The PEARL interactive web-based learning and planning platform

Work Package 5

Deliverable Report 5.5

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Abstract (for dissemination, 100 words)	This document presents the design and development of an Interactive Web-based learning and planning platform. WebLP is an online rich client application that provides an interface between PEARL and the members of the Learning and Action Alliances (LAAs) in the case study areas. It is accessible to stakeholders either directly or through expert workshop facilitators and allows for the visualization of the effect of alternative choices on their risk situation and its propagation through time under different scenarios.
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Abbreviations List	
Term	**Description**
ABM	Agent Based Model
ADS	Architectural Decision and Strategy
API	Application Programming Interface
BBOX	Bounding Box
DB	Database
DC	Design Consideration
DTMM	Data Transfer and Migration Module
EJB	Enterprise Java Bean
EWS	Early Warning System
FRI	Flood Resilience Index
FTP	File Transfer Protocol
GIS	Geographical Information System
GPS	Global Positioning System
GUI	Graphical User Interface
IDF	Intensity-Duration-Frequency
JEE	Java Enterprise Edition
JWS	Java Web Start
KB	Knowledge Base
LLAs	Learning and Action Alliances
OGC	Open Geospatial Consortium
ORM	Object Relational Mapping
OS	Operating System
OSGi	Open Services Gateway Initiative
RCP	Rich Client Platform
RDBMS	Relational Database Management System

RIA	Rich Internet Application
SAS	Simulating Authorities' decision making for the Selection of resilience strategies
SJAPI	Satways Javascript API
SLD	Styled Layer Descriptor
WebLP	Web Learning and Planning (WebLP) Platform
WFS	Web Feature Service
WMS	Web Map Service

Contents

1 Introduction

In this deliverable the Web Learning and Planning (WebLP) Platform of PEARL is presented. The PEARL WebLP is an online rich client application that provides an interface between PEARL and the members of the Learning and Action Alliances (LAAs) in the case study areas.

It is accessible to stakeholders either directly or through expert workshop facilitators and allows for the visualization of the effect of alternative choices on their risk situation and its propagation through time under different scenarios.

The WebLP is an Enterprise Multi-Tier software system consisting of several modules and providing the necessary mechanism to be easily extended with additional ones. It supports different user profiles that have access to different parts of the client application and integrates a series of tools that have been developed in other PEARL work packages. WebLP is a GIS based application allowing a customized experience in which different combination of choices by the stakeholders will extract different modelling results from the platform's database.

2 System Overview

The PEARL WebLP is an online WebGIS application that provides an interface between PEARL and the members of the Learning and Action Alliances (LAAs) in the case study areas. It is accessible to stakeholders either directly or through expert workshop facilitators and allows for the visualization of the effect of alternative choices on their risk situation and its propagation through time under different scenarios.

The WebLP supports different user profiles that have access to different parts of the client application and a scenario based separation of tools that have been developed as part of Task 3.7 (Risk Assessment due to combined extreme events) where risk assessment in all nine EU case studies is carried out. WebLP is a GIS based application allowing a customized experience in which different combination of choices by the stakeholders will extract different modelling results from the platform's database.

The users have access to the main parameters/decision variables of the models developed under Task 3.6 and are able to visualize the effect of changes in these parameters (e.g. different strategies, governance options and interventions) on the evolution of risk through time for their own case. In other words, the platform presents the stakeholders with alternative risk futures on the basis of the chain of decisions taken, allowing going back at any point of the decisions cascade to explore its consequences while linking the decisions with the specific stakeholders involved.

The system also allows users to state and explore what-if questions - either by running new simulations using selected PEARL models (primarily developed in Task 3.6) or by exploring already saved ones in the stakeholder mode.

The system is also populated with sets of risk analysis results for the Case studies. Each set includes multiple scenario runs that cover many plausible decisions of the stakeholders enabling them to explore the resulting outcomes.

The development framework incorporates the latest industry standards (JEE, OSGi, OGC etc) and provides extensibility via a well-defined Application Programming interface (API).

Two main modes of using the platform are supported (accessible through different user profile logins):

- an expert/plugin contributor mode, in which expert facilitators (or stakeholder consultants) use the full functionality of the platform to setup and evaluate new scenarios using PEARL models, algorithms and datasets that are accessible through the platform. Analysis in this mode will clearly require significant computational time (to setup and process a scenario) and hence will be undertaken prior to and in preparation for LAA workshops;
- a stakeholder mode, in which stakeholders interact with the platform in real time (prior and during the workshops), make decisions (from a wide, pre-computed set of options) and investigate/visualize their impacts under different scenarios for their own case. The assumption here is that stakeholders learn better when they can experiment in a safe environment in which they can ask what-if questions and visualize the effects of their decisions on indicators they are interested in (e.g. public security, regional expenditure and losses, investment costs etc).

3 Design Considerations

The WebLP has been designed as a multi-user and extensible WebGIS platform that provides the means to register tools and data that have been developed in other work packages. The goal was to allow users to state and explore the outcome of what-if questions - either by running new simulations using selected PEARL models (primarily developed in T3.6) that operate remotely, as a service in the expert mode (that will be then incorporated into the stakeholder mode) or by exploring already saved ones in the stakeholder mode.

Through this framework, several scientific disciplines can work together to access risk, validate results, and present findings in a unified manner. As a result, the WebLP framework provides an efficient online application integrating existing modelling tools and data in a standardised fashion.

The criteria that were taken into account in order to design the WebLP platform are presented in the following table:

Table 1: WebLP Design Considerations

Code	Design Consideration	Description
DC.1	Platform Independence	Many factors influence a software package ease of use including the Operating System (OS) and coding language. The WebLP should be accessible from multiple OS.
DC.2	Flexible and Intuitive GUI	The GUI is an important factor in the design of the WebLP because it determines its usability. For non-experts, grappling with risk assessment concepts is usually quite difficult. In this context, the WebLP should provide an easy-to-use and intuitive GUI.
DC.3	Modularity and Extensibility	The WebLP design needs to be fully modular, allowing project partners to incorporate tools and simulation results from previous work packages and tasks.
DC.4	Multi User Support	The WebLP will be accessible over the web to multiple registered users with different access roles.
DC.5	Web based	The platform ideally should be accessible via the Web (either as a pure Web based or browser downloadable rich client application)
DC.6	Integrated Map engine	Many risk modelling systems are based on Geographical Information System packages which are provided under expensive commercial licenses.. A key WebLP design consideration is to integrate open source 2D and 3D GIS engines that support open standards.

DC.7	Development Simplicity	Provide the means for scientists/developers to develop new WebLP plugins in an easy manner hiding the details of Web and Database access protocols.
DC.8	OGC Standards Conformance	Lack of interoperability when using location content limits options for developers and reduces opportunities for technology convergence. The Open Geospatial Consortium has defined and maintained standards that enable integration of location content into any application, service, or software tool. As a WebGIS application the WebLP should be compatible with the main standards WMS and WFS.
DC.9	Open Source	The WebLP should make use of Open Source technologies as much as possible

The following Use Case UML diagram presents the main use cases of the WebLP. The functionality is organised in the following three groups:

- Administration
- Plugin Contribution
- Scenario and Tool Selection

The administration package encompasses user requirements from the point of view of WebLP application administration (management of organizations, users, roles, access rights and application settings).

The plugin contribution package encompasses the application interactions from the PEARL project partners point of view (synchronizing data with the WebLP DB, managing layers in GeoServer, registration of Web plugins and access rights). Finally, the scenario and tool selection package consists of the functionality available to the end users.

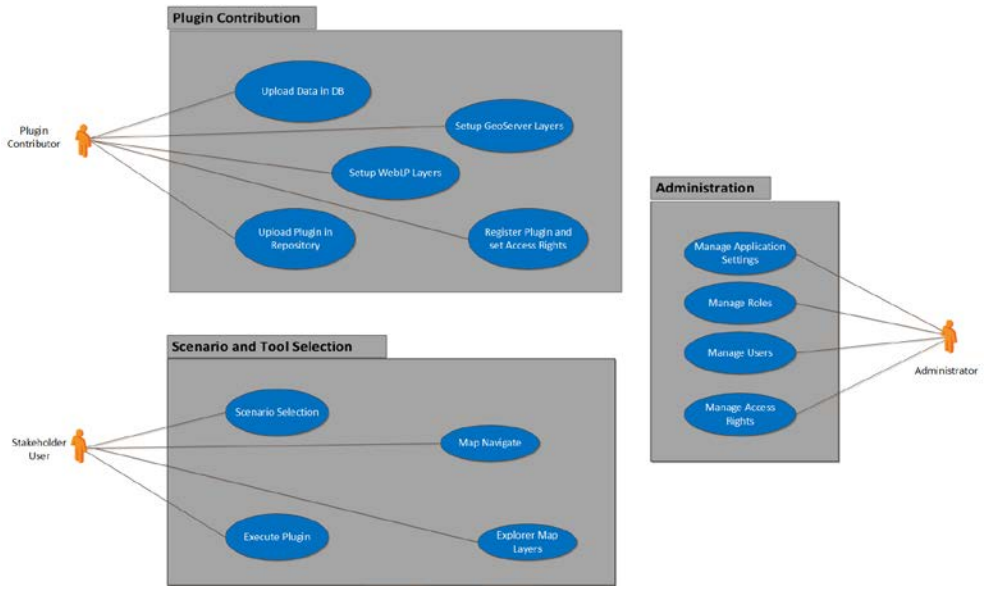

Figure 1: WebLP Use Case diagram

4 Architectural Decisions and Strategies

In this section the main decisions and strategies that affect the overall organization of the WebLP and its higher-level structures will be described. These strategies specify the approach and the mechanisms used in the system architecture (Section 5).

The following Table 2 summarizes the decisions and strategies. The considerations which led to the selection of a specific technology are laid down, referencing the related goals and principles as stated in the previous Section. Additionally, any design goals or priorities that were balanced or traded-off in the selection process are also detailed.

Table 2: Architectural Decisions and Strategies

Code	Decision / Strategy	Description	Design Considerations Ref. Codes
ADS.1	Java Coding Language	This choice was based on both platform independence and the modularity and extensibility offered by the JVM based Eclipse Rich Client Platform and Open Services Gateway Initiative technologies (see ADS.5 and ADS.6). In this decision we traded-off the potentially enhanced performance of other languages against the flexibility, modularity and extensibility offered by Java/OSGi.	DC.1 – "Platform Independence"
ADS.2	Java Enterprise Edition	The JEE is a widely used enterprise computing platform developed under the Java Community Process. The platform provides an API and runtime environment for developing and running enterprise software, including network and web services, and other large-scale, multi-tiered, scalable, reliable, and secure network applications.	DC.1– "Platform Independence", DC.4 – "Multi-User Support", DC.5 – "Web based"
ADS.3	Object Relational Mapping	Object Relational Mapping (ORM) adds an additional abstraction layer between object-oriented programming languages and relational databases. It enables the development of sustainable software making the programming layer independent from the underlying database.	DC.7 – "Development Simplicity"
ADS.4	Web Start based Rich Client application	The Java Web Start is a framework developed by Sun Microsystems (now Oracle) that allows users to start application software for the Java Platform directly from the Internet using a web browser. Some key benefits of this technology include seamless version updating for globally distributed applications and greater control of memory allocation to the Java virtual machine.	DC.5 – "Web based"

ADS.5	Service Platform	The OSGi Service Platform is the de-facto standard for modularised Java Language. It is a framework that provides a dynamic environment for the deployment of services and modules (referred as bundles in OSGi terminology).	DC.3 – "Modularity and Extensibility"
ADS.6	Eclipse RCP	RCP which provides the architecture and framework to build rich client application. RCP's close integration with OSGi makes it one of the only UI technologies to leverage modularity from the ground up.	DC.2 – "Flexible and Intuitive GUI", DC.3 – "Modularity and Extensibility"
ADS.7	GeoServer	An open source server for sharing geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards.	DC.8 -" Standards Conformance", DC.9 – "Open Source"
ADS.8	Leaflet, WorldWind	Leaflet is a popular open-source JavaScript library for interactive 2D maps and WorldWind is a Virtual Globe (Open source) engine.	DC.6 – "Integrated Map engine" , DC.9 – "Open Source"

5 Architecure

The PEARL interactive web-based learning and planning platform (WebLP) is based on the Eclipse Rich Client Platform (RCP) on the client side and JEE on the server side. The WebLP client is a Rich Internet Application (RIA) that can be launched either via the Java Web Start technology or as a standalone Desktop application. It consists of a set of OSGi core Java plugins, a set of Mapping plugins and a set of additional plugins, one of them acting as a wrapper for Web plugins developed by partners of PEARL. The following figure depicts the set of OSGi bundles loaded by the underlying OSGi platform at runtime (Eclipse Equinox).

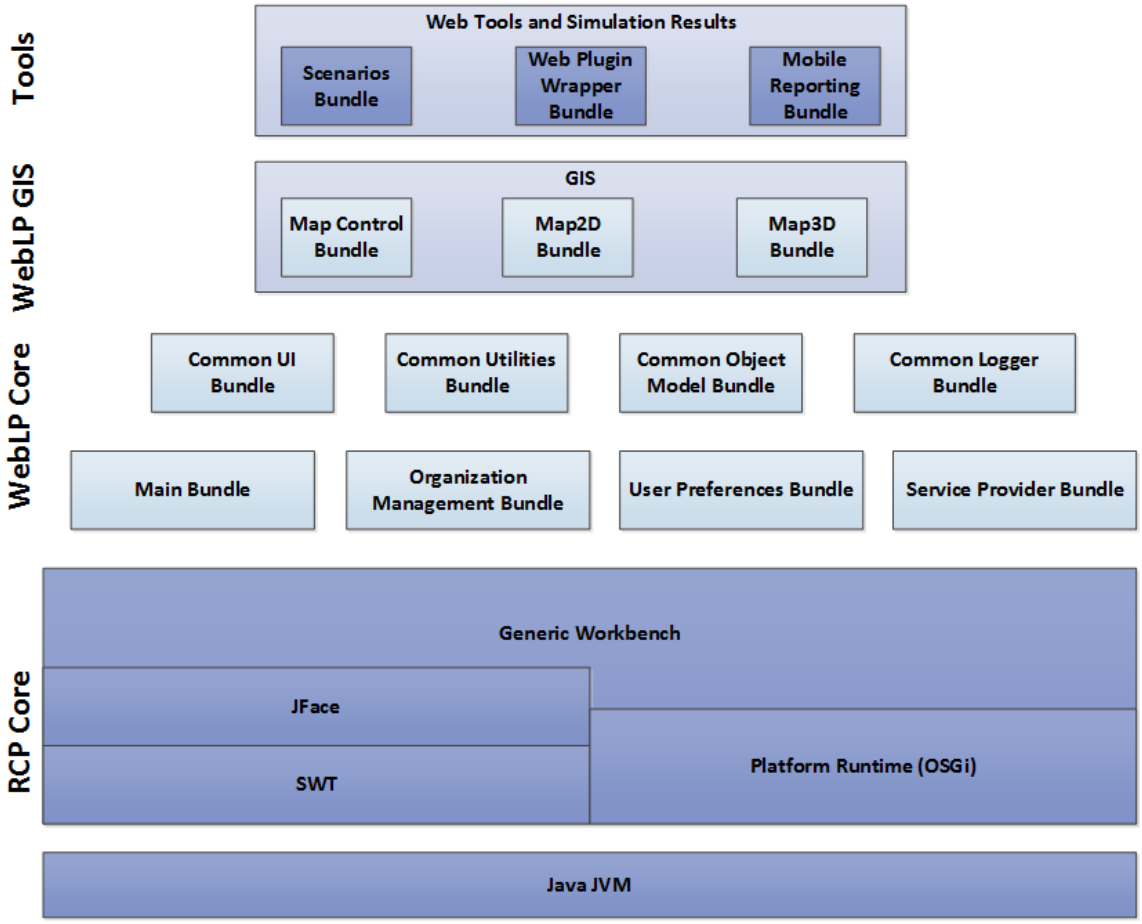

Figure 2: The WebLP software stack of OSGi bundles

A set of the bundles shown in Figure 2 interacts with a number of Enterprise Java Beans (EJBs) components on the server side and a Messaging Broker for real time notifications. Static geographical layers (vector) are served either from the GeoServer instance via OGC protocols or from internet sources (e.g. tile based) and depicted using the 2D and 3D Map plugins. On the back end a PostgreSQL RDBMS with the PostGIS extension is deployed which enhances the database with geospatial capabilities.

End users only have to launch the application and interact with it, while PEARL partners/developers have access to the following services:

- The plugin upload area through Secure FTP
- The GeoServer Web interface for administering GIS layers
- The backend PostgreSQL/PostGIS database for uploading data and GIS layers

The UML Deployment diagram is depicted in the following figure.

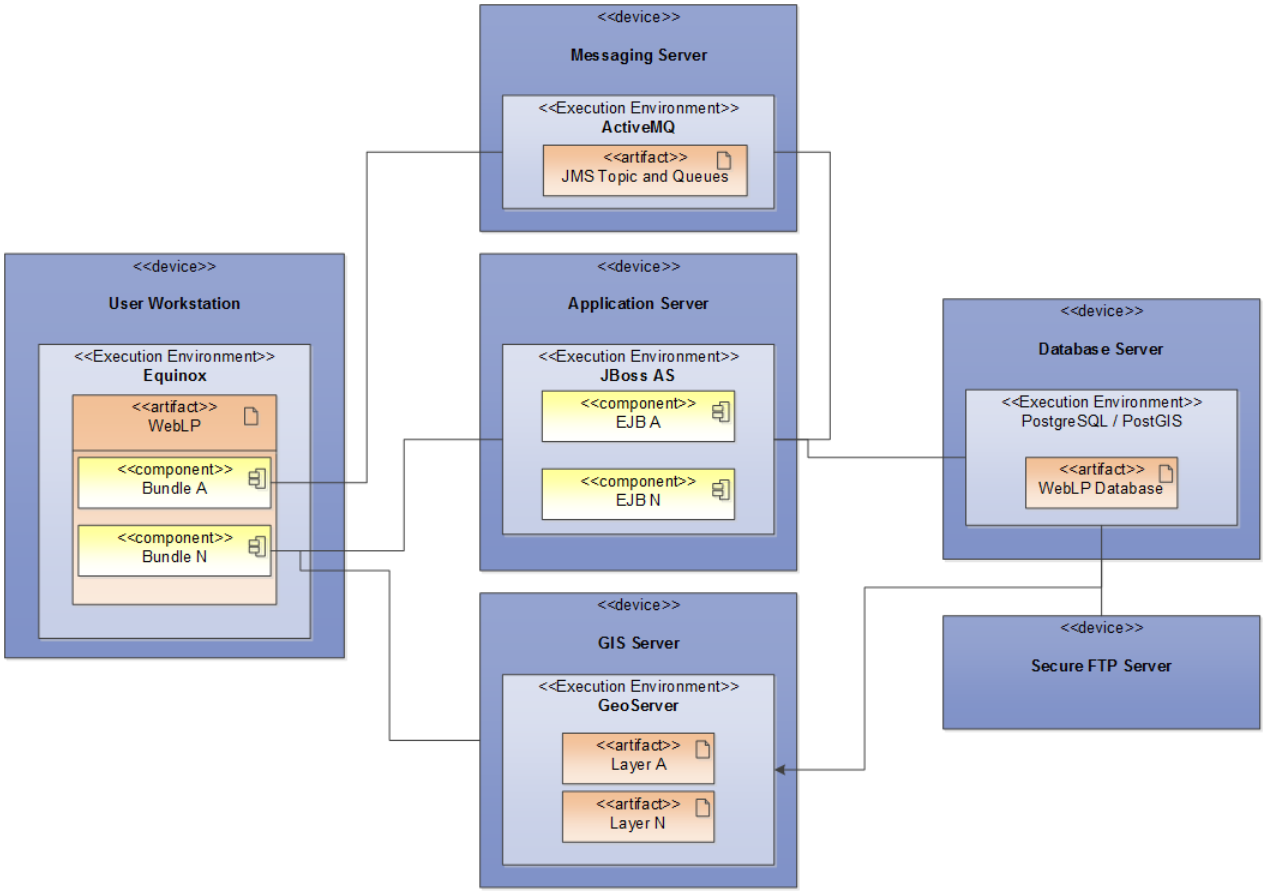

Figure 3: The CEF generic deployment diagram

5.1 User Interface

The application can be launched via Java Web Start (JWS) from a Browser using the following URL: http://satways.static.otenet.gr:8083/pearl-weblp

Once called from a Web Browser the home page of the application will appear (see Figure 4).

Figure 4: Home page of the WebLP Platform

The User interface consists of the following sections (see Figure 5):

- Main menu
- Main toolbar
- Top right user information toolbar
- Right hand side toolbar
- Status bar
- Views

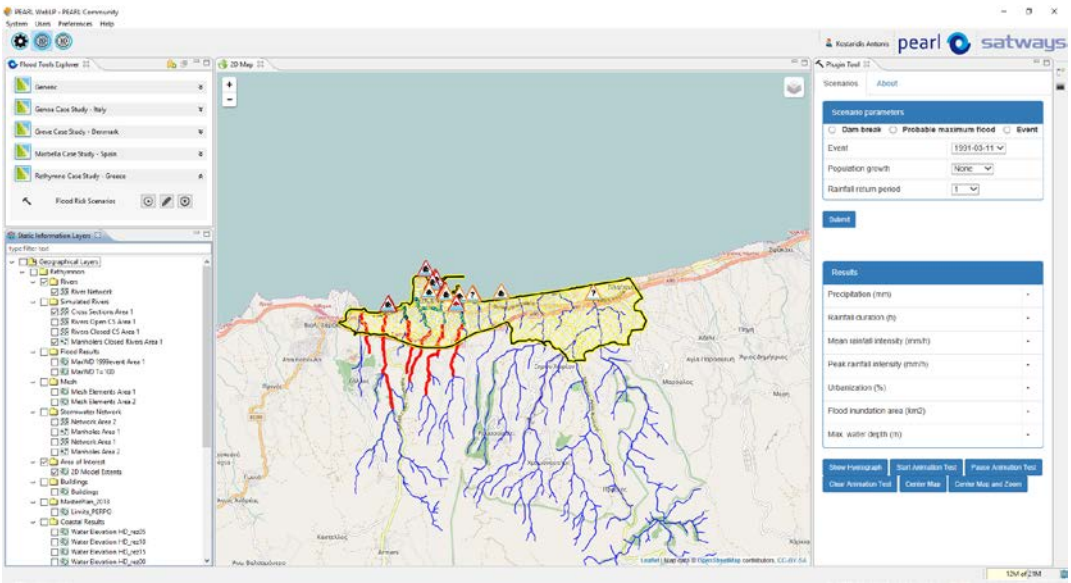

Figure 5: User interface sections

The main toolbar contains a number of buttons that activate a perspective when pressed. In the above figure the following perspectives appear on the main toolbar:

- The administrator perspective (only visible to the Administrator Role)
- The 2D Map perspective
- The 3D Map perspective

Each of the aforementioned perspectives determines which set of views is visible on the screen. In addition each perspective determines which tools appear on the rest of the toolbars or which menus appear in the Main menu area.

A View, when visible, occupies a part of the perspective area. It can be minimised (in any of the right, left and bottom toolbars) or it can be detached from the main window (detached View). In addition each View can contain one or more controls or buttons in the view bar area.

The 2D and 3D Map perspectives contain the same set of Views apart from the Map View itself (2D or 3D). These perspectives contain the necessary views for accessing the PEARL learning and planning tools developed by PEARL partners. The perspectives consist of the following Views:

1. The Flood Tools Explorer View
2. The Static Information Layers View
3. The 2D Map View or 3D Map View depending on the perspective
4. The Tool View (minimised fast View on the right hand side toolbar)
5. The Console View (minimised fast View on the right hand side toolbar)

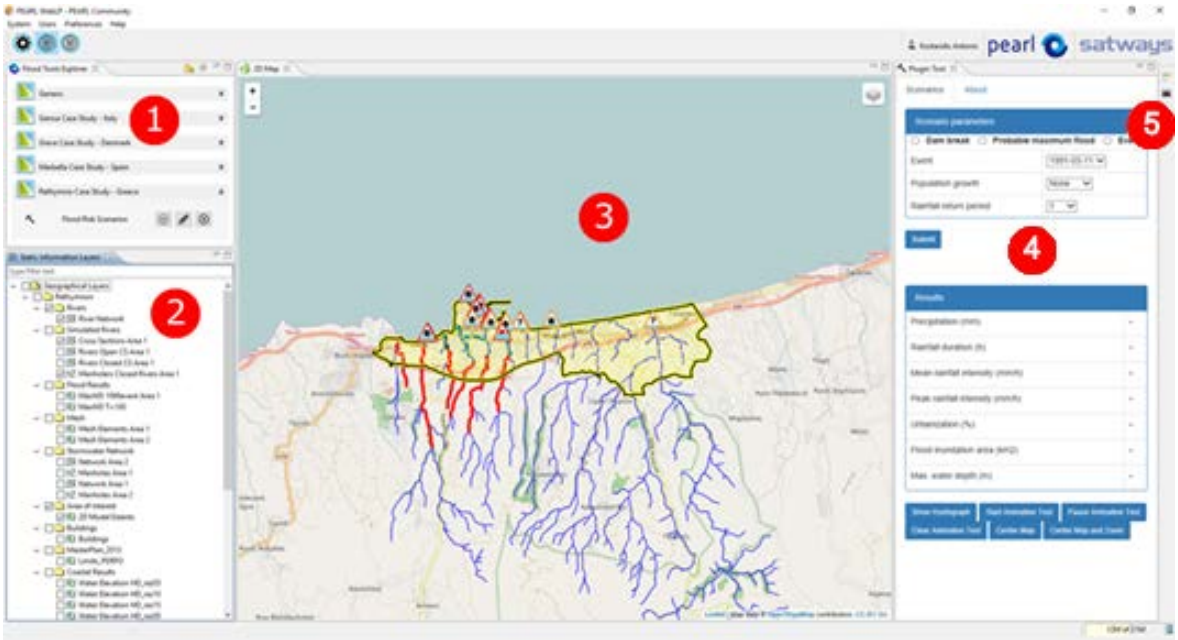

Figure 6: Main views and sections of the User interface

5.2 Scenario Manager

The Flood Tools Explorer View is the navigation window from which learning and planning tools for each of the PEARL case study areas:

- Can be executed
- Can be registered, edited, deleted (by developers)

Each Case study organizes its tools in an Expand bar widget. The creation, edit and delete operations require user access rights which are associated with a user role. The predefined Role "**Web Plugin Contributor**" has full access rights to create a new Web plugin/tool for any of the Case Study areas while the Role "Viewer" has only viewing rights (e.g. for stakeholders users).

The following Case Study areas have been configured into the platform:

- Generic
- Greve Case Study – Denmark
- Marbella Case Study – Spain
- Genoa Case Study - Italy
- Rethymno Case Study – Greece

Depending on the use Role each case study tool/plugin appears in the following way:

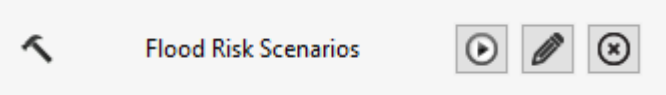

Figure 7: Tool entry in Flood Tools explorer View

The tool entry consists of an icon, a plugin/tool name followed by a set of buttons. The first button executes the tool, the second edits the tool (if the user has the access rights) and the third tool deletes the plugin from the Case Study. The icon on the right hand side indicates whether the tool is visible or not. A tooltip functionality supports the user by describing the meaning of the icon. The following visibility options are supported:

a) A plugin can be visible only to the user who has developed it

b) A plugin can be visible to everyone in the same group/organization as the developer

c) A plugin can be visible to everyone accessing the platform

This way, PEARL contributors were able to test their tools before publishing them to other users or they can limit the access to a specific group of people.

5.3 Layer Explorer

The Static Information Layers View allows the management of WMS layers from GeoServer instances and their categorisation in folders. The View tools are provided in a right-click context menu. The following options exist (depending on the selected element):

- Element Group
    - Add New group
    - Edit Group
    - Delete Group
- Element WMS Layer
    - Add WMS Layer
    - Zoom Extent
    - Identify Feature
    - View Legend
    - Z-Index -> Bring to front or Set to Back
    - Edit
    - Delete

Section 6 describes the usage of this View as a means of visualising published simulation results.

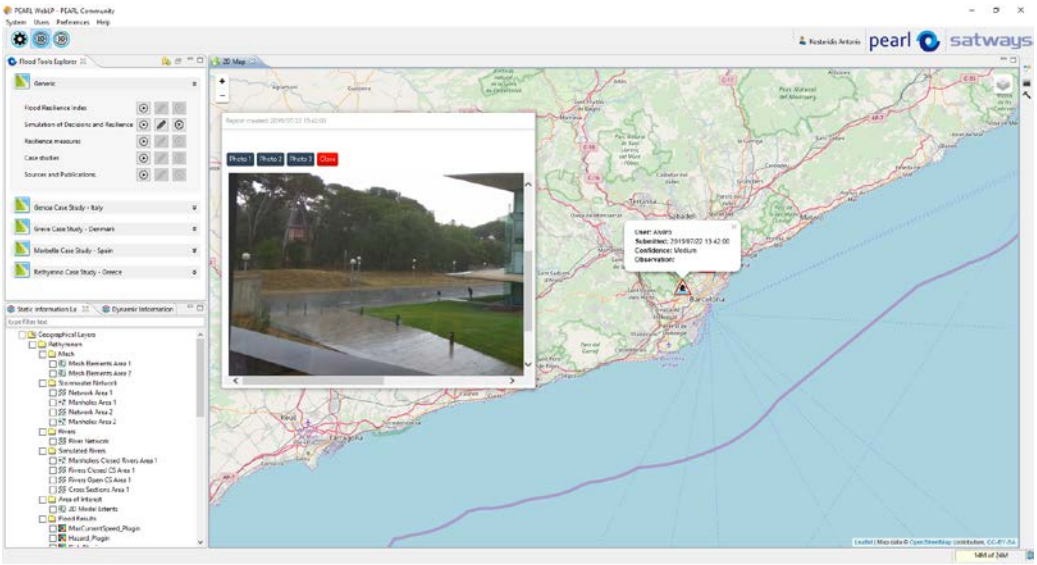

Figure 8: PEARL Detective mobile reports integration

5.4 2D and 3D Maps

The Map views (2D, 3D) allow the interaction with the mouse (zoom in/out, pan) and provide on screen controls for:

- Zoom in
- Zoom out
- Selection of base maps
    - GoogleMaps basemaps for the 2D Map (use the  button)
    - BingMap basemaps for the 3D Map (use the  button)

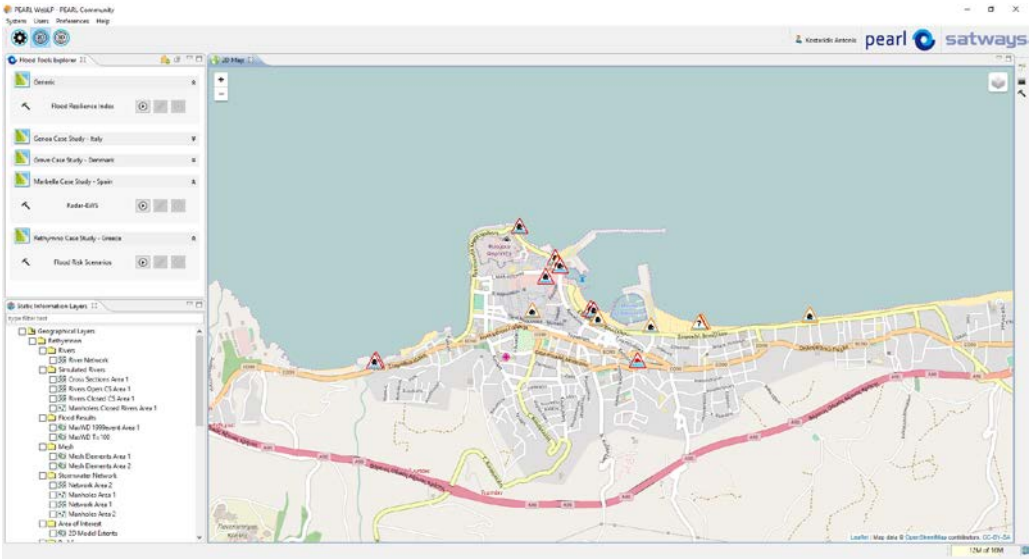

Figure 9: 2D Map View

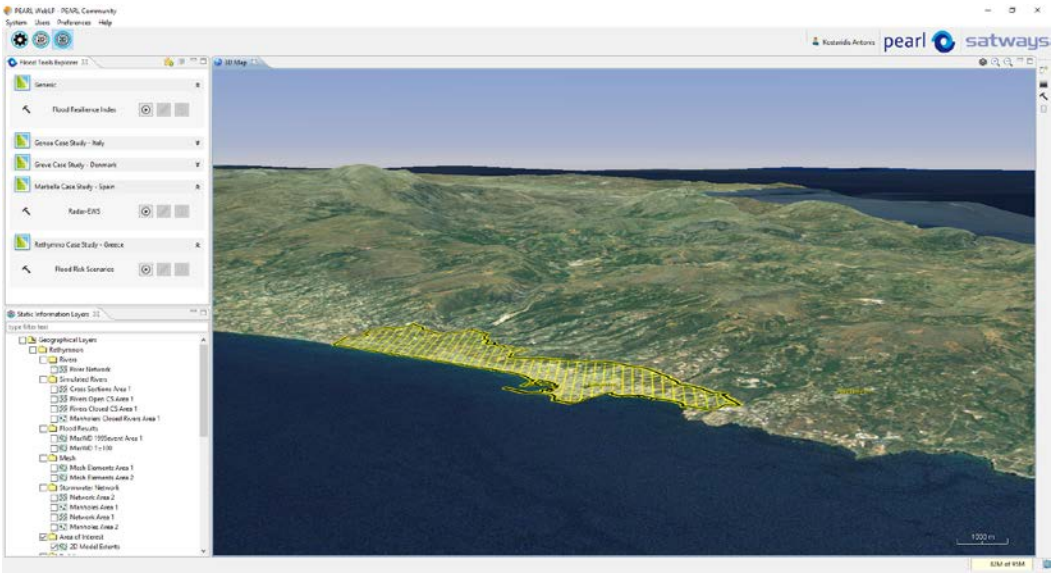

Figure 10: 3D Map View

5.5 Water Detective Reports

In Task 4.5 of the DoW it was requested to develop a generic, multilanguage smartphone app to facilitate informal-based dissemination during crisis, including mapping, citizen reporting and self-organising digital volunteers. As a result of this task Pearl Detective, an application for Android mobile phones, has been developed by HydroLogic [1]. This crowdsourcing application allows citizens to document and report incidents in their city and to upload the reports to the Pearl Detective platform. With the camera integrated in their mobile phones they are able to enhance their reports with pictures while the location of the incidents is automatically retrieved via GPS and submitted together with the report.

In order to make citizen reports available also to the WebLP platform a Data Transfer and Migration Module (DTMM) has been created which periodically retrieves reported incidents from the Pearl Detective DB, identifies newer, undocumented ones and stores them in a database readily available to WebLP as shown in Figure 11.

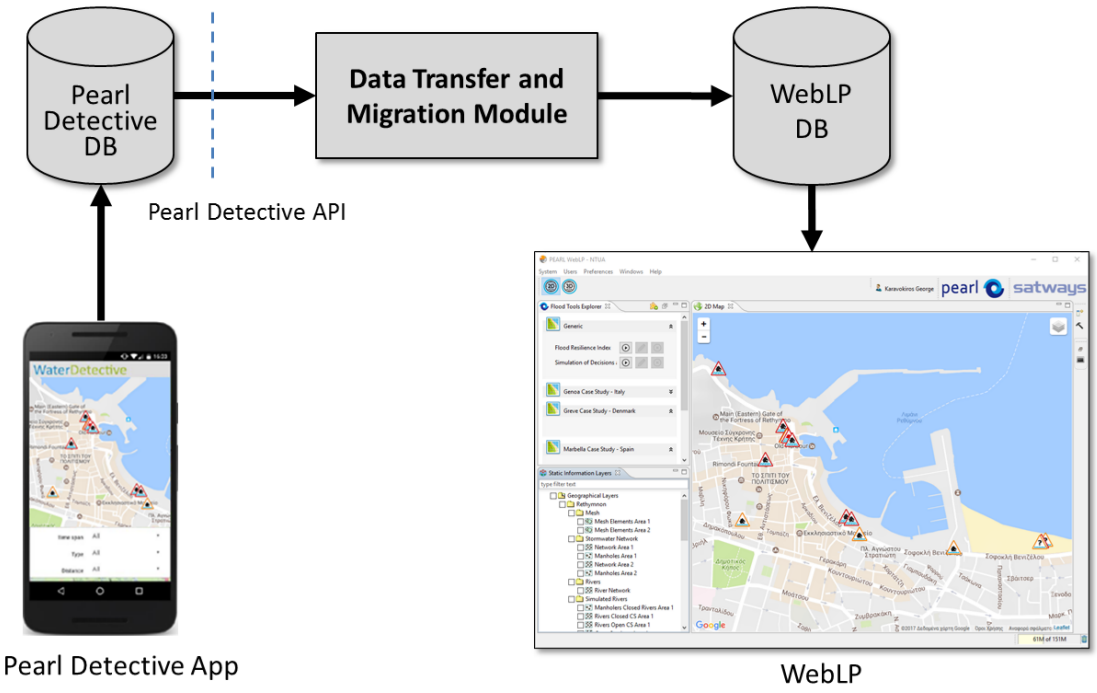

Figure 11: Data flow from the Pearl Detective to the WebLP platform

The DTMM uses the Pearl Detective API [5] to retrieve the information from the Pearl Detective endpoint using GET requests. This endpoint requires by default a query parameter that identifies the mobile app data source. For the PEARL project, the mobile App id is 10. Next to the app id, a number of filters can narrow down the selection of reports. One of these filters allow the specification of a bounding box (Bbox) for which results are requested. This is particularly useful when reports only from a selected case study area are of interest.

On the other hand, the DTMM has access to the WebLP DB through psycopg2, a database API for the Python programming language connecting to PostgreSQL DBMS (such as WebLP).

The DTMM is executed in regular time intervals and performs the following steps:

- Gets the reports from the Pearl Detective DB using the Water Detective API
- Retrieves the last report stored in the WebLP database and identifies its timestamp
- Compares the timestamps from the reports in the two databases and identifies those reports in Pearl Detective DB which are not yet stored in the WebLP database
- Updates the WebLP database with new reports, including photos, comments and feedbacks.

From the WebLP client point of View, Water detective reports are presented as map layers both on with different icons. Each report is associated with description and media which are available via map feature interaction (Figure 8).

5.6 Extending the Platform

The platform contributors are able to develop a new **Web Plugin**. Currently two options are supported:

- **Remote Web plugins**: These are normal Web applications that are hosted in different servers than the WebLP and are accessible via the Internet Explorer Web Browser.
- **Local Web plugins**: These are Web applications that have been uploaded to the WebLP servers via FTP.

For both options the WebLP provides a mechanism (via Java to Javascript and vice versa) for Javascript method calls between the Web plugin and the WebLP modules (Maps, Database etc).

For each case study area a number of Web plugins have been developed by the PEARL project partners as additional modules of WebLP.

These Web plugins are either standalone (e.g. the Flood Resilience Index Tool) or interacting with the platform modules via the Javascript API (see Section 8).

5.6.1 Registering a Web Plugin

In order to register a new remote Web plugin a plugin contributor launches the application and selects either the 2D Map or 3D Map perspective. In order to register a new local plugin a user must press the  button that appears on the Flood tools Explorer toolbar. The following wizard dialog will become visible:

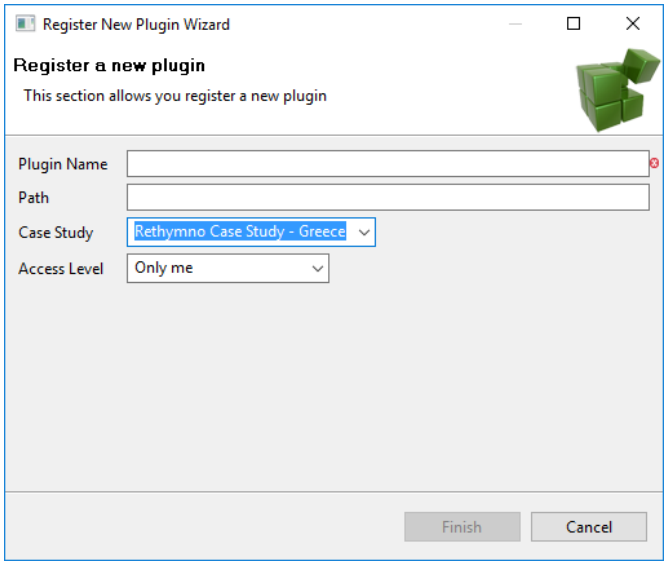

Figure 12: Register new plugin wizard dialog

The dialog page requests as input:

- Plugin Name: This is the name that will appear in the expand bar.

- Path: This is the path and filename of the Web plugin. Depending on nature of the plugin (local or remote) the plugin contributor should enter a valid absolute or relative URL accordingly.
- Case study: This is a drop down menu from which users should select the case study under which the new tool will appear.
- Access level: This is the drop down menu for selecting the visibility level of a Web plugin.

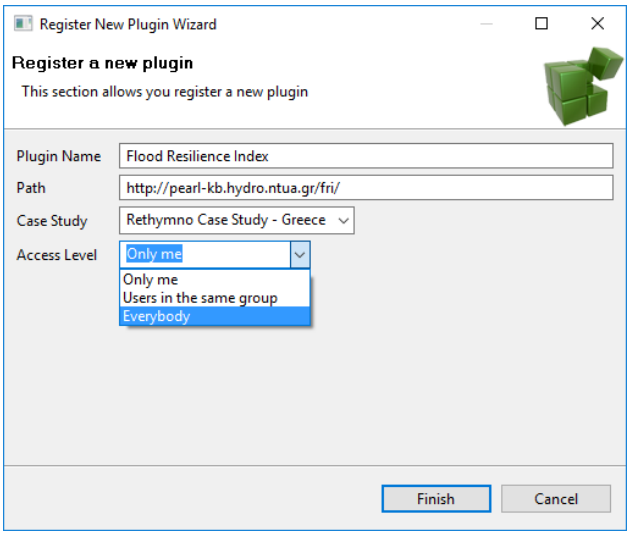

Figure 13: The remote web plugin details of the Flood Resilience Index tool

After pressing the finish button the plugin appears under the selected case study.

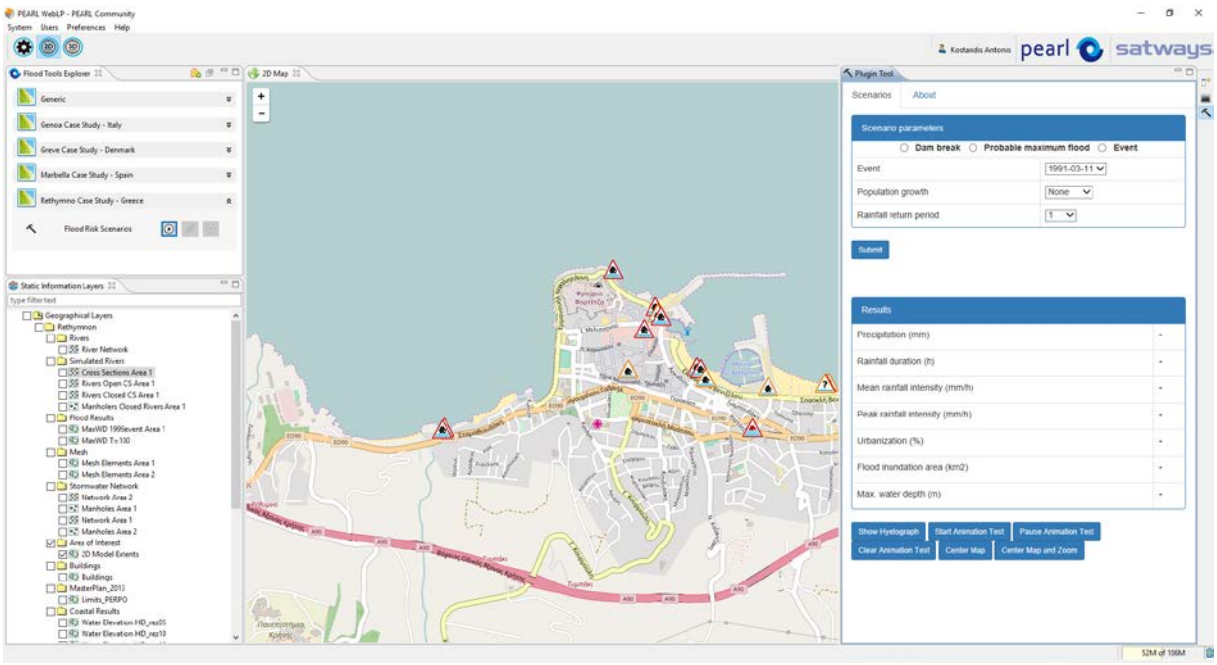

Figure 14: Executing the Flood Risk Scenarios plugin

In general, a Local Web plugin is a semi-autonomous Web application i.e. consisting of HTML/Javascript pages. In order for each Web application (Local or Remote) to interact with the rest of the WebLP Modules/Bundles, WebLP offers a java-javascript based API (Application Programming Interface) called SJAPI.

The current version of the SJAPI provides methods (see Section 8) mainly to interact with the Map modules and with the backend database such as the following:

- Add and remove WMS layers already defined in GeoServer
- Query backend PostgreSQL/PostGIS database tables (without the need of advanced SQL skills)
- Show plugin resource images
- Play and control WMS layer animation
- Center and zoom the 2D/3D maps

6 Case Studies Simulation Results

The WebLP platform enables and assists the organisation and visualisation of geospatial data (point, polyline, polygon and raster format). This is of primary importance for all steps of flood risk assessment. Hence, the stakeholders are equipped with a platform in which all necessary data for the learning and planning process can be stored and visualised. The components of an urban system that play a significant role in water dynamics i.e. the evolution of flood risk are entities such as road network, buildings, land uses, catchment boundaries, etc. are embedded in models set ups and can be accessed through the platform's interface. Furthermore, datasets including various layers of data input and simulation results can be shared with different groups of stakeholders, which do not have access to complex tools such as hydrodynamic models.

For the case study of Rethymno, a number of datasets has been stored on the developed GeoServer and made accessible through the platform interface as static layers (WMS layers). Data has been organised in folders under a tree view based on users' needs. The layersare symbolised depending on their type (point, polyline, polygon or rasters) as presented in Figure 15. Representative names have also been given to each geographical entity. Table 3 below provides an overview of the available layers.

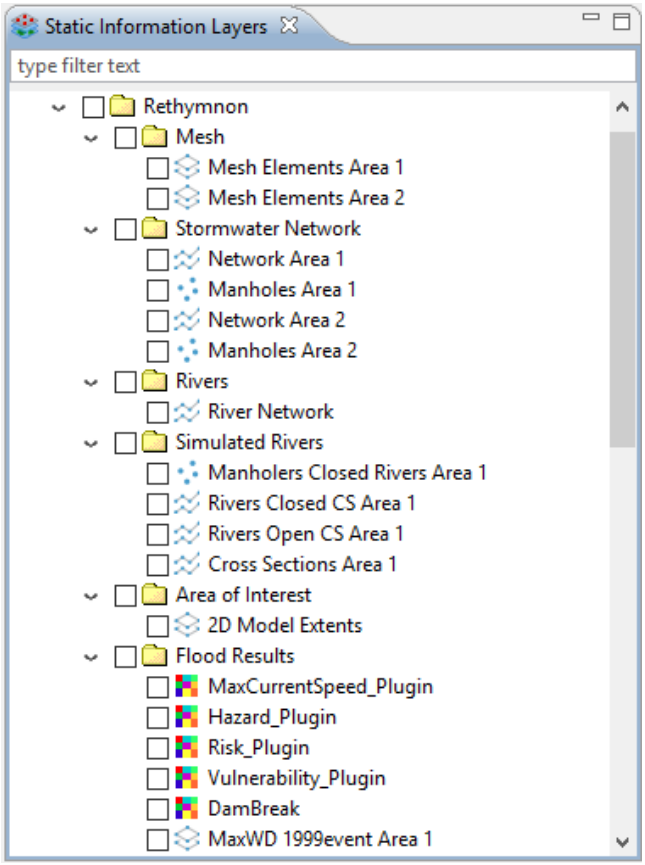

Figure 15: Tree view of static information layers

Table 3: Geographical entities used in Rethymno's model chains and accessed through the WebLP interface (organised in folders)

Geographical Layers
Rethymno
Catchments
Catchments *(polygon shp)*
Rural Catchment *(polygon shp)*
Urban Catchments *(polygon shp)*
Master Plan_2013
Limits of future urban planning *(polygon shp)*
Other data
Precipitation Stations *(point shp)*
Land Use – Manning *(polygon shp)*
Road Network
National Road Network *(polyline shp)*
Major Road Network *(polyline shp)*
Secondary Road Network *(polyline shp)*
Paths *(polyline shp)*
Buildings
Buildings *(polygon shp)*
Area of Interest
2D model Extents *(polygon shp)*
Simulated Rivers
Cross sections of open channels/rivers *(polyline shp)*
River bed lines of open channel flow *(polyline shp)*
River bed lines of closed channel flow *(polyline shp)*
Manholes of closed channel flow *(point shp)*
River Network
River Network *(polyline shp)*
Stormwater Network
Drainage Network *(polyline shp)*
Manholes of Drainage Network *(point shp)*
Mesh
Mesh Elements of Area 1 *(polygon shp)*
Mesh Elements of Area 2 *(polygon shp)*

To enhance even more user's capabilities, stakeholders are also able to create different types of layer styles in order to present the datasets of their case studies based on their requirements. By creating different SLD files (Styled Layer Descriptor) in GeoServer, the users are able to create a whole library of styles through which visualisation style of WMS layers might be altered at any time (apart from the predefined ones already provided to them by the developers).

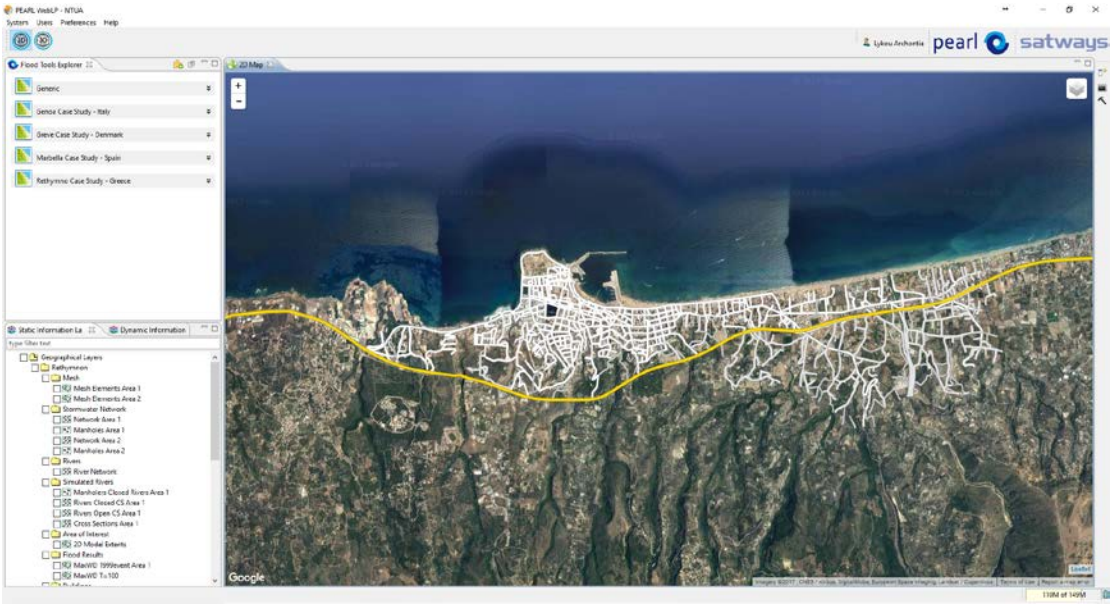

Figure 16: Road network styles based on their classification (national, major, secondary and paths)

7 Web Plugins

7.1 Flood Resilience Index

The PEARL FRI Tool has been developed as part of Task 5.2 of the project. The concept is based on the Flood Resilience Index (FRI), developed within FP7 Project CORFU (e.g. [6]). A number of experts have contributed in the review and enhanced the methodology ensuring that all relevant aspects for the analysis of extreme events in coastal regions have been taken into account ([7]). The new methodology has been implemented as part of the PEARL Knowledge Base (PEARL KB), accessible through its website[1].

Additionally, the same application has been adapted to serve as one of several plugin tools capable to be accessed through the WebLP Platform. In order to achieve this goal, some aspects of the initial application design have been modified. More specifically, a) the header and footer of the application have been removed including the main menu of PEARL KB and b) the design of the web pages has been made more responsive which allows the plugin application to better fit to the overall design of WebLP. The methodology used and the underlying technology allows the development of the application in one place, eliminating duplicate code. New versions of the FRI application are automatically adopted in both systems PEARL KB and WebLP. Figure 17 shows the integration of the PEARL FRI Tool as a remote plugin in WebLP.

By using the tool, users are able to estimate the resilience of their city for a specific flood event or flood type event in five dimensions, namely natural, physical, economic, social and institutional and visualize the results in a spider diagram. The results can be compared with other cities participating in the project as case study sites.

[1] http://pearl-kb.hydro.ntua.gr/

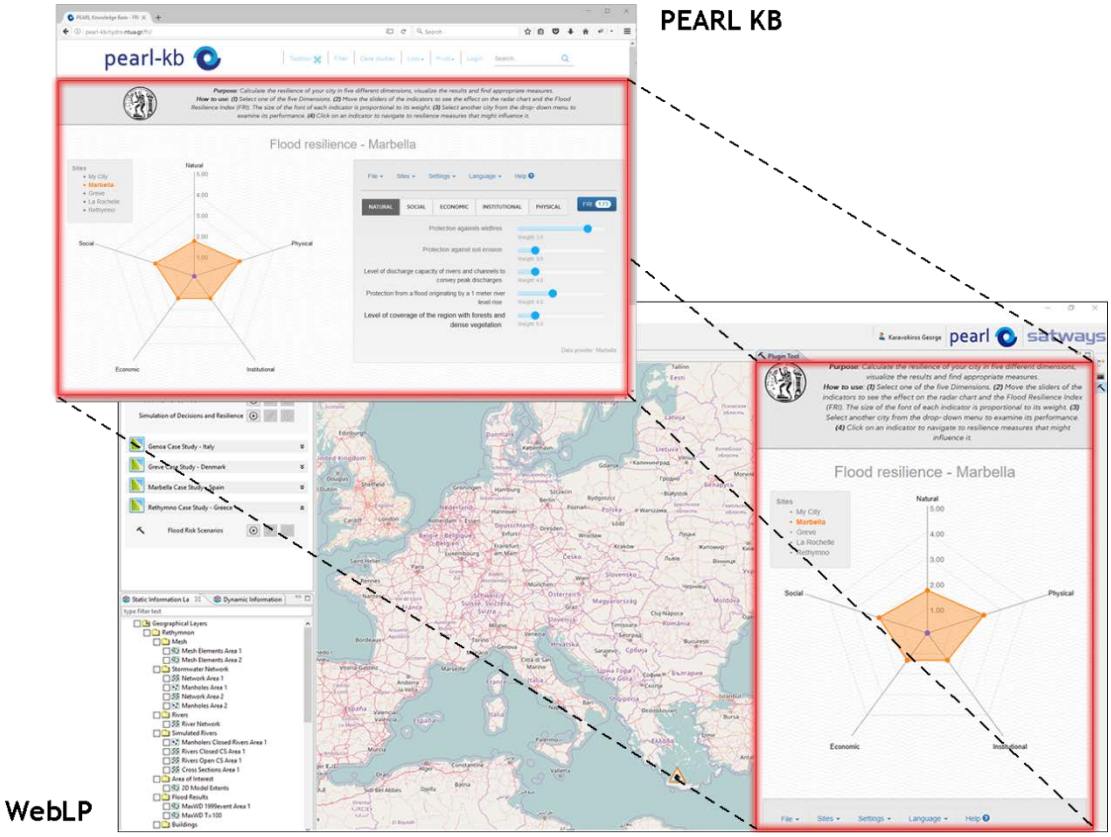

Figure 17: Selection and execution of the PEARL FRI Tool as WebLP plugin

7.2 Flood Risk at Rethymnon

A plugin for the visualization of flood risk for the Rethymnon case study region has been developed. It is based on a series of maps and layers which have been produced during the PEARL project involving rainfall-runoff, hydrological and 2D models. The user is able to visualize the results from several scenarios, including:

- A catastrophic precipitation event occurred on the 10 November 1999 causing great damages to the city and the citizens' property. On that day within 8 hours a total precipitation of 120,6 mm was recorded. It is estimated that such an even has a return period of about T=90 years.
- Precipitation events of 50, 100 and 1000 years return period and 12 hours duration. The hyetograph of these events was produced based on the Intensity-Duration-Frequency (IDF) curves while using the alternating block method. The IDF curves were obtained from the published outcomes of Floods Directive's implementation in the island of Crete.

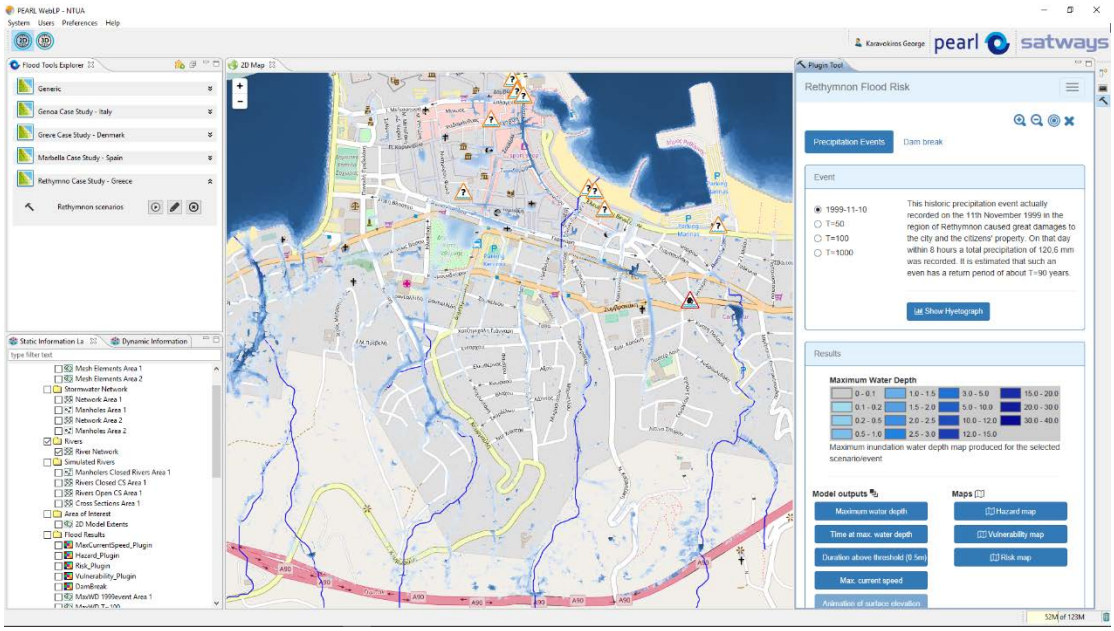

Figure 18: Rethymno's Flood Risk plugin showing the maximum water depth of the historic event from 1999.

The hyetograph of each of the aforementioned hydrologic scenarios can be displayed on the screen. A number of results corresponding to the scenarios can be examined including the following:

- **Maximum Water Depth**: Maximum inundation water depth map produced for the selected scenario/event (see Figure 18).
- **Time at Maximum Water Depth**: The time when the maximum inundation water depth was recorded for the selected scenario/event
- **Duration Above Threshold**: Duration for which the water depth value was higher than the defined depth threshold value for the selected scenario/event. The depth threshold value was set equal to 0.5 m.
- **Maximum Current Speed**: Maximum current speed map produced for the selected scenario/event.
- **Vulnerability Map**: Vulnerability map produced after conducting vulnerability assessment at a block level. Vulnerability was estimated based on the combination of susceptibility, lack of coping and lack of adaptive capacity. For the assessment, geospatial and statistical data of Rethymno was used. The vulnerability index values have been normalised (0-100) and classified as Very Low, Low, Medium, High and Very High.
- **Hazard Map**: Hazard maps produced after conducting hazard assessment and its classification in 3 intensity levels i.e. Low, Medium, High. Classification was based on flood characteristics i.e. maximum water depth and velocities outputs of the selected scenario/event.
- **Risk Map**: Risk map produced after conducting a qualitative flood risk assessment i.e. combining hazard and vulnerability maps. Flood risk was classified as Low, Medium, High.

In addition to the above scenarios, a hypothetical dam break scenario of Potamon-Amariou Dam has been investigated (Figure 19). The dam is located 10 km upstream from the city of Rethymnon, was built in 2009 and has a capacity of 22.5 mil. cubic metres. 2D hydraulic modelling has been accomplished while using the dam break discharge as an upstream boundary condition. Dam break discharge chart was provided by OAK S.A., while the dam break study was conducted by Dr. Alexandros Mentes on 2005.

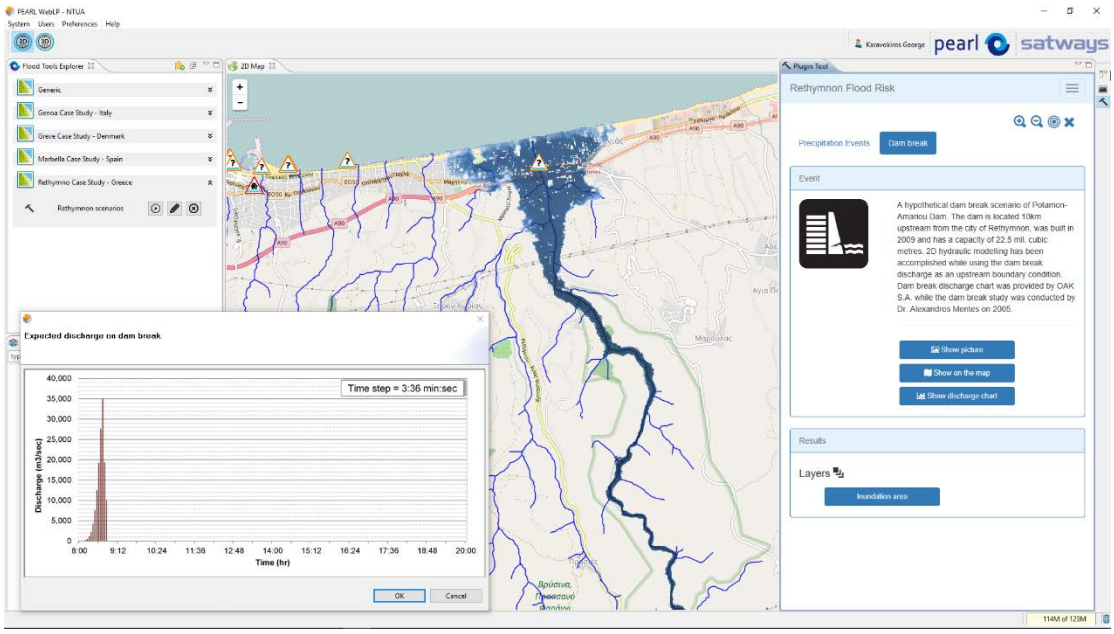

Figure 19: Dam break scenario

Some simple but useful GIS functions have been embedded into the plugin, utilizing the API of WebLP, such as returning the viewport to Rethymnon after panning and zooming to another region and clearing the map from all layers. Other static layers can be selected from the left pane of WebLP (e.g. river network, catchment area) providing additional

7.3 Knowledge Base

A number of plugins have been created for the WebLP platform retrieving information stored in the PEARL Knowledge Base (PEARL KB), originally developed for Task 5.3. These plugins support stakeholders and experts in their goal to select resilience measures against extreme hydro-meteorological events in coastal regions. The approach followed in WebLP is the same as in PEARL KB: a) help stakeholders to identify vulnerabilities (using the PEARL FRI Tool), b) support them in identifying resilience measures, c) show them where best practices have been applied and d) discover relevant publications. For each of these tasks an appropriate plugin has been created in alignment to the functionality developed for PEARL KB, while their appearance has been adjusted to the specific needs of the WebLP user interface.

7.3.1 Resilience measures

The landing page of this plugin allows the user to narrow down the list of measures stored in PEARL KB by specifying filters in the categories a) problem type, b) measure type, c) spatial scale and d) land use. The process is supported by illustrations for each selection (Figure 20). Following the resulting pages the user is navigated to detailed information

related to his selection. The responsive design of the website allows the pages to be rendered in a way that makes optimal use of the space on the right pane the WebLP user interface, adjusting their appearance according to the width and height of the pane (Figure 21).

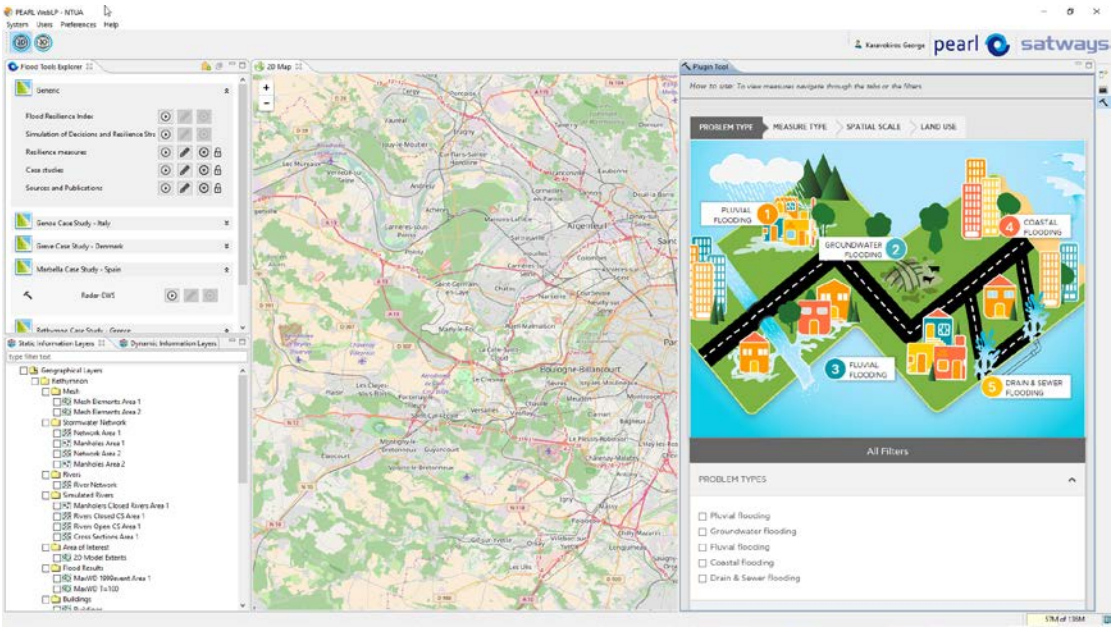

Figure 20: Landing page of the resilience measures plugin

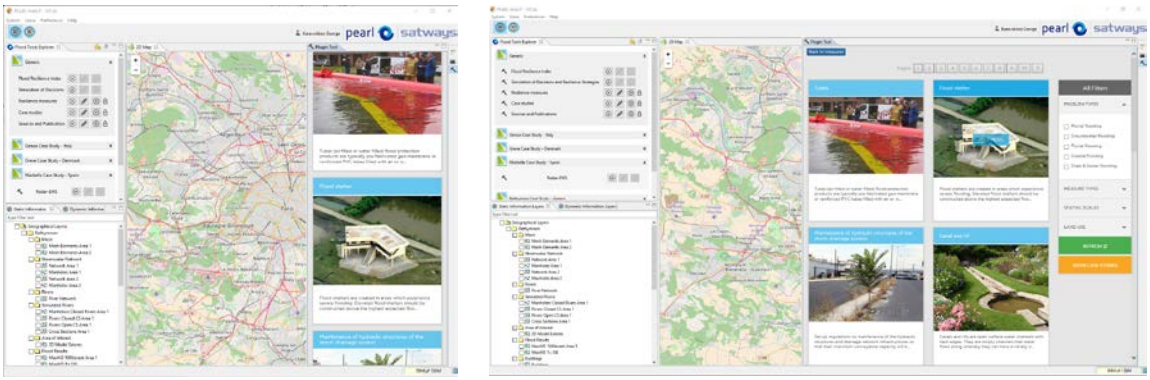

Figure 21: Two different views of the same results that make optimal use of the given space

7.3.2 Case studies

The Case studies plugin provides direct access to the applications of resilience measures documented in the PEARL KB. The user is able to select a case study on the map by zooming to the area of interest and clicking the reference point or by selecting the case study from the list (Figure 22). Full text search on the textual information of case studies (name, description etc.) is also provided. By navigating to the detail page all characteristics of the case study are provided. At the same time the map in the main pane of WebLP is panned and zoomed to display the selected area.

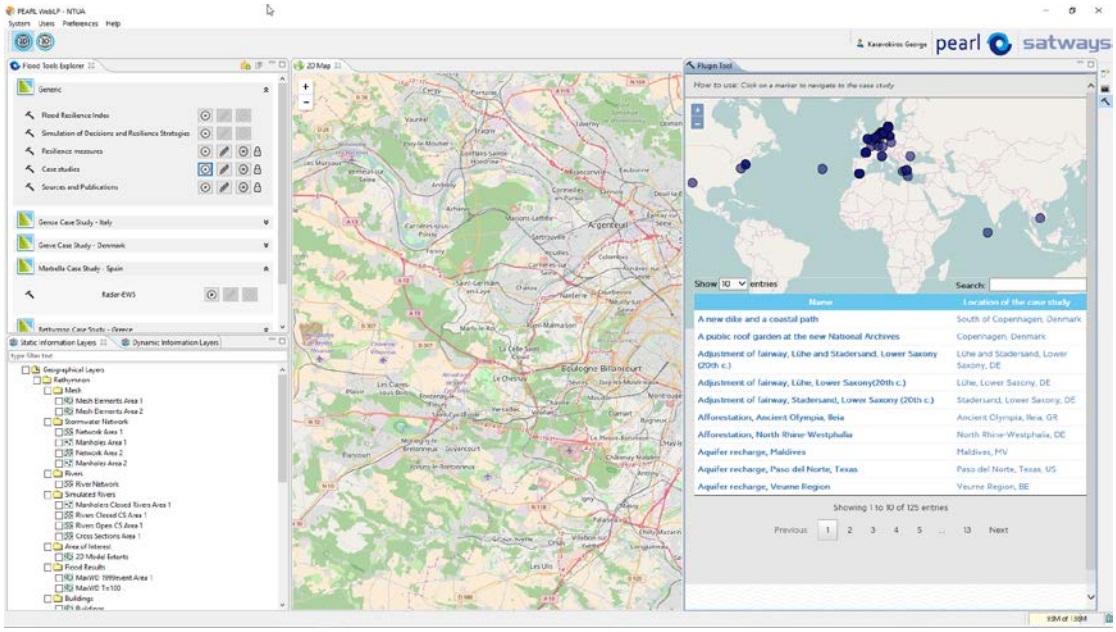

Figure 22: Landing page of the case studies plugin

7.3.3 Sources and Publications

A number of sources and publications related to resilience measures and their applications have been documented in PEARL KB. The user of WebLP can search their metadata and be navigated to more detailed information through this plugin (Figure 23).

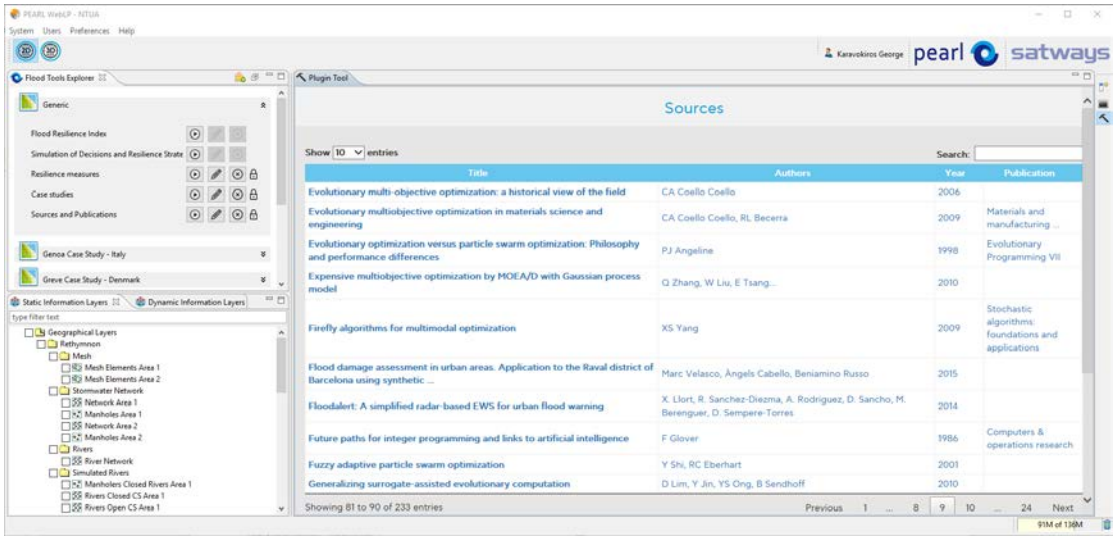

Figure 23: Sources and publications accessible through WebLP

7.4 Simulation of Decisions and Resilience Strategies

For the purpose of Task 5.4 an institutional agent based model PEARL ABM SAS has been developed. It simulates how authorities prepare themselves against flood risk and interact with other stakeholders. The model consists of agents representing: the central authorities, the local authorities (region, municipality), critical infrastructure owners (water utility company) and other stakeholders (construction companies, general public).

PEARL ABM SAS can be accessed through the PEARL Toolbox which will be described in deliverable D5.4, and also from the WebLP platform (see Figure 24). In order to achieve this, PEARL ABM SAS supports secure user authorisation through http requests originating from WebLP. The procedure is as follows:

When the http request from the WebLP platform is received, PEARL ABM SAS is looking for two parameters: a) the username and b) a key. The key is an MD5 hashed value of a text which is composed of two elements: the username and a “salt” string (known to both platforms). In order to keep things as simple as possible the text from which the key is created by applying the MD5 algorithm is actually the concatenation of the username and the “salt” value.

PEARL ABM SAS checks then if the key is the expected one and in case of a match the user is authenticated, logged in and redirected to the index page of PEARL ABM SAS. If it is the first time this user gains access to PEARL ABM SAS, i.e. the user has not been registered yet, a new user with the received username is created in the database.

Figure 24: Accessing PEARL ABM SAS from within the WebLP platform

7.5 Early Warning System of Marbella

Description

This plugin links the radar-based flood EWS developed in PEARL WP4 for Marbella with the WebLP, showing in real time the areas forecasted to have rain accumulations in a 30-minutes interval exceeding a given threshold.

The Cloud radar-based Early Warning System [EWS] implemented in Marbella case study[2] uses radar precipitation estimates to calculate a short-term precipitation forecast (Nowcast [8]). PEARL Deliverable 4.5 will describe the system in detail.

Both the observed and forecasted precipitation fields are used to calculate 30-minute accumulations in a moving window scheme. Maximums in time of those fields are used to define the areas potentially affected by accumulations in a 30-minutes window exceeding a given threshold (see details in [9]).

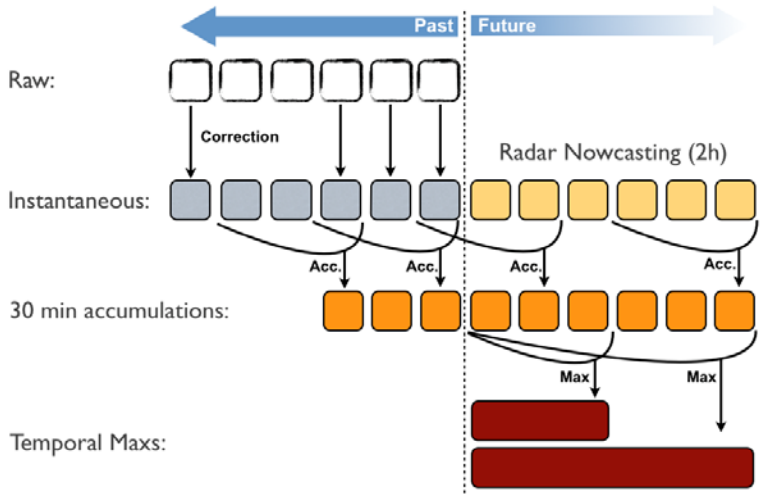

Figure 25: Radar data flux scheme. Vertical dashed line divides past and future. Red boxes represent the forecasted maximum for each location in the next 1h /2h, and are the fields used to define the areas shown in the plugin

Implementation

The Real-time EWS plugin is made up of the back-end part that computes the areas forecasted to have 30-minute rain accumulation values over certain thresholds, and the front-end part that allows for the interactive display of this information (see Figure 26).

[2] The radar-based EWS implemented in Marbella case study is available at http://www.pearl-fp7.eu/portfolio-item/ews/

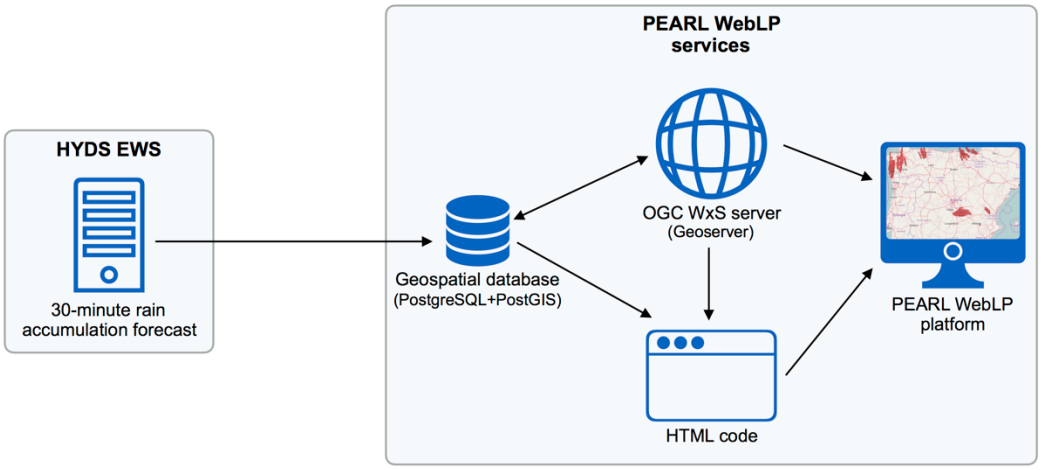

Figure 26: Schematic of the Real-time EWS plugin

On the back-end part, when there is new radar information available (every ~10 minutes), the Marbella EWS computes the areas forecasted to exceed 1, 5, 10, 15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 45, 55, 65, 75 and 85 mm 30-minute rain accumulation based on weather radar data (see [2] for more details) and inserts the shapes (geometries) corresponding to these areas into the Geospatial database of the WebLP platform. Table *marbella_accum_30min* of the database stores the information in the following fields:

- *forecast_horizon_h* (Integer): Horizon of the forecast (1h or 2h).
- *threshold_mm* (Float): 30-minute rain accumulation exceeded in the area.
- *simulation_time* (String): Timestamp corresponding to the beginning of the forecast in YYYYMMDDhhmm format (Y=year, M=month, D=day, h=hours, m=minutes).
- *the_geom* (PostGIS geometry object): Definition of the area.

Therefore, each row of this table contains the areas (*the geom*) corresponding to the forecast exceeding a certain threshold (*threshold_mm*) up to a specific horizon (*forecast_horizon_h*) and includes the timestamp of the forecast start (*simulation_time*).

The front-end part is implemented using the infrastructure described in Section 5.6. The areas inserted in the Geospatial database are linked to a map layer in the OGC WxS server that dynamically retrieves the information according to the map requests. Finally, a simple HTML code layouts the interface that allows the interaction with the user through the WebLP platform (see Figure 27).

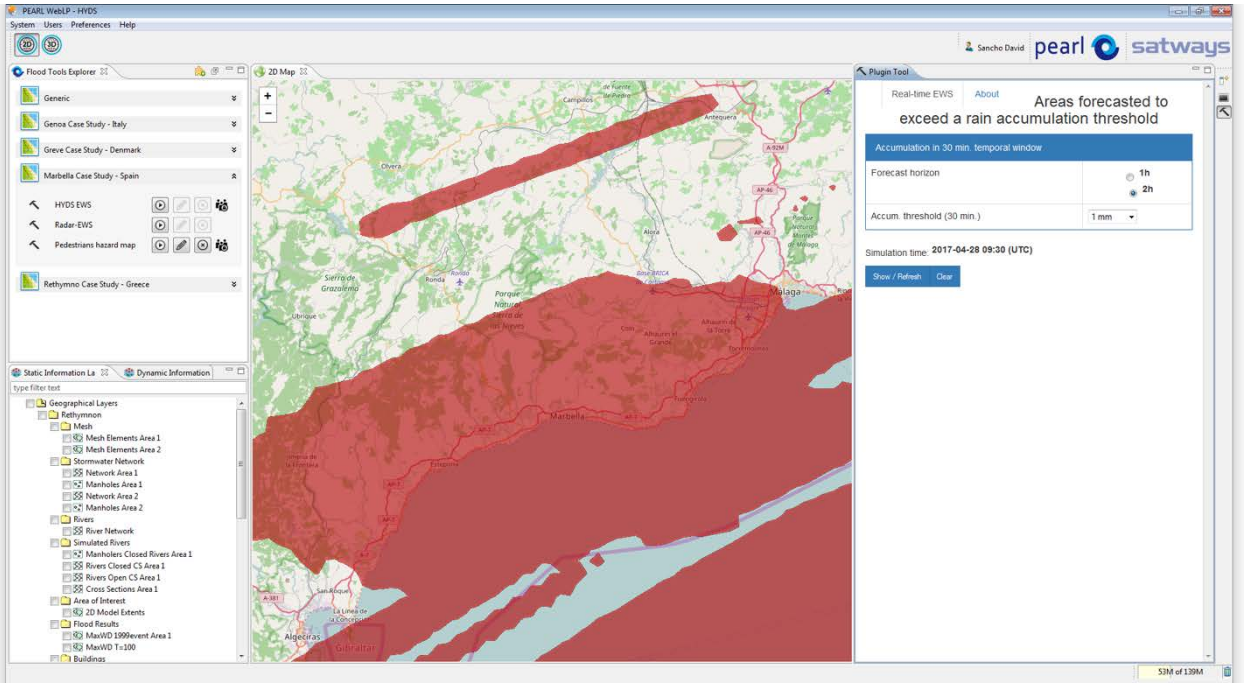

Figure 27: Marbella EWS plugin running on the WebLP platform

Through the graphical interface, the user can choose the forecast horizon (between 1 hour or 2 hours) and the accumulation threshold (between the computed ones: 1, 5, 10, 15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 45, 55, 65, 75 and 85 mm) and visualize the corresponding areas over a map. Additionally, the plugin also shows the simulation time of the information displayed.

7.6 Pedestrians hazard map of Marbella

Description

This plugin shows the pedestrian hazard maps derived from a combination of two flow parameters: velocity and flow depths, calculated using a 1D/2D detailed coupled model for different return periods (see [10] and PEARL Deliverable 6.2 for a complete description). Thresholds for flood hazard mapping were raised from a specific study about hazard criteria in flooded streets during heavy storm events [11]. According to this study, high hazard conditions were defined beyond the product $(v \cdot y) = 0.22 m^2/s$, depth > 0.5 and velocity >1.88 m/s, while for medium hazard, values $(v \cdot y)$ between 0.16 m^2/s and 0.22 m^2/s were considered as thresholds.

Two sets of hazard maps are visualized: Current hazard maps, and simulated hazard maps after the implementation of a set of resilience measures (see Deliverable 6.2).

Implementation

The implementation of the Pedestrian hazard maps plugin is very similar to the one of Real-time EWS plugin, except that unlike the rain accumulation areas, the hazard maps are static (e.g. they are calculated once offline and do not change over time). As explained above, there are two kind of maps (current and simulated) which are served by the OGC WxS service. In turn, the map server retrieves the information from table *marbella_hazard_map* of the Geospatial database, which is stored in the following fields:

- *return_period* (Integer): Return period in years (*1*, *10*, *20*, *50* or *100*).
- *map_type* (String): Whether this map represents the current hazard (*current*) or the simulated hazard after the implementation of resilience measures (*with_measures*).
- *ped_level* (String): Hazard level for pedestrians corresponding to this map (*Low*, *Medium* or *High*).
- *the_geom* (PostGIS geometry object): Definition of the hazard maps.

Then, this plugin is made up essentially of the front-end part only that allows for the interactive display of the pre-calculated hazard maps (see Figure 28).

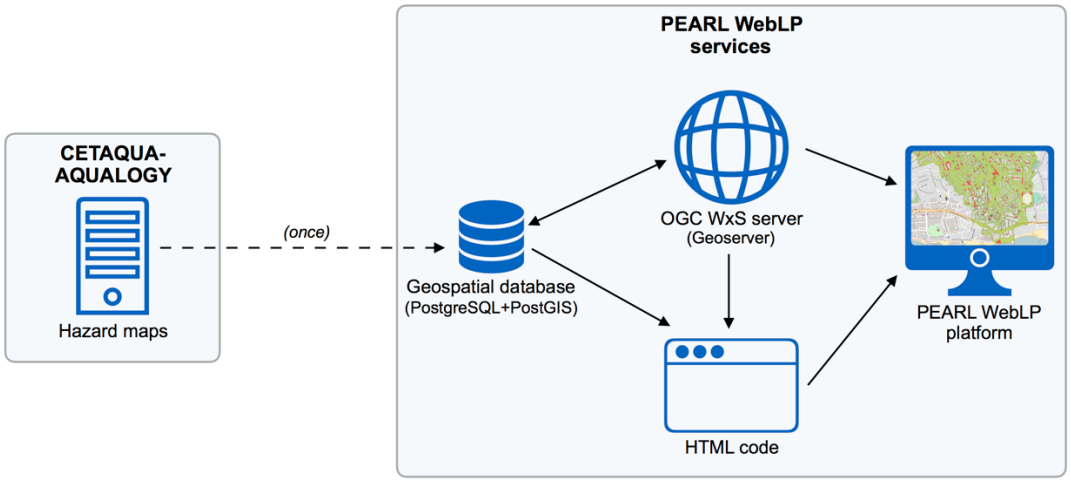

Figure 28: Schematic of the Pedestrian hazard maps plugin

As part of the front-end of the plugin, a simple HTML code has been developed to layout the interface that allows the interaction with the user through the WebLP platform as illustrated in Figure 29.

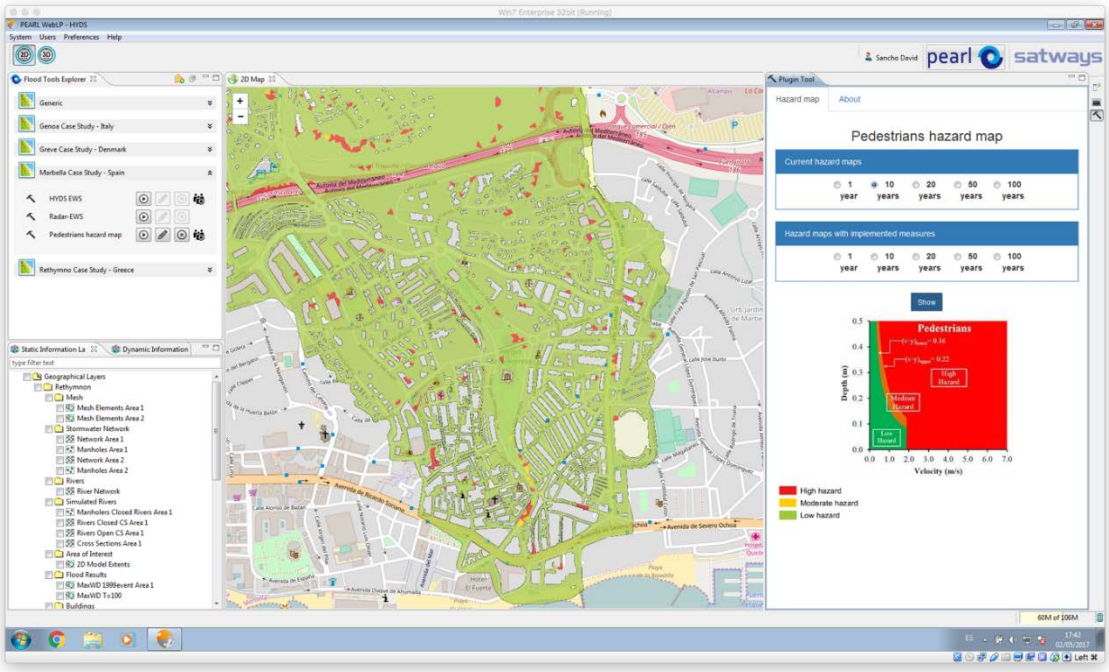

Figure 29: Pedestrians hazard map plugin running on the WebLP platform for the Marbella pilot site

Through the graphical interface, the user can choose the return period (1, 10, 20, 50 or 100 years) of the desired map type (current status or with implemented resilience measures) and visualize the corresponding pedestrian hazard maps.

8 Web Plugin Application Programming Interface

The exposed Javascript methods of Satways Javascript Application programming interface are presented in the following Table 4.

Table 4: Javascript methods of Satways Javascript Application

Method	Description	Parameters
sjapi_searchLayer	Performs an SQL query to a database table by requesting the table columns and the SQL Where clause.	• **db_table** (String) • **db_columns** (String comma separated column names) • **sql_whereClause** (String)
sjapi_addWMSLayer	Adds a GeoServer WMS layer into the Map component of the WebLP platform	• **WMS Server URL** (String, empty denotes the default WMS server url) • **Layer name** (String, includes the workspace) • **CQL_Filter** (String)* • **Style** • **Opacity** (String 0 – 1.0) • **Request Type** (String TILE or IMAGE values)
sjapi_removeWMSLayer	Removes a GeoServer WMS layer from the Map component of the WebLP	• **WMS Server URL** (String, empty denotes the default WMS server url) • **Layer name** (String, includes the workspace) • **CQL_Filter** (String)*
sjapi_removeAllWMSLayers	Removes all WMS layers from the Map created by Web Plugins	Empty
sjapi_showImageResource	Shows an image relative to the plugin location	• **imageRelativePath** (String) • title (String)
sjapi_centerMap	Centers the maps (2D, 3D) to a specific location without changing the current zoom level	• **Longitude** (String containing a double number) • **Latitude** (String containing a double number)
sjapi_centerMapAndZoom	Centers the maps (2D, 3D) to a specific location and zoom level	• **Longitude** (String containing a double number) • **Latitude** (String

		containing a double number) • **zoomLevel** (String containing an integer)
sjapi_startLayerAnimation	Animates a number of WMS layers in the specified order	• **unique Animation Key** (String) • **GeoServer URL** (empty String denotes the default Satways GeoServer) • Layers (array of strings) • Sleep time between layers in milliseconds (String containing a number)
sjapi_pauseLayerAnimation	Pauses a specific animation	• **unique animation Key** (String)
sjapi_clearLayerAnimation	Clears the animated layers from the map	• **unique animation Key** (String)

For more information on the CQL_Filter:
http://docs.geoserver.org/stable/en/user/services/wms/vendor.html

The CQL_Filter allows us to select specific features from the database feature layer. In this smaple plugin we are using the “FID_1” column of the database in order to request every time a single feature as a result of the user selections in the plugin UI.

9 Conclusions

The designed and developed PEARL WebLP is a modular and extensible WebGIS platform that provides an interface between PEARL and the members of the Learning and Action Alliances (LAAs) in the case study areas.

Accessible to stakeholders either directly or through expert workshop facilitators allows for the visualization of the effect of alternative choices on their risk situation and its propagation through time under different scenarios. This is accomplished via an extensible software mechanism where tools that have been developed in other work packages are integrated.

10 References

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