# Requirement Analysis and Specification Document

***Emilia-Romagna region** exposure to potential risk and hazard to **flooding** and its impact on **households***

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# 1. Introduction

Europe and Asia are the continent most at risk of suffering from natural disasters. Earthquakes, landslides, flooding, and volcanic activities are a few examples of what Europe faces yearly. The most common natural disaster affecting people globally is floods, Especially as climate change alters weather patterns and man-made development encroaches upon areas that act as natural reservoirs of excess precipitation. This occurs when precipitation increases over a long period, causing a growth in the river flow. Eventually, the outcome is an overflow into surrounding areas. Flooding and landslide risks are continuously increasing because of climate change; therefore data analysis, compilation, and visualization of data is crucial in communicating this rising threat to public authorities and citizens alike.

## 1.1 Contextualization

According to Steinhausen et al. (2022), Italy is the third country with the highest probability of suffering from flooding after Germany and France. Flooding has constantly proved to be a hazard for many Italian cities, impacting households and posing a severe risk to citizens' safety and health. Flooding is a significant and persistent problem in several Italian cities, particularly in the Emilia-Romagna region, which was last hit by a devastating flood in May 2023 which killed 17 people and caused over 7 billion euros in damage (Bertazzi, Marco) Therefore, it is crucial to assess the possible risks and dangers related to flooding in the area while devising effective solutions to lessen their impact.

## 1.2 Objectives

The RASD document provides a comprehensive and assertive analysis of this issue, focusing on critical aspects such as requirements, stakeholders, actors, and use cases; to facilitate better planning and flood-risk management to prevent or mitigate future flooding scenarios. This will be obtained by building a web application as an open-source, for any user to access and benefit from the information captured.

## 1.3 Scope and Limitations

The development of a web-based tool for different users to query, visualize, and analyze data related to flood risk in the northern Italian region of Emilia-Romagna is proposed. The user will be able to save this data in PDF format as well. The data related to flood risk will be redeemed from the PIR (Hazards and Risk Indicators) of The Italian Institute for Environmental Protection and Research (ISPRA) IdroGEO API. The data will break down 6 categories for flood risk assessment, divided into three different risk levels (low, medium, high) for all 330 comuni of the Emilia-Romagna region. The six categories are as follows:

1.) Surface area at low, medium, and high risk
2.) Population at low, medium, and high risk
3.) Families at low, medium, and high risk
4.) Buildings at low, medium, and high risk
5.) Local Businesses at low, medium, and high risk
6.) Cultural Heritage Sites at low, medium, and high risk

The web application proposed will allow the user to obtain values associated with the percentage risk of flooding, correlating to low, medium, and high values as stated above. The period used to feed the software uses a European Union-wide standard aggregated in 2014.

## 1.4 Solution Overview

A demographic informational table will be displayed showing an overview of the indicators. Population, families, and surface area that may be at risk. The table will evidence the count of people, families, and surface extension in each of the categories (high, medium, and low). On the other hand, a second table will be displayed belonging to the built areas at risk. Buildings, industries, and cultural heritage constructions are the ones being evaluated. Finally, a bar graph table will be shown and it will depict the combined indicators' risk levels.

Data will be available and displayed to the user, in the following formats:

- Metadata text
- Attribute tables
- Regional map
- Local "comune" map
- Bar graph for each

## 1.5 Definitions

The following definitions help to distinguish and explain complicated jargon in the following sections of this document.

| Definitions | |
|---|---|
| **PostgreSQL** | An open-source database management system used to query and store data retrieved from various sources. |
| **UML (Use Case Diagram)** | Use case diagram that shows participating actors, entry conditions, and flow of events. Exit conditions, exceptions, and requirements |
| **API (Application Programming Interfaces)** | A type of software interface that provides a way for two or more computer programs or components to communicate with each other. |
| **Jupyter Notebook** | An open-source web application for developing software using Python language. |
| **Flask** | A collection of libraries and modules that enable web application developers to write applications without worrying about low-level details such as protocol, thread management, etc. |
| **Web Server** | A computer system that stores, processes, and delivers web content such as web pages, applications, images, and videos across the internet |
| **REST API** | An acronym for Representational State Transfer, a simple and efficient web interface that receives HTTP requests (GET, POST, PUT, DELETE, etc.) and furnishes resources in various formats such as JSON or XML. |
| **IdroGEO** | A public web platform that disseminates and displays data related to flood and landslide risk in Italy at the local, regional, and national levels. |

# 2. Phenomena Description

## 2.1 World Phenomena

The real-world phenomena related to our study are the probability of flooding in a given area and the potential damage posed to the households in that area.

Flooding occurs because of high precipitation levels and rainfall intensity. The severity and probability of flooding vary depending on the local topography, terrain, and the degree of flood control infrastructure development.

The flood indicator can be calculated using various models. In this case, we adopt the flood indicator provided by IdroGEO.

Likewise, the severity of the impact on local households can also be calculated using multiple models. In this scenario, we will focus on the web app, and provide users with the necessary data in the query results, such as the number of families, residences, buildings, etc., enabling users to obtain the data and conduct their analysis.

## 2.2 Machine Phenomena

**Data acquisition and update**: get relative data in time via an API request.

**Data visualization**: to visualize the base map, for users to intuitively interact with the map data, and display the spatial analysis results.

**Geospatial data analysis**: Performing spatial analysis by using geopandas.

**Data storage**: storing the acquired data for user manipulation and geospatial analysis,

## 2.3 Shared Phenomena

**Search:** Allows both user and the machine to query for geospatial coordinates, to obtain the area of flood risk analysis and its information.

**Retrieve data:** After choosing a location, the geospatial coordinates information is retrieved by the machine and user.

**Visualization:** The machine provides a visualized map of various colors, corresponding to the aforementioned risk matrix, for users to identify and evaluate.

**Sort and Analyze:** The user can specify certain variables using the interface, which the machine can recall information related to Metadata text, Attribute tables, Regional map, and Risk matrix of place and season.

# 3. Requirements

The success of the software will be achieved by providing visually clear and easy-to-use software.

## 3.1 Functional requirements

- The system will allow users to query a specific comune's flood risk.
- The system can retrieve and display a list of each category (surface area, population, families, buildings, business units, and cultural heritage) and their associated percentage of risk (low, medium, and high) for each commune.
- The program will retrieve and plot a bar graph highlighting the percentage breakdown of each comune's risk level (low, medium, and high) by category (surface area, population, families, buildings, business units, and cultural heritage).
- The program will plot and provide an overall risk score.

## 3.2 Non-Functional requirements

- Data visibility will be clear and attractive, a color gradient will differentiate flood risk indicators according to low, medium, and high risk.
- The base map will utilize OpenStreetMap (OSM), a familiar open-source mapping source that is easy to navigate.
- The program's interface will be informative, showing the geographic coordinates/projection and legend that delineates the indicators.
- The information concerning demographic data and flood risk indicators will be displayed in English for ease of use.

## 3.3 Technical requirements

- The language of implementation will be Python, using Anaconda and Jupyter Notebook as development tools.
- Geopandas will be mainly used to visualize and analyze data.
- REST API will be used as the web service, which provides a way for applications such as IdroGeo to communicate over the web by representing resources in a stateless manner.
- The database will be handled by using PostgreSQL, an open-source object-relational database management system (ORDBMS), to store data and recall data from IdreGeo's API.

# 4. Stakeholders

Several users can be presumed to utilize this software for various applications. It was decided early on to not require a log-in procedure as this would limit user interaction with the platform. As such, the software is open to many users; local citizens, non-governmental organizations, and municipalities alike can utilize the software's visualization functionality to determine areas of higher risk, both geospatially and in terms of demographics (surface area, population, and families at risk) and built area (buildings, local businesses, and cultural heritage at risk). Considering that flooding issues affect not only households but flora and fauna, institutions, commercial properties, and health centers among others; the users taken into account are:

- The Academy
- Governmental and non-governmental organizations
- Municipalities
- Environmental Protection Agencies

This data will allow an easy way for these stakeholders and institutions to perform research, analysis, predictions, statistical comparisons, and relations based on flood risk within Emilia-Romagna. It will contribute to policy-making, and hazard risk management for local and national authorities concerned with flood risk. The new web service will provide the civil engineering, urban planning, and architectural sectors with tools to evaluate current building zoning, the localization of new projects, and updated risk guidelines for building construction within areas of potential flooding. This will allow better management and assessment,  to avoid any vulnerable situation for the citizens in Emilia-Romagna risk of flooding wise.. Environmental Protection

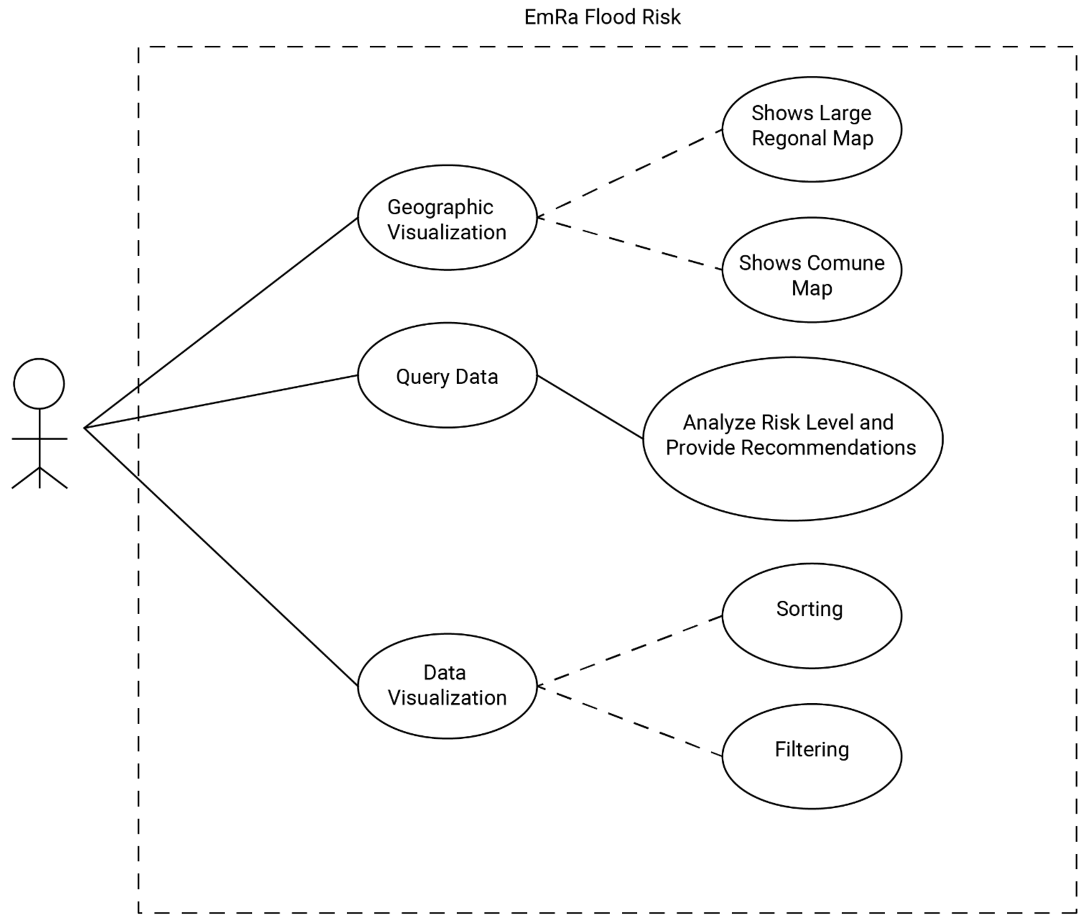
Agencies can use the information to relocate and protect different species while also locating potential sites for water retention reservoirs and other strategies (such as increasing groundwater retention and permeable surfaces) in high flood-risk zones to reduce the adverse effects of flooding.

# 5. Domain Assumptions

Users will have access to the project repository in GitHub. This platform will serve as a channel where users can provide feedback, resolve frequently asked questions, and give constructive criticism to improve the service. This will be achieved by providing a general e-mail for users to write the developers to provide constructive feedback and criticism.

# 6. Use Cases

In this section, we present the use cases that define the interactions between users and the system. These use cases provide a detailed description of how the system will behave in response to various user actions, encapsulating both functional requirements and user expectations. By examining these scenarios, stakeholders can better understand the system's functionality and developers can derive concrete requirements for implementation.




| Use Case No. 1 | |
|---|---|
| **Name** | Data Query |
| **Primary Actors** | User |
| **Entry** | Hazard Risk Identification |

| | |
|---|---|
| **Flow of Events** | **1.** User accesses the search field to start the query<br><br>**2.** User indicates the desire to search for a specific place and its flooding risk<br><br>**3.** User selects the scenario and season<br><br>**4.** System displays search results matching users' supplied criteria<br><br>**5.** User acknowledges |
| **Exit** | User acknowledges information retrieved |
| **Exceptional Cases** | **a.** User searches an area out of the study zone<br><br>**b.** User decides to change zone before querying information |
| **Special Requirements** | User only receives the information searched and not other |
| **User Story** | As a user, I want to query data so that I can identify possible hazard risks in Emilia-Romagna's zones |

**Table No. 2** - Use Case No. 1

| **Use Case No. 2** | |
|---|---|
| **Name** | Data Analysis |
| **Primary Actors** | User |
| **Entry** | Analytical assessment with provided data |
| **Flow of Events** | **1.** User sorts the relevant information<br><br>**2.** User asks the system to display the metadata and attribute tables<br><br>**3.** System displays search results matching users' supplied criteria<br><br>**4.** User acknowledges |

| | |
|---|---|
| **Exit** | User acknowledges information retrieved |
| **Exceptional Cases** | **a.** User searches for additional information that is not provided by the software<br><br>**b.** User decides to change zone while querying information |
| **Special Requirements** | User only receives the information searched and not other |
| **User Story** | As a user, I want to analyze data in a particular area, so that I can identify possible hazard risks in Emilia-Romagna's zones. |

**Table No. 3** - Use Case No. 2

| **Use Case No. 3** | |
|---|---|
| **Name** | Statistical Analysis |
| **Primary Actors** | User |
| **Entry** | Statistical Computations |
| **Flow of Events** | **1.** User selects the basic statistical computations to be calculated<br><br>**2.** System displays data results matching users' supplied criteria<br><br>**3.** User acknowledges |
| **Exit** | User acknowledges information retrieved |
| **Exceptional Cases** | **a.** User desires more complex calculations<br><br>**b.** User decides to change statistical computation before previous calculations have been displayed |
| **Special Requirements** | User only receives the information searched and not other |
| **User Story** | As a user, I want to run statistical analyses, so that I can comprehend the probability, correlations, and risk in Emilia-Romagna's zones |

**Table No. 4** - Use Case No. 3

| **Use Case No. 4** | |
|---|---|
| **Name** | Data Visualization |
| **Primary Actors** | User |
| **Entry** | Data Visualization |
| **Flow of Events** | **1.** User specifies the data that wants to be visualized<br><br>**2.** User determines the way the data is represented (tables/graphs)<br><br>**3.** User acknowledges |
| **Exit** | User acknowledges information retrieved |
| **Exceptional Cases** | **a.** User does not specify the data to be displayed<br><br>**b.** User decides to change data while representing information |
| **Special Requirements** | User only receives the information searched and not other |
| **User Story** | As a user, I want to visualize data in different forms, so that I can study possible hazard risks in Emilia-Romagna's zones |

**Table No. 5** - Use Case No. 4

| **Use Case No. 5** | |
|---|---|
| **Name** | Data Download |
| **Primary Actors** | User |
| **Entry** | Data Download |

| | |
|---|---|
| **Flow of Events** | **1.** User specifies the data that wants to be downloaded<br>**2.** User determines the format in which the data is downloaded (cvs, txt, xml)<br>**3.** User acknowledges |
| **Exit** | User acknowledges information retrieved |
| **Exceptional Cases** | **a.** User does not specify the format<br>**b.** User decides to change format while downloading information |
| **Special Requirements** | User only receives the information searched and not other |
| **User Story** | As a user, I want to download data in different formats, so that I can study possible hazard risks in Emilia-Romagna's zones |

**Table No. 6** - Use Case No. 5

# 4. Bibliography

Bertazzi, Marco. “Servono 5 Miliardi: La Conta Dei Danni Tra Campi, Aziende, Strade e Turismo.” La Repubblica, 21 May 2023.

Paleari, S. (2018). Natural disasters in Italy: do we invest enough in risk prevention and mitigation? International Journal of Environmental Studies, 75(4), 673–687. https://doi.org/10.1080/00207233.2017.1418995

Mazzella, Daria, et al. “Landslides and Floods in Italy: Hazard and Risk Indicators – 2021 Edition.” ISPRA Istituto Superiore per La Protezione e La Ricerca Ambientale, 2021, www.isprambiente.gov.it/.

Steinhausen, M., Paprotny, D., Dottori, F., Sairam, N., Mentaschi, L., Alfieri, L., Lüdtke, S., Kreibich, H., and Schröter, K. (2022) Drivers of future fluvial flood risk change for residential buildings in Europe. Global Environmental Change, 76: 102559.