



score

D8.6-Tools to access and visualize SCORE data and outcomes

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Meaning / Full text
2D	Two-dimensional
3D	Three-dimensional
API	Application Programming Interface
CCLL	Coastal City Living Lab
CRUD	Create, read, update, and delete
CSS	Cascading Style Sheets
CZML	Cesium Markup Language
DT-EWS	Digital Twin-Early Warning Support
EBA	Ecosystem-Based Approach
EWS	Early-Warning support
GeoJSON	Geographic JavaScript Object Notation
GIS	Geographic Information System
gITF	Graphics Language Transmission Format
HTML	HyperText Markup Language
KML	Keyhole Markup Language
OGC	Open Geospatial Consortium
REST	Representational State Transfer
SIP	SCORE Information and communication technologies (ICT) platform
UI	User interface
USE	User Scenario Evaluation
URL	Uniform Resource Locator
Web GIS	Web-based Geographic Information System
WFS	Web Feature Service
WMS	Web Map Services
WMTS	Web Map Tile Services





BACKGROUND: ABOUT THE SCORE PROJECT

SCORE is a four-year EU-funded project aiming to increase climate resilience in European coastal cities.

The intensification of extreme weather events, coastal erosion and sea-level rise are major challenges to be urgently addressed by European coastal cities. The science behind these disruptive phenomena is complex, and advancing climate resilience requires progress in data acquisition, forecasting, and understanding of the potential risks and impacts for real-scenario interventions. The Ecosystem-Based Approach (EBA) supported by smart technologies has potential to increase climate resilience of European coastal cities; however, it is not yet adequately understood and coordinated at European level.

SCORE outlines a co-creation strategy, developed via a network of 10 coastal city 'living labs' (CCLs), to rapidly, equitably and sustainably enhance coastal city climate resilience through EBAs and sophisticated digital technologies.

The 10 coastal city living labs involved in the project are: Sligo and Dublin, Ireland; Barcelona/Vilanova i la Geltrú, Benidorm and Basque Country, Spain; Oeiras, Portugal; Massa, Italy; Piran, Slovenia; Gdansk, Poland; Samsun, Turkey.

SCORE will establish an integrated coastal zone management framework for strengthening EBA and smart coastal city policies, creating European leadership in coastal city climate change adaptation in line with The Paris Agreement. It will provide innovative platforms to empower stakeholders' deployment of EBAs to increase climate resilience, business opportunities and financial sustainability of coastal cities.

The SCORE interdisciplinary team consists of 28 world-leading organisations from academia, local authorities, RPOs, and SMEs encompassing a wide range of skills including environmental science and policy, climate modelling, citizen and social science, data management, coastal management and engineering, security and technological aspects of smart sensing research.





EXECUTIVE SUMMARY

This document is a deliverable of the SCORE project, funded under the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003534.

This document is part of the technical deliverables of the Work Package 8 (WP8) regarding the development of a GIS Based Early Warning Support and Digital Twin system for SCORE stakeholders and CCLs. The aim of this document is to outline the tools developed to access and visualize SCORE data and outcomes, introducing its general architectural components and web technologies used for its development.

These tools were developed as a web application for the SCORE Digital Twin-Early Warning Support (DT-EWS) system that enable end-users to interact with the and the SCORE Information and communication technologies (ICT) platform (SIP) data and the DT-EWS data subsystems and functionalities through a web user interface. This web application is composed of two main components: the Web-based Geographic Information System (Web GIS), and the User Scenario Evaluation (USE) Interface.

This document introduces the development aspects for the prototype of the DT-EWS web user interface in its first version which is available online for testing at the following URL: <https://score-dt-ewss.test.spatialdynamicslab.xyz>. During the SCORE project, various deliverable versions of this system will be released, refining each to address bugs, improve features, usability, and the integration with the DT-EWS backend platform. Every release will have a distinct version number.

LINKS WITH OTHER PROJECT ACTIVITIES

The inputs used as the basis for the design and development of the DT-EWS web user interface, components and tools introduced in this document, as part of the SCORE WP8 T8.3, are the SCORE project deliverables D8.1 - GIS Based Digital Twin Platform functional requirements [1], D8.2 - GIS Based Early Warning and Digital Twin Platform system architecture and design [2], and D8.3 - GIS Based Early Warning and Digital Twin Platform Interface Control Document [3]. This web application is designed to work and interact closely with the GIS-based Digital Twin - Early Warning Support (DT-EWS) prototype, processes and APIs developed as part of SCORE project WP8 T8.2 and introduced in D8.4 and D8.5. Also, it is designed to connect to and access the data and resources created by the different WPs and CCLs that are exposed via the SCORE Information and communication technologies (ICT) platform (SIP) [4] [5] developed in the WP5. The details of this DT-EWS web application are introduced in the D8.7 release notes.

The outputs of this document are relevant for the SCORE WP8 system further development, integration, deployment (project tasks T8.2, T8.3, T8.4), and for the subsequent activities of system validation and assessment (project task T8.5), whose plan is reported in detail in the D8.10 [6].





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1. Introduction

This document is part of the technical deliverables of the Work Package 8 (WP8) regarding the development of a Geographic Information System (GIS) Based Early Warning Support and Digital Twin system for SCORE Coastal City Living Labs (CCLL) and stakeholders. The system purpose is to provide local and national governance with data-driven tools to formulate resilience management strategies, and design and implement actions to mitigate and adapt to climate changes, considering variables such as demographics, urban infrastructure, hydrographic, weather, environmental and geospatial data, etc. and other influencing factors. The focus of this report, D8.6, is to give an overview of the tools developed to access and visualize SCORE data and outcomes. A full description of these tools is available in D8.7. These tools were developed as a web application for the SCORE Digital Twin-Early Warning Support (DT-EWS) system. Then, this document focuses on the frontend (client-side) interface of the DT-EWS system which was developed to facilitate comprehensive user interaction with geospatial data, user scenarios, simulations, warnings, etc. managed by the backend subsystems and processes.

1.1. Scope of the Document

This report outlines the web user interface for accessing and visualising data managed by the DT-EWS system, introducing its general architectural components and modules, together with the web technologies used. The details about the system functionalities and user-oriented documentation (see D8.7), as well as the backend processes, data management, and server-side computations (see D8.4. and D8.5), are outside the scope of this document.

2. DT-EWS Web User Interface

The DT-EWS web user interface (UI) is organised to integrate diverse data sources and present them in an accessible and structured manner. It is designed for enabling users to access and interact with the SCORE Information and communication technologies (ICT) platform (SIP) and the DT-EWS platform backend processes and Application Programming Interfaces (API) via its two main subsystems: User Scenario Evaluation (USE), and the Early-Warning support (EWS). This DT-EWS web application serves as a client visualisation tool for the SCORE project backend technologies, processes, and data resources. It enables stakeholders to access geospatial data from the SIP baseline maps and sensors data, the DT-EWS scenarios evaluation, simulations outputs, maps and alerts and flooding warnings, etc. helping users to understand the geographical context and situation of its city as well as interpret USE and EWS outputs, real-time and forecasted data in their CCLL. The first version of the system is available online for testing at the following <https://score-dt-ewss.test.spatialdynamicslab.xyz>.

2.1. System Architecture: Technologies & Components

The DT-EWS web application is a web client develop to communicate to the backend subsystems and APIs that manage the heavy-duty logic of digital twin simulations, and processing of baseline and historical data, geospatial information, sensor near-real time data, and forecasts. The webapp enables access to those backend resources by managing user authentication and sessions. Then, its high-level architecture is structured into two main components, catering to specific user needs: the Web-based Geographic Information System (Web GIS), and the User Scenario Evaluation (USE) Interface.

The following technologies were used for the development of the system components:





Django web framework [7]: This web development framework based on the Python programming language is used in conjunction with Gunicorn and Nginx web server technologies, to control views, Unified Resource Locator (URL) paths, and functions to pre-process some data coming from the backend for optimizing frontend data accessibility. These view-based functions act as a middleware, streamlining backend interactions and enhancing web data access and visualization. The Django views easily integrate HyperText Markup Language (HTML) coded templates with client-based scripting for user interactions using JavaScript, ReactJS [8] components, and Axios [9] when some requests directly from the browser are done to the backend APIs and web services. Also, it handles API requests to the backend using token authentication.

CSS and JavaScript libraries: Offer interactive client-side functionalities and enhance user experience. The web app uses Tailwind CSS [10] (Cascading Style Sheets), Flowbite [11], JavaScript, and Axios to create an application user interface which enables create, read, update, and delete (CRUD) operations to communicate with the backend APIs, having a complete User Scenario Evaluation Interface for the management of scenarios by the end-user. Also, the Plotly [12] JavaScript library is used for creating some charts to access past data from sensor observations. JavaScript facilitates dynamic frontend operations. Axios offers a promise-based HTTP client enabling Representational State Transfer (REST) API calls directly from the browser when is required. Tailwind CSS facilitates frontend design, responsiveness, and styling, and Flowbite Django UI complements Tailwind CSS, providing interactive UI components for Django-based web applications.

Web GIS and web mapping libraries: Offer an interactive web mapping interface that implements industry-standard methods for geographic data access from the backend subsystems and geospatial servers, such as the Open Geospatial Consortium (OGC) [13] data formats, Web Map Services (WMS), Web Feature Service (WFS), and Web Map Tile Services (WMTS) standards. It enables several data connectors supporting not only OGC services but also other common format files and services as KML (Keyhole Markup Language) or GeoJSON (Geographic Javascript Object Notation) (see D8.2 for a complete list). The Web GIS uses the open-source JavaScript framework TerriaJS [14], a geospatial catalogue explorer and data visualization platform which is developed using ReactJS, a free and open-source front-end JavaScript library for building user interfaces based on components. The TerriaJS framework seamlessly integrates Leaflet [15] for 2D interactive mapping and Cesium [16] for 3D web-based geospatial visualization.

By employing this combination of technologies, the DT-EWS web UI delivers a robust, user-friendly, and technologically advanced platform to facilitate optimal data management, geospatial visualisation, and user interaction. All the technologies used by this system are open-source technologies, which makes it flexible, scalable, and secure. The use of well-tested technologies and frameworks helps to ensure the quality, reliability, and usability of the DT-EWS web app.

Based on the previous technologies and component a high-level system architecture is introduced in Figure 1.



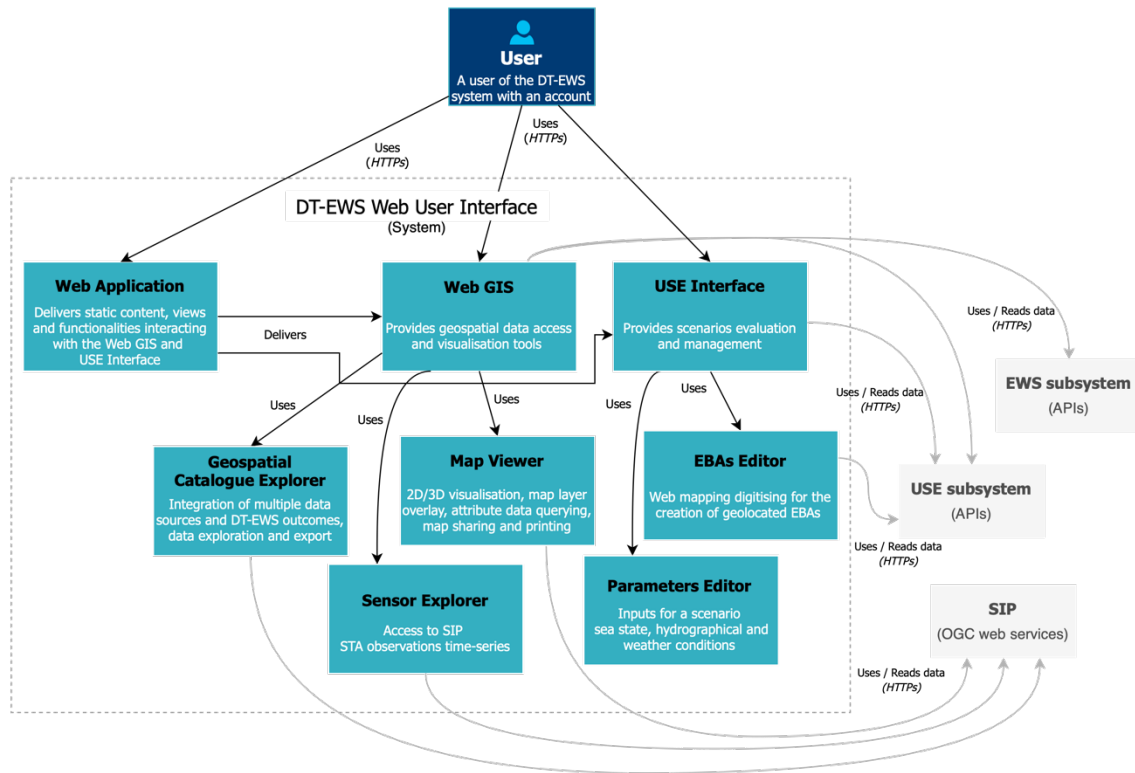


Figure 1: DT-EWS web user interface high-level architecture

2.1.1. DT-EWS System User Authentication

The DT-EWS system integrates a comprehensive user authentication mechanism, rooted in the DT-EWS USE user management, to ensure data security and user-specific interactions. When a user initiates a login, credentials are transmitted using end-to-end encryption and subsequently validated against the backend database. Beyond mere access, the backend USE enables a role-based access control framework, providing granularity in permissions for different functionalities and datasets depending on the user role and the CCLL of the current user session. This not only facilitates a tailored user experience but also adds an additional layer of security by restricting operations based on user roles. Session management is also of paramount importance; thanks to the USE API, the system employs a token-based authentication method ensuring secure, stateless communication between client and server. Upon logging out, these session tokens are invalidated at the server side and deleted in the client, effectively terminating the user session, and reinforcing the overall system security.

2.1.2. Web-based Geographic Information System (Web GIS)

The Web GIS component is founded on the TerriaJS framework, chosen for its advanced capabilities in geospatial data exploration and visualisation. This component offers a sophisticated yet intuitive interface for users to access and visualize SCORE data and outcomes. This component ensures that several geospatial data, real-time sensor data, and forecasted scenarios are presented seamlessly. The DT-EWS Web GIS is a comprehensive tool that can handle vast datasets, 3D/2D map viewing, and integrated cataloguing. It enables to easily manage the diverse SCORE's geospatial data integration, outcomes, and visualizations. The main aspects of this component are:

- **Data cataloging and integration:** The Web GIS offers a **Geospatial Catalogue Explorer** which converges multiple data sources and formats, providing users with a comprehensive view of current CCLL states, forecasted scenarios, simulation outputs and other relevant and contextual geodata layers and maps.





Through advanced cataloging, it ensures that all SCORE data available to a CCLL user is effectively integrated for access and visualisation.

- **Interactive data exploration and visualisation:** Users are equipped with tools to actively search and explore the different datasets available, to access attribute data from a map layer, for advanced editing of styles for the map layer visualisation based on its attribute data, for creating data stories, and printing maps. Also, the **Sensor Explorer** enables sensor querying and advanced charting for sensor observations time-series.
- **3D/2D visualisation:** The **Map Viewer** offers a dual mode of data representation. Users can analyse data from a 3D perspective or using the 2D map view, ensuring adaptability to various analytical and visualisation requirements for both 3D models data and 2D map layers. This component integrates Cesium JavaScript library and WebGL for a full 3D globe in the browser and Leaflet JavaScript library for 2D mapping capabilities. The 2D mapping engine provides users with access to diverse range of geospatial data formats, both vector and raster data. For vector data, it supports formats like GeoJSON, KML, Shapefile, and OGC services such as WFS. Raster data compatibility includes OGC WMS and WMTS formats. For 3D mapping, it supports formats like Graphics Language Transmission Format (gITF) and Cesium Markup Language (CZML), along with the 3D Tiles OGC web service specification.
- **Data sharing and collaboration:** Users can get a unique URL to share a map view of the Web GIS with all the active geospatial layers they have in the Map Viewer, and their Data Stories.

2.1.3. User Scenario Evaluation (USE) Interface

The USE interface is designed for efficient scenario management within the DT-EWS web user interface. Centred around the management and evaluation of user scenarios, this interface provides:

- **CRUD Operations:** The interface enables users to create, read, update, and delete scenarios, facilitating dynamic data inputs as simulation parameters (weather, sea, and hydrographical conditions) and the creation of EBA solutions through the EBA “palette” available for a CCLL and web map digitalisation and editing.
- **Scenario Evaluation:** After scenario design, EBAs creation, and parameters input and selection, users can run a simulation with the backend USE digital twin-based models processes, integrating climate and weather data, urban-scale models, real-time, forecasted, and baseline geospatial data.
- **Simulation Output Integration:** Simulation status and post-evaluation results are available to the users and the geospatial outcomes for a simulation are available in the Web GIS component. USE outputs are directly linked to the Web GIS component, allowing immediate visualisation and overlay with existing geospatial datasets for analysis, map printing and sharing.





3. References

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