumption data of the selected point as it is shown on Figure 8.

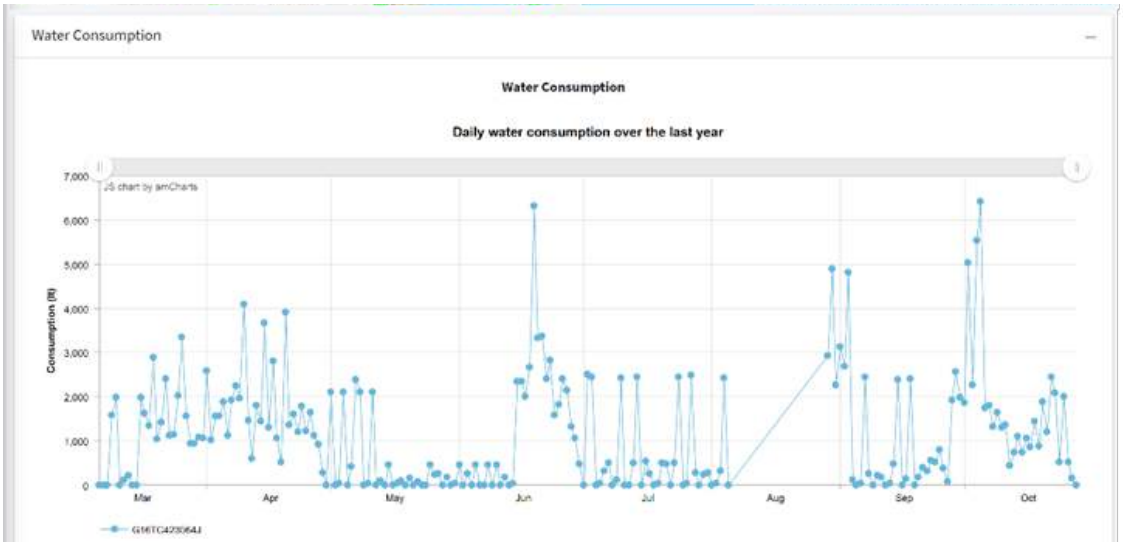


Figure 8: Main page of City Dashboard showing the daily water consumption of the selected consumption point.

Public officials can also click on the "Add to chart" option to see multiple consumption points data in the same graph view and be able to compare the different consumptions. Figure 9 shows as an example the daily water consumption over the last year for three selected consumption points that have been "added to the chart".

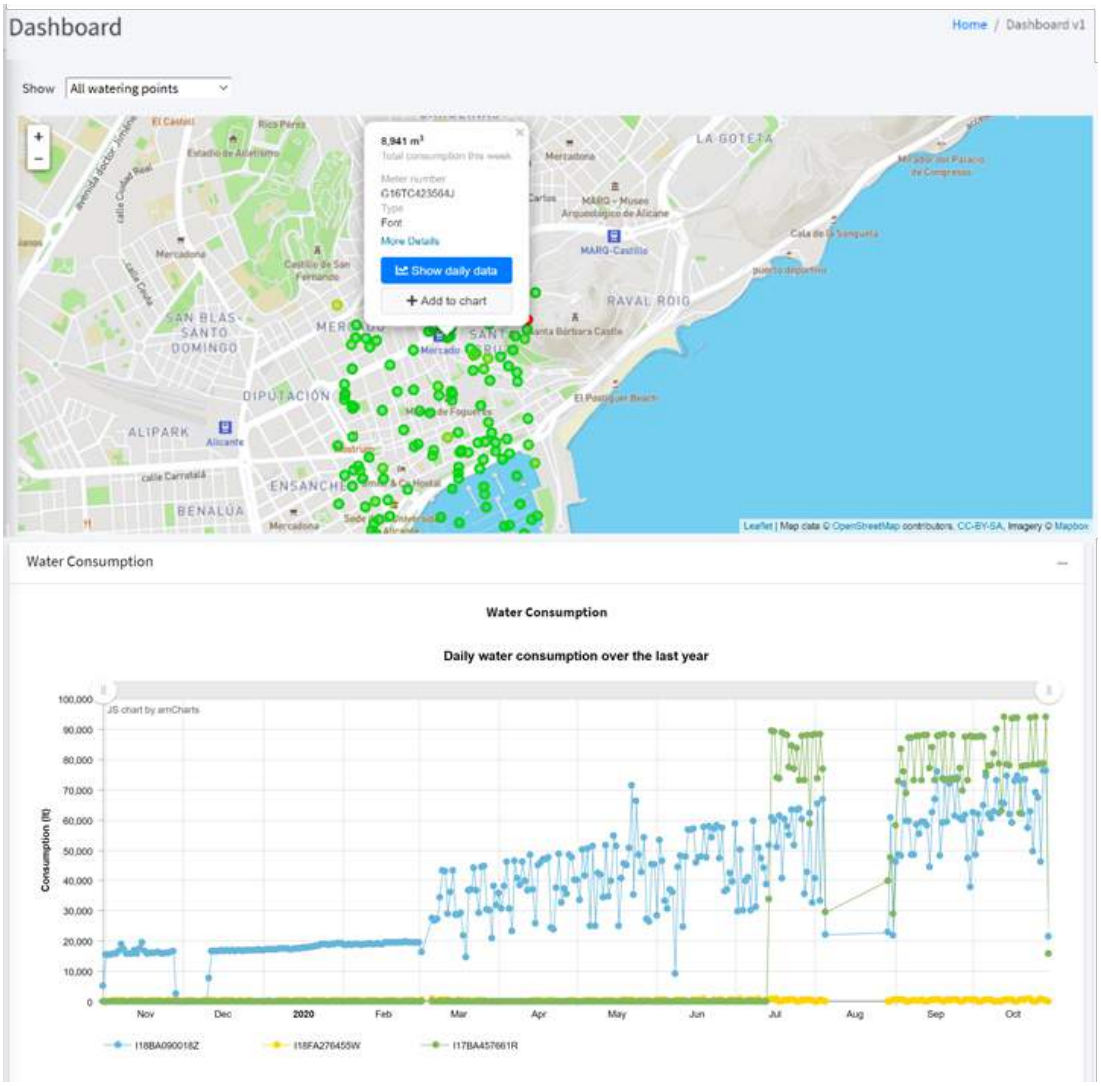


Figure 9: Main page of City Dashboard showing the daily water consumption of the three selected consumption points.

When the user clicks on the "More Details" option of the selected consumption point, the s/he is redirected to the consumption point details page as shown in Figure 10. That page provides a detailed view of the consumption at the selected point as follows. First the water consumption of the selected point during the last week compared to the previous week is shown in a sliding window format. For example, if today is Tuesday, last week's consumption will be from the previous Tuesday to today and the previous week will be from Tuesday two weeks ago to previous Tuesday. At the top of the weekly water consumption graph, the water consumption change since last week is shown as a percentage number. The page also provides the monthly water consumption of the selected point during this year compared to the previous year. The graph that compares monthly water consumption shows water consumption of each month of the current year compared with the previous year in a sliding window format, similarly to the case of the weekly consumption. For instance, if today is the 18th of November, the graph shows water consumption comparisons from November of the previous year compared with November two years ago to October of this year compared with October of the previous year. In addition, the details page presents the yearly water consumption of the selected point and the daily, weekly, monthly and yearly water consumption change. At the top of the monthly water consumption graph, it is shown the water consumption change since last month.

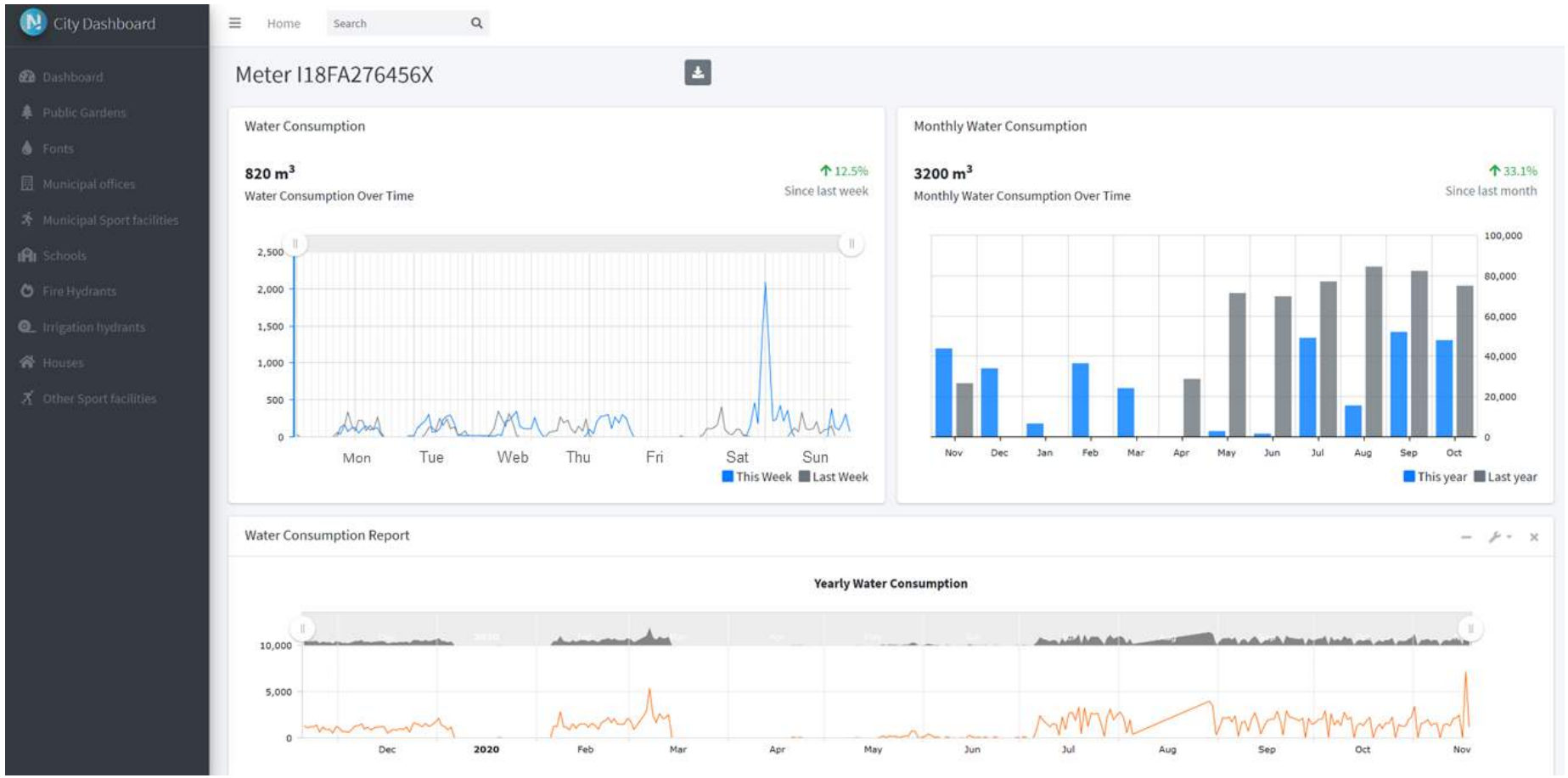


Figure 10: Consumption point details page.

The user has the option to download the graphs as a pdf report by clicking the "Download" button in the consumption point details page. Figure 11 shows part of the water consumption report of the selected consumption point. The pdf reports can be distributed to interested stakeholders, can be printed and placed in bulletin boards, etc.

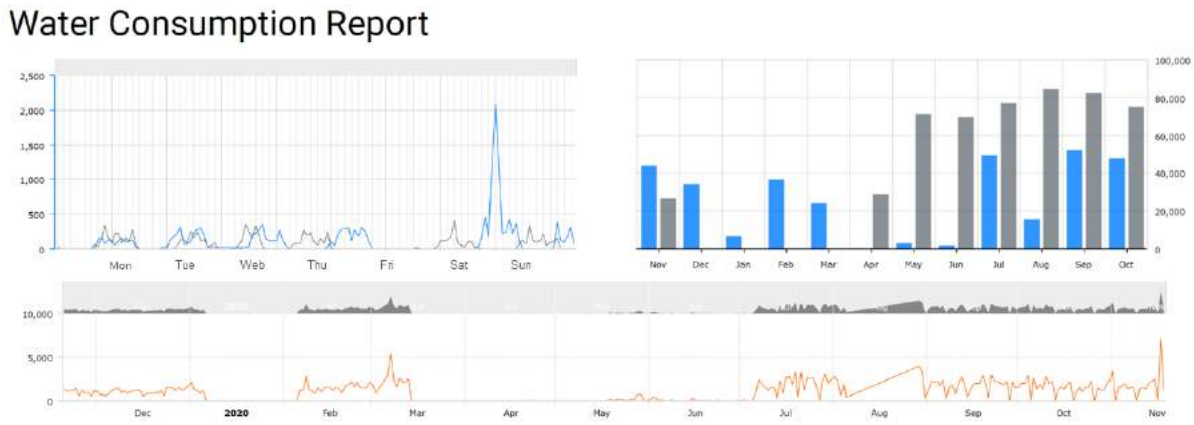


Figure 11: Indicative example of the Water Consumption Report pdf file showing the water consumption information for a selected point.

3.4 Activity Statistics

The user can navigate through the menu on the left side of the dashboard, to pages showing aggregated information for all the consumption points of each type. Note that these pages are similar to the details page of a consumption point as described above, but provide an aggregated for a selected type of points Figure 12 provides an indicative view of the Public gardens page, which shows the water consumption of public gardens during the last week compared to the previous week. It also shows the monthly water consumption of public gardens during this year compared to the previous year. In addition, it presents the yearly water consumption of public gardens and the daily, weekly, monthly and yearly water consumption change. The user can download a pdf report dedicated to the consumption points of a specific type, by clicking the "Download" button.

Figure 12: Indicative detailed view of the aggregate consumption of points of type Public Garden.

The dashboard also provides a list view, in which all consumption points of the specific type (public gardens in the example). The list can be seen by clicking the "View all" button. Figure 13 presents all the public gardens sorted by their water consumption in descending order. Users can search a consumption point by its name or meter ID, and see more details about each consumption point by clicking the search icon in the "More" column, which redirects to the corresponding consumption point details page.

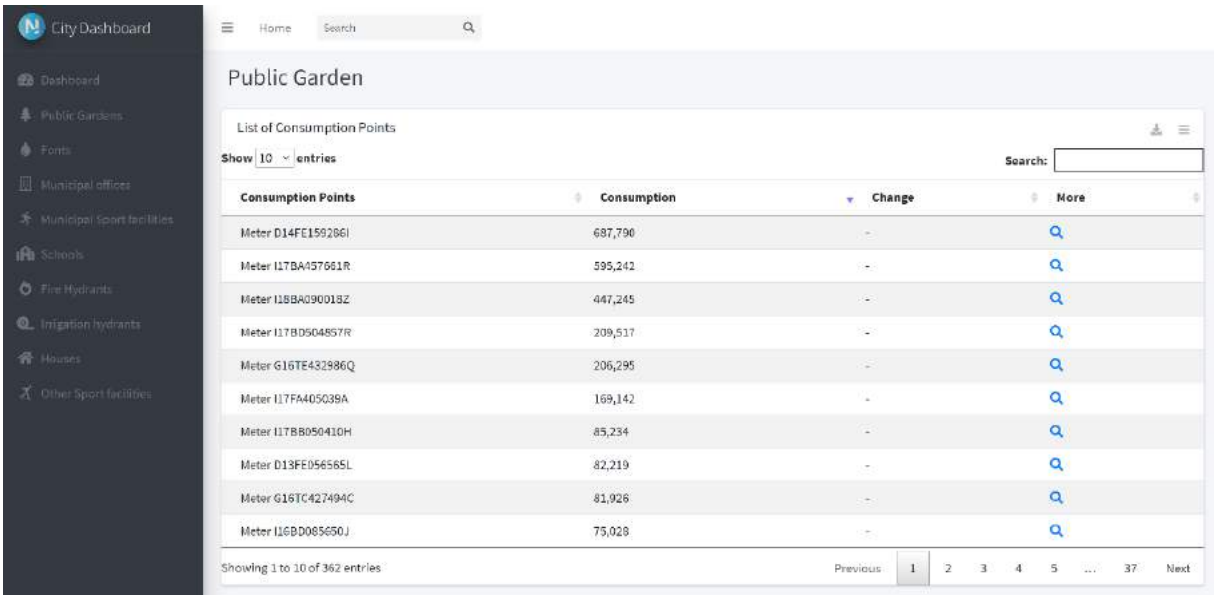
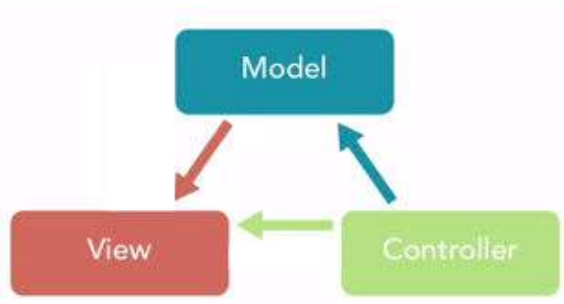


Figure 13: Indicative list view of consumption points. The view shows public gardens in Alicante.

3.5 Implementation

An online version of the Consumption Awareness Dashboard for Water Management Companies & Public officials can be accessed at the following url: http://water-awareness.imu-projects.eu/city/. The server side components have been implemented in the python programming language using the Django web application framework (https://www.djangoproject.com). Django is an open source high-level Python Web framework that encourages clean and pragmatic design. The framework supports the Model-View-Controller (MVC) pattern, a software architecture pattern that separates data presentation from the logic of handling user interactions. MVC has been described as one of the best ways to create client-server applications and the majority of web application frameworks are built around the MVC concept.



- The **Model** layer handles the data representation, it serves as an interface to the data stored in the database itself, and also allows to interact with the data without having to get perturbed with all the complexities of the underlying database.
- The **View** layer represents what is presented to the end user.
- The **Controller** layer provides the logic to either handle presentation flow in the view or update the model's data. It also gets information from the user through the view and implements the given logic by either changing the view or updating the data via the model.

Moreover, the dashboard integrates javascript libraries for different user interface components as follows:

- The Leaflet.js library (https://leafletjs.com/) is used for generating map layouts. Leaflet is a lightweight, open-source JavaScript library for mobile-friendly interactive maps. Leaflet is used in

combination with Mapbox.js, another open source JavaScript library which is used to add interactivity, and customize the map experience in a web application.

- With respect to data visualizations in charts, the amCharts (https://www.amcharts.com/) javascript library is used. The library provides all required functionalities to build and generate intuitive data visualizations and charts.

With respect to data access and retrieval and for the purposes of the mid-term implementation of the consumption awareness dashboard, available consumption data are fetched from an FTP server provided by Aguas de Alicante and are stored in a database configured for the NAIADES dashboard. An ETL process has been defined and implemented, and is scheduled to be executed on a daily basis in order to fetch available data. This process is depicted in Figure 14 and consists of the following steps:

a) Discovery of newly delivered consumption files; these are CSV (comma separated values) files which contain the consumption point id, the date of the measurement and the related consumption information.
b) Download of the newly discovered consumption files to the server hosting the consumption data database.
c) Extraction of data from the downloaded files, transformation to match the consumption data database schema, and storage in the database.
d) Marking of the downloaded files as "processed" in order to maintain an internal state and continue monitoring the remote FTP server for new content.

In order to avoid tight coupling of the City Dashboard application with the consumption database, an API that allows structured consumption information retrieval has been defined and implemented. This approach allows better controlling access to the underlying database, planning access patterns ahead, as well as optimizing the data retrieval process as a whole. It should be noted that the ETL process described above should be seen as a temporary measure enabling to feed the consumption awareness dashboard with data to facilitate its development until the platform is fully running. As soon as the NAIADES IoT platform has been fully integrated, the consumption awareness dashboard will be connected to it, so that all aspects related to fetching, validating, storing and serving water consumption data will be handled by the NAIADES IoT platform, which will integrate and extend the ETL process described above. The integrated approach will enable data consumption in a FIWARE compatible format, ensuring interoperability and portability in the sense that the consumption awareness dashboard could be easily deployed to any other setting designed under the same standard.

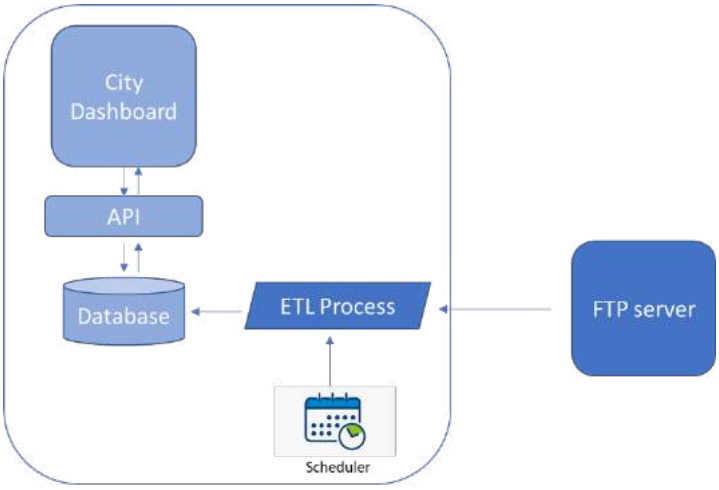


Figure 14: ETL process for fetching data from Aguas de Alicante.

The schema of the raw csv formatted consumption data provided by Aguas de Alicante is shown in the following table and include the meter number, the type of consumption point (activity) and periodicity metered consumption as well as the point's location (latitude and longitude).

Meter Number	GISAgua ID	Activity	Periodicity	Year	Month	Consumption	Latitude	Longitude
09818105	3608	Garden	MANUAL	2019	7	1	38.34	-0.48

The consumption awareness dashboard makes use of a PostgreSQL database, a powerful, open source, object-relational database technology. The raw consumption data are stored using the schema depicted in Figure 15.

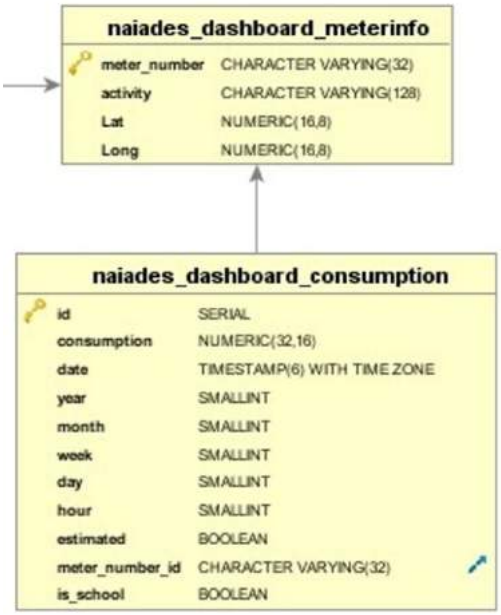


Figure 15: Database schema of the NAIADES consumption awareness dashboard.

The naiades_dashboard_meterinfo table contains the following attributes:

- **meter_number**: the meter number of each consumption point.
- **activity**: the activity of each consumption point. The activity could be public garden, school, font etc.
- **lat**: the latitude coordinate of each consumption point.
- **long**: the longitude coordinate of each consumption point.

The naiades_dashboard_consumption table contains the following attributes:

- **id**: An automatically incremented value that's used to uniquely identify each consumption point.
- **consumption**: the water consumption of each consumption point.
- **date**: the date of which the consumption was measured.
- **year**: the year of which the consumption was measured.
- **month**: the month of which the consumption was measured.
- **week**: the week of which the consumption was measured.
- **day**: the day of which the consumption was measured.

- **hour**: the hour of which the consumption was measured.
- **estimated**: True for estimated consumptions, False for measured.
- **meter_number_id**: the meter number of the consumption point.
- **is_school:** True if the consumption point is school, False if it is not school.

4 Water Consumption Awareness Dashboard for Public Employees

4.1 Overview

The Carouge watering use case focuses on raising awareness on flower boxes watering consumption and improving the watering processes efficiency towards water conservation and time savings for public employees.

The city of Carouge maintains a number of flower boxes that are organised in clusters throughout the city that need frequent watering. The flower boxes in a cluster are typically located close to one another in a distance from one to two meters. A typical example of such a flower box cluster can be seen in the left part of Figure 16. There can be clusters that contain flowers in direct ground, i.e. without boxes as depicted in the right side of Figure 16. One flower box per cluster is equipped with a so called urban box, which is a sensor container with a sensor that can sense soil humidity and which is equipped with a LoRa emitter (Adeunis Analog PWR). The latter is used to communicate the measurements to the context manager of the NAIADES platform through the Carouge LoRa network.

Figure 16: Flower clusters in Carouge: Clusters of flower boxes (left) or clusters in direct ground (right).

City workers are using electric watering trucks such as the one depicted in the left part of Figure 17, to water the flower boxes, a process that is executed from spring to autumn every year. NAIADES provides sensors to measure and monitor the water consumption so that watering recommendations can be communicated to city workers in order to avoid spending more water and watering time than it is actually needed. The recommendations are generated with the support of a predictive model.

In order to measure and monitor the water consumption, a Raspberry Pi module that includes a waterflow and a GPS sensor has been installed in the trucks, in the position in indicated by the yellow arrow in Figure 17. The Raspberry Pi is installed close to the tank, on the truck, rather than the hose side, so that it is less likely that it gets broken or damaged. Moreover, a tablet is provided to city workers and installed in the truck through which the city workers can access the NAIADES watering app (the blue arrow in Figure 17 points to the approximate location where the tablet is positioned). The tablets remain on the truck cabin during all the watering process, i.e. from the time the truck departs from its parking location to the time it gets back to it after having watered all the flower boxes that need water that day.

Figure 17: Electric Watering Truck and Watering Hose.

The Raspberry Pi prototype module integrates on the edge the water flow to total volume and then pushes the data as an event to the NAIADES context manager through the Tablet's WiFi hotspot and then through the tablet's internet connection. Each event includes the water volume, the start irrigation time, the end irrigation time, the truck id and the GPS position. An event is generated each time that water flow sensor value drops to 0lt/s i.e. each time the employee closes the hose, reflecting the total volume of water that exited the hose from the time the employee opened it to the time s/he closed it. Typically, an event corresponds to the irrigation of a single box, although there can be exceptions to that. In any case, water consumption data with the same GPS location are summed and attributed by the NAIADES platform to the consumption of the corresponding cluster as a whole. Consumption per box is calculated by dividing with the number of boxes, in the case of box clusters. There are three trucks equipped with one tablet each – most of the time only one is out for watering at the same time, but it can happen that more than one is operating simultaneously, but never on the same cluster. The watering hose used to water the plants, which are depicted in the right part of Figure 17, can produce variable flow (full closed, full open and intermediate positions).

The main issue in the as-is situation is that plants watering commonly leads to unnecessary water consumption and waste of human resources in terms of employees' time, since all the clusters are watered a fixed number of times per week independently of the weather conditions and the plant's humidity level.

The aim of the water consumption dashboard for public employees, hereafter referred to as the NAIADES watering app, is exactly to solve this issue allowing the efficient watering of the flower boxes on an as needed basis. More specifically, the app aims to nudge city workers to follow the suggested watering schedule, making them aware of the water consumption and the plants watering needs. The application accommodates the city staff needs by providing functionalities for capturing information related to the flower boxes to be irrigated as well as by presenting watering schedules related information and consumption per watering point. With respect to the flower box information, this includes the type of soil and the type of flowers, the location of the box, the exposure to sun the date of the box installation and its size. The application makes use of the NAIADES AI analytics and predictive services (WP5) that provide recommendations of optimal scheduling of watering activities, along with recommended watering amounts per box. In addition, NAIADES watering app allows reporting problems related to watering, including broken sensors, wrong data, problems with the box and flowers destroyed.

Adopting an agile development approach as described in section 2, based on our first discussions with the end users, user stories came up that were used as the basis for developing application mockups using FluidUI[2], a wireframing tool allowing interactive previews as well as testing of the prototype wireframes on any mobile or tablet device. These mockups were subsequently used for further discussions with the end users, leading to refined versions of the mockups that were subsequently used as the basis for the actual development of the first version of the application. In the following we present the user stories in section 4.2, the mockups in section 4.3 and the first version of the NAIADES watering application along with its main functionalities in section 4.4. Finally, the implementation details are presented in section 4.5.

4.2 User stories

Table 1: User stories for the NAIADES watering app

Story ID	As a	I want	So that	Comment (e.g., priority, status (ongoing / stopped), to be detailed, comes from Story ID #)

[2] https://www.fluidui.com/

1	Dept Manager and Flowers team Manager	to manage the work force based on the current and forecasted need, from my PC	I can better plan the employees' schedule and resources and spare time by watering only when and where is needed, instead of watering all the clusters 3-4 times per week.	Employees and manager look at their PC or tablets to visualise the data.
2	Employee: Water	To start the day knowing the amount of water left in the flower boxes (humidity) and the need to water some boxes (clusters) during that day	I know when to water the boxes of a cluster (today, tomorrow, after tomorrow) and which cluster. To add real data to the decision-making process and plan. The employees have the final decision to water today or wait for tomorrow.	Access via a tablet. Do I need to go watering today or if it is better to wait for tomorrow.
3	Employee: Water, truck	to look at the tablet and see what the best track/roads is to get to the next cluster of flower boxes (less traffic or no accident) and how much water he may need inside the water tank.	To decrease the time to go and the number of km. To have the optimized road for today watering	Access via tablet with position tracking. *Since the "trucks" are actually small electrical vehicles that are authorized to drive everywhere, the traffic avoidance feature is less critical, more a nice to have.*
4	Employee: Water Box No 1 with the sensor	to know the number of litres of water required for each box of the cluster (or for the whole cluster there are no boxes)	I know how much water I should pour into each of the boxes without sensor (the cluster). I expect that each of these boxes requires the same amount of water that was poured in the box with sensor).	When the employee starts watering, the waterflow sensor should be activated automatically The water quantity per box is simply the water for the cluster divided by the number of boxes Assuming that each box will have the same conditions and need the same amount of water. Neither the operator nor the system will be able to distinguish between boxes with a sensor and boxes without.
5	Manager, Employees on their PC	to see in the screen and print a compiled monthly report of the water consumption per box and per cluster	I can show the trend of water consumption per cluster, the time spent and the km and have a monitoring of the monthly progress	
6	Manager, Employees on their PC	To have a monthly report about the number of km by trucks, how much time and how many litres of water were	I can make adjustments needed to improve the algorithm and the prevision in order to	The time estimation is mainly meant to provide a quantifiable trend but does not need to be too much granular.

		needed, as well as a review of the related problems	decrease the water consumption	

4.3 Application Mockups

A set of mockups were developed during the initial stages of the app design to allow stakeholders from Carouge to visualize the functionalities of the app and understand its envisaged added value. The mockups provided the means to gather feedback from the users and tailor the functionalities of the app to the needs of the users.

As can be seen in the mockups of the application depicted in Figure 18, at first login the user has to setup one or more flower boxes, by providing information related to the type of soil, type of flowers, exposure of the box to the sun (shadow, mid-sunny, sunny), the date of installation along with the box size. The location of the box is set either by entering its address or on the spot through the tablet's GPS.

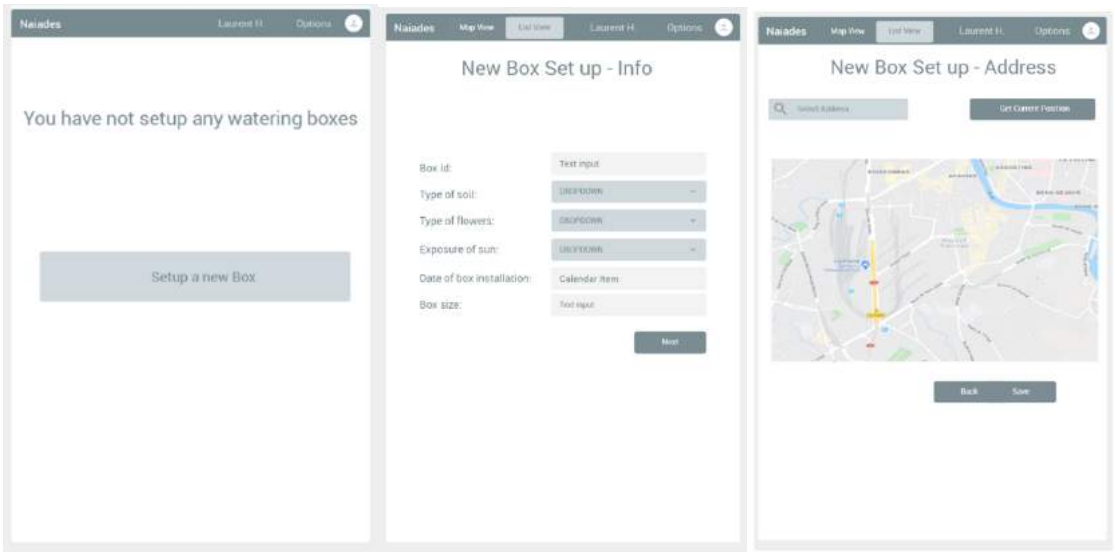


Figure 18: New Flower Box Set up Mockups.

As can be seen in the mockups of Figure 18, the main view of the app is a map view through which the user can see the location of the boxes, along with their watering needs for today, tomorrow, etc. Boxes representing clusters that need watering are depicted with a red market, while those that are humid enough are depicted with a green marker. In the same view the user can also select a box by clicking on the respective marker to see its parameters or can choose to see the box details including historical humidity and watering data, in which case s/he is redirected to the view depicted on the middle of Figure 18. The user can also choose to view the route from the current location to the boxes that need watering, as can be seen in the right part of Figure 19.

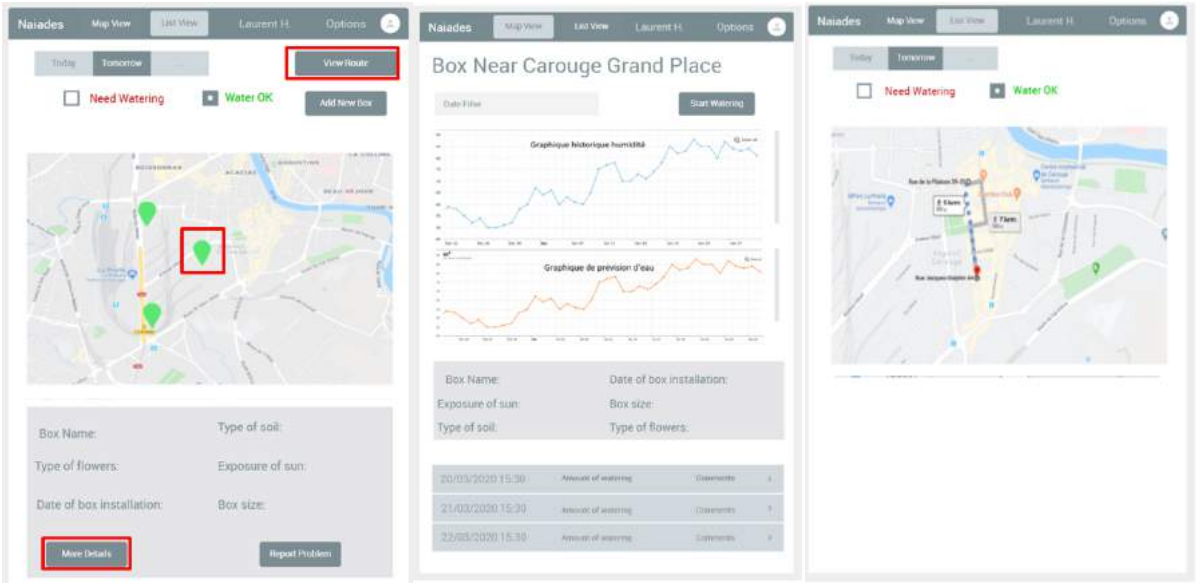


Figure 19: Map view and Box details Mockups.

As can be seen in the left part of Figure 20, there is also a list view, through which the user can search for boxes, see them in a list, edit them, check their humidity level, the recommended watering amount and be directed to the view where s/he can see more details. There is also a view shown in the middle of Figure 20, in which the users can report problems related to watering, including broken sensors, wrong data, problems with the box, flowers destroyed etc. Finally, as can be seen in the right part of Figure 20, there is also see a progress bar showing the current watering amount from the start of the watering session as a percentage of the total watering amount needed.

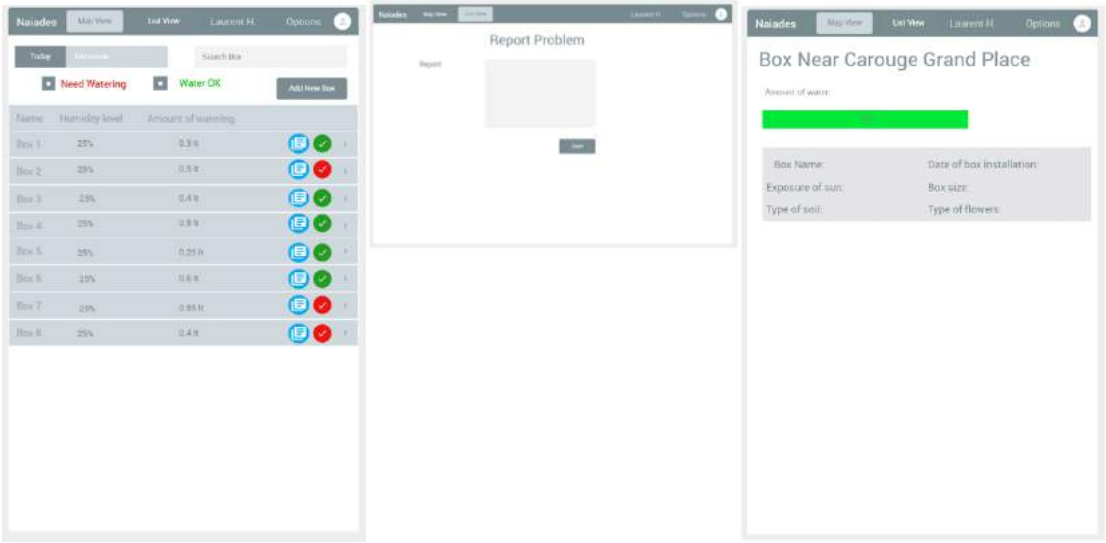


Figure 20: List view, Problem Reporting and Watering Completion Status Mockups.

4.4 The NAIADES Watering App

Following the pilot's stakeholder feedback provided on the basis of the mockups, the first version of the web-based watering application has been developed. The diagram presented in Figure 21 provides an overview of the application's information architecture, while in the rest of this section more details about the various views of the application are provided.

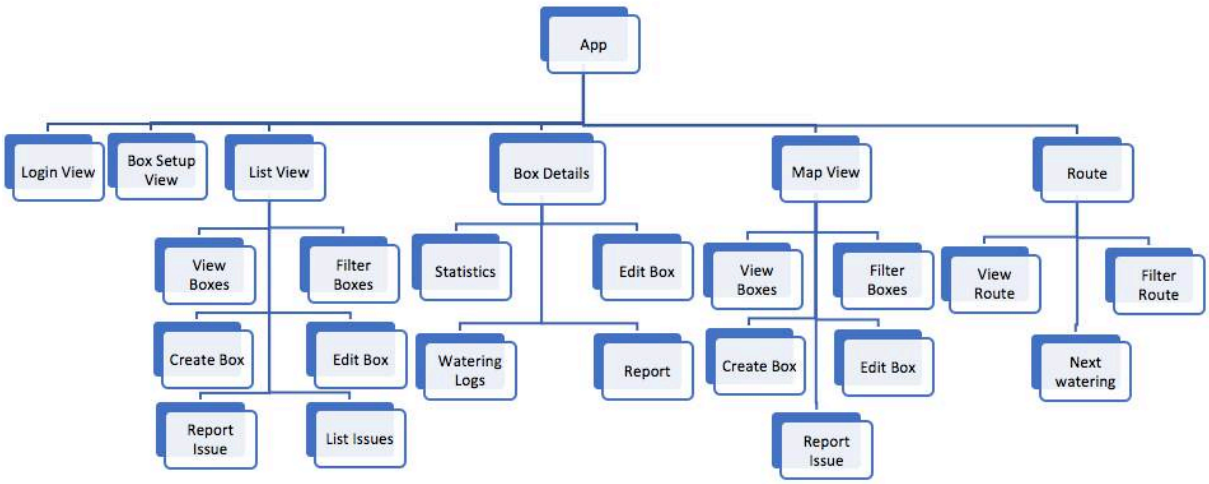


Figure 21: NAIADES Watering App Information Architecture.

4.4.1 Login View

Firstly, city workers login to the NAIADES watering app using their credentials. The login page is presented in Figure 22.

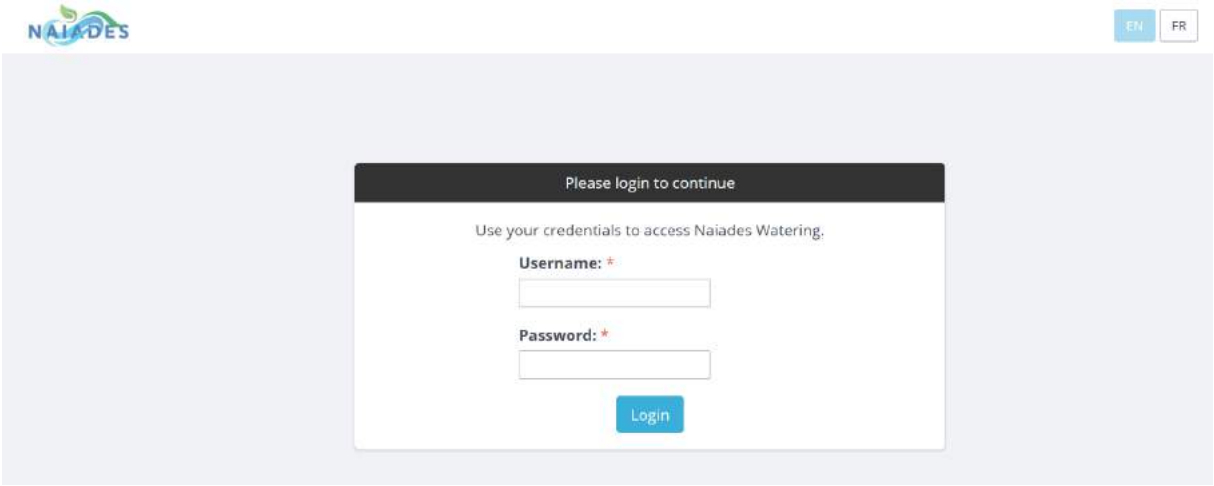


Figure 22: Login page of the Watering app.

Three main roles are foreseen for the NAIADES Watering application at this point as follows:

- **Admin users**: This role has access to all functionalities and data of the application. The admin user can configure user accounts, manage the application, set up boxes and have global access to the data which are available in the application.
- **Department/Flower Team Managers**: This role is mainly interested in having access to compiled monthly reports and data enabling informed decision making. The provided reports for example enable users of this role to identify trends and monitor the progress regarding the monthly water consumption per cluster, the total distance travelled by the trucks, the total time needed for the watering process, as well the related problems that have been reported through the application.
- **Employees:** These users should be able to set up boxes and want access to operational information related to the amount of water left in the flower boxes (humidity), the specific clusters that need to be watered during the day, the best route to get to the next cluster that needs watering, the number of litres of water required for each box of the cluster, as well as for the cluster as a whole and information about the progress of the watering process compared to the recommendation.

4.4.2 Box Setup View

When the city worker logs into the app for the first time, the screen shown in Figure 23 appears, since no box has been created yet. The user has to configure on or more flower boxes, at first login by clicking the button "Set up a new Box". The application then redirects the user to the New Box-Set up page.

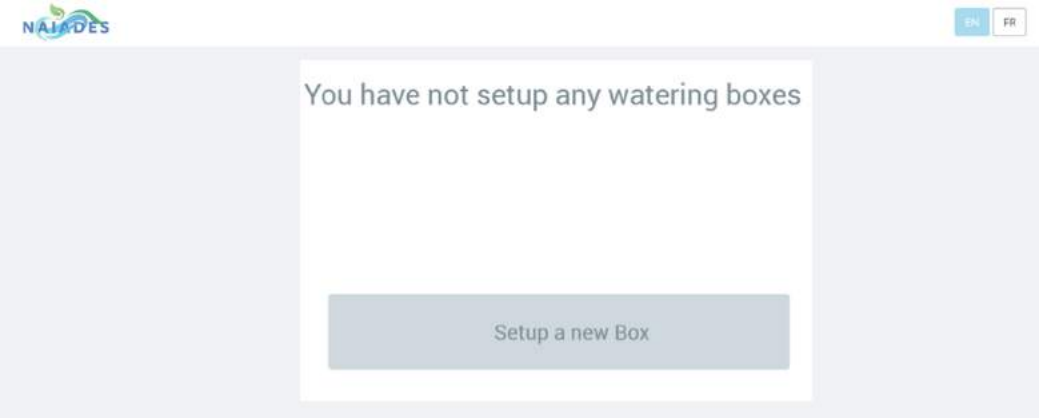


Figure 23: "Set up a new box" Page.

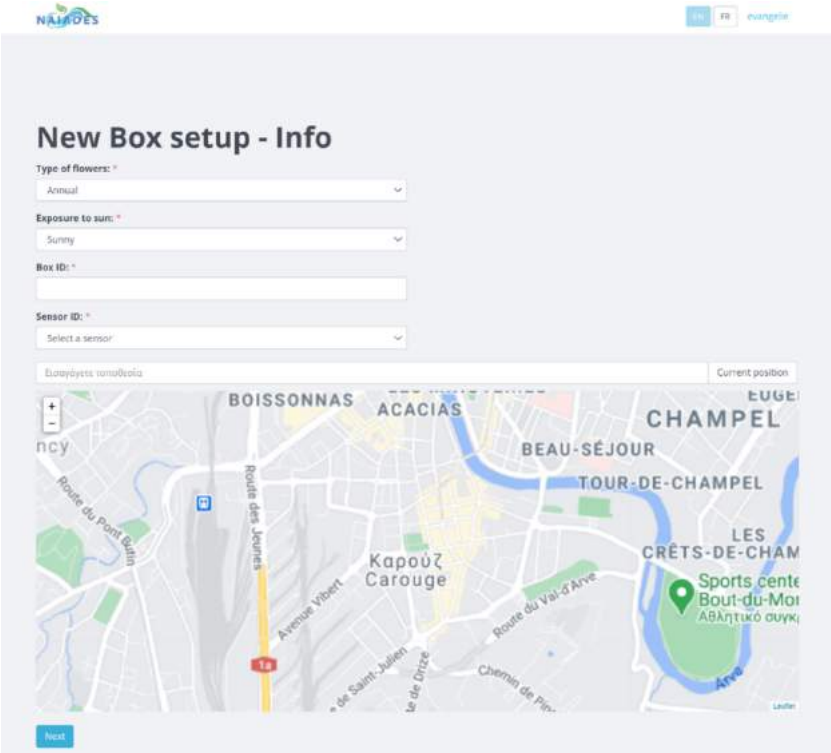


Figure 24: Screenshot of the "New Box - Set up" page.

The New Box setup page (Figure 24) allows the user to setup a new box by filling the related flower box information, including the type of flowers, the exposure to sun, a unique box identifier and the corresponding sensor ID. A list of all available sensors that have been registered in the LoRa network of Carouge is automatically retrieved through a call to the NAIDES context manager, and the user can select one of them through a dropdown list. This approach allows the user to switch the sensor from one cluster to another. Note that when new sensors are added to the context manager, these are automatically "discovered" by the watering app and are displayed to the user in subsequent flower box configurations. The user can select the address of the new box, either by adding it directly, or by clicking on the "Get current

position" button. After entering the box's address, the user clicks on the "Save" button. A new box is created and the app redirects the user to the list view presented in the next section.

4.4.3 List View

In the list view page (Figure 25), users can see all boxes in a list that is sorted by the suggested date of watering and check the watering status. Boxes that according to the recommendation of the NAIADES AI module should be watered today are listed on the top, followed by those that need to be watered tomorrow and the day after. In addition to the information about when the boxes of a cluster should be watered (today, tomorrow, day after tomorrow), the employees can also see the humidity level and the suggested amount of water for each box. The boxes that need to be watered today are annotated with red color, while the boxes that need to be watered tomorrow and later than tomorrow are annotated with a green color. The user can edit each box and view more details by clicking on the box name.

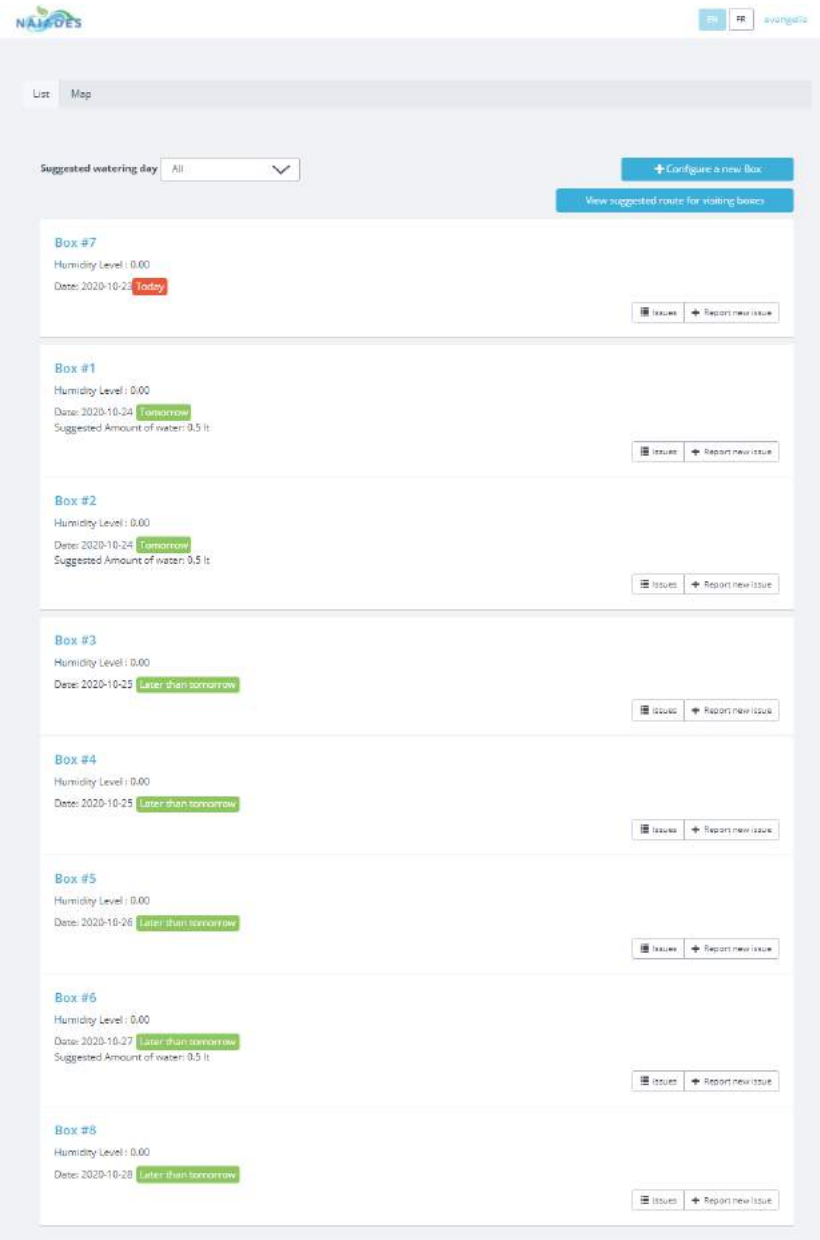


Figure 25: List view page of Flower Boxes.

City workers can filter the boxes of the list by the suggested watering day (today, tomorrow or after tomorrow). In the example shown in Figure 26 the user has applied the filter so that s/he can see only the boxes that need to be watered today.

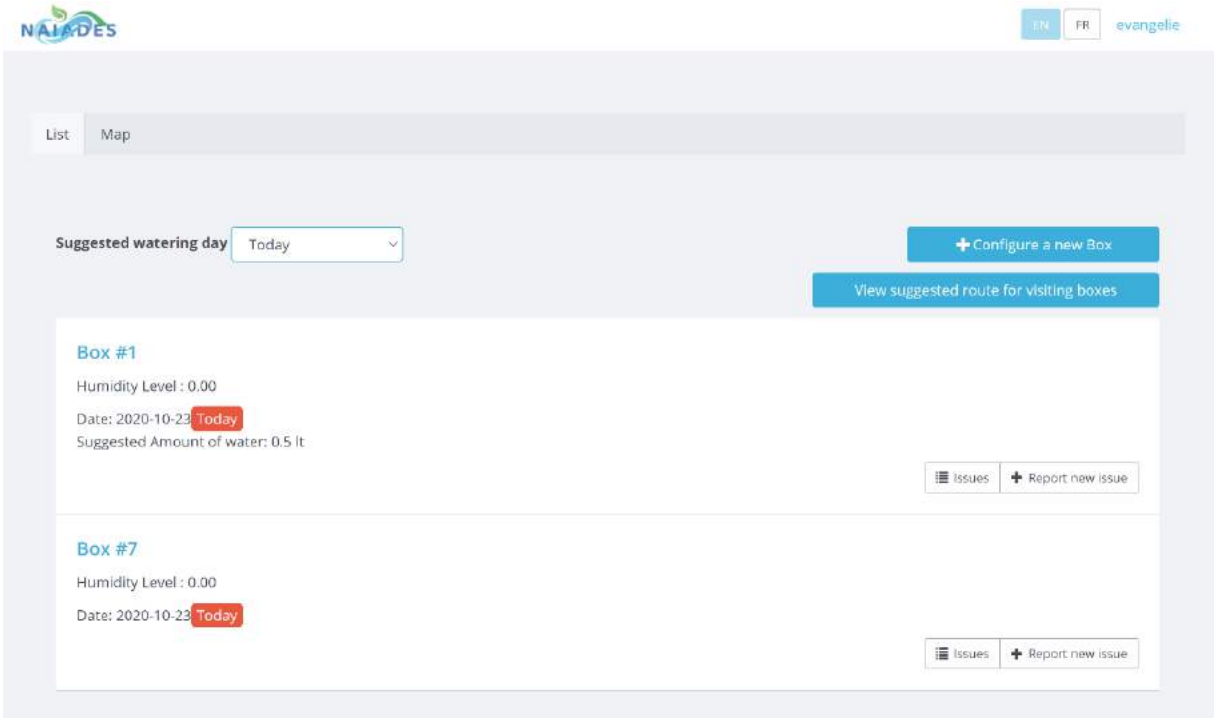


Figure 26: List view page showing the boxes that need water today.

City workers can also report problems per flower box by clicking on the "Report new issue" button. The application redirects them on the page depicted in Figure 27 where different types of problems related to watering can be reported, including broken sensors, wrong data, problems with the box, flowers destroyed etc.

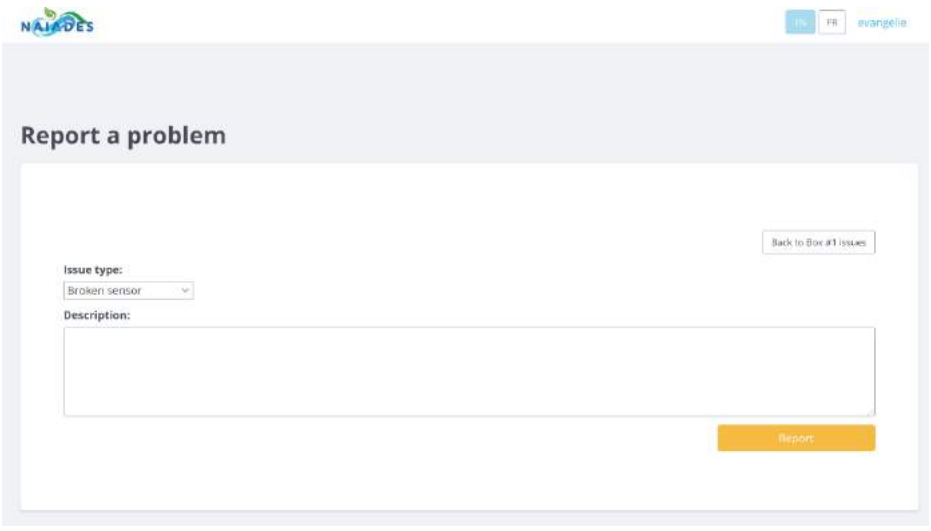


Figure 27: Report problem page.

Users can also see the all the reported issues for each box by clicking on the "Issues" button. Figure 28 depicts an indicative example of all the reported issues for Box 1.

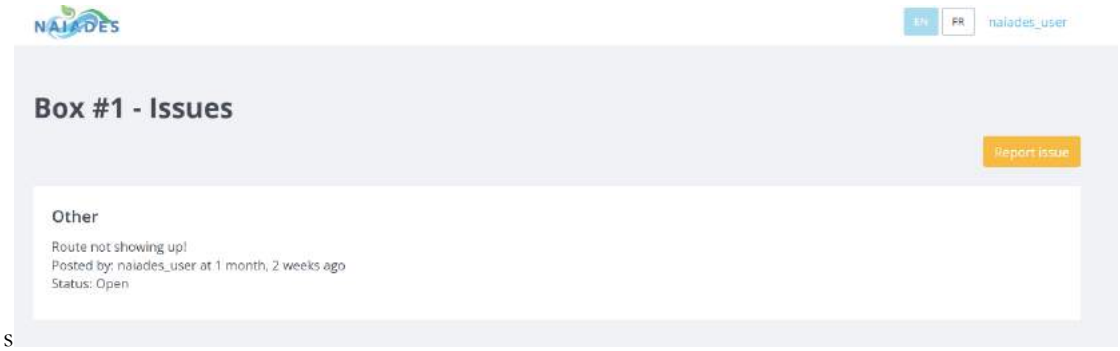


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Figure 28: Screenshot of page showing the reported issues of Box #1.

4.4.4 Box Details View

In the "Box Details" view users can see historical humidity measurements, watering recommendation data and past watering logs, for the particular box (Figure 29).

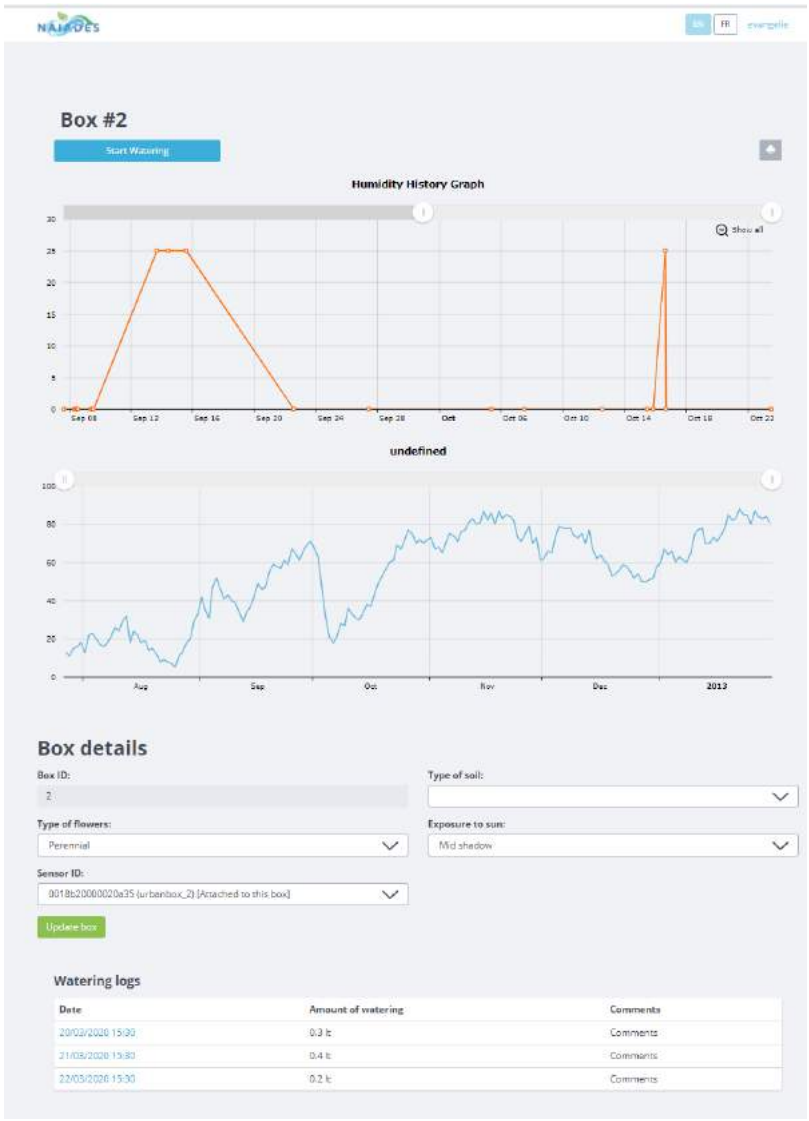
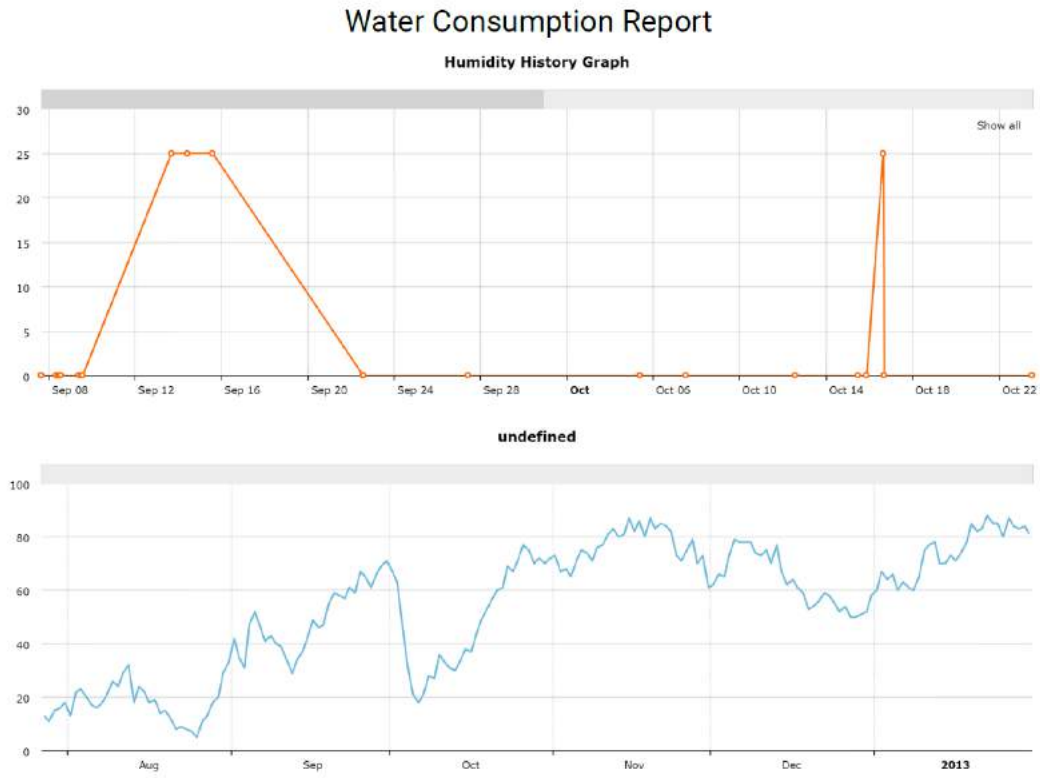


Figure 29: "Box Details – History" page

Furthermore, users can download as a pdf file a monthly report of the water consumption per box. Figure 30 shows an example of such a report.



Box Details

Box ID:	2	Type of soil:	Terrau
Type of flowers:	Perennial	Exposure to sun:	Mid shadow
Sensor ID:	0018b20000020a35	Humidity:	0

Watering Logs:

Date	Amount of water	Comments
20/10/2020	0.5 lt	Comments
23/10/2020	0.5 lt	Comments
25/10/2020	0.5 lt	Comments

Figure 30: Water Consumption Report of Box #2.

4.4.5 Map View

On the Map view page, city workers can see all boxes on a map represented by a marker, the color of which indicates their watering needs (Figure 31). The boxes that need to be watered today are annotated with red colour marker, while those that need to be watered tomorrow or the day after tomorrow are annotated with a green colour marker.

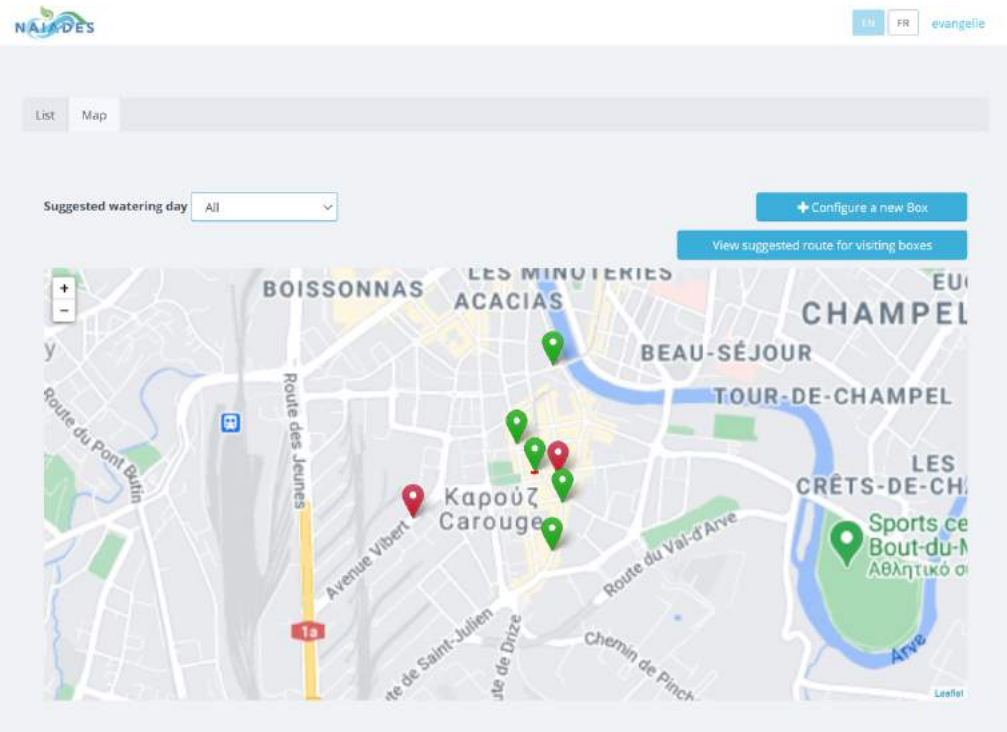


Figure 31: Map view page of flower boxes location. Boxes that need to be watered today are annotated with red colour marker, while those that need to be watered tomorrow or the day after tomorrow are annotated with a green colour marker.

Users can also apply filters, in a similar manner to the list view, so that they can only see on the map the boxes that need to be watered today (see Figure 32), tomorrow or the day after tomorrow.

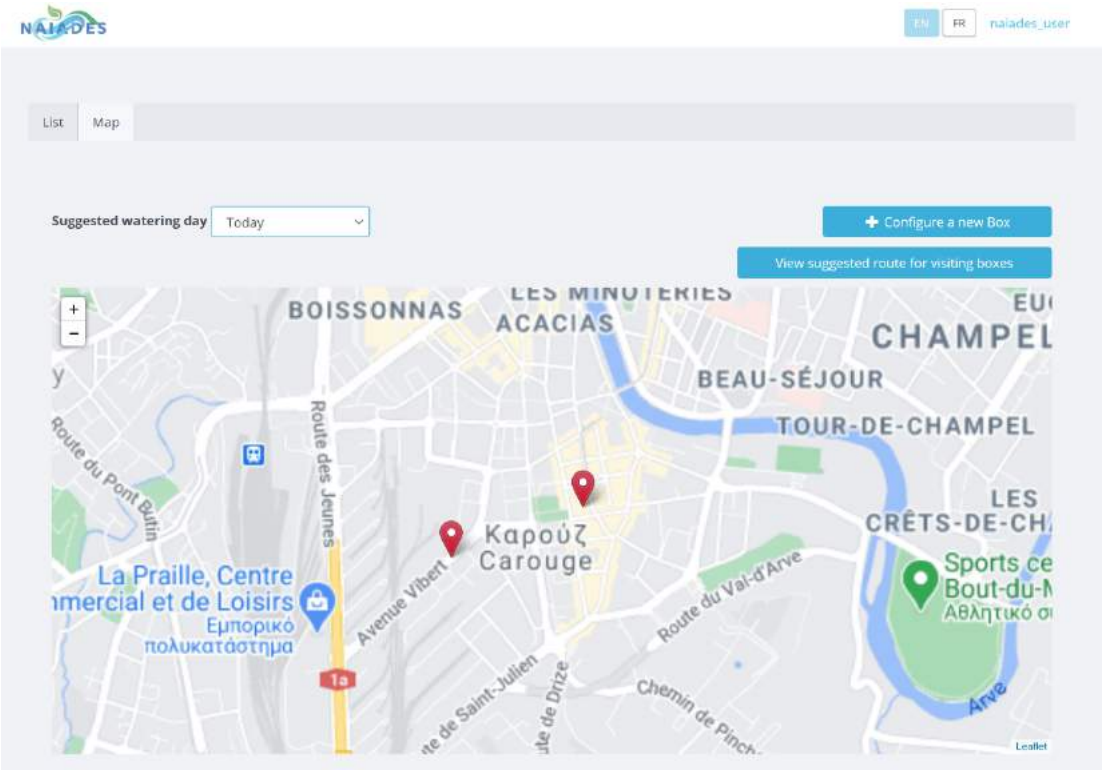


Figure 32: Map view page showing the boxes that need water today.

When the user clicks on a specific box, a pop up window appears showing its details (Figure 33), including the date it was watered last, the suggested date it should be watered next, the type of the flowers it contains and its sun exposure. Through the popup the user can navigate to the box details or problem reporting pages.

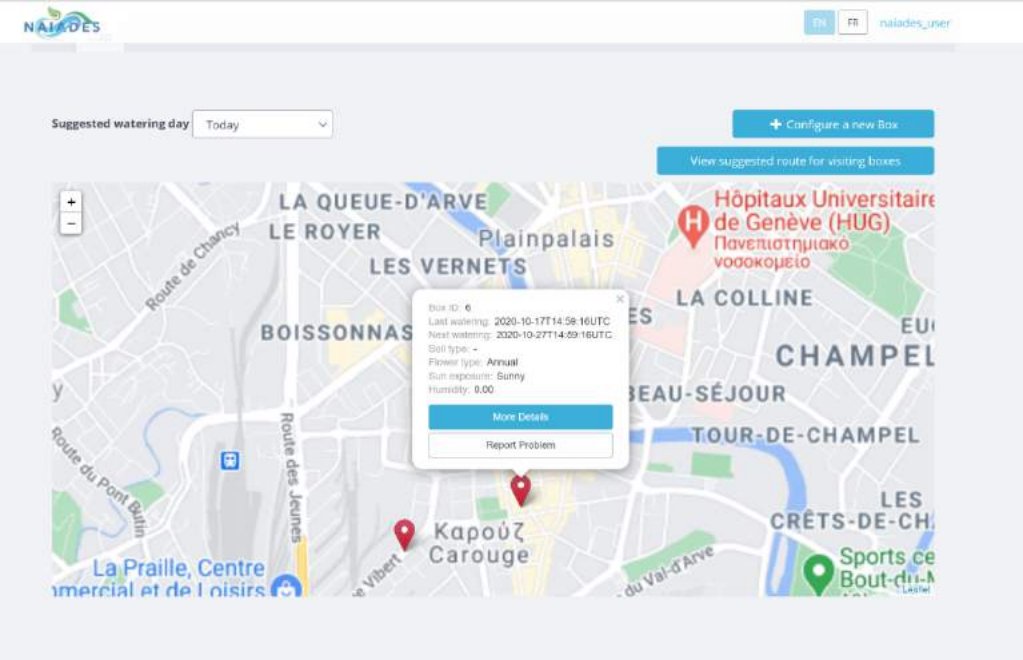


Figure 33: Map view page showing the box details pop up window.

4.4.6 Route

Clicking on the button "View suggested route for visiting boxes" either from the list or from the map view, the user is navigated to the Route view depicted in Figure 34. The app calls the Google directions' API to calculate the fastest route from the current location of the user to the location where the trucks are parked at the end of their shift, by including as waypoints the list of coordinates of boxes that still need to be watered today. In this view, users can also see the next cluster of flower boxes that needs to be watered together with the amount of water the box needs. The operator is free to ignore the advice about which cluster should be watered next, in which case a new route can be calculated. When the truck is moving between the location of the clusters, the user's position is updated on the map. Finally, users can apply a filter, so that they can select for which day they want to see the suggested route.

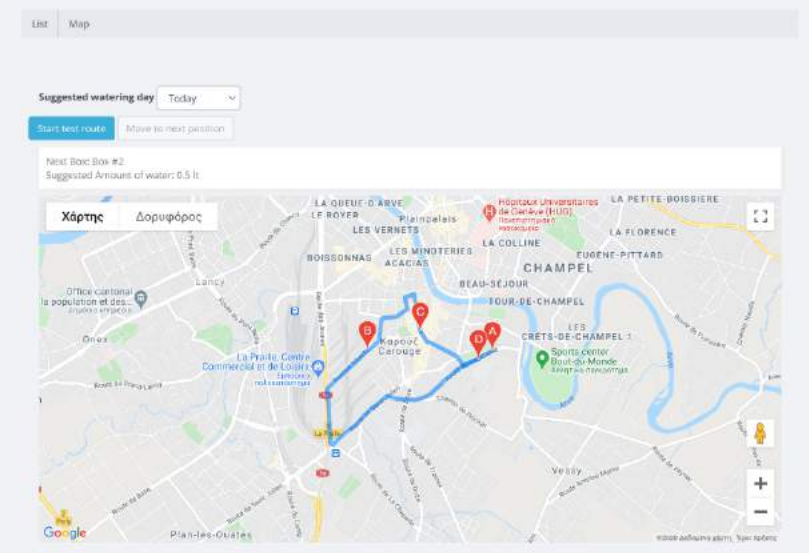


Figure 34: "View route" page showing suggested route for today.

4.4.7 Multilingual Support

Finally, it should be noted that the application has multilingual support, with content provided in both English and French. The translation in French was performed in collaboration with the partners from Carouge as public employees there mainly speak French. Figure 35 shows for example the list view page in French.

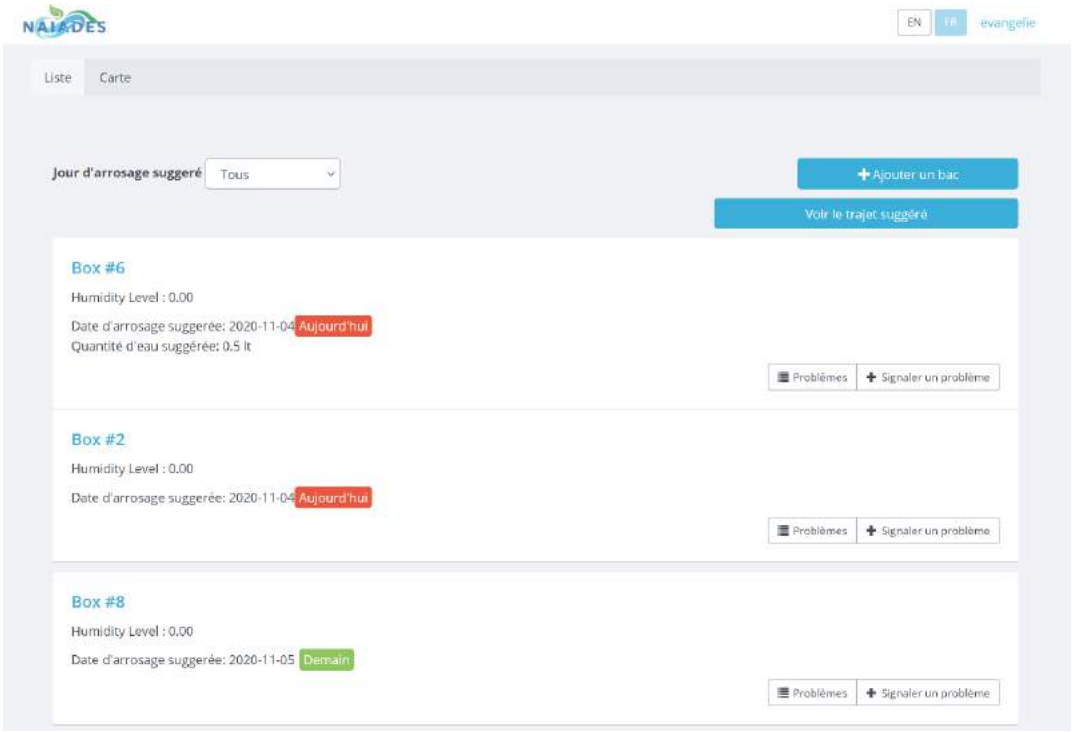


Figure 35: Indicative view of the watering app in French.

4.5 Implementation

An instance of the NAIADES watering application can be found at http://water-awareness.imu-projects.eu/watering/. The app has been implemented in python using the Django web application

framework (https://www.djangoproject.com – see section 3.5 for further information regarding the Django framework).

Moreover, the watering app integrates the Google Maps JavaScript API for the display of the maps showing the location of the flower boxes. The suggested routes for watering boxes are created using the Google Directions API. The Directions API is a service that calculates directions between locations using an HTTP request. The API returns the most efficient routes when calculating directions. Travel time is the primary factor optimized, but the API may also take into account other factors such as distance, number of turns, traffic and many more when deciding which route is the most efficient. It should be noted that the choice of the Google mapping library was based primarily on the fact that many consumers have used and are familiar with the look and feel of Google Maps, while the Google family of APIs also provide a robust set of components and services for developers to integrate into their app and offer many articles and posts written about them, giving a good level of community support and interest. Moreover, Google Maps integrates traffic related information for many locations, including for the city of Carouge. This information ensures that when the directions to a destination are calculated, potential delays due to traffic are considered and the suggested routes are adjusted to avoid such delays when possible.

Furthermore, the application has been integrated with the Context Manager API, allowing users to update information in the central NAIADES database. This integration allows users to create and edit flower boxes, check their watering status, and view additional details about them. Further details on the data schema which is used to describe flower boxes in the NAIAIDES context manager can be found in deliverable D3.9.

The mid-term version of the watering application stores user credentials and reported problems in a local database. This local database is based on PostgreSQL whereas Figure 36 depicts the related database schema.

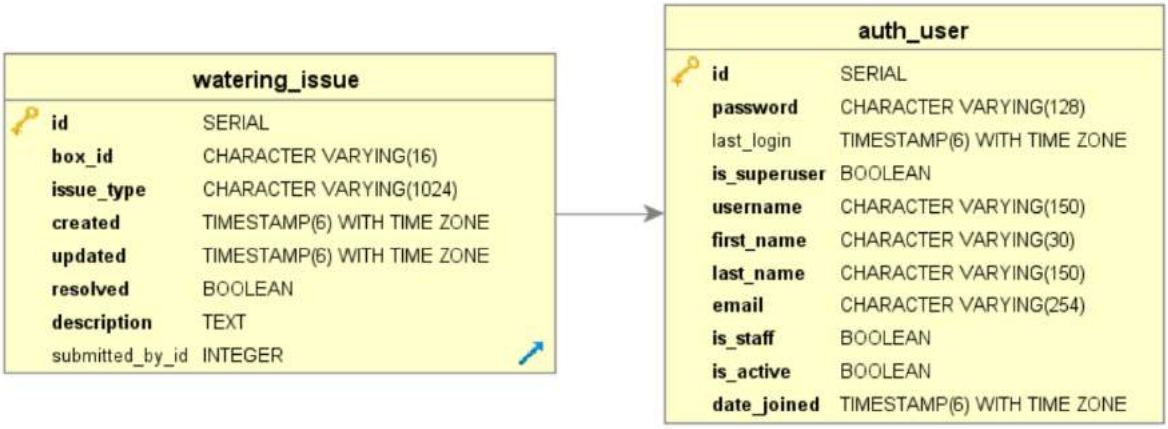


Figure 36: Database schema of the watering app

The auth_user table contains the following attributes:

- **id**: the id of the user.
- **password**: a hash of, and metadata about, the password.
- **last login**: the datetime of the user's last login.
- **is_superuser**: True if the user has all permissions without explicitly assigning them.
- **first_name**: the first name of the user.
- **last_name**: the last name of the user.
- **email:** the email of the user.
- **is_staff**: True if the user can access the admin site.

- **is_active**: True if the user account is active.
- **date_joined**: the datetime designating when the account was created.

The watering_issue table contains the following attributes:

- **id**: an automatically incremented value that's used to uniquely identify each watering issue.
- **box_id**: the id of the box.
- **issue_type**: the type of the issue.
- **created**: the date that the issue was created.
- **updated**: the date that the issue was updated.
- **resolved**: True if the issue was resolved.
- **description**: the description of the issue.
- **submitted_by_id**: the id of the user that submitted the issue.

5 Water Consumers Awareness Dashboard

5.1 Overview

Water management companies & public officials need to be able to deploy ICT-supported behavioural change support programs to engage consumers in water conservation. In NAIADES we focus on school students, a group of consumers that can provide a channel for generating great impact, due to its educational potential, expected higher responsiveness, longer term effect of the intervention, and the multiplier effect at social level. Based on the state-of-the art analysis reported in D6.1, there is only a limited number of studies examining the application of behavioural change support systems in schools with the goal to nudge students towards water conservation. Visser et al. (2019) for example investigated the effect of interventions aiming to encourage responsible water usage in schools, such as feedback on daily and weekly water consumption and comparative feedback on the relative consumption to other schools. In this study, the interventions were communicated through emails, while they resulted in reduced water usage in the schools by 15%, translating to significant water savings. In NAIDES, we employ a web-based water awareness and behavioural change support application, in order to change students' perceptions and actions towards water conservation. To the best of our knowledge and based on the analysis performed in D6.1, there is a gap in state-of-the-art and practice with respect to the use of web-based applications for inducing positive behavioral change of students towards water conservation.

A meta-analysis of behavioural change outcomes in other domains, revealed a significantly increased effect of Web-based interventions compared to non-Web-based interventions (such as email) in terms of the user behavioural change achieved (Wantland et al., 2004). Other persuasive intervention studies have reported mixed findings regarding the effect of human versus automated support (Shim et al., 2017). In any case, the provision of interventions through a web application is more useful in forging an ongoing relationship with the students compared to using email. When a student pays regular visits to the web-based application, to monitor her school's progress in terms of water conservation, she is likely to be more aware about the school's water consumption, as well as become more engaged in actions with a positive effect on the school's water footprint, and ultimately contribute in increasing the effect of the intervention in her school.

To this end, we developed a web-based behavioural change support dashboard to be demonstrated on younger users at public schools with the support of their teachers. The so-called Water Consumers Awareness Dashboard allows running behavioural change support campaigns at schools, monitor them and assess their impact. It also supports different persuasive strategies including self-monitoring and feedback, social comparisons and rewards, suggestions and social norm based messages. In the following we present the main functionalities of the NAIADES School Dashboard.

5.2 The NAIDES School Dashboard

5.2.1 Information Architecture

The following diagram (Figure 37) provides an overview of the information that is presented in the NAIADES water consumers awareness dashboard.

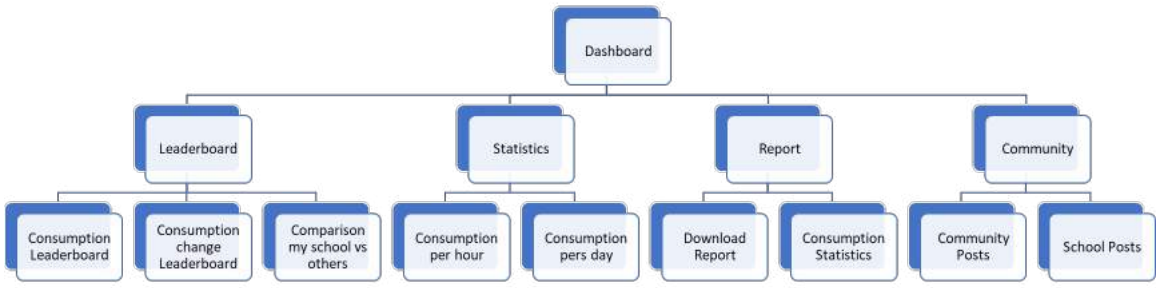


Figure 37: NAIADES School Dashboard Information Architecture.

5.2.2 Leaderboard

Firstly, school managers and students login to the NAIADES school dashboard using their school's credentials. Different types of users with different dashboards views are supported per school. More specifically, we have created two accounts for each school, one for the managers and one for the water end users. The login page is presented at Figure 38.

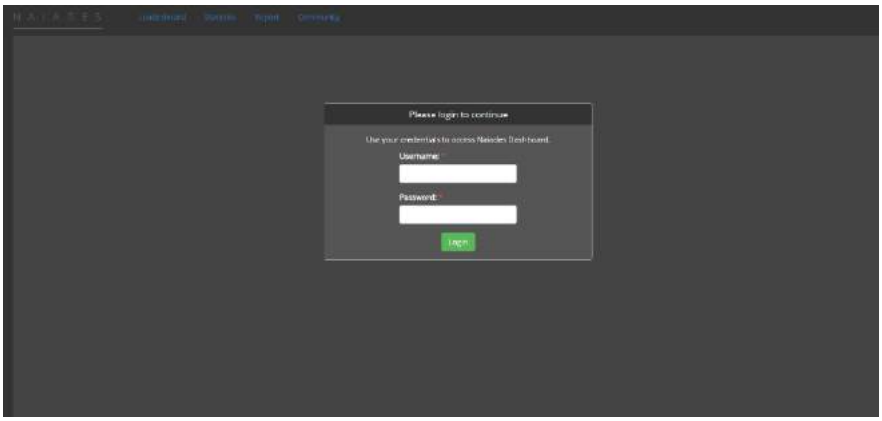


Figure 38: Login page.

When students log into the app for the first time, the screen below (Figure 39) appears. To motivate students to reduce their water consumption we provide them a leaderboard that shows the schools ranked based on the average water consumption per student in the last week. Also, the dashboard provides feedback and comparison based interventions in order to persuade students to make more sustainable choices. As it is shown on the Figure 39, the dashboard shows a graph that compares water consumption of students' school compared to average water consumption and the water consumption of the best 20% of schools. Moreover, a persuasive message is included in case the student's school is ranked low in the list, nudging the students to try more to reduce their consumption!

Figure 39: Leaderboard that shows the schools ranked based on their water consumption in the last week

In the main page of the dashboard on the consumption change tab, students can see a leaderboard that shows the schools ranked based on the degree that their water consumption has changed from last week. To motivate students to reduce their water consumption we provide them a graph that compares water consumption change of the students' school compared to the average water consumption change this week and the water consumption change of the best 20% of schools, as depicted in Figure 40.

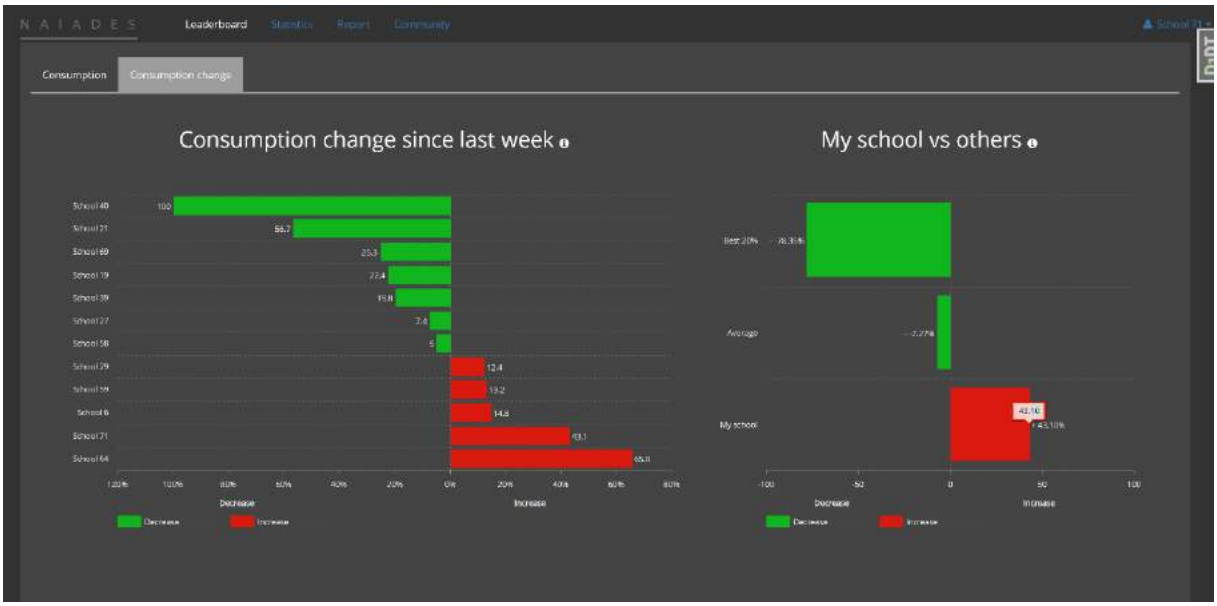


Figure 40: Leaderboard that shows the schools ranked based on their water consumption change since last week

5.2.3 Statistics

The total water consumption per hour and total water consumption per day of each school is presented in the "Statistics" page (Figure 41).

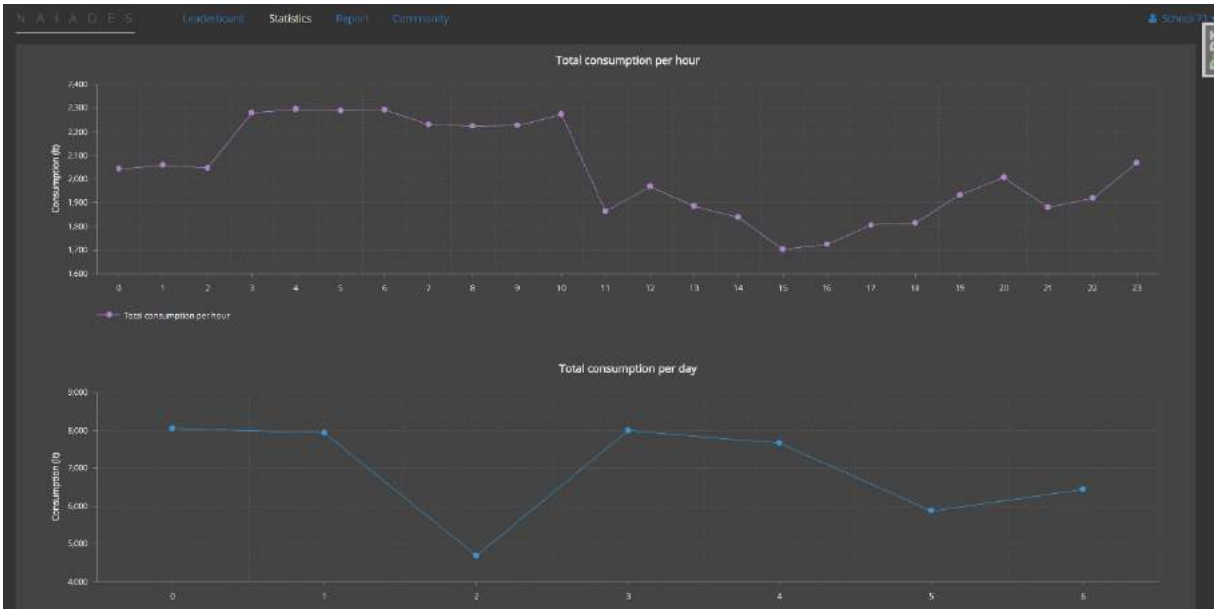


Figure 41: Statistics page.

5.2.4 Report

A water consumption weekly report is also presented as shown on Figure 42.

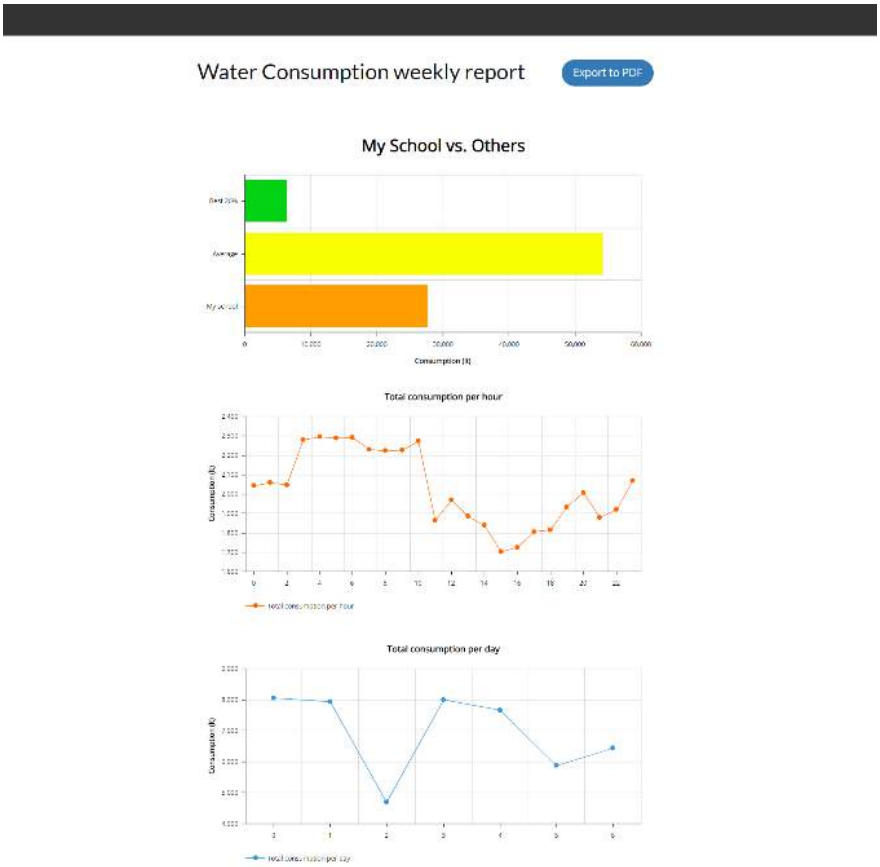


Figure 42: "Report" page.

Teachers and students can download the report by clicking on the button "Export to PDF". Figure 43 shows the water consumption report of the student's school.

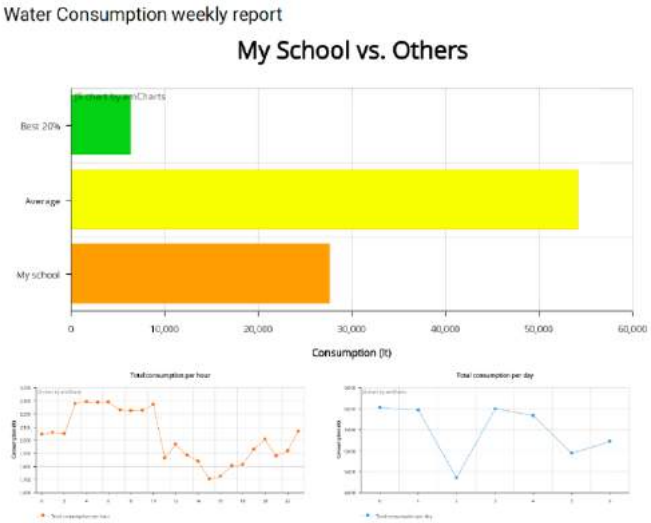


Figure 43: Water Consumption Report

5.2.5 Community

The Water Consumers Awareness Dashboard also provides a forum where students can share their posts with other students either from the same school or from other schools. Figure 44 shows the community posts. Note that the posts are moderated by the teachers who are responsible to posting in the application.

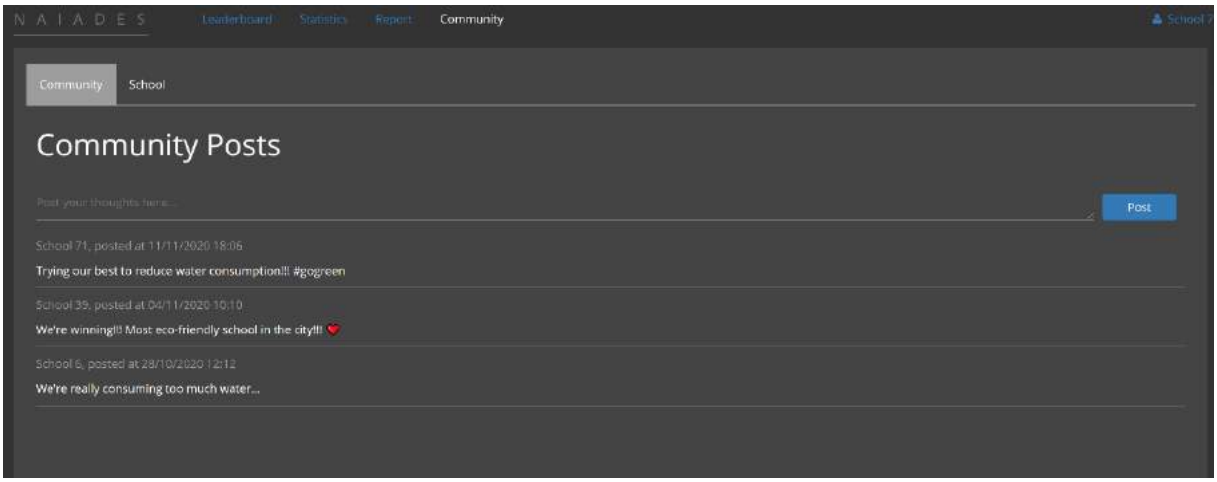


Figure 44: Community Posts.

Figure 45 shows the school posts.

Figure 45: School posts.

5.3 Implementation

An online version of the NAIADES School Dashboard can be found at the following url: http://water-awareness.imu-projects.eu/ The dashboard has been implemented using Django web application framework (https://www.djangoproject.com – see section 3.5 for further details on the selected framework). Moreover, it uses amCharts (https://www.amcharts.com/) for data visualization.

The consumption data from schools are provided by Aguas de Alicante and are consumed through the ETL process described in section 3.5. For this mid-term version of the dashboard, a database has been configured based on PostgreSQL and a related schema has been developed that holds the information required by the schools' dashboard, as shown in Figure 46.

Note that in order to avoid tightly coupling the Schools Dashboard application with the consumption database, an API that allows structured consumption information retrieval has been defined and implemented. The second version of the Schools Dashboard application will be connected to the NAIADES data management framework.

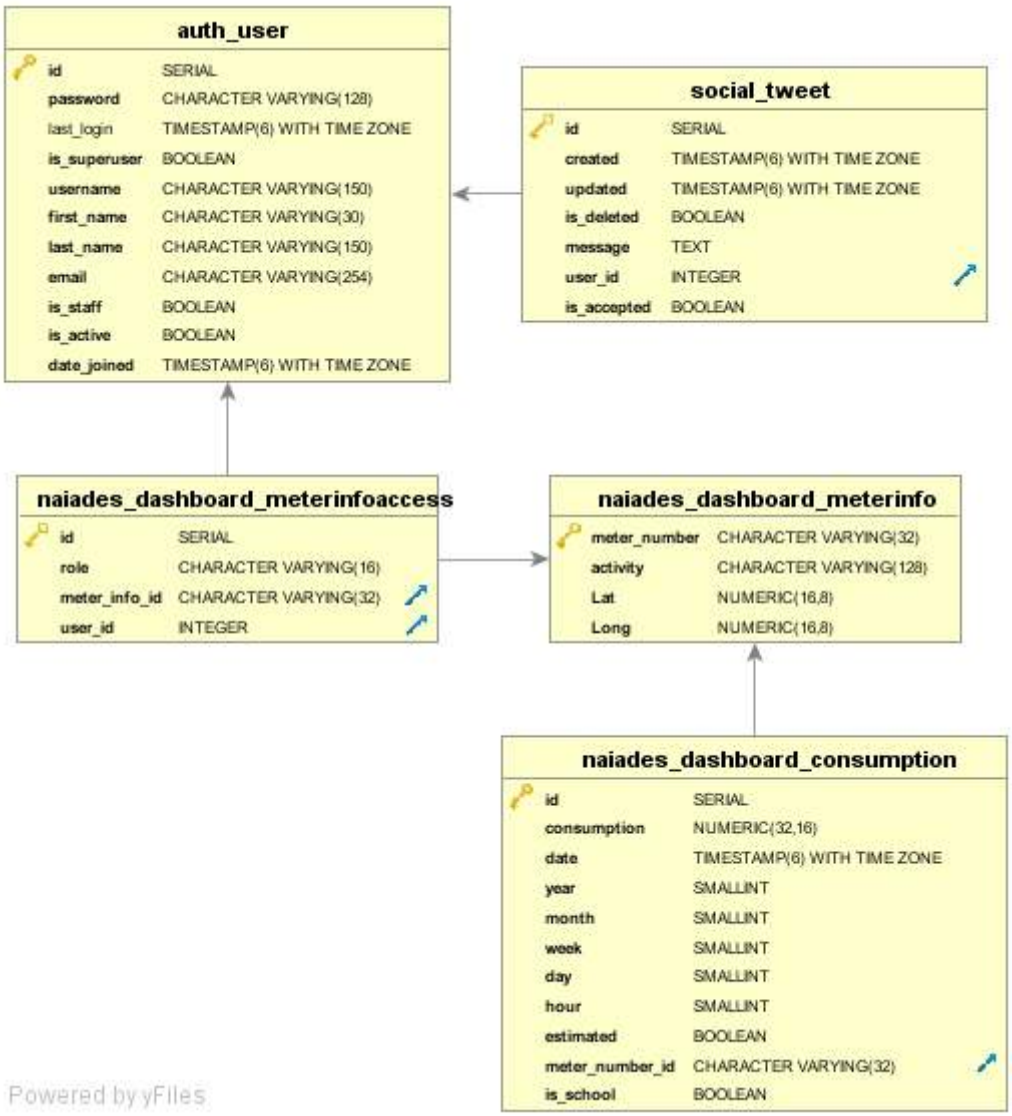


Figure 46: Database schema of the NAIADES school dashboard

The auth_user table contains the following attributes:

- **id**: the id of the user.
- **password**: a hash of, and metadata about, the password.
- **last login**: the datetime of the user's last login.
- **is_superuser**: True if the user has all permissions without explicitly assigning them.
- **first_name**: the first name of the user.
- **last_name**: the last name of the user.
- **email:** the email of the user.
- **is_staff**: True if the user can access the admin site.
- **is_active**: True if the user account is active.
- **date_joined**: the datetime designating when the account was created

The social_tweet table contains the following attributes:

- **id**: an automatically incremented value that's used to uniquely identify each post.
- **created**: the date that the post was created.
- **updated**: the date that the post was updated.

- **is_deleted**: True if the post is deleted, False if the post is active.
- **message**: the message of the post.
- **user_id**: the id of the user that created the post.
- **is_accepted**: True if the post is accepted, False if the post is not accepted.

The naiades_dashboard_meterinfoaccess table contains the following attributes:

- **id**: an automatically incremented value that's used to uniquely identify each record of the table.
- **role**: the role of the user. The role could be either manager or student.
- **meter_info_id**: the meter number of each consumption point.
- **user_id**: the id of each user.

The naiades_dashboard_meterinfo table contains the following attributes:

- **meter_number**: the meter number of each consumption point.
- **activity**: the activity of each consumption point. The activity could be public garden, school, font etc.
- **lat**: the latitude coordinate of each consumption point.
- **long**: the longitude coordinate of each consumption point.

The naiades_dashboard_consumption table contains the following attributes:

- **id**: An automatically incremented value that's used to uniquely identify each consumption point.
- **consumption**: the water consumption of each consumption point.
- **date**: the date of which the consumption was measured.
- **year**: the year of which the consumption was measured.
- **month**: the month of which the consumption was measured.
- **week**: the week of which the consumption was measured.
- **day**: the day of which the consumption was measured.
- **hour**: the hour of which the consumption was measured.
- **estimated**: True for estimated consumptions, False for measured.
- **meter_number_id**: the meter number of the consumption point.
- **is_school**: True if the consumption point is school, False if it is not school.

6 Conclusions and Next Steps

This deliverable described the work performed within T6.2, T6.3 and T6.4 of the project. The work is driven by the NAIADES framework for water consumption awareness and behavioural change support which is described in D6.1 and is summarized in Section 2 of this deliverable. The framework synthesizes awareness and behavioural change support services for different types of users, including water consumers, employees of water companies and public administrations, which leverage the data and AI services residing in the NAIADES intelligence framework.

The implementation work for the NAIADES awareness and behavioural change support services has resulted in three applications: i) the Consumption Awareness Dashboard for Water Management Companies & Public officials that provides tools and mechanisms for related stakeholders to better understand available consumption data; (ii) the Consumption Awareness Dashboard for Public Employees which focuses on the pertinent problem of flower boxes watering in municipalities and aims at improving the watering processes efficiency towards water conservation and time savings for public employees; and (iii) the Water Consumers Awareness Dashboard that allows water management companies & public officials to deploy ICT-supported behavioural change support programmes in order to engage consumers in water conservation. With respect to the Water Consumers Awareness Dashboard, in NAIADES we focus on school students, a group of consumers that can provide a channel for generating great impact, due to its educational potential, expected higher responsiveness, longer term effect of the intervention, and the multiplier effect at social level. For each application, the deliverable provided a detailed description of the provided functionalities and all the technical implementation details.

In terms of next steps, the development of the NAIADES services for awareness and behavioural change support will continue in a second implementation iteration which will include refinements and updates based on users' feedback as well as their integration with the NAIADES data management framework, AI services and identity management approach. The results of the second version and final version of the apps will be reported in deliverable D6.3 (due in M30). The final version of the applications will be evaluated in real life settings within WP8.

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