European Program for Wildfire-Prepared Communities

FIREPRIME

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Deliverable D3.2
The FIREPRIME App

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Abstract	This report outlines the key technical features of the FIREPRIME App designed and implemented to assess wildfire risk at homeowner scale. It provides an in-depth look at the system's rationale and architecture, including the risk assessment algorithm, technology used, components, requirements and specifications

(1) Draft / Final
(2) Public / Restricted / Internal

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1. Introduction and objectives

The current document is part of the FIREPRIME project that aims to develop the knowledge, tools and services needed to build and implement an integral program on risk prevention and preparedness across European WUI communities, with the focus on civil protection. These developments will be implemented and tested in local communities of 3 pilot areas: the province of Barcelona in Spain (Mediterranean Europe), Tyrol in Austria (Central Europe), and Gothenburg in Sweden (Northern Europe).

Therefore, the project seeks to increased wildfire risk knowledge and assessments, by considering specific wildfire risk components and its underlying drivers for a given region/area and to increase evidence-based public risk awareness, education and preparedness among the population for wildfires.

In particular, FIREPRIME will contribute to the achievement of these outcomes by:

- Developing and implementing risk assessment tools and guidelines to be applied at property level (households and infrastructures).
- Developing and implementing risk awareness and education activities at community level in the pilot sites by producing educational and interactive material for the public, packaged for application beyond the pilot municipalities.

This deliverable belongs to WP3 “Program Development” and summarises results of tasks T3.1 whose main objective is to o develop resources and services to empower homeowners and residents in wildfire preparedness, featuring the FIREPRIME homeowner fire safety stream. The main product developed within this stream is a Smart Phone App, which is intended to help WUI residents across EU to analyse wildfire risk in their property.

This document is structured as follows: **Section 2** summarizes the risk assessment methodology integrated into the app, focusing on its two main components: wildfire hazard and property vulnerability. **Section 3** provides a brief overview of the app's software and architecture, including a link to a demo video showcasing its appearance and functionalities.

2. Methodology to assess wildfire risk at property level

A methodology that quantifies risk as a function of hazard, exposure and vulnerability has been developed specifically for the property level.

2.1. Definition of the hazard

A hazard is a process or phenomenon that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation (UNDRR, 2017). Wildfires are natural hazards and they can be characterized by their location, intensity or magnitude, frequency and probability. In this context, the term wildfire danger can also be used, which is depends on the likelihood of having an ignition and the behaviour (propagation and intensity) of the fire once it is ignited (Oom et al., 2021). The European Forest Fire Information System (EFFIS) has mapped wildfire danger in Europe based on the number of days with high-to-extreme fire danger by weather experienced by each area. This information is extrapolated based on the Fire Weather Index (FWI), which accounts for the effects of fuel moisture and weather conditions on fire behaviour. Long term FWI data series are used to assess wildfire danger: an area with high-to-extreme fire danger by weather is defined as a location in which a high FWI (equal to or greater than 30). Figure 1 shows that the areas located in Southern Europe experience high fire weather indices, while in northern areas, the index is lower.

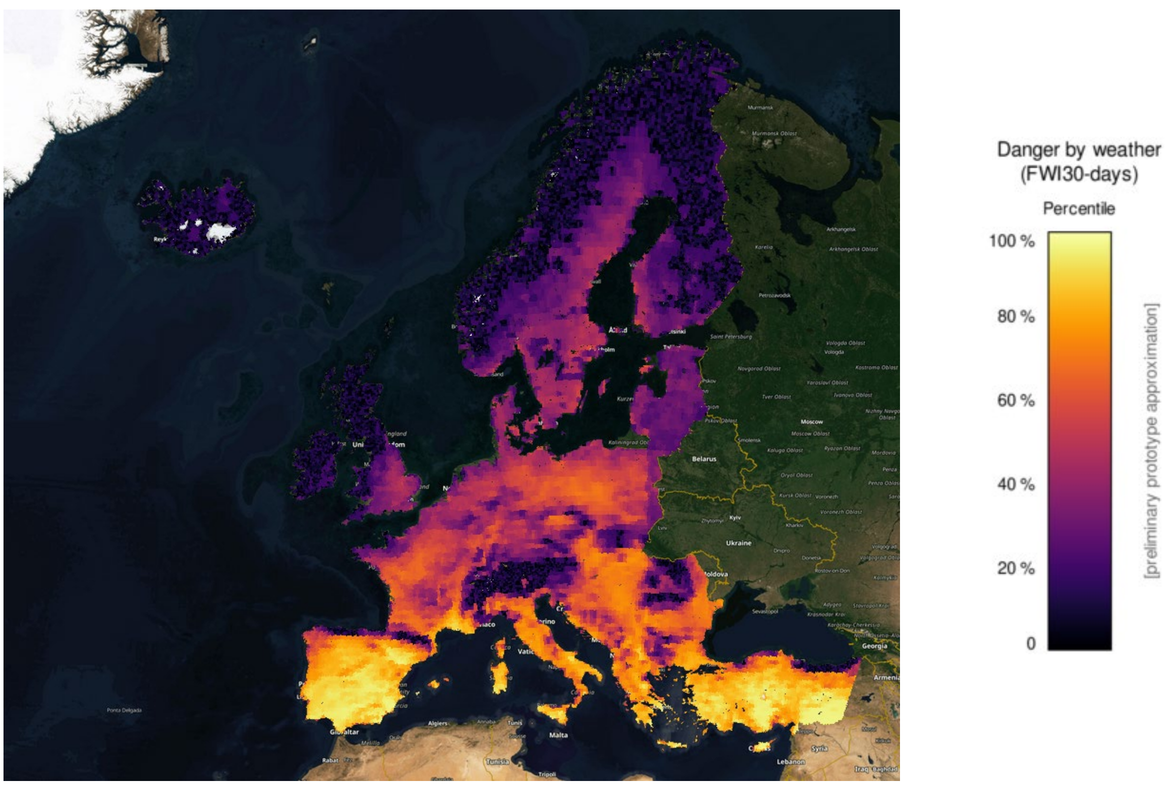

Figure 1. Danger by weather (EFFIS)

2.2. Definition of exposure and vulnerability

Exposure is the situation of people, infrastructure, housing and other tangible human assets located in hazard-prone areas (UNDRR, 2017). In the case of wildfires, it is the thermal insult experienced by an asset or person based on their location. At the property level, exposure depends on the fuels located in the surroundings of a building, which can be ignited by firebrands, radiant heat or direct flame contact and can cause further fire spread through a property. These fuels include ornamental and wildland vegetation, fences, hedgerows, stored materials, outbuildings (e.g., garden or storage sheds) and other man-made or artificial fuels (e.g., garden furniture, LPG tanks, etc.). These fuels very often lack any type of management (Molina-Terrén et al., 2019) and, in case of ignition, consequences might have a severe impact (Pastor, 2019).

Vulnerability includes the conditions determined by physical, social, economic and environmental factors which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards (UNDRR, 2017). At the property level, building and property vulnerability is defined by the susceptibility of each building and property element to fire exposure. Regardless of building designs and practices, houses at the WUI always present elements that are weak to fire exposure. These building sub-systems are responsible for houses' vulnerability, either because they are combustible or made out of materials sensitive to fire, or because their geometry enhances heat transfer (Vacca et al., 2020a).

A description of a building's elements that are susceptible to fire has been given in detail by Vacca et al. (2020b). These elements include:

- The materials that comprise the building's envelope and their combustibility;
- The roof and gutters, which are points in which vegetal debris such as pine needles can accumulate and ignite.
- Glazing systems, which may crack and collapse when exposed to heat, allowing firebrands, smoke and flames to enter the building.
- Ventilation openings, through which firebrands, smoke or flames can enter the building.
- Semi-confined spaces with a large accumulation of combustible materials. If one of these structures is connected to the main buildings and the elements present in these areas are ignited, the great heat build-up created by the fire could cause great damage to the main structure's envelope.

Within the developed methodology, fire exposure and structural susceptibility are quantified through a fault tree analysis, with the top event "Fire inside building" (Figure 2). The top event depends on two intermediate events: the structural susceptibility of the analysed building and the fire exposure of the building, which depends on the different pathways through which the fire can spread through the property up to the building. This top event identifies the vulnerability to fire of a property.

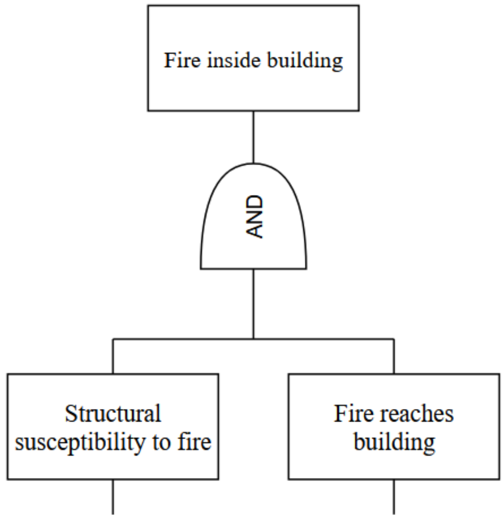

Figure 2: Fault tree structure

The intermediate event “Structural susceptibility to fire” is further analysed based on the following vulnerable elements:

- Façade materials;
- Roof and gutter materials and maintenance;
- Glazing systems and their protection;
- Vents and their protection;
- The wall(s) shared between the building and a semi-confined space with combustible materials.

The intermediate event “Fire reaches building” is further analysed based on the following ways through which a fire can spread on a property, thus reaching the building:

- Poor management of fuels located close to the building;
- Poor management of artificial fuels located within 30 m of the building;
- Poor management of vegetation (ornamental and wildland) located within 30 m of the building;
- Property perimeter;
- The slope on which the property is placed on.

Each of these intermediate events is further analysed into several basic events, to which probability of failure is assigned based on a poll of the WUI fire experts of the consortium of the project. This way, fire exposure and susceptibility to fire can be quantified for each analysed property. In this case, the top event identifies a property’s vulnerability to fire as a function of both exposure and susceptibility. The values obtained for the intermediate events “Structural susceptibility to fire” and “Fire reaches building” are multiplied to identify the probability that the fire would enter and thus ignite a building located at the WUI.

2.3. Definition of risk

Risk is quantified as function of hazard, exposure and vulnerability. Within this methodology, the exposure term is included within the vulnerability term.

Risk is here calculated as:

$$R = H \cdot V$$

Where R is the risk level [%], H is the hazard identified from the EFFIS map (with values from 0 to 1), and V is the vulnerability of the property, or the probability that the fire will enter the building [%].

3. The Smart Phone App

The FIREPRIME smartphone app is designed to help homeowners assess and mitigate wildfire risk with ease and accessibility. Available for both Android and iOS, the app provides an intuitive interface for evaluating home and property vulnerability and potential fire exposure through a structured questionnaire and receiving actionable recommendations. The following subsections outline the key software features and architectural design.

The app and a video material demoing the tool in use is available at: https://github.com/FIREPRIME-APP.

3.1. Software Description

This section illustrates, via an example, the FIREPRIME app main functionalities. The non-functional requirements for this app are critical because of the final users' diversity and the possibility of being used in a low-connectivity area. The application should support multi-language, be adapted to the country, be really easy to use, be functional even if there is no connection to the Internet, and be available for both Android and iOS systems.

To start with the risk assessment, the homeowner needs to register the house in the application, providing the address where the house is located. The homeowner can register and assess the risk for more than one house (see Figure 3, left).

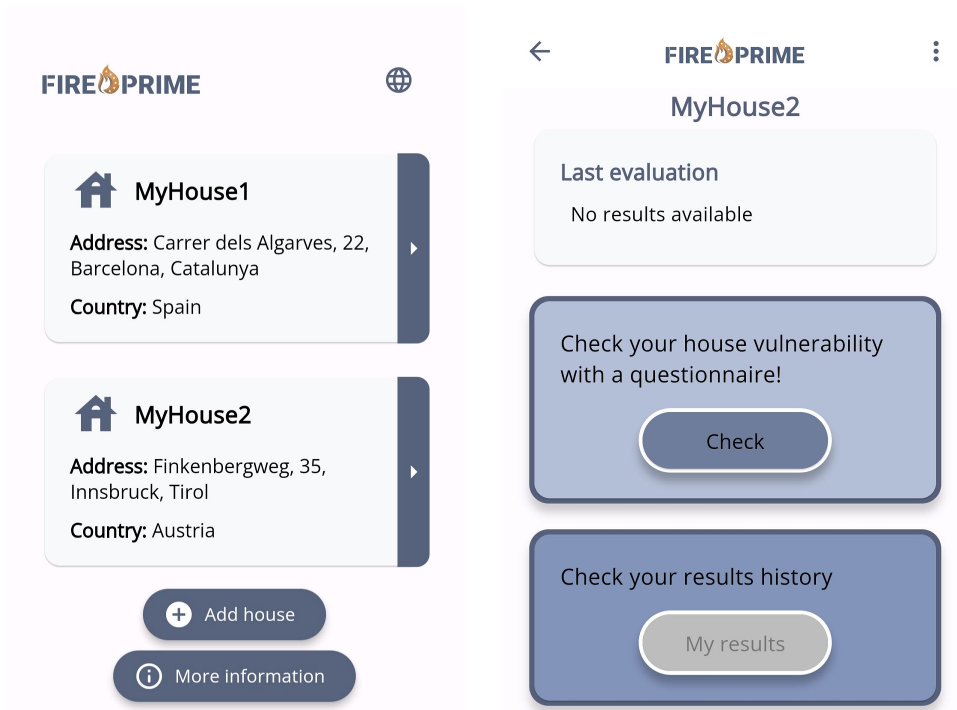

Figure 3. FIREPRIME app house registration

Once a house is registered, the homeowner is requested to answer a questionnaire that includes a total of 25 multi-choice questions (Figure 3, right, clicking on *Check* button). The first set of questions are related to the house characteristics and the second set to the house surroundings. Questions include a description and a set of images to make it easier for the user to understand what is being asked; those images can be different depending on the country defined in the house address. Figure 4 shows some examples of questions, from left to right, a question without images, a question with one image, and a question with several images presented as a carousel.

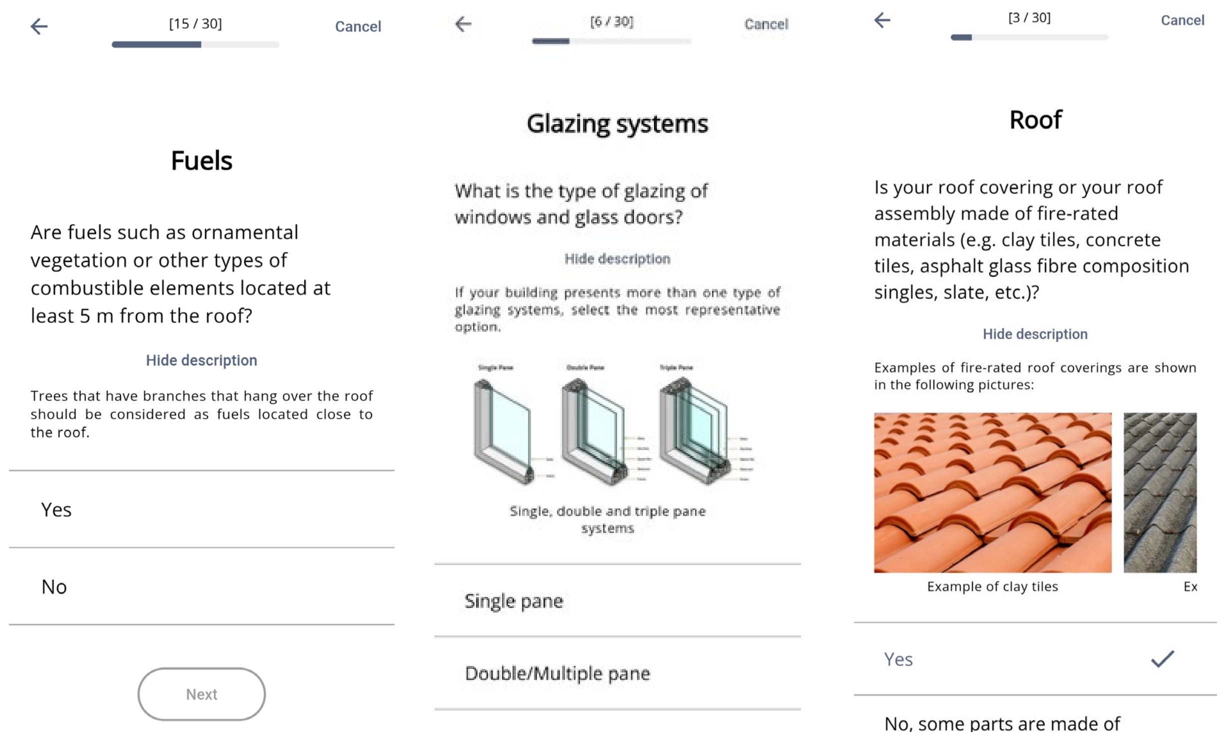

Figure 4. FIREPRIME app questionnaire

When all the questions are answered, the app shows the risk assessment result representing the wildfire risk index: a number from 0 to 100 where 0 represents the lower risk and 100 the higher risk. Figure 5 shows the assessment result; the risk index value is complemented with a graphical representation using a gauge chart coloured from green (values near to 0 representing low risk) to red (values near to 100 representing high risk). The risk index is calculated as the multiplication of two components: fire hazard level of the area where the house is located and house vulnerability factor. The hazard level is based on the Fire Weather Index[1] provided by Copernicus[2,3] the Earth Observation component of the European Union's space programme integrated at the European Forest Fire Information System (EFFIS). The vulnerability factor is calculated using the fault tree model developed in the FIREPRIME Project, detailed in section 2.2 whose input are the answers from the questionnaire. In the example shown in Figure 5, the homeowner can see a risk index value equals to 53 that is the result of multiplying 0.75 (fire hazard level as a percentage) and 71 (vulnerability factor), both numbers being shown using a progress chart just below the gauge.

[1] The Fire Weather Index (FWI) is a meteorologically based index used worldwide to estimate fire danger. The concrete value used is the "Danger by weather" data that corresponds to the number of days with high-to-extreme fire danger by weather (FWI >= 30).

[2] https://www.copernicus.eu/

[3] https://forest-fire.emergency.copernicus.eu/apps/fire.risk.viewer/

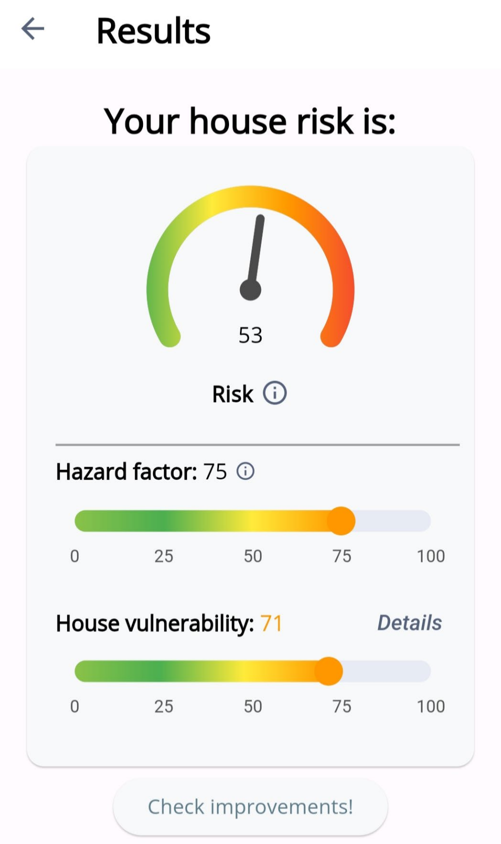

Figure 5. FIREPRIME app risk assessment results

The risk index value 53 is near the midpoint of the scale, suggesting a moderately concerning state, but the vulnerability factor is 71, near to the risky area. In order to understand the house characteristics that are negatively affecting the vulnerability, the user can see the detailed assessment clicking in "Details" button next to "House vulnerability", the details are shown just below (*Figure 6*, left). The details correspond to the result of the evaluated properties defined on the fault tree model; likewise, these properties' evaluations are numerical values from 0 to 100, also represented graphically using a progress chart (green for low good values and red for high bad values). In this example, the vulnerability property worst ranked is the house glazing system, with a value of 59 (*Figure 6*, right).

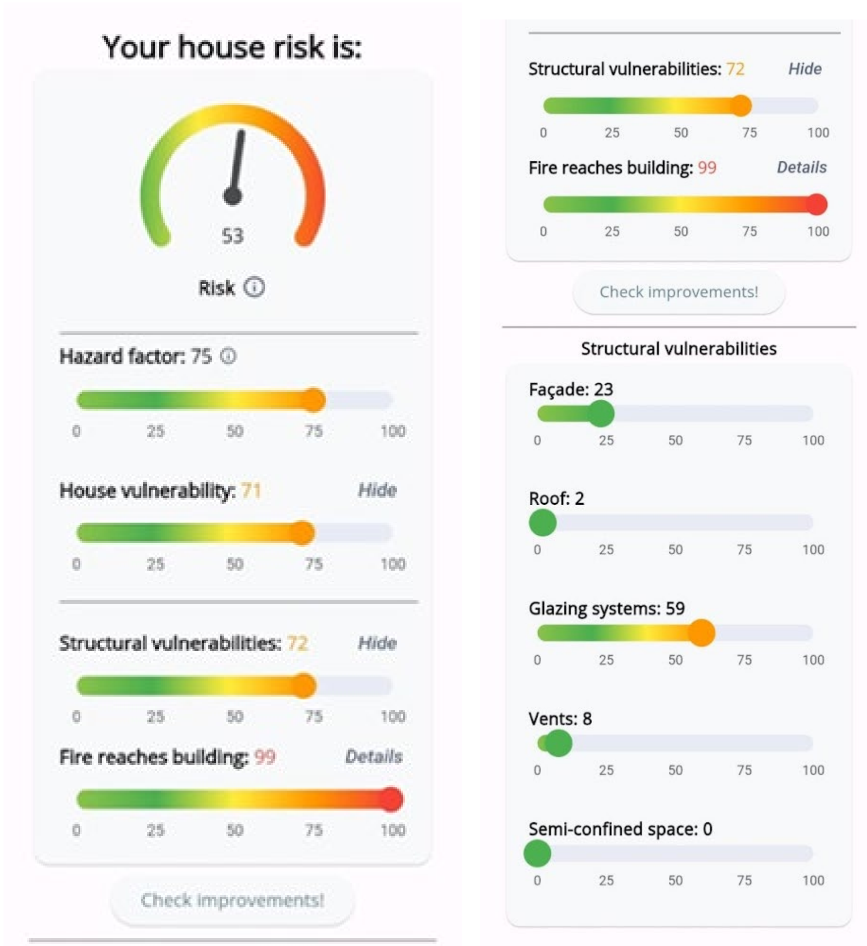

Figure 6: FIREPRIME app risk assessment details

Based on the answers from the questionnaire, using the button "Check improvements" just below the risk assessment (see *Figure 6*, left), the user obtains a list of recommendations of changes on the house to decrease the fire vulnerability (see Figure 7). For example, to improve the glazing systems, the app recommends "replacing the shutters with aluminium or fire-rated".

Figure 7. FIREPRIME app improvement suggestions

When the homeowner performs the suggested renovations, they should change one or more answers in the questionnaire to reflect the new house or surrounding characteristics, and then ask the app to reassess the risk. When the user performs more than one risk assessment, the app provides a historical risk assessment view (*Figure 8*, left, clicking on *My results* button in the results history box), using a chart to provide graphical representation of the risk factor evolution over time. In the example used in this section, selecting the last evaluation, the user can see that the risk index value (26) is better than the previous one (53).

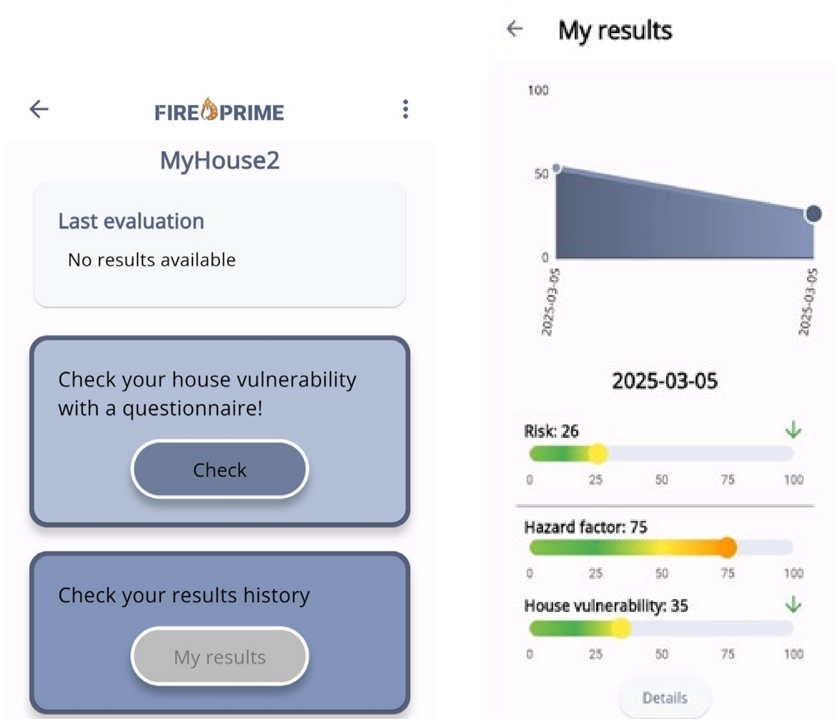

Figure 8: FIREPRIME app risk assessment evolution

The application also includes usage monitoring, storing anonymised information on how the final users navigate through the screens and options, providing valuable feedback to be used to enhance the user experience.

3.2. Architecture

The FIREPRIME app is a mobile application with a modular, loosely coupled and extensible layered architecture to provide flexibility and ease of integration of new components (see *Figure 9*). It is worth mentioning that the entire execution takes place locally on the user's mobile device, whilst having a cache-based resilient communication with external services, ensuring a smooth experience independent of internet connectivity issues.

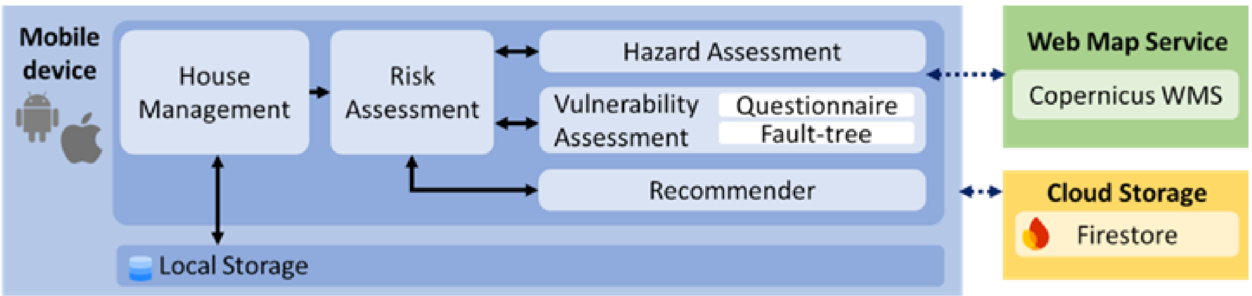

Figure 9: FIREPRIME App architecture

The *House Management* component is the main entry-point of the app and responsible for managing the different houses of the end-user. This component interacts with *Risk Assessment* whenever a new risk assessment is initiated by the end-user. The *Risk Assessment* component orchestrates the *Hazard Assessment*, and the *Vulnerability Assessment*.

The *Hazard Assessment* component computes the hazard level of the area where the house is located. It communicates with an external *Web Map Service* (WMS) that provides data related to the hazard level of an area. In the current implementation, the FIREPRIME app is integrated with the *Copernicus WMS*, which provides the hazard level from any area in Europe. Nevertheless, the app can be easily extended with additional WMS if needed. In case that the *Hazard Assessment* can't connect to the *Web Map Service*, it uses the hazard level of the area, previously stored in cache.

The *Vulnerability Assessment* component computes the vulnerability of the house. It is composed of a *Questionnaire* to interact with the end-user and a *Fault-tree* to compute the vulnerability of the house based on the questionnaire's responses. The fault-tree component uses fault-tree analysis to compute the vulnerability of the house based on the user's responses.

When the risk value is obtained, the *Recommender* is triggered to suggest recommendations to the end-user on how to mitigate the vulnerability of their houses. The *Recommender* follows a rule-based approach, in which, based on the responses of the user and the values obtained in the assessment, it provides a list of actionable recommendations to reduce the risk of their houses.

Finally, the application tracks the user interactions with its functionalities and securely stores this data in the cloud using Firestore[4]. To protect the privacy of the end-users, all information is anonymized, and only interaction patterns—excluding responses or risk-related data—are recorded. This information enables the collection of implicit feedback, helping to refine and guide the app's future development.

The app has been implemented using Flutter[5]. Flutter is a cross-platform framework that enables the development of apps for multiple platforms using a single codebase. This feature enabled the FIREPRIME app to be available for both Android and iPhone devices seamlessly.

[4] https://firebase.google.com/docs/firestore

[5] https://flutter.dev/

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