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Requirement Analysis and Specification Document

An interactive application to support disaster management activities during the prevention and preparedness phase

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1 Introduction

1.1 Propose

In addressing multi-hazard disasters and climate change factors, the adaptive risk management strategies need to be built under the visualized information. Therefore, the Web GIS platform serves as a vital tool for accessing geospatial data, maps, reports, and risk indicators related to the Italian Landslide Inventory, national hazard maps, and risk assessments.

The larger amount of analyzed information on controversial natural hazards connects to a strategic web service for the Italian Institute for Environmental Protection and Research (ISPRA) and more generally for a Public Administration (PA).

Given the importance of natural disaster education in both geography curriculum and education for sustainable development (ESD), leveraging Web GIS for dynamic monitoring, forecasting, and early warning of disasters has emerged as a viable approach.

1.2 Scope

According to the open sources from ISPRA datasets, developing a client-server application is that supports users in querying and visualizing data that are retrieved from the well-defined The Italian Institute for Environmental Protection and Research (ISPRA) IdroGEO API. The web service would use data related to the PIR (Hazards and Risk Indicators).

The system to develop should be composed of three main components:

- A database where data are ingested beforehand.

- A web server (backend) that exposes a REST API used for querying the database and retrieving data.

- A dashboard (built using Jupyter Notebooks) that exploits the web server to provide means for requesting, processing (e.g., space-time aggregations), and visualizing data (e.g., maps, charts, etc.).

The web service allows the officials and the public to monitor the analysis done by our application and cope to the relevant results with risk instructions and visualized information between the emerging areas such dip slopes, landslide dams, low-lying regions and so on.

1.3 Overview

The offering unprecedented capabilities for decision-makers, researchers, and practitioners. In results, the platform would provide datasets and correlate images about natural hazards. Implementing search functionalities and filters within the web GIS interface can aid users in retrieving specific datasets. Visualization tools such as interactive maps to help in presenting the retrieved data in a comprehensible manner.

1.4 Ancronyms and definitions

Name	Definition
Web application	Web application is a software application that runs on a web server and is accessed through a web browser over the internet, allowing users to interact with dynamic content and functionality.
REST	Representational State Transfer (REST) is an architectural style for designing networked applications, emphasizing stateless communication between client and server using standard HTTP methods for data transfer and manipulation.
REST API	It is an Application Programming Interface that satisfies the constrains of REST architecture an allows the interaction with RESTful web services
GitHub	Web-based hosting service used for the development of our Open-Source project.
Python	High-level programming language we are going to use for building our software. It will be the basis of every functional tool used in our web application.
PostgreSQL	It is an open-source Database Management System, which uses a

	client-server model where the server program manages the database files and accepts connections to the database from client applications.
DBMS	DBMS, or Database Management System, is software that facilitates the creation, organization, storage, retrieval, and management of data in a structured format, ensuring efficient and secure access to information.
RASD	It outlines the functional and non-functional requirements of a project, serving as a blueprint for development and guiding stakeholders throughout the project lifecycle.
ISPRA	Italian Institute for Environmental Protection and Research: It is a governmental body responsible for environmental monitoring, protection, and research in Italy, contributing to sustainable development and environmental conservation efforts.
PIR	Hazards and Risk Indicators: It refers to a set of metrics used to assess potential hazards and risks associated with natural disasters or other adverse events, aiding in decision-making and risk management strategies.
GeoPandas	It is a Python library that extends the capabilities of the Pandas library to handle spatial data, enabling geospatial analysis and manipulation of vector data within a DataFrame structure.

Table 1: Ancronyms and definitions

2 Application domain and phenomena description

2.1 User

In terms of diverse usages, the possible users are distinguished below:

a. Residents:

Residents can use Web GIS to understand nearby natural disaster risks, view real-time data and alerts, plan evacuation routes, and learn about the location and accessibility of local rescue resources.

b. Civil protection or insurance companies:

Civil protection or insurance companies can utilize Web GIS to analyze geographic information data, formulate emergency response plans, assess risks and potential impacts, guide resource allocation, and monitor and manage the progress of disaster response.

c. Academic Researchers:

Academic researchers can leverage Web GIS to collect and analyze real-time and historical geographic data, conduct disaster risk assessment and modeling, explore disaster mechanisms and trends, and provide scientific support and recommendations for disaster management.

2.2 Dataset

ISPRA datasets encompass a wide range of environmental data collected and curated by the Italian Institute for Environmental Protection and Research (ISPRA). These datasets provide valuable insights into various aspects of the environment, including landslides, flooding, water resources, biodiversity, land use, population, and climate change.

Information on ISPRA datasets

Background Geodata

2.3 Operations

2.3.1 User operations: Based on user operations on Web GIS, the following points can be summarized:

a. Requesting Hazards and Risk Indicators Based on User Requirements (Location, Disaster Type, Impact Target)

For users, they can specify the location, type of disaster, and the target of interest to request relevant hazards and risk indicators.

b. Downloading Data

Users have the option to download the requested data for further analysis or offline use.

c. Visualizing Requested Data

The requested data is visualized on the Web GIS platform in a user-friendly manner.

d. Sorting and Filtering Data:

Users can sort and filter the data based on various criteria such as date, magnitude, severity, or proximity to a specific location.

2.3.2 System operations*:* In this client-server application scenario, the process unfolds as follows:

a. Web Client Requests Data through an API:

The web client, such as a browser or a mobile application, sends a request to the server's API endpoint, specifying the desired data or action.

b. Server Responds by Querying the Database:

Upon receiving the request, the server processes it and formulates a database query based on the parameters provided. The server interacts with the underlying database management system (DBMS) to retrieve the requested data from the database.

c. Server Returns Results in JSON Format:

Once the database query is executed and the results are obtained, the server formats the data into JSON (JavaScript Object Notation) format.

d. Server Parses and Returns to the Frontend Page:

The server then sends the JSON-formatted data back to the web client as part of the HTTP response. Upon receiving the response, the web client parses the JSON data and dynamically updates the frontend page's content, such as displaying search results, generating interactive charts or maps, or populating forms with retrieved information.

2.4 Phenomena

2.4.1 World phenomena

a. PIR

Monitoring and assessing flood and landslide risks are essential components of disaster management.

b. Surface

Surface area refers to the measurement of the physical extent of land or water bodies. It is an important parameter for various spatial analyses, such as land use planning, habitat assessment, and environmental impact studies.

c. Population:

Population data provides insights into the distribution, density, and demographics of people within a geographic area.

d. Families:

Family units represent the social structure of households within a population.

e. Buildings:

Building data includes information about the spatial distribution, characteristics, and usage of structures within a geographic area.

f. Business Units:

Business unit data encompasses information about commercial establishments, industries, and economic activities within a region.

g. Cultural Heritage:

Cultural heritage includes tangible and intangible assets that hold cultural, historical, or archaeological significance.

2.4.2 Machine phenomena:

a. Database Queries:

Database queries involve the retrieval of information from a database based on specified criteria. In the context of machine phenomena, this may include querying a database to retrieve relevant data related to PIR (Flood Risk & Landslide Risk) through API requests.

b. Storing Query and Analysis Results in the Database:

After querying the database and analyzing the retrieved data, the results are typically returned and stored back into the database for future reference or analysis. This ensures that the processed data is readily available for further processing or visualization.

c. Data Analysis and Calculation:

Data analysis involves performing calculations, sorting, and other analytical tasks on the retrieved dataset.

d. Visualization of Data through Maps and Tables:

This visualization aids in understanding the patterns, trends, and relationships present in the data.

2.4.3 Shared phenomena:

a. User Database Query Requests:

Users interact with the system by querying the database based on their specific requirements. This involves retrieving PIR (Flood Risk & Landslide Risk) data based on a specified geographic area or querying for specific types of PIR data.

b. Visualization of User-Queried or Analyzed Data:

The system visualizes this data to facilitate understanding and interpretation. Visualization techniques such as maps, charts, graphs, and tables are used to represent the queried or analyzed data in a user-friendly format.

c. User Registration, Login, and Logout:

The system provides user management functionalities, allowing users to register for an account, log in to access system features and data, and log out once their session is complete.

3 User case

In this section, we will show the possible functions ans use cases of the website, and consider the exceptions that may occur under different condition.

Use case 1:Specified Condition Data Query	
Name	Specified Condition Data Query
User	Register User
Condition	The users who have successfully logged in and connected to the Internet
Flow of Events	The events follow this order: 1. User inputs or selects query conditions on the interface; 2. After confirming the query conditions, the user clicks the "Query" button; 3. Display eligible data; 4. The user reviews the query results and may perform further filtering or export data operations.
Exit condition	Users can exit the query function at any time by closing the web page or navigating to other pages
Exceptions	1. The user enters query conditions in an incorrect format 2. There are system errors or data source connection issues 3. The query results are empty

Table 2: Specified Condition Data Query

Use case 2: Data Geographic Visualization	
Name	Data Geographic Visualization
User	Register User
Condition	1. The users who have successfully logged in and connected to the Internet; 2. The users have completed the criteria query
Flow of Events	The events follow this order: 1. Users trigger the visualization process by clicking the "Visualize" button; 2. The system generates a geographic visualization
Exit condition	1. They can exit by clicking the "Exit Visualization" button; 2. Users can exit the function at any time by closing the web page or navigating to other pages
Exceptions	1. No data matches the selected criteria; 2. In case of data retrieval errors or map rendering issues

Table 3: Data Geographic Visualization

Use case 3: Base Map Switch	
Name	Base Map Switch
User	Register User
Condition	1. The users who have successfully logged in and connected to the Internet; 2. The users have completed the criteria query or data visualization
Flow of Events	The events follow this order: 1. Users locate the base map switch functionality on the map interface; 2. Users click the “base map switch” button, triggering the action to switch the base map; 3. The system loads the appropriate map data based on the user's selected base map type, replacing the current map display
Exit condition	1. Users can exit the function at any time by closing the web page or navigating to other pages 2. They can exit by clicking the "Exit " button
Exceptions	1. Users select an invalid base map type; 2. Users encounter issues while switching base maps

Table 4: Base Map Switch

Use case 5: Register	
Name	Register
User	All no-registered user
Condition	The user can register access the website by clicking the “ Register” button.
Flow of Events	The events follow this order: 1. A user open the website; 2. Clicks on the “ Register ” button; 3. User puts the “ username ” and “ password”; 4. After completing the above steps, users successfully register as a new user of the website and relocates to the login screen.
Exit condition	The username is already in use
Exceptions	The user already exists in the database

Table 5: Register

Use case 6: Log In	
Name	Log In
User	Register User
Condition	The users have registered an account.
Flow of Events	The events follow this order: 1. User accesses the web page and navigates to the Log In section; 2. User enters their username and password into the designated fields; 3. The user triggers the log in process by clicking the "Log In" button; 4. Upon successful log in, the user is redirected to a dashboard, account page.
Exit condition	1. The users can log out by clicking the "Log Out" button; 2. Users can exit the Log In feature by navigating away from the logged-in area of the website
Exceptions	1. The user enters incorrect username/ password 2. The user forgets their password

Table 6: Log In

1.1 Use case diagram

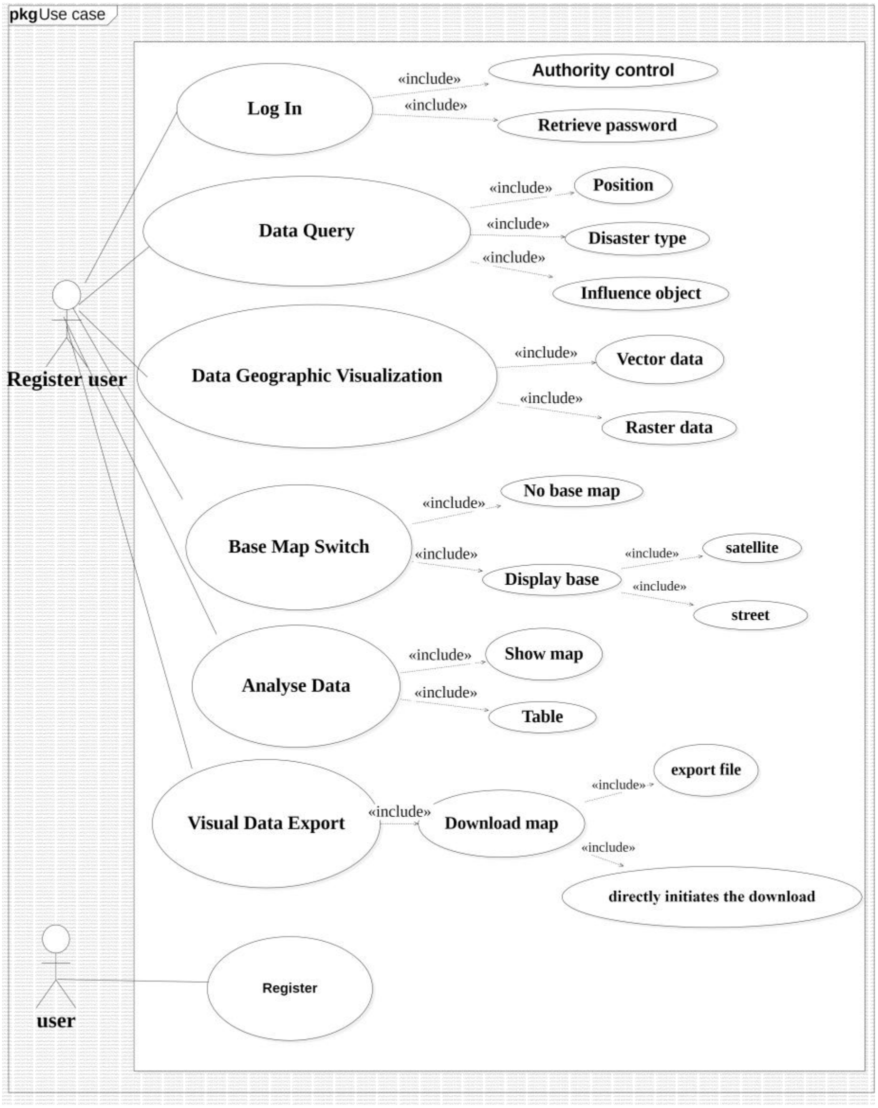

Figure 1: UML

4 Functional requirements and Domain Assumptions

4.1 General user interface requirements

Our purpose is constructing a web application that offers to the users an attractive, easy to use and more importantly, a useful and comfortable environment, for analyzing and in all, for interpreting the data they are interested in. According to these properties we listed some general requirements:

a. Intuitive Navigation: Design an intuitive navigation system that allows users to easily move between different sections of the application.

b. Visual language: The language of the website will be in English, since it is a common language for everyone.

c. Clear Labeling and Icons: Help users understand their functions at a glance. Avoid ambiguous or overly technical language that may confuse users.

d. Accessible Fonts and Colors: Choose fonts and colors that are easy to read.

e. Visual Feedback: Provide visual feedback to users when they perform actions, such as clicking a button or submitting a form.

f. Error Handling: Implement clear error messages and instructions to guide users if they encounter any issues while using the application.

4.2Requirements

4.2.1 Functional requirements

R1: Map

- Interactive Map Display: Implement a feature-rich map interface.The map should support basic operations such as panning, zooming, and rotation to allow users to navigate freely across the map.
- Layer Management: Enable users to toggle between different layers of information on the map, such as satellite imagery, topographic maps, weather overlays and administrative boundaries.Users should be able to open or close different layers based on their needs, allowing them to view the desired information according to the current task or situation.

R2: Dashboard

- Dashboard Layout: The web should present an interactive dashboard with which the user can interact.
- Visual Analytics Widgets: Include a variety of visual analytics widgets on

the dashboard, such as charts, graphs, gauges, and timelines.

R3: Data

- Data comparability: Enable users to compare data across different time periods and geographical locations within the application.
- Real-time Data : Ensure that the application retrieves and displays the most recent data entries from the dataset to provide users with up-to-date information. Implement mechanisms for real-time data updates

R4: Registration / Login / Logout

- User Registration: Allow new users to register an account by providing necessary information such as username, email address, and password.
- User Login: Provide a secure login interface where registered users can authenticate themselves using their username and password.
- Logout Functionality: Provide users with a convenient way to log out of their accounts securely. Redirect users to home page after successful logout.
- Authority control: Define roles such as admin, regular user, and guest, and assign appropriate permissions to each role to control access to sensitive functionalities.

4.2.2 Technological requirements

R1: Development Framework and Tools

- Database: PostgreSQL and PostGIS
- Web server: Flask
- Data processing and utilities: Pandas, GeoPandas, Dask, Xarray, Rasterio
- Dashboard: Jupyter Notebook, Jupyter Widgets, ITables, Mercury, Matplotlib, Plotly, Bokeh, IpyLeaflet, Folium, geemap

- Version control: Implement version control using Git and host the code repository on GitHub.

R2: Agile Software Development

Adopt agile development methodology Scrum which we use Jira as the software platform for iterative and incremental development, enabling flexibility, collaboration, and responsiveness to changing requirements.

4.3 Domain assumptions

4.3.1 User Authentication Assumptions

- It is assumed that users are able to provide valid login credentials to authenticate their identity, and the system is capable of correctly identifying and verifying user identities.

- Users are expected to have basic knowledge of computer literacy and are familiar with standard web browser navigation, including dropdown menus, zooming, and panning operations. They possess a basic understanding of the map interface.

4.3.2 Data Assumptions

It is assumed that the PIR (Preparedness, Incident, and Recovery) API is available at all times, and data is accurately stored in the database.

4.3.3 User Network Connection Assumptions

Users' client devices are assumed to support access to the web application and have an internet connection capable of supporting server-side rendering of the application's services.

4.3.4 User Behavior Assumptions

Users are assumed to have a certain level of computer literacy, enabling them to navigate the web application using standard browsers.