POLITECNICO
MILANO 1863

Requirement Analysis and Specification Document (RASD)

Group name: PolimiGeo

Professor Giovanni Quattrocchi
Professor Vasil Yordanov

Seyed Mohammad Moein Peyghambar Zadeh: 10921320

Saeed Mehdizadeh: 10891394

Hadi Kheiri: 10946669

Vanessa Goletti: 1070668

1. Introduction

1.1. Context and motivations

This project centers on the integration of Geographic Information Systems (GIS) and Earth Observation (EO) data for effective flood risk management, with a particular focus on Emilia-Romagna, Italy, a region highly vulnerable to floods. In 2021, the environmental protection agency *ISPRA* warned that 93.9 percent of Italian cities were at risk of flooding, landslides, and coastal erosion. Emilia-Romagna – before seventeen lost their lives and fifty thousand were displaced due to two devastating floods last May – was flagged by *ISPRA* as the Italian region most at risk. The project is motivated by the significant economic and social impacts of floods in Italy, which require precise flood risk assessments to support not only insurance companies but also urban planners and governmental bodies in their risk management and urban development planning.

1.2. Definitions, acronym, abbreviations

- **GIS (Geographic Information System):** A system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data.
- **EO (Earth Observation):** The process of collecting information about the Earth's physical, chemical, and biological systems via remote sensing technologies, typically involving satellites.
- **DEM (Digital Elevation Model):** A digital representation of ground surface topography or terrain.
- **ISPRA (Italian Institute for Environmental Protection and Research):** The agency providing environmental data and analysis, including the *IdroGEO* API (Application Programming Interface) for hazard data.

1.3. Solution overview

The proposed solution uses GIS and EO data to develop an advanced method for flood risk assessment. This method involves using high-resolution digital elevation models (DEMs), analysis of historical flood data, and other critical geographic and environmental factors to produce detailed flood risk maps. These maps will aid insurance companies in assessing flood risks accurately and aid urban planners and governmental agencies in formulating strategies for land use planning, disaster preparedness, and infrastructure development to mitigate the impact of floods. Data will be acquired from the *IdroGEO* website, managed by *ISPRA*, and processed using *PostgreSQL* and *Jupyter Notebooks*

1.4. Scope and limitations

Scope:

- The project is designed to develop a flood risk assessment tool tailored for the insurance market in Italy.
- It aims to support urban planners in making informed decisions about land use and infrastructure projects to enhance flood resilience.
- Governmental bodies can use the insights provided by the project for disaster preparedness and emergency response planning.
- The project includes data from three administrative levels: Region, Province, and Municipalities.

Limitations:

- The predictive accuracy of the flood risk maps depends heavily on the quality and resolution of the input data, such as DEMs and historical flood records.
- The model is most effective in areas covered by comprehensive EO and GIS data and might not fully represent regions with insufficient data coverage.
- Unpredictable external factors, such as abrupt climatic shifts or unforeseen environmental events, may influence the accuracy and reliability of risk assessments.

2. Requirements

2.1. Stakeholders

- **Insurance Companies:** They have a personal stake in exact flood risk assessments to decide insurance premiums and coverage.
- **Urban Planners:** Their decisions impact land use, infrastructure, and community resilience. Flood risk maps will guide their planning efforts.
- **Governmental Bodies (Local and Regional):** Responsible for disaster preparedness, emergency response, and policy implementation.
- **Environmental Agencies:** Their ability in GIS and EO data contributes to the project's effectiveness.
- **Local Communities:** Residents and businesses in flood-prone areas are directly affected by flood risks.

2.2. Actors

- **User:** The primary user of the Flood Risk Assessment Tool, responsible for assessing and managing flood risks. This actor incorporates flood risk data into planning and development processes, uses data for emergency preparedness, and contributes to policy-making decisions about flood risk management. Users may include professionals such as urban planners, disaster management specialists, insurance analysts, and governmental officials involved in risk assessment and mitigation strategies.

- **System Administrators:** Responsible for the maintenance and overall management of the Flood Risk Assessment Website/Application. Their roles include updating GIS data, ensuring data integrity, managing user accounts, performing system backups, and adjusting risk parameters within the software. System Administrators ensure the smooth operation of the system, troubleshoot technical issues, and implement necessary updates or modifications based on user feedback and system requirements.

2.3. Domain assumptions

- **Spatial Data Types:**

  Assumptions about the types of spatial data relevant to flood risk management, including data on the population, businesses, families, buildings, and historical heritage sites exposed to high flood risk will be included.

- **Data Sources:**

  Data for this software is acquired from the *IdroGEO* website (https://beta.idrogeo.isprambiente.it/app/), managed by the Italian Institute for Environmental Protection and Research (ISPRA). This includes various datasets relevant to flood hazard assessments and risk management.

- **Flood Hazard Assessment:**

  Assumptions about the methods and techniques used to assess flood hazards, including statistical analysis of historical flood data, flood frequency analysis, and scenario-based modeling based on past events.

- **Vulnerability Assessment:**

Assumptions about the factors that contribute to the vulnerability of assets and communities to flooding, including building types, infrastructure networks, population density, and socioeconomic indicators.

- **Risk Assessment:**

Assumptions about the methods used to quantify and prioritize flood risks, including risk matrices, loss estimation models, and multi-criteria decision analysis based on historical data.

2.4. Requirements

Developing software for flood risk management in geoinformatics involves addressing a wide range of functional, non-functional, and technical requirements to effectively analyze, model, and mitigate flood risks based on the provided data. Here's a list of requirements:

Functional Requirements:

1. The system shall allow users to sign up the web application.
2. The system shall allow users to log in and log out the web application.
3. The system shall allow users to view the dashboard.
4. The system shall allow users to adjust the parameters.
5. The system shall allow users to view flood risk map.
6. The system shall allow users to view analyzed reports.
7. The system shall allow users to download the reports.
8. The admin must have the ability to update GIS data.

Non-Functional Requirements:

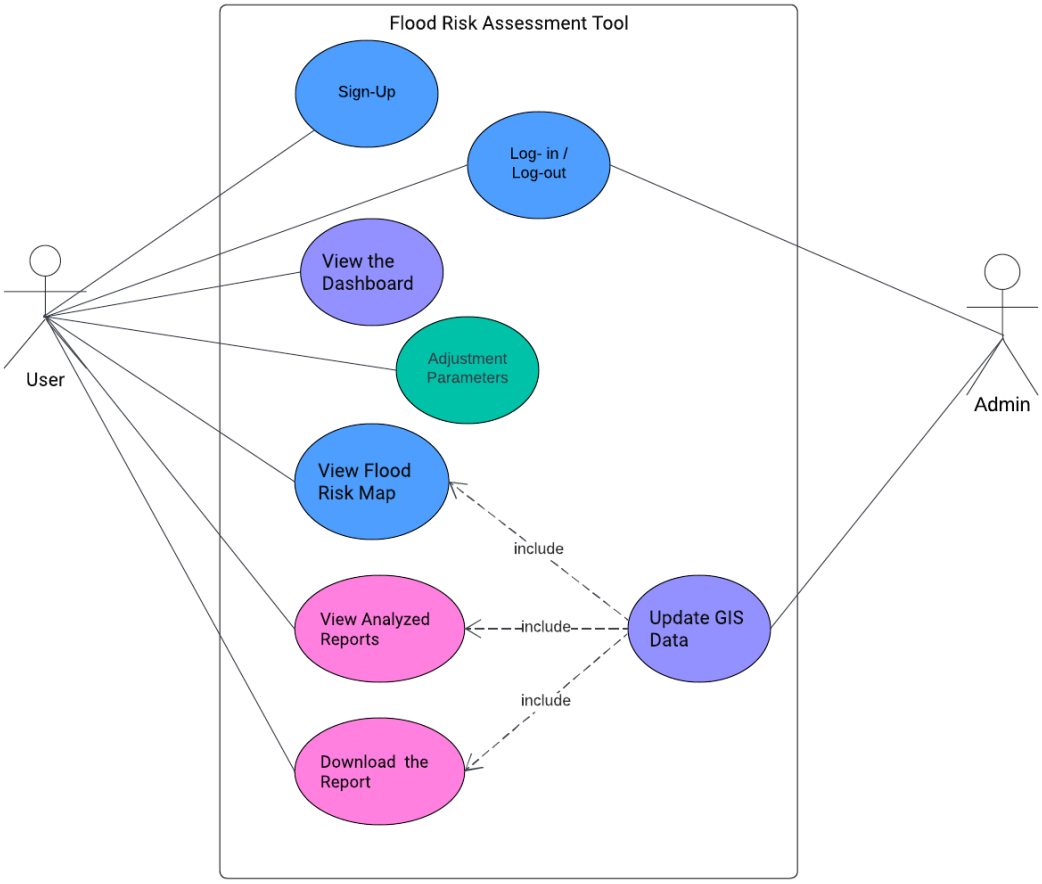
1. The system must provide fast response times, with actions initiated by users reflected in device states less than 100 milliseconds.
2. The system must ensure encrypted communication between devices.
3. The system must include secure user authentication.
4. The system must have reliability higher 99% uptime.

Technical Requirements:

1. Data must be acquired from the *IdroGEO* website (https://beta.idrogeo.isprambiente.it/app/), managed by *ISPRA*.
2. Use *PostgreSQL* with *PostGIS* for spatial data storage and management.
3. Develop the backend using *Flask*, exposing a *REST* API for querying and retrieving data.

4. Utilize Python libraries such as Pandas, GeoPandas, and so on for data processing and analysis.
5. Develop an interactive dashboard using *Jupyter Notebooks, Folium and plotly* for data visualization.
6. Use Visual Studio Code (*VSCode*) and *GitHub* for version control and collaboration.

2.5. Use case diagram and description



Use Case Diagram Structure

- **User**:
  - Sign-up
  - Log-in/ Log-out
  - View the Dashboard
  - Adjust Parameters
  - View Flood Risk map

        - View Analyzed Data
        - Download the report
    - **Admin**
        - Log-in/ Log-out
        - Update GIS data

2.6. Use cases

Actors: User, Admin

Conditions: Always true.

1. User Registration:

- **User:** Non registered user;
- **Flow of Events:**
    1. The user visits the registration page;
    2. They provide the necessary information (such as username, email, and password);
    3. The system validates the input data (e.g., checks if the email is unique);
    4. If validation passes, the system creates a new user account;
- **Exceptional Cases and Special Requirements:**
    - The user's name already exists in the database;

2. User Login:

- **User:** registered user
- **Flow of Events:**
    1. The user visits the login page;
    2. They enter their credentials (username/email and password);
    3. The system verifies the credentials against stored data;
    4. If valid, the user gains access to their account;
    5. A session token or cookie is generated for subsequent requests;
- **Exceptional Cases and Special Requirements:**
    - The user is not registered yet or has put the wrong name or password.

3. User Logout:

- **User:** registered user
- **Flow of Events:**

1. The user clicks the “Logout” button or link;
2. The system invalidates the session token or cookie;
3. The user is redirected to the login page or a logged-out state;
4. Any temporary data (e.g., shopping cart items) is cleared;

- **Exceptional Cases and Special Requirements:**
  - Log Out was unsuccessful due to browser error.

4. Query Data:

- **User**: Registered users
- **Flow of Events:**
  1. The actor goes to the ‘New Project’ section;
  2. The actor starts a new query by choosing the size and which territory he wants to study;
  3. The query is processed;
- **Exceptional Cases and Special Requirements:**
  - The system crashed

5. View Flood Risk Map: View current flood risks, Access historical flood data

- **Flow of Events:**
  1. The User logs into the GIS System;
  2. The User selects the option to View Flood Risk Map;
  3. The GIS System retrieves the current flood risk data and displays it;
  4. The User can interact with the map (zoom in/out, pan, etc.);
  5. Exit condition: The User closes the Flood Risk Map;
- **Exceptional Cases and Special Requirements:**
  - If the GIS System fails to retrieve current flood risk data, it displays an error message;
  - If historical flood data is not available for the selected period and area, it informs the User.

6. View Risk Assessment Reports: Allows location-specific reports;

- **Flow of Events:**
  1. The User selects the option to Generate Risk Assessment Reports;
  2. The User specifies the criteria for the report

3. The Risk Assessment System processes the data and generates a detailed risk assessment report;
4. The User can view the report;

- **Exceptional Cases and Special Requirements**:
  - If the Risk Assessment System encounters errors during data processing, display an error message;
  - The User may need to provide additional information (e.g., risk tolerance levels) for customized reports.

7. Adjust Risk Parameters: Modify flood prediction models, Update risk thresholds based on new data

- **Flow of Events**:
  1. Selects Adjust Risk Parameters;
  2. Modifies flood prediction models;
  3. Updates risk thresholds based on new data;
  4. Changes are validated and applied.
- **Exceptional Cases and Special Requirements**:
  - Warns if model changes yield unexpected results;
  - Alerts if risk thresholds are extreme.

2.7. User stories

1. As a user i can register and login to the system using information.
2. As a User I can **view the current flood risks** in my area, so that I can analyze trends and make informed decisions.
3. As a User, I can **generate a risk assessment report**, I can specify the location and risk parameters to make informed decisions.
4. As a User responsible for **maintaining GIS data**, I can adjust new parameters so that our geographic information remains up-to-date and reliable.
5. As a User I can **adjust risk parameters** and update risk thresholds, so that I can modify the flood prediction models.

3. Bibliography

1 Trigila A., Iadanza C., Lastoria B., Bussettini M., Barbano A. (2021) Dissesto idrogeologico in Italia: pericolosit`a e indicatori di rischio - Edizione 2021. ISPRA, Rapporti 356/2021