D2.5: Final report on SILVANUS formal assessment methodologies

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Abstract:	D2.5 outlines the final version of the Impact assessment framework to be adopted in the second phase of the SILVANUS pilot activities. The final impact assessment framework will be used to evaluate the performance and effectiveness of the SILVANUS platform and its components (User Products, UPs) during WP9 pilot activities. For every UP a set of KPIs, to evaluate performance, have been identified, as well as surveys to evaluate the SILVANUS platform.

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List of acronyms and abbreviations

ACRONYM	Description
CSA	Coordination and Support Action
DX.Y	Deliverable X. Y (X refers to the WP and Y to the deliverable in the WP)
EC	European Commission
EI	Expected Impact
EU	European Union
IA	Innovation Action
KPI	Key Performance Indicators
MVP	Minimum Viable Product
PS	Pilot Site
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
UI	User Interface
UP	User Product
UX	User Experience
WP	Work Package
FDI	Fire Danger Index

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Executive Summary

The purpose of this deliverable is to publish the finalised version of formal assessment methodology to be adopted in the second iteration of pilot demonstration activities. SILVANUS is an environmentally sustainable and climate resilient forest management platform to prevent and combat against forest fires. Such platform will be demonstrated and validated across eight (8) EU Member States regions, France, Italy, Slovakia, Greece, Czech Republic, Portugal, Croatia, and Romania, and three (3) non-EU (and International) countries namely Indonesia, Australia, and Brazil.

The first impact assessment framework has been used to serve as a catalyst for the development of the Final impact assessment framework. Since the second iteration of pilot activities is already underway, the Final impact assessment framework will be used to evaluate the performance and effectiveness of the SILVANUS platform throughout the ongoing second iteration of pilot activities.

The building of the impact assessment framework needs to consider several variables. To do so, the deliverable extends from "D8.3 - Report on SILVANUS final reference architecture" and "D8.4 - SILVANUS platform" the two deliverables that report on the architectural components of the final report on the SILVANUS platform reference architecture.

This deliverable differs from D2.3 in the following key aspects:

- The list of User Products (UPs) has been updated to include all the products that the SILVANUS project had developed, extending beyond MVP.
- The specifications for each UP have been revised to reflect their integration into the SILVANUS platform.
- The KPIs for each UP have been refined to better align with their specific functionalities.
- The mapping established between each UP and the Expected Impacts (EIs) set by the Green Deal for 2030 has been clarified.

1 Introduction

The SILVANUS project aims to create an environmentally sustainable and climate-resilient forest management platform designed to prevent and combat fire ignition, as well as develop recovery plans to enhance forest resilience. To ensure the platform's high performance, it will be tested through pilot demonstrations in various scenarios and environmental conditions. These pilot activities will take place in eight EU member states: France, Italy, Slovakia, Greece, Czech Republic, Portugal, Croatia, and Romania, in addition to Indonesia, Australia, and Brazil.

As a mean of verification of the correct use, efficiency, and performance of the platform, an assessment framework, that will be the final version of the already delivered D2.3, will be realised and presented in D2.5, and will collect and analyse the outputs obtained from the pilots' demonstrations.

Following an increase in extreme wildfires, the Green Deal prioritized the reduction of forest fire incidence and extent, along with the need to predict and manage environmental disasters, in the Horizon 2020 calls. The measurable goals that funded actions should aim to achieve to maximize their impact are the Expected Impacts (EIs), which need to be accomplished by 2030 and will be further explored in the D2.5.

D2.5's objective is to develop the **second and final version of the Impact assessment framework** and implement it during the final tranche of pilot sites to evaluate the project platform. This deliverable aims to present the **final set of identified User Products** (introduced in D8.3) and establish a set of **KPIs** that will serve as quantifiable measures for use in pilot scenarios.

The second version of the SILVANUS platform is committed to incorporating an Integrated Fire Management (IFM) approach, as discussed during the 1st project review. This approach considers an updated set of functionalities (User Products, or UPs) that are part of, and integrated into, the latest version of the SILVANUS platform. The role of these functionalities in various phases of the project, and subsequently in the pilot activities, has been thoroughly detailed in D8.3, D8.4, and partially in this deliverable.

SILVANUS collaborates with its sister projects (TREEADS and FIRE-RES) under the coordination of the CSA Firelogue to achieve the EI goals outlined by the Green Deal. The main objective of these projects is to establish a common methodology for impact assessment. This deliverable will explore in more detail the links between the UPs developed in SILVANUS with each of the EI of the Green Deal. D2.5 also highlights the collaborative efforts with these projects.

The document contains the following sections detailed below:

Section 2: Background Information provides an overall view of the initial version of the impact assessment framework, and the updates that have been provided in D2.5, including a brief description of the final set of identified User Product that will be used to validate the final set of the project pilots. Additionally, the cooperation with Firelogue and WFRM projects is mentioned.

Section 3: Adopted Approach provides a detailed description of how SILVANUS' UP indirectly impact the EI of the Green Deal, along with a justification for the reasoning behind these connections. Additionally, a set of KPIs has been defined for the validation of each User Product (UP).

Section 4: SILVANUS Platform describes the architecture of the final version of the SILVANUS platform and introduces a survey designed to assess user satisfaction with the platform.

Section 5: SILVANUS Formal Assessment Framework provides an overview of the final version of the impact assessment framework and explains its structure in detail. Additionally, it outlines how the final impact assessment framework will be implemented and validated during the project's last tranche of pilots.

Section 6: Conclusions provides the overall conclusions of the deliverable.

ANNEX I: UP KPIs Additional Information includes additional information regarding the KPIs that have been assigned to each UP, including eventual internal testing and validation, and their application in pilots' scenarios.

ANNEX II: Contribution from ASSET - Historical review of forest resilience to wildfires provides an analysis carried out by the partner ASSET of the historical reports (2010-2022) on wildfires in the 11 demonstration sites, to collect and analyse the most common causes of wildfires, e.g., climatic factors, weather conditions, human negligence. It also seeks to systematically classify the case studies by cause using, for example, GIS georeferenced files from the EFFIS platform - European Forest Fire Information System.

2 BACKGROUND INFORMATION

2.1 Updates of Impact Assessment framework

The scope of the impact assessment framework is to evaluate the SILVANUS platform and its individual functionalities in reaching the scope for which it has been developed that arise from the objectives set by the Green Deal related to wildfire.

The initial version of the impact assessment framework was developed based on a limited set of features that can be considered a Minimum Viable Product (MVP). These functionalities have been categorized and detailed within a series of User Products (UPs), each primarily focusing on the outcomes of specific technical work packages and tasks. The features included in the MVP, identified since the project's kick-off, were:

- UP1: AR/VR training toolkit for trainers
- UP2: Fire danger risk assessment
- UP3: Fire detection based on social sensing
- UP4: Fire detection from IoT devices
- UP5: Fire detection from UAV/UGV
- UP6: Fire spread forecast
- UP7: Biodiversity profile mobile application
- UP8: Citizen engagement program and mobile app

As the project progressed, the number of features (UPs) have been enriched (as shown in Table 1), and these now represent the full functionality of the SILVANUS platform.

The final version of the SILVANUS impact assessment framework incorporates the factors considered in the initial assessment, along with the new features introduced by the completed SILVANUS platform and the addition of new user products. All SILVANUS UPs implement key project enablers aligned with the three identified Phases A, B, and C. These will guide the design of the SILVANUS platform architecture and the development of the necessary components.

UP#	Description	Phase	WP/Task	UP owner
UP1	AR/VR Training Toolkit	A	T3.4	SIMAVI
UP2	Fire Danger Risk Assessment	A/B	T3.2/T5.1	SIMAVI/CMCC
UP3	Fire Detection based on Social Sensing	B	T4.4	CERTH
UP4	Fire inspection using UAVs and IoT devices	B/A/C	T4.3 /T5.1	CTL /ATOS
UP5	Fire detection using UAVs and UGVs	A/B	T4.5/ T4.6	CSIRO/ 3MON/TRT
UP6	Fire spread forecast	A/B	T5.1/ T5.3	EXUS/ TUZVO
UP7	Biodiversity profile mobile application	A/B/C	T2.4	VTG
UP8	Citizen's engagement programme using mobile app and CEP course	A/B/C	T3.5/T3.6	HB/ MDS/ UISAV
UP9	Decision Support System	A/B/C	T5.3	INTRA, UTH, AMIKOM, CTL, AUA
UP10	SILVANUS forward command centre	B	WP5	DELL
UP11	SILVANUS platform and dashboard	A/B/C	WP5	ITTI
UP12	MESH-in-the-Sky	A/B/C	WP5	RINI

Table 1 - UPs included in the 2nd SILVANUS platform release

The final version of the **impact assessment framework** takes in consideration the following factors:

- the scope of the platform. That is: to provide technological and decision-making support in preparedness (phase A), response (phase B) and recovery (phase C) phase of wildfire management cycle and increase the human, environmental and economy resilience to wildfires;
- the expected impact set by the Green Deal, shown in Table 2. The Green Deal has set 8 EI related to wildfires and SILVANUS will directly target them as it has been developed in order to contribute to achieving such targets;
- the 2nd version of the SILVANUS platform. As the project progressed, the final impact assessment framework took into account the innovations and features introduced in the second version of the SILVANUS platform.
- the organisation of the pilots' activities. As during the pilots' activities no real fire (even in controlled environments) will be set up to evaluate the efficiency of the platform, many UPs that are built to directly tackle fire (for detection or response) will need to be tested accordingly. Hence, simulation will be made during the pilots and some KPIs will be indirectly measuring the efficiency of the UPs in achieving the EIs, where direct measuring of UP efficiency will not be an option.

EI1	EI2	EI3	EI4	EI5	EI6	EI7	EI8
0 fatalities from wildfires	0% reduction in accidental fire ignitions	5% reductions in emissions from wildfires	Control of any extreme and potentially harmful wildfire in less than 24 hours	50% of Natura 2000 protected areas to be fire-resilient	50% reduction in building losses	90% of losses from wildfires insured	25% increase in surface area of prescribed fire treatment at EU level

Table 2 - Expected Impacts set by the Green Deal that shall be reached by 2030 in Europe, with respect to 2019

As the platform has evolved, the individual UPs are no longer treated as standalone components but are now fully integrated within the SILVANUS platform to provide a cohesive solution. Although the functionalities are aligned with the defined Phases A, B, and C, the platform's overall design and implementation are guided by the principles of the IFM approach. This ensures that all phases work together in a seamless and coordinated manner to deliver a comprehensive and effective fire management strategy.

2.2 User Product Description

The SILVANUS UPs are intended for use across the different pilot sites as reported in D9.2. Their definitions were initially outlined in D8.3 and further detailed in a tabular format using the template provided in Table 3.

UPX – [UP name]	
UP leader	*Name/s of the partner that leads the development of the User Product*
UP description	*Description of the UP (what does it do, what can it be used for?)*
UP features in SILVANUS' platform	*List the main and secondary functionalities that will be included in SILVANUS' platform*
Testing sites	*In what pilot site/sites will the UP be tested?*

Table 3 - User Product definition template

UP1: AR/VR Training Toolkit for trainers

UP leader	SIMAVI
UP description	The AR/VR solution developed in SILVANUS is a complex toolkit for training first responders (fire fighters) through virtual modeling environments and real-life situations and wildfires simulations. The AR/VR platform allows first responders to experience training exercises and complex simulations, based on the real data from operational scenarios. The solution provides the first responders relevant information in real-time about the event (wildfire), status and environment, to speed up decision-making in case of major incidents and critical situations. It acts both as a player and as an authoring tool, enabling the users to participate in training programs and create also training scenarios based on their specific needs. Moreover, the AR/VR solution is designed for first responders to avoid dangerous situations and react in critical situations, but also to gain experience and learn about safety procedures by attending VR simulations inspired from real scenarios.
UP features in SILVANUS' platform	The AR/VR Training tool is a separate module and only a lite integration is possible.
Testing sites	Romanian pilot, French pilot

Table 4 - UP1 "AR/VR Training Toolkit for trainers" specification linked to pilot activities

UP2a: Fire Ignition Models	
UP leader	SIMAVI
UP description	This tool will generate and display the probability of fires and their frequency.
UP features in SILVANUS' platform	Depending on the selection made on a map and the historical data available for that area, the probability of occurrence of fires and their frequency will be generated and illustrated.
Testing sites	Romanian pilot

Table 5 - UP2a "Fire Ignition Models" specification linked to pilot activities

UP2b: Fire Danger Index	
UP leader	CMCC
UP description	The fire danger tool is responsible for forecast of Fire Danger Index (FDI) for the following day using ML based methods. The FDI gives the probability of forest fire occurrence in a pilot region on a 6-point scale (low values on the scale indicates low probability of wildfire and high values indicate high probability). The ML based FDI uses as input weather forecast, vegetation, land surface temperature, Corine land cover (CLC) classes, and variables concerning human involvement in forest fires (population density, road distances etc.). The weather forecast for the following day on each day is consumed from DDS, processed and combined with other inputs to produce the map of FDI. The forecast of the FDI shows which region of the pilot site which are at high risk of having wildfires. Having a map of the FDI thus helps in managing better the resources for fighting eventual fires that may happen on the following day.

UP features in SILVANUS' platform	• Primary functionality:
	    ○ Computation of the FDI and visualize in the Silvanus dashboard.
	• Secondary functionality
	    ○ Daily computation of the FDI for the pilot region

Testing sites	The FDI will be computed for at least 3 pilot sites – in particular Gargano (Apulia, Italy), Tepilora (Sardinia, Italy), and Cova da Beira (Covilhã, Portugal). In the year 2024 UP2b will produce FDI index on the day of the pilot activities for these pilots.

Table 6 - UP2b “Fire Danger Index” specification linked to pilot activities

UP3: Fire Detection based on Social Sensing	
UP leader	CERTH
UP description	The UP3 specializes in social media sensing and concept extraction to aid in the early detection of wildfires. By monitoring real-time data from platforms such as Twitter, the UP collects and analyses information based on predefined search criteria (e.g., keywords, phrases, or specific accounts) related to wildfire incidents. It detects potential fire events reported by citizens and visualizes these events within the Silvanus Dashboard for enhanced situational awareness. This integrated system offers a dynamic, of almost real-time display of fire activity, empowering authorities to respond swiftly and efficiently to emerging threats.
UP features in SILVANUS’ platform	The UP offers several key functionalities to support wildfire detection and response. It continuously monitors social media platforms, using a specialized crawler to collect posts containing fire-related keywords. Leveraging the Social Media Analysis Toolkit, it analyses both visual and textual content from the gathered posts to extract meaningful information. The Fire Event Detection Module then identifies potential wildfire incidents from this data. These detected fire events are visualized on the Silvanus Dashboard, where they are displayed as pins on an interactive map. This real-time visualization provides critical insights, enabling stakeholders to quickly assess fire locations and make informed decisions for effective wildfire management.
Testing sites	2023: Greece (PSTE) - Chalkida , France (lead PUI) - Limoges, Italy (lead ASSET) - Gargano National Park, Indonesia (lead AMIKOM) - Palangkaraya, Banjarmasin, Yogyakarta, Australia (lead CSIRO) - Brisbane 2024: Czech Republic (lead FRS) - Ostrava, Krásná, Italy (lead PRN) - Gargano and Sardinia, France (lead PUI) - Limoges, Greece (lead PSE) EVOIA

Table 7 - UP3 “Fire Detection based on Social Sensing” specification linked to pilot activities

UP4a: Fire Detection from IoT Devices	
UP leader	CTL
UP description	The developed IoT device collects data from its camera and sensors, and transmits them though the available networks (e.g., cellular) to SILVANUS cloud/FCC for storing and visualisation purposes. Furthermore, onboard processing of the collected images is performed (prior to their transmission), using lightweight ML algorithms, for the detection of smoke and fire. In the case, a fire or smoke outbreak is detected an alert is generated in the SILVANUS dashboard to inform the necessary authorities. Furthermore, the IoT data are fed to DSS-IDI (UP9h) for their further processing to create possible threat alerts, if needed. This device can be placed in the areas of interest, for example mounted on a tree or pole, to continuously monitor the area for any potential wildfires. In the case of a detected fire event, the IoT will increase its monitoring in order to provide more frequent updates to the necessary fire distinguishing authorities, which can increase the effectiveness and reduce response times. The collected data can be

	used to create archives of the area and studied by the interested authorities (e.g., foresters) to be used as a reference point in case of a reforestation action or to perform pruning in excessive vegetation growth. Lastly, multiple IoTs can be deployed around an area undergoing a prescribed burning, to monitor and alert when the fire approaches, helping to prevent it from spreading in unwanted directions.
UP features in SILVANUS' platform	The UP's main functionalities include the continuous monitoring and in-situ data collection (images and sensor readings – e.g., temperature). The identification of fire/smoke events from images and lastly, the generation of fire/smoke alerts in the SILVANUS dashboard. Secondary functionalities are the secure transmission of data, IoT system monitoring and old data removal, for security and storage availability reasons.
Testing sites	2023: Croatia, France and Australia. Gargano – Italy and Greece tabletop exercises. 2024: Czech Republic, Italy (Gargano and Sardinia) - remotely, Portugal, Croatia, Greece.

Table 8 - UP4a "Fire Detection from IoT Devices" specification linked to pilot activities

UP4b: Fire Detection at the Edge - from UAV Data	
UP leader	ATOS (EVIDEN)
UP description	This module detects fire and smoke in images in "near" real time using high-end devices for the analysis. Images of videos are provided by UAVs (sent via streaming transmission during flight or downloading them when landing) and ingested into the system. From this point, the module takes the photos or videos and analyses them. As an output, the images or videos with the fire and smoke detected are sent (with boxes over fire and smoke)
UP features in SILVANUS' platform	Detection of fire and smoke in images or videos in near real time: - Phase A: for prevention of fires using drones - Phase B: for improving operator awareness during fight against fire
Testing sites	2023: Greece (presential) 2024: Presential in Czech Republic, Portugal, Italy (both pilots) and Greece. Romania in remote

Table 9 - UP4b "Fire Detection at the Edge using UAV Data" specification linked to pilot activities

UP5: Fire detection using UAVs and UGVs	
UP leader	CSIRO
UP description	This module deploys a ground robot to the field and detects smoke and fire.
UP features in SILVANUS' platform	This module also generates 3D lidar information about the environment and quantifying undergrowth that can be used by domain experts to predict spread.
Testing sites	Australia QCAT

Table 10 - UP5 "Fire detection using UAVs and UGVs" specification linked to pilot activities

UP6: Fire spread forecast - modelling	
UP leader	EXUS
UP description	This module predicts the spread of fire over the next 24-hour period, given information about the current fire front, local meteorological conditions, local terrain and fuel/canopy information.

UP features in SILVANUS' platform	The main functionality is the prediction of fire front location in 28 discrete times over the next 24-hour period. The fire location is given as a probability/confidence of the fire being in the indicated location at a given time. As secondary functionality, the module further predicts the heat per unit area and provides a list of spot fire locations.
Testing sites	Czech Republic, Italy (Gargano and Tepilora), France, Greece

Table 11 - UP6 "Fire spread forecast - modelling" specification linked to pilot activities

UP7: Biodiversity profile mobile application (Woode app)	
UP leader	VTG
UP description	The Fire Prevention and Awareness Support mobile application (Woode) serves an important role in collecting important information about biodiversity of the forests, processing and extracting high level information, and spreading awareness regarding forest biodiversity and protection. The data derived from the collection and analysis will enable deeper understanding of the relation between the biodiversity of forests and fire related aspects such as landscape management and fire fuel threat assessment.
UP features in SILVANUS' platform	The features of the Woode mobile application can be categorised into application side and server (data processing) side. From the application side, Woode offers features for user to create account, take pictures of tree leaves, browse through collection of data, and read information about the biodiversity. The application has been optimised to provide necessary functionalities even during period without internet connection (when operated in the forest areas). From the server side (data processing), the Woode application offers range of computer vision solutions, including low level feature extraction, image segmentation, regions of interest detection, deep learning algorithms for object recognition and image classification.
Testing sites	Czech Republic, Slovakia, Italy, France, Greece, Indonesia, Australia

Table 12 - UP7 "Biodiversity profile mobile application (Woode app)" specification linked to pilot activities

UP8a: Citizen Engagement Application	
UP leader	MDS
UP description	The SILVANUS Citizen Engagement App is an important channel for citizens to increase their awareness regarding wildfires and their impact as well as engage them in fire-prevention and rehabilitation actions. The main goals are: - Unify scattered information and content from approved sources (firefighters, authorities, first responders) and tools regarding wildfire management in a single user-friendly application. - Provide a reliable communication channel between Citizens and Authorities/Firefighters through various information sharing features. - Increase Situational Awareness and engage Citizens in fire-prevention and rehabilitation actions. - Promote SILVANUS' innovation actions.
UP features in SILVANUS' platform	The app allows users (citizens) to create their profile, where they can browse through the content in the app and additionally, they can make fire reports. This data is then sent to the SILVANUS dashboard.
Testing sites	Czech Republic, Italy, Portugal, Slovakia, Croatia

Table 13 - UP8a "Citizen Engagement Application" specification linked to pilot activities

UP8b: Citizen application for situational awareness and information sharing (Fire Reporting and Fire Warnings)	
UP leader	UISAV
UP description	The SILVANUS Citizen Engagement App module is designed for information sharing among citizens, with a focus on wildfire reporting and warnings. The application uses the concept of information channels to facilitate the search for specific details. Its key objectives are: - Allowing citizens to search for relevant information across various channels, particularly the wildfire information channel. - Enabling citizens to report spotted wildfires. - Receiving information reported by other users. - Providing updates on wildfire-affected areas and validated wildfire reports from responsible authorities. Wildfire reporting is based on the user's location and the location of the reported fire. Reports are instantly delivered to subscribed online users on their mobile devices and sent to the SILVANUS dashboard through the EmerPoll platform via the SAL component.
UP features in SILVANUS' platform	The app module allows users to search for specific information channels, subscribe or unsubscribe to channels, and view reported content within them. Users can also share both textual and visual content, such as photos. Additionally, the module can display extra information, such as areas affected by wildfires (represented as polygons on a map) or evacuation routes (displayed as lines on a map).
Testing sites	2023: Slovakia (Poľana), Italy (Gargano), Indonesia (Palangkaraya, Banjarmasin, Yogyakarta), Australia (Brisbane) 2024: Czech Republic (Ostrava, Krásná), Italy (Gargano and Tepilora), Portugal (Covilhaã), France (Limoges), Croatia (Split), Slovakia (Zvolen)

Table 14 - UP8b "Citizen application for situational awareness and information sharing (Fire Reporting and Fire Warnings)" specification linked to pilot activities

UP9a: Resource allocation of response teams (DSS-RAR)	
UP leader	INTRA
UP description	This UP suggests to the commander the optimal allocation of fire fighting resources (including aerial and terrestrial means, engine and hand-based) taking as input the fire spread forecast, the population density of the threatened areas and the available fire-fighting resources.
UP features in SILVANUS' platform	The UP visualises on a map the allocation of resources and the latest version takes into consideration the road existence for terrestrial vehicle-based crews.
Testing sites	As the UP depends on the fire spread model output, it will be tested wherever the FSM is tested, i.e. Czech Republic, Italy (Gargano and Tepilora), France, Greece

Table 15 - UP9a "Resource allocation of response teams (DSS-RAR)" specification linked to pilot activities

UP9b: Health impact assessment (DSS-HIA)	
UP leader	UTH
UP description	To mitigate the adverse health effects associated with pollutants emitted during a fire event, this UP provides real-time information regarding air quality to civil protection agencies, firefighting personnel, and local citizens. Through the

	continuous assessment of emission levels in the field and the subsequent calculation of an air quality index and a set of relative risk indicators (KPIs), this component enhances effective decision-making processes and issues warnings related to the health and safety of individuals in the impacted vicinity.
UP features in SILVANUS' platform	- Monitoring concentrations of wildfire emissions leveraging portable and stationary IoT devices. - Evaluation of (European) Air Quality Index. - Provision of health-related recommendations to general population and sensitive groups. - Estimation of a list of relative risk indicators (KPIs) pertaining to short and long-term exposure to harmful wildfire pollutants.
Testing sites	Czech Republic, Portugal, Croatia, Greece, Italy (remotely)

Table 16 - UP9b "Health impact assessment (DSS-HIA)" specification linked to pilot activities

UP9c: Evacuation route planning (DSS-ERP)	
UP leader	UTH
UP description	The primary aim of this UP is to enhance the evacuation planning decision-making. By integrating the outputs of other SILVANUS components, such as fire spread predictions, leveraging data from a multitude of internal and external sources this component is capable of producing a comprehensive list of routes that facilitate the secure relocation of individuals.
UP features in SILVANUS' platform	- Determination of a set of alternative safe routes that exclude areas under wildfire threat, adopting different transportation means. - Estimation of time interval within which the departure is considered as safe.
Testing sites	Czech Republic, Portugal, Croatia, Greece, Italy (remotely)

Table 17 - UP9c "Evacuation route planning (DSS-ERP)" specification linked to pilot activities

UP9d: Ecological resilience index (DSS-ERI)	
UP leader	AMIKOM
UP description	ERI analyzes the forest condition over time, with the input from earth observation data (NDVI) and stakeholder entry (forest fire event, program, policy). ERI focuses on how forests recover from forest fires.
UP features in SILVANUS' platform	1. Receive input for fire incidents, rehabilitation programs, policy, and soil measurement and store data of forest fire-related variables 2. Transforming the satellite image into NDVI 3. Overlay the spatial-temporal data on the base map 4. Provide time series analysis of the forest development prior, on fire incident and after forest rehabilitation 5. The system will show disturbance magnitude, recovery magnitude, elasticity (recovery speed), and malleability
Testing sites	Cova de Biera (Portugal), Gargano (Italy), Pod Polani (Slovakia), Sterea Elada (Greece), National Sebangau Park (Indonesia)

Table 18 - UP9d "Ecological resilience index (DSS-ERI)" specification linked to pilot activities

UP9e: Continuous monitoring of rehabilitation strategy index (DSS-CMRSI)	
UP leader	AMIKOM

UP description	CMRI analyzes the forest condition over time, with the input from earth observation data, stakeholder entry and provides Spatio-temporal analysis of forest condition and the influencing factor including societal aspects, and climate changes. CMRSI focuses on providing time series information on variables that influence forest fires.
UP features in SILVANUS' platform	1. Receive input for fire incident, rehabilitation programs, policy and soil measurement and store data of forest fire related variables 2. Transforming the satellite image into required index (NDVI, NBR) 3. Store societal related data on spatial temporal manner 4. Provide graphical visualization of variables Fire events, Soil types, Programs, Policies/Regulations, NBR, NDVI, Precipitation, Temperature, GDP, and Population density then overlay the selected data on the base map
Testing sites	Cova de Biera (Portugal), Gargano (Italy), Pod Polani (Spovakia), Sterea Elada (Greece), National Sebangau Park (Indonesia)

Table 19 - UP9e "Continuous monitoring of rehabilitation strategy index (DSS-CMRSI)" specification linked to pilot activities

UP9f: Biodiversity Index Calculation (DSS-BIC)	
UP leader	AMIKOM
UP description	BCI analyses the forest condition over time, with the input from MODIS data and stakeholder entry. BIC focuses on providing time series information on biodiversity properties that influence forest fires.
UP features in SILVANUS' platform	Receive input for fire incident, rehabilitation programs, policy and soil measurement and store data of forest fire related variables Provide graphical visualization of variables Fire events, Soil types, Programs, Policies/Regulations, Shannon index and Evenness
Testing sites	Cova de Biera (Portugal), Gargano (Italy), Pod Polani (Spovakia), Sterea Elada (Greece), National Sebangau Park (Indonesia)

Table 20 - UP9f "Biodiversity Index Calculation (DSS-CMRSI)" specification linked to pilot activities

UP9g: Soil erosion index	
UP leader	AUA, AMIKOM
UP description	The DSS Soil Erosion Index (SEI) is an environmental monitoring system designed to assess and predict soil erosion in forested areas, particularly those impacted by wildfires. This tool integrates various data sources to provide comprehensive insights into soil erosion dynamics, aiding environmental researchers, forest managers, and policymakers in their efforts to manage and mitigate soil erosion effectively. It aggregates topographic data, precipitation data, and vegetation type from sources such as Digital Elevation Models (DEM), Copernicus satellite images and other environmental datasets. Therefore, transforming topographic data into critical variables such as slope and flow path length. It utilizes precipitation data and vegetation type to assess soil erosion risk accurately.
UP features in SILVANUS' platform	Data Collection - Receives Digital Elevation Models (DEM) in geotiff format for topographic data. - Collects monthly average precipitation data in CSV or raster format. - Utilizes vegetation type data from Copernicus satellite images. User Input and Customization

	- Users select the area of interest and provide precipitation data and vegetation type, or use default values for simulation. - The system processes the input data to run the analysis. Visualization and Decision Support - Outputs results in CSV format, providing a comprehensive soil erosion index. - Visualizes soil erosion risk and trends through numeric tables, graphs, and detailed descriptive reports.
Testing sites	Sterea Ellada (Greece)

Table 21 - UP9g "Soil erosion index" specification linked to pilot activities

UP9h: Integrated Data Insights	
UP leader	CTL
UP description	Designed to enhance wildfire management through real-time data analysis and decision support. It integrates data from multiple sources into the Semantic Knowledge Base (SemKB) and employs an alert-based system that uses predefined rules and real-time data to generate alerts of varying severity levels. Continuously monitors environmental data, such as temperature, humidity, gas concentrations, and air quality metrics, to detect conditions indicative of potential wildfire threats. The system provides timely and accurate alerts, categorizing the severity of detected conditions to facilitate appropriate responses. It enhances situational awareness, improves the accuracy and timeliness of alerts, offers automated decision support, and is scalable and flexible to adapt to new data sources and evolving wildfire risks.
UP features in SILVANUS' platform	Real-Time Data Monitoring and Integration: Continuous monitoring of environmental data from various sources (e.g., sensors, social media). Integration into the Semantic Knowledge Base (SemKB) for comprehensive, real-time analysis. Alert-Based System: Generation of alerts based on predefined rules and real-time data. Categorization of alert severity levels to indicate varying degrees of wildfire risk and inform appropriate response measures. Decision Support System (DSS): Automated decision support providing actionable insights. Facilitates rapid and informed responses to wildfire threats, reducing the need for manual analysis. Situational Awareness Enhancement: Aggregation of diverse data sources to provide a holistic view of wildfire conditions. Visualization of wildfire risks and environmental conditions on a user-friendly, map-based interface through Threat Alerts layer. Scalability and Flexibility: Modular design allowing for easy integration of new data sources and technologies. Adaptability of rules and data processing mechanisms to address evolving wildfire risks and incorporate new insights.
Testing sites	Italy, Portugal, Greece

Table 22 - UP9h "Integrated Data Insights" specification linked to pilot activities

UP9i: Priority Resource Allocation based on Forest Fire Probability (DSS)	
UP leader	AMIKOM
UP description	**PRA based on FFP** refers to applications for Decision Support Systems (DSS) that can be used by forest owners, government officials, forest managers, or fire brigades to effectively and efficiently prevent forest fires or mitigate their impact if they occur. This application displays the fire probability levels across various areas and indicates the priority levels of resources.
UP features in SILVANUS' platform	The app receives raw data from satellite images, GDEM, administrative data and historical event. Raw data are extracted into 14 independent variables: temperature, precipitation, slope, aspect, vegetation type, land usage, GDP, distance to road, distance to settlement, fuel load, elevation, historical fire, NDVI, and population density). The independent variables are calculated into two dependent variables: fire probability level and priority resources allocation level.
Testing sites	Cova de Biera (Portugal), Gargano (Italy), Pod Polani (Spovakia), Sterea Elada (Greece), National Sebangau Park (Indonesia)

Table 23 - UP9i "Priority Resource Allocation based on Forest Fire Probability (DDS)" specification linked to pilot activities

UP9j: Multilingual Forest Fire Alert System	
UP leader	AMIKOM
UP description	The multilingual application for early warning system based on social media
UP features in SILVANUS' platform	Provide nearly real-time early warning based on social media (currently we use X platform) streaming data. The early warning notification will be sent to user that is interested to the location considering the user type. Moreover, the notification contains additional information (e.g. Fire Probability) that supported by Data Fusion Apps.
Testing sites	Cova de Biera (Portugal), Gargano (Italy), Pod Polani (Spovakia), Sterea Elada (Greece), National Sebangau Park (Indonesia)

Table 24 - UP9j "Multilingual Forest Fire Alert System" specification linked to pilot activities

UP9k: DSS Deep Learning Model for Wildfire Severity Prediction using EO4Wildfires	
UP leader	AUA
UP description	The DSS Deep Learning Model for Wildfire Severity Prediction leverages the advanced capabilities of deep learning and extensive satellite data to predict the severity of wildfires (shape and size). Utilizing the comprehensive EO4Wildfires dataset, this service offers a cutting-edge solution for forest fire management, disaster response, and resource allocation. The module combines data from Sentinel-1 (Synthetic Aperture Radar) and Sentinel-2 (Multispectral Imagery) satellites. It also includes crucial meteorological variables from NASA Power, such as temperature, precipitation, and soil moisture. The model utilizes both Image Segmentation Networks (e.g., ResNet, EfficientNet) and Visual Transformers for accurate predictions. The models are fine-tuned to improve precision in predicting the burned area, focusing on significant wildfire events. The dataset covers 31,730 wildfire events from 2018 to 2022 across 45 countries. It is annotated with data from the European Forest Fire Information System (EFFIS) for reliable wildfire detection and size estimation. Data Collection: Aggregates multispectral imagery, SAR data, and meteorological variables. Processes data using bounding box coordinates and event dates to generate a comprehensive dataset.

	Model Training Deep learning models are trained using the EO4Wildfires dataset, focusing on significant wildfire events. Data preprocessing steps include exclusion of empty labels and very small events to refine model accuracy. Prediction and Analysis The trained models predict wildfire severity by estimating the potential burned area. Predictions are validated against ground truth data to ensure reliability and accuracy. Decision Support Outputs are used to inform and guide forest protection agencies and emergency responders. Provides a minimum baseline for evaluating upcoming wildfire risks during fire seasons. The benefits of the DSS are the following: Enhanced Preparedness: Allows for proactive measures in wildfire-prone areas, reducing potential damage. Resource Optimization: Facilitates efficient allocation of resources and personnel in response to predicted wildfire severity.
UP features in SILVANUS' platform	Provide maps showing the potential wildfire size.
Testing sites	Greece, Brazil, Italy, France, Poland

Table 25 - UP9k "DSS Deep Learning Model for Wildfire Severity Prediction using EO4Wildfires" specification linked to pilot activities

UP9l: DSS SIBYLA	
UP leader	TUZVO
UP description	DSS Sybila allows modelling and simulation of different initial forest stand structures, a wide range of natural conditions defined by ecological (site) classifications (climate, air, and soil characteristics). It also provides forest managers with various thinning and felling regimes, ecological information on biodiversity, biomass volume and structure, nutrients in trees, oxygen production and carbon dioxide consumption. The economic aspect is considered in the form of assortment structure of produced wood, forest revenues and management costs.
UP features in SILVANUS' platform	Module Generator This module generates data of individual trees (diameter, height, crown parameters, spatial coordinates, quality parameters) from different source information. Module Medium This module is used for the selection of forest stands (simulation plots) for prognosis. Module Localizer Using this module, climate, soil, and air characteristics are set up for individual forest stands. Module Cultivator: This module provides a user with great possibilities to set up thinning and treatment measures in forest stands. Module Prophesier This module runs growth simulations of forest stands with a possibility to set up the type of the growth prognosis. Module Calculator This module aggregates tree results of the growth simulation to per area results. Module Explorer

	This module presents the results of the growth simulation in the form of tables, graphs, pictures of forest stands, and virtual reality. Module Analyst This module is used for the analysis of the results in the form of time series, while the development of characteristics is presented in tables and graphs. Module Expert: This module provides information for advanced users about growth prognosis.
Testing sites	The UP was tested in Slovak Pilot Site in 2023. It will be tested for the Polana region in 2024.

Table 26 - UP9I "DSS SIBYLA" specification linked to pilot activities

UP10: SILVANUS forward command centre	
UP leader	DELL
UP description	The Forward Command Centres (FCCs) within the SILVANUS architecture are critical mobile or static units deployed near wildfire incidents, enabling fire commanders to manage operations using devices such as laptops or tablets. Acting as frontline versions of Edge Micro Data Centres (EMDCs), FCCs integrate with IoT Gateways to gather and pre-process data from IoT sensors.
UP features in SILVANUS' platform	Hosting and running the critical mission applications of the SILVANUS platform at the fire incident sites. Process and network connectivity with all essential resources and services. UGI for fire incident management.
Testing sites	The Forward command centre will be present in Gargano, Greek, France, Croatia Portugal, Pugila, Tepilora and Slovakia pilots

Table 27 - UP10 "SILVANUS forward command centre" specification linked to pilot activities

UP11: SILVANUS platform and dashboard - Geographical information system	
UP leader	ITTI
UP description	Dashbord is the SILVANUS UI that integrates most of the UPs into single interface.
UP features in SILVANUS' platform	Displaying UP data from SAL / GIS and providing interactive functions for selected layers.
Testing sites	Dashboard will be presented in most / all 2024 pilot sites.

Table 28 - UP11 "SILVANUS platform and dashboard - Geographical information system" specification linked to pilot activities

UP12: MESH-in-the-Sky	
UP leader	RINI
UP description	Mesh-in-the-Sky uses a Software Defined Radio (SDR) based mesh communication system integrated with Unmanned Aerial Vehicles (UAVs). It provides a versatile broadband network adaptable to various communication environments, forming a self-healing, mobile IP mesh network. Each SDR device can automatically connect and route data without user intervention, making it suitable for harsh environments and rapid deployment scenarios.
UP features in SILVANUS' platform	The Mesh-in-the-Sky provides a robust communications system for use in communication-denied environments, allowing other OEM partners to connect their hardware and software solutions to the SILVANUS platform seamlessly. This enables integration and interoperability of diverse technologies, ensuring reliable data transmission and operational coordination.

Testing sites	Dashboard will be presented in most / all 2024 pilot sites. Mesh in the Sky was tested in various pilots and integration events. More specifically, it was tested during the 2023 pilot in Opatia, Croatia and in 2024 it was tested during the pilots in Czech Republic and Italy. In addition, system was tested during the integration event in Warsaw. More trials are scheduled in October 2024 in France and in Croatia.

Table 29 - UP12 "MESH-in-the-Sky" specification linked to pilot activities

2.3 Cooperation with Firelogue and WFRM projects

The eight expected impacts (EIs) (mentioned in Table 2 and elaborated in more detail in Section 3.1) outlined by the Green Deal require achieving eight specific targets by 2030, using 2019 data as a baseline. SILVANUS, together with its sister Innovation Action (IA) projects TREEADS and FIRE-RES, the Coordination and Support Action (CSA) Firelogue, and other wildfire management projects such as FirEUrisk, must collaborate closely to work toward these goals. A coordinated effort among these four projects has already begun, with Firelogue leading the initiative.

The main objective of these projects in achieving the EIs is to establish a similar methodology for impact assessment of each project. Since the release of deliverable D2.3, the projects have actively engaged in workshops and regular meetings (nine in total as of September 12) to share their approaches, exchange valuable feedback, and offer advice on how the impact assessment of their technologies and platforms can align with Green Deal requirements. The cooperation continued through the advancement of workgroup discussions, joint presentations at events, promotions of the EU Fire Projects United initiative, the discussions on synergies between the projects, common policy strategies, etc.

The projects' cooperation through clustering events and workshops have been extensively discussed in D10.4.

To ensure a more unified response to wildfire management challenges, there will be a concerted effort to align with the IFM approach. SILVANUS and the other named projects will actively work together to develop a shared understanding and implementation of IFM principles. This will be achieved through targeted collaboration aimed at integrating IFM strategies into each project's framework, thereby maximizing the collective impact on wildfire prevention, preparedness, and resilience.

This ongoing collaboration will continue, with the projects maintaining communication and regularly updating each other on progress, while working to identify common ground for further successful cooperation. The outcomes of these meetings and working groups will be detailed in the deliverables of Firelogue.

3 ADOPTED APPROACH

3.1 Linking UP with EI

The collaboration between SILVANUS, Firelogue, and the sister projects TREEADS and FIRE-RES has resulted in the adoption of a shared definition of Green Deal's Expected Impacts (EIs). This definition has been included in Firelogue's D3.1 "Impact Assessment Harmonization" and is presented in Table 30.

EI#	EI	Definition	Achievability
EI1	0 fatalities from wildfires	Fatalities are defined as those that would not have otherwise occurred, if there had not been a wildfire. This includes direct fatal casualties (in the fire), as well as any indirect fatalities as a result of injuries caused by a wildfire incident. Even if the casualty dies at a later date, any fatality whose cause is attributed to a wildfire is included.	Difficult to achieve
EI2	50% reduction in accidental fire ignitions	Human caused wildfires as a result of accidental (not intentional) ignition sources are ignitions that were not intentional, and can be altered through prevention efforts (USDA, White, R. & USDA, 2000). In these fire ignitions, all human causes (electrical, network, railroad, campfire, smoking, fire use, candles, cooking/electrical appliances, equipment, railroad, juveniles, farm machinery etc…) are included.	Not easily achievable
EI3	55% reduction in emissions from wildfires	- carbon dioxide (CO_2) emissions; - nitrous oxide (N_2O) emissions; - hydrogen emissions; - a wide range of organic compound and reactive gasses; - greenhouse gasses (GHG) emissions.	Likely achievable
EI4	Control of any extreme and potentially harmful wildfire in less than 24 hours	Control is the process of completely suppressing the combustion in the perimeter of the wildfire. Control occurs by removing one of the three ingredients fire needs to burn: heat, oxygen, or fuel, within 24 hours since the recording of the initial ignition time. Harmful wildfires are those that can potentially become social, economic, and environmental disasters.	Achievable
EI5	50% of Natura 2000 protected areas to be fire resilient	- Officially declared Natura 2020 areas; - fire resilience based on the geographical coverage area; - fire-resistant ecosystems by promoting the resilience of old-growth forests or by adapting young forest under natural evolution to expected climate change impacts, optimizing protection and provision functions in managed areas; - two forms of resilience: (i) Adaptive resilience to wildfire centres on managing both the human and non-human environment in response to changing climate and fire regimes and increasing wildfire risks and exposure of human communities; (ii) Transformative-resilience requiring a profound shift in the human relationship with the environment and the wildfires, that embraces the	Achievable

		dynamic and rapidly changing role of fire in social ecological systems.	
EI6	50% reduction in building losses	- A building is a structure with a roof and walls, such as a house or factory; - structural loss means any loss as a result of wildfire ignitions.	Achievable
EI7	90% of losses from wildfires insured	Types of insured losses include home property, garage, tool shed, belongings, vehicles, businesses, etc..., and anything else that can be insured.	Likely achievable
EI8	25% increase in surface area of prescribed treatment at EU level	- Prescribed fire treatments include the planned use of fire to achieve precise and clearly defined objectives; - introduced in south Europe to control fire regimes by managing fuels, counteracting the disappearance of biomass-consuming practices and reducing the fire risks inherent in highly flammable forests and shrublands; - the primary objective prescribed burning is to reduce risks to human and natural assets via modifications to fire behaviour, although prescribed burning can be undertaken to promote ecological assets or for cultural purposes.	Likely achievable

Table 30 - Common Expected Impacts' definition

The contribution of SILVANUS towards achieving the EIs cannot be directly measured, but an indirect assessment is feasible. This contribution can be demonstrated by linking each User Product (UP) to the EIs, as was done in D2.3. Each UP, depending on its features, contributes to certain EIs, with some having a direct connection and others an indirect one. Table 57 summarizes the links between all UPs and the EIs.

Based on the links in Table 57, it is clear that the SILVANUS platform will contribute to nearly all the EIs, either directly or indirectly, with the exception of EI2 and EI8, which are less emphasized, as they are linked to only a few UPs. It can be highlighted that the number of UPs associated with an EI doesn't necessarily mean that the EI is fully covered, since a single UP can have a more significant and direct impact on an EI than multiple UPs combined.

Table 57 aims to highlight the connections between the SILVANUS platform's UPs and the EIs. Additionally, identifying which EIs are most effectively addressed by SILVANUS will be helpful in upcoming joint meetings with TREEADS, FIRE-RES, and Firelogue. This will allow to determine which EIs are well-covered by the projects and identify any that may require further attention thanks to the sister projects' cooperation. Detailed descriptions of how each UP contributes to the KPIs are provided in the following tables.

UP1		**AR/VR training toolkit for trainers**
EI#	**Y/N**	**Explanation**
EI1	Y	The training activities increase the knowledge of those involved in extinguishing forest fires and, as a result, contribute to reducing the risk of accidents and implicitly to the preservation of lives during wildfires.
EI2	N	
EI3	N	
EI4	N	
EI5	N	
EI6	N	
EI7	N	
EI8	N	

Table 31 - UP1 "AR/VR training toolkit for trainers" links with EI

UP2a		Fire ignition models
EI#	**Y/N**	**Explanation**
EI1	Y	The development of this model pursues three main outcomes: analysing frequency and probability of fire occurrence in the SILVANUS pilots, determine which factors influence most fire occurrence and create an easy visualization tool for the results for a greater reach. Predicting in advance the risk zones of fire can be a tremendous advantage in preparation for wildfires, with impact on the environment. Regarding the environment, predicting the probability of a fire for a certain month of the year and a specific region, based on historical datasets is of great importance.
EI2	N	
EI3	N	
EI4	N	
EI5	N	
EI6	N	
EI7	N	
EI8	N	

Table 32 - UP2a "Fire ignition models" links with EI

UP2b		Fire danger index
EI#	**Y/N**	**Explanation**
EI1	Y	The FDI forecast made by UP2b can be used to identify areas which are at high risk of wildfires. Hence, measures can be taken to reduce the possibility of outbreak of wildfire through public engagement and allocating resources for quick response in the eventuality that an outbreak occurs.
EI2	Y	UP2b can identify areas at high risk of fire occurrence. These areas can potentially be cordoned off from the public, therefore reducing the risk of accidental fires caused by human movement.
EI3	N	The UP2b can only produce forecast of FDI which can help mitigate the chances of outbreak of wildfire, but it does not have any direct effect on the emission from wildfires.
EI4	N	While indirectly, UP2b allows better allocation of resources which can, in theory, result in quicker response to fire outbreaks but it is difficult to establish a direct cause and effect relationship between UP2b and EI4.
EI5	N	UP2b has no contribution in the level of resilience of fire prone areas.
EI6	Y	FDI forecast does not have a direct impact on the safety of human-made constructions, however reducing the risk of outbreak of wildfires through an early warning system based on the FDI forecast produced by UP2b indirectly leads to the safety of human-made constructions.
EI7	N	FDI produced by UP2b cannot influence the trends in the field of insurance.
EI8	N	UP2b does not affect the regulations on prescribed burning in the European region.

Table 33 - UP2b "Fire danger index" links with EI

UP3		Fire detection based on social sensing
EI#	**Y/N**	**Explanation**
EI1	Y	The UP helps to identify early-stage fire incidents via social media, which can contribute to reducing fatalities by providing early warnings and faster response times to wildfires reported by citizens.
EI2	N	Fire detection based on social sensing is not directly related to preventing accidental fire ignitions, as this UP focuses on identifying existing incidents rather than preventing them.
EI3	N	The UP does not have a direct impact on reducing emissions from wildfires, as it focuses on detecting fires rather than controlling their intensity or duration.

EI4	N	While early detection contributes to quicker response times, the UP does not control wildfires directly or guarantee suppression within 24 hours.
EI5	N	Fire detection via social sensing does not directly improve the fire resilience of Natura 2000 areas, as it is focused on detection rather than resilience building or forest management.
EI6	Y	Early detection can reduce building losses by alerting authorities and citizens to nearby fires sooner, allowing for evacuation and firefighting efforts before significant structural damage occurs.
EI7	Y	The identification of fire incidents can help improve insured losses by notifying individuals and businesses early, leading to quicker action and the possibility of claiming insurance with more timely evidence.
EI8	N	Fire detection based on social sensing does not directly increase the surface area of prescribed treatments; it focuses on identifying wildfire occurrences rather than managing or reducing fire risk through prescribed burns.

Table 34 - UP3 "Fire detection based on social sensing" links with EI

UP4a		**Fire detection from IoT devices**
EI#	**Y/N**	**Explanation**
EI1	Y	The early identification of fire/smoke, provided by the deployed devices, can alert the responsible authorities of a fire/smoke event and reduce response times, hence minimise the chances of a fire spreading and any direct/indirect fatalities.
EI2	N	The deployed algorithms check only for the existence of fire/smoke in the image and not their origin.
EI3	Y	The early detection of fire/smoke by the IoT devices can alert authorities quickly, reducing response times and fire distinguishing, thus reduce gas emissions.
EI4	N	The IoT devices provide only monitoring/detection services and not fire controlling.
EI5	N	
EI6	Y	IoT devices can be placed on/around buildings to detect approaching fires and alert authorities to handle the fire before it approaches the properties.
EI7	Y	IoT devices can be placed in the perimetry of the insured items to identify any potential fires in the surrounding area.
EI8	N	The IoTs can help to monitor the prescribed treatments but not encourage their usage.

Table 35 - UP4a "Fire detection from IoT devices" links with EI

UP4b		**Fire detection at the edge - from UAV data**
EI#	**Y/N**	**Explanation**
EI1	Y	If fire/smoke is detected on time, the operator awareness will improve thus improving operations and saving people´s lives.
EI2	N	
EI3	N	
EI4	Y	By improving operator awareness (status and position of the fire) the fire will be extinguish sooner.
EI5	N	
EI6	Y	By improving operator awareness (status and position of the fire) the fire will be extinguish sooner, thus reducing building loses.
EI7	Y	By improving operator awareness (status and position of the fire) the fire will be extinguish sooner.
EI8	N	

Table 36 - UP4b "Fire detection at the edge using UAV data" links with EI

UP5		**Fire detection using UAVs and UGVs**
EI#	**Y/N**	**Explanation**

EI1	Y	The ability for a fire officer to control multiple robots to observe and report back on fire location and severity is expected to reduce fatalities to forest fire workers by keeping them away from the blaze, while monitoring from a safe distance.
EI2	N	
EI3	Y	Pre-fire robotic assessments of vegetation thickness and canopy coverage are expected to improve the information required for controlled burns. More accurate choices of where and when to apply controlled burns is expected to reduce the number of devastating forest fires, and their emissions.
EI4	N	
EI5	Y	One of the proven ways to make forests resilient to fires is through controlled burns. In order to this to be effective and economical, they should happen at the right time and place. We have demonstrated robotic assessment of forest density metrics and ground humidity sensing while mapping the forest. This information is expected to be an important part of well-informed controlled burn strategies.
EI6	N	
EI7	N	
EI8	N	

Table 37 - UP5 "Fire detection using UAVs and UGVs" links with EI

UP6		**Fire spread forecast - modelling**
EI#	**Y/N**	**Explanation**
EI1	Y	Accurate forecast of the future fire spread can inform firefighters on where to concentrate suppression efforts to reduce/eliminate fatalities.
EI2	N	
EI3	N	
EI4	Y	Accurate forecast of the future fire spread can inform suppression efforts in critical points to constrain spread.
EI5	N	
EI6	Y	Accurate forecast of the future fire spread can inform firefighters on where to concentrate suppression efforts to reduce/eliminate building losses.
EI7	N	
EI8	N	

Table 38 - UP6 "Fire spread forecast - modelling" links with EI

UP7		**Biodiversity profile mobile application (Woode app)**
EI#	**Y/N**	**Explanation**
EI1	Y	The quick access to the biodiversity data and fire fuel allocation can positively improve the capabilities of the authorities to tackle the wildfire and thus reduce casualties.
EI2	N	
EI3	N	
EI4	Y	The information about the fire fuel extracted from the biodiversity data can give important clues to the authorities regarding the likelihood of the fire spread and its direction, increasing the efficiency of the decision making in the situations of the fire.
EI5	Y	Awareness, education and cooperation with forest stakeholders on adaptive and effective ecological resilience can greatly improve forest resilience.
EI6	Y	The Forest biodiversity is affecting the wildfire behaviour. The comprehensive data about the biodiversity of forests can improve allocation of extinguishing resources that will mitigate building losses.
EI7	N	
EI8	N	

Table 39 - UP7 "Biodiversity profile mobile application (Woode app)" links with EI

UP8a		Citizen engagement application
EI#	**Y/N**	**Explanation**
EI1	Y	Training and educational activities increase trust in authorities and as a result following of the required safety measures that could result in preserving lives during the wildfires.
EI2	Y	Citizen awareness and changed behaviour diminishes the risk of fires caused by humans.
EI3	N	
EI4	Y	CEP raises citizens' willingness and ability to spot dangerous signals of fire start, while their awareness of instant communication channels increases probability of timely notification and shortens the time of response.
EI5	Y	Helps in achieving resilience to wildfire by helping a profound shift in the human relationship with the environment and the wildfires, that embraces the dynamic and rapidly changing role of fire in social ecological systems.
EI6	Y	Increases safety measures of the buildings by promoting knowledge and training citizens to increase fire safety of their houses, farms and other buildings.
EI7	Y	Promotes awareness of losses in fires and the necessity to insure properties, especially the estates.
EI8	N	

Table 40 - UP8a "Citizen engagement application" links with EI

UP8b		Citizen application for situational awareness and information sharing (Fire Reporting and Fire Warnings)
EI#	**Y/N**	**Explanation**
EI1	Y	Good communication means and timely use of those could result in preserving lives during the wildfires.
EI2	Y	Citizen awareness and possibility to detect fire danger and reach relevant authorities in time diminishes the risk of fires caused by humans.
EI3	N	
EI4	Y	CEP raises citizens' willingness and ability to spot dangerous signals of fire start, while their awareness of instant communication channels increases probability of timely notification and shortens the time of response.
EI5	Y	Helps in achieving resilience to wildfire by helping a profound shift in the human relationship with the environment and the wildfires, that embraces the dynamic and rapidly changing role of fire in social ecological systems.
EI6	N	
EI7	Y	Promotes awareness of losses in fires and the necessity to insure properties
EI8	N	

Table 41 - UP8b "Citizen application for situational awareness and information sharing (Fire Reporting and Fire Warnings)" links with EI

UP9a		DSS - Resource allocation of response teams (DSS-RAR)
EI#	**Y/N**	**Explanation**
EI1	Y	DSS suggests to the commander the allocation of firefighting resource considering as high priority to save the population. Areas with non-zero population are prioritised in resource allocation so that the fire is extinguished in time.
EI2	N	
EI3	Y	Indirectly, as this UP proposes the optimised resource allocation that would lead to the fire being extinguished, the percentage of emissions is significantly reduced (as the fire will stop earlier).
EI4	Y	This UP is directly contributing to accelerating the fire extinction by suggesting the optimal allocation of available resources.

EI5	N	
EI6	Y	The DSS-RAR priorities the extinction of fire in areas where population exists which is also the areas where buildings exist. In a future extension, the algorithm can directly be fed with the buildings' locations and made to prioritise (after human lives) the buildings.
EI7	N	
EI8	N	DSS-RAR has the potential to be upgraded with the feature of considering the fire as a "fire extinction" means in a post -project version.

Table 42 - UP9a "Resource allocation of response teams (DSS-RAR)" links with EI

UP9b		**Health impact assessment (DSS-HIA)**
EI#	**Y/N**	**Explanation**
EI1	Y	Real-time assessment of the harmful wildfire pollutants levels and subsequent characterization of quality of the ambient air, as well as the provision of health-related instructions and estimation of relative-risk indicators can contribute to ensuring health and safety and eliminating human losses.
EI2	N	
EI3	Y	The integrated network of available mobile and portable SILVANUS IoT infrastructure can contribute to the effective early detection of a wildfire and its immediate extinguishing also resulting in the reduction of emissions.
EI4	Y	The early and accurate detection of the wildfire by the SILVANUS IoT devices can strengthen the efforts to extinguish it quickly.
EI5	N	
EI6	Y	Monitoring of wildfire behaviour by IoT devices can enhance the more efficient allocation of extinguishing resources that will mitigate building losses.
EI7	N	
EI8	N	

Table 43 - UP9b "Health impact assessment (DSS-HIA)" links with EI

UP9c		**Evacuation route planning (DSS-ERP)**
EI#	**Y/N**	**Explanation**
EI1	Y	The determination of routes that do not intersect with the wildfire threat forecast, as well as the proactive estimation of the accepted departure delay can support efforts to reduce/eliminate fatalities.
EI2	N	
EI3	N	
EI4	N	
EI5	N	
EI6	N	
EI7	N	
EI8	N	

Table 44 - UP9c "Evacuation route planning (DSS-ERP)" links with EI

UP9d		**Ecological resilience index (DSS-ERI)**
EI#	**Y/N**	**Explanation**
EI1	N	
EI2	Y	Educating and promoting biodiversity monitoring could help reduce accidental ignitions.
EI3	N	

EI4	N	
EI5	Y	Education and cooperation with forest stakeholders on adaptive or transformative ecological resilience are expected to improve forest resilience.
EI6	N	
EI7	N	
EI8	N	

Table 45 - UP9d "Ecological resilience index (DSS-ERI)" links with EI

UP9e		**Continuous monitoring of rehabilitation strategy index (DSS-CMRSI)**
EI#	**Y/N**	**Explanation**
EI1	N	
EI2	N	
EI3	Y	Knowing the current condition of forests will make it easier for policymakers to take appropriate steps to reduce potential emissions caused by fires.
EI4	Y	By knowing the fuel load in the area, policymakers will be able to take preventive steps to handle fires within 24 hours.
EI5	Y	If the NATURA 2000 areas are included in the areas that must be monitored in our application, their resilience can be tracked simultaneously and continuously. This can help increase awareness in those areas.
EI6	N	
EI7	N	
EI8	Y	By knowing forest conditions through our application, fire officials can manage or isolate flammable assets when a fire is intentionally started.

Table 46 - UP9e "Continuous monitoring of rehabilitation strategy index (DSS-CMRSI)" links with EI

UP9f		**Biodiversity Index Calculation (DSS-BIC)**
EI#	**Y/N**	**Explanation**
EI1	N	
EI2	N	
EI3	N	
EI4	N	
EI5	Y	A higher biodiversity index and evenness index are expected to result in greater fire resilience.
EI6	N	
EI7	N	
EI8	N	

Table 47 - UP9f "Biodiversity Index Calculation (DSS-CMRSI)" links with EI

UP9g		**Soil erosion index**
EI#	**Y/N**	**Explanation**
EI1	N	The DSS Soil Erosion Index (DSS-SEI) focuses on assessing and predicting soil erosion in forested areas affected by wildfires. While it provides valuable information on post-wildfire environmental impacts, it does not directly contribute to reducing fatalities from wildfires. Therefore, it does not assist in achieving the goal of zero fatalities resulting from wildfires.
EI2	N	The DSS-SEI does not address the reduction of accidental fire ignitions. Its primary function is to monitor and predict soil erosion, not to prevent human-caused wildfire ignitions from sources like electrical faults, campfires, or equipment use. Thus, it does not contribute to a 50% reduction in accidental fire ignitions

EI3	N	The DSS-SEI does not contribute to reducing emissions from wildfires.
EI4	N	The DSS-SEI does not assist in controlling extreme and potentially harmful wildfires within 24 hours. It is designed for post-wildfire analysis to assess soil erosion risks, not for real-time wildfire suppression or control efforts.
EI5	Y	By providing detailed assessments of soil erosion in forested areas, including Natura 2000 protected areas, the DSS-SEI supports informed decision-making for land management and rehabilitation efforts. This information can enhance the adaptive and transformative resilience of these ecosystems to wildfires by guiding soil conservation and restoration strategies.
EI6	N	The DSS-SEI does not directly contribute to reducing building losses from wildfires. Its primary focus is on environmental monitoring of soil erosion rather than on protecting buildings or infrastructure from fire damage.
EI7	N	The DSS-SEI does not relate to insurance coverage for losses from wildfires
EI8	Y	By accurately assessing soil erosion risks and identifying areas vulnerable to degradation, the DSS-SEI can inform the planning and implementation of prescribed treatments such as reforestation, controlled burns, or other soil conservation practices.

Table 48 - UP9g "Soil erosion index" links with EI

UP9h		**Integrated Data Insights**
EI#	**Y/N**	**Explanation**
EI1	N	UP9h can contribute by providing timely alerts, but it cannot ensure zero fatalities.
EI2	N	UP9h can aid in monitoring and alerting but cannot directly influence ignition sources.
EI3	Y	UP9h can help by providing real-time data and alerts that facilitate timely interventions to control and reduce wildfire spread.
EI4	Y	UP9h enhances situational awareness and timely decision-making, aiding in the rapid control of wildfires.
EI5	Y	UP9h can contribute by providing data and alerts that support resilience-building measures and adaptive management strategies.
EI6	Y	UP9h can help by providing early warnings and combined knowledge to guide firefighting efforts and protect structures.
EI7	Y	UP9h may assist by highlighting risk areas and promoting the importance of insurance through its historical data insights.
EI8	Y	UP9h may support this by providing data on high-risk areas that would benefit from prescribed burning, aiding in planning and execution.

Table 49 - UP9h "Integrated Data Insights" links with EI

UP9i		**Priority Resource Allocation based on Forest Fire Probability (DSS)**
EI#	**Y/N**	**Explanation**
EI1	Y	Unauthorized individuals or those at high risk of injury should avoid areas with a high fire probability
EI2	Y	Areas with high fire probability should minimize human activity and receive increased funding for disaster mitigation.
EI3	N	
EI4	N	
EI5	N	
EI6	N	
EI7	N	
EI8	N	

Table 50 - UP9i "Priority Resource Allocation based on Forest Fire Probability (DSS" links with EI

UP9j		Multilingual Forest Fire Alert System
EI#	**Y/N**	**Explanation**
EI1	N	While the DSS-MFAS can significantly reduce the risk of fatalities by providing timely alerts, it cannot guarantee zero fatalities due to the unpredictable nature of wildfires and other external factors beyond the system's control.
EI2	N	The DSS-MFAS primarily focuses on alerting than direct prevention of fire ignitions. While it can help in early detection, reducing accidental fire ignitions by 50% would require targeted prevention efforts, education, and regulation beyond the scope of what the DSS-MFAS is designed to achieve.
EI3	Y	The DSS-MFAS can contribute to a 55% reduction in emissions from wildfires by enabling quicker detection and timely response, which can prevent fires from spreading extensively. By reducing the size and intensity of wildfires, the system can significantly lower the overall emissions produced during such events.
EI4	N	The DSS-MFAS can assist in early detection and timely response but controlling an extreme and potentially harmful wildfire in less than 24 hours depends on various factors such as the availability of firefighting resources, weather conditions, and terrain. The system alone cannot guarantee complete suppression of a wildfire within this timeframe.
EI5	N	The DSS-MFAS can enhance fire detection and response but achieving 50% fire resilience in Natura 2000 protected areas requires broader ecological management strategies, adaptive and transformative resilience measures, and long-term environmental planning beyond the system's capabilities.
EI6	Y	The DSS-MFAS can contribute to a 50% reduction in building losses by providing early detection and timely alerts, allowing for quicker evacuation and firefighting efforts. This can help prevent fires from spreading to buildings, thereby reducing the likelihood of structural losses.
EI7	N	The DSS-MFAS cannot directly influence the insurance coverage of losses from wildfires. While it can help mitigate wildfire damage, the level of insurance coverage is determined by individual choices, insurance policies, and regulations, which are outside the system's control.
EI8	N	The DSS-MFAS is focused on alerting and response rather than on the implementation of prescribed fire treatments. Increasing the surface area of prescribed treatments at the EU level would require coordinated land management policies, resources, and practices, which are beyond the system's direct capabilities.

Table 51 - UP9j "Multilingual Forest Fire Alert System" links with EI

UP9k		DSS Deep Learning Model for Wildfire Severity Prediction using EO4Wildfires
EI#	**Y/N**	**Explanation**
EI1	Y	The UP9k contributes to achieving zero fatalities from wildfires by providing accurate predictions of wildfire size and severity. By forecasting the potential impact of a wildfire if it ignites, emergency responders and authorities can better plan evacuations, allocate resources, and implement safety measures to protect lives. This proactive approach enhances the ability to prevent fatalities resulting from both direct and indirect effects of wildfires.
EI2	N	The UP9k does not address the reduction of accidental fire ignitions. Its focus is on predicting the severity and spread of wildfires after they have ignited, not on preventing the ignition sources themselves. Therefore, it does not contribute to reducing accidental human-caused wildfires stemming from various ignition sources like electrical faults, campfires, or equipment use.
EI3	Y	By accurately predicting the potential size and severity of wildfires, the UP9k aids in more effective firefighting and suppression efforts. Early and efficient intervention can lead to smaller burned areas, thereby reducing the emissions released from wildfires. This contributes to a reduction in carbon dioxide, nitrous oxide, and other harmful emissions, aligning with the goal of a 55% reduction in emissions from wildfires.
EI4	Y	The UP9k ability to forecast the potential size and shape of extreme wildfires enables quicker and more strategic response efforts. By understanding how a wildfire might develop within the first 24 hours, firefighting teams can implement targeted strategies to suppress the fire more effectively.

		This supports the goal of controlling any extreme and potentially harmful wildfire in less than 24 hours.
EI5	N	The UP9k does not directly contribute to making Natura 2000 protected areas fire resilient.
EI6	Y	By forecasting the potential impact of wildfires, the UP9k project helps in planning and implementing measures to protect buildings and infrastructure. Accurate predictions allow for better resource allocation to defend structures, evacuate areas if necessary, and minimize structural losses. This contributes to the goal of a 50% reduction in building losses due to wildfires.
EI7	N	The UP9k does not address insurance coverage related to wildfire losses. Its scope is limited to predicting wildfire severity and does not involve financial instruments or policies that would increase the percentage of losses from wildfires that are insured. Though UP9k could be utilized in an underwriting manner, since it could be applied to historical datasets and estimate the risks which are associated with insurance services
EI8	N	The UP9k does not contribute to increasing the surface area of prescribed fire treatments. While it aids in understanding potential wildfire impacts, it does not involve the planning or implementation of prescribed burns or other fuel management practices intended to reduce fire risks in forests and shrublands.

Table 52 - UP9k "DSS Deep Learning Model for Wildfire Severity Prediction using EO4Wildfires" links with EI

UP9l		**DSS SIBYLA**
EI#	**Y/N**	**Explanation**
EI1	N	UP9l does not address 0 fatalities from wildfires.
EI2	N	P9l does not address 50% reduction in accidental fire ignitions.
EI3	N	P9l does not address 55% reduction in emissions from wildfires.
EI4	N	P9l does not address control of any extreme and potentially harmful wildfire in less than 24 hours
EI5	Y	Allowing modelling the tree growth rate and simulation of different forest management regimes, it is used for finding optimum scenarios of sustainable forest management under the climate change. There belong also the Natura 2000 protected areas. Existence of a set of available forest management scenarios allow the forest managers to manage the forest in a way to increase its fire resilience and keep the principles of sustainability and biodiversity.
EI6	N	P9l does not address 50% reduction in building losses.
EI7	N	UP9l does not address insurance coverage related to wildfire losses.
EI8	Y	UP9l addresses 25% increase in surface area of prescribed treatment at EU level. The UP allows to calculate different scenarios and forest management regimes, even forest stand structure including the volume of biomass, which supports the prescribed fuel treatment activities as at stand, local, regional, national and EU level.

Table 53 - UP9l "DSS SIBYLA" links with EI

UP10	**SILVANUS forward command centre**
This is not applicable as forward command centres are implemented as enablers to other UPs by hosting mission-critical applications and UPs of the SILVANUS platform at fire incident sites. Therefore, UP10 does not cover expected impacts.	

Table 54 - UP10 "SILVANUS forward command centre" links with EI

UP11	**SILVANUS Platform and Dashboard - Geographical information system**
Silvanus Dashboard is the unified user interface displaying data from other UPs and providing means to provide user input to selected UPs. As such, UP11 should be considered as an enabler for the impact of other UPs and UP11 itself covers the Expected Impacts indirectly.	

Table 55 - UP11 "SILVANUS Platform and Dashboard - Geographical information system" links with EI

UP12		MESH-in-the-sky
EI#	**Y/N**	**Explanation**
EI1	N	"Mesh-in-the-Sky" does not address 0 fatalities from wildfires.
EI2	N	"Mesh-in-the-Sky" does not address 50% reduction in accidental fire ignitions.
EI3	N	"Mesh-in-the-Sky" does not address 55% reduction in emissions from wildfires.
EI4	N	"Mesh-in-the-Sky" does not address control of any extreme and potentially harmful wildfire in less than 24 hours.
EI5	N	"Mesh-in-the-Sky" does not address fire resilience in Natura 2000 protected areas.
EI6	N	"Mesh-in-the-Sky" does not address 50% reduction in building losses.
EI7	N	"Mesh-in-the-Sky" does not address insurance coverage related to wildfire losses.
EI8	N	"Mesh-in-the-Sky" does not address prescribed fire treatment at EU level.

Table 56 - UP12 "MESH-in-the-sky" links with EI

	EI1	EI2	EI3	EI4	EI5	EI6	EI7	EI8
UP1	X							
UP2a	X							
UP2b	X	X				X		
UP3	X					X	X	
UP4a	X		X			X	X	
UP4b	X			X		X	X	
UP5	X		X		X			
UP6	X			X		X		
UP7	X			X	X	X		
UP8a	X	X		X	X	X	X	
UP8b	X	X		X	X		X	
UP9a	X		X	X		X		
UP9b	X		X	X		X		
UP9c	X							
UP9d		X			X			
UP9e			X	X	X			X
UP9f					X			
UP9g					X			X
UP9h			X	X	X	X	X	X
UP9i	X	X						
UP9j			X			X		
UP9k	X		X	X		X		
UP9l					X			X
UP10	/	/	/	/	/	/	/	/
UP11	/	/	/	/	/	/	/	/
UP12								

Table 57 - Links between User Products and Expected Impacts

3.2 Identification of UPs' Key Performance Indicators

3.2.1 *UP1: AR/VR training toolkit for trainers*

KPI no.	KPI name	KPI description
KPI-1	N° of training scenarios created >= 3	At least 3 training scenarios must be created.
KPI-2	N° of training environments created >= 3	At least 3 different virtual environments must be created
KPI-3	Implement multiplayer support for at least 3 users	At least 3 different users will be able to attend a training scenario (multiplayer support)
KPI-4	N° of scenarios with audio interface support applied in VR >= 3	The users attending at least 3 scenarios in multiplayer mode and support multiple audio interfaces at the same time
KPI-5	Audio stream response rate <= 3	The users attending the scenario in multiplayer mode must be able to communicate using audio with delays no more than 3 seconds.
KPI-6	Audio reconnection retries while internet gets resumed within 1 minute >= 3	The audio must be able to reconnect once the internet connection will be resumed. There must be at least 3 retries within 1 minute.
KPI-7	Update of multiplayer synchronization while internet is reliable < 1 second	The multiplayer user actions must be updated in <1 second between users (assuming the internet connection is reliable)
KPI-8	N° of firefighters trained > 50	The goal is to have at least 50 firefighters trained by the last version of the SILVANUS' product. Every trained firefighter will have to fill the learning evaluation survey.

Table 58 - KPIs for UP1: "AR/VR training toolkit for trainers"

3.2.2 *UP2a: Fire ignition models*

KPI no.	KPI name	KPI description
KPI-1	Number of pilots >= 3	UP2a will be tested in at least 3 Pilots
KPI-2	Sensitivity/recall > 85% for training dataset.	Sensitivity/recall is a measure of how well a ML model can detect positive instances, in particular what proportion of actual positives is identified correctly. It does so by dividing the correctly predicted positive samples by the total number of positives, either correctly predicted as positive or incorrectly predicted as negative. The sensitivity/recall of the model on the testing dataset must be higher than 85%.
KPI-3	Specificity > 60% for training dataset	Specificity measures the proportion of true negatives that are correctly identified by the ML model. It does so by dividing the correctly predicted negative samples by the total number of negatives, either correctly predicted as negative or incorrectly predicted as positive. The

		specificity of the model on the testing dataset must be higher than 60%.

Table 59 - KPIs for UP2a "Fire ignition models"

3.2.3 UP2b: Fire danger index

KPI no.	KPI name	KPI description
KPI-1	Number of pilots >= 3	UP2b will be tested in at least 3 Pilots
KPI-2	Sensitivity/recall > 85% for training dataset.	Sensitivity/recall is a measure of how well a ML model can detect positive instances, in particular what proportion of actual positives is identified correctly. It does so by dividing the correctly predicted positive samples by the total number of positives, either correctly predicted as positive or incorrectly predicted as negative. The sensitivity/recall of the model on the testing dataset must be higher than 85%.
KPI-3	Specificity/Precision > 60% for training dataset	Specificity measures the proportion of true negatives that are correctly identified by the ML model. It does so by dividing the correctly predicted negative samples by the total number of negatives, either correctly predicted as negative or incorrectly predicted as positive. The specificity of the model on the testing dataset must be higher than 60%.
KPI-4	Model assessmnet on historical fires	Qualitative asssessmnet of the ML-model on historical fires in the pilot region

Table 60 - KPIs for UP2b "Fire danger index"

3.2.4 UP3: Fire detection based on social sensing

KPI no.	KPI name	KPI description
KPI-1	N° of tests made >= 6 (1 per pilot)	UP3 must be tested at least once in each of the 6 pilots that have been identified to be supported. Test can be offline (at any point, using benchmarks datasets or annotation from the pilot users) or online (during a pilot demonstration).
KPI-2	F-measure of relevance prediction > 90%	The harmonic means of precision (how many of the posts classified as relevant are actually relevant) and recall (how many of the relevant posts are classified as relevant) must be more than 90%.
KPI-3	Accuracy of fire detection in images > 75%	More than 75% of the collected social media images must be correctly classified as images that show fire or not.
KPI-4	Precision of fire events detection (% correctly identified) > 80%	More than 80% of the fire events detected by UP3 must be real incidents.

KPI-5	Retrieval time (from publication to collection) < 5 minutes	The duration between the publication of a social media post (time that it is posted online) and its retrieval by the crawler of UP3 must be less than 5 minutes.
KPI-6	Analysis time (from collection to enhancement and storage) < 2 minutes	The duration between the retrieval of a social media post by UP3 and its complete analysis and storage to a database must be less than two minutes.
KPI-7	F1 score of location extraction > 92% in English, location extraction > 85% in other languages (Italian, Greek, French)	Location extraction from tweets using text information should achieve an F1 score of over 92% in English, as well as in other languages including Italian, Greek, and French.
KPI-8	N° of tests made >= 6 (1 per pilot)	UP3 must be tested at least once in each of the 6 pilots that have been identified to be supported. Test can be offline (at any point, using benchmarks datasets or annotation from the pilot users) or online (during a pilot demonstration).

Table 61 - KPIs for UP3 "Fire detection based on social sensing"

3.2.5 UP4a: Fire detection from IoT devices

KPI no.	KPI name	KPI description
KPI-1	N° of tests made in SILVANUS pilots >= 6	UP4a must be tested at least once for each one of the 6 pilots where the UP will be deployed. Test may entail both offline and online experiments depending on the data collected, namely retrospective, benchmark datasets for the fire/smoke detection or acquired sensor data from the designated pilot site.
KPI-2	False alarm rate < 15% for fire and < 20% for smoke	It is very usual for IoT devices installed "on the wild" to get a great deal of data and many of the cases to produce False Alarms. This increased significantly when dealing with smoke particles and smoke detection, as fog and cloud particles could be misclassified as True Positives (TP), producing erroneous alarms. For this reason, it is expected that fire events will have lower false alarm rate, compared to smoke, because of their significant difference from the forest area. Hence, we expect a false alarm rate below 15% for fire and below 20% for smoke.
KPI-3	True positives > 70% for fire and smoke	It is expected that the True Positives of a fire/smoke event would be more than 70%, and it will reach even higher rates, when starting gathering data for each use case and fine-tuning the fire/smoke models.
KPI-4	Missing rate < 5% for fire and < 10% for smoke	It is expected that the missing rate for the fire detection model in UP4a will be lower than 5%, as the model is severely relying on the colour of the image and yellow/red particles are considerably different from the green/brown colour of the designated areas. As for smoke detection, the missing rate will be 10%, as there is a higher chance of

		confusing smoke with mist/clouds because of their similar colour and shape.
KPI-5	Time needed to correctly identify ignition and notify firefighters and citizens < 1 minute	Considering that the camera on UP4a will capture 3 to 5 frames per second and the communication delay via the cellular network might reach up to 10 seconds, it is expected that the duration between the fire ignition and the notification of the firefighters and citizens will not exceed the 1 minute.
KPI-6	N° of tests made in SILVANUS pilots >= 6	UP4a must be tested at least once for each one of the 6 pilots where the UP will be deployed. Test may entail both offline and online experiments depending on the data collected, namely retrospective, benchmark datasets for the fire/smoke detection or acquired sensor data from the designated pilot site.

Table 62 - KPIs for UP4a "Fire detection from IoT devices"

3.2.6 UP4b: Fire detection at the edge- from UAV data

KPI no.	KPI name	KPI description
KPI-1	Average time between fire detection in the image and alert notification <= 2 minutes.	To detect response time. Only from "detection in the image" to alert communication. Otherwise, it is impossible since the idea of the use case is that the drone will flight and then, upon landing, will pass the photos to the system. In this scenario, total time between taking photo, detection and alert will exceed 2 minutes in most cases.
KPI-2	Percentage of false alarms generated by the system <= 5%	To detect the amount of false positives

Table 63 - KPIs for UP4b "Fire detection at the edge- from UAV data"

3.2.7 UP5a: UGV monitoring of wildfire behaviour

KPI no.	KPI name	KPI description
KPI-1	N° of tests made >= 10	At least 10 trial runs with different robots (Spot legged robot and Titan tracked robot) generating 3D maps with tree biomass density estimation and smoke/fire detection.
KPI-2	Mean % of false alarm < 10	The mean percentage of false alarm sent by the UP should be lower than 10%.
KPI-3	Accuracies	The accuracy depends on the sparsity of the forest, but in general, similarly to UAVs, fire must be detected by the UGV on an area no more than 50x50 m with 80% of accuracy.
KPI-4	Detection time < 10 minutes	This is dependent on the distance between fire front and point of initial deployment of the robot. In practical scenarios, this is expected to be less than 10 minutes for efficient response.

KPI-5	Spread Prediction Improvement	The fire spread prediction will be based on the humidity and biomass density estimation extracted from 3D reconstructed lidar data.

Table 64 - KPIs for UP5a "UGV monitoring of wildfire behaviour"

3.2.8 UP5b: UAV monitoring of wildfire inspection

KPI no.	KPI name	KPI description
KPI-1	Number of pilots >= 3	The number of pilots on which UP5b has been tested is superior or equal to 3.
KPI-2	Arbitrary shape and nb of drones >=4	The algorithm must have been tested on arbitrary shapes (possibly nonconvex or with holes) and with at least 4 drones.
KPI-3	Execution time < 1 min	The total execution time of the algorithms (zone decomposition and flight path calculation should be under one minute.
KPI-4	N° of tests made >= 10	At least 10 flights, with different drones and different upload/download system with different video/photo resolutions from different angle of the fire/smoke.

Table 65 - KPIs for UP5b "UAV monitoring of wildfire inspection"

3.2.9 UP6: Fire spread forecast - modelling

KPI no.	KPI name	KPI description
KPI-1	N° of scenarios simulated >= 3	By "scenario" it is meant the particular topography and forest and fuel characteristics for a specific area completed with information on actual weather situation. Therefore, the fire spread model will be tested in at least 3 pilot locations.
KPI-2	Accuracy compared to the state-of-the-art software predictions after 1 hour > 80%	Accuracy is complex to measure for fire spread, as several parameters are involved: direction of spread, burnt area, location of fire front. Here it is used burnt area as a proxy for accuracy: the burnt area predicted by the fire spread model and state of the art software, e.g., the area between the initial fire front and the fire front after 1 hour, shall be within 80% of each other.

Table 66 - KPIs for UP6 "Fire spread forecast - modelling"

3.2.10 UP7: Biodiversity profile mobile application (Woode App)

KPI no.	KPI name	KPI description
KPI-1	N° of training samples in the database > 10000	The aim is creating a large corpus of data related to the types of trees. This will enable the deep learning algorithms to provide more accurate results in classification and detection tasks. Minimum amount of 10000 images will be included in the training set database.

KPI-2	N° of species in the database > 100	The training dataset will include over 100 tree species to cover most of the trees present in European forests, especially those included in targeted pilot sides.
KPI-3	Minimum number of photos required for the identification of the species >= 2	The Woode mobile application will require minimum of 2 images of tree leaf to accurately identify the type of the tree. However, the deep learning algorithms and tailored solution for enhancement of the training data will be developed and optimised to such degree that the application should return correct result even with one image provided, in most of the cases.
KPI-4	Correctly identified > 90%	The computer vision and deep learning units will be developed and optimised to achieve over 90% of detection accuracy.
KPI-5	No identification < 5%	The Woode application will be designed to classify most of the input images, with only less than 5% window allowed for no identification.

Table 67 - KPIs for UP7 "Biodiversity profile mobile application (Woode App)"

3.2.11 UP8a: Citizen engagement application

KPI no.	KPI name	KPI description
KPI-1	N° of members consulted through public forum for the evaluation of public campaign > 500	At least 500 members consulted through public forum for the evaluation of public campaign.
KPI-2	N° of evaluation surveys gathered > 100	A number of surveys will be issued throughout the project. Three surveys have already been conducted among the partner organisation investigating partner competencies and modes of citizen engagement activities in place. Further surveys will be issued to collect experienced needs of those involved in various stages of wildfire protection (from those involved in raising awareness about risks of wildfire and prevention strategies, to first responders and firefighters and authorities in charge). Considering the above, the number of evaluation surveys will be higher than 100.
KPI-3	Number of modules in the CEP mobile App >= 3	There will be at least three different modules in CEP App. Namely: User Management Module, Notification Module, and Content Visualizations.
KPI-4	80% of users are overall satisfied with the app (answered 4-5 in survey)	From the surveys and interviews in the pilots and dissemination events
KPI-5	Number of downloads > 100 in both Google Store and Apple Play	Data provided from Google and Apple analytics. From the release of the app till the end of the project (M42).

Table 68 - KPIs for UP8a "Citizen engagement application"

3.2.12 UP8b: Citizen application for situational awareness and information sharing (Fire Reporting and Fire Warnings)

KPI no.	KPI name	KPI description
KPI-1	Reporting accuracy rate >= 90%	Measure the accuracy of fire reports submitted from the SILVANUS application to citizens to ensure reliable and valid information for situational awareness
KPI-2	Response time <= 5 minutes	Average time between fire report submission and acknowledgment/notification
KPI-3	Percentage of fire warnings effectively reaching targeted user groups >= 95%	Evaluate the application's efficacy in disseminating fire warnings to the intended audience, ensuring widespread awareness and preparedness
KPI-4	Number of citizen-contributed reports or application views per month >= 150	To analyse the community participation

Table 69 - KPIs for UP8b "Citizen application for situational awareness and information sharing (Fire Reporting and Fire Warnings)"

3.2.13 UP9a: DSS - Resource allocation of response teams (DSS-RAR)

KPI no.	KPI name	KPI description
KPI-1	Optimisation Runtime <= 10 minutes	Once that the inputs data (fire spread projection) are ingested and analysed, ensures the resource optimisation algorithms completes within 10 minutes
KPI-2	Stakeholder Satisfaction Rate ≥ 90%	Achieve high satisfaction rates from stakeholders, including firefighting units, based on the effectiveness of resource allocation decisions

Table 70 - KPIs for UP9a "DSS - Resource allocation of response teams (DSS-RAR)"

3.2.14 UP9b: Health impact assessment (DSS-HIA)

KPI no.	KPI name	KPI description
KPI-1	Emission concentrations Accuracy >= 90%	Ensures that the DSS accurately monitors emission concentrations by the fire, achieving an accuracy rate of at least 90%.
KPI-2	Information Sharing in < 15 min	Share air quality information with relevant stakeholders within 15 minutes of pollutant detection
KPI-3	Air quality index accuracy >= 80%	Ensures the estimation of the air quality index of at least 80% of accuracy
KPI-4	Accuracy of detection of (PM2.5, O3, NO2, SO2) to be > 80%	Ensures that the detection of the pollutant has an accuracy rate of at least 80%

Table 71 - KPIs for UP9b "Health impact assessment (DSS-HIA)"

3.2.15 UP9c: Evacuation route planning (DSS-ERP)

KPI no.	KPI name	KPI description
KPI-1	Accuracy of Route Recommendations > 95%	Ensure that the DSS provides evacuation route recommendations with an accuracy rate of over 95%
KPI-2	Timeliness of Route Planning < 10 minutes	Generate evacuation route plans within 10 minutes of receiving fire spread forecast data
KPI-3	Number of Route Options Provided ≥ 3	Provide at least 3 distinct evacuation route options based on fire spread forecasts, considering different scenarios (e.g., car, bicycle, by foot) and different targets (e.g., children, old people, people with limited mobility)

Table 72 - KPIs for UP9c "Evacuation route planning (DSS-ERP)"

3.2.16 UP9d: Ecological resilience index (DSS-ERI)

KPI no.	KPI name	KPI description
KPI-1	Ensuring NDVI calculation are valid and reliable. Comparison between manual calculation standard third-party application (ArcGIS) versus self-build calculation in OFM application with a target >90% similarity	We use Sentinel 2 Image data, from 2016 until 2024 in time series manner and convert into NDVI and spatially aggregate the result in the area under observation

Table 73 - KPIs for UP9d "Ecological resilience index (DSS-ERI)"

3.2.17 UP9e: Continuous monitoring of rehabilitation strategy index (DSS-CMRSI)

KPI no.	KPI name	KPI description
KPI-1	Ensuring NDVI calculation are valid and reliable. Comparison between manual calculation standard third-party application (ArcGIS) versus self-build calculation in OFM application with a target >90% similarity	We use Sentinel 2 Image data, from 2016 until 2024 in time series manner and convert into NDVI and spatially aggregate the result in the area under observation
KPI-2	Ensuring NBR calculation are valid and reliable. Comparison between manual calculation standard third-party application (ArcGIS) versus self-build calculation in OFM application with a target >90% similarity	We use Sentinel 2 Image data, from 2016 until 2024 in time series manner and convert into NBR and spatially aggregate the result in the area under observation

Table 74 - KPIs for UP9e "Continuous monitoring of rehabilitation strategy index (DSS-CMRSI)"

3.2.18 UP9f: Biodiversity Index Calculation (DSS-BIC)

KPI no.	KPI name	KPI description
KPI-1	Ensuring variable Shannon Index acquired from various sources are valid and reliable. Measurable activity: comparing ArcGIS and OFM calculation with a target of >90% similarity value	We use MODIS data sources in yearly series 2016 until now to acquire various land cover. After collecting data of the various land cover and the size of each land cover, sum all the land cover in the selected pilot areas. For each land cover, calculate its proportion relative to the total number of the total land cover. The Shannon Index and the sum is taken over all species. The resulting value of higher values indicate greater diversity. Values can range from 0 (no diversity) to greater values (more diverse landscapes).
KPI-2	Ensuring variable Evenness acquired from various sources are valid and reliable. Measurable activity: comparing ArcGIS and OFM calculation with a target of >90% similarity value	We use MODIS data sources in yearly series 2016 until now to acquire various land cover. After collecting data of the various land cover and the size of each land cover, sum all the land cover in the selected pilot areas. For each land cover, calculate its proportion relative to the total number of the total land cover. The Shannon Index and the sum is taken over all species. Then sum the Sannon Index with the number of land cover to get the Evenness number.

Table 75 - KPIs for UP9f "Biodiversity Index Calculation (DSS-BCI)"

3.2.19 UP9g: Soil erosion index

KPI no.	KPI name	KPI description
KPI-1	Soil Erosion Prediction Accuracy >= 70%	Achieve an accuracy rate of at least 70% in predicting soil erosion compared to validated field measurements
KPI-2	Data Integration Completeness >= 95%	Ensure that at least 95% of relevant environmental and topographic data is accurately integrated and available for analysis
KPI-3	Data Processing Time <= 10 minutes	Ensure that the system processes input data and provides soil erosion analysis results within 10 minutes, facilitating timely decision-making

Table 76 - KPIs for UP9g "Soil erosion index"

3.2.20 UP9h: Integrated Data Insights

KPI no.	KPI name	KPI description
KPI-1	Data Integration Completeness >= 95%	Ensure that at least 95% of relevant data from project components UP3, UP4a, and UP9b is accurately integrated into the Knowledge Base

KPI-2	Response Time for Data Queries <= 10 seconds	Achieve an average response time of 10 seconds or less for executing SPARQL queries on the RDF-based Knowledge Graph
KPI-3	Severity Level Precision >= 95%	Ensure that the accuracy in categorizing alerts into the correct severity levels is >=95%
KPI-4	Stakeholder Engagement Activities	Conduct at least 4 stakeholder engagement activities through the last year of the project (e.g., during pilot activities) to gather feedback and ensure the system meets user needs and expectations
KPI-5	System Uptime and reliability	Ensure a 90% of time the alert system is operational and available for use.

Table 77 - KPIs for UP9h "Integrated Data Insights"

3.2.21 UP9i: Priority Resource Allocation based on Forest Fire Probability (DSS)

KPI no.	KPI name	KPI description
KPI-1	Ensuring variable NDVI acquired satellite image source are valid and reliable. Measurable activity: Difference calculation methods resulting >90% similarity value.	We calculated two methods (using ArcGIS manually vs. Developing Coded method) and were compared from data sources: satellite image. The results surpassed 95% similarity
KPI-2	Ensuring variable Fuel Load Variable are valid and reliable. Measurable activity: Difference calculation methods resulting >90% similarity value.	We calculated two methods (using ArcGIS manually vs. Developing Coded method) and were compared from data sources: satellite image. The results surpassed 95% similarity
KPI-3	Ensuring variable Aspect Variable are valid and reliable. Measurable activity: Difference calculation methods resulting >90% similarity value.	We calculated two methods (using ArcGIS manually vs. Developing Coded method) and were compared from data sources: satellite image. The results surpassed 95% similarity
KPI-4	Ensuring variable Slope Variable are valid and reliable. Measurable activity: Difference calculation methods resulting >90% similarity value.	We calculated two methods (using ArcGIS manually vs. Developing Coded method) and were compared from data sources: satellite image. The results surpassed 95% similarity
KPI-5	Ensuring variable Elevation Variable are valid and reliable. Measurable activity: Difference calculation methods resulting >90% similarity value.	We calculated two methods (using ArcGIS manually vs. Developing Coded method) and were compared from data sources: satellite image. The results surpassed 95% similarity

Table 78 - KPIs for UP9i "Priority Resource Allocation based on Forest Fire Probability (DSS)"

3.2.22 *UP9j: Multilingual Forest Fire Alert System*

KPI no.	KPI name	KPI description
KPI-1	Accuracy of classification models > 90%	Ensure that the system accurately detects the language preference of a user, fire event, and location.
KPI-2	Classification Time <= 4 minutes for processing 100 tweets	Ensure that the system immediately detects the language preference of a user, fire event, and location.
KPI-3	Email Push Success Rate per minute >= 30 emails	Successfully send email alerts to users for at least 30 emails per minute.
KPI-4	System Uptime >= 99.9%	Maintain a system uptime of at least 99.9% so that users receive early warning alerts and access detailed fire probability data.

Table 79 - KPIs for UP9j "Multilingual Forest Fire Alert System"

3.2.23 UP9k: DSS Deep Learning Model for Wildfire Severity Prediction using EO4Wildfires

KPI no.	KPI name	KPI description
KPI-1	Absolute Percentage Difference	>= 90%
KPI-2	Boolean Mask Accuracy >= 90%	Achieve at least 90% accuracy in generating Boolean masks for affected (burned) areas.
KPI-3	Data Request Response Time <= 5 minutes	Ensure that requests for data (both Sentinel and meteorological) are responded to within 5 minutes
KPI-4	Model Training Dataset Size >= 10,000 images	Ensure that the training dataset, "EO4WildLife," contains at least 10,000 images to maintain robustness and accuracy
KPI-5	Model Inference Time <= 3 minutes	Ensure that the model processes input data and produces severity and Boolean mask outputs within 3 minutes
KPI-6	False Positive Rate <= 5%	Ensure that the false positive rate for predicting wildfire severity is no more than 5%

Table 80 - KPIs for UP9k "DSS Deep Learning Model for Wildfire Severity Prediction using EO4Wildfires"

3.2.24 UP9l: DSS SIBYLA

KPI no.	KPI name	KPI description
KPI-1	Accuracy metric	Accuracy compared to the comparable forest growth models is at least 85%
KPI-2	Biodiversity Indices Calculated >= 5	Calculate at least 5 different forest biodiversity indices for comprehensive ecological assessment

KPI-3	Economic Analysis Accuracy >= 85%	Ensure the accuracy of economic analysis (revenues and costs) derived from forest stand simulations is at least 85%
KPI-4	Thinning and Felling Regimes Simulated >= 3 per Scenario	Simulate at least 3 different thinning and felling regimes per scenario to offer comprehensive forest management options

Table 81 - KPIs for UP9I "DSS SIBYLA"

3.2.25 UP10: SILVANUS forward command centre

KPI no.	KPI name	KPI description
KPI-1	Data Retrieval Success Rate >= 98%	Ensure a high success rate of at least 98% for retrieving data from both the Edge Micro Data Center (EMDC) and the SILVANUS cloud
KPI-2	Data Integration Latency <= 10 minutes	Achieve integration of data from sources such as satellites and local government within 10 minutes

Table 82 - KPIs for UP10 "SILVANUS forward command centre"

3.2.26 UP11: SILVANUS platform and dashboard – Geographical information system

KPI no.	KPI name	KPI description
KPI-1	User interface Responsiveness <= 2 seconds	Ensure that the dashboard responds to user inputs within 3 seconds
KPI-2	Data Upload Latency <= 30 seconds	Achieve upload of data from various sources within 30 seconds
KPI-3	Data Integration Latency <= 30 seconds	Achieve integration of data from various sources, including social media, IoT sensors, and UAVs, within 5 minutes

Table 83 - KPIs for UP11 "SILVANUS platform and dashboard – Geographical information system"

3.2.27 UP12: MESH-in-the-sky

KPI no.	KPI name	KPI description
KPI-1	Network Setup Time <= 10 minutes	Ensure that the SDR-based ad-hoc mesh network can be established within 10 minutes
KPI-2	Connection Reliability >= 99%	Maintain a connection reliability rate of at least 99% in diverse and harsh environments.
KPI-3	Latency <= 30 seconds	Ensure that the network latency remains under 30 seconds
KPI-4	Battery Life >= 12 hours	Ensure that each RiniLink SDR device can operate for at least 12 hours on battery power
KPI-5	Self-Healing Capability Activation Time <= 30 seconds	Ensure that the network can reconfigure itself and restore communication within 30 seconds in the event of a node failure, maintaining continuous operation

Table 84 - KPIs for UP12 "MESH-in-the-sky"

4 SILVANUS PLATFORM

4.1 SILVANUS' high-level architecture

The (final version of the) high level architecture of SILVANUS platform has been described in D8.3. This update has relied on the feedback from the first round of pilots and on the advancements in the SILVANUS platform components. To facilitate the understanding for the reader, we copy here an extract of D8.3.

The SILVANUS innovations target the three identified Phases A, B and C. Each Phase defined by a number of activities related to (A) Prevention and Preparedness, (B) Detection and Response and (C) Restoration and Adaptation. The interaction between these phases is achieved through the application of integrated fire management approach. The SILVANUS platform is designed as a distributed system of systems catering to the needs and demands of interdisciplinary stakeholders involved in the above Phases.

The challenge of continuously monitoring the forest infrastructure is achieved with the use of sensors (static environmental sensors and mobile sensors being deployed in response to incident reports carried by a Unmanned Aerial Vehicle (UAV) or Unmanned Ground Vehicle (UGV)). The information collected from such distributed sensor systems are then subsequently processed at both cloud platform and/or near-edge solutions. While Phase A and Phase C data collection, assessment and monitoring will take place in the cloud, the need for (near-) real-time analysis on the behaviour and spread of wildfire will be continually analysed at the near-edge computational infrastructure. Due to the inherent heterogeneity of data sources, SILVANUS has developed a unique ingestion service based on Apache Nifi to handle complex and continuous stream of sparse data that is being collected from various sources.

For Phases A and C, SILVANUS addresses the requirements of the modelling of ecological environment for sustainable forest management through the development of structured knowledge models that support the collection and formalisation of a biodiversity profile for a specific geographic region. The SILVANUS project has proposed a biodiversity index that considers the historical context of the geographic region. The index will be used to monitor the forest resources and recommend measures to nurture balanced rehabilitation and growth of nature. Additionally, SILVANUS will develop a citizen science programme to engage with diverse communities and avail the effectiveness of semantic technologies to facilitate knowledge sharing among stakeholders. The knowledge developed in the project will be used to enhance preparedness for combating wildfires, response coordination and rehabilitation activities. The development of an advanced semantic engine component builds on the ontology structure and will facilitate multi-lingual representation of biodiversity and ecological analysis models. The human factor consideration will include the impact of negligence and the ability to share information on the identification of safety violations. The project will incorporate the use of advanced Deep-Learning (DL) (a category of Machine Learning (ML) algorithms) for concept extraction and performing contextual filtering of large-scale vocabulary of information resulting in timely alerts for the respective authorities to plan their actions and resources distribution proactively.

For Phase B, SILVANUS will develop and evaluate a sustainable forest management toolkit that will leverage the knowledge gathered on the geographical context to build advanced visualisation maps which can be used in training activities (executed in phase A) along with the deployment of technologies to detect wildfires. The recent advancements in the field of AI, ML, big-data technologies, cloud computing, edge analytics, UAVs, UGVs, information fusion, granular statistical models and 3D visualisation and environmental sensing using IoT devices will be cumulatively integrated within the platform. Data acquisition in SILVANUS focuses on three forms of data sources namely (i) continuous stream of information; (ii) periodic data sources and (iii) sparse data that will be classified based on the fire ignition events (pre-fire ignition, post fire ignition, and post fire suppression). The pre-fire ignition data collection process will implement data interfaces to Copernicus and other Earth Observation data repositories and environmental sensors. Additional data sources for pre-fire ignition models include social media sensing on suspected human negligence, accidental fire causes, agricultural burnings, firecrackers, etc., as well as static topological data e.g., topographic, geological, burning fuel data etc. The post fire ignition data collection interface implements data ingestion from dynamic sensors which are deployed to perform inspection of suspected fire ignition. The use of aerial platform (UAVs) and ground vehicles (UGVs) will be leveraged to evaluate the effectiveness of the overall data collection process. An advanced data analytics toolkit is developed to enable the collection and aggregation of complex data structures, harmonised with the development of semantic information fusion engine. The normalised data sources mapped upon the forest landscape models will be used to accurately evaluate the threat of wildfire spread and develop risk assessment and mitigation strategies. These activities will also be supported on mobile command centres equipped with an edge enabled computational unit to process and visualise information collected from the field. The dynamic modelling of weather patterns will be accounted in modelling the spread of wildfire and thus will support exchange of information to the frontline firefighters.

The conceptual diagram of the SILVANUS platform is depicted in Figure 1.

Figure 1 SILVANUS platform and targeted services

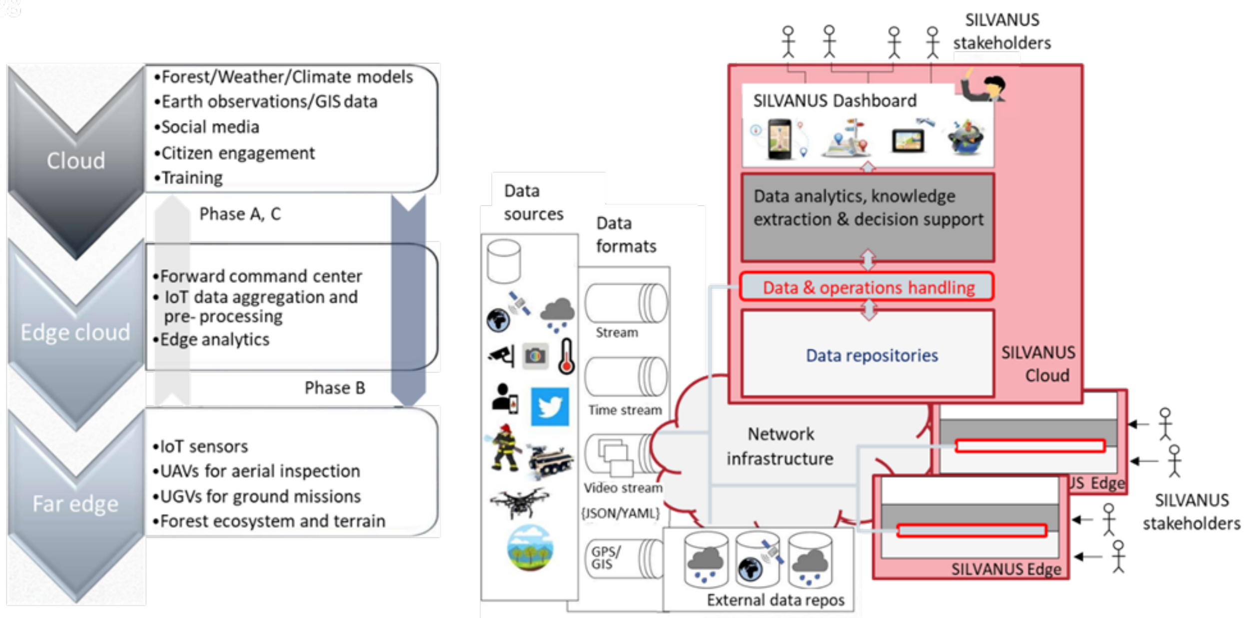


Figure 1 - SILVANUS platform and targeted services

The platform's architecture and its tools are designed to adopt IFM strategies by ensuring that prevention, detection, response, and post-fire restoration are managed in a coordinated and seamless manner. SILVANUS will actively work to align its technological components and methodologies with IFM best practices, ensuring that its solutions not only address individual phases but also contribute to a holistic, end-to-end fire management strategy.

4.2 Identification of SILVANUS Platform's User Satisfaction Survey

The User Satisfaction Survey has been created to gather feedback from end users (e.g., firefighters, citizens, etc.) during the pilot trials of the SILVANUS platform. While KPIs are valuable for assessing the technical performance of the UPs, these surveys provide direct insights into the users' experience with the platform, helping to determine whether the tools are useful for their regular field operations as they are or if adjustments are needed to better align with their daily tasks.

This is why it is essential to consider both the KPIs of each platform component and the user experience evaluation. The technical metrics alone may not provide a full picture of the platform's effectiveness in real-world scenarios. By integrating user feedback, developers can ensure that the platform not only meets technical standards but also fits seamlessly into the operational workflow of end users.

By analysing the results from both the KPIs and the user satisfaction surveys, platform developers will be able to refine and improve the components based on their performance in the pilot activities and the users' perceptions. For example, a tool that predicts fire spread with 100% accuracy but is difficult to use (e.g., requiring extensive training or having slow processing times not aligned with operational needs) may have limited applicability in real-life scenarios, potentially leading to low adoption by end users. Therefore, the combination of technical performance and user experience is key to the platform's success and its wider adoption in the field.

The general structure of the questionnaires is the following:

<table>
<tr><th colspan="5">General feedback</th></tr>
<tr><td colspan="5">1) How satisfied are you overall with the SILVANUS platform?</td></tr>
<tr><td>1. Very dissatisfied
☐</td><td>2. Dissatisfied
☐</td><td>3. Neither dissatisfied nor satisfied
☐</td><td>4. Satisfied
☐</td><td>5. Very satisfied
☐</td></tr>
<tr><th colspan="5">Usability and clarity</th></tr>
<tr><td colspan="5">2) How clear to understand are the provided analytics (layers)?</td></tr>
<tr><td>1. Not clear at all
☐</td><td>2. Not clear
☐</td><td>3. Neither clear nor unclear
☐</td><td>4. Unclear
☐</td><td>5. Very unclear
☐</td></tr>
<tr><td colspan="5">3) Do you feel like the platform is fast and responsive? If not, are there any particular instances where it is slower? Please specify.</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">4) Are you already regularly using a forest fires management platform? If yes, which one? How did you find SILVANUS platform compared to what you are currently using? Please describe.</td></tr>
<tr><td colspan="5"></td></tr>
<tr><th colspan="5">Product value and general use</th></tr>
<tr><td colspan="5">5) How valuable do you find the SILVANUS platform for firefighting training in simulated wildfire scenarios?</td></tr>
<tr><td>1. Not valuable at all
☐</td><td>2. Not valuable
☐</td><td>3. Neither valuable nor not valuable
☐</td><td>4. Valuable
☐</td><td>5. Very valuable
☐</td></tr>
<tr><td colspan="5">6) How valuable do you find the SILVANUS' platform for managing and responding to wildfires?</td></tr>
<tr><td>1. Not valuable at all
☐</td><td>2. Not valuable
☐</td><td>3. Neither valuable nor not valuable
☐</td><td>4. Valuable
☐</td><td>5. Very valuable
☐</td></tr>
</table>

7) How valuable do you find the SILVANUS' platform for decision making and wildfire mitigation efforts?				
1. Not valuable at all ☐	2. Not valuable ☐	3. Neither valuable nor not valuable ☐	4. Valuable ☐	5. Very valuable ☐
8) How valuable do you find the SILVANUS' platform for firefighting efforts and increasing awareness of fire incidents?				
1. Not valuable at all ☐	2. Not valuable ☐	3. Neither valuable nor not valuable ☐	4. Valuable ☐	5. Very valuable ☐
9) How likely are you to incorporate the SILVANUS platform into your regular operations?				
1. Very unlikely ☐	2. Unlikely ☐	3. Neither likely nor unlikely ☐	4. Likely ☐	5. Very likely ☐
10) I feel like the platform helped/made me more qualified to help in a real-life scenario.				
1. Strongly disagree ☐	2. Disagree ☐	3. Neither agree nor disagree ☐	4. Agree ☐	5. Strongly agree ☐
11) Can you provide examples of situations where the mapping and environmental data were particularly valuable or lacking? Please describe.				
12) Where there any instances where you found the SILVANUS platform to be particularly accurate or inaccurate? Please provide examples.				
Improvements and additional features				
13) Are here any specific features or functionalities that you would like to see added in the SILVANUS platform. Please specify and explain why are these needed				
14) Are there any aspects of the SILVANUS platform that you think need improvement? Please specify.				
Additional comments				
15) Do you have any more recommendations or remarks that could help to improve the SILVANUS platform?				

Table 85 - SILVANUS Platform's User Satisfaction Survey Template

5 SILVANUS FORMAL ASSESSMENT FRAMEWORK

This deliverable outlines the final version of the impact assessment framework, initially introduced in D2.3. Its purpose is to evaluate the performance of the platform during the final phase of pilot activities. At this stage, the SILVANUS platform has reached a level of maturity that allows it to be considered as a whole, without the need, as in the past, to break it down into its individual components. However, it remains useful to analyse each User Product individually to develop a more comprehensive and effective impact assessment framework.

Building on the approach taken in the previous version, the key aspects considered for the development of this framework are:

- **A set of KPIs for each UP**. These will be used to evaluate their performance in achieving their objectives during the pilot activities. Successfully meeting the KPIs will demonstrate that the UP is functioning as expected, fulfilling its intended goals. As each UP contributes to multiple EIs, proving the UP's effectiveness will, in turn, confirm that the SILVANUS platform is indirectly contributing toward meeting the EIs. In the initial version of the deliverable, 8 UPs were considered. In this updated version, the number has increased and reached 12 final UPs, including various sub-components. The new KPIs were developed based on evaluations conducted during different scenarios tested in the first phase of pilot activities.
- **User satisfaction surveys for the SILVANUS platform**: In the previous version of the impact assessment framework, separate surveys were conducted for each UP to evaluate users' experiences, primarily focusing on the usability and clarity of the UP interfaces. In the final version, a single comprehensive user satisfaction survey was implemented to assess and enhance both the UI and UX design of the entire platform.

5.1 Using the Final impact assessment framework

The SILVANUS impact assessment framework will be actively utilised in WP9 and pilot activities. Various sets of UPs, along with the entire platform, will be deployed during the pilot scenarios, and data related to the achievement of KPIs, as well as feedback from the user satisfaction surveys, will be collected.

The analysis of the results from the impact assessment framework can lead to several outcomes. The KPIs for each UP will serve to verify that the expected performance was achieved during the pilots, ensuring that sufficient data has been collected by comparing the pilot results with the predefined KPIs.

Additionally, by evaluating the feedback from the user satisfaction surveys, further insights can be gained. Based on user responses, it can be determined whether the platform is intuitive and user-friendly for the end users. If the feedback is positive, this would confirm that the SILVANUS platform could be effectively used in real-world wildfire management operations. The feedback from end users will be invaluable in identifying areas for improvement, ensuring that the platform remains useful and relevant beyond the project's conclusion.

Most of the UPs have already been tested or internally validated by their respective UP leaders. However, since some UPs were not included in the initial MVP version, they were not tested during the first tranche of pilots. These will instead be validated during the 2024 pilot activities.

6 CONCLUSIONS

Deliverable 2.5 outlines the updates made to the impact assessment framework, which was initially introduced in D2.3. The framework described in this deliverable represents the final version, to be used during the last phase of the SILVANUS pilots. It will serve as a key tool for evaluating the performance of the SILVANUS platform across the pilot sites.

The final version of the framework includes:

- KPIs for each UP, which must be achieved during the pilot activities to assess performance.
- A user satisfaction survey for the SILVANUS platform, designed to evaluate the end users' experience and gather suggestions for additional features to enhance the platform.

The results from the assessment of the SILVANUS platform during the pilot activities will be used to evaluate the performance of each UP that comprises it, ensuring that the expected performance and quality standards are met.

Collaboration with Firelogue and the other IA projects, TREEADS and FIRE-RES, will continue to focus on defining a common impact assessment framework. This framework will measure the collective contribution of the three IA projects toward achieving the EIs set by the Green Deal. The common impact assessment framework will differ from the individual SILVANUS framework, as they serve distinct purposes. While the common framework will assess the joint impact of the three projects on the EIs, the SILVANUS framework is designed to verify that the platform is functioning as intended, linking to the EIs indirectly.

Additionally, since these impacts pertain to the EU level, it will be necessary to consider the market adoption of the projects' solutions across Europe to estimate their overall contribution.

The final version of the SILVANUS impact assessment framework will be an integral part of WP9 activities during the pilot phase.

APPENDIX I: UP KPIs additional Information

APPENDIX I contains additional information on the selection of KPIs for each UP. Some information for certain UPs is missing but will be defined during the execution of the pilots.

6.1 UP1: AR/VR training toolkit for trainers

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP1			
KPI-1	N° of training scenarios created >= 3	For the table-top exercise in the Romanian Pilot (September 2024) 3 training scenarios have been created. For the French Pilot the modelling of two scenarios are also implemented. Reference: Delivrable D3.4, Section 6.		Romanian Pilot, French Pilot
KPI-2	N° of training environments created >= 3	For the Romanian Pilot anf for the French Pilot three virtual environments have been created (on the field and the Command Center). Reference: Delivrable D3.4, Section 6.		Romanian Pilot, French Pilot
KPI-3	Implement multiplayer support for at least 3 users	We already trained 23 firefighters in the Romanian Pilot. The French pilot will folow on 11-12 October.		Romanian Pilot, French Pilot
KPI-4	N° of scenarios with audio interface support applied in VR >= 3	This KPI was assessed during the training session in the Romanian Pilot (September 2024).		Romanian Pilot, French Pilot
KPI-5	Audio stream response rate <= 3	This KPI was assessed during the training session in the Romanian Pilot (September 2024).		Romanian Pilot, French Pilot
KPI-6	Audio reconnection retries while internet gets resumed within 1 minute >= 3	Delivrable D3.4 section 6		Romanian Pilot, French Pilot
KPI-7	Update of multiplayer synchronization while internet is reliable < 1 second	This KPI was assessed during the training session in the Romanian Pilot (September 2024).		Romanian Pilot, French Pilot
KPI-8	N° of firefighters trained > 50	We already trained 23 firefighter in Romanian Pilot. The French pilot will folow on 11-12 October.		Romanian Pilot, French Pilot

Figure 2 - UP1: AR/VR training toolkit for trainers additional information

6.2 UP2a: Fire ignition models

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP2a			
KPI-1	Number of pilots >= 3	For ML the model has been tested on dataset for mediterranean region.	The UP was not applied on pilots in 2023 as it was under	The UP will be applied in the coming pilot activities for Gargano, Tepilora and Portugal.
KPI-2	Sensitivity/recall > 85% for training dataset.			KPI is not applicable to pilot exercises.
KPI-3	Specificity > 60% for training dataset			KPI is not applicable to pilot exercises.

Figure 3 – UP2a Fire ignition models additional information

6.3 UP2b: Fire danger index

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP2b			
KPI-1	Number of pilots >= 3	This KPI does not require any internal testing or validation.	This UP cannot be applied to pilots.	This UP cannot be applied to pilots.
KPI-2	Sensitivity/recall > 85% for training dataset.	This KPI is established based on the work of Kondylatos et al. 2022. These refer to the performance of the test dataset during the training of the ML model used for FDI forecast.	The UP2b was not applied to pilots in the year 2023.	This UP cannot be tested in the pilot sites as wild fires are probabilistic event.
KPI-3	Specificity/Precision > 60% for training dataset	This KPI is established based on the work of Kondylatos et al. 2022. These refer to the performance of the test dataset during the training of the ML model used for FDI forecast.	The UP2b was not applied to pilots in the year 2023	This UP cannot be tested in the pilot sites as wild fires are probabilistic event.
KPI-4	Model assessmnet on historical fires	We test this KPI internally on the pilot site comparing the historical fires detected with the prediction of FDI in the same period.	The UP2b was not applied to pilots in the year 2023	This UP cannot be tested in the pilot sites as it concerns historical fires in the pilot region.

Figure 4 - UP2b Fire danger index additional information

6.4 UP3: Fire detection based on social sensing

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	**UP3**		**Reported in D9.3**	
KPI-1	N° of tests made >= 6 (1 per pilot)	please refer to Deliverble 9.3 in section 3.3	Participated in 5 pilots: Greece (PSTE) - Chalkida France (lead PUI) - Limoges Italy (lead ASSET) - Gargano National Park Indonesia (lead AMIKOM) - Palangkaraya, Banjarmasin, Yogyakarta Australia (lead CSIRO) - Brisbane	Participated in pilots: Czech Republic (lead FRS) - Ostrava, Krásná UP3 is expected to participate in the Italian pilot in Gargano lead by PRNT, France pilot in Limoge lead by PUI and Greek pilot in Evoia lead by PSTE.
KPI-3	F-measure of relevance prediction > 90%	please refer to Deliverble 9.3 in section 3.3	The relevance estimation for Greek language achieved: F-measure: 0.871 The relevance estimation for English language achieved: F-measure: 0.974 The relevance estimation for Italian language achieved: F-measure: 0.920	
KPI-4	Accuracy of fire detection in images > 75%	please refer to Deliverble 9.3 in section 3.3	Fire detection accuracy: 93.74% Smoke detection accuracy: 86.42%	
KPI-5	Precision of fire events detection (% correctly identified) > 80%	please refer to Deliverble 9.3 in section 3.3	Through experimentation with a historical Twitter dataset covering fires in the Greece region from 2019 to 2021, the baseline method of fire event detection modules identified 47 events, of which 41 were confirmed as real fires, achieving an accuracy of approximately 87.2%.	
KPI-6	Retrieval time (from publication to collection) < 5 minutes	please refer to Deliverble 9.3 in section 3.3	CERTH is unable to bear the financial burden of increasing the monthly rate limit set by the new X API changes, resulting in the current 30-minute crawling frequency. Nevertheless, in the scenario of commercial exploitation, CERTH has the capability to achieve nearly real-time crawling, significantly lowering the interval to well below 5 minutes.	
KPI-7	Analysis time (from collection to enhancement and storage) < 2 minutes	please refer to Deliverble 9.3 in section 3.3	The complete analysis of a social media post and storage to a database take approximately 1-10seconds.	
KPI-8	F1 score of location extraction > 92% in English , location extraction > 85% in other languages (Italian, Greek, French)	please refer to Deliverble 9.3 in section 3.3!	Location extraction achieved: English (F1-score): 94.31% Italian (F1-score): 88.2% Greek (F1-score): 89.1% French (F1-score): 89,.6%	

Figure 5 - UP3: Fire detection based on social sensing additional information

6.5 UP4a: Fire detection from IoT devices

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	**UP4a**		**Reported in D9.3**	
KPI-1	N° of tests made in SILVANUS pilots >= 6	-	Participated in 3 field exercises (Croatia, France, and Australia), with 2 different tests being carried in Australia (static IoT and IoT on moving UGV). Also, offline data were collected from Italy, for the tabletop exercise, which contained smoke from 2 different sources and were used for the testing of the ML detection models contained in the IoT. Total tests: 6 (in 3 pilots and 1 tabletop exercise)	IoT has been tested in 2024 Czech pilot and will be further tested in Prortugal, Croatia and Greece. It's algorithm's will also be tested in Italy but with the use of EMDCs (Gateways) instead of the IoT. After the completion of all pilots and the collection of sample images from them, the KPIs will be reevaluated.
KPI-2	False alarm rate < 15% for fire and < 20% for smoke	please refer to Deliverable 4.2 section 5.2.1.4 AI model training for fire detection (6%) Smoke detection false alarm rate: 20%	Fire detection false alarm rate: 5% Smoke detection false alarm rate: 17%	
KPI-3	True positives > 70% for fire and smoke	please refer to Deliverable 4.2 section 5.2.1.4 AI model training for fire detection (79%) Smoke detection true positives: 80%	Fire detection true positives: 90% Smoke detection true positives: 93%	
KPI-4	Missing rate < 5% for fire and < 10% for smoke	please refer to Deliverable 4.2 section 5.2.1.4 AI model training for fire detection (21%) Smoke detection missing rate: 20%	Fire detection missing rate: 10% Smoke detection missing rate: 7%	
KPI-6	Time needed to correctly identify ignition and notify firefighters and citizens < 1 minute	In lab tests data transmission using Wi-Fi was ~10.5s and with 4G: ~35s	**Measurements for 6fps** Data collection: ~ 6.6s Data processing: ~ 2.24s Data transmission: Wi-Fi: ~ 11.2s 3G: ~ 37.2s Total time: 20.5 - 46s	

Figure 6 - UP4a: Fire detection from IoT devices additional information

6.6 UP4b: Fire detection at the edge – from UAV data

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP4b			
KPI-1	Average time between fire detection in the image and alert notification <= 2 minutes	Time is validated by the log of the program during execution. Average proccessin time is 14 fps for a 640 pixel image	Used in two pilots. No measures were taken (tabletop exercises with no integration with Dashboard available yet)	Using video stream: approx 12 fps in Czeck rep, In an image per image analysis: 110-224 ms per image (depending onnumber of fire/smoke detected)
KPI-2	Percentage of false alarms generated by the system <= 5%	False positives were detected during training and validation of the model (using a dataset of training of 30000 images)	No false detected	1 false instance detected using real time video stream. No false in images. No numbers were taken in czeck republic, but this is less than 1%. Numbers will be take in next pilots

Figure 7 - UP4b: Fire detection at the edge – from UAV data additional information

KPI-1: Average time between fire detection in the image and alert notification <= 2 minutes
Explanation: It is important to avoid any unnecessary delays between the detection of fire and smoke in the images and the alert to be sent to the operator. Time of response is essential when combating fire. Operators need to be aware of the real situation as soon as possible.
Way of measure: The KPI has been measured during the pilots by counting the total time it takes from the reception of the image until the output of the image with the detections overlaid. This does not include the time it takes for the SAL to respond to the ingestion of the image (since this is out of our control).
Results during pilots:
2023: no measures were taken. Since the pilots were "tabletop" exercises and no integration with the dashboard was available at that time, no measures were taken.
2024: Czech Republic pilot:

- Using video stream: approx. 12 fps with near real time video feed
- In an image per image analysis: 110-224 ms per image (depending on number of fire/smoke detected) and the size of the image

KPI-2: Percentage of false alarms generated by the system <= 5%
Explanation: It is critical for the operations (both in phase A and B) that every alert to be a real instance of fire or smoke and not a false detection of fire/smoke (false positive). Also, we have to avoid instances when the fire is present and there is no detection (false negatives). That way the operator can focus on real menaces and not false ones and avoid wasting time. If the system detects too many false positives, the operators will lose faith in its results and the module won´t be used or noticed.
Way of measure: The KPI has been measured during the pilots by counting the total number of false detections, that is the number of times when we detected something as "fire" or "smoke" not being a real fire or smoke. This number is then divided between the total number of detections.
Results during pilots:
2023: no false detections were detected
2024: Czech republic pilot: At least, 1 false positive detection instance was detected using the real time video stream. No falses were detected during the images analysis. No statistics were calculated in Czech Republic, but result is less than 1%. Detailed statistics will be taken for the next pilots

6.7 UP5a: UGV monitoring for risk and wildfire behaviour

KPI no.	UP5a	Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI-1	N° of tests made >= 10	cf D4.5	Used in one pilot in Australia. 3D maps of the environment were sucessfully generated	No 2024 Pilot performed
KPI-2	Mean % of false alarm < 10	cf D4.5	Used in one pilot in Australia. No false alarms were reported	No 2024 Pilot performed
KPI-3	Accuracies	All smoke generated with artificial smoke machine was successfully detected	Area of 50x50 m covered. Accuracy on limited experiements with artificial smoke machine was 100%	No 2024 Pilot performed
KPI-4	Detection time < 10 minutes	cf D4.5	In pilot, smoke was detected in less than 10 minutes	No 2024 Pilot performed
KPI-5	Spread Prediction Improvement	Smoke machines were used to artificially simulate the fire, so spread prediction quantization was not possible	No prediction was made due to the use of artificial smoke machines	No 2024 Pilot performed

Figure 8 - UP5a: UGV monitoring for risk and wildfire behaviour additional information

6.8 UP5b: UAV monitoring of wildfire inspection

KPI no.	UP5b	Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI-1	Number of pilots >= 3	cf D4.4	Slovak Pilot (Field), Gargano Pilot (Tabletop), Greek Pilot (Tabletop)	Czech Pilot (field), Croatian and Slovak Pilot part 2 (intended)
KPI-2	Arbitrary shape and nb of drones >=4	cf D4.4	In lab experiments	TBD
KPI-3	Execution time < 1 min	cf D4.4	Yes for all pilots	TBC
KPI-4	N° of tests made >= 10		partialy done, only the mapping was done from 90° angle and only the photos were taken, more than 20 flights have been made with 3 different types of drones (DJI Mavic 2 Zoom, DJI Mavic Enterprise 2, DJI M30)	6 flights with 2 different type of drones (DJI Mavic 3T, DJI Mavic 2 Zoom)

Figure 9 - UP5b: UAV monitoring of wildfire inspection additional information

6.9 UP6: Fire spread forecast – modelling

KPI no.	UP6	Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI-1	N° of scenarios simulated >= 3			UP will be demonstrated in Gargano, Tepilora, France and Greece, thus testing 4 scenarios vs. KPI of 3.
KPI-2	Accuracy compared to the state-of-the-art software predictions after 1 hour > 80%	Splitting of available dataset into training (70%) and testing (30%) groups and achieving ~93% accuracy with initial model inference. Accuracy from the pilot demonstrations will be measured by comparing our own predictions with those of the state of the art software (FlamMap) using identical inputs, at the 1 hour forecast mark.		For each pilot tested, an equivalent flammap run will be developed and tested. The accuracy, in terms of burnt area within 1 hour, will be reported based on the FSM and the FlamMap outputs.

Figure 10 – UP6 Fire spread forecast – modelling additional information

6.10 UP7: Biodiversity profile mobile application (Woode App)

KPI no.	UP7	Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI-1	N° of training samples in the database > 10000	cf D5.4	Data collected from Pilots of France, Czech Republic, Croatia, Slovakia, Greece, Italy, Indonesia and Australia	Data collected from pilots from Slovakia, Italy, Croatia, Czech Republic
KPI-2	N° of species in the database > 100	cf D5.4		
KPI-3	Minimum number of photos required for the identification of the species >= 2	cf D5.4		
KPI-4	Correctly identified > 90%	cf D5.4		
KPI-5	No identification < 5%	cf D5.4		

Figure 11 - UP7 Biodiversity profile mobile application (Woode App)

6.11 UP8a: Citizen engagement application

KPI no.	UP8a	Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI-1	N° of members consulted through public forum for the evaluation of public campaign > 500	Posters campaign, online Silvanus CEP course users' feedback and surveys from the app	Pilot in Croatia	Online campaign
KPI-2	N° of evaluation surveys gathered > 100	Focus groups and surveys with local stakeholders carried out in six countries. Evaluation surveys collected in relation to CEP course and mobile app promotion, usage, and evaluation (pilots and online).	Pilot in France	Pilots in Czech Republic, Italy, Portugal, Slovakia, Croatia
KPI-3	Number of modules in the CEP mobile App >= 3	D3.3	The number of modules in at this point of the development was 1	All modules are integrated for the pilots 2024. Test with stakeholders.
KPI-4	80% of users are overall satisfied with the app (answered 4-5 in survey)	This new KPI will be an extension from the KPIs from D3.3 focused in the UP	Surveys were not yet regarding the functionality of the app, but more about the UI and future features. (So this couldn't be answered yet)	In Czech Republic, Italy, Portugal, Croatia and Slovakia Pilots through surveys
KPI-5	Number of downloads > 100 in both Google Store and Apple Play	This new KPI will be an extension from the KPIs from D3.3 focused in the UP	Only in Google Store with a total number of downloads: 6 (dicember 2023)	Number obtain after the pilots and the dissemination events.

Figure 12 - UP8a: Citizen engagement application additional information

6.12 UP8b: Citizen application for situational awareness and information sharing (Fire Reporting and Fire Warning

KPI no.	UP8b	Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI-1	Reporting accuracy rate >= 90%	The updated version of the SILVANUS App was installed on volunteers' mobile devices, which was able to measure distance to the simulated fire. The volunteers were instructed to report the estimated location of a fire. Based on the measurement and volunteers' estimation of the distance, they was instructed to perform the second reporting. The results from the reports were collected by EmerPoll.		Measures were performed during the Czech pilot
KPI-2	Response time <= 5 minutes	Response times and network connection reliability have been an issue since the early stages of development, impacting the data protocols used. The data is sent in a single message containing an image overview via a secure MQTT channel, while full-resolution images are sent through a separate HTTPS connection. Sharing withing the subscribed group is almost instant.	Slovak pilot validation (lack of Internet connection, slow speed), Czech pilot (response time measurements)	Czech pilot (response time measurements along with offline messages)
KPI-3	Percentage of fire warnings effectively reaching targeted user groups >= 95%	Cannot be evaluated because it was not deployed in the real situations. Comunity use (instant messaging within the community of users) was valitated during the pilot demonstrations.		
KPI-4	Number of citizen-contributed reports or application views per month >= 150	The app was realeased for specifc testing user groups (mostly firefighters and volunteer firefighters in the SILVANUS project) during the pilot scenarios.	Slovak pilot (developers and project partners played role of citizens), Czech pilot (the volunteers played role of citizens)	Czech pilot (volunteer firefighters from Plamen and other volunteers played role of citizens)

Figure 13 - UP8b: Citizen application for situational awareness and information sharing (Fire Reporting and Fire Warning additional information

6.13 UP9a: DSS - Resource allocation of response teams (DSS-RAR)

KPI no.	UP9a	Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI-3	Optimisation Runtime <= 10 minutes	The DSS provides the optimised resource allocation in significantly less time than 10min.	only demo	yes
KPI-4	Stakeholder Satisfaction Rate ≥ 90%	Will be provided after 2024 pilots	only demo with	yes

Figure 14 - UP9a: DSS - Resource allocation of response teams (DSS-RAR) additional information

6.14 UP9b: Health impact assessment (DSS-HIA)

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP9b			
KPI-1	Emission concentrations Accuracy >= 90%	please refer to D5.3 in section 6 and D4.5 in sections 4.2.3, 4.3.3, 4.4.3. Internal testing and validation is also presented in paper: https://doi.org/10.3390/s24072273	Greek pilot. No measures were taken - tabletop exercise.	
KPI-2	Information Sharing in < 15 min	please refer to D5.3 in section 6 and D4.5 in sections 4.2.3, 4.3.3, 4.4.3. Internal testing and validation is also presented in paper: https://doi.org/10.3390/s24072273	Greek pilot. No measures were taken - tabletop exercise, no integration with Dashboard available yet.	
KPI-3	Air quality index accuracy >= 80%	please refer to D5.3 in section 6 and D4.5 in sections 4.2.3, 4.3.3, 4.4.3. Internal testing and validation is also presented in paper: https://doi.org/10.3390/s24072273	Greek pilot. No measures were taken - tabletop exercise.	
KPI-4	Accuracy of detection of (PM2.5, O3, NO2, SO2) to be > 80%	please refer to D5.3 in section 6 and D4.5 in sections 4.2.3, 4.3.3, 4.4.3. Internal testing and validation is also presented in paper: https://doi.org/10.3390/s24072273	Greek pilot. No measures were taken - tabletop exercise.	

Figure 15 - UP9b: Health impact assessment (DSS-HIA) additional information

6.15 UP9c: Evacuation route planning (DSS-ERP)

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP9c			
KPI-1	Accuracy of Route Recommendations > 95%	please refer to Deliverable 5.3 in section 7	Greek pilot. No measures were taken - tabletop exercise.	
KPI-2	Timeliness of Route Planning < 10 minutes	please refer to Deliverable 5.3 in section 7	Greek pilot. No measures were taken - tabletop exercise, no integration with Dashboard available yet.	
KPI-3	Number of Route Options Provided ≥ 3	please refer to Deliverable 5.3 in section 7	Greek pilot. No measures were taken - tabletop exercise.	

Figure 16 - UP9c: Evacuation route planning (DSS-ERP) additional information

6.16 UP9d: Ecological resilience index (DSS-ERI)

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP9d			
KPI-1	Ensuring NDVI calculation are valid and reliable. Comparison between manual calculation standard third party application (ArcGIS) versus self build calculation in OFM application with a target >90% similarity	Intenal validation has been carried out and get 99,24% similar for NDVI	No	Participation pending - Italy, Prortugal, Greece, Slovakia, Indonesia

Figure 17 - UP9d: Ecological resilience index (DSS-ERI) additional information

Explanation of app:
ERI analyses the forest condition over time, with the input from earth observation data (NDVI) and stakeholder entry (forest fire event, program, policy). ERI focuses on how forests recover from forest fires.
How to measure all variables:
Once the fire data is obtained, satellite imagery is downloaded for the dates just before and immediately after the fire incident. From these images, the NDVI (Normalized Difference Vegetation Index) values are extracted. The NDVI value before the fire serves as a baseline representing normal conditions. We then monitor for an NDVI value that reaches approximately 70% of this baseline to determine if the fire-affected area has recovered.

In the case of Cova de Beira, which experienced a fire in August 2017:

- The NDVI value before the fire was 0.26 (May 2017).
- During the fire, the NDVI value dropped to 0.06 (September 2017).
- By September 2019, the NDVI had risen again to 0.19.

Results:

The central discussion variable in ERI is NDVI. Generally, the comparison calculations between ArcGIS method and direct coded calculation (Python based) almost similar (>99%).

KPI-1: Ensuring NDVI calculation are valid and reliable. Comparison between manual calculation standard third party application (ArcGIS) versus self build calculation in OFM application with a target >90% similarity

Explanation: NDVI is the important variable to measure the greenness of the forest. Normalized Difference Vegetation Index (NDVI) is a widely used remote sensing index that provides a quantitative measure of vegetation health and density, making it a critical tool for assessing forest quality. It is calculated using the difference between the near-infrared (NIR) and red (visible) light reflected by vegetation, using the formula:

$NDVI=(NIR+Red)(NIR-Red)$

Methods of measure: We use Sentinel 2 Image data, from 2016 until 2024 in time series manner and convert into NDVI and spatially aggregate the result in the area under observation.

Results: Internal validation has been carried out and get 99,24% similar for NDVI. The detail NDVI Measurement Result Comparison is shown in Table 86.

LOCATION	MONTH	NDVI OFM	NDVI Manual	NDVI Accuracy	
GARGANO	2016-01	0.78406	0.78830	99.46%	98.51%
	2017-01	0.35564	0.34011	95.63%	
	2018-02	0.41046	0.41137	99.78%	
	2019-07	0.51030	0.51260	99.55%	
	2020-06	0.50137	0.50354	99.57%	
	2021-10	0.16613	0.16344	98.38%	
	2022-07	0.39048	0.39172	99.68%	
	2023-06	0.33824	0.33951	99.62%	
	2024-06	0.51356	0.48745	94.92%	
SEBANGAU	2017-08	0.24214	0.24204	99.96%	99.96%
	2018-08	0.29362	0.29337	99.91%	
	2019-07	0.40170	0.40148	99.94%	
	2020-06	0.45159	0.45150	99.98%	
	2021-04	0.43377	0.43381	99.99%	
	2022-05	0.42194	0.42197	99.99%	
	2023-08	0.42143	0.42125	99.96%	
	2024-07	0.39379	0.39400	99.95%	
				Average	99.24%

Table 86 - Detail NDVI Measurement Result Comparison

6.17 UP9e: Continuous monitoring of rehabilitation strategy index (DSS-CMRSI)

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP9e			
KPI-1	Ensuring NDVI calculation are valid and reliable. Comparison between manual calculation standard third party application (ArcGIS) versus self build calculation in OFM application with a target >90% similarity	Intenal validation has been carried out and get 99,24% similar for NDVI	No	Participation pending - Italy, Prortugal, Greece, Slovakia, Indonesia
KPI-2	Ensuring NBR calculation are valid and reliable. Comparison between manual calculation standard third party application (ArcGIS) versus self build calculation in OFM application with a target >90% similarity	Intenal validation has been carried out and get 99,89% similar for NBR	No	Participation pending - Italy, Prortugal, Greece, Slovakia, Indonesia

Figure 18 - UP9e: Continuous monitoring of rehabilitation strategy index (DSS-CMRSI) additional information

Explanation of app:
CMRSI analyses the forest condition over time, with the input from earth observation data, stakeholder entry and provides Spatio-temporal analysis of forest condition and the influencing factor including societal aspects, and climate changes. CMRSI focuses on providing time series information on variables that influence forest fires. Six variables involved, 4 direct interpretations from sources, 2 calculated parameter that need validations of the results due to difference method. Both parameters are NDVI and NBR. NDVI has validated that the method and validation have presented in UP9d above.
KPI-1: Ensuring NDVI calculation are valid and reliable. Comparison between manual calculation standard third-party application (ArcGIS) versus self-build calculation in OFM application with a target >90% similarity

The method and the result of this measurement is the same with NDVI measurement in 3.2.16.
KPI-2: Ensuring NBR calculation are valid and reliable. Comparison between manual calculation standard third-party application (ArcGIS) versus self-build calculation in OFM application with a target >90% similarity
Explanation: The Normalized Burn Ratio (NBR) is a satellite-derived index used extensively in forest management and environmental monitoring to assess fire impact and post-fire recovery. It utilizes reflectance data from the near-infrared (NIR) and shortwave infrared (SWIR) spectral bands to highlight burned areas and measure the severity of fire damage. NBR values typically range from -1 to +1, with negative values representing water bodies, low values indicating bare or unburned land, and high values correlating with healthy vegetation.
Methods of measure: We use Sentinel 2 Image data, from 2016 until 2024 in time series manner and convert into NBR and spatially aggregate the result in the area under observation

Results: Internal validation has been carried out and get 99,89% similar for NBR. The detail NBR measurement comparison is shown in the Table 87.

LOCATION	MONTH	NBR OFM	NBR Manual	NBR Calculation	
GARGANO	2016-01	0.55887	0.52498	93.94%	97.67%
	2017-01	0.29018	0.27174	93.64%	
	2018-02	0.29271	0.29438	99.43%	
	2019-07	0.38489	0.38724	99.39%	
	2020-06	0.36904	0.37159	99.31%	
	2021-10	0.16338	0.16309	99.83%	
	2022-07	0.22388	0.22440	99.77%	
	2023-06	0.29526	0.29597	99.76%	

	2024-06	0.35792	0.33626	93.95%	
SEBANGAU	2017-08	0.16992	0.16942	99.71%	99.89%
	2018-08	0.20527	0.20479	99.77%	
	2019-07	0.30683	0.30636	99.85%	
	2020-06	0.38129	0.38130	100.00%	
	2021-04	0.36547	0.36560	99.96%	
	2022-05	0.35722	0.35741	99.95%	
	2023-08	0.33785	0.33792	99.98%	
	2024-07	0.34289	0.34311	99.94%	
				Average	98.78%

Table 87 - Detail NBR Measurement Result Comparison

6.18 UP9f: Biodiversity Index Calculation (DSS-BIC)

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	**UP9f**			
KPI-1	Ensuring variable Shannon Index acquired from various sources are valid and reliable. Measurable activity: comparing ArcGIS and OFM calculation with a target of >90% similarity value	Internal Validation in 5 location reult 100% similarity between OFM and ArcGIS calculation	No	Participation pending - Italy, Prortugal, Greece, Slovakia, Indonesia
KPI-2	Ensuring variable Evenness acquired from various sources are valid and reliable. Measurable activity: comparing ArcGIS and OFM calculation with a target of >90% similarity value	internal validation has been caried out 100% accepted	No	Participation pending - Italy, Prortugal, Greece, Slovakia, Indonesia

Table 88 - UP9f: Biodiversity Index Calculation (DSS-BCI) additional information

Explanation of app:

BCI analyses the forest condition over time, with the input from MODIS data and stakeholder entry. BIC focuses on providing time series information on biodiversity properties that influence forest fires.

How to measure all variables:

Data sources were captured from *MODIS Land Cover Image, Type Yearly Global 500m*.

The classifications as follows:

Value	Color	Description
1	[illegible]	Evergreen Needleleaf Forests: dominated by evergreen conifer trees (canopy >2m). Tree cover >60%.
2	#086a10	Evergreen Broadleaf Forests: dominated by evergreen broadleaf and palmate trees (canopy >2m). Tree cover >60%.
3	#54a708	Deciduous Needleleaf Forests: dominated by deciduous needleleaf (larch) trees (canopy >2m). Tree cover >60%.
4	#78d203	Deciduous Broadleaf Forests: dominated by deciduous broadleaf trees (canopy >2m). Tree cover >60%.
5	#009900	Mixed Forests: dominated by neither deciduous nor evergreen (40-60% of each) tree type (canopy >2m). Tree cover >60%.
6	#c6b044	Closed Shrublands: dominated by woody perennials (1-2m height) >60% cover.
7	#dcd159	Open Shrublands: dominated by woody perennials (1-2m height) 10-60% cover.
8	#dade48	Woody Savannas: tree cover 30-60% (canopy >2m).
9	#fbff13	Savannas: tree cover 10-30% (canopy >2m).
10	#b6ff05	Grasslands: dominated by herbaceous annuals (<2m).
11	#27ff87	Permanent Wetlands: permanently inundated lands with 30-60% water cover and >10% vegetated cover.
12	#c24f44	Croplands: at least 60% of area is cultivated cropland.
13	#a5a5a5	Urban and Built-up Lands: at least 30% impervious surface area including building materials, asphalt and vehicles.
14	#ff6d4c	Cropland/Natural Vegetation Mosaics: mosaics of small-scale cultivation 40-60% with natural tree, shrub, or herbaceous vegetation.
15	#69fff8	Permanent Snow and Ice: at least 60% of area is covered by snow and ice for at least 10 months of the year.
16	#f9ffa4	Barren: at least 60% of area is non-vegetated barren (sand, rock, soil) areas with less than 10% vegetation.
17	[illegible]	Water Bodies: at least 60% of area is covered by permanent water bodies.

Figure 19 - The classifications of MODIS Land Cover Image, Type Yearly Global 500m

The classifications above then applied to the map using ArcGIS resulting the different landcover area as follows:

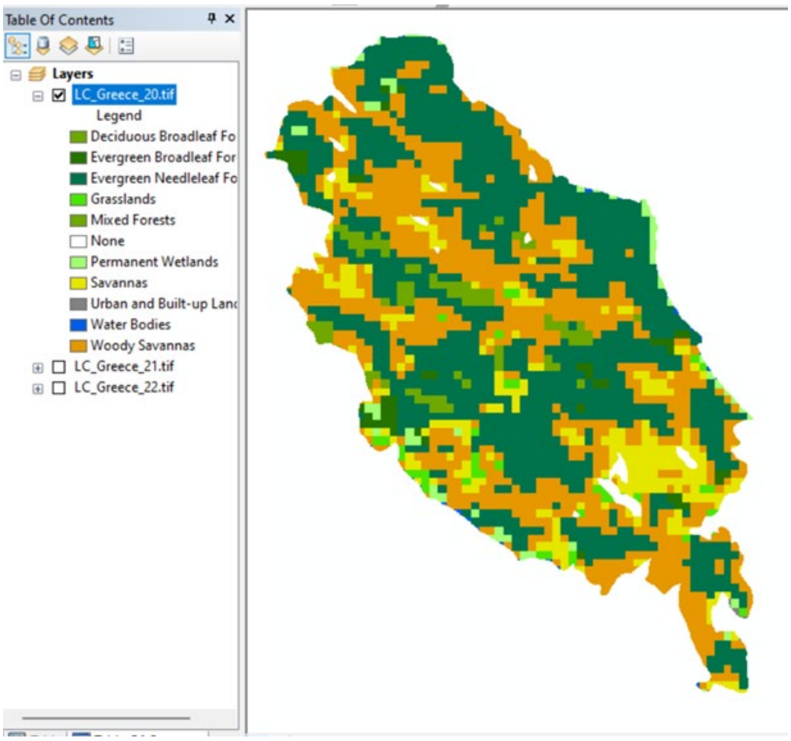


Figure 20 - Results of pilot area according to the classifications

KPI-1: Ensuring variable Shannon Index acquired from various sources are valid and reliable. Measurable activity: comparing ArcGIS and OFM calculation with a target of >90%

Explanation: The Shannon Index, also known as the Shannon-Wiener or Shannon-Weaver Index, is a widely used metric in biodiversity monitoring that quantifies species diversity in a community. It considers both the number of species (species richness) and their relative abundance (evenness), making it a comprehensive measure of ecosystem health.

Methods of measure: We use MODIS data sources in yearly series 2016 until now to acquire various land cover. After collecting data of the various land cover and the size of each land cover, sum all the land cover in the selected pilot areas. For each land cover, calculate its proportion relative to the total number of the total land cover. The Shannon Index and the sum is taken over all species. The resulting value of higher values indicate greater diversity. Values can range from 0 (no diversity) to greater values (more diverse landscapes).

Results: Internal Validation in 5 locations result 100% similarity between OFM and ArcGIS calculation

KPI-2: Ensuring variable Evenness acquired from various sources are valid and reliable. Measurable activity: comparing ArcGIS and OFM calculation with a target of >90% similarity value

Explanation: Evenness describes how equal the community is in terms of the number of individuals per species. If every species in a community has roughly the same number of individuals, the community has high evenness. Conversely, if a few species dominate, and others are rare, the community has low evenness.
Methods of measure: We use MODIS data sources in yearly series 2016 until now to acquire various land cover. After collecting data of the various land cover and the size of each land cover, sum all the land cover

in the selected pilot areas. For each land cover, calculate its proportion relative to the total number of the total land cover. The Shannon Index and the sum is taken over all species. Then sum the Shannon Index with the number of land cover to get the Evenness number.

Results: internal validation shows 100% similar between different methods

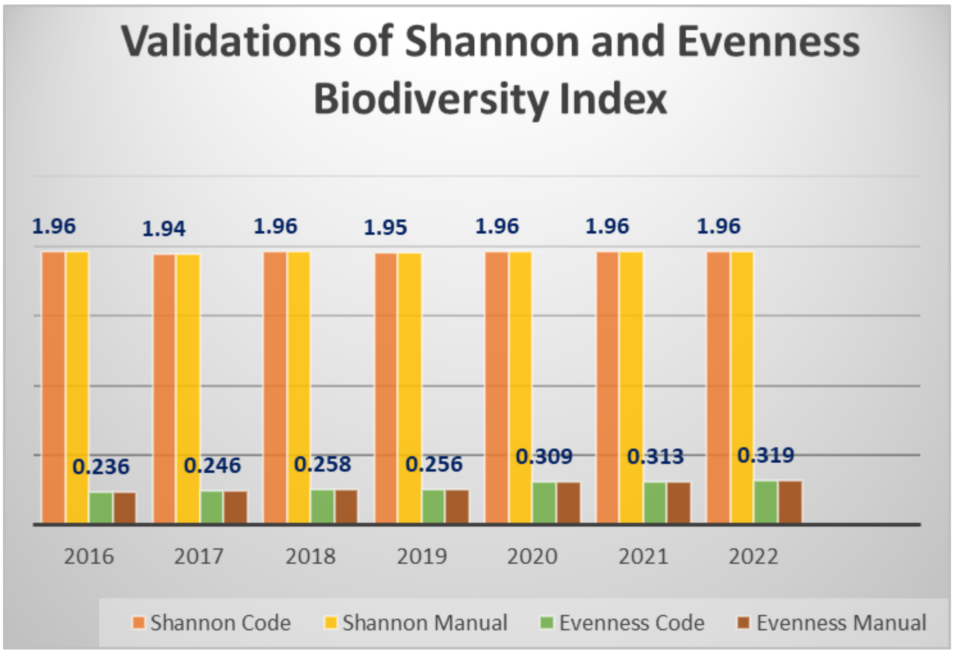


Figure 21 - Validation results of Shannon Index and Evenness: ArcGIS vs. Coded calculation

KPI-3: Ensuring the feature meet user requirements their target 70% of features pass according to user acceptance on admin side
Explanation: Feature requirement acceptance is a critical phase in the software development lifecycle, ensuring that all stakeholders agree on what a feature should achieve and how it should behave. It serves as a formal validation that a feature or set of functionalities meets the intended business needs and quality standards.
Methods of measure: test in the pilots, we will give them user acceptance questionnaire, we will analyse the user acceptance of from the stake holder who used the application and quantify their acceptance questionnaires.
Results: internal validation has been caried out 100% accepted
KPI-4: Ensuring user impressive experience of using the application, the measurable target all users experience aspect (attractiveness, perpetuity, efficiency, dependability and novelty) is above average
Explanation: Measuring the success and impact of an application is crucial for understanding its performance, user satisfaction, and business value. Depending on the type of application and its goals, several key metrics can provide insights into how well an app is performing.
Methods of measure: UP9d tested in the pilots, we will give them user experience questionnaire.
Results: internal user experience has been carried and consider as good.

6.19 UP9g: Soil erosion index

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP9g			
KPI-1	Soil Erosion Prediction Accuracy >= 70%	Internal test and validation with sample data acquired by AUA for Greece (Fthiotida, Prefecture of Central Greece).		Participation scheduled for the pilot in Greece.
KPI-2	Data Integration Completeness >= 95%	True for the internal test and validation performed with the sample data. Data used for internal system testing come from the territory of Central Greece region (STEREA ELLADA) in the form of maps with the data of the following variables: (R) Rainfall erosivity (K) Soil erodibility factor (LS) Topographic factor (dimensionless) which incorporates the individual slope length (dimensionless) and slope steepness (dimensionless) factors (C) Cover management factor (dimensionless) (P) Conservation practice factor (dimensionless)		Participation scheduled for the pilot in Greece.
KPI-3	Data Processing Time <= 10 minutes	The soil erosion analysis runs within the specific time limits.		Participation scheduled for the pilot in Greece.

Figure 22 - UP9g: Soil erosion index additional information

The soil erosion index runs on the server side as a script using as input the data files needed and outputs geotiff/shp files with the index value per cartographic unit.

Inputs:

The soil erosion index uses the following data as input:

- Rainfall erosivity factor (MJ mm ha-1 h-1 y-1) (R)
- Soil erodibility factor (t ha h ha-1 MJ-1 mm-1) (K)
- Topographic factor (dimensionless) which incorporates the individual slope length (dimensionless) and slope steepness (dimensionless) factors (LS)
- Cover Management Factor (C)
- Conservation practice factor (P)

R is the rainfall erosivity factor, measured in megajoules millimeters per hectare per hour per year (MJ mm ha^{-1} h^{-1} y^{-1}). It quantifies the effect of rainfall impact and runoff on soil erosion. The R factor represents the erosive force of rainfall in a particular location. It accounts for the intensity and kinetic energy of rainfall events, which influence the potential for soil particles to be detached and transported. Areas with high rainfall intensity and volume will have higher R values, indicating a greater potential for soil erosion due to rain. Calculating R involves analyzing historical rainfall data to assess the frequency and magnitude of erosive storms.

K is the soil erodibility factor, measured in tons hectare hours per hectare per megajoule per millimeter (t ha h ha^{-1} MJ^{-1} mm^{-1}). It reflects the susceptibility of soil particles to detachment and transport by water. The K factor indicates how easily a soil can be eroded based on its inherent properties. Factors influencing K include soil texture (proportions of sand, silt, and clay), organic matter content, soil structure, and permeability. Soils with high silt content and low organic matter are generally more erodible, resulting in higher K values. Understanding K helps in identifying vulnerable soils that require more intensive conservation practices.

LS is the topographic factor (see Figure 23 below), a dimensionless value combining the effects of slope length (L) and slope steepness (S). The LS factor accounts for the influence of topography on erosion rates.

- Slope Length (L): Represents the distance from the origin of overland flow to the point where either the slope decreases enough for deposition to occur, or the flow concentrates into a defined channel.
- Slope Steepness (S): Reflects the effect of slope gradient on erosion; steeper slopes increase the velocity of runoff, enhancing its erosive power.

Together, L and S quantify how topography accelerates soil erosion. Longer and steeper slopes contribute to higher LS values, indicating greater erosion potential due to gravity and runoff dynamics.

C is the cover management factor, a dimensionless value ranging from 0 to 1. The C factor represents the effect of vegetation cover and management practices on soil erosion rates. Zero indicates complete protection of the soil (e.g., dense forest or grass cover). One represents bare soil with no protective cover

(e.g., freshly plowed field). Lower C values mean that the land cover is effective in reducing soil erosion by absorbing the impact of raindrops, slowing down runoff, and binding the soil with roots. Crop type, cropping sequence, residue management, and surface roughness all influence the C factor. Effective land management practices aim to reduce the C value to minimize erosion.
P is the conservation practice factor, a dimensionless value ranging from 0 to 1. The P factor measures the effectiveness of soil conservation practices that reduce erosion by influencing the flow pattern and direction of runoff. Zero corresponds to highly effective conservation practices being in place. One refers to no conservation practices are implemented; conventional up-and-down slope farming is practiced. Conservation practices include contour farming, strip cropping, terracing, and the use of diversion structures. These practices disrupt the flow of water, reduce runoff velocity, encourage water infiltration, and promote sediment deposition, thereby lowering the P value. Implementing effective conservation measures is crucial for soil preservation, especially on sloped agricultural lands.

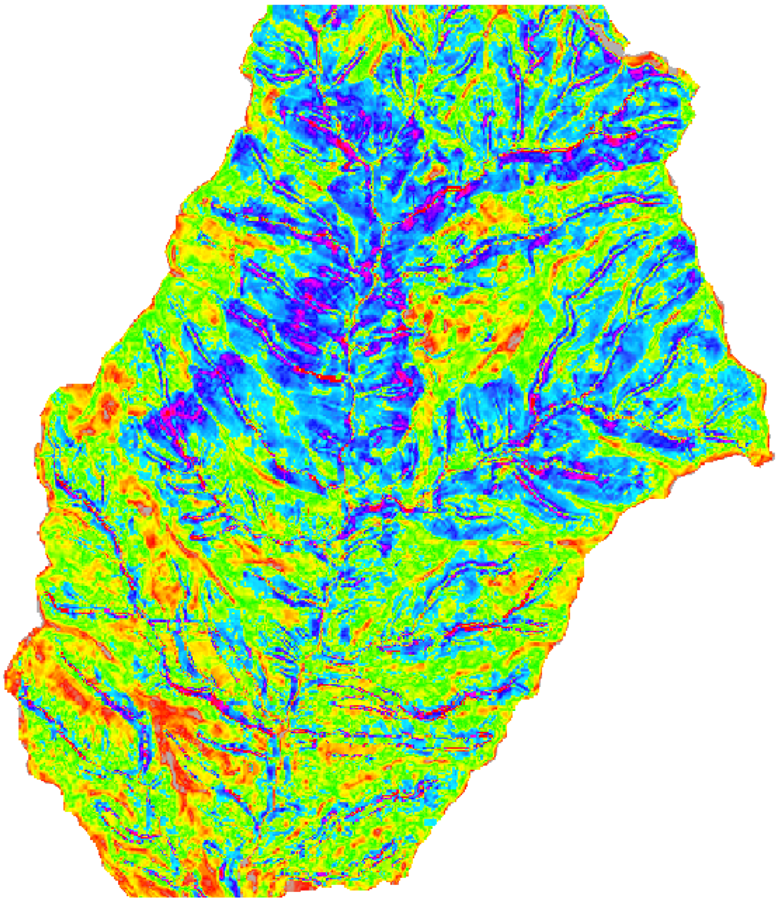


Figure 23 - Example Input Parameter: LS

Output:
Variable A represents the average annual soil loss per unit area, typically measured in tons per hectare per year (t ha^{-1} y^{-1}). It quantifies the expected amount of soil erosion from a specific area over a year. This variable is the primary output of the USLE model. It provides an estimate of how much soil is being lost due to erosion processes like water runoff and rainfall impact. Understanding A helps land managers and policymakers assess the severity of soil erosion in a given area and implement appropriate soil conservation measures. A value greater than 0 indicates ongoing soil loss, with higher values signifying more severe erosion.
The result of an example calculation based on sample input data from the territory of Central Greece region (STEREA ELLADA) is depicted in the following Figure 24.

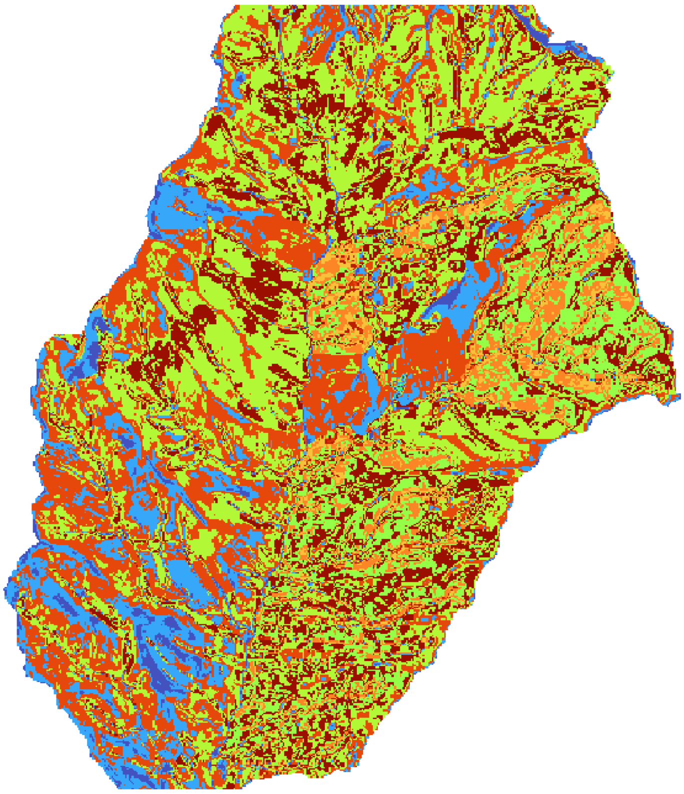


Figure 24 - Example of calculated soil erosion index

6.20 UP9h: Integrated Data Insights

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP9h			
KPI-1	Data Integration Completeness >= 95%	100% accurate integration during internal testing with synthetic data	No participation - Was under construction	Participation pending - Italy, Prortugal, Greece
KPI-2	Response Time for Data Queries <= 10 seconds	<10 seconds during internal testing with synthetic data (the more complex the query, the lower the response time)	No participation - Was under construction	Participation pending - Italy, Prortugal, Greece
KPI-3	Severity Level Precision >= 95%	Difficult to achieve such validation	No participation - Was under construction	Participation pending - Italy, Prortugal, Greece
KPI-4	Stakeholder Engagement Activities	pending pilots	No participation - Was under construction	Participation pending - Italy, Prortugal, Greece
KPI-5	System Uptime and reliability	No such validation happened	No participation - Was under construction	Participation pending - Italy, Prortugal, Greece

Figure 25 - UP9h: Integrated Data Insights additional information

6.21 UP9i: Priority Resource Allocation based on Forest Fire Probability (DSS-PRAFFP)

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP9.i			
KPI-1	Ensuring NDVI variable acquired satellite image source are valid and reliable . Measurable activity: Difference calculation methods resulting >90% similarity value.	Validation method comparison between satellite map using GDAL vs. ArcMap. The results show that both image give 100% simillarity	No	Participation pending - Italy, Prortugal, Greece, Slovakia, Indonesia
KPI-2	Ensuring variable Fuel Load Variable are valid and reliable . Measurable activity: Difference calculation methods resulting >90% similarity value.	Validation satellite image in Gargano pilot and calculated three values of Fuel load: Max, Mean and Min. Both method show 100% simillarity values	No	No
KPI-3	Ensuring variable Aspect Variable are valid and reliable . Measurable activity: Difference calculation methods resulting >90% similarity value.	Validation satellite image in Gargano pilot and calculated three values of Fuel load: Max, Mean and Min. Both method show 100% simillarity values	No	No
KPI-4	Ensuring variable Slope Variable are valid and reliable . Measurable activity: Difference calculation methods resulting >90% similarity value.	Validation satellite image in Gargano pilot and calculated three values of Fuel load: Max, Mean and Min. Both method show 100% simillarity values	No	No
KPI-5	Ensuring variable Elevation Variable are valid and reliable . Measurable activity: Difference calculation methods resulting >90% similarity value.	Validation satellite image in Gargano pilot and calculated three values of Fuel load: Max, Mean and Min. Both method show 100% simillarity values.	No	No

Explanation of app: The application objectives are giving the stake holders of forest levels of fire risk probability and priority resources allocations levels. All levels are divided into 4: 1 as the lowest level to 4 the highest level. Both output variables are calculated from 14 variables input using Fuzzy logic, Bayes Theorem and Montecarlo method.

How to measure all variables:

All data variables acquired from various sources are valid and reliable (14 variables: temperature, precipitation, slope, aspect, vegetation type, land usage, GDP, distance to road, distance to settlement, fuel load, elevation, historical fire, NDVI, and population density). Measurable activity: Difference calculation methods resulting >90% similarity value.

Results:

KPI-1: Ensuring NDVI calculation are valid and reliable. Comparison between manual calculation standard third-party application (ArcGIS) versus self-build calculation in OFM application with a target >90% similarity

Explanation: NDVI is the important variable to measure the greenness of the forest. Normalized Difference Vegetation Index (NDVI) is a widely used remote sensing index that provides a quantitative measure of vegetation health and density, making it a critical tool for assessing forest quality. It is calculated using the difference between the near-infrared (NIR) and red (visible) light reflected by vegetation, using the formula:

NDVI=(NIR+Red)(NIR−Red)

Methods of measure: We use Sentinel 2 Image data, from 2016 until 2024 in time series manner and convert into NDVI and spatially aggregate the result in the area under observation.

Results: Internal validation has been carried out and get 100% similar for NDVI

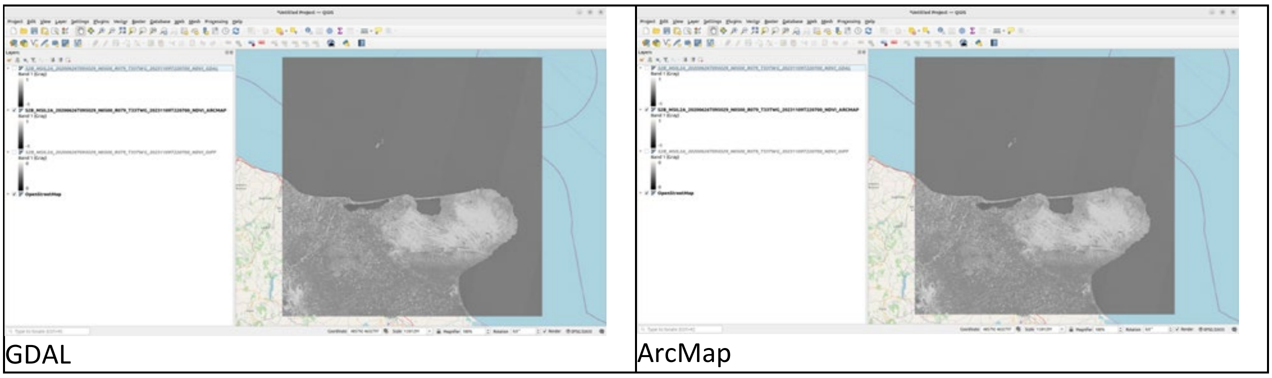


Figure 26 - NDVI Comparison between two methods: using GDAL method vs. ArcMap method

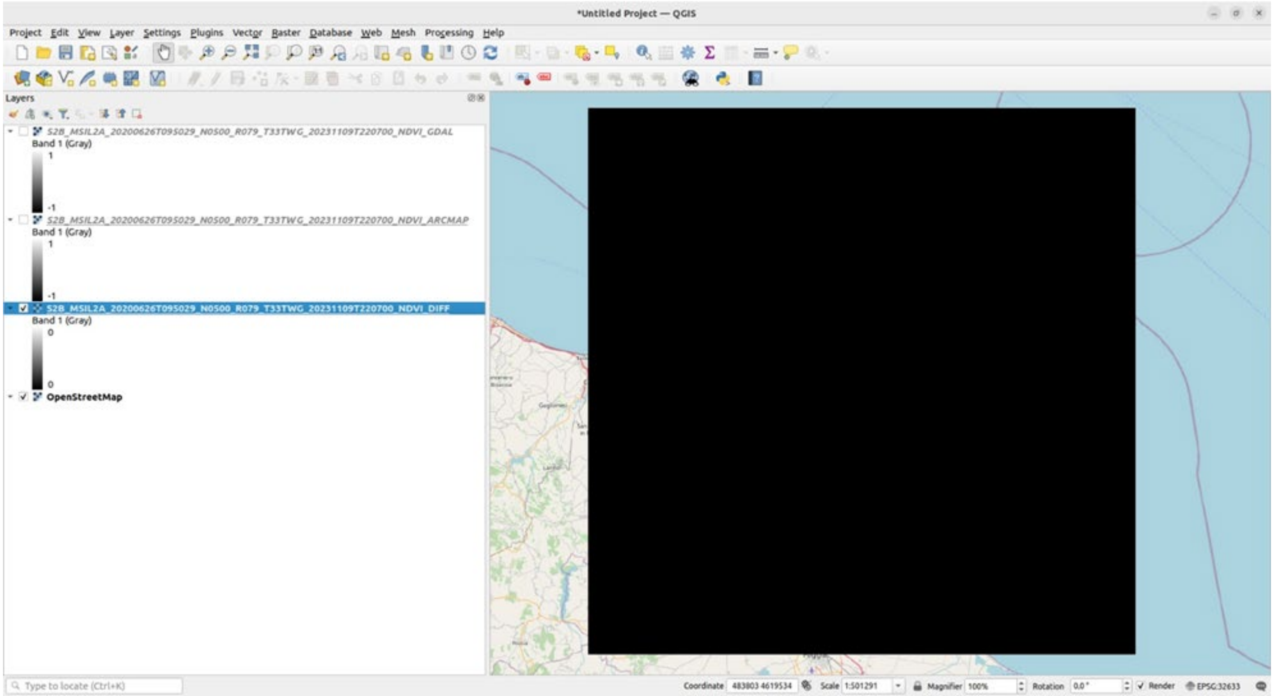


Figure 27 - Difference = (GDAL- ArcMap) and Black color means zero difference or 100% similarity

KPI-2: Ensuring variable Fuel Load Variable are valid and reliable. Measurable activity: Difference calculation methods resulting >90% similarity value.

Explanation: Fuel Load refers to the amount of combustible material (vegetation) available in a particular area that can feed a fire. It is a critical variable used to predict fire behaviour, fire risk, and to develop strategies for fire suppression and prevention. Fuel load is typically measured in terms of weight (such as tons per acre or kilograms per square meter) and can vary depending on the type and condition of the vegetation.
Methods of measure: Here we use one satellite image of Gargano and calculated: Mean, Max and Min Value (ArcGIS&Code)
Results: Internal validation has been carried out and get 99,99% similar for Fuel Load

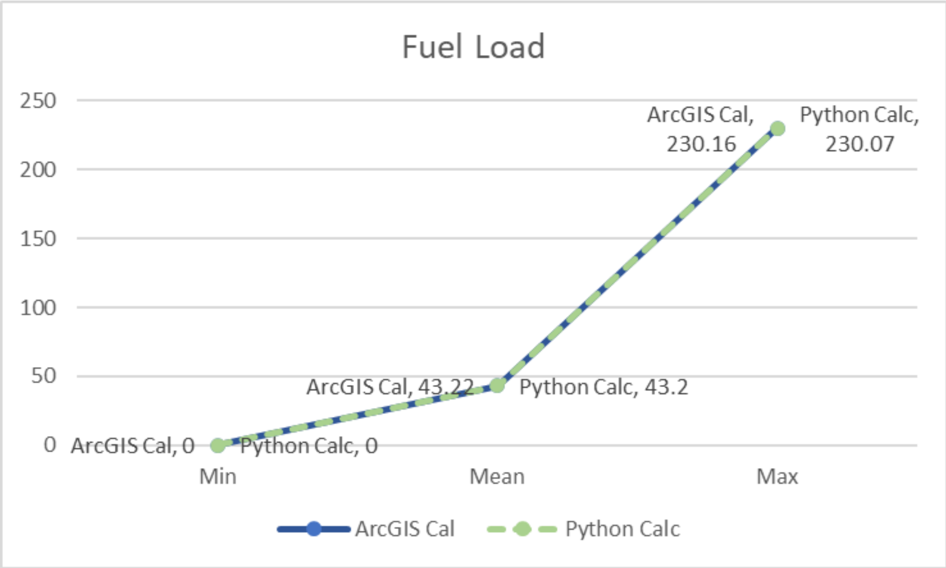


Figure 28 - Results of Fuel Load validations comparisons between ArcGIS vs. Coded calculation and show 100% similarity

KPI-3: Ensuring variable Aspect Variable are valid and reliable . Measurable activity: Difference calculation methods resulting >90% similarity value.

Explanation: Aspect refers to the compass direction that a slope faces. It is an important variable because it influences how solar radiation affects the temperature, moisture content, and ultimately the flammability of fuels (vegetation) on a slope.

Methods: Here we use one satellite image of Gargano and calculated: Mean, Max and Min Value (ArcGIS&Code)

Results: Internal validation has been carried out and get 99,99% similar for Fuel Load

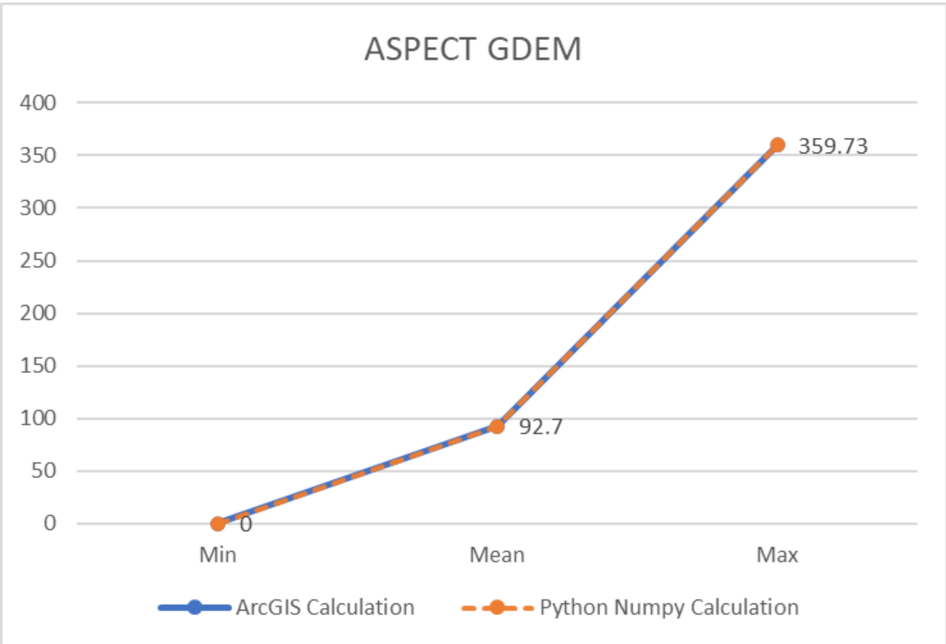


Figure 29 - Results of Aspect validations comparisons between ArcGIS vs. Coded calculation and show 100% similarity

KPI-4: Ensuring variable Slope Variable are valid and reliable. Measurable activity: Difference calculation methods resulting >90% similarity value.

Explanation: Slope refers to the steepness or incline of the terrain, expressed as a percentage or in degrees. Slope is a crucial variable because it significantly influences how a fire behaves, especially in terms of **rate of spread** and **fire intensity**.

Methods: Here we use one satellite image of Gargano and calculated: Mean, Max and Min Value (ArcGIS&Code)
Results: Internal validation has been carried out and get 99,99% similar for Fuel Load

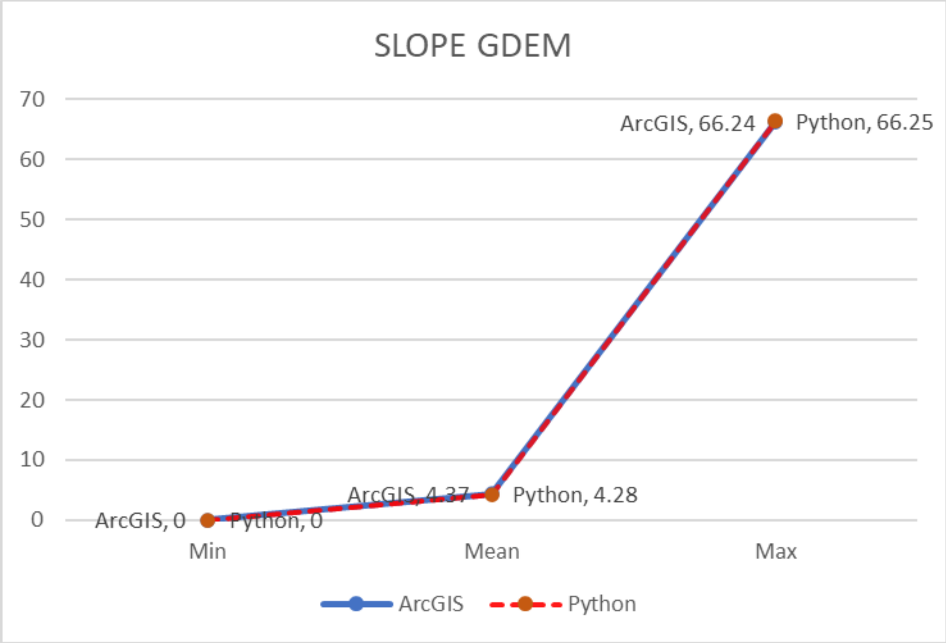


Figure 30 - Results of Slope validations comparisons between ArcGIS vs. Coded calculation and show 100% similarity

KPI-5: Ensuring variable Elevation Variable are valid and reliable. Measurable activity: Difference calculation methods resulting >90% similarity value.

Explanations: Elevation refers to the height above sea level of a particular area, and it is a key variable that influences fire behaviour. While elevation itself does not directly cause fire spread, it has an indirect effect by influencing other environmental factors like temperature, humidity, wind patterns, vegetation types, and the amount of available fuel.
Methods: Here we use one satellite image of Gargano and calculated: Mean, Max and Min Value (ArcGIS&Code)
Results: Internal validation has been carried out and get 99,99% similar for Fuel Load

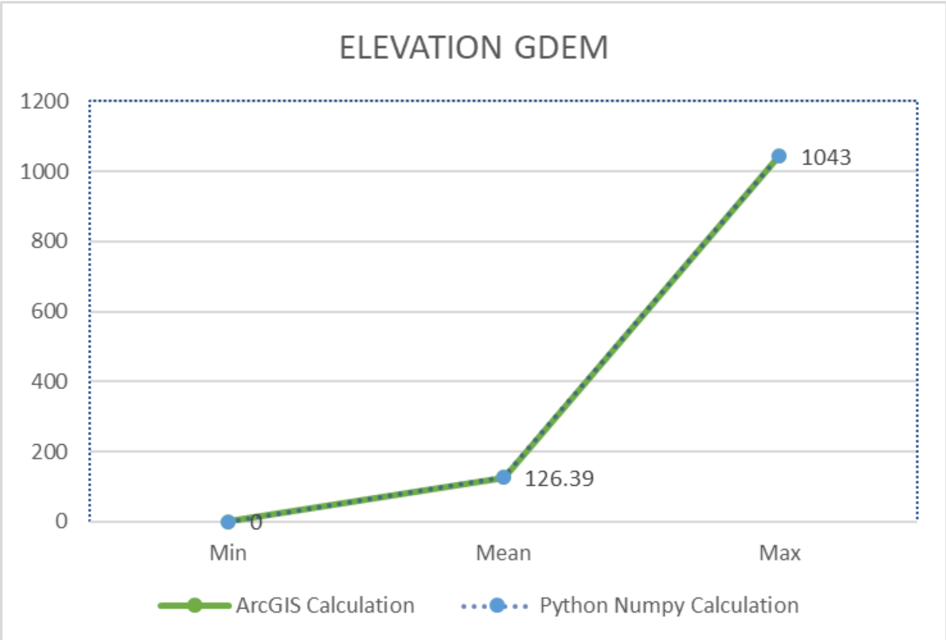


Figure 31 - Results of Elevation validations comparisons between ArcGIS vs. Coded calculation and show 100% similarity

6.22 UP9j: Multilingual Forest Fire Alert System

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP9j			
KPI-1	Accuracy of classification models > 90%	Language detection accuracy is 99.6%, Fire event detection accuracy is 91.85%, and Location detection accuracy is 98.52%	no	not yet
KPI-2	Classification Time <= 4 minutes for processing 100 tweets	Classification Time is 181.96 seconds or 3.03 minutes.	no	not yet
KPI-3	Email Push Success Rate per minute >= 30 emails	The E-mail Push Success Rate per minute is 39.64 emails.	no	not yet
KPI-4	System Uptime >= 99.9%	System Uptime is 99.98% in 2 days experiments.	no	not yet

Figure 32 - UP9j: Multilingual Forest Fire Alert System additional information

The Multilingual Forest Fire Alert System (DSS-MFAS) is designed with four critical Key Performance Indicators (KPIs) that determine its overall effectiveness and operational reliability. These KPIs are structured to ensure the system meets its primary objectives of detecting and processing fire-related information across diverse languages and contexts. The detailed specifications and performance criteria for these KPIs are outlined in Table 59, providing a comprehensive overview of the system's expected performance metrics.

KPI no.	Target	Description	Internal Testing Result
KPI-1	Accuracy of classification models > 90%	Ensure that the system accurately detects the language preference of a user, fire event, and location.	Language detection accuracy is 99.6%, Fire event detection accuracy is 91.85%, and Location detection accuracy is 98.52%
KPI-2	Classification Time <= 4 minutes for processing 100 tweets	Ensure that the system immediately detects the language preference of a user, fire event, and location.	Classification Time is 181.96 seconds or 3.03 minutes.
KPI-3	E-mail Push Success Rate per minute >= 30 emails	Successfully send e-mail alerts to users for at least 30 emails per minute.	The E-mail Push Success Rate per minute is 39.64 emails.
KPI-4	System Uptime >= 99.9%	Maintain a system uptime of at least 99.9% so that users receive early warning alerts and access detailed fire probability data.	System Uptime is 99.98% in 2 days experiments.

Table 89 – UP9j Multilingual Forest Fire Alert System (DSS-MFAS) KPIs

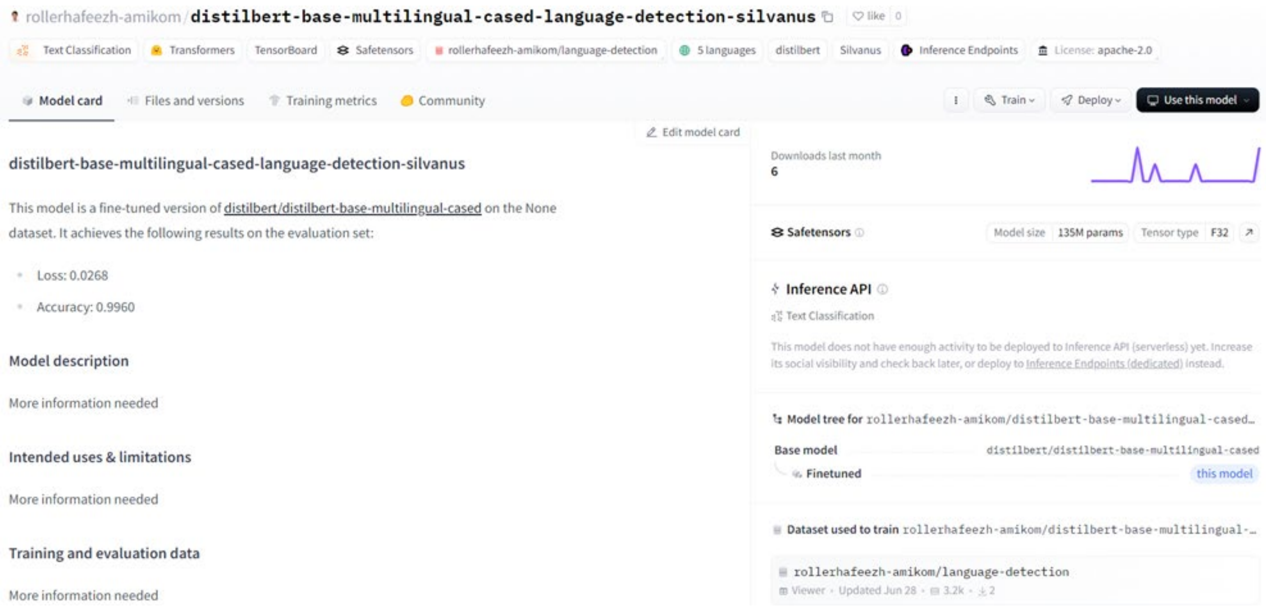


Figure 33 - Language Detection Model

The first KPI focuses on the system's ability to accurately identify the language of a tweet, detect potential fire events, and determine the specific location of the incident. This detection accuracy is essential for enabling multilingual monitoring and timely responses. The system's capacity to discern language nuances, extract relevant fire-related information, and accurately geolocate incidents is fundamental to its core functionality. Specifically, the system demonstrates a language detection accuracy of 99.6%, as shown in Figure 33. In addition, the fire event detection accuracy is reported at 91.85%, illustrated in Figure 34, while the location detection accuracy reaches 98.52%, as depicted in Figure 35. These high levels of accuracy ensure that DSS-MFAS has achieved the KPI-1.

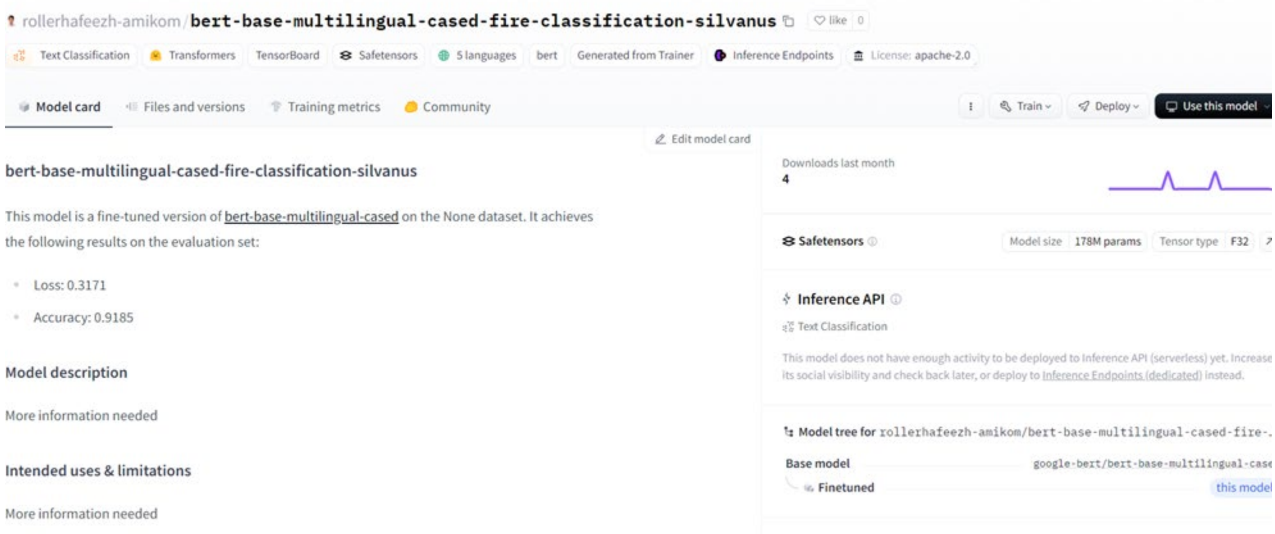


Figure 34 - Fire event detection model

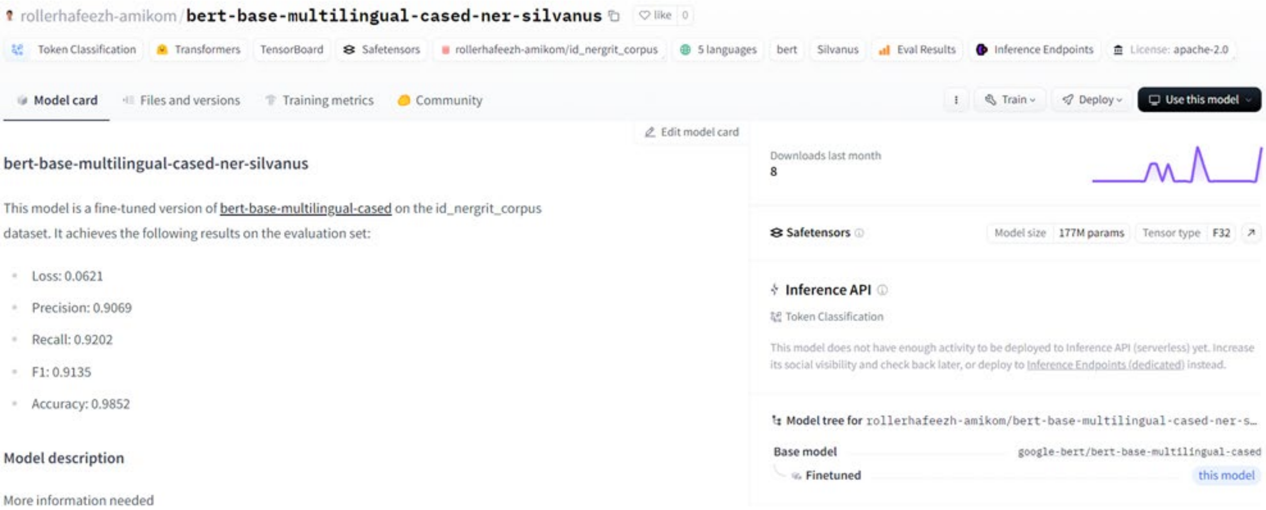


Figure 35 - Location detection model

The second KPI centers on the need for near real-time processing. For the system to be effective, it must analyze incoming tweets with minimal delay, ensuring that critical information is captured and acted upon almost instantly. This real-time capability is vital for promptly detecting and relaying alerts to stakeholders, enhancing the system's responsiveness during emergencies. The system's average processing time is 181.96 seconds, approximately 3 minutes, as indicated in Figure 36. Since the KPI-2 requirement specifies that processing time should be less than 4 minutes, this target is successfully achieved.

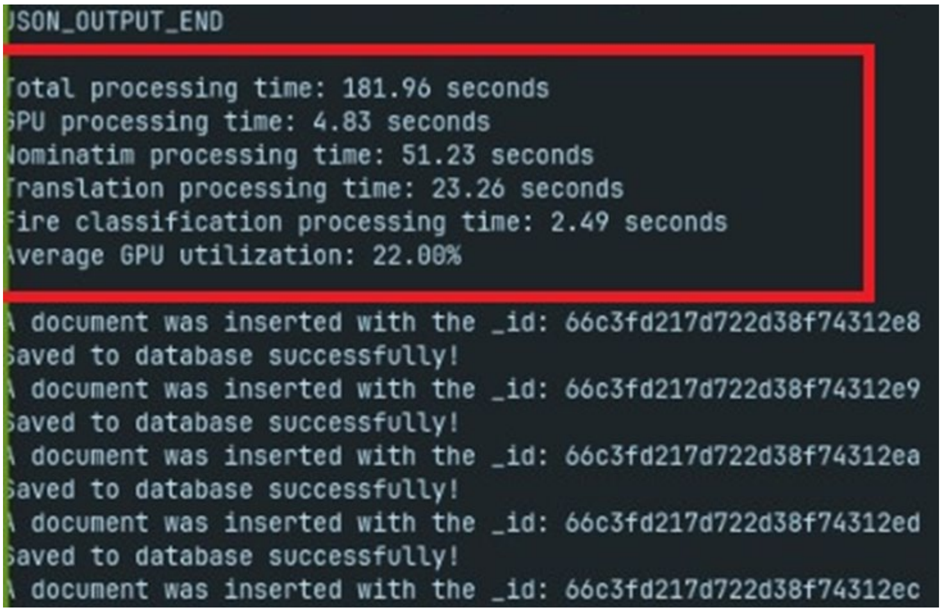


Figure 36 - Computation time for all detection processes of 100 tweets (1)

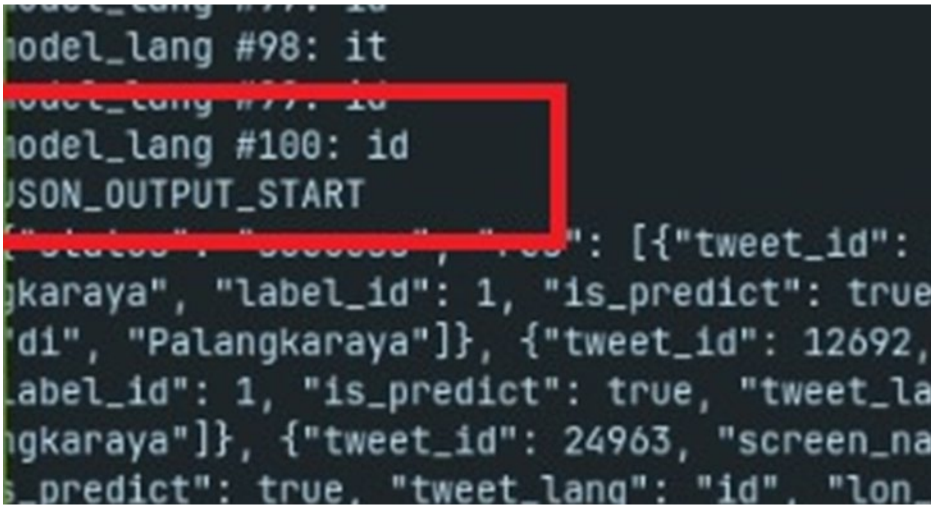


Figure 37 - Computation time for all detection processes of 100 tweets (2)

The third KPI assesses the system's ability to send alerts in bulk. Given the diverse range of recipients, including emergency responders and local authorities, the system must be capable of distributing email notifications to multiple addresses simultaneously. This functionality is critical for disseminating timely information during high-risk events, ensuring that all relevant parties are promptly informed. We successfully sent 39 emails per minute, surpassing the target rate of 30 emails per minute, thus fulfilling KPI-3 as illustrated in Figure 38.

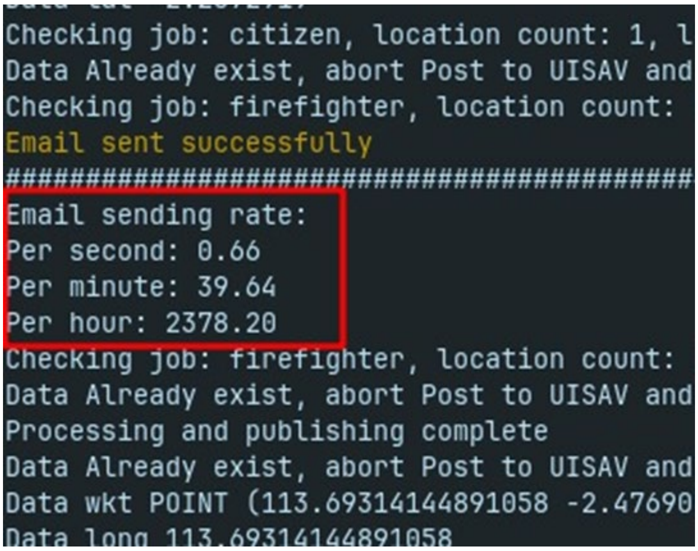


Figure 38 - The email push rate

The final KPI addresses the system's robustness under heavy computational load. As the DSS-MFAS scales to monitor extensive geographic areas and process large volumes of tweets, it must remain stable and perform consistently even under significant stress. Maintaining operational efficiency and reliability in these conditions is essential for the system's long-term effectiveness. As shown in Figure 39, the server maintained continuous operation without a restart for 3 days, while the sms-core, responsible for tweet classification, was restarted only once after 2 days online. Similarly, the SMS rate, which manages email distribution, was restarted once within the same period. Calculating uptime, the server's uptime is 100%, as it did not restart. Since restarts typically take 3 minutes, the sms-core and sms-rate uptimes are calculated as (2880 minutes – 3 minutes) / 2880 minutes = 99.98%. Since the uptime exceeds 99.9%, KPI-4 is also considered achieved.

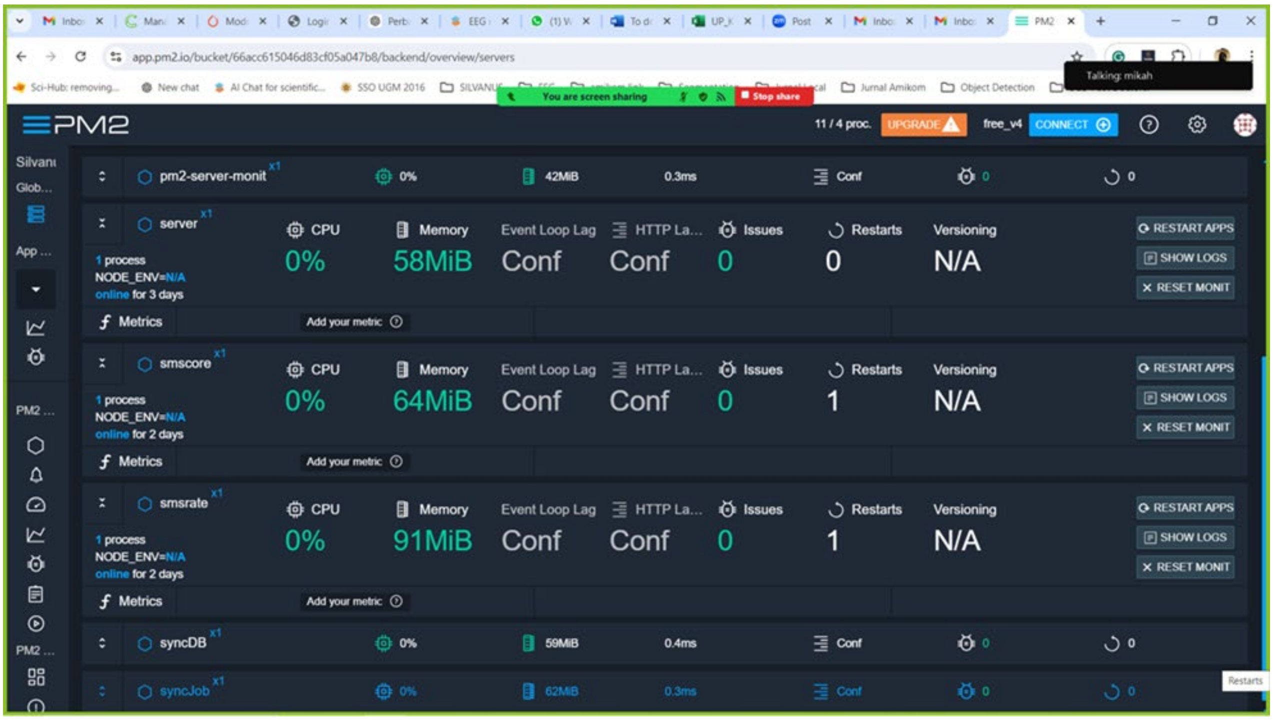


Figure 39 - The uptime of server, sms-core, and sms-rate

In summary, the DSS-MFAS has demonstrated strong performance across all four KPIs, indicating its effectiveness in detecting, processing, and disseminating critical information while maintaining stability under varying operational conditions.

6.23 UP9k: DSS Deep Learning Model for Wildfire Severity Prediction using EO4 Wildfires

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP.9k			
KPI-1	Absolute Percentage Difference	Paper published: EO4WildFires: An Earth Observation multi-sensor, time-series machine-learning-ready benchmark dataset for wildfire impact predictionEO4WildFires: An Earth Observation multi-sensor, time-series machine-learning-ready benchmark dataset for wildfire impact prediction. RSCy 2023 · Mar 23, 2023	No participation, as the paper, model and algorithm were being prepared	Will be presented in the French Pilot on10-12 October 2024
KPI-2	Boolean Mask Accuracy >= 90%			
KPI-3	Data Request Response Time <= 5 minutes			
KPI-4	Model Training Dataset Size >= 10,000 images			
KPI-5	Model Inference Time <= 3 minutes			
KPI-6	False Positive Rate <= 5%			

Figure 40 - UP9k: DSS Deep Learning Model for Wildfire Severity Prediction using EO4 Wildfires additional information

UP9k investigates the applicability of deep learning models for predicting the severity of forest wildfires, utilizing an innovative benchmark dataset called EO4WildFires. EO4WildFires integrates multispectral imagery from Sentinel-2, SAR data from Sentinel-1 and meteorological data from NASA Power annotated with EFFIS data for forest fire detection and size estimation. Resulting in a coverage of 45 countries (Figure 41) with a total of 31730 wildfire events from 2018 to 2022. All these various sources of data are archived into data cubes, with the intention of assessing wildfire severity by considering both current and historical forest conditions, utilizing a broad range of data including temperature, precipitation, and soil moisture. The experimental setup has been arranged to test different deep learning architectures' effectiveness in predicting the size and shape of wildfire burned areas. The study incorporates both Image Segmentation networks and Visual Transformers, employing a consistent experimental design across various models to ensure comparability of results. Adjustments were made to the training data, such as the exclusion of empty labels and very small events, to refine the focus on more significant wildfire events and potentially improve prediction accuracy. The models' performance was evaluated using metrics like F1 Score, IoU Score, and Average Percentage Difference (aPD). These metrics offer a multi-faceted view of model performance, assessing aspects such as precision, sensitivity, and the accuracy of the burned area estimation. Through extensive testing with Image Segmentation networks and Visual Transformers, the research not only aims at enhancing the accuracy of estimating the burned area but also underscores the significance of quality training data and the comparative effectiveness of traditional segmentation methods over transformer-based models for this specific application.

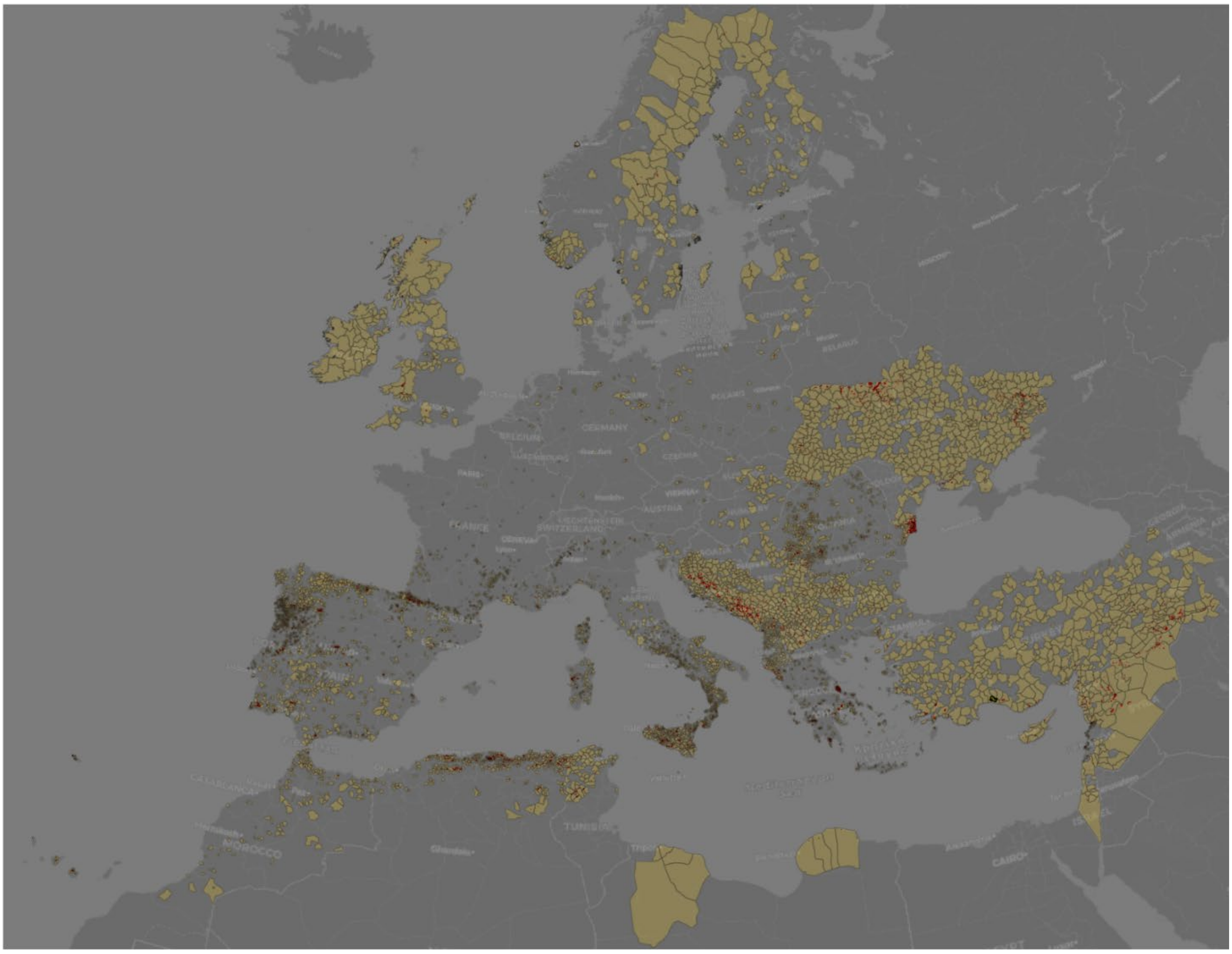


Figure 41 - Wildfires events (2018-2022) with the corresponding affected level-4 administration bound- aries - yellow polygons: administrative boundaries (level 4) of affected areas, red points: locations of wildfires events

A number of example case studies are presented to demonstrate the usability and potential of forecasting wildfire size in a more qualitative manner. The case studies are based on the Copernicus Emergency Management Service (EMS) - Mapping service, specifically its Rapid Mapping Portfolio and the EFFIS dataset.

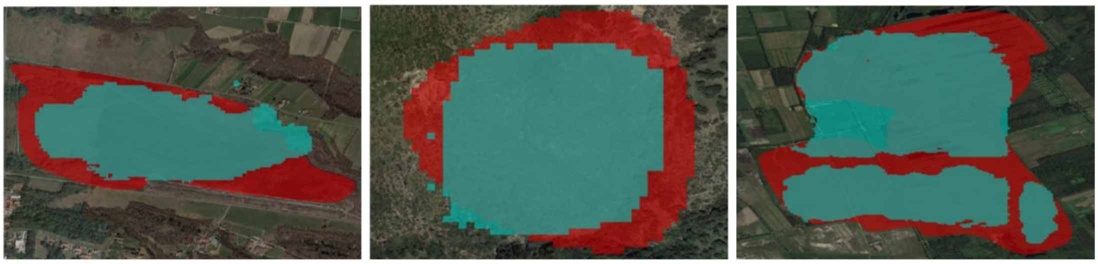
EMS offers quick geospatial information in response to emergencies, utilizing satellite imagery and other data. It aims to support emergency management activities by providing standardized products, such as pre-event and post-event analysis, including fast impact assessment and detailed damage grading. The service operates under two production modes to cater to urgent and less urgent needs, ensuring timely delivery of critical information for disaster response efforts. Among the geospatial products of the EMS are the burned areas, which are produced using very high resolution satellite images (< 0.5m) with high quality procedures that involve manual digitization and corrections to produce the final maps. For this purpose, we utilized:

- EMSN077: Post-disaster mapping of forest fires in De Meinweg National Park, Germany - Netherlands border.

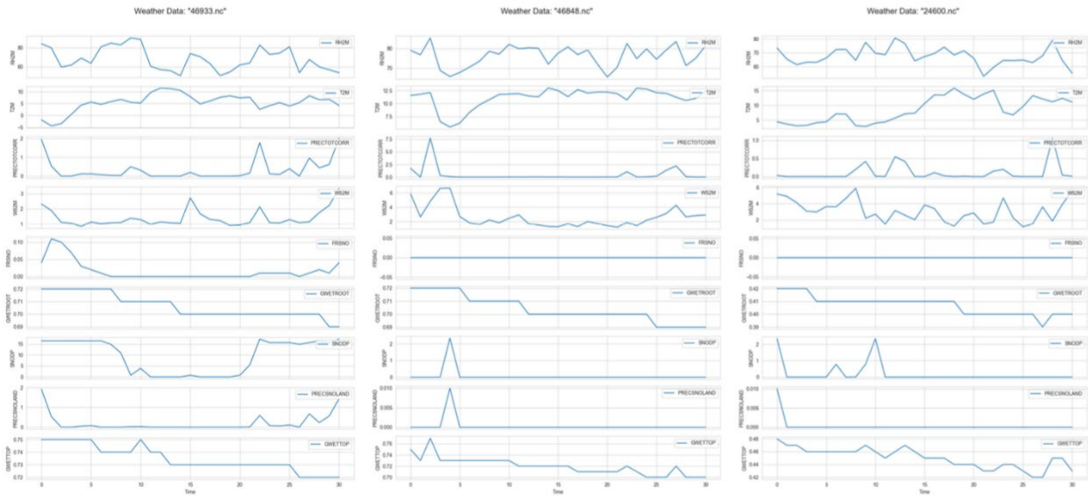
- EMSN090: Wildfires in Piedmont region, Italy.

Figure 42 shows the location of the case studies on a map. North's Italy case and Netherland's case are based on EMSN090 and EMSN077 correspondingly, while the rest rely on the EFFIS.

Figure 42 - Use case map overview



(a) Predicted (cyan) vs Ground truth (red).



(b) 30 days past meteorological time series variables.

Case Study #	Predicted	Ground truth	% Difference
54278	4620	4486	2.99
24600	49641	63619	-21.97
46848	750	1075	-30.23
46933	5589	8211	-31.93
54455	844	974	-13.35
55463	172	217	-20.74

Table 90 - Number of pixels predicted, ground truth and corresponding % difference

Table 1: Number of pixels predicted, ground truth and corresponding % difference.
Key takeaway from the case studies examination is that the developed methodology can be used to forecast wildfire size if it actually ignites. From Table 90 it is shown that although the errors will be in the range of 20-25%, this is a constant underestimation of the predictor. Thus, this gives a minimum baseline for evaluating upcoming risks during the fire season. Our proposed methodology is not intended to be used as a precision wildfire spread model, rather as a tool to forecast the potential size and shape of the wildfire if it occurs, so as to act as a utility tool that helps in the planning phase. Although shape is not the explicit optimization parameter, the models as they are trained learn the relevant pattern to predict the shape, since they are image segmentation models.

6.24 UP9l: DSS SIBYLA

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP.9l			
KPI-1	Accuracy metric	Paper published: Mahnken, M. et al. (2022). Accuracy, realism and general applicability of European forest models. In Global Change Biology, 28: 6921–6943.		
KPI-2	Biodiversity Indices Calculated >= 5	Paper published: Spulak, O., Souček, J. (2010). The Sibyla model and development of beech forests affected by air pollution. In Cent. Eur. J. Biol., 5(3): 371–383.		UP`s models and outputs are going to be demostrated during Slovak Pilot demonstration in 2024. Participants are foresters and firefighters.
KPI-3	Economic Analysis Accuracy >= 85%	Paper published: Roesiger, J. et al. (2017). Compensation payments for alternative forest management supporting nature conservation – a case study based on SIBYLA tree growth simulator and silvicultural cost model. Austrian Journal of Forest Science, Issue 1A.		UP`s models and outputs are going to be demostrated during Slovak Pilot demonstration in 2024. Participants are foresters and firefighters.
KPI-4	Thinning and Felling Regimes Simulated >= 3 per Scenario	Paper published: Fabriak, M., Valent, P., Scheer, Ľ. (2018). Thinning trainer based on forest-growth model, virtual reality and computer-aided virtual environment. In: Environmental modelling & software, 100: 11-23.	Demonstrated during Slovak Pilot Demonstration in 2023. Results of modelling were visualised by virtual reality in 3D cave. The scenarios of thinning and felling regimes were selected by the participants of the demonstration.	UP`s models and outputs are going to be demostrated during Slovak Pilot demonstration in 2024. Participants are foresters and firefighters.

Figure 43 - UP9l: DSS SIBYLA additional information

6.25 UP10: SILVANUS forward command centre

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP12			
KPI-1	Data Retrieval Success Rate >= 98%	This has been tested by ingesting batches of files in the cloud and then retrieving them from the FCC. Same was done for the EMDC	No	FCC validation will be done in the in Gargano, Greek, France, Portugal, and Slovakia pilots.
KPI-2	Data Integration Latency <= 10 minutes	This was tested by requesting the data from the Data Ingestion Pipeline queues and timing the time till the data was delivered	No	FCC validation will be done in the in Gargano, Greek, France, Portugal, and Slovakia pilots.

Figure 44 - UP10: SILVANUS forward command centre

6.26 UP11: SILVANUS platform and dashboard – Geographical information system

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP11			
KPI-1	User interface Responsiveness <= 2 seconds	This has been tested using standard browser tools e.g. on networking and manuall tests. The time from login to dashbord being displayed is within the parameters.		Depends on network perfomance and set-up.
KPI-2	Data Upload Latency <= 30	This has been tested in mauall tests. The time to upload data is within the KPI defined.		Depends on network perfomance and set-
KPI-4	Data Integration Latency <= 30	Achieved, all the necesasry UPs have been integrated and tested in manuall tests.	N/A (mock were presented)	Review meeting. Will be presented in all

Figure 45 - UP11: SILVANUS platform and dashboard – Geographical information system additional information

6.27 UP12: MESH in the sky

		Internal testing and validation	2023 Pilot validation	2024 Pilot validation
KPI no.	UP12			
KPI-1	Network Setup Time <= 10 minutes	Network set up time is measured by a timer from the moment the last mesh node is powered up to the moment all mesh nodes are synchronised.	Mesh-in the Sky was validated during the pilot in Opatia, Croatia. Integration with CATALINK sensors and compelte end-to-end conenctivity was demonstrated	Mesh-in-the-Sky was demonstrated during pilots in Czech Republic and Italy. These were live flights with mesh nodes on the drone and on the ground and interconencting numoerous sensors into a unified network. RINICOM also particiapted in integration excercise in Poland, and future live demonstrations are planned in France and Croatia in October 2024.
KPI-2	Connection Reliability >= 99%	Connection reliability is measured internally by network management system (NMS) over a given time interval		
KPI-3	Latency <= 30 seconds	Glad-to-glass latency (from teh camera to PC monitor) is used for measurements of video latency using dedicated set up in our laboratory. Usual network latency used measured by NMS though pings		
KPI-4	Battery Life >= 12 hours	This parameter is provided by battery supplier as we use OEM batteries		
KPI-5	Self-Healing Capability Activation Time <= 30 seconds	This parameter is measured by NMS and it shows maximum time required to find alternative route on network configuration		

Figure 46 – UP12 MESH in-the-sky additional information

APPENDIX II: Contribution from ASSET

6.28 Historical review of forest resilience to wildfires

6.28.1 Objectives

The goal of the Task 2.5 "Forest resilience from historical case studies" is to review the historical reports on past forest fires across 11 demonstration sites participating in the consortium. The structured representation of forest fire causes such as human negligence, environmental impact, climate and weather conditions and installation of power grid lines among others will be reviewed in detail for the development of most common causes of forest fire. The outcome from the task will be used to model the demonstration scenarios outlined in WP9.

The objective of the task is to collect historical records of wildfires, with details on the sources of origin along with the investigative analysis. The case-studies will be systematically categorised into (i) human causes; (ii) environment factors and (iii) impact of critical infrastructure services such as energy distribution. Each of the case-studies will be analysed along with the EO and Copernicus data sources to document the transformation of forest landscape after the spread of wildfire. The task will consolidate the such case-studies collected across continents towards the development of scenarios which will be considered within the project demonstration.

In detail, the activities are organized as follows:

- review the historical reports on past forest fires across 11 demonstration sites;
- represent the forest fire causes such as human negligence, environmental impact, climate and weather conditions in order to represent most common causes of forest fire;
- collect historical records of wildfires, with details on the sources of origin along with the investigative analysis;
- systematically categorize the case-studies by causes.

The task duration is M6 - M30. Below are some summary data:

Task Leader: ASSET (ITALY)

Task Participants: INTRA, SIMAVI (ROMANIA), EAI, ADP (PORTUGAL), VMG, CMCC F, Z&P, EXUS, RINI (CROATIA), MD, WUT, HB, AUA (GREECE), SGSP, PUI (FRANCE), LETS, PNRT (ITALY), SMURD, ASFOR (ROMANIA), KEMEA (GREECE), HRT, AHEPA, OIR, FRB MSR (CZECH REPUBLIC), HVZ, PLAMEN, TUZVO (SLOVAKIA), AMIKOM (INDONESIA), UFRJ (BRAZIL)

Demonstration sites:

ID (D2.1)	Pilot site	Owner	Contact
1	**France**-Titanobel	**PUI** (Pompiers de l'urgence internationale)	Iliana I.Korma i.korma@gmail.com
2	**Italy** Gargano National Park - Tepilora Park	**ASSET** (Regional Strategic Agency for the Ecosustainable Development of the Territory)	Giuseppe Garofalo giuseppe.garofalo@asset.regione.puglia.it
		PNRT (Parco Naturale Regionale di Tepilora)	parcoditepilora@gmail.com mulassloredana@gmail.com mariannamossa@gmail.com

			pnrtsilvanus@gmail.com
3	**Romania**- Rodna National Park	**ASFOR** (Romanian Forestry Association), **SIMAVI** (Software Imagination and Vision srl)	Laura asforh2000@gmail.com mircea.segarceanu@gmail.com
4	**Greece**- Region of Evia	**KEMEA** Center for Security Studies (Kentro Meleton Asfaleias)	Georgios Sakkas g.sakkas@kemea-research.gr
5	**Portugal**- Quinta da França	**ADP** (Aguas de Portugal)	m.carvalho@adp.pt carlos.brito@adp.pt
6	**Czech Republic**- Krásná	**FRB MSR** (Fire rescue brigade of moravian silesian region hasicsky zachranny sbor moravskoslezskeho kraje)	Gašparín Marek Marek.Gasparin@hzscr.cz
7	**Croatia**- Training Center of Šapjane in Učka Nature Park Liburnija	**HVZ** (Hrvatska Vatrogasna Zajednica)	zeljko.cebin@hvz.hr
8	**Slovakia**- Podpolanie	**TUZVO** (Technical University in Zvolen), **PLAMEN** (Obcianske zdruzenie Plamen Badin), **UISAV** (Institute of Informatics of the Slovak Academy of Science)	Andrea Majlingová majlingova@tuzvo.sk
9	**Australia**- Queensland Centre for Advanced Technologies	**CSIRO** (Commonwealth Scientific and Industrial Research Organization)	paulo.borges@data61.csiro.au Tirtha.Bandy@data61.csiro.au
10	**Brazil**- Pantanal Matogrossense National Park	**UFRJ** (Federal University of Rio de Janeiro)	rogerio@ntt.ufrj.br nelson@ntt.ufrj.br
11	**Indonesia**- Sebangau National Park	**AMIKOM** (Yayasan AMIKOM Yogyakarta)	Kusrini Kusrini kusrini@amikom.ac.id Gardyas Adninda gardyasadninda@amikom.ac.id Arief Setyanto arief_s@amikom.ac.id

Table 91 - Demonstration sites information

6.28.2 Data collection method and sources

In order to collect data on historical forest fires across 11 demonstration sites, listed above, a standard method of cataloging fire causes was adopted. The scientific activities started in April 2022.

To do this, a common terminological taxonomy about fire causes was studied from the technical literature (Lovreglio et al., 2008); then the significant information was extrapolated.

Indicare con una crocetta le 8 motivazioni più importanti	Graduatoria delle 8 motivazioni segnate dalla crocetta (da 1 a 8)	
		1. INCENDI DI ORDINE NATURALE
☐	☐	1001 – Incendi causati da fulmini
☐	☐	1002 – Incendi causati da autocombustione
		2. INCENDI DI ORDINE ACCIDENTALE
☐	☐	2001 – Incendi causati da scintille dalle ruote dei treni
☐	☐	2002 – Incendi causati da marmitte catalitiche
☐	☐	2003 – Incendi causati da scintille di trattori o altri motori agricoli
☐	☐	2004 – Incendi causati da corto circuito lungo condutture elettriche
		3. INCENDI DI ORDINE COLPOSA O INVOLONTARIA
☐	☐	3001 – Incendi causati da mozziconi di sigaretta o fiammiferi lungo le reti viarie
☐	☐	3002 – Incendi causati da mozziconi di sigaretta o fiammiferi in aree di campagna
☐	☐	3003 – Incendi causati da mozziconi di sigaretta o fiammiferi in aree boschive
☐	☐	3004 – Incendi causati da mozziconi di sigaretta o fiammiferi lungo line ferroviarie
☐	☐	3101 – Incendi causati da attività di ripulitura di incolti
☐	☐	3102 – Incendi causati da eliminazione di residui vegetali forestal e agricoli (per esempio avanzi di potatura)
☐	☐	3103 – Incendi causati da attività di miglioramento o rinnovazione del pascolo
☐	☐	3104 – Incendi causati da bruciatura delle stoppie
☐	☐	3105 – Incendi causati da attività di ripulitura di scarpate stradali o ferroviarie
☐	☐	3201 – Incendi causati da attività ricreative e turistiche (per esempio fuochi di barbecue)
☐	☐	3202 – Incendi causati da lanci di petardi o razzi, brillamento di mine e esplosivi, lancio di mongolfiere di carta
☐	☐	3203 – Incendi causati dall'uso di apparecchi a motore, a fiamma, elettrici e meccanici
☐	☐	3204 – Incendi causati da manovre militari o esercitazioni di tiro
☐	☐	3205 – Incendi causati da bruciatura di rifiuti in discariche abusive

(segue)

Segue Tabella 2

Indicare con una crocetta le 8 motivazioni più importanti	Graduatoria delle 8 motivazioni segnate dalla crocetta (da 1 a 8)	
☐	☐	3206 – Incendi causati da cattiva manutenzione di elettrodotti o dalla rottura e caduta a terra di conduttori
☐	☐	3207 – Incendi causati da cacciatori
		4. INCENDI DI ORIGINE DOLOSA
☐	☐	4001 – Incendi causati da ampliamento, apertura o rinnovazione del pascolo a spese del bosco
☐	☐	4002 – Incendi causati dalla volontà di recuperare terreni agricoli a spese del bosco per attivare contributi comunitari (per esempio impiantando oliveto)
☐	☐	4003 – Incendi causati con l'intento di guadagnare dalla scomparsa della vegetazione a fini di coltivazione agricola (per esempio ampliando l'area coltivabile)
☐	☐	4004 – Incendi causati a fini di speculazioni edilizia (per esempio pensando di eliminare i vincolo)
☐	☐	4005 – Incendi causati per facilitare apertura di piste forestali, per risparmiare manodopera nelle operazioni colturali, per ottenere distruzione di copertura forestale e facilitare le operazione di utilizzazione
☐	☐	4006 – Incendi causati da questioni occupazionali connesse agli operai degli Enti Locali (per esempio protesta contro licenziamento, protesta contro chiusura cantieri, protesta contro mancata apertura cantieri)
☐	☐	4007 – Incendi causati con l'intento di distruggere per mezzo del fuoco opere forestali non ben eseguite o non collaudabili
☐	☐	4008 – Incendi causati con l'intento di essere inclusi come operai nelle squadre antincendio o nei lavori di ricostituzione
☐	☐	4009 – Incendi causati da azioni riconducibili al bracconaggio (per esempio vendette, protesta contro sanzioni)
☐	☐	4010 – Incendi causati per ottenere prodotti conseguenti al passaggio del fuoco (per esempio funghi, asparagi)
☐	☐	4011 – Incendi causati dalla criminalità organizzata
☐	☐	4101– Incendi causati da vendette o ritorsioni dei confronti della Pubblica Amministrazione
☐	☐	4102 – Incendi causati da conflitti o vendetti tra proprietari
☐	☐	4103 – Incendi causati da protesti contro i vincoli imposti nelle arie protette
☐	☐	4104 – Incendi causati per gioco o divertimento
☐	☐	4105 – Incendi causati con l'intento di deprezzare aree turistiche, anche come atto di intimidazione
☐	☐	4106 – Incendi causati da fatti riconducibili a contrapposizioni politiche
☐	☐	4107 – Incendi causati da atti terroristici
☐	☐	4108 – Piromania

Figure 47 - Fire causes. Source: Lovreglio et al., 2008

Following, a first draft table was drawn up on excel with all the main categories and specifically:

1. Pilot description: pilot; country; pilot description; size area;
2. Description of predisposing factors of fires: Land Cover Type; Protected area - nature conservation sites; Topographic structure (slope, exposure, etc.); Climatic zone of the pilot area; Average elevation of the Pilot Site (m above sea level); Soil textural composition in the pilot site; Soil fertility in the Pilot Site (associated to the % organic carbon or organic matter content); Soil depth in the Pilot Site (cm); Tree species composition; Average tree

characteristics; Presence of a Plan for fire prevention, mitigation and forest restoration; Restored areas (ha); Min-max average temperatures in the fire season; Moisture in the fire season; Rainfall (mm/year);

3. Event categorization: Fire per year; Fire per month (in the fire season); Total Wooded Area Burned (ha); Total other Areas Burned (ha); Interventions against fire events; Tree species composition burned; Fire severity (for each fire event in the last 10 years); Fire season; Days of the week with mayor number of fires; Time slot; Air operations (number); Availability of helicopter landing pads; Availability of water supply; Reachability (time / mean of transport);
4. Determinant causes of fires: list of Lovreglio et al. (2008) causes;
5. Mapping section, in which Shapefile or geographical coordinates of each fire event in each pilot area are requested.

The drafted table was shared with local expert actors, and specifically with the Civil Protection that validated the contents. Moreover, the table fields already requested in Deliverable 2.1 questionnaire were identified in order to avoid redundancies in the compilation.

Only afterwards, the excel file was shared with all the partners of Task 2.5 to validate and share the contents.

No feedback was received from the Task partners, except from Exert.ai Naples, which suggested simplifying the table by following the European fire causes taxonomy by EFFIS. Specifically, the list of causes suggested by the Executive report "Harmonized classification scheme of fire causes in the EU adopted for the European Fire Database of EFFIS" of the JRC Scientific and Policy Reports of the European Commission has been reported. In detail, the causes adopted are:

Fire causes	**CATEGORY**	**GROUP**	**CLASS**
	100 UNKNOWN	100 Unknown	100 Unknown
	200 NATURAL	200 Natural	201 Lightning 202 Volcanism 203 Gas emission
	300 ACCIDENT	300 Accident	301 Electrical power 302 Railroads (Railways) 303 Vehicles 304 Works 305 Weapons (firearms, explosives, etc.) 306 Self-ignition (auto-combustion) 307 Other accident
	400 NEGLIGENCE	410 Use of fire	411 Vegetation management 412 Agricultural burnings 413 Waste management 414 Recreation 415 Other negligent use of fire
		420 Use of glowing objects	21 Fireworks, firecrackers and distress flares 422 Cigarettes 423 Hot ashes 424 Other use of glowing object
	500 DELIBERATE	510 Responsible (arson)	511 Interest (profit) 512 Conflict (revenge) 513 Vandalism 514 Excitement (incendiary) 515 Crime concealment 516 Extremist

		520 Irresponsible	521 Mental illness 522 Children
	600 REKINDLE	600 Rekindle	600 Rekindle

Figure 48 - Fire causes. Source: JRC EFFIS, 2008

For the collection of fire causes historical data, a significant period was selected from the point of view of statistical analysis (at least 10 years). Specifically, we choose to collect the last 10 years, from 2012 to 2022. Requests from task partners asking to start from 2010 until 2022, therefore we have adjusted the period (2010 - 2022).

Particular attention was paid to the request for georeferenced data indicating the pilot area. This data is crucial for delimiting the intervention perimeter (not always specified in the project proposal, and in some cases, as in Italy, it concerns two different regions, Puglia and Sardegna).

The table was therefore shared with the project partners, and the objectives and required data were explained in detail in several organized calls, giving deadlines for data collection, both intermediate and final (further discussions were organized with individual partners to homogenize responses, because each country has its own system, and to collect data, incomplete and partial).

6.28.3 Data collected and analysed

The analysis of historical forest fire data conducted on the 11 pilots has revealed some critical issues that could not have been highlighted in the initial planning phase.

The first, and most important issue, was that not all partners have available shapefiles (GIS vector data storage format) to store the position, shape and attributes of the geographical features of the areas identified as pilots for the Silvanus project.

The solution we identified to address this lack of data was to use the European platform EFFIS - European Forest Fire Information System (see chapter 4.5).

The second issue was that some countries did not send data, some years are missing, some data are missing or are not geolocalized, leading to problems of comparison.

The main cause is to be found in the fact that in some cases the consortium partners were not the main stakeholders who by mission are considered the most suitable for the possession and management of this data. Therefore, the provision of this information by the competent bodies has not always been effective.

A summary of data collected from the excel spreadsheets is shown below.

Pilot 1. France- Titanobel

The partner PUI-POMPIERS DE L'URGENCE INTERNATIONALE provided aggregate data, regarding the occurrence of fires, at national level, and only in the years 2017-2022. No shapefiles were available.

- Analyzed size area: unknown
- Land cover type (ha)
  - Artificial surfaces: unknown
  - Agriculture areas: unknown
  - Forests and semi-natural areas: unknown
  - Protected area: unknown
- Dominant factors determining wildfires (temperature, moisture, slope, rainfall, etc.)
  - Min-max average temperatures in the fire season: unknown

- Moisture in the fire season: unknown
- Rainfall (mm/year): unknown
Fire events 2017-2022: 138
- 2010: unknown;
- 2011: unknown;
- 2012: unknown;
- 2013: unknown;
- 2014: unknown;
- 2015: unknown;
- 2016: unknown;
- 2017: 35 (69,75 ha);
- 2018: 0;
- 2019: 38 (85,56 ha);
- 2020: 30 (42,59 ha);
- 2021: 15 (24,57 ha);
- 2022: 20 (26,25 ha);

- Prevalent causes: unknown, accident, negligence
  - Unknown: 15
  - Accident: 4
- Type of fire: ground, underground:
  - not available
- Georeferenced shp: no

Pilot 2. Italy - Parco Nazionale del Gargano - Gargano National Park

The Gargano National Park was instituted by Presidential Decree of 5 June 1995. It insists on the municipalities of Apricena, Cagnano Varano, Carpino, Ischitella, Tremiti Islands, Lesina, Manfredonia, Mattinata, Monte Sant'Angelo, Peschici, Rignano Rodi Garganico, San Giovanni Rotondo, San Marco in Lamis, Sannicandro Garganico, Serracapriola, Vico del Gargano, Vieste.

The territory is divided into zone 1 and zone 2, zone 1 is the area of significant natural, landscape and cultural interest with a limited or non-existent degree of anthropisation. Zone 2 is the area of naturalistic, landscape and cultural value with a greater degree of anthropisation.

In the Gargano National Park there are 15 Sites of Community Importance and 4 Special Protection Areas.

- Analyzed size area: 121.118 ha
- Land cover type (ha) - Source Corine Land Cover
  - Artificial surfaces (Class 1): 1.325,33 ha - 1,09%
  - Agriculture areas (Class 2): 29.125,40 ha - 24,03%
  - Forests and semi-natural areas (Class 3): 80.177,48 ha - 66,15%
  - Wetland Areas (Class 4): 1.056,51 ha - 0,87%
  - Water bodies (Class 5): 9.519,28 ha - 7,85%

  - Protected area: 121.118 ha - 100%

- Dominant factors determining wildfires (temperature, moisture, slope, rainfall, etc.)

  The fire season is the summer season (June - August)

  - Min-max average temperatures in the fire season:

The average annual temperature ranges between 6° C in the winter months and 34° C in the summer months, with an annual range of approximately 16-18° C, while the period in which values below or slightly above 0° C are recorded is related to the altitude of the area as well as to the distance from the sea.

Therefore, in the coastal areas the thermometer rarely drops below zero, while in the high Gargano area temperatures of -10° C can be recorded, generally limited to short periods or, in some years, temperatures drop below zero even for periods of more than 40-50 days that are more or less continuous.

- Moisture in the fire season:

The mapping of the monthly average values of relative humidity shows that July is particularly dry for the entire promontory, while this factor tends to increase in the months of of June, August and September.

- Rainfall (mm/year):

The distribution of rainfall over the year generally follows the typical Mediterranean rainfall regime, i.e. with abundant winter-spring rainfall and accentuated dryness.
Mediterranean rainfall regime, that is, with abundant winter-spring rainfall and accentuated aridity summer dryness.

Generally, there is modest rainfall along the coasts (600-700 mm/year) while, at the increase in altitude, they become more and more accentuated, reaching 1,200 mm/year in the Umbra Forest area.
in the Foresta Umbra area.

Very singular is the northern slope of the promontory that enjoys, due to the effect of the humid currents from the north, as well as a higher amount of precipitation on average, than that of the southern slope, as well as an accentuated atmospheric humidity.

Fire events 2010-2022 (number):

Source: Plan AIB Gargano National Park 2014-2018

- 2010: 21 (total area 139.76 ha, of which 55.04 ha is wooded and 84.72 ha is unwooded)
- 2011: 40 (total area 687.68 ha, of which 297.66 ha is wooded and 390.03 ha is unwooded)
- 2012: 55 (total area 387.30 ha, of which 258.32 ha is wooded and 128.98 ha is unwooded)

Source:
https://www.mase.gov.it/sites/default/files/archivio/allegati/aib/dpn_aib_statistiche_pn_1997_2015.pdf

- 2013: 16 (total area 20.25 ha, of which 16,84 ha is wooded and 3,41 ha is unwooded)
- 2014: 13 (total area 1.49 ha, of which 1,03 ha is wooded and 0,46 ha is unwooded)
- 2015: 36 (total area 143,05 ha, of which 90,82 ha is wooded and 52,23 ha is unwooded)

- 2016: unknown
- 2017: unknown
- 2018: unknown
- 2019: unknown

- 2020: unknown
- 2021: unknown
- 2022: unknown

- Prevalent causes: unknown, accident, negligence (%)

  Source: Plan AIB Gargano National Park 2014-2018 (2003/2012)

  - Unknown: -
  - Accident: 1%
  - Negligence: 29%
  - Arson: 70%
  - Natural: 0%

- Type of fire:

  Source: Plan AIB Gargano National Park 2014-2018

  - Underground: is a type of fire that is rare in Gargano areas.
  - Ground: is a fire that spreads by consuming the lower layers of vegetation, dry leaves, dead branches, grasses and shrubs in the undergrowth, without the flames affecting the tree crowns.
  - Crown: fire that starts as a surface fire, passing through the crowns if the continuity conditions allow this transition; it affects the entire volume of the stand passing from crown to crown, supported or not by surface fires (passive or active crown fire respectively)
  - Combination: is a fire that, favored by the vertical continuity of the fuels, the so-called fuel ladder, consumes the dry branches of the lower layers of the tree strata, allowing the combustion process to pass into the upper tree level. The transition from surface fire to crown fire begins with the ignition of one or more trees.
  - Other : -

- Georeferenced shp: yes

Pilot 2. Italy- Parco Naturale Regionale di Tepilora

The regional natural park of Tepilora extends into the territories of the municipalities of Bitti, Lodè, Posada, Torpè.

- Analyzed size area (Ha): 7,877.00
- Land cover type (Ha)
  - Artificial surfaces: 44.11
  - Agriculture areas: 918.46
  - Forests and semi-natural areas: 6,454.41
  - Wetlands areas: 98.46
  - Water bodies areas. 361.55
  - Protected area: 7,877.00
- Dominant factors determining wildfires (temperature, moisture, slope, rainfall, etc.)
  - Min-max average temperatures in the fire season: Min 17,0 °C Max 30,0 °C
  - Moisture in the fire season: 30%
  - Rainfall (mm/year): 950

  Fire events 2010-2022 (number):

- 2010: 2
- 2011: 2
- 2012: 1
- 2013: 0
- 2014: 2
- 2015: 2
- 2016: 1
- 2017: 0
- 2018: 0
- 2019: 0
- 2020: 2
- 2021: 0
- 2022: 0

- Prevalent causes: unknown, accident, negligence (%)
  - Unknown: 0.00
  - Accident: 5.00
  - Negligence 35.00
  - Deliberate/Arson 60.00
- Type of fire: Underground, Ground (surface), Crown, Combination, Other (number):
  - Ground (surface)
- Georeferenced shp: yes

Pilot 3. Romania- Rodna Mountains National Park

The partner ASFOR provided data required in the excel spreadsheet, partially incomplete. Fire events were known in terms of burnt hectares and not in terms of number of occurrences. Prevalent causes of fires were unknown. No shapefiles were available.

- Analyzed size area: 47177 ha
- Land cover type (ha): unknown
- Protected area: 3300 ha
- Dominant factors determining wildfires (temperature, moisture, slope, rainfall, etc.): unknown
- Fire events 2010-2022: unknown
- - 2010: unknown
- - 2011: unknown
  - 2012: unknown
  - 2013: 10,1 ha;
  - 2014: 14,75 ha;
  - 2015: 0 ha;
  - 2016: 5 ha;
  - 2017: 5 ha;
  - 2018: 3 ha;
  - 2019: 3,5 ha;
  - 2020: 114,68 ha;
  - 2021: 0 ha;
  - 2022: 64,45 ha;
- Prevalent causes: unknown, accident, negligence
  - not available
- Type of fire: ground, underground
  - not available
- Georeferenced shp: no

Pilot 4. Greece- Region of Northern Evia (Euboea), Municipalities of Istiaia-Aidipsos and Limni-Mantoudi-Agia Anna

The partner KEMEA provided detailed data as requested by the survey. Shapefiles were available for the pilot area.

- Analyzed size area: 186945,85 ha
- Land cover type (ha)
  CORINE CODE AREA (ha)
  - Discontinuous urban fabric (112) 1680.38 ha
  - Non-irrigated arable land (211) 12483.22 ha
  - Fruit trees and berry plantations (222) 703.63 ha
  - Olive groves (223) 12190.50 ha
  - Pastures (231) 172.01 ha
  - Industrial or commercial units (121) 178.41 ha
  - Mineral extraction sites (131) 1991.33 ha
  - Sport and leisure facilities (142) 24.50 ha
  - Complex cultivation patterns (242) 14411.20 ha
  - Land principally occupied by agriculture, with significant areas of natural vegetation (243) 17171.99 ha
  - Broad-leaved forest (311) 7773.80 ha
  - Coniferous forest (312) 43859.51 ha
  - Mixed forest (313) 16697.97 ha
  - Natural grassland (321) 4430.82 ha
  - Moors and heathland (322) 960.28 ha
  - Sclerophyllous vegetation (323) 15885.01 ha
  - Transitional woodland/shrub (324) 32390.24 ha
  - Beaches, dunes, sands (331) 239.19 ha
  - Moors and heathland (332) 32.17 ha
  - Sparsely vegetated areas (333) 2800.10 ha
  - Inland marshes (411) 50.66 ha
  - Salt marshes (421) 129.67 ha
  - Coastal lagoons (521) 45.02 ha
  - Sea and ocean (523) 508.81 ha
- Protected area: 31455,27 ha
- Dominant factors determining wildfires (temperature, moisture, slope, rainfall, etc.)
  - Min-max average temperatures in the fire season: 18,5C° - 28,6C°
  - Moisture in the fire season: 67%
  - Rainfall (mm/year): 572,73 (2021)
- Fire events 2010-2022: 641
- - 2010: 146
- - 2011: 66
  - 2012: 55;
  - 2013: 65;
  - 2014: 82;
  - 2015: 42;
  - 2016: 39;
  - 2017: 27;
  - 2018: 58;
  - 2019: 59;
  - 2020: 51;
  - 2021: 51;

- 2022: unknown;
- Prevalent causes: unknown, accident, negligence
  - Unknown: 56,2%
  - Natural: 4,6%
  - Accident: 2,9%
  - Negligence: 21,6%
  - Deliberate: 10,9%
- Type of fire: ground, underground
  - Crown
  - Combination
- Georeferenced shp: yes

Pilot 5. Portugal- Quinta da França

Partner ADP provided partially complete data. Fire events were recorded and prevalent causes of fires were reported. Shapefiles were available for the pilot area.

- Analyzed size area: unknown
- Land cover type (ha): unknown
- Protected area: unknown
- Dominant factors determining wildfires (temperature, moisture, slope, rainfall, etc.): unknown
- Fire events 2010-2021: 334
  - 2010: 41 (1540 ha);
  - 2011: 36 (538 ha);
  - 2012: 35 (917 ha);
  - 2013: 122 (3315 ha);
  - 2014: 5 (unknown);
  - 2015: 40 (1474 ha);
  - 2016: 5 (226 ha);
  - 2017: 20 (23065 ha);
  - 2018: 4 (379 ha);
  - 2019: 8 (765 ha);
  - 2020: 15 (2727 ha);
  - 2021: 3 (29 ha);
  - 2022: not available;
- Prevalent causes: unknown, accident, negligence
  - Unknown: 150
  - Negligence: 33
  - Volunteer: 19
  - Natural:3
- Type of fire: ground, underground
  - not available
- Georeferenced shp: yes

Pilot 6. Czech Republic- Krásná

- Analyzed size area: 4.409,5 ha
- Land cover type (ha)
  - Artificial surfaces: 154,33 ha (3,5%)
  - Agriculture areas: 745,21 ha (16,9%)
  - Forests: 3.483,51 ha (79,0%)

- Water bodies: 26,46 ha (0,6%)

- Protected area: 4395 ha
- Dominant factors determining wildfires (temperature, moisture, slope, rainfall, etc.)
  - Min-max average temperatures in the fire season: 0C° - 20,5C°
  - Moisture in the fire season: not available
  - Rainfall (mm/year): 960
- Fire events 2012-2022: 12
  - 2012: unknown;
  - 2013: unknown;
  - 2014: unknown;
  - 2015: 2 (0,03 ha);
  - 2016: unknown;
  - 2017: 2 (0,01 ha);
  - 2018: 2 (0,005 ha);
  - 2019: 2 (0,01 ha);
  - 2020: 2 (0,02 ha);
  - 2021: 2;
  - 2022: unknown;
- Prevalent causes: unknown, accident, negligence
  - Unknown: 8
  - Negligence (use of fire): 4
- Type of fire: ground, underground
  - not available
- Georeferenced shp: no

Pilot 7. Croatia- Training Center of Šapjane in Učka Nature Park Liburnija

- Analysed size area: 15,7 ha (firefighters training grounds and facilities)
- Land cover type (ha)
  - Artificial surfaces: 30.800 ha (57,7%)
  - Agriculture areas: 10.176 ha (19,0%)
  - Forests and semi-natural areas: 12.410 ha (23,3%)
- Protected area: 10.160,14 ha
- Dominant factors determining wildfires (temperature, moisture, slope, rainfall, etc.)
  - Min-max average temperatures in the fire season: 16.6C° - 36C°
  - Moisture in the fire season: 75%
  - Rainfall (mm/year): 83.3 mm
- Fire events 2012-2022: 88
  - 2012: 15 (27,5 ha);
  - 2013: 6 (1,7 ha);
  - 2014: 2 (0, 007 ha);
  - 2015: 13 (1,39 ha);
  - 2016: 8 (2,19 ha);
  - 2017: 7 (3,01 ha);
  - 2018: 2 (0,03 ha);
  - 2019: 9 (3,1 ha);
  - 2020: 5 (0,19 ha);
  - 2021: 12 (5,3 ha);
  - 2022: 9 (4,8 ha);
- Prevalent causes: unknown, accident, negligence
  - Accident: 45
  - Unknown: 26
- Type of fire: ground, underground

- Ground: 57
- Underground: 15
▪ Georeferenced shp: no

Pilot 8. Slovakia- Podpolanie

▪ Analysed size area: unknown
▪ Land cover type (ha): unknown
▪ Protected area: unknown
▪ Dominant factors determining wildfires (temperature, moisture, slope, rainfall, etc.): unknown
▪ Fire events 2012-2022: 663
- 2010: 62;
- 2011: 89;
- 2012: 160;
- 2013: 39;
- 2014: 46;
- 2015: 44;
- 2016: 37;
- 2017: 83;
- 2018: 38;
- 2019: 65;
▪ Prevalent causes: unknown, accident, negligence
- Negligence, Use of fire: 532
- Accident: 53
- Negligence, Use of glowing objects: 39
- Deliberate, Responsible: 22
- Deliberate, Irresponsible: 1
- Rekindle: 6
- Unknown: 5
▪ Type of fire: ground, underground: unknown
▪ Georeferenced shp: no

Pilot 9. Australia- Queensland Centre for Advanced Technologies (QCAT)

Brief description of the site:

▪ Analyzed size area: 40 ha
▪ Land cover type (ha)
- Artificial surfaces: 5 ha
- Agriculture areas: 0 ha
- Forests and semi-natural areas: 23 ha
▪ Protected area: 12 ha
▪ Dominant factors determining wildfires (temperature, moisture, slope, rainfall, etc.)
- Min-max average temperatures in the fire season: 21.6 - 30.4 C
- Moisture in the fire season: 57% humidity
- Rainfall (mm/year): 1,011.5
▪ Fire events 2010-2022 (number): 0
- 2010:
- 2011:
- 2012:
- 2013:
- 2014:

- 2015:
- 2016:
- 2017:
- 2018:
- 2019:
- 2020:
- 2021:
- 2022:

▪ Prevalent causes: unknown, accident, negligence (%)
  - Unknown: N/A
  - Accident: N/A
  - Negligence N/A
▪ Type of fire: Underground, Ground (surface), Crown, Combination, Other (number): N/A
▪ Georeferenced shp: yes/no No

Pilot 10. Brazil- Pantanal Matogrossense National Park

We did not receive any input data.

Pilot 11. Indonesia- Sebangau National Park

▪ Analyzed size area: 542.171,1 ha
▪ Land cover type (ha)
  - Artificial surfaces: 88,39 ha (0,02%)
  - Agriculture areas: 1.916,55 ha (0,36%)
  - Forests and semi-natural areas: 60.726,92 ha (11,30%)
  - Wetlands: 478.849,93 ha (88,32%)
  - Water bodies: 589,31 ha (0,11%)
▪ Protected area: 542.171,1 ha
▪ Dominant factors determining wildfires (temperature, moisture, slope, rainfall, etc.)
  - Min-max average temperatures in the fire season: unknown
  - Moisture in the fire season: unknown
  - Rainfall (mm/year): 14,10 (year 2022)
  Fire events 2017-2022: 138
  - 2010: unknown;
  - 2011: unknown;
  - 2012: unknown;
  - 2013: 2 (164,5 ha);
  - 2014: 1 (50 ha);
  - 2015: 1 (455 ha);
  - 2016: unknown;
  - 2017: 1 (1 ha);
  - 2018: unknown;
  - 2019: 3 (696 ha);
  - 2020: 2 (11 ha);
  - 2021: unknown;
  - 2022: unknown;
▪ Prevalent causes: unknown, accident, negligence
  - not available
▪ Type of fire: ground, underground:
  - combination
▪ Georeferenced shp: no

6.28.4 *Brief discussion on the data analysed*

As already mentioned in chapter 4.3, some countries did not send all the requested data, some years were missing, some data was missing or they were not geolocalized, which led to problems of standardization and comparison between the various pilots.

However, from the documents analysed until now, it is clear that in almost all the pilot cases, there is information relating to the type of vegetation burned while information relating to the causes of fire is almost never present.

The reason lies in the fact that, in some countries, before being able to officially classify the cause of a fire, investigations are necessary by the relevant police bodies, and then such data are covered by investigative secrecy.

Below a comparative discussion of elaborated data:

- GIS is not a system commonly used in the delimitation of geographical areas with reference to fire management. This causes a lack of information in the management of all phases relating to the fire. Therefore, Silvanus has demonstrated that harmonization at European level (and beyond) can contribute to improving policies and strategies for fighting fires.

- Although there is a classification of fire causes at European level (see JRC Effis 2008), adopted in the survey carried out for the Silvanus pilots, the analysis highlighted that:

  1) In data collection there is no conformity between the practice in use in individual countries and the classification cited.

  2) The data are not comparable in terms of time ranges, they are provided in an aggregate and non-punctual form on individual fire cases (in some cases there are procedural constraints before disclosure).

  Therefore, Silvanus has demonstrated that conformity at European standards for fire categorization can contribute to improving policies and strategies for prevention of fires.

6.28.5 *EFFIS*

Another complementary source useful for uniformly mapping fires over the years in a common period is EFFIS (https://effis.jrc.ec.europa.eu/), although this only relates to the European context.

EFFIS - European Forest Fire Information System - supports the services in charge of the protection of forests against fires in the EU and neighboring countries and provides the European Commission services and the European Parliament with updated and reliable information on wildland fires in Europe .

EFFIS, based on data from the Copernicus programme, is a platform aimed at exchanging data and information relating to the monitoring and mapping of forest fires, and their effects on the environment.

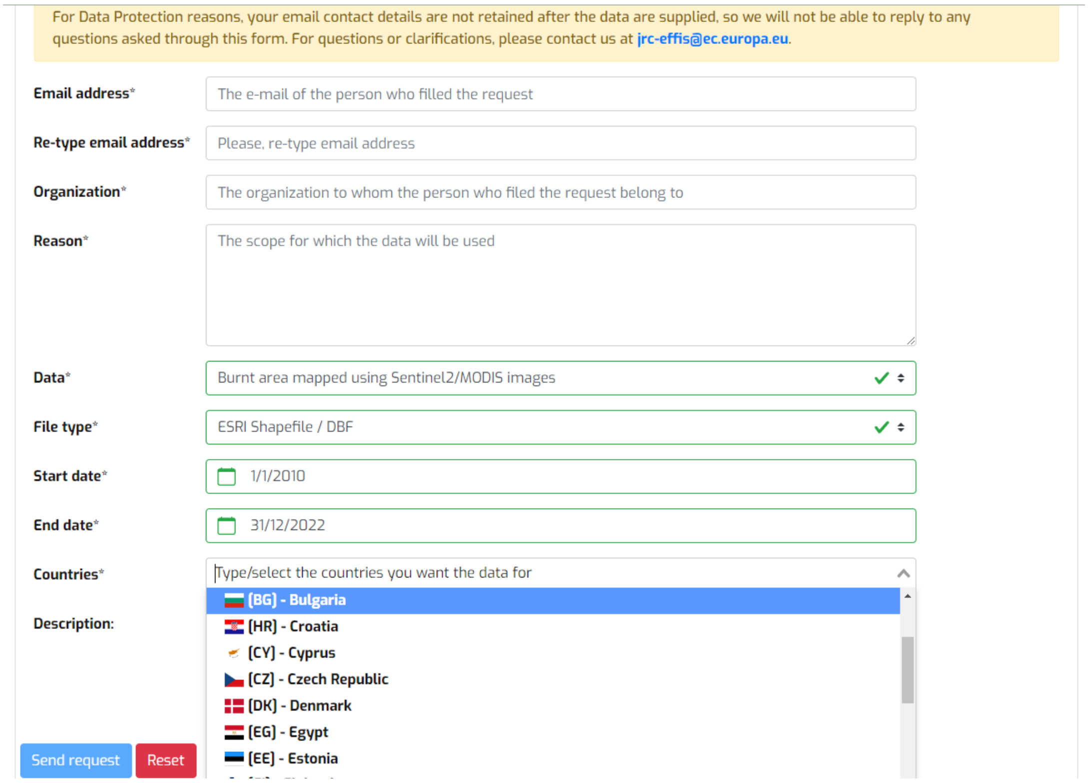
EFFIS provides data in shapefile format and cover 75%-80% of the total burned areas in Europe, providing information with a spatial resolution of 250 m and mapping burned areas larger than 30 ha.

Data from EFFIS are available for all EU countries, but are not available for non-EU countries. Furthermore, given the technical detection limitations, in some cases it does not provide data that is totally comparable to that available from relevant bodies such as Civil Protection, etc., when present, leading to the loss of minor fires in the pilot areas.

Nevertheless, the open data of the burnt areas was downloaded from the EFFIS platform in shapefile format, for uploading into geographic information systems (e.g. q-gis).

Shapefiles were downloaded from the link: https://effis.jrc.ec.europa.eu/apps/data.request.form/.

In detail, the data required are: email addresses and organization of the applicant, the request reason, the typology of data (the choice is between: 1. Thermal anomalies from VIIRS sensors NOAA and SUOMI-NPP satellites; 2. Thermal anomalies from MODIS sensors AQUA and TERRA satellites; 3. Burnt area mapped using Sentinel2/MODIS images), the typology of file (the choice is between: 1. ESRI Shapefile/DBF; 2. GeoJSON; 3. KML; 4. MS Office Open XML spreadsheet; 5. CSV - Comma separated values); the period of analysis (start date and end date), the countries among European ones, and finally possible description.



For Data Protection reasons, your email contact details are not retained after the data are supplied, so we will not be able to reply to any questions asked through this form. For questions or clarifications, please contact us at jrc-effis@ec.europa.eu.

Email address* The e-mail of the person who filled the request
Re-type email address* Please, re-type email address
Organization* The organization to whom the person who filed the request belong to
Reason* The scope for which the data will be used
Data* Burnt area mapped using Sentinel2/MODIS images
File type* ESRI Shapefile / DBF
Start date* 1/1/2010
End date* 31/12/2022
Countries* Type/select the countries you want the data for
[BG] - Bulgaria
[HR] - Croatia
[CY] - Cyprus
[CZ] - Czech Republic
[DK] - Denmark
[EG] - Egypt
[EE] - Estonia
Description:
Send request Reset

Figure 49 - Effis screen from which to download files. Source: Effis

The files were downloaded on behalf of the ASSET Agency for the SILVANUS project; the files downloaded are "Burnt area mapped using Sentinel2/MODIS images" in ESRI shapefile format, in the period 1 January 2010 - 31 December 2022, for all partner countries with the pilot (Greece, Romania, Italy, France, Czech Republic, Slovakia, Croatia, Portugal). As already mentioned, data from non-EU countries are not present and specifically, it was not possible to download data from Indonesia, Brazil and Australia.

Analyzing the data, the tables contain the following data for each fire (polygon with its own ID):

- Initial Data and Final Data of the fire
- Extent in hectares
- Country
- Localisation on a provincial scale
- Municipality
- Locality
- Source
- The percentage of burnt area for each tree species (broadleaved, coniferous, mixed, sclerophil, transition, other natural)
- Land use (agriculture, artificial, other)
- Percentage of Natura 2000 area burnt

- Date of update
- European-wide codes

Italy_EFFIS DATA — Elementi Totali: 6470, Filtrati: 6470, Selezionati: 0

	id	initialdat	finaldate	area_ha	iso2	iso3	country	admlvl1	admlvl2	admlvl3	admlvl5	ıap_sourc
1	486...	02/04/20...	02/04/2021	1	IT	ITA	Italia	Sud	Calabria	Catanzaro	Amato	sentinel
2	211...	31/10/20...	31/10/2022	1	IT	ITA	Italia	Isole	Sicilia	Palermo	Monr...	sentinel
3	202...	01/06/20...	01/06/2022	1	IT	ITA	Italia	Isole	Sicilia	Enna	Aidone	sentinel
4	209...	05/08/20...	05/08/2022	0	IT	ITA	Italia	Sud	Calabria	Catanzaro	Gimi...	sentinel
5	211...	24/10/20...	24/10/2022	1	IT	ITA	Italia	Isole	Sicilia	Catania	Bronte	sentinel
6	1889	16/07/20...	16/07/2010	197	IT	ITA	Italia	Isole	Sicilia	Caltaniss...	Gela	modis
7	1983	05/08/20...	05/08/2010	410	IT	ITA	Italia	Isole	Sicilia	Caltaniss...	Bom...	modis
8	2836	02/09/20...	02/09/2010	79	IT	ITA	Italia	Isole	Sardegna	NULL	Arzac...	modis
9	3802	23/08/20...	23/08/2010	112	IT	ITA	Italia	Isole	Sicilia	Agrigento	Real...	modis
10	3999	16/07/20...	16/07/2010	35	IT	ITA	Italia	Isole	Sicilia	Palermo	Villaf...	modis
11	1431	16/07/20...	16/07/2010	43	IT	ITA	Italia	Isole	Sicilia	Agrigento	Licata	modis

	broadleave	coniferous	mixed_fore	sclerophil	transition	other_natu	agricultur	artificial	other_perc	natura2k_p	noneu	updated	area_code	eu_area
1	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	0	0	26/01/2022	EU	EU
2	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	0	0	02/11/2022	EU	EU
3	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	0	0	03/06/2022	EU	EU
4	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	0	0	18/08/2022	EU	EU
5	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	0	0	25/10/2022	EU	EU
6	0	0	0	25,75757...	0	23,73737...	50,5050...	0	0	0	0	26/01/2022	EU	EU
7	0	0	0	0	0	27,25060...	72,7493...	0	0	0	0	26/01/2022	EU	EU
8	0	0	0	41,24999...	0	0	58,7499...	0	0	0	0	26/01/2022	EU	EU
9	0	0	0	0	0	89,18918...	10,8108...	0	0	0	0	26/01/2022	EU	EU
10	0	0	0	17,14285...	0	0	82,8571...	0	0	0	0	26/01/2022	EU	EU
11	0	0	0	0	0	86,36363...	13,6363...	0	0	0	0	26/01/2022	EU	EU

Figure 50 - Table with data from the Shapefile. Source: Effis. Authors' elaboration in QGIS

Thanks to the downloaded information layers, it was possible to create a tabular and geographical overview, enabling the comparison between the states containing the pilots. Extracts of maps processed with open Q-GIS software are shown below.

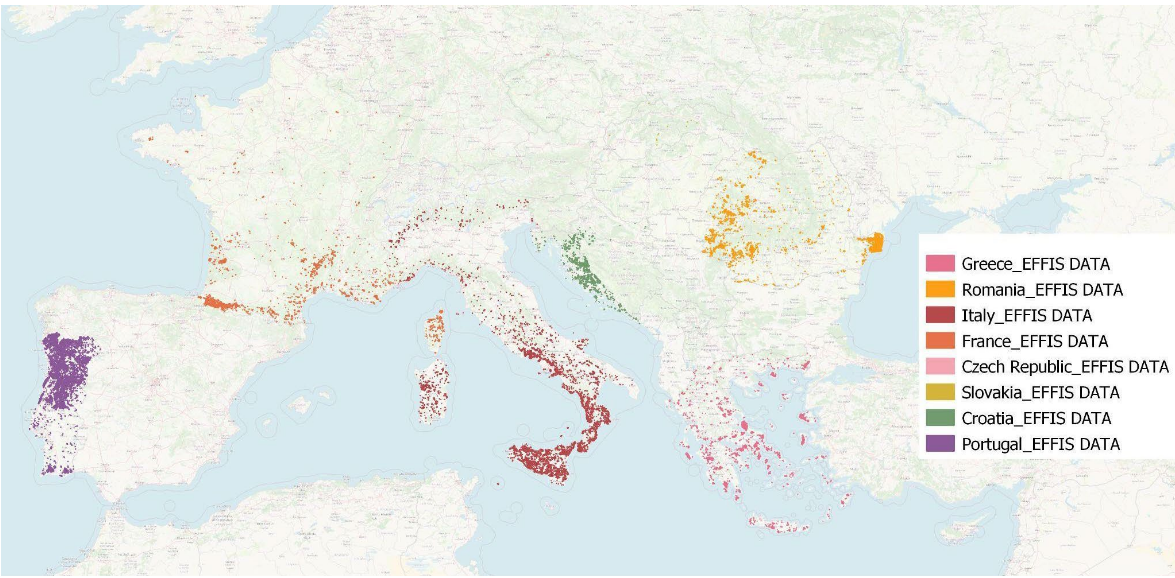


Figure 51 - Map of forest fires in the pilot countries (years 2010-2022). Source: Effis. Authors' elaboration in QGIS

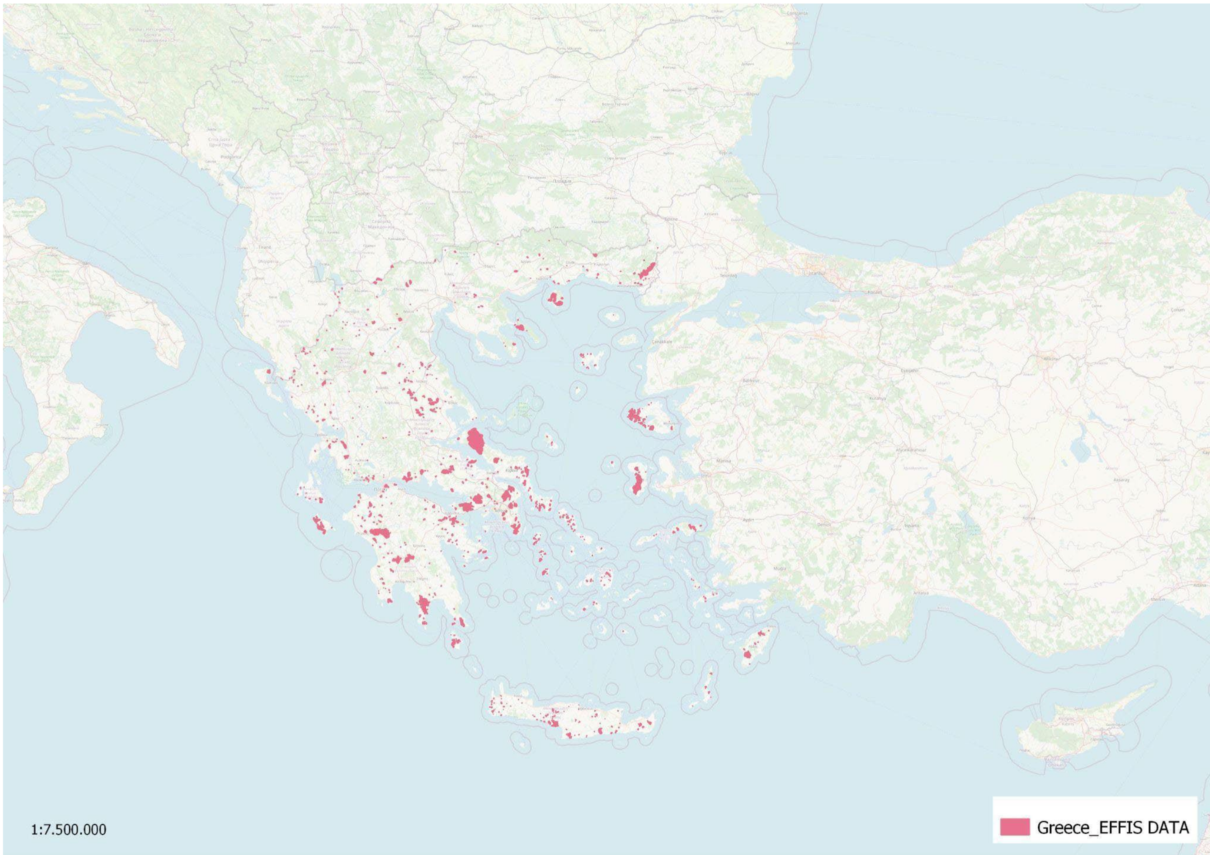


Figure 52 - Map of forest fires in Greece (years 2010-2022). Source: Effis. Authors' elaboration in QGIS

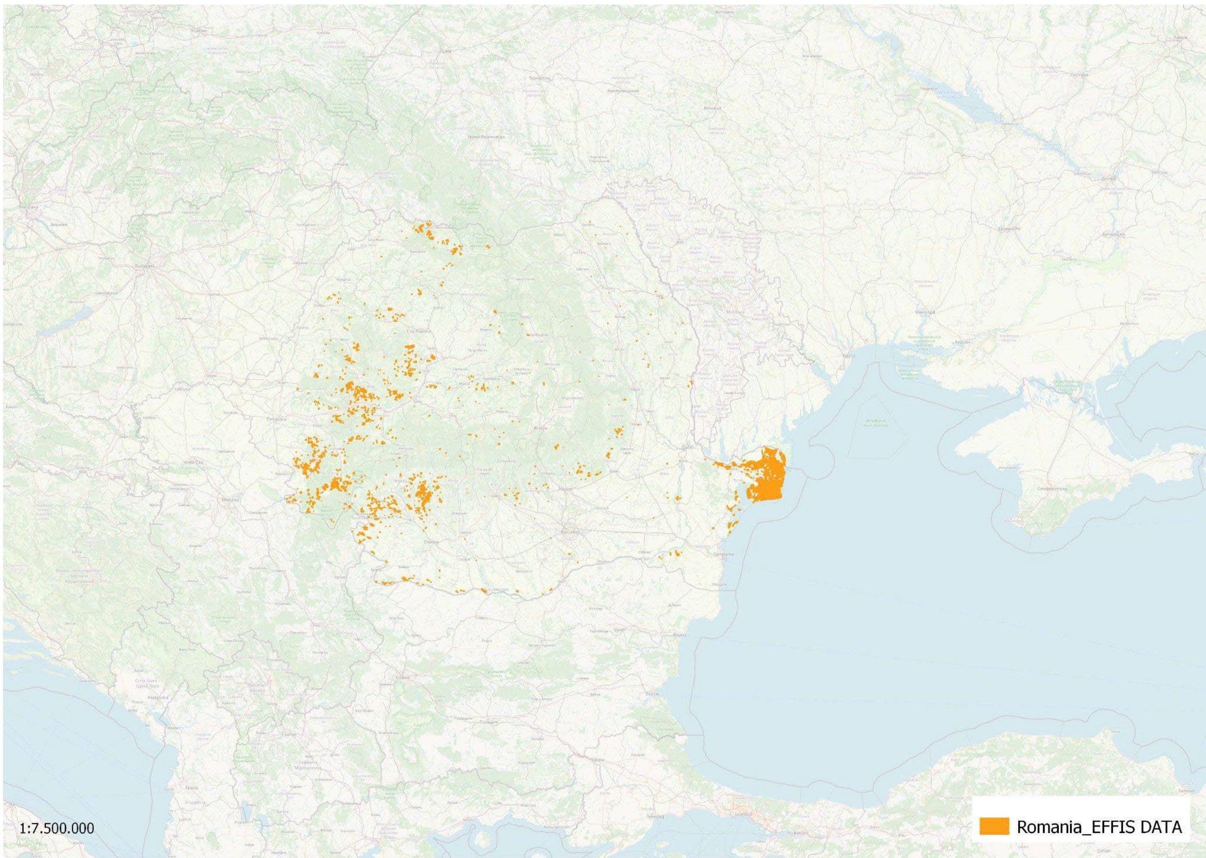


Figure 53 - Map of forest fires in Romania (years 2010-2022). Source: Effis. Authors' elaboration in QGIS

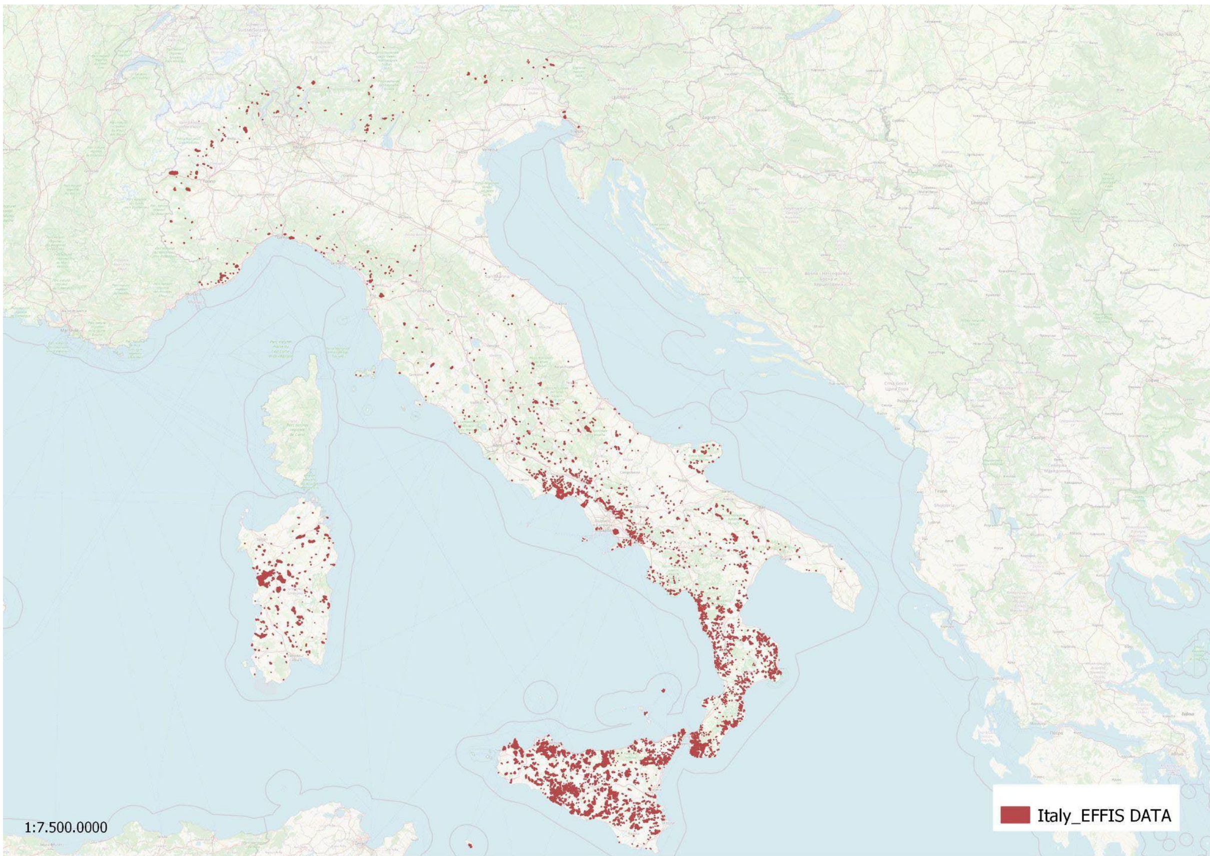


Figure 54 - Map of forest fires in Italy (years 2010-2022). Source: Effis. Authors' elaboration in QGIS

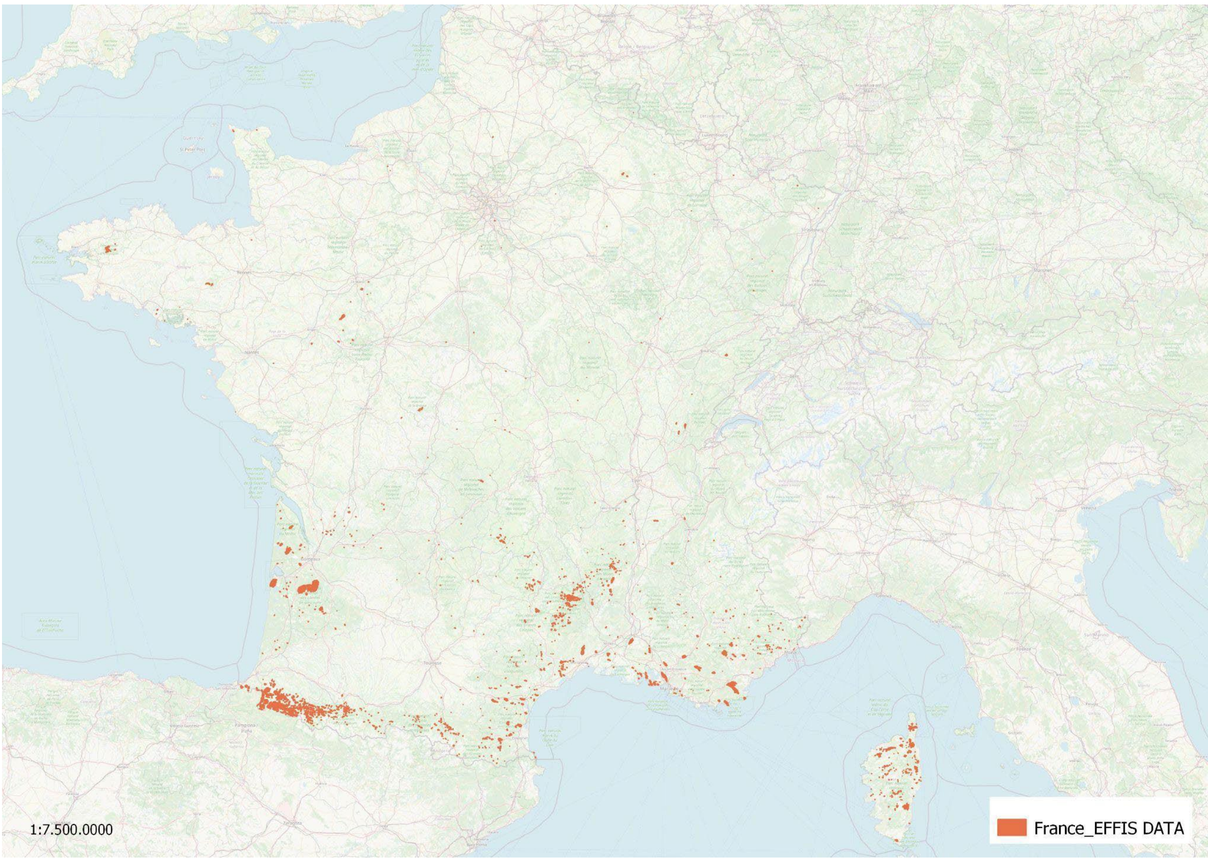


Figure 55 - Map of forest fires in France (years 2010-2022). Source: Effis. Authors' elaboration in QGIS

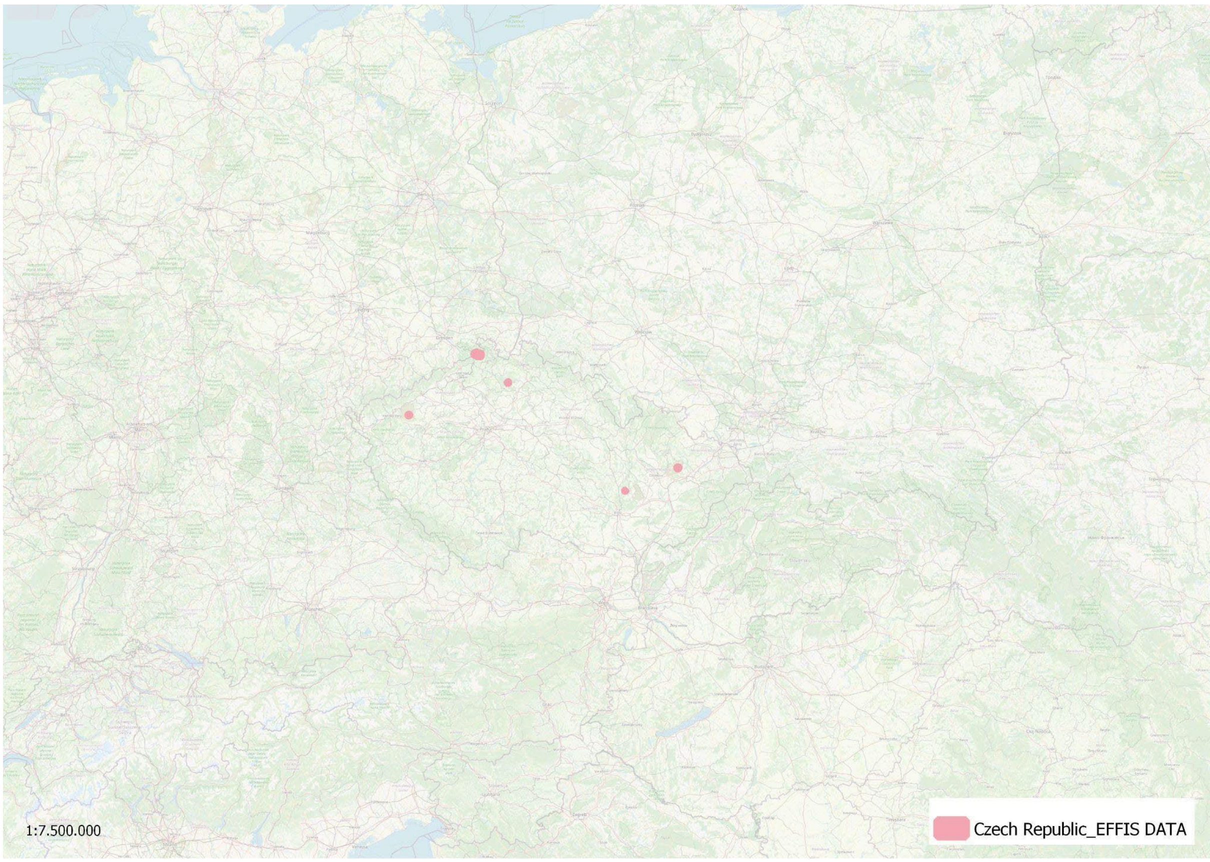


Figure 56 - Map of forest fires in Czech Republic (years 2010-2022). Source: Effis. Authors' elaboration in QGIS

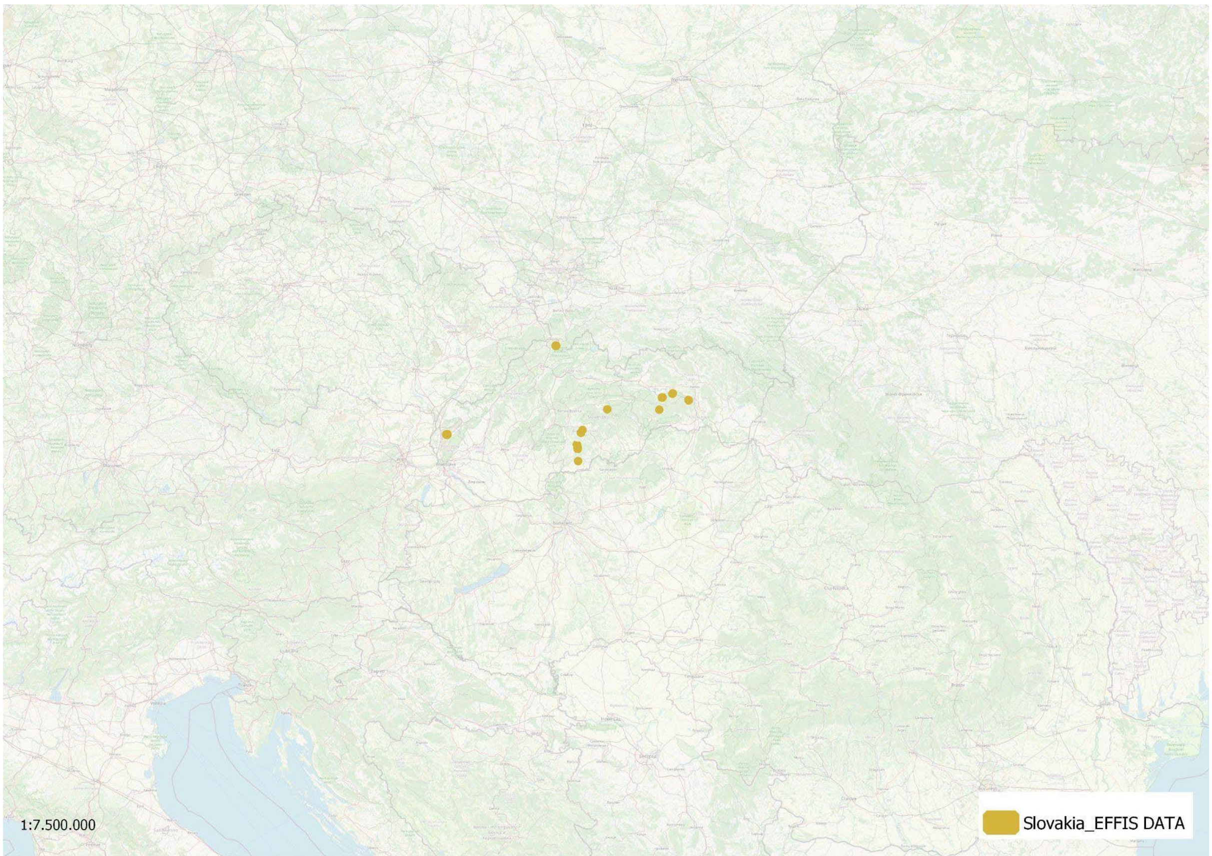


Figure 57 - Map of forest fires in Slovakia(years 2010-2022). Source: Effis. Authors' elaboration in QGIS

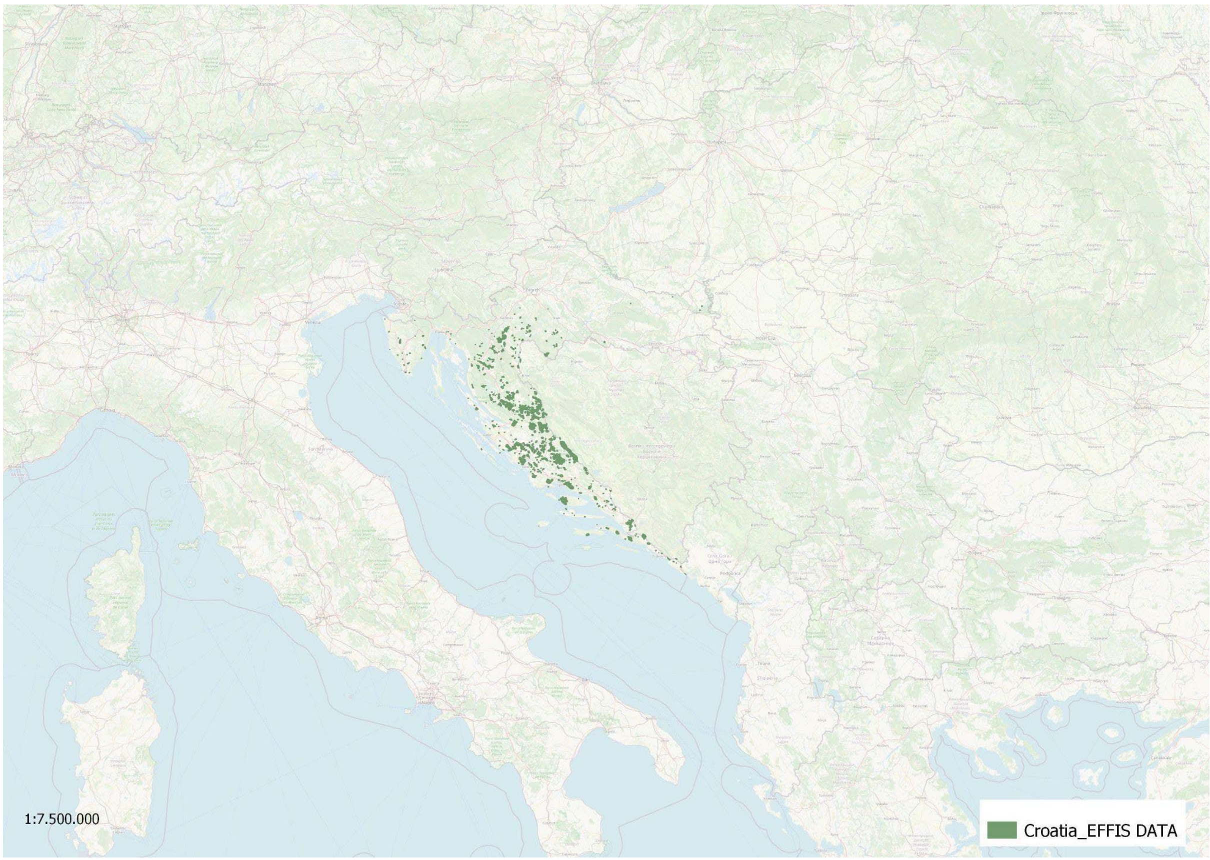


Figure 58 - Map of forest fires in Croatia(years 2010-2022). Source: Effis. Authors' elaboration in QGIS

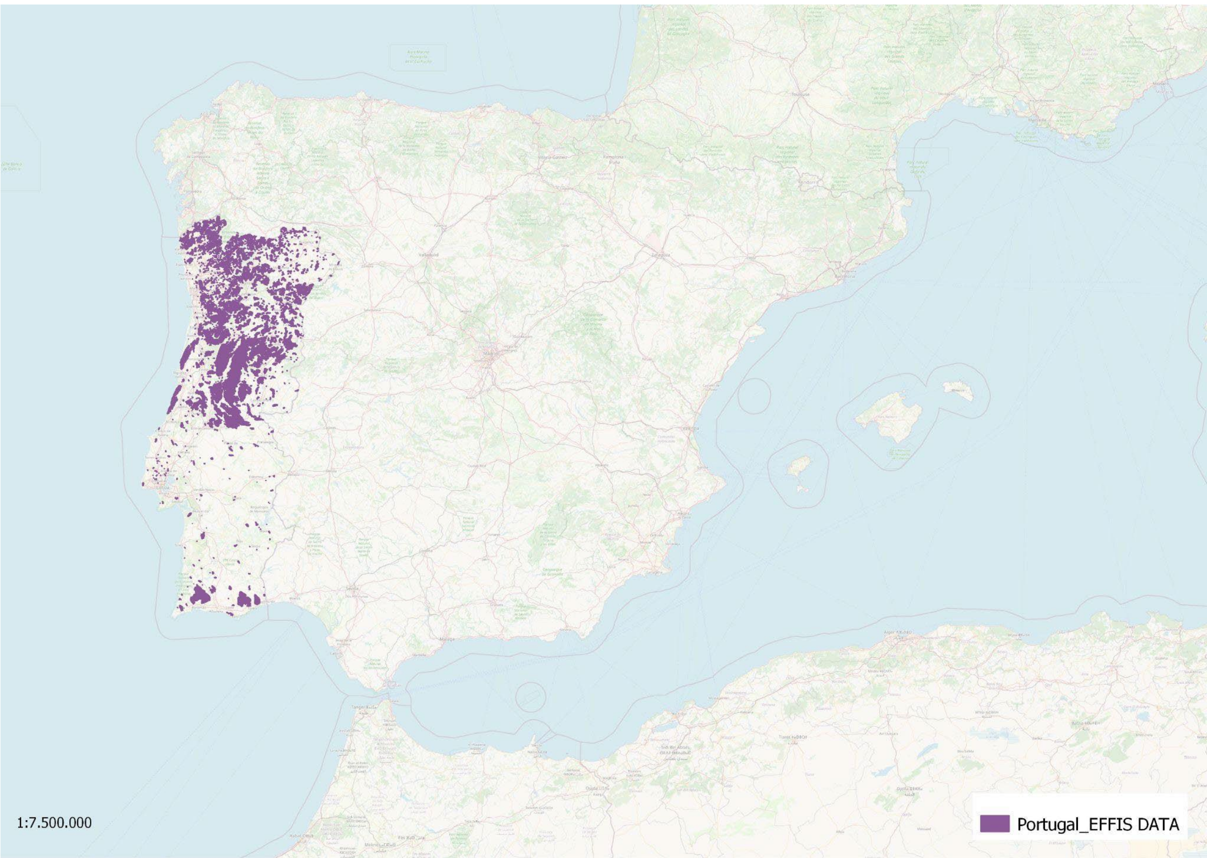


Figure 59 - Map of forest fires in Portugal (years 2010-2022). Source: Effis. Authors' elaboration in QGIS

6.28.6 Conclusions

The analysis of historical forest fire data conducted on the 11 pilots has revealed some critical issues that could not be highlighted in the initial planning phase.

The first, and most important difficulty, was that not all partners have shapefiles (GIS vector data storage format) available to store the position, shape and attributes of the geographical features of the areas identified as pilots for the Silvanus project.

A first solution identified to address this lack of data was to use the European platform EFFIS (European Forest Fire Information System).

EFFIS, based on data from the Copernicus programme, is a platform aimed at exchanging data and information relating to the monitoring and mapping of forest fires, and their effects on the environment.

Data from EFFIS are available for all EU countries, but are not available for non-EU countries. Furthermore, in some cases it does not provide data that is totally comparable to that available from relevant local bodies, when present, leading to the loss of minor fires in the pilot areas.

From the documents analyzed until now, it is clear that in almost all pilot cases, there is information relating to the type of vegetation burned while information relating to the causes of fire is almost never present. The reason lies in the fact that, in some countries, before being able to officially classify the cause of a fire, investigations are necessary by the relevant police bodies, and then such data are covered by investigative secrecy.

Therefore, as a future step, following the path of simplification, we think it is possible to intervene on the lack of required data, involving other stakeholders who, for their mission, are considered more suitable for the possession and management of historical wildfire data. Furthermore, it would be appropriate to standardize the way in which the causes of fires are filed, as this data is not present to date.

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