PIISA

Piloting Innovative Insurance Solutions for Adaptation

D3.10: Preliminary Design of the New Insurance Instrument

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Executive Summary

Wildfires are a growing threat across Europe, causing significant economic and ecological damage. **Portugal, one of the most wildfire-prone regions in Europe**, faces increased fire risks due to climate change (Galizia, et al., 2021). In response to this, public authorities, including the Agency for Integrated Rural Fire Management (AGIF), have initiated efforts to mitigate such risks. AXA Climate, in partnership with AGIF, is piloting a project under the PIISA project, funded by Horizon Europe, to develop **innovative wildfire insurance solutions that incentivize adaptation measures at both the household and forest management levels.**

The Piloting Innovative Insurance Solutions for Adaptation (PIISA) project is a three-year initiative involving 12 partners from five EU countries, including research institutions, meteorological agencies, and insurance experts. It focuses on co-developing climate-resilient insurance portfolios and data-sharing solutions for climate risk and losses. The project is organized in several pilot projects, including one in Central Portugal, which aims to develop and test new insurance models for forests against wildfires, which is the focus of this project report.

This report is prepared for the **partners of the PIISA and Horizon Europe projects** as an initial step to raise awareness about the project's scope, promote collaboration among the consortium members, and minimize the risk of duplicating efforts within and across related projects. Additionally, it is intended to engage **other insurance companies**, encouraging them to feedback into and adapt the project's models for use in different regions and contexts.

This pilot project, centered in Central Portugal, aims to address the increasing wildfire risks in the country by co-developing and implementing new insurance models. These models are designed to **encourage and financially support the adoption of wildfire adaptation measures,** such as constructing firebreaks in high-risk areas. The Central Portugal pilot project is organized into three iterative loops, each focusing on different aspects of insurance development and risk mitigation. The first loop involves defining the study area, collecting and harmonizing data relating to the studied region (vegetation, topography, weather, fire history), and mapping current wildfire risks. The second loop will involve the design and testing of insurance instruments tailored to both households and forest managers, incorporating mitigation measures into pricing structures. The final loop will explore the replicability of these solutions in other European regions.

Loop 1, which is the primary focus of this report, involved a thorough assessment of wildfire risks in Central Portugal. In collaboration with the Central Regional Coordination and Development Commission (CCDRC) and AGIF, the project team **identified high-risk areas and gathered essential data to map current wildfire risks.** This phase also involved the **development of various wildfire mitigation scenarios** based on Portugal's National Adaptation Plan (NAP). These scenarios will inform the design of innovative insurance models in Loop 2, which will incorporate wildfire risk adaptation measures in the pricing model. Such measures have the potential to lower insurance premiums by reducing the burned area.

The co-creation process is a key aspect of PIISA, involving stakeholders in the design, development, and delivery of the insurance solutions. The pilot's first loop, running from December 2023 to June 2024, focused on co-designing plans and activities with partners and stakeholders, followed by the co-development of localized knowledge related to wildfire risks, adaptation measures and insurance products, which were iteratively refined based on stakeholder feedback. This report outlines the methodology employed, shares preliminary results from Loop 1, and presents the next steps in the project's development. This pilot project, as a part of the overall PIISA project, is paving the way for innovative insurance solutions that can play a crucial role in safeguarding Europe's forests, promoting sustainable forest management, and enhancing climate resilience.

Keywords

Climate-resilience, parametric insurance, climate adaptation, forest risk management, wildfires, Portugal

Abbreviations and acronyms

Acronym	Description
AGIF	Integrated Rural Fire Management Agency (Agência para a Gestão Integrada de Fogos Rurais)
CCDRC	Central Regional Coordination and Development Commission
CMCC	Euro-Mediterranean Center on Climate Change (Centro euro-Mediterraneo sui Cambiamenti Climatici)
FMI	Finnish Meteorological Institute
GEDI	Global Ecosystem Dynamics Investigation
ICNF	Portuguese National Authority for Nature Conservation (Instituto da Conservação da Natureza e das Florestas)
KPI	Key Performance Indicator
MODIS	Moderate Resolution Imaging Spectroradiometer
NAP	National Adaptation Plan
NASA	National Aeronautics and Space Administration
PIISA	Piloting Innovative Insurance Solutions for Adaptation
SRTM	Shuttle Radar Topography Mission
WP	Work Package

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1 Introduction

Wildfires are a major hazard in Europe, causing extensive economic and ecological losses (EEA, 2021). Wildfires are getting more common in several regions of the world, partially due to changes in climate, with an increase in dry and warm conditions, but communities, individuals, and forests are not prepared to cope with these increasing fire risks. The European continent presents an overall high population density, with high economic activity, distributed in a mosaic of landscapes. Wildlands are the main land cover type (39%) presenting most of the fuel load (i.e. burnable surface), followed by agriculture (33%), whereas urban settlements occupy a small share of the total area (3%) (European Union, 2018). Europe faces growing fire risk due to increasing population, expansion of the wildland-urban interface, and land-cover changes, which influence wildfire frequency and intensity. Portugal is one of the most fire prone regions in Europe (Galizia, et al., 2021), and wildfires have caused significant damages and casualties in recent years. In 2017, Portugal experienced the worst wildfire season ever recorded in terms of burned area, fatalities, and structures affected, when two extreme wildfire complex events affected the Central Region. In that year, the Portuguese government reported a total of approximately 2000 wildfires, burning an area of 539,920 hectares of forests, shrubland, and agricultural land and causing over 100 deaths (Leone, Elia, et al., 2023). In response to these rising risks, Portugal has taken some steps, including the creation of the Agency for Integrated Rural Fire Management (AGIF), a public body under the supervision and oversight of the Prime Minister whose mission is to deploy a fire management system and reduce the impacts of wildfire in Portugal. For this pilot, AXA Climate will partner with AGIF to study adaptation measures and their integration into wildfire insurance models.

This project is deemed all the more relevant as more than 100 wildfires started in northern Portugal on the 14th of September, 2024, with significant increase in their surface extension and intensity in the following days, leading to a declaration of "state of calamity" by Portugal’s Prime Minister on the 17th of September. The related carbon emission from these wildfires has already surpassed 1.9 megatonnes, the worst in 22 years (Copernicus, 2024). The start of these wildfires co-occurred with a polar incursion in the region -storm Boris- fueled by sharp contrasts of polar air and moist and warm air from the Mediterranean region. The southward polar incursion created an atmospheric flow featuring a prominent atmospheric ridge pattern over Portugal, which brought strong anomalous dry air flow coming from northern Africa, and creating suitable conditions for the wildfires in Portugal, while at the same time enhancing conditions for torrential and extreme rainfall in Central Europe. Similar ridge-like atmospheric conditions have been recognized for years to increase the probability of occurrence of wildfires in Portugal (Pereira, et al. 2005). A combination of a targeted monitoring system and a combination of atmospheric forecasts at weather and sub seasonal timescales can help predict these events, in a way complementing via Forecast-based Action mechanisms the role of financial instruments such as the wildfire index-based insurance products discussed in this deliverable.

The growing wildfire risk in Europe, exacerbated by climate change, underscores the need for effective adaptation measures (EEA, 2021). In Portugal, while adaptation measures are crucial for reducing vulnerability, the widespread lack of insurance coverage for wildfires presents an additional challenge. At the household level, there is currently little incentive to insure against or adapt to wildfire risk, since the government fully compensates impacted households for reconstruction costs. While losses caused by weather and climate related hazards from 1980-2019 amounted to 7591 million euros in Portugal, only 9% of this amount was insured (at 650 million euros), highlighting the protection gap for insurance (Leal, Hudson, et al., 2022). Additionally, the high perceived cost of forest insurance, driven by limited data and the difficulty of quantifying wildfire risks, further discourages uptake.

This project is therefore investigating and developing innovative wildfire insurance, aiming to improve affordability and uptake at both the household and forest association levels. It will specifically focus also on how adaptation measures can be incorporated into the insurance design and pricing, potentially offering cost-savings through lower risk and vulnerability, thereby making insurance schemes more attractive to customers. Adaptation measures could include the construction of fire breaks and the reduction in the amount of forest biomass available to burn in the most exposed regions, which would subsequently decrease the frequency and intensity of fires, reducing the overall risk and impact of wildfires. Monitoring wildfire risk and its impacts could also be implemented in climate services. Information such as the Fire-Weather Index at high resolution, as well as burned surfaces and burn severity could be included in a specific platform to support the expansion of the parametric insurance framework in Europe. Effective and innovative insurance schemes play a crucial role in encouraging and supporting adaptation by reducing risks and, in turn, lowering costs for policyholders, while also transferring the residual risk to insurance companies. This dual approach helps promote resilience in the face of climate-related hazards, as individuals and organizations are better protected and motivated to implement risk-reducing strategies.

PIISA is a three-year Research and Innovation project with climate adaptation and insurance at its core. It is funded under Horizon Europe, and includes twelve partners from five EU countries, spanning research and academia, meteorological agencies, climate risk and sustainable innovative consulting, and insurance experts. The project focuses on co-developing climate-resilient insurance portfolios and data-sharing solutions for climate risk and losses. Work Package (WP) 3, led by the Finnish Meteorological Institute (FMI), focuses on pilot projects across three sectors: Cities and Well-being (Task 3.2), Food and Agriculture (Task 3.3), and Forestry (Task 3.4). This is the second of the two pilots belonging to Task 3.4, related to forests, and is focused on the design and development of innovative insurance models, learning from existing forest insurance schemes. It studies effective adaptation measures and how they could increase the viability of such insurance schemes. It focuses on Portugal as a first location, with our pilot areas located in the Centre of Portugal.

The remainder of this paper is organized as follows: Section 2 provides an overview of the project and its primary objectives, highlighting the need for innovative insurance solutions in the context of climate-related risks for forests. Section 3 details the approach and methodology employed in the pilot, focusing on the co-creation process and the structure of the three loops designed to refine and test insurance products. Section 4 covers the first loop of the project, showcasing the iterative design and development process, while Section 5 provides preliminary processes and results from Loop 2. Section 6 details some project challenges and limitations, and finally, Section 7 outlines the next steps and upcoming work planned for the subsequent loops.

2 Project Overview and Objectives

This is the second of the two pilots belonging to the PIISA task related to forests. This pilot begins with Loop 1, where we define a study region in Portugal in collaboration with the Central Regional Coordination and Development Commission (CCDRC) and their regional fire management commission. We conduct interviews with the local partner in order to find a location with high wildfire risks, as well as a socio-economic context broadly representative of the national population. After defining the study region, we collect and harmonize all the necessary data to map the current wildfire risk. We then identify potential wildfire adaptation measures relevant for the central Portugal context to build out different scenarios of wildfire mitigation. These are based on the country's National Adaptation Plan (NAP), as well as the CCDRC and their regional fire management commission guidelines and upcoming adaptation strategies.

In Loop 2, we will begin by testing and refining various wildfire models to accurately map wildfire risks across the study region. These models will incorporate factors such as land cover, topography, historical fire data, and various other climate variables to simulate potential fire behaviour under a range of conditions, including both with and without the incorporation of adaptation and mitigation measures into the model. Mitigation measures previously identified in the rural fire management plan will be tested and simulated to measure their effectiveness in wildfire risk mitigation. The goal is to assess how the different adaptation measures, such a fire breaks, controlled burns, and vegetation management, are in reducing wildfire risk.

We will then evaluate the feasibility of implementing a household wildfire insurance program. This will involve analyzing how pooling risk across multiple households could lead to reduced premiums, especially for those who have adopted fire adaptation measures. The aim is to incentivize households to adopt the most cost-effective adaptation strategies by providing financial rewards in the form of lower insurance premiums. To further incentivize mitigation, we will explore innovative insurance instruments that tie premium reductions to risk-reducing actions taken by households or communities. This approach will encourage continuous risk reduction and adaptation efforts.

As part of this analysis, we will compare different models for funding insurance premiums, including publicly funded subsidies versus full compensation models, to identify the most cost-effective approach for both insurers and policyholders under various mitigation scenarios. Additionally, we will conduct a comprehensive review of existing cost-effective forest risk reduction measures to ensure that the proposed wildfire insurance scheme aligns with proven strategies. Our final goal is to design a parametric wildfire insurance product where premiums decrease in proportion to the reduction in wildfire risk.

Lastly, we will test the replicability and transferability of what is developed in Portugal in other areas in Europe to scale up this innovative insurance model across several regions and populations.

3 Approach and Methodology

The pilot will be implemented in three loops, each with a specific aim, as listed below.

1. Loop 1: The adaptation measures in Portugal's NAP that have the potential to be combined with innovative insurance instruments are identified. One of the key criteria of this pilot project is the ability to incentivize adoption of the most cost-effective adaptation measures. Measures will be targeted at two levels: the forest management level and individual household level, with pilot candidates put forward in the Central region by the CCDRC and AGIF. AGIF also offer their guidance through External Advisory Board support.

2. Loop 2: This loop consists of designing new insurance instruments, under two levels of action: (i) development of insurance solutions tailored to individual households to incentivize and support wildfire prevention measures; and (ii) exploration of holistic insurance packages designed for forest managers. This includes developing, testing and calibrating the fire models and simulating the impact of adaptation measures in reducing the burned area.

3. Loop 3: In this loop, the potential applicability of the developed solutions will be tested in other regions of Europe. A webinar to present the developed wildfire insurance concepts as well as the lessons learned from Loops 1 and 2 will be organized with a group of stakeholders identified by WP4. Due to the webinar, the potential for replication, as well as the main barriers and enablers will be identified with active participants in a workshop that will be organized separately.

Co-creation is one of the key development methods used in piloting. Co-creation in this PIISA pilot follows a structured approach, with each loop organized into three distinct phases: Co-design, Co-development, and Co-delivery. In the Co-design phase, stakeholders collaborate to define the objectives, activities, and scope of the pilot, refining the understanding of problems and needs. The Co-development phase involves jointly developing knowledge, tools, or solutions, incorporating stakeholder feedback iteratively. Finally, in the Co-delivery phase, these solutions are applied and tested with stakeholders and end-users, gathering feedback for further refinement. Each loop in the process undergoes these three phases, ensuring continuous collaboration and improvement.

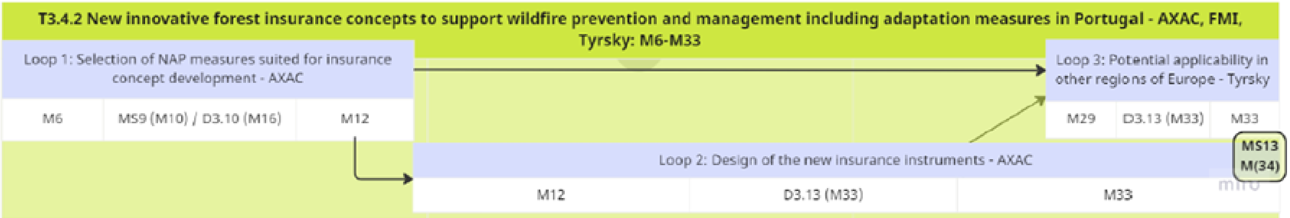

Figure 1: Overview of the different Loops

4 Loop 1

4.1 Overview

Table 1 provides an initial project overview:

Overview		
Period	From December 2023 to June 2024	
Objectives	The objective of this loop is to understand the baseline – or the current situation in Portugal regarding wildfire risks. These include: • Finalizing the pilot areas with the onboarding of the local stakeholders • Gathering the information necessary for the development phase • Harmonize all data necessary for wildfire simulations • Map the current wildfire risk in the study area • Identify the current and planned mitigation measures implemented in the study region based on the NAP • Build mitigation scenarios	
Methodology	• Interviews with AGIF experts to understand central Portugal challenges and the NAP • Desk review of historical fires in the area with AXA Climate current wildfire insurance tools • 1h workshop every three months with PIISA members involved in this pilot to present the intermediate results and findings	
KPIs	KPI description	Target value
KPI 1	Scenarios of wildfire mitigation	3
KPI 2	Number of interviews with AGIF	3

KPI 3	Number of wildfire mitigation measures periodized for different levels of wildfire mitigation	3-5
Support expected from the other WPs	Expected results from: • Task 1.1: Challenges, barriers, and opportunities to reduce insurance protection gap and accelerate adaptation and resilience • Task 1.2: Gather all the data and map the current wildfire risk • Task 1.3: Prioritization of the wildfire mitigation measures with the local partner • Task 1.4: Build wildfire mitigation scenarios for risk modelling • Task 2.1: Actuarial Risk Modelling, state-of-the art, challenges and innovation potential. • Task 2.2: Framework for harmonized sharing of risk and losses data • Task 2.4: Co-development of the services for the pilots	
Partners involved	AXA Climate, Fondazione CMCC, FMI, Amigo Climate, Tyrsky	
Stakeholders involved	AGIF	
Output	• Gather information about historical wildfires, climate, and vegetation in the study area • Map current wildfire risk at plot level • Identify and prioritize the mitigation measures that are going to be used in modelling the scenarios • Build the wildfire mitigation scenarios	

Table 1: Overview of Phase 1

An initial analysis of Portugal's forest landscape was conducted, showcasing that fire has remained a major hazard and driver of forest cover change in Portugal, with evolving climate conditions likely to drive increasing risks of wildfires. The wildfires occurred primarily in northern and central Portugal, with an increasing trend of burned areas over the past decades, from 1975 to 2017, as can be seen in Figure 2 (Meneses, Reis, et al., 2018). For example, the wildfires that occurred on 17 and 18 June 2017 alone caused more than 40,000 ha of burned area, and 64 fatalities, according to the Portuguese National Civil Protection Authority (ibid). An intense heat wave preceded the fires, with many areas of Portugal seeing temperatures more than 40°C. At the same time, forest insurance is often considered too costly by insurers and policyholders due to limited knowledge and quantifiable assessment frameworks. Households therefore have little incentive to insure or adapt to wildfire risk, as they receive full government compensation for reconstruction costs.

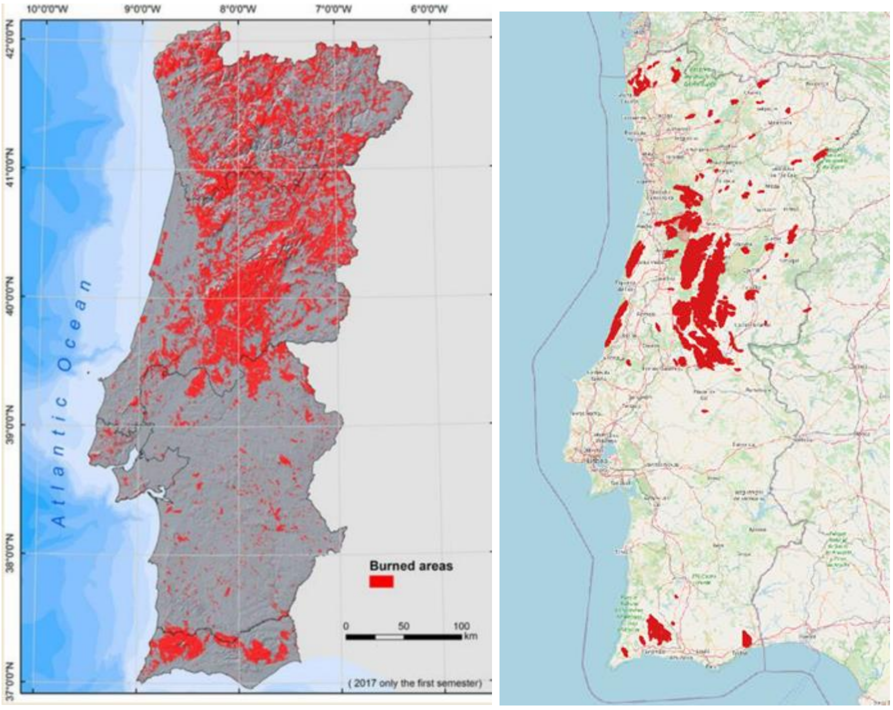

Figure 2: Map of the historical burned areas in Portugal (1975-2017) and extreme wildfire events over the recent period (2015 and 2021).

4.2 Pilot Location

The pilot location is in the Centre of Portugal, in the Caramulo and Ribeira de Mega region. Figure 3 displays the study areas and their locations. The pilot areas were chosen based on their history of wildfire losses, diversity of exposures (forest and houses) and the presence of more consistently developed adaptation plans. Both pilot areas are characterized by a Mediterranean climate, with hot, dry summers and mild, wet winters. During the summer, prolonged periods of high temperatures, low humidity, and strong winds create ideal conditions for wildfires (Turco, 2019). These fire-prone climate conditions are getting more frequent and intense with climate change (Galizia 2023). Both regions are covered by dense pine forests, eucalyptus plantations, and shrubs, which are highly flammable and act as abundant fuel sources for wildfires. Eucalyptus species, in particular, are known for their high oil content, which increases the intensity of fires and the speed at which they spread. In addition, the region's forests are often under-managed, with large accumulations of dry leaves, branches, and deadwood, further increasing the risk.

The Caramulo region has been the site of several devastating wildfires in recent years, most notably in 2013, when a series of fires burned over 9,000 hectares, resulting in loss of lives and significant damage to the environment and infrastructure. The Caramulo region has also high population exposure with many small villages and people living in the wildland-urban interfaces. Ribeira de Mega has also been impacted by wildfires, such as in 2017 when the region was almost totally devastated by the previously mentioned large fire of 2017 (Pedrógão Grande Fire). Ribeira de Mega is dominated by a more dispersed rural population, with large areas of continuous

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unmanaged forest. The chosen area was focused on as the goal was to study an area with high wildfire exposure, which is also representative of the region's socio-economic characteristics.

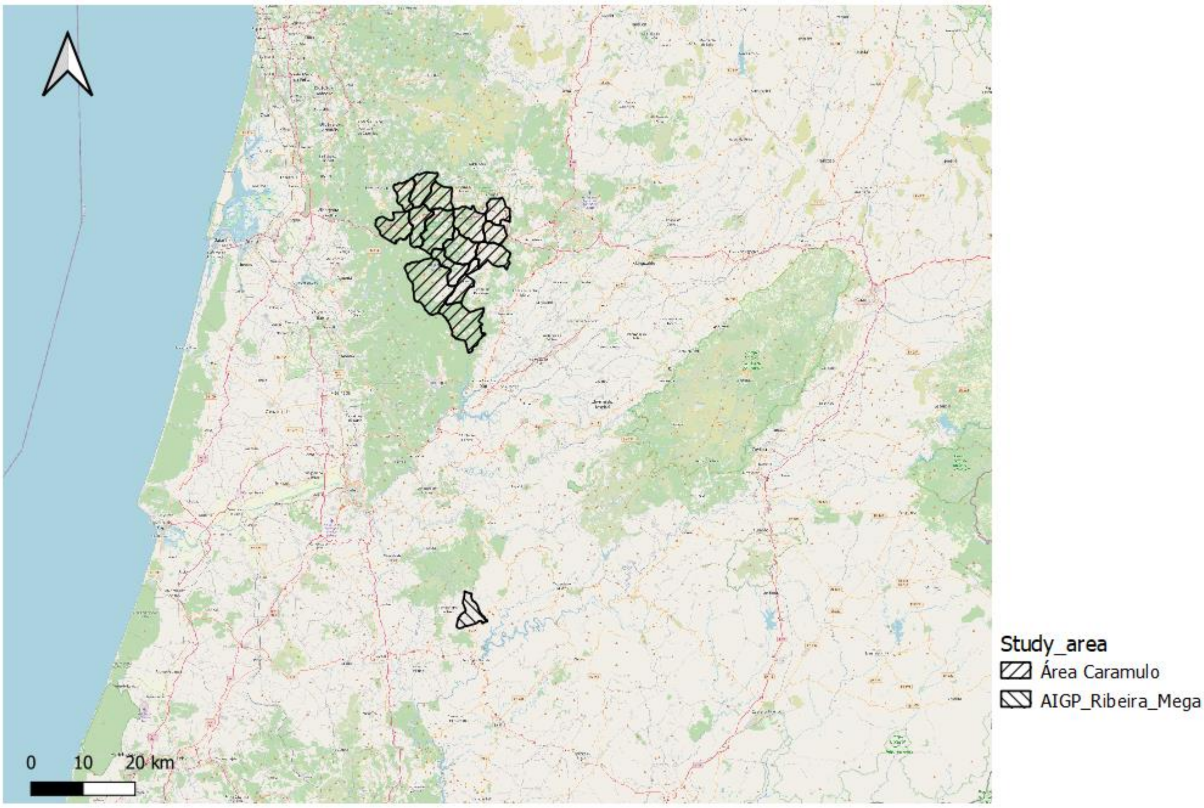


Figure 3: Pilot areas in the center-north of Portugal. Area of Caramulo and Ribeira Mega were selected based on the planned adaptation measures, in agreement with AGIF and CCDRC teams

4.3 Rural Fire Management System

This pilot involves a partnership with the CCDRC and AGIF of Portugal. The project first identified adaptation measures relevant to wildfire risk in central Portugal, drawing on the NAP of Portugal and collaborating with the CCDRC. This was followed by the collection and harmonization of all necessary data to map and model wildfire risk accurately at the pilot location. The wildfire model developed will then be updated to incorporate adaptation strategies and scenarios for wildfire mitigation in subsequent loops, eventually leading to the creation of an innovative wildfire insurance scheme. This scheme will be designed to incorporate wildfire risk mitigation into its pricing structure, identifying key stakeholders such as policyholders, premium financers, and beneficiaries.

A questionnaire was designed to gain insights on Portugal's NAP and the related adaptation strategies and climate service needs. It involved questions regarding the organization and planning of wildfire mitigation activities, regulations, prioritization of areas at risk and the type of mitigation measures implemented in the region. The questionnaire was shared with various stakeholders and was administered by AGIF.

The NAP focuses on enhancing and caring for rural spaces, modifying behaviors of community members by focusing on education and awareness raising efforts, and efficient risk management. It aims to achieve (i) the reduction of the cumulative burned area to less than 660,000 ha; (ii) the reduction of the percentage of fires larger than 500 ha to less than 0.3% of the total number of fires; and (iii) the reduction of loss of lives in rural fires.
It involves two key strategies:

1. Primary network of fuel management strips (or simply, fire breaks): A primary network of fuel management strips is identified in the NAP. These strips aim to intercept the fire spread and create favorable conditions to stop fires. The strips have a standard width of 126 meters, and are established in strategic locations within rural territories to segment forest areas, ideally ranging between 500 to 10,000 hectares.
2. Secondary network of fuel management strips: The secondary network of fuel management strips serves to stop the fire spread, passively protecting routes, infrastructure, social facilities, and built-up areas. Its standard width is 50m for isolated buildings, 100m for populated clusters with more than 10 houses that are not more than 50m apart, and 10m for each side of roads, including railways and power transmission lines and the strategic fuel management.

The policy response to the increasing wildfire threat in Portugal is outlined in the National Integrated Fire Management Plan, developed by AGIF. This adaptation plan emphasizes a fuel management program aimed at reducing the wildfire exposure of vulnerable communities, as well as minimizing the area burned and the occurrence of large wildfires (greater than 100 hectares). Figure 4 illustrates the various adaptation measures planned for the Ribeira da Mega region. These mapped measures will be incorporated into landscape models to simulate the impact of fire breaks on vegetation cover, enabling the assessment of wildfire risk both with and without the implementation of adaptation strategies.

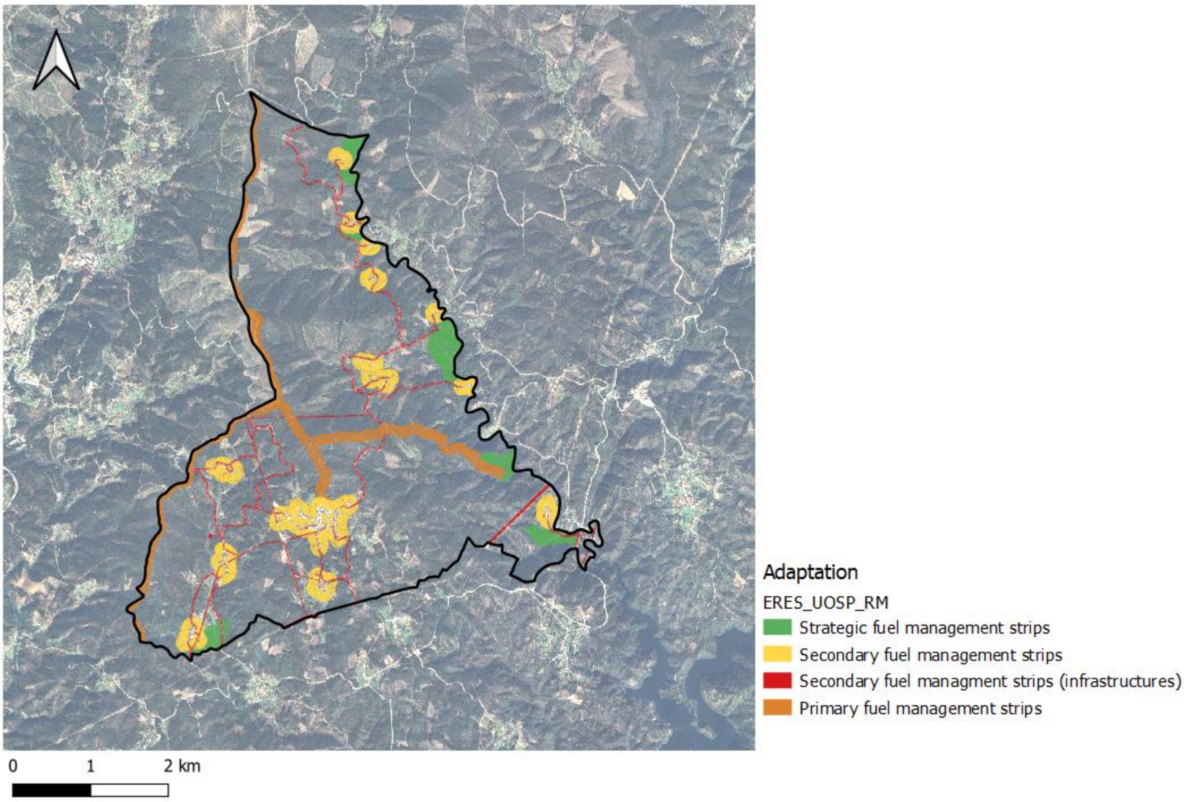


Figure 4: Wildfire adaptation measures defined for Ribeira da Mega area, including different fuel management types to decrease wildfire risk in the study region

4.4 Iterative Design and Development

The iterative research and design process was structured around many work sessions that were conducted between December 2023 and September 2024. These sessions facilitated continuous collaboration and refinement, allowing the different stakeholders to input and feedback into the design process at every stage, ensuring the overall effectiveness and relevance of the final deliverables. Further details regarding the timeline and workplan surrounding these work sessions can be seen in Table 2.

Date	Type of Activity	Partners Involved	Summary
13.12.2023	Kickoff Meeting	AXA Climate, AGIF/CCDRC, FMI	Portuguese speaking pilot kickoff held with AGIF/CCDRC (local partners for ground-based data and wildfire adaptation in Portugal), and FMI. Questionnaire on adaptation measures and climate services needs sent to AGIF.

04.03.2024	Work session 1	AXA Climate, Amigo Climate, CMCC, FMI, Tyrsky	First session focused on discussions around challenges and insurance needs, and initial conversations about wildfire modeling options.
30.05.2024	Work session 2	AXA Climate, FMI, CMCC	Presentation of 8 key wildfire risk reduction measures. Two pilot sites selected in Portugal. Presentation on modelling wildfire mitigation (fire breaks, thinning, prescribed burn)
20.06.2024	Work session 3	AXA Climate, AGIF	Data collection completed. First step involves modelling extreme fire events in Portugal to understand how models behave. Need to involve Portuguese fire researchers to feedback into the work, plans for a potential scientific publication.
01.08.2024	Loss and Damage Work Group	AXA Climate, AGIF, CMCC,	Discussion on the wildfire pilot rollout. Emphasized alignment between PIISA project and the Loss and Damage Working Group (municipalities, local insurance, and potential frameworks).
02.08.2024	Work Session 4	AXA Climate, FMI, AGIF, CMCC	Presentation of initial fire simulations and modeling conducted. Plans for new type of model to include adaptation measures, and for calibration of models with FMI

Table 2: Work Session Breakdown

Wildfire parametric insurance works by analyzing historical burned areas and comparing them with past losses and damages experienced by clients or communities. Unlike traditional indemnity insurance, which compensates based on the actual loss incurred, parametric insurance uses third-party data to establish an insurance pricing model tied to specific environmental triggers, such as the size of the burned area or fire intensity. This is measured by third-party data such as satellite data, and when these predefined thresholds are met, payouts are automatically triggered, providing rapid financial relief without the need for loss assessments.

Wildfire parametric insurance primarily functions by studying the historical burned areas, comparing them with the historical losses and damages by the client or community, and using this data to develop an insuring pricing model. Intuitively, an event or an area with lower risk will have a lower premium, while that of a higher risk will result in a higher premium. However, adaptation measures provide an opportunity to decrease the risk and subsequently the price of the insurance policy, which is a key focus of this pilot project. Some of these adaptation measures can be seen in Figure 5, though the primary focus of this pilot will be the fire breaks adaptation strategy, as the models are more accurate for them. There is a precedent for integrating wildfire adaptation into insurance risk pricing, shown through a study led by The Nature Conservancy (TNC) and Willis Towers Watson (WTW) in 2021, which found that the wildfire risk reduction benefits of ecological forestry for insurance are quantifiable, significant, and far-reaching. They showed that ecological forestry at a landscape scale can significantly reduce expected residential home losses due to wildfires, consequently reducing residential insurance premiums. Furthermore, they found that wildfire parametric insurance premium estimates decrease with ecological forestry, with 20% to 40% reductions for case study scenarios consistent with the scale of the French Meadows ecological forest project studied in the report (TNC & WTW, 2021).

Figure 5: Overview of Adaptation Strategies to mitigate the wildfire risk.

In order to quantify the benefits of the adaptation measures it was necessary to collect a set of climate, vegetation, topography and fire data for the study areas to feed the fire spread models which will be used to simulate adaptation scenarios. The data was collected from open-source datasets such as the historical weather conditions, collected from ERA5- Land hourly data from 2000-present day; Portuguese land cover data; topography from SRTM; forest canopy height from GEDI NASA; historical fire from MODIS; and the ICNF national dataset. A summary of the data used in this project is summarized in Table 3. All the spatial data was harmonized (resampled to 100m spatial resolution), with initial raster maps visible in Figure 5, and soon will be publicly available.

Type	Input	Description	Spatial resolution	Source
Vegetation	Land cover	Land Cover Map 2010 (COS 2018)	100 m	https://snig.dgterritorio.gov.pt/
Vegetation	Forest canopy height	GEDI Lidar measurements and Landsat data (2019)	30 m	https://glad.umd.edu/dataset/gedi

Topography	Topography (DEM)	SRTM-GL1 elevation data (2000)	30 m	https://appeears.earthdatacloud.nasa.gov/task/area
Weather	Weather conditions (T, RH, Wind)	ERA5-Land data, hourly from 2000 to 2023	9 km	https://cds.climate.copernicus.eu/
Fire history	Observed fires	Extracted from MODIS burned area MCD64A (2001-2023)	500 m	https://lpdaac.usgs.gov/products/mcd64a1v006/
Fire history	Extreme fires	Extreme wildfire events (2015-2021) ground-based	100 m	https://essd.copernicus.org/articles/15/3791/2023/

Table 3: Overview of data sources, resolution and source.

The landscape data, including vegetation and topography, are presented in a static landscape file (Figure 6), representing the current conditions of vegetation and fuel loads in the study area. This information will be used to calibrate fire models in order to replicate historical fire regimes during Loop 2 of the analysis.

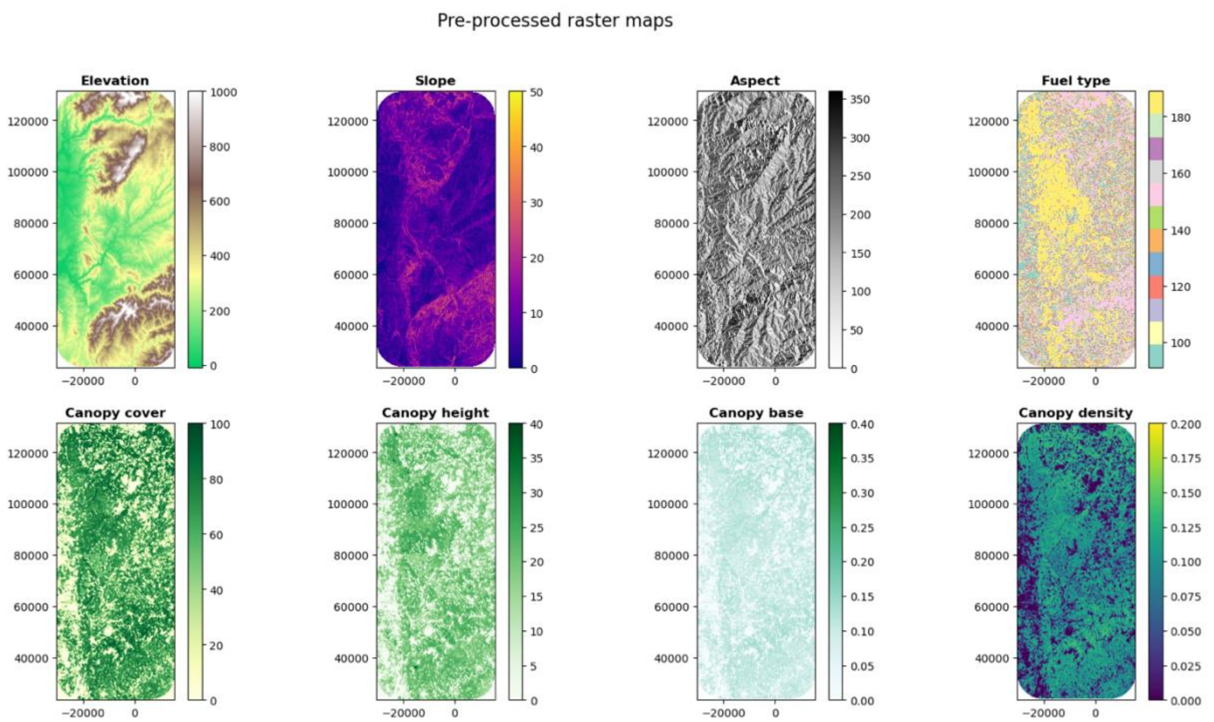


Figure 6: Postprocessed data collected and harmonized used as in the fire model as inputs.

5 Loop 2: Wildfire Modeling Process

The wildfire modeling process for the study region was commenced by AXA Climate, following the general outline showcased in Figure 7. This process which will estimate the insurance premium based on annual expected losses. Figure 7 also demonstrates how adaptation measures could be included into the modeling process. This analysis will be conducted at a later stage of the pilot, and will form the basis to develop an innovative insurance product.

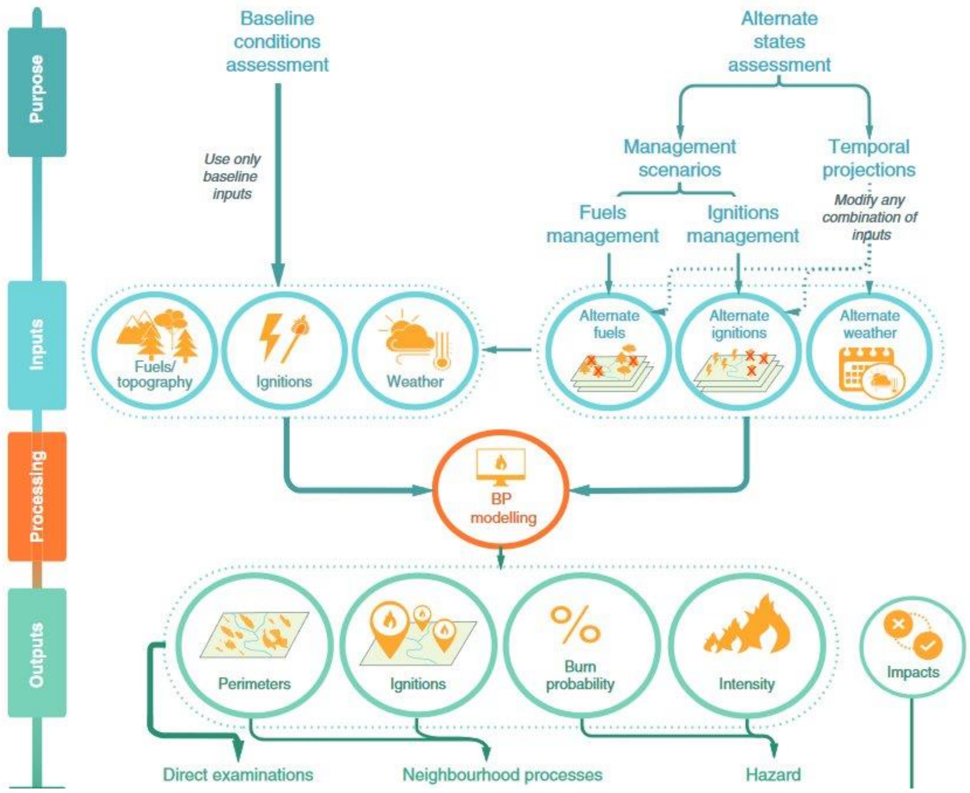


Figure 7: Simulation based burn probability modeling overview (Parisien, et al., 2019)

Preliminary model calibration results can be seen in Figure 8, where simulated fires are highly correlated and largely overlapping with historical fires in Portugal. This shows promising initial results, which will be further investigated and developed in upcoming loops of the pilot.

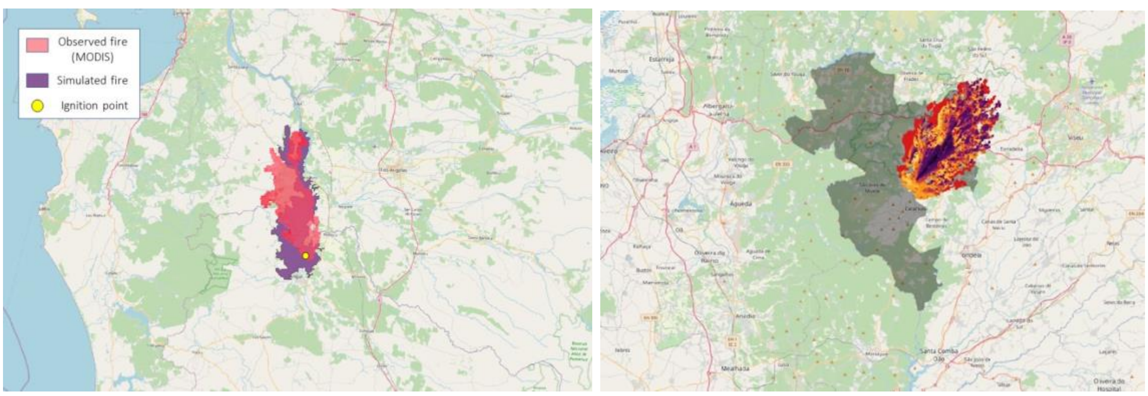


Figure 8: Comparison between observed and simulated extreme fire events in 2020 (Left) and 2017 (Right) respectively

6 Project challenges and limitations

The project also faces some limitations that could impact its outcomes. One key limitation is the limited availability of historical wildfire loss data in monetary terms, which is crucial for accurately assessing the financial impact of wildfires over time. This data gap, supplemented by the limited availability of ground-based wildfire records, hinders our ability to validate and refine loss reduction models, as financial losses from past events could serve as a reference point for assessing the effectiveness of adaptation models and insurance solutions. We are working in close collaboration with AGIF to ensure any updated financial loss information is provided to us to incorporate into the model. If no such data is procured through the duration of the project, we can utilize data from other similar regions as a proxy to feed into our work.

Additionally, the complexity of the models and the significant computing power required for simulations could present some technical challenges. Calibration efforts aimed at replicating the historical distribution of fire size and burned area are therefore limited by these technical constraints. For the time being, the model also does not account for mitigation actions related to changes in vulnerability, human behavior, and firefighting efforts, which are all important factors in real-world wildfire scenarios, but challenging to accurately model due to the high uncertainty and lack of comprehensive data. However, some data such as on firefighting efforts could be included in the model to improve the performance of simulations, if available in coming loops.

There also exists a mismatch between economic losses and the perceived risk, which could lead to inaccurate assessments of wildfire risk impacts. One of PIISA's objectives is to also bridge this knowledge gap, and this deliverable will contribute to reduce this mismatch. There is also a lack of detailed datasets to build characteristics, material resistance, and vulnerability curves specific to different structures and forest types at a EU level, which could hinder the replicability potential of this project. These limitations add challenges toward accurately modeling and predicting wildfire impacts.

However, it's important to highlight that without fire, there is no risk, and therefore no losses. Wildfire simulation modeling studies have proved helpful for predicting the catastrophic events causing the most extensive threat and losses to property and natural values (Ager, et al., 2021). The proposed method is robust enough to estimate where fires may occur, as well as how likely they are, which is crucial for risk assessment. This lends credibility toward assessing the risk, which guides us to the development of an insurance policy. Finally, as building-specific vulnerability assessments and economic loss data improve, they can be integrated into the insurance framework, helping to reduce some uncertainties of the risk assessment process.

7 Next steps and Upcoming Work

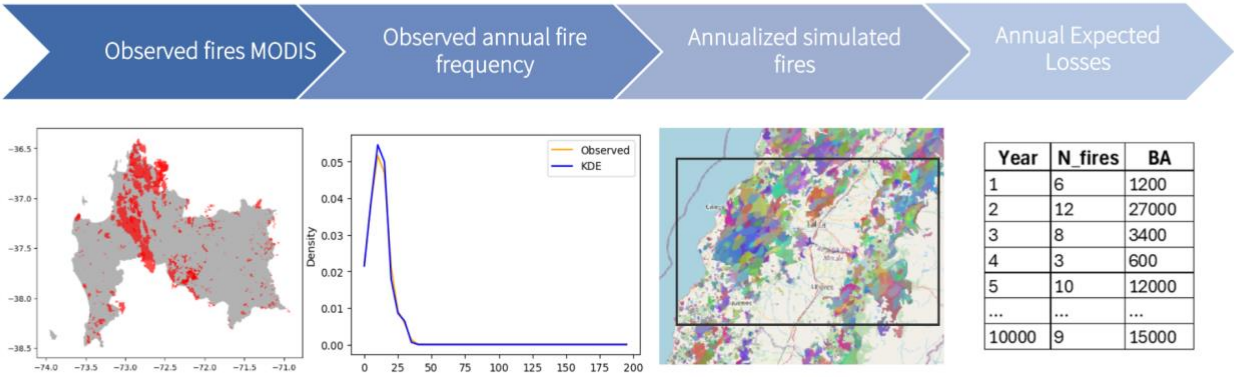
Upcoming work for this project will involve additional modeling fire spread to further understand potential wildfire dynamics and their impact, including by reproducing fire size distribution and burned areas. The AXA Climate and FMI models will be calibrated and compared for large fires in Portugal, the wildfire catalogues of simulated fires will be built, and the wildfire spread will be simulated again under various scenarios of adaptation. This will be done in one of the two following ways:

1. Adding adaptation scenarios and running new fire scenarios: The first method is outlined in Figure 7, and involves incorporating alternate adaptation scenarios into the wildfire model itself, which will be followed by running new simulations to understand how these interventions affect the wildfire behavior.

2. Intersection of simulated fires with existing fire containment thresholds: The second method involves overlaying simulated fire data with predefined thresholds for fire containment, as established by existing research. One such threshold that could be utilized is the containment of fires with flame lengths up to 2.5 meters, as suggested by Aparicio et al. (2022). This threshold is significant as it represents a critical point at which fires can typically be contained by firefighting efforts under a baseline scenario. Such a model would help refine insurance models by identifying where losses are more likely to occur based on the likelihood of uncontrollable fire behavior, and could also enable the development of a targeted risk mitigation strategy in high risk areas.

The model will then be further tested and calibrated by comparing it with observed losses to ensure accuracy and reliability, and this will be vigorously peer-reviewed and feedbacked by inviting local scientists and experts.

To provide an example overview of what this entire process would look like, a potential post processing outline going from the historical and observed fires to the annual expected losses from simulation of 10.000 hypothetical years can be studied in Figure 9.



Year	N_fires	BA
1	6	1200
2	12	27000
3	8	3400
4	3	600
5	10	12000
...	...	...
10000	9	15000

Historical wildfires over 23 years are used to represent the fire regime of a fire regime region where the client is located.

The number of observed fires per year is computed and a distribution is fitted to represent the annual variability of fire occurrences in the region.

Based on the fitted distribution a specific number of fire events is randomly selected from the wildfire catalogue to build hypothetical years.

The process is computed 10K times to reproduce hypothetical years. Each fire polygon is intersected with the client's forest plot and the burned area is computed to estimate the AEL.

Figure 9: Post Processing: Wildfire catalogue to AEL

The remainder of Loop 2 will focus on designing new insurance instruments through two levels of action: (i) developing tailored insurance solutions for individual householders to incentivize and support wildfire prevention measures, and (ii) exploring insurance packages for forest managers. Based on the chosen strategy, various wildfire mitigation and adaptation scenarios will be built, providing insights into effective risk reduction strategies. The project will then calculate the potential reduction in insurance premiums that could result from implementing these mitigation measures, offering a more affordable and sustainable insurance solution.

Finally, in Loop 3, the potential applicability of the developed solutions will be tested in other regions of Europe. A webinar will be organized to present the wildfire insurance concepts developed in Loops 1 and 2, along with the lessons learned. The webinar will target stakeholders defined by WP4 and will help identify the potential for replication, as well as barriers and enablers, with active participation from stakeholders in a workshop setting.

The final outputs of this project would therefore include updated insurance schemes designed for the pilot location, which will then be tested and potentially replicated in other European locations. The results of this replication exercise will also be provided. Several surveys and workshops to increase awareness as well as receive feedback into the work will be conducted, and finally an updated report will be published, outlining the final results of the pilot project, and all its stages.

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8 Bibliography

Ager, A.A.; Day, M.A.; Alcasena, F.J.; Evers, C.R.; Short, K.C.; Grenfell, I. Predicting Paradise: Modeling future wildfire disasters in the western US. Sci. Total Environ. 2021, 784, 147057

Alcasena, F., Ager, A., Le Page, Y., Bessa, P., Loureiro, C., Oliveira, T., 2021. Assessing Wildfire Exposure to Communities and Protected Areas in Portugal. Fire 4, 82. https://doi.org/10.3390/fire4040082

Agência para a Gestão Integrada de Fogos Rurais. (AGIF). National Plan for Integrated Plan for Integrated Wildfire Management 2020–2030; Agency for Integrated Rural Fire Management: Lisbon, Portugal, 2020

Aparício, B. A., Alcasena, F., Ager, A., Chung, W., Pereira, J. M., & Sá, A. C. (2022). Evaluating priority locations and potential benefits for building a nation-wide fuel break network in Portugal. *Journal of environmental management*, *320*, 115920. Retrieved from https://doi.org/10.1016/j.jenvman.2022.115920

Copernicus. (2024). Record wildfires emissions in Portugal. Atmosphere Monitoring Service. Retrieved from https://atmosphere.copernicus.eu/copernicus-record-wildfires-emissions-portugal

European Environment Agency. (EEA). (2021). Forest fires in Europe. Retrieved from https://www.eea.europa.eu/en/analysis/indicators/forest-fires-in-europe

European Union. (2018). Copernicus Land Monitoring Service 2018. European Environmental Agency (EEA). Retrieved from https://land.copernicus.eu/

Galizia, L. F., Curt, T., Barbero, R., & Rodrigues, M. (2021). Understanding fire regimes in Europe. *International Journal of Wildland Fire*, *31*(1), 56–66. Retrieved from https://doi.org/10.1071/wf21081

Leal, M., Hudson, P., Mobini, S., Sörensen, J., Madeira, P. M., Tesselaar, M., & Zêzere, J. L. (2022). Natural hazard insurance outcomes at national, regional and local scales: A comparison between Sweden and Portugal. *Journal of Environmental Management*, *322*, 116079.

Leone, V., Elia, M., Lovreglio, R., Correia, F., & Tedim, F. (2023). The 2017 extreme wildfires events in Portugal through the perceptions of volunteer and professional firefighters. *Fire*, *6*(4), 133.

Meneses, B. M., Reis, E., & Reis, R. (2018). Assessment of the recurrence interval of wildfires in mainland Portugal and the identification of affected LUC patterns. *Journal of Maps*, *14*(2), 282–292. Retrieved from https://doi.org/10.1080/17445647.2018.1454351

Parisien, M. A., Dawe, D. A., Miller, C., Stockdale, C. A., & Armitage, O. B. (2019). Applications of simulation-based burn probability modelling: a review. *International journal of wildland fire*, *28*(12), 913-926.

Pereira, M. G., Trigo, R. M., da Camara, C. C., Pereira, J. M., & Leite, S. M. (2005). Synoptic patterns associated with large summer forest fires in Portugal. *Agricultural and Forest Meteorology*, *129*(1-2), 11-25.

The Nature Conservancy (TNC) & Willis Towers Watson (WTW). (2021). Wildfire Resilience Insurance: Quantifying the risk reduction of ecological forestry with insurance. Retrieved from https://www.nature.org/content/dam/tnc/nature/en/documents/FINALwildfireresilienceinsurancesummaryofinsights6.27.21PAGES.pdf