D2.3 – Report on SILVANUS formal assessment methodology

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Abstract:	Deliverable 2.3 describes the SILVANUS' first version of the impact assessment framework and its development. The impact assessment framework has been built to measure the efficiency of the User Products (UPs) included in the Minimum Viable Product described in D8.1, during the first round of pilot demonstrations. For every UP a set of KPI, to evaluate performance, have been identified, as well as surveys to evaluate the UP interfaces.

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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
FIPAS	Fire Prevention and Awareness Support mobile application
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

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Executive Summary

This deliverable envisages to present the first version of the Impact assessment framework that will be used for the evaluation of the SILVANUS platform. 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, Czechia, Portugal, Croatia, and Romania, and three (3) extra-EU countries, Indonesia, Brazil, and Australia.

In the light of above, the deliverable illustrates the procedures adopted to evaluate the first release of SILVANUS platform through the pilot activities. The building of the impact assessment framework needs to consider several variables. To do so, it strictly collaborates with D8.1 outputs based on the architectural components of the first release of the SILVANUS platform, labelled Minimum Viable Product (MVP), that contains a limited set of functionalities, that have been named User Products (UPs). To build the impact assessment framework, there is the need to collect inputs from the UP leaders as well, to get the necessary data and material for the development of the assessment framework.

This deliverable reports on the relevant information collected from each UP, to analyse the characteristics and Key Performance Indicators (KPIs) provided by UP Leaders. The Expected Impacts (EIs) set as goals by the Green Deal has been listed and deepened in the deliverable. Subsequently, each UP has been linked to one or more EI.

In order to follow the European Commission (EC) indications, the funded projects under the same call (two IA projects, FIRE-RES[1] and TREEADS[2], and one CSA project, Firelogue[3]) need to jointly collaborate throughout the development of each project, in order to contribute towards reaching the Green Deal goals listed in the EIs. The whole collaboration among the partners will be divided in several areas, among which Impact assessment. This partnership, even though each project has different specific objectives, allows for a more EI-oriented shared impact assessment framework development.

This deliverable also elaborates on the methodology being adopted for the building of the framework; each step is deepened in detail.

The adopted approach delivers:

- A set of KPIs for every UP to assure that enough tests are made and to measure their performance.
- Surveys for UP1 and UP8 to measure the efficiency of the training programmes that they deliver.
- Surveys for all UPs to assess the perception of the users while testing the UPs, evaluating the User Interface (UI) and User Experience (UX) of the UPs interface.

As the User Interface of the UPs as well as initial mock-ups have not been designed yet, and neither the training programmes, at the time of delivery of D2.3, only the KPIs for each UP are available. The surveys will be realised at a later time once the interfaces are designed, and the training programmes finalised.

The framework developed in this deliverable will be used by the UP testers to evaluate the performance of the MVP and the experience that they had while using it.

The outputs of D2.3 will be used to improve the quality of the UPs included in the MVP and will put the basis for the development of D2.5 “Final report on SILVANUS formal assessment methodology”.

[1] Project ID: 101037419, website: https://fire-res.eu/

[2] Project ID: 101036926, website: https://treeads-project.eu/

[3] Project ID: 101036534, website: https://firelogue.eu/

The surveys generated by the deliverable will follow iterative processes of refinement in order to integrate new information acquired from the demonstration activities. Such process will increase its performance for the assessment of the released platform versions.

1 Introduction

SILVANUS project is envisaged to deliver an environmentally sustainable and climate resilient forest management platform aiming to prevent and combat the ignition of fires, and to develop recovery plans to make the forest resilient. In order to guarantee the high performance of the SILVANUS platform, tests will be realised through pilot demonstrations in different scenarios and environmental conditions. Pilot activities will be carried out in eight EU Member States regions: France, Italy, Slovakia, Greece, Czechia, Portugal, Croatia, and Romania, as well as in Brazil, Indonesia, and Australia.

As a mean of verification of the correct use, efficiency, and performance of the platform, an assessment framework, that will collect and analyse the outputs obtained from the pilot demonstrations, will be realised and presented in D2.3. After an increase of extreme wildfires, the Green Deal put as priorities for Horizon 2020 calls the reduction of incidence and extent of forest fires, and the necessity to predict and manage environmental disasters. The measurable achievements that the funded actions should contribute to in order to maximise the impact, are the Expected Impacts (EIs) that needs to be achieved by 2030 and will be further investigated in the Deliverable.

The objective of the present deliverable is the formalisation of a first assessment methodology for the evaluation of the project platform. Feedback from the stakeholders on the effectiveness of technological intervention delivered in each phase (A, B, or C of the demonstrations) will be collected and integrated in the framework. The funded projects under the call LC-GD-1-1-2020: "Preventing and fighting extreme wildfires with the integration and demonstration of innovative means", aim at setting a groundwork for a common impact assessment methodology. Therefore, the three Innovation Actions (IAs) SILVANUS, TREEADS, and FIRE-RES will provide support to the Coordination and Support Action (CSA) Firelogue to strengthen the impact of each intervention against wildfires, and to contribute towards the achievement of the Green Deal targets. Task 2.6 will contribute to the formulation of the present deliverable (D2.3), and to D2.5, namely "Final report on SILVANUS formal assessment methodology".

The first step into developing the SILVANUS platform assessment framework has been the collection of information about the technologies that will be used across all the 11 pilot sites. With the deployment of the first version of the platform, a minimum set of functionalities have been included. Their classification has been made in the context of several User Products (UPs).

In D2.3, the initial EIs towards which each UP contributes, directly or indirectly, have been identified, providing an explanation to why such links have been set. Afterwards, Key Performance Indicators (KPIs) used to measure the performance of the activities carried out have been identified; in addition, for UP1 and UP8 a learning evaluation survey will be created to assess the performance of the training programmes. Moreover, evaluation surveys have been created to: i) evaluate the experience of the user while testing that specific UP; ii) evaluate the User Interface (UI) and the User Experience (UX) about the interface of that specific UP. Based on the type of activity that is wanted to assess, two different version of surveys will be introduced: User satisfaction surveys and Learning evaluation surveys.

D2.3 is structured as follows. In chapter 2, the EIs and UPs, that are the starting point for the creation of the impact assessment framework, are analysed and described. Chapter 3 focuses on the approach adopted for the Impact assessment framework. It explains how the UPs and EIs are linked, how the KPIs have been identified, and provides information on the building of the evaluation strategy, differentiating between the two categories previously mentioned. With the consolidation of the information above, the first SILVANUS impact assessment that will be exploited in the pilot sites is drafted in chapter 4 deepening how the framework will be used, and how the results will be used and how the project will benefit from them. The last chapter, chapter 5, collects a summary of the deliverable, and provides the inputs for the realisation of the final assessment framework.

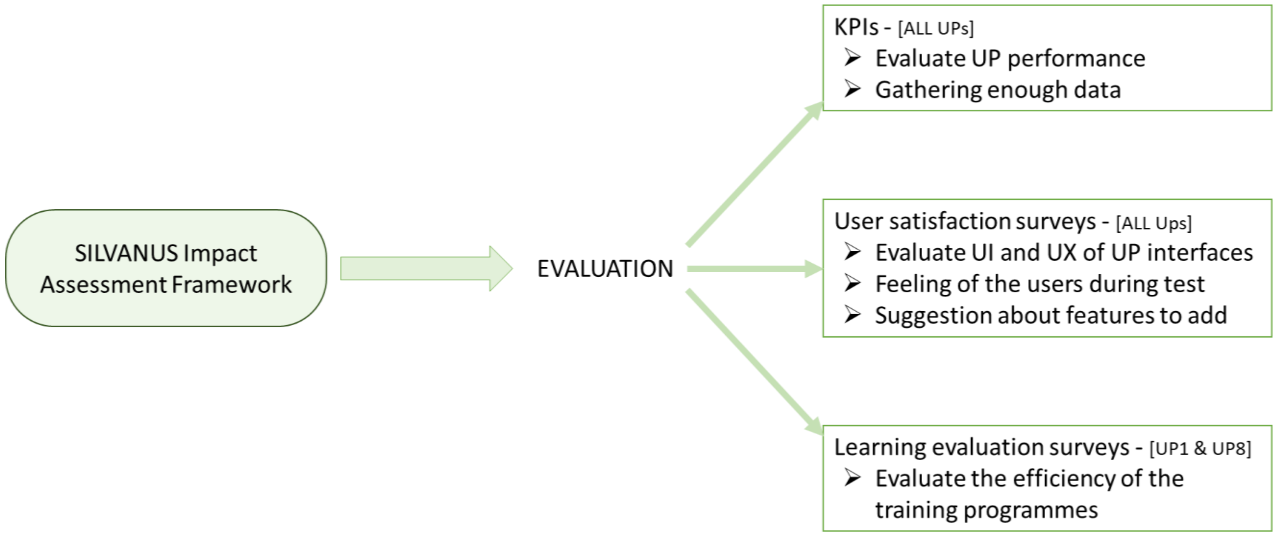

Figure 1: Schema of SILVANUS first version of the impact assessment framework

2 Background Information

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. Based on this definition, the first version of the impact assessment framework was built by taking into 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 1. 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 current status of the platform**. As different functionalities will be released by SILVANUS, it is important to consider the status as some functionalities will be released later during the project and are not currently available nor detailed enough. Specifically, the first version of the platform will be released as a Minimum Viable Product (MVP) and will be made of a total of eight UPs, hence the first version of the impact assessment framework will consider just these features;
- **the organisation of the pilot activities**. As during the pilot 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.

Table 1: Expected Impacts set by the Green Deal that shall be reached by 2030 in Europe, with respect to 2019

EI1	EI2	EI3	EI4	EI5	EI6	EI7	EI8
0 fatalities from wildfires	50% reduction in accidental fire ignitions	55% 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

2.1 Cooperation with Firelogue and sister projects TREEADS and FIRE-RES

The expected impacts set by the Green Deal requires to reach eight targets by 2030, considering data from 2019. SILVANUS, along with its sister projects IAs TREEADS and FIRE-RES and the CSA Firelogue, has to contribute jointly with them in order to achieve such targets. As the targets refers to 2030 but all the projects will end before then, it is necessary to elaborate the EIs to find achievable KPIs that are aligned with the duration of the projects. In order to do so, a cooperation between the four projects has started and is coordinated by Firelogue.

At the moment the cooperation has brought to the organisation of joint meetings, that are described with more details in *D10.2: "Annual Report on SILVANUS Dissemination Activities v1"* with all the IAs and coordinated by Firelogue to discuss about the creation of a common impact assessment framework. These meetings allowed to align the three projects' ideas regarding the EIs and brought to the decision to adopt the constraint that the EIs cannot be modified, but it is possible to modify the context and refine the target. In addition, the achievability of the EIs was discussed, and it was agreed to create a common set of realistic KPIs that could be used to evaluate the impact of the three IAs jointly; this will be based on the EIs while referring to a realistic time period that is achievable by the three IAs. The creation of this set of KPIs is still ongoing and will be discussed and further detailed during the next joint meetings.

During the meetings the definition of a common baseline was discussed as well, in particular to identify the potential sources that can be checked to verify the joint impact of the project and that are needed to measure specific data, like: extent of burnt area, number of buildings affected by the wildfire and so on. To face this, it was decided that the three IAs had to provide to Firelogue the data sources that they're going to individually use, and Firelogue had to take care of combining such information in a single shared document. Additionally, discussions involved the proposal of a different baseline to measure the contribution to the EIs, not considering just the year 2019 that was stated in the Call for Proposal. The proposed idea is to take a longer period of time and taking an average from it, in order to avoid the statistical influence that may happen by considering a single year. This as well is still in the making and will be further developed in the near future.

These discussions brought Firelogue to create a common document, included in Firelogue's D3.1: "*Impact Assessment Methodology Harmonization*", that was shared across the three IAs to gather specific information about each one. This document gathered and structured the relevant information from each IA project as follows:

1. individual analysis of the EIs, defining for each one:
    a. definitions;
    b. the phase/s to which they can be linked;
    c. a list of KPIs that will be used by the project to target them;
    d. comments regarding the achievability;
2. a list of the proposed technologies / innovations, and for each to provide:
    a. a short description of the technology;
    b. the starting TRL and the target one;
    c. the phase that will benefit from the technology / innovation;
    d. the country / region where the technology / innovation will be tested;
    e. the EI that the technology / innovation will contribute in achieving;
    f. the category of the technology / innovation (technology, wildfire risk management measure, operating standards, processes, etc…);
    g. the technological category (like, cameras & sensors, earth observation, simulations and models, etc…);
3. the impact assessment methodology and criteria that will be used, describing how the technologies developed intend to achieve the EIs and the methodology that will be used to measure the impact;
4. the data requirement and sources that will be used, and for each data to provide:
    a. a short description;
    b. the related EI;
    c. the format;
    d. the minimum required baseline period;
    e. the pilot areas of interest,
    f. to state if the dataset is publicly available, if the project has access to the dataset and a link to the data source;
5. the affected stakeholders that are involved in the activities, and for each one to provide:
    a. the name of the organisation;
    b. the type of organisation;
    c. the country;

d. the point of contact;
e. the relation to the activities.

In addition, a first draft of a common impact assessment has been brought by TREEADS, that will be further developed, that might be used to measure the impact brought by the three IAs jointly. The idea is to estimate the contribution that each project's solution has towards certain EI by using a percentage, based on the results obtained during the pilot activities and their adoption in EU, by adding an estimation of the region that will adopt them. By combining these data, it will be possible to measure the contribution that the three IAs has jointly towards reaching the EIs. This common impact assessment has been discussed in just one meeting, September 8th 2022, and will be further detailed in the next workshops.

The cooperation between SILVANUS, FIRE-RES, TREEADS and Firelogue, regarding the creation of a common impact assessment framework, will continue with the organisation of short workshops on a quarterly basis to:

- keep the momentum and alignment between the projects to make sure that discussion and topics for impact assessment are aligned, jointly reaching EIs and avoiding overlaps;
- follow up on how the individual projects impact assessment methodology are formed and how they keep evolving;
- understand what the synergy areas between the projects are and what the overlapping ones are too, to contribute jointly to all the EIs comprehensively;
- keep jointly elaborating to form a harmonized methodology, as all IAs are substantially contributing to achieve the targets.

2.2 Analysis of the Expected Impacts

The cooperation of SILVANUS with Firelogue and the sister projects TREEADS and FIRE-RES has brought to the adoption of a common definition of the EIs, that has been submitted in *D3.1 "Impact assessment harmonization"* of Firelogue and that is reported in Table 2.

Table 2: Common Expected Impacts' definition

EI#	EI	Definition	Phase	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.	A, B, C	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	A	Not easily achievable

		appliances, equipment, railroad, juveniles, farm machinery etc…) are included.		
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.	A, B	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.	A, B	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 dynamic and rapidly changing role of fire in social ecological systems[4].	A, C	Achievable
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.	A, B	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.	A, C	Likely achievable

[4] McWethy, David B., et al. "Rethinking resilience to wildfire." Nature Sustainability 2.9 (2019): 797-804. https://doi.org/10.1038/s41893-019-0353-8

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[5].	A	Likely achievable

2.3 User Product description

The building of an impact assessment framework to evaluate the SILVANUS platform must consider the functionalities that are available. SILVANUS will release several versions of the platform, the first one will possess a limited number of features that can be interpreted as a Minimum Viable Product (MVP). The features that will be included in the MVP have been identified since the project kick-off and are specified and accurately described within *D8.1: "Report on SILVANUS reference architecture*" and are the following:

- 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's engagement programme and mobile app.

Like it has already been stated in D8.1, each UP demonstration will be deployed in a limited number of pilot sites (PS) that will provide a controlled environment for system integration, validation, and experimentation.

[5] Penman, Trent D., et al. "Prescribed burning: how can it work to conserve the things we value?" International Journal of Wildland Fire 20.6 (2011): 721-733. https://doi.org/10.1071/WF09131

Table 3: Pilot sites where each UP will be deployed

	UP1	UP2	UP3	UP4	UP5	UP6	UP7	UP8
PS1 – France		X	X	X			X	
PS2 – Italy		X	X	X	X	X	X	X
PS3 – Romania	X							
PS4 – Greece			X	X		X	X	X
PS5 – Portugal						X		X
PS6 – Czech Rep.								
PS7 – Croatia				X				
PS8 – Slovakia		X	X		X	X	X	X
PS9 – Australia			X	X	X			
PS10 – Brazil								
PS11 - Indonesia			X					

For each feature, several technical specifications have been described in D8.1. In the tables below each UP included in the MVP is briefly described with a focus on its involvement in the pilots.

Table 4: User Product specifications linked to pilot activities template

UPX – [UP name]	
UP leader	*Name/s of the partner that leads the development of the User Product*
Related tasks	*Task/s related to the development of the User Product*
UP description	*Description of the UP (what does it do, what can it be used for?)*
Innovation brought by the UP	*Description of the innovation that the UP brings, compared to the existing technology*
UP features in the MVP	*List the main and secondary functionalities that will be included in the MVP*
Possible extensions	*List the functionalities that will/could be made available for the final version of the UP (released with the full platform), if applicable. Differentiate between the features that will be included for sure, and some that could eventually be included* *Functionalities that **will** be made available for the final version of the UP:* *Functionalities that **could** be made available for the final version of the UP:*
Related phases	*What phase does this UP benefit?*
Phase contribution	*How does this UP contributes to the related phase/phases*
Testing sites	*In what pilot site/sites will the UP be tested?*

Table 5: UP1 "AR/VR training toolkit for trainers" specification linked to pilot activities

UP1 – AR/VR training toolkit for trainers	
UP leader	SIMAVI
Related tasks	T3.4

UP description	The AR/VR solution developed within SILVANUS project is a complex toolkit for training first responders (fire fighters) through virtual modelling 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. There will be 2 software packages. 1) VR Application designed for online/offline training for first responders. There will be at least 1 role and 1 environment implemented within the first version of the product. A VR Environment similar to the actual one in Rodnei Mountains will be developed and included. 2) XR Application designed for targeting the Operational Pilot will assure live communication between first responders. The application will showcase a holographic map of the actual pilot. The first version of the product will showcase the functionality of widgets. Widgets will be used to assure connection with the platform.
Innovation brought by the UP	The AR/VR training toolkit for trainers 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. The AR/VR solution acts both as a player and as an authoring tool, enabling the users to experience training programs and create also training scenarios based on their specific needs. The solution allows the implementation of training programs in a virtual environment (VR/simulations), based on scenarios specific to operational modes.
UP features in the MVP	- Main menu integration - Integration of the Rodnei Mountains virtual environment - Coordinator’s role implementation (3D view) - Forest ranger’s role implementation (VR view) - VR movement and basic interactions (grabbing, navigating) - Webview support integration for maps.
Possible extensions	**Functionalities that will be made available for the final version of the UP:** Adding roles for firefighters, volunteers, drone piloting. Adding fire extinguishing interactions, drone piloting interactions, fire truck interactions. **Functionalities that could be made available for the final version of the UP:** Adding tree cutting specific interactions in VR, Vehicle driving interactions (fire truck, ATV, off-road car)
Related phases	Phase A, Phase B
Phase contribution	The training programs developed within the AR/VR solution will be delivered to the first responders (fire fighters), particularly in Phase A.
Testing sites	PS3 (Romania)

Table 6: UP2 “Fire danger risk assessment” specification linked to pilot activities

UP2 – Fire danger forecast	
UP leader	CMCC

Related tasks	T5.1
UP description	UP2 provides information about the fire danger for a specific area on a certain forecasting period (for the next hours, days, months). Fire danger is a broad scale assessment of the conditions that reflect the potential, over an area, for a fire to ignite, spread and require suppression action. It is the sum of the factors affecting the initiation, spread, and resistance to control the fire in a specific given area. It is typically expressed as a semi-quantitative index (e.g., from very high to very low).
Innovation brought by the UP	Using data-driven approaches (ML/DL) that based on heterogenous and high-resolution data sources (weather, satellite, human activity, …) provide better accuracy for the fire danger forecast at local scale. Providing the fire danger information through an API that facilitates the integration of the component within the downstream applications (SILVANUS platform, GIS, and end-users legacy applications)
UP features in the MVP	Main functionality in the MVP is the production of fire danger maps for the next day (up to 3 days). The UP will provide a prediction of the probability of fire danger in a certain area for the next day. The map is visualized using different colours according to the classes (very low, low … extreme).
Possible extensions	Functionalities that **will** be made available for the final version of the UP: - UP2 will provide Fire danger maps for the next hours (up to 3 hours), next days (up to 3 days), next months (up to 6 months) - Fire danger maps will be produced by Data-driven approaches (i.e., ML Models) and empirical approaches (i.e. FWI, …) Functionalities that **could** be made available for the final version of the UP: - N/D
Related phases	Phase A, Phase B
Phase contribution	UP2 mainly contributes to Phase A providing information about the conditions that reflect the potential over an area for a fire to ignite and spread. It contributes also to Phase B since provides information where the fire is most probable to ignite and spread so it can be used as input for improving early detection of wildfire (e.g., increasing the monitor frequency by the sensors, planning drone missions to monitor area with high fire risk).
Testing sites	PS2 (Italy), PS8 (Slovakia), PS5 (Portugal), PS4 (Greece)

Table 7: UP3 "Fire detection based on social sensing" specification linked to pilot activities

UP3 – Fire detection based on social sensing	
UP leader	CERTH
Related tasks	T4.4
UP description	- UP3 is responsible for providing warnings of active fires or indications that could lead to a fire incident, based on crowdsourced information. Social media data are collected in a real-time manner, analysed to extract further knowledge (e.g., location, type of event, detected fire in image, etc.) and clustered into groups that refer to the same event to avoid multiple warnings.

Innovation brought by the UP	The key innovations introduced by this UP are: - Generate “alerts” that contain information about active fires through the analysis of crowdsourced social media data by extracting location information from posts, allowing the system to precisely geotag fire-related events on a map. The system's innovative event detection algorithm groups similar events together. This technology ensures efficient resource allocation and reduces information overload for users. - Advanced image analysis techniques, the system identifies images that depict fire-related scenes, enhancing the accuracy of fire event detection by extracting visual concepts from images shared on Twitter - Natural language processing and machine learning models to detect fire-related mentions in tweets, ensuring that fire-related posts are accurately identified and analyzed. This innovation significantly enhances the system's ability to provide timely alerts based on textual content. - Offers an intuitive and user-friendly map-based web application that visualizes both individual posts and clustered fire events. This interactive interface enhances user engagement and enables users to gain insights into the geographic distribution and progression of fire incidents. The map-based visualization adds a spatial dimension to fire awareness and enhances collaboration among users. - Offers public awareness and communication as the public can be educated on using social media and be an active member in fire-fighting using in every post related to fire information usefull for the identification of fire such as hashtags, retweets, location etc.
UP features in the MVP	The main functionalities that will be included in the MVP are: (i) the real-time collection of tweets based on user-defined search criteria, e.g., keywords, (ii) the extraction of locations to geotag the posts, (iii) the extraction of visual concepts from Twitter images, (iv) the detection of fire events according to tweets, and (v) visualization of posts and events on a map-based Web application. Secondary functionalities that could be included in the MVP, in case they are mature by then, are any additional analyses on the textual or visual content of the social media data, such fire detection on images and textual concepts extraction.
Possible extensions	Functionalities that **will** be made available for the final version of the UP: - Fire detection on images - Relevance classification - Fake news detection - Text categorization - Textual concepts extraction - Event recognition - Connection to other visualizations through semantic representation. Functionalities that **could** be made available for the final version of the UP: - Crawling from Facebook and scrapping websites

Related phases	Phase B
Phase contribution	Social Media Sensing contributes to Phase B with the early-stage detection of forest fire events based on public social media posts. It could also potentially support Phase A for discovering citizen recklessness that could lead to fires and Phase C for detecting unofficial/unorganized reforestation activities.
Testing sites	PS1 (France), PS2 (Italy), PS4 (Greece), PS8 (Slovakia), PS9 (Australia), PS11 (Indonesia)

Table 8: UP4 "Fire detection from IoT devices" specification linked to pilot activities

UP4 – Fire detection from IoT devices	
UP leader	CTL
Related tasks	T4.3, T5.1
UP description	UP4 is responsible to detect fires, and possibly smoke, on remote areas and provide the appropriate warning to firefighters, public authorities, and relevant stakeholders, through SILVANUS' user interface. UP4 will include the development of a portable kit, easily adjustable and setup on forest areas, where there is a strong indication that fire might be ignited and are in need of daily monitoring. The kit will include a gateway (e.g., Raspberry PI), RGB camera, weather sensors and a SIM adaptor. The kit will be used to monitor an area 24/7 and raise an alarm whenever a fire event is spotted. Outcome will be pushed on the cloud and SILVANUS platform for further analysis. The kit is also expected to relate to external devices and sensors that are placed in pilot cases (such as Portugal and Italy), as well as to collaborate with the Forward Command Centers (FCCs) that will have the capability to run further analysis on the edge.
Innovation brought by the UP	• Easy to setup device for continuous monitoring of remote areas/regions of interest • Use of ML for detection of fire and smoke on the far edge (i.e., on the device instead of the cloud), which in turn speeds up the detection and response time of a fire event • Secured (wireless) communication with the SILVANUS platform • Reduction of camera (e.g., IP) lagging/delay when broadcasting data to a secondary location, since data are processed on the spot • Collection of both sensory and visual data, with the second being also processed by ML algorithms, for the monitoring of an area of interest
UP features in the MVP	The main functionality that UP4, that will be included in the MVP, is the detection of fire ignition in designated forest areas. More specifically, UP4 will act as a frontline component that will monitor and analyse visual and weather data to abruptly detect the presence of smoke and fire in remote areas and SILVANUS pilots. As secondary functionalities that will be included in the MVP, UP4 will deploy a component for the secure transmission of data through the available Cellular network. UP4 will also develop a component that will be responsible for the subscription of this product in SILVANUS topics to be able to receive and broadcast messages to the other components of the system. Dockerization of the components will be performed on the edge, as well as the storage and removal of meaningful and useless data.

	System update will also run on UP4 so that the end-users and technicians will be able to update the deployed edge models remotely.
Possible extensions	Functionalities that **will** be made available for the final version of the UP: - Integrate other sensors on top of the gateway and send further analysis on the SILVANUS platform. This extension will include the capturing of humidity, wind, and temperature data to feed the appropriate components and predict the possibility of the ignition of a new fire event. Functionalities that **could** be made available for the final version of the UP: - Deploy a smoke detection algorithm on the gateway that can spot early fire ignition and raise an alarm even sooner.
Related phases	The great benefit of UP4 component is that it can be placed in all pilot sites that are covered by a cellular network. It will act as a frontline component that will abruptly detect the ignition of a fire event and will notify the public authorities and first responders accordingly. In essence UP4 will be the frontline defence of SILVANUS platform and the first one that will detect fire events.
Phase contribution	Phase B
Testing sites	PS1 (France), PS2 (Italy) - two separate pilots (Puglia and Sardinia), PS4 (Greece), PS7 (Croatia), PS9 (Australia)

Table 9: UP5 "Fire detection from UAV/UGV" specification linked to pilot activities

UP5 – Fire detection from UAV / UGV	
UP leader	CSIRO, 3MON, TRT
Related tasks	T4.5, T4.6
UP description	Fire detection from UAV / UGV supports the process of identifying, spotting and reporting a wildfire quicker compared to existing systems and procedures. This includes the use of autonomous and semi-autonomous vehicles for navigating the wildfire regions in order to access the wildfire spread while firefighters remain a safe distance away.
Innovation brought by the UP	UAV: The UAV fleet trajectory optimization module is based on innovative optimization techniques and computational geometry and allows automated mission planning by procuring monitored zone subdivision for surveillance work distribution, optimal path computation for individual agents and optimized combinatorial choice of sensor to drone allocation. The corresponding module combines all aspects of mission planning into one algorithmic run and allows taking practical constraints into account while providing results fast enough to be compatible with semi real-time use. That last point is particularly important as mission planners and decision maker need computational support to be efficient enough to allow agile reactions and what-if analysis in real time in the decision command centre. UGV: The UGV technology applies innovative analysis techniques on the registered lidar data to provide robust estimates of foliage density, foliage

	coverage and tree density in the proximity of the UGV. This provides a 3D understanding of the forest structure. We use an advanced deep re-localisation pipeline to register lidar data streaming from multiple agents, increasing the efficiency of quantitative analysis of trees, as mentioned earlier, on a large scale in GNSS-degraded forest areas. We also employ an innovative technique for classifying grass and foliage based on lidar double-returns, that has not been used previously. This technique is used to allow the vehicle to drive over plants and grass, while stopping before hitting trees or rocks.
UP features in the MVP	UAV: Taking photos/video with GNSS data of the land and sending them to the system for analysis and detection of smoke/fire. Providing a situational awareness for the incoming/deployed firefighting teams about the fire, direction of spread, smoke, intensity of flames in real time. UGV: Offline: Creating 3D lidar maps and extracting georeferenced environment information (humidity, under canopy biomass density, distribution of trees, etc) for offline processing for fire prevention. Online: Navigating near the fire front to observe the spread of fire and providing situational awareness for the incoming/deployed firefighting teams about the fire, direction of spread, smoke, intensity of flames in real time.
Possible extensions	Functionalities that **will** be made available for the final version of the UP: - UAV: Do a recon flight semi-automatic (with pilot supervision) and send the images to the Silvanus platform in almost real time for the recognition. - UGV: Creation of 3D maps for biomass density estimation for fire prevention and real-time fire detection under canopy in sparse forest areas (given the navigational challenges in obstacle detection). Functionalities that **could** be made available for the final version of the UP: - UAV: Automatic flights with recognition software in the drone. - UGV: Navigating in areas of high complexity (dense forest with multiple obstacles/debris)
Related phases	UAV: Phase B UGV: Phase A, Phase B
Phase contribution	UAV: In phase A, monitoring the landscape. In phase B, recognition of a wildfire as soon as possible so that the firefighters could be send and contain the fire when it is still small fire. Also providing real time information for the firefighters about the fire from above (smoke conditions, direction of spread, fuel, intensity of flames, nearby houses, structures, people...). UGV: In phase A, extracting information about the forest environment for offline understanding of fire risk.
Testing sites	UAV: PS5 (Portugal), PS8 (Slovakia); UGV: PS9 (Australia)

Table 10: UP6 “Fire spread forecast” specification linked to pilot activities

UP6 – Fire spread forecast	
UP leader	EXUS, TUZVO
Related tasks	T5.1, T5.3

UP description	The fire spread forecast predicts where the fire front will spread to and the area damaged by fire at a given time during wildfire. The forecast helps the fire commanders visualise how the probable fire spread and assist in efficient deploying firefighting resources to combat the fire and plan civilian evacuations routes. The fire spread forecast is also useful for firefighter training and preparedness
Innovation brought by the UP	The main innovations introduced by this UP are: • Complete integration of input data handling pipeline with SILVANUS platform, automating the tool operation. Therefore, it can be run by anyone and does not require an expert. • The tool prediction speed is independent of the fire front length; therefore, the prediction speed is much faster compared to state-of-the-art deterministic models. The speed advantage is evident for large fire fronts, where forecasts for the next 24-hour period can be returned in a few seconds (e.g., <10 seconds). • A lightweight version of the algorithm is planned capable of handling missing data (with reduced accuracy), allowing for predictions to be made even if the local command centre is not connected to the SILVANUS cloud. • Results are presented in a probabilistic fashion, giving confidence intervals for the fire front location at future times.
UP features in the MVP	Predicts the spread of the fire over time. Includes a visualisation of the predicted location of the fire front at certain time steps for specific time interval chosen considering the expected duration of wildfire, assessed based on actual weather situation and volume of available fuel.
Possible extensions	Functionalities that **will** be made available for the final version of the UP: - Prediction of the spread of the fire over time for specified time steps. Functionalities that **could** be made available for the final version of the UP: - N/A
Related phases	Phase A, Phase B
Phase contribution	In Phase B (firefighting), knowledge of where the fire is most likely to spread to is critical to deploy the sources and resources most effectively. Further, planning possible evacuation routes is dependent on which routes are likely to remain open in the future, or whether there is a probability that the fire will have spread to those routes. Finally, the same aspects can be applied in Phase A to training scenarios as well as to planning and testing the suitability of chosen fire tactics.
Testing sites	PS2 (Italy), PS5 (Portugal), PS8 (Slovakia), + PS4 (Greece)

Table 11: UP7 “Biodiversity profile mobile application” specification linked to pilot activities

UP7 – Fire Prevention and Awareness Support mobile application (FIPAS)	
UP leader	VTG
Related tasks	T2.4

UP description	The Fire Prevention and Awareness Support mobile application (FIPAS) 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.
Innovation brought by the UP	Innovation brought by UP7 is deepened in the following paragraph
UP features in the MVP	Functionalities that will be included in the MVP fall under two categories, the application side and server (data processing) side. From the application side, FIPAS will offer features for user to create account, take pictures of tree leaves, browse through collection of data, and read information about the biodiversity. Application will be optimised to provide necessary functionalities even during period without internet connection. From the server (data processing side), the MVP will include 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.
Possible extensions	Functionalities that **will** be made available for the final version of the UP: - N/A Functionalities that **could** be made available for the final version of the UP: - Map-based features, semantic analysis and data modelling solutions.
Related phases	Phase A
Phase contribution	FIPAS will contribute to the Phase A through collection and processing of data related to biodiversity of the forest. Focus will be put on images of tree leaves to determine the type of forest/trees and other related information that can enhance forest landscape models for wildfire threat assessment.
Testing sites	France (PS1), Italy (PS2), Greece (PS4), Slovakia (PS8)

Woode as a tool for forest fire management

The use of FIPAS (currently renamed as **Woode**) would allow the creation and consolidation of the forest landscape assets by modelling the spread of **tree density** and identifying **tree species**. Both of these parameters (density and species) are critical to better understand and to improve the quality of ecological resilience indicators to maintain a sustainable forest. Tree density refers to the percent of the area covered by trees. Hence, tree density is an important parameter to estimate shape and size of the potential fuel in a given forest area. Light fuels include dead leaves, needles, small brush and small trees. They cause rapid spread of fires and act as sparking factor for heavier fuels. On the other hand, heavy fuels including stumps, large logs and heavy branches are slower burning, but when ignited, these fuels are harder to extinguish. Having a good model of the forest landscape and its tree density is critical to understand the quantity of both light and heavy fuels on the forest. Here, the **Woode** application will have a direct impact and "***the data derived from the collection and analysis will enable a deeper understanding of the relationship between the biodiversity of forests and fire-related aspects***".

The second critical aspect of the contribution of **Woode** to "***a deeper understanding of the relationship between the biodiversity of forests and fire-related aspects***", is the above-mentioned knowledge of tree species in a given forest. Indeed, some types of trees are much more susceptible to fires than others. Many scientific studies have demonstrated that different tree species have different impact on the spread of wildfire[6]. One of the most important features of the **Woode** App is the semi-automated classification and recognition of tree species. This in turn leads to a direct relation between the Woode application and its usefulness for both prevention and combating of forest fires. A more detailed description of the relationship between biodiversity knowledge, in particular, tree types in a forest and ***fire-related*** aspects is briefly summarized next. A more detailed report including reference to relevant literature is given in the Annex.

When properly cared for, a fire-resistant tree will not ignite as quickly or burn with as much intensity as other vegetation. Characteristics of Fire-Resistant Trees[7]:

- High water content in bark and leaves
- Annually sheds leaves in winter (Deciduous)
- Thick and large leaves
- Produces less wax, resin, or oil
- The sap is thinner or water-like and does not smell strongly

These types of trees can still be damaged or killed by a wildfire, but their bark and foliage burn slower and can reduce the speed at which a fire grows. Two examples of such tree types follow. A longer list is provided in the annex.

- The Mountain Ash is a deciduous tree with dark green leaves that can grow up to 12 inches long. The Mountain Ash tree grows slowly up to 20ft – 30ft tall and 15ft – 20ft wide. They grow best in full sun to lightly shaded areas and require low to medium amounts of water.
- The Mediterranean cypress is not fireproof[8], but it may be as close as a tree can get. Researchers have found in a lab that the Mediterranean cypress can withstand fire conditions for up to seven times as long as other trees before it ignites. This is largely due to the tree's thick, scale-like leaves. They retain water extremely well and keep the Mediterranean cypress moist when other plants and trees would have already dried out. Their fallen leaves retain water too, forming a closely-packed carpet on the floor of the forest, a bit like a sponge.

On the other hand, coniferous trees have a large amount of sap in their branches[9]. This sap burns very quickly and supports fast-moving wildfires. These types of trees also tend to grow much closer together than deciduous trees. Being more tightly packed makes it easier for fire to burn effortlessly through an area of coniferous forest by simply moving from treetop to treetop. Over time, dead branches and needles accumulate on the forest floor. This debris amount for important fuel for wildfires. Since many coniferous trees have low-lying branches, wildfires can easily move from the forest floor to the forest canopy.

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[6] https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/formain15744/$FILE/tree-species-impact-wildfire-aug03-2012.pdf

[7] https://www.vintagetreecare.com/fire-resistant-trees-to-create-a-defensible-space

[8] https://treevitalize.com/fire-resistant-tree-species/

[9] https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/formain15744/$FILE/tree-species-impact-wildfire-aug03-2012.pdf

Lodgepole pine, black spruce, white spruce, and balsam fir are all prominent coniferous species in Alberta. These evergreen trees burn anywhere from five to 10 times faster than other species of leafy trees.

As a conclusion, fire behaves differently in different forest cover types. The knowledge of tree types and density in a given forest is then critical for both prevention and combating of forest fires. This in turn means that ***"the data derived from using the Woode Application will enable a deeper understanding of the relationship between the biodiversity of forests and fire-related aspects".***

Table 12: UP8 "Citizen's engagement programme and mobile app" specification linked to pilot activities

UP8 – Citizen's engagement programme and mobile app	
UP leader	HB, MDS
Related tasks	T3.5, T3.6
UP description	The citizen engagement programme (CEP) identifies various modes of interactions between the SILVANUS system and citizens and defines prioritised modes and the information to be shared or collected. The citizen engagement mobile application serves an important role in disseminating information related to the awareness of wildfire prevention and response and collecting important information about events hazardous to the forests, processing and extracting high level information, and spreading awareness regarding forest fire prevention and restoration. Additionally, the mobile app is designed to send real-time alerts to users about potential fire hazards in their area based on data collected from the SILVANUS components. It will also enable citizens to report signs of potential fires, such as smoke or a sudden increase in temperature, which are then verified and used to send early warnings to others in the vicinity.
Innovation brought by the UP	The innovation of our Citizen's Engagement Program and mobile app lies in its comprehensive and community-centered approach. Unlike existing apps that provide initial alerts about natural disasters, our app will send real-time information based on SILVANUS integrated services, while also enabling citizens to report signs of potential fires, thereby increasing the amount of data available for early warning and potentially leading to faster response times. Furthermore, the app provides continuous updates throughout the incident, including the spread of the fire, evacuation orders, and the safest routes to take, as well as tips and guidance on how to protect oneself during the incident. This continuous flow of information is crucial for citizens to make informed decisions during an emergency. Additionally, our app serves as a two-way communication channel between citizens and local authorities, allowing users to report suspicious activities, request help, and receive important announcements and updates, enhancing coordination during emergencies. Lastly, our engagement program is not merely a mobile app, but a holistic program that includes activities and campaigns to raise awareness about fire prevention and safety, a proactive approach that is often lacking in existing products that focus more on response and recovery.
UP features in the MVP	The MVP will aim to increase the citizen awareness about wildfires causes and prevention measures through the engagement programme and the app. In particular, it will aim to provide the users with information about preventing wildfires but also to contribute with signalling and informing about accidental wildfires. Briefly the main points for each phase are as

	following: phase A: visualizations and educational content regarding fire prevention; phase B: communication/notification channels (one way, possibly two-way) for fire detection: phase C: educational modules regarding reforestation.
Possible extensions	Functionalities that **will** be made available for the final version of the UP: - Increase public/citizen awareness – through several different citizen engagement activities such as an alerting system via a Citizen Engagement Toolkit (mobile application) for signalling accidental fires and activating mitigation strategies. The citizen engagement toolkit comprises several different modules, where each module will incorporate various elements (e.g., raising awareness, sharing information, learning contents, etc) - Prophylactic wildfire prevention strategy, where areas at high risk of wildfire can be treated and protected from ignitions throughout the peak fire season. Functionalities that **could** be made available for the final version of the UP: - Inform citizens about potential soil rehabilitation strategies; provide a restoration roadmap of natural resources; could also include gamified components towards improved fire-safety-aware behaviour and attitudes. - The app could serve as a crucial communication tool between citizens and local authorities, allowing users to report suspicious activities or signs of a fire, request help if needed, and receive important announcements and updates from local authorities.
Related phases	Phase A, Phase B (Maybe Phase C)
Phase contribution	The CEP will actively engage with citizens to raise awareness about fire-risks and prevention measures and to raise their level of preparedness (phase A). It will also play an important role in helping citizens to act responsibly and to be aware of various means of fire prevention and recovery (phase B). The information disseminated through SILVANUS CEP will also be beneficial towards steps taken for forest restoration (phase C).
Testing sites	PS2 (Italy), PS8 (Slovakia), PS5 (Portugal), PS4 (Greece)

3 Adopted approach

To build the impact assessment framework for the SILVANUS platform, several factors were considered:

- the scope of the platform;
- the expected impact set by the Green Deal;
- the current status of the platform;
- the organisation of the pilot activities.

These factors have been described thoughtfully in section 2. The last factor, i.e., the organisation of the pilot activities, sets constraints in the development of the impact assessment framework. As pilot activities will not set up real fire and the solutions brought by the project will not be adopted at EU level during the project lifetime, it is necessary to evaluate the efficiency of the platform in contributing to the achievement of the EIs by adopting an indirect approach.

Considering the above listed factors and that only a certain set of functionalities will be included in the first version of the platform, it has been decided to build the impact assessment framework taking in account only the UPs that are included in the MVP that have been described in Section 2.3. For every UP two different evaluation measures have been developed:

1) **KPIs**, to evaluate the performance of the UP based on its expected outcomes.
2) **Evaluation survey**, to assess the perception of the users while using the UP, evaluating the User Interface (UI) and User Experience (UX) design about the interface of the UP. In addition, surveys have been created to evaluate the performance of the training programmes delivered by UP1 "AR/VR training toolkit for trainers" and UP8 "citizen's engagement programme and mobile app".

To define the set of KPIs that will be used to evaluate the performance of the platform during pilot activities, the following approach has been used:

1) First of all, the contribution that each UP can have on every EI has been identified, be it a direct or indirect contribution. Each link between UP and the EI has been justified accordingly and is reported in the tables in section 3.1. These links are helpful to understand how and in what extent the SILVANUS platform will contribute towards reaching the EIs. The contribution of the SILVANUS platform to the Green Deal EIs will be further analysed in the future during the project and is a current topic of discussion in the cooperation with Firelogue and the other IA projects.
2) For every UP, a set of KPIs has been identified by the UP Leaders. This will be used to measure the efficiency of the UP during the pilot activities, being a target that should be reached during the activities to validate the performance of the UP. These are listed in section 3.2, and an appropriate description has been added to allow a clear interpretation of each one. In the first version of the impact assessment framework, KPIs to assess the performance of UPs working jointly have not been identified but will be included in the final version.
3) In addition, for some UPs, an initial set of question to be included in the user evaluation surveys have been identified. As the interface of the UP has not been designed yet, these questions are rather generic at the moment and will be further detailed later on, once the interfaces are ready. For instance, the questions focus on asking the feeling of the users about the UP, understanding if they find it useful, easy to use and clear. Further content will be added to the surveys and will focus on evaluating the UI and UX design of the UP's interfaces. Only for UP1 and UP8, specific surveys have been designed and will be further developed to assess the performance of the training programmes.

To summarize, the KPIs will be used to evaluate the quantitative performance of the UPs, while the surveys for the qualitative performance, based on the experience that the user had while using the technical UPs and during the training programmes.

3.1 Linking UP with EI

SILVANUS shall contribute jointly with TREEADS and FIRE-RES towards reaching the EIs set by the Green Deal by 2030, considering data from 2019. The contribution that SILVANUS brings towards reaching the EI cannot be directly measured, but an indirect measurement is possible. The contribution that SILVANUS brings towards reaching the EI can be shown by linking every UP to EIs. Each UP, based on its features, can provide contribution towards reaching certain EI, to some of them a direct link can be found, while an indirect one for others. In Table 13 the links between all the UP and the EI are summarized.

Table 13: Links between User Products and Expected Impacts

	EI1	EI2	EI3	EI4	EI5	EI6	EI7	EI8
UP1	X		X	X		X	X	
UP2	X	X	X	X	X	X	X	X
UP3	X		X	X	X	X	X	
UP4	X		X	X	X	X	X	
UP5	X		X	X	X	X	X	
UP6	X		X	X	X	X	X	X
UP7		X	X	X	X			X
UP8	X	X	X	X		X	X	

Based on the links shown in Table 13, it appears that the first version of the platform will contribute, in a direct or indirect manner, to all the EIs apart from EI2 and EI8 that are less covered, with both having links with only three UPs. It must be taken in account that this is the first version of the platform and additional UPs will be added in that may cover these UPs in a more extensive way. In addition, having a lot of UPs contributing to an EI does not necessarily mean that the EI is fully covered, as a single UP may contribute towards an EI in a much more significant and direct way than more UP jointly. The scope of Table 13 is to resume what links have been found between the UPs that will be delivered with the MVP and the EI. Furthermore, knowing what EI are more addressed by SILVANUS will be useful in the joint meetings with TREEADS, FIRE-RES and Firelogue to understand which EIs are more covered by the projects and what are the EIs that may need to be more addressed by the three IAs. The contribution of each UP to the KPIs are described in more detail in the tables below.

Table 14: UP1 "AR/VR training toolkit for trainers" links with EI

UP1		AR/VR training toolkit for trainers
EI#	**Y/N**	**Explanation**
EI1	Y	Developing a successful AR/VR training toolkit for the firefighters will lead to a better organisation of their workforce, which will lead to an increase of their efficiency in fighting wildfires, thus being able to reduce the number of fatalities.
EI2	N	

EI3	Y	The development of an effective training toolkit will increase the efficiency of firefighters in tackling wildfires; thus, they will be able to control the wildfire faster, leading to a reduction in emissions.
EI4	Y	The development of an effective training toolkit will increase the efficiency of firefighter in tackling wildfires; thus, they will be able to control wildfires faster.
EI5	N	
EI6	Y	The development of an effective training toolkit will increase the efficiency of firefighter in tackling wildfires; thus, they will be able to control the wildfire faster, leading to a reduction of the building losses caused by wildfires.
EI7	Y	Proving the efficiency of the training toolkit for firefighters, insurance companies may be more willing to insure some areas at risk at a lesser price, thus encouraging more people to insure their goods at risk.
EI8	N	

Table 15: UP2 "Fire danger risk assessment" links with EI

UP2		**Fire danger risk assessment**
EI#	**Y/N**	**Explanation**
EI1	Y	Knowing what the fire danger risk of an area is could improve awareness, preparedness and prevention, reducing the number of fatalities.
EI2	Y	Acknowledging the fire risk of an area could allow to provide extra safety measures, like reducing the energy that passes in some power lines when critical conditions are reached.
EI3	Y	Acknowledging the fire risk of an area could improve preparedness/readiness, allowing a faster response of firefighters, thus potentially reducing emissions caused by wildfires.
EI4	Y	Acknowledging the fire risk of an area could improve preparedness/readiness, allowing a faster response of firefighters, thus potentially reducing time to suppress wildfires.
EI5	Y	Acknowledging the fire risk of an area could improve preparedness/readiness, allowing a faster response of firefighters, thus potentially reducing time to suppress wildfires or to plan and implement wildfire prevention actions (fuel reduction, prescribed fires), that will contribute to the long-term resilience of Natura 2000 areas.
EI6	Y	Knowing what the fire danger risk of an area is could allow a better planning of fire defences to protect buildings, or to avoid buildings in some critical areas.
EI7	Y	Knowing what the fire danger risk of an area is could be valuable to insurance companies to understand the probability of a fire to appear in a certain area and to adjusting the rate accordingly.
EI8	Y	Using this tool in pair with UP6 could allow to identify the best conditions to accomplish the prescribe fire treatment minimizing the risk of a fire to get out of control, thus encouraging the use of this practice.

Table 16: UP3 "Fire detection based on social sensing" links with EI

UP3		**Fire detection based on social sensing**

EI#	Y/N	Explanation
EI1	Y	The use of fire detection based on social media will allow to detect fire earlier, that will allow the firefighters to act sooner, thus reducing the spread of the wildfire and reducing the number of fatalities.
EI2	N	
EI3	Y	The early detection of wildfires will allow to control the wildfire earlier, as a consequence emission caused by the wildfire will decrease.
EI4	Y	The early detection of wildfires will allow a faster response of the firefighters, reducing the time needed to control the wildfire.
EI5	Y	The early detection of wildfires will allow a faster response of the firefighters, reducing the time needed to control the wildfire and potential impacts, enabling on-going natural regeneration processes towards mature and more resilient habitats and reducing the risk of "locking" the system in a stage dominated by fire-prone communities (e.g., fire-prone shrublands).
EI6	Y	The early detection of wildfires will allow to control the wildfire earlier, as a consequence there will be reduction of damage caused by the wildfire, including building losses.
EI7	Y	Proving the effectiveness of this tool to early detect wildfires could encourage insurance companies to redefine fire insurance rates, encouraging people to insure their goods.
EI8	N	

Table 17: UP4 "Fire detection from IoT devices" links with EI

UP4		**Fire detection from IoT devices**
EI#	**Y/N**	**Explanation**
EI1	Y	The use of fire detection with IoT devices will allow to detect fires earlier, that will allow the firefighters to act sooner, thus reducing the spread of the wildfire and eventually the number of fatalities.
EI2	N	
EI3	Y	The early detection of wildfires will allow to control the wildfire earlier and consequenctly emissions caused by wildfires will decrease.
EI4	Y	The early detection of wildfires will allow a faster response of the firefighters, reducing the time needed to control the wildfire, achieving response record bellow 24 hours.
EI5	Y	The early detection of wildfires will allow a faster response of the firefighters, reducing the time needed to control the wildfire and potential impacts, enabling on-going natural regeneration processes towards mature and more resilient habitats and reducing the risk of "locking" the system in a stage dominated by fire-prone communities (e.g., fire-prone shrublands).
EI6	Y	The early detection of wildfires will allow to control the wildfire earlier, consequently there will be reduction of damage caused by the wildfire, including building losses.
EI7	Y	Proving the effectiveness of this tool to early detect wildfires could encourage insurance companies to redefine fire insurance rates, encouraging people to insure their goods.
EI8	N	

Table 18: UP5 "Fire detection from UAV/UGV" links with EI

UP5		Fire detection from UAV/UGV
EI#	**Y/N**	**Explanation**
EI1	Y	The use of fire detection with UAV/UGV devices will allow to detect fires earlier, that will allow the firefighters to act sooner, thus reducing the spread of the wildfire and reducing the number of fatalities.
EI2	N	
EI3	Y	The early detection of wildfires will allow to control the wildfire earlier, as a consequence emission caused by the wildfire will decrease.
EI4	Y	The early detection of wildfires will allow a faster response of the firefighters, reducing the time needed to control the wildfire.
EI5	Y	The early detection of wildfires will allow a faster response of the firefighters, reducing the time needed to control the wildfire and potential impacts, enabling on-going natural regeneration processes towards mature and more resilient habitats and reducing the risk of "locking" the system in a stage dominated by fire-prone communities (e.g., fire-prone shrublands).
EI6	Y	The early detection of wildfires will allow to control wildfires earlier, as a consequence there will be reduction of damage caused by the wildfire, including building losses.
EI7	Y	Proving the effectiveness of this tool to early detect wildfires could encourage insurance companies to redefine fire insurance rates, encouraging people to insure their goods.
EI8	N	

Table 19: UP6 "Fire spread forecast" links with EI

UP6		Fire spread forecast
EI#	**Y/N**	**Explanation**
EI1	Y	Being able to predict the spread of the wildfire could allow the firefighters to fight the wildfire by acting in advance, thus reducing potential damage and reducing potential fatalities.
EI2	N	
EI3	Y	Understanding how the fire will develop can guide firefighting efforts, leading to a more efficient way of fighting the fire and thus reducing emissions.
EI4	Y	Being able to predict the spread of the wildfire could allow the firefighter to fight it by acting in advance, this will allow to reduce the time needed to control wildfires and to preserve the protected values.
EI5	Y	Being able to predict the spread of the wildfire will allow a better response of the firefighters, planning the number of sources and resources, choosing the most effective fire tactics and reduce the time needed to control the wildfire and potential impacts, enabling on-going natural regeneration processes towards mature and more resilient habitats and reducing the risk of "locking" the system in a stage dominated by fire-prone communities (e.g., fire-prone shrublands).
EI6	Y	Being able to predict the spread of the wildfire could allow the firefighters to fight the wildfire by acting in advance, thus reducing potential damage and reducing the number

		of building losses by the wildfire. Early identification of fire spread towards populated areas can help guide firefighting efforts, minimizing damage and loss to property/buildings.
EI7	Y	Being able to simulate the spread of wildfire could be useful for insurance companies to evaluate the insurance rate of some areas. E.g., if in an area there is a recurring fire ignition in area (caused by particular conditions like power lines or natural cause), different simulations (considering different conditions like weather etc…) could be made to identify the areas that are more at risk.
EI8	Y	Using this tool in pair with UP2 could allow to identify the best conditions to accomplish the prescribe fire treatment minimizing the risk of a fire to get out of control, thus encouraging the use of this practice.

Table 20: UP7 "Biodiversity mobile profile application" links with EI

UP7		**Biodiversity mobile profile application**
EI#	**Y/N**	**Explanation**
EI1	N	
EI2	Y	The use of the biodiversity application by people visiting a forest site will enable gathering an important information about the type of the forest, which in combination with data gathered through other sensors of the Silvanus platform can provide critical information about the condition of the forest and fire risk.
EI3	Y	Understanding the biodiversity of the forest will increase the efficiency of firefighters in tackling wildfires; thus, they will be able to control the wildfire faster, leading to a reduction in emissions.
EI4	Y	Understanding the conditions and fire risk of the forest could allow the firefighter units to choose right strategy and reduce the time needed to control wildfires.
EI5	Y	Understanding the biodiversity of a Natura 2000 site will be helpful to identify the best resilience strategies that could be adopted in that area. The app could contribute to deliver detailed information on structural and phenological indicators required to assess fire risk and to plan and implement management actions to increase resilience.
EI6	N	
EI7	N	
EI8	Y	Using the application and gathered data in combination with UP2 and UP6 could enable to identify the best conditions and tailored strategies for fire treatment in respect to specific area.

Table 21: UP8 "Citizen's engagement mobile programme and mobile app" links with EI

UP8		**Citizen’s engagement mobile programme and mobile app**
EI#	**Y/N**	**Explanation**
EI1	Y	Engaging with citizens will result in increasing their awareness about wildfires, as well as preventative measures leading to improved safety measures and reaction in the presence of wildfires (e.g., by avoiding actions that can lead to fire ignition or knowing how to safely navigate evacuation in times of fire).

EI2	Y	Engaging with citizens will result in increasing their awareness about potential causes of wildfires and environmental conditions, this awareness is expected to help citizens assess fire danger levels and hence act accordingly to reduce accidental fire ignitions.
EI3	Y	Raised awareness among citizens will indirectly relate to the EI3 as reduction in human caused wildfires will contribute towards reduction in emission from wildfires also.
EI4	Y	The SILVANUS CEP will indirectly support EI4, as the information gathered through CEP activities will inform of fire instances and cold lead to improved control of wildfires by the fire-control services. Additionally, during a fire, the app provides continuous updates on the situation, including the spread of the fire, evacuation orders, and the safest routes to take, as well as tips and guidance on how to protect oneself from smoke inhalation and safely evacuate.
EI5	N	
EI6	Y	The engagement program includes activities and campaigns to raise awareness about fire prevention and safety, such as organizing workshops on creating a fire-safe environment at home and running campaigns to encourage citizens to keep their surroundings clean and free of combustible materials. Engaging with citizens will result in increasing their awareness about wildfires, and patterns of spread, which may lead to improved decisions by citizens about safe positioning of their properties and adopting fire safety measures in their property plans.
EI7	Y	Engaging with citizens will result in increasing their awareness about various aspects of wildfires including economic impacts, this may lead some to insure their properties based on their acknowledge about wildfire related risks in their area and sound economic mitigation measures.
EI8	N	

3.2 Identifying Key Performance Indicators

To evaluate the performance of UPs in achieving their scope it is necessary to define a set of KPIs, that needs to be as objective as possible and leaving no room for interpretation. The role of the KPIs in the impact assessment is to set targets that needs to be reached during pilot activities to assure that there is enough data to analyse and that the performance of the UP is in line with what has been proposed. KPIs can be divided in two types:

- a first one, related to the number of tests performed and that must be reached to have enough data for the evaluation,
- a second type is directly linked with the performance of the UP.

As the UPs are different between each other, the related KPIs are different as well, in particular regarding UP1 and UP8, the results coming from these UPs, that is the efficiency of the trainings programmes, for firefighters with UP1 and for citizen with UP8, cannot be determined by using KPIs, hence for these two UPs the evaluation of the performance will be made by using the data gathered by the surveys. For all the other UPs, the performance will be verified by analysing their performance in comparison to the target KPIs while considerations about their design and features will be gathered through the surveys.

In the sections below a short description of the set of KPIs of every UP is described along with the explanation about why the set is relevant to verify the performance of the UP. In addition, each KPI is described in detail in order to leave no room for interpretation.

3.2.1 UP1: AR/VR training toolkit for trainers

Table 22: KPIs for UP1 "AR/VR training toolkit for trainers"

KPI	Description
N° of training scenarios created >= 3	At least 3 training scenarios must be created.
N° of training environments created >= 3	At least 3 different virtual environments must be created
Implement multiplayer support for at least 3 users	At least 3 different users will be able to attend a training scenario (multiplayer support)
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
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.
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.
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)
N° of firefighters trained > 17	The goal is to have at least 17 firefighters trained by the first version of the product. Every trained firefighter will have to fill the learning evaluation survey.

3.2.2 UP2: Fire danger risk assessment

Table 23: KPIs for UP2 "Fire danger risk assessment"

KPI	Description
Number of pilots >= 3	UP2 will be tested in at least 3 Pilots
Sensitivity/recall > 85%	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 must be higher than 85%.

Specificity > 60%	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 must be higher than 60%.

3.2.3 UP3: Fire detection based on social sensing

Table 24: KPIs for UP3 "Fire detection based on social sensing"

KPI	Description
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).
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%.
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.
Precision of fire events detection (% correctly identified) > 80%	More than 80% of the fire events detected by UP3 must be real incidents.
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.
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.
Event detection time (from publication to event (warning) generation) < 10 minutes	The duration between the publication of a social media post and the generation of a warning about an event that was detected based on this post must be less than 10 minutes.
F1 score of location extraction > 92%.	More than 92% F1 score for the locations (NER) in English or other popular languages, more than 89% Precision for less represented ones.

3.2.4 UP4: Fire detection from IoT devices

Table 25: KPIs for UP4 "Fire detection from IoT devices"

KPI	Description

N° of tests made >= 6 (at least 1 per selected pilot)	UP4 must be tested at least once for each one of the 6 pilots where the UP will be deployed. Test could be both offline and online depending on the data collected, namely retrospective, benchmark datasets for the fire detection or acquired sensor data from the designated pilot site.
False alarm rate < 15%	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 mis-classified as True Positives (TP), producing erroneous alarms. For the MVP, where only fire detection is going to be developed in UP4, it is expected that fire events will have a false alarm rate below 15%, as fire is significantly different from the forest area (yellow and red instead of green).
True positives > 70%	It is expected that the True Positives of a fire event would be more than 70%, and it will reach even higher rates, when gathering data for each use case and fine-tuning the fire model.
Missing rate < 5%	It is expected that the missing rate for the fire detection model in UP4 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.
Number of identi-fications > 80%	More than 80% of the fire events detected by UP4 must be real fire incidents.
Time needed to correctly identify ignition and notify firefighters and citizens < 1 mi-nute	Considering that the camera on UP4 will father 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 fire-fighters and citizens will not exceed the 1 minute.
Firefighters time to act after igni-tion notification < 30 minutes	The duration between the generation of fire ignition warning and its broadcast to the SILVANUS platform, until the first fire responders reach the area is expected to be less than 30 minutes.

3.2.5 UP5: Fire detection from UAV/UGV

Table 26: KPIs for UP5 "Fire detection from UAV/UGV"

KPI	Description
N° of tests made >= 10	UAV: At least 10 flights, with different drones and different upload/download sys-tem with different video/photo resolutions from different angle of the fire/smoke. UGV: 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 de-tection.
Mean % of false alarm < 10	UAV: False alarm could be caused by mist, fog, smoke from a chimney, light that do not originate from fire, campfire. The mean percentage of false alarm sent by the UP should be lower than 10%. UGV: The mean percentage of false alarm sent by the UP should be lower than 10%.

Accuracies	UAV: The fire must be detected by drone on an area no more than 50x50 m with 75-95% of accuracy, no more 100x100 m with 60-85% of accuracy. UGV: 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.
Detection time < 10 minutes	UAV: The detection time must be no more than 10 minutes from the departure of the drone. UGV: 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.
Spread Prediction Improvement	UGV: the fire spread prediction will be based on the humidity and biomass density estimation extracted from 3D reconstructed lidar data.

3.2.6 UP6: Fire spread forecast

Table 27: KPIs for UP6 "Fire spread forecast"

KPI	Description
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.
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.

3.2.7 UP7: Biodiversity profile mobile application

Table 28: KPIs for UP7 "Biodiversity profile mobile application"

KPI	Description
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.
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.
Minimum number of photos required for the identification of the species >= 2	The FIPAS 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.

Correctly identified > 90%	The computer vision and deep learning units will be developed and optimised to achieve over 90% of detection accuracy.
No identification < 5%	The FIPAS application will be designed to classify most of the input images, with only less than 5% window allowed for no identification.

3.2.8 UP8: Citizen's engagement programme and mobile app

Table 29: KPIs for UP8 "Citizen's engagement programme and mobile app"

KPI	Description
N° of citizen engaged > 500	Social media engagement for forest management authorities, landowners, public authorities and visitors of eight (8) pilot sites (as outlined in Section 1.3.3 of the DOA) through at least three (3) platforms. The activities include: promotion of citizen engagement activities and use of citizen-engagement-toolkit through 500 local authorities, and extend invitations to external stakeholder advisory group from the list of past projects.
N° of citizen-engagement-tool-kit assessment provided > 200	Citizen-engagement-tool-kit assessment will be provided by at least 200 of the already engaged users in UP8.
N° of members consulted through public forum for the evaluation of public campaign > 2000	At least 2000 members consulted through public forum for the evaluation of public campaign.
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.
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.
Number of other CEP activities >= 3	In addition to the CEP App, the SILVANUS CEP is envisaged to include multiple other modes of engagement including social media (e.g., Twitter and LinkedIn), Mass Media (e.g., participation in radio and TV programs or publication of popular scientific articles), Public Events (e.g., presentations at related fairs, and other public gatherings), and Campaigns (e.g., at schools, or social campaigns directed at broader audiences).

3.3 Building the Evaluation Surveys

The "Survey[10]" is a commonly used tool for the assessment of a product quality and usability, as perceived by the end users (product = good/ service). It allows an efficient quantitative measurement of the product characteristics. An appropriate use of the survey allows the collection of useful information on the basis of which evaluation can be made, that will allow for better decisions to be made under the performance's point of view[11].

The aim of the process of developing a survey is to identify a set of questions that should allow the interviewed users to express, in a very simple and immediate way, feelings, impressions and attitudes that arise when experiencing-using the product under consideration. The ultimate goal is to create/identify successful products (goods/services) that can successfully satisfy end user's requirements. To succeed, it is necessary that the product has a sufficiently high UX. The definition of the representative sample of users, for the analysis that must be carried out, is of fundamental importance for a good market analysis. Different users or different groups of users may judge the same product differently, regarding their user experience, for instance because they have different needs or different skills or competences in using the product. Depending on the interpretation given to the database collected, it is possible to define the user experience as a set of distinct quality criteria that includes the classic criteria of usability, such as efficiency, controllability or learning, and quality criteria not direct or hedonic such as stimulation, enjoyment of use, novelty, emotions or aesthetics. This has the advantage of dividing the general notion of user experience into a series of simple quality criteria, that describe distinct and relatively well-defined aspects of the user experience that can be measured independently.

The process of creating a survey should ensure that all relevant product characteristics are considered so that it is possible to better understand how the end user perceives and actually needs some functionality compared to other. Giving a quantitative interpretation of the user's perception of the product can be strategically successful.

Generally, regardless of the type of answers that can be given to the survey, for a better analysis, it is essential that the questions are: clear, brief, understandable, unambiguous, related to a specific time frame and no negative wording should be used that may confuse the user who is called upon to answer. This will involve finding a valid and reliable database on which to base an equally valid and reliable analysis. Another fundamental characteristic is the objectivity of the question. In formulating questions, the writer should not go to condition the choice of the answer with personal prejudices that may influence the user's answer. On the other side, it is necessary to stimulate the user by arguing and diversifying the questions from different points of view, thus it will be possible to obtain as many positive and negative points of view of the interviewee.

Surveys can be built in several manners, and they can be generally divided in the following classes:

- Open = user response is free and unpredictable. The data collected will be more complex, statistically speaking, because of their variety. In some cases, it will be necessary to give constraints to the respondent, such as a maximum limit of characters or suggesting words that can be used in giving the answer;
- Closed = the answer is recommended to the user who must choose the one that most represents it from a group of finished answers. Data collection in this case is facilitated because there is a

[10] Creswell, J. W. (2014). Research Design: Qualitative, Quantitative and Mixed Methods Approaches (4th ed.). Thousand Oaks, CA: Sage

[11] Laugwitz, Bettina, Theo Held, and Martin Schrepp. "Construction and evaluation of a user experience questionnaire." Symposium of the Austrian HCI and usability engineering group. Springer, Berlin, Heidelberg, 2008.

higher level of standardisation of responses. Therefore, there are going to be simple and of immediate understanding answers;

- Structured = the answer is a hybrid of the two points before. There are recommended closed answers but at the same time the interviewee could select, for example, the "other" answer that will allow the insertion of a comment that motivates the choice given. The level of complexity of analysis of the data collected, in the latter case, will be greater because of the "open" answers that the users interviewed can give[12].

The evaluation surveys built for the UPs that will be available in the first version of the SILVANUS platform have been designed in a structured manner, with a prevalence of closed questions to assess the UI and UX of the UP and open question to ask the users about any observation that they have regarding the performance of the UP and about possible functionalities that could be added to it to increase its performance. Building the surveys in this way will allow to gather a lot of information about the UI and UX of the UP, that will allow an improvement of the product. In addition, it will leave the users free to provide suggestions about additional features that could be used to further improve the UP, by considering the point of view of the users that are directly using the UP and are not involved in its development, and that are not being influenced by it.

A survey could be created to investigate individual topics or a multiple combination of topics, in this case the decision is up to the interviewer in the very first stages of definition and validation of the survey.

The topics of study could be:

- Attractiveness = Overall impression of the product. Do users like or dislike is? Items: annoying / enjoyable, good / bad, unlikable / pleasing, unpleasant / pleasant, attractive / unattractive, friendly / unfriendly;
- Perspicuity = Is it easy to get familiar with the product? Items: not understandable / understandable, easy to learn / difficult to learn, complicated / easy, clear / confusing;
- Efficiency = Can users solve their tasks with the product without unnecessary effort? Items: fast / slow, inefficient / efficient, impractical / practical, organized / cluttered;
- Dependability = Does the user feel in control of the interaction? Items: unpredictable / predictable, obstructive / supportive, secure / not secure, meets expectations / does not meet expectations;
- Stimulation = Is it exciting and motivating to use the product? Items: valuable / inferior, boring / exiting, not interesting / interesting, motivating / demotivating;
- Novelty = Is the product innovative and creative? Items: creative / dull, inventive / conventional, usual / leading edge, conservative / innovative[13].

The evaluation surveys for all the UPs considers these topics to assess the experience of the users in using the product. In addition, for UP1 and UP8 the performance of the trainings delivered by them will be assessed with the analysis of the results coming from the evaluation survey. For these two UPs, the analysis of the results coming from the evaluation surveys will be used to evaluate the performance of the UP, unlike the other where the evaluation surveys will be used to evaluate mostly the UI and UX of the product.

Once the database has been obtained, in order to have a high quality of data or to carry out the analysis of the goodness of a product (good/service) at the best, it is necessary to evaluate its reliability with certain logics, during the generation and validation phase of the survey. The surveys have been devised as part of the impact assessment framework in Task 2.6 and will be finalised once the interface of the UPs is complete

[12] Martin, Elizabeth. "Survey questionnaire construction." Survey methodology 13 (2006): 2006.

[13] Schrepp, Martin, Andreas Hinderks, and Jörg Thomaschewski. "Applying the user experience questionnaire (UEQ) in different evaluation scenarios." International Conference of Design, User Experience, and Usability. Springer, Cham, 2014.

and will be used during the pilot activities in WP9. The exploitation of the surveys will be performed in T9.6: "Pilot outcome assessment and replicability studies" by analysing the effectiveness of pilot demonstrations.

Once the surveys will be filled, during T9.6, the evaluation phase will consider several requirements in order to analyse the quality of the questions distributed to the end users. Among these, there are:

- Did the user answer all the questions?
- Has the user skipped a number of questions such that the analysis could be negatively affected?
- Could the answers provided alter/contaminate the overall data obtained from the analysis?
- Do the answers follow a logical criterion or are they inconsistent with each other in some cases?
- Are there repetitive response sequences or in general abnormalities?

The data should be analysed from their most significant point of view. Depending on the level of reliability of the data collected, it will be possible to comprehensively infer the level of goodness of the product (good/service) that has been used/consumed by the basket of users that it was decided to interview.

For the first version of the impact assessment framework two different type of surveys have been devised.

- The first one, to evaluate the user satisfaction coming from the use of the UP. These will be created for all the UPs and will allow to understand the perception of the user regarding the UI and UX of the UP.
- The second type will be developed only for UP1 "AR/VR training toolkit for trainers" and UP8 "Citizen's engagement programme and mobile app" and will be used to evaluate what the users are able to learn thanks to the programmes included in the UP. This is applicable only for these two UPs as they're the only UPs that delivers some training activities, to firefighters for UP1 and to citizen for UP8.

To distinguish these two types of survey from here on, the term **user satisfaction survey** will be used for the first type and **learning evaluation survey** for the second type.

3.3.1 User Satisfaction surveys

The user satisfaction survey is a necessary component of the impact assessment framework as it allows to understand the feeling that the users have in using the UPs of the SILVANUS platform. The KPIs are necessary to measure the performance of the UPs, on the other hand, the user satisfaction surveys are needed to understand the feelings of the user about using the UP and the quality of the design of the interface, particularly their UI and UX. The user satisfaction surveys will be used to evaluate the interface that is developed for every UP, based on the perception of the users, and not the performance of the UP itself.

User satisfaction surveys have been devised for every UP during the activities of Task 2.6 and will be completed by the respective UP leader once the interface of the UPs is completely defined. The surveys will be made of a set of agree/disagree questions, aiming to understand the perception of the users coming from its experience with the UP, targeting aspects that cannot be covered by the KPIs, i.e., if the UP is easy to use, if it's interface it's clear or the signal that are sent by it are clear. In addition to the agree/disagree questions, open questions will be included as well, allowing the user to be free to provide potential suggestions about features that could be added and useful while operating the UP and are not included in its current version. These may be not included because they are planned be added in the next versions, or because they have not been thought yet, in this case it could be decided to include them if they could add some benefits to the UP. Analysing the result coming from these surveys will allow to improve the design of the UPs making it easier and clearer to use by the users. The analysis of the open questions will allow to consider the inclusion of some additional features to the UPs that have been not thought yet but that could be valuable for the stakeholders that will be using the product.

In order to increase the accuracy of the results coming from the user satisfaction survey it will be necessary to carry out **a high number of surveys**, to **a high number of different users**, under **a high number of different conditions**. This will allow to reduce the influence of personal preferences and having the results coming from the surveys to be as objective as possible. In addition, it is also fundamental to gather surveys from different testing scenarios, because there is the possibility that in some scenarios the UP will be performing properly while in other ones poorly because of the different conditions of the sites. For example: a particular format of data could be processed faster by the UP; having the UP tested in two different scenarios, one using data in the format that is processed faster and the other one in a format that is processed more slowly will bring to different results in the surveys, the first one will conclude that the UP is fast to process, while the second that it is slow. Comparing the outcomes of the surveys from the two scenarios will bring out the differences in the survey's results, and, by analysing the difference in the scenarios, it will be possible to find that the UP is slower to process data of a specific format.

The first drafts of the user satisfaction survey are reported in the appendix of this deliverable, as an example the question of the evaluation survey is reported in Table 30.

Table 30: User evaluation survey of UP6 "Fire spread forecast"

1) How easy to understand did you found the iteration layer of the fire spread forecasting?				
1. Not easy at all ☐	2. Not easy ☐	3. Neither easy nor not easy ☐	4. Easy ☐	5. Very easy ☐
2) How satisfied are you with the presentation of the result?				
1. Not satisfied at all ☐	2. Not satisfied ☐	3. Neither satisfied nor not satisfied ☐	4. Satisfied ☐	5. Very satisfied ☐
3) How easily recognizable is the burnt area?				
1. Not easily at all ☐	2. Not easily ☐	3. Neither easily nor not easily ☐	4. Easily ☐	5. Very easily ☐
4) How satisfied were you with the processing time of the fire spread model?				
1. Not satisfied at all ☐	2. Not satisfied ☐	3. Neither satisfied nor not satisfied ☐	4. Satisfied ☐	5. Very satisfied ☐
5) How easily did you find the fire spread model to start?				
1. Not easy at all ☐	2. Not easy ☐	3. Neither easy nor not easy ☐	4. Easy ☐	5. Very easy ☐

6) How easy was it to insert the input data to the fire spread model?				
1. Not easy at all ☐	2. Not easy ☐	3. Neither easy nor not easy ☐	4. Easy ☐	5. Very easy ☐
7) What did you expect from UP6 but you didn't find?				
8) Do you have any recommendations to improve the product?				

3.3.2 Learning Evaluation surveys

To properly evaluate UP1 "AR/VR training toolkit for trainers" and UP8 "citizen engagement programme and mobile app" a different approach is needed in comparison to the other UPs. As these UPs include training activities with human participant, it is important to evaluate the effectiveness of the training programme as they cannot be completely assessed using the KPIs alone. The KPIs that have been set for both these UPs are targets that must be reached to assure that enough tests are carried out and that enough scenarios, for UP1, or modules, for UP8, are included, that will allow the surveys to reach statistic evidence.

The aim of the learning evaluation surveys is to understand the impact that the training programmes have on its participants, verifying that the objectives of the training program are met during the activities. Once the evaluation survey had been fulfilled, the results will be analysed to verify if the training programmes were effective and if the appropriate results are reached by the surveys. The analysis of the survey is a necessary process to understand the feelings of the users about the training programme, to verify if the objectives are met and if the experience during the training programmes has been pleasant and useful. The analysis of the surveys is planned to be carried out adopting the Kirkpatrick model[14], that will be adapted to match the objectives of SILVANUS. The classic Kirkpatrick model is composed of 4 stages, that measure different factors, that are:

- **Reaction**, that analyses the feelings of the participants about the programme;
- **Learning**, that analyses the changes of the participants in the intended knowledge, skill, attitude, confidence and commitment caused by the programme;
- **Behaviour**, that verifies if what has been learnt during the programmes by the participants is applied in their work or in their daily behaviour;
- **Results**, that measures the degree to which the targeted outcomes occur following the training.

As both the training programmes are not ready at the time of the submission of deliverable D2.3 and being that the evaluation surveys need to be built upon the programmes, the surveys will be built once the training programmes are ready and will be added to the impact assessment framework.

[14] https://kirkpatrickpartners.com/the-kirkpatrick-model/

4 SILVANUS 1st Impact Assessment Framework

The first version of the impact assessment framework that will be used to evaluate the performance of the platform during the first tranche of pilot activities that will be carried out under WP9 is made of different components that have been accurately described in section 3. To sum up, the components of the first version of the impact assessment framework are the following:

- **A set of KPIs for every UP**. Those will be used to evaluate their performance in achieving their scope during the trials in the pilot activities. Achieving the KPIs will prove that the UP is properly performing, while if they are not reached that it is not. The analysis of the results will allow the identification of the causes that led to the underperformance of the current version of the UP and address these issues in the development of the next version, thus increasing the performance of the UP. As every UP provides contribution towards several EI, demonstrating that the UP is properly performing will prove that the SILVANUS platform is contributing towards reaching the EI.
- **User satisfaction surveys for every UP**. Those will be used to assess the experience of the uses while using the UP, targeting predominantly the usability and clearness of the UP interface. The results of these survey will be used to improve the UI and UX design of the UPs as well as identifying additional features that could be added to increase the functionality of the UP. Those are not complete for all UPs, at the time of the delivery date for D2.3, because the interfaces of the UPs have not been defined yet. The user satisfaction surveys will be completed once the interface of all the UPs included in the MVP are completely defined and will be integrated in the first version of the impact assessment framework.
- **Learning evaluation surveys, only for UP1 and UP8**, not included in Figure 2. Those will be used to evaluate the efficacy of the training programme developed within UP1 and UP8. Analysing the results coming from these surveys will allow to verify the perception of the participants about the training programmes, understanding if the trainings are efficient as they are or if they need to be changed. Like the user satisfaction survey, these surveys have not been prepared yet as they will be based upon the training programmes delivered by the two UPs. Those have not been finalised, at the time of D2.3 delivery date, hence the learning evaluation surveys will be finalised once the training programmes are ready and will be then integrated in the impact assessment framework.

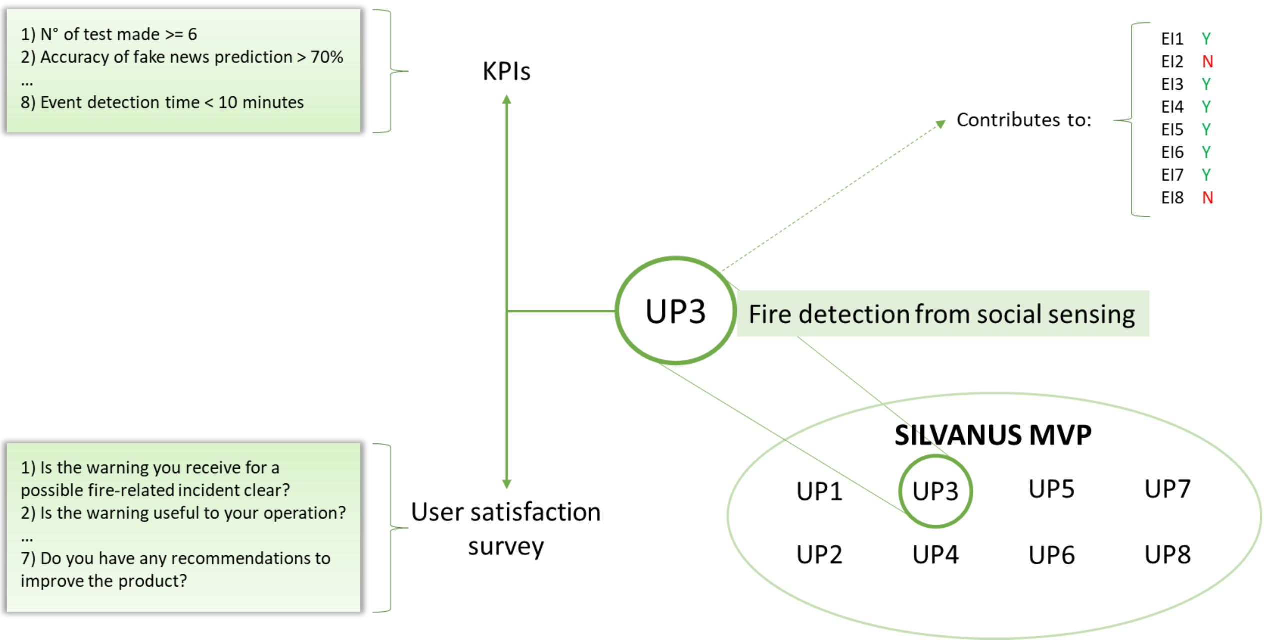

Figure 2: Impact assessment framework schema, applied to UP3

4.1 Using the Impact Assessment Framework

Once the first version of the platform is completed, it will be subjected to validation processes before its official delivery. When the MVP gets the validation, it will be distributed among the end users, that will test it in the demonstration activities planned and arranged in WP9, carried out in 11 pilot sites (see Table 3). The first manche of demonstration activities will test the eight UPs included in the MVP, described in section 2.3, and consequently, the first version of the impact assessment framework will be used to evaluate the performance of each UP.

The surveys will follow the indications coming from the set-up of pilot activities during WP9 in terms of data collected, information provided by both UP leaders and UP users on pilot areas and locations, activities carried out, date and timing of the performances, number of UP tests executed, name of the operators, and so on. At the current stage, no surveys can be developed until all the information mentioned above are provided by the end users, and UP leaders and participants.

As already mentioned, pilot activities exploiting the eight UPs will be performed in 11 sites, namely France, Italy, Romania, Greece, Portugal, Czech Republic, Croatia, Slovakia, Australia, Brazil, and Indonesia. All the measurements and collection of specific data detailed in D8.1 by the UP Leaders required for each UP will be tested during these demonstration processes.

After all the indications from WP9 are collected after technological advancements, the surveys will be developed tailored to the acquired information and distributed to the stakeholders. The outputs expected from the results of the surveys include information on the accomplishment of the KPIs identified in each UP, for both user satisfaction and learning evaluation.

Once the pilot activities have been carried out, the impact assessment framework will be used to verify the KPIs, and to check if the UP performed as they were supposed to and how the UP users felt about using it. To reduce the influence that may rise from statistics it is important to carry out a lot of tests with different users in different scenarios. Doing so will allow to have results from the impact assessment framework that are as objective as possible.

The impact assessment framework will be used by the UP users once the activities have been carried out and will be linked to the scenario in which it has been tested. At this stage, the survey results will be collected, and KPIs will be analysed.

The collection of the UP users' feedback and responses will allow the enrichment of the framework, which will follow an iterative process of refinement by adding further elements necessary for a better evaluation of the demonstration activities.

The pilot activities and their evaluation will be carried out following the procedure shown below:

1. **Set up pilot activities and finalise impact assessment framework**. This phase will allow to determine the data that needs to be measured during the pilot demonstration to be able to properly assess the performance of the UPs. The impact assessment framework will be finalised by adding to the already existing KPIs and surveys a set of questions that will allow to identify the pilot demonstration scenario that they refer to (pilot test ID).
2. **Run pilot activities**. This phase matches with the pilot scenarios and will be carried during the lifetime of WP9 tasks, following the instructions provided by the organisation of the pilot activities and measuring the necessary data to be able to properly assess the results coming from the pilot activities.
3. **Carry out the surveys**. This phase will use the surveys included in the impact assessment framework to collect the feedback gathered by the participants to the training programmes and the users of the UPs.

4. **Verify KPIs**. This phase will use the KPIs included in the impact assessment framework and compare them with the performance achieved during the pilot activities by the SILVANUS platform and its component.
5. **Analise KPIs and survey results**. This phase will analyse the result of every UP, by verifying what KPIs have been reached by the UPs and which not, analysing the causes that may have caused the UP to fail reaching them. Additionally, the collected user satisfaction surveys will be analysed to understand the perception of the users about the UP as well as to write down their suggestions. Not the least, the learning evaluation surveys will be analysed to verify the impact that the training programmes of UP1 and UP8 had on the participants.
6. **Use the results**. The results coming from the previews phase will be sent to the UP leaders, this will allow them to check the main findings obtained during the pilot demonstrations and identify the features that performed as supposed and the ones that underperformed, as well as the most relevant feedback from the users/participants.
7. **Update of the UPs and the platform**. The UPs will be updated appropriately according to the results obtained during the demonstrations, by enhancing the functionalities that underperformed and including new features, previously identified (see tables in section 2.3) or suggested by the users in the user satisfaction surveys. Additionally, new UPs will be included in the platform.
8. **Repeat**. These procedures will be carried out a second time, by considering the new versions of the UPs that have been update, the new UPs added to the platform and the impact assessment framework updated to match these new components.

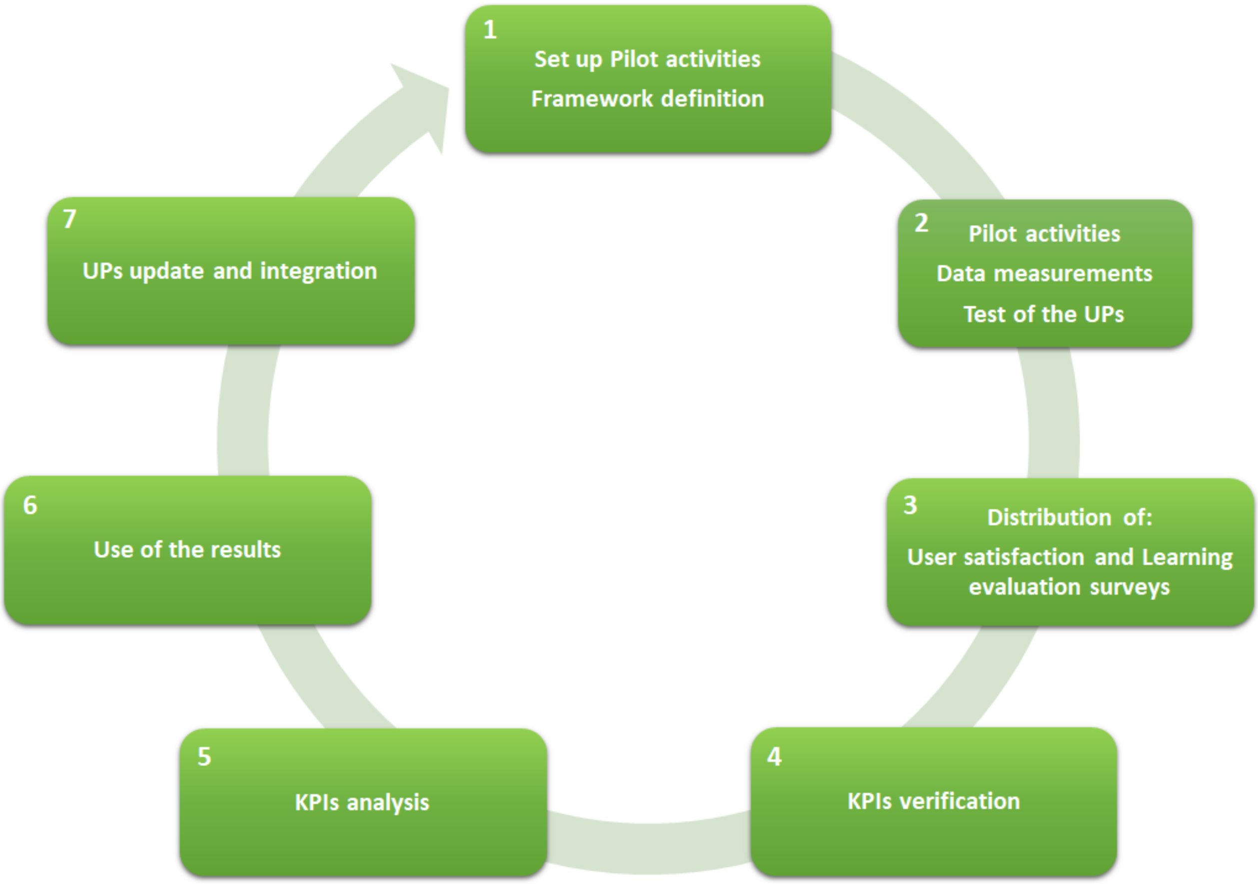

Figure 3: Iteration process of pilot activities and evaluation

4.2 Using the results from the assessment

The analysis of the result of the impact assessment framework can bring several outputs. First of all, by checking if the KPIs have been reached during the pilots or not, if not, further analysis can be made that will allow understanding what caused the underperformance of the tested UP. This will allow adjusting its features to be able to reach the targets in the next version of the platform. This may lead to an improvement of the components of the platform, increasing its overall performance, and making it able to better fulfil its scope.

The KPIs of a UP will be used to verify that the expected performance of the UP is achieved during the pilots and that enough data is gathered, comparing the results coming from pilot activities with the set KPIs. E.g., considering UP2:

- The first KPI is “number of pilots >=3”, in this case, the KPI assures that enough data is gathered during pilot activities and is achieved if UP2 is tested in at least 3 different pilot demonstrations.
- The second KPI is “sensitivity/recall > 85%”, in this case, the KPI will be compared with the performance of the UP in the pilot demonstrations. The sensitivity/recall achieved during all the pilot demonstrations will be compared with the set target. If the sensitivity/recall is higher than 85%, the UP will have performed as supposed to, if it’s lower, the UP will have underperformed.
- The third KPI is “specificity > 60%”, that works similarly to the second KPI. The specificity achieved during the pilot activities will be measured and compared with the target. If it is higher than 60%, the UP will have performed as supposed, if lower, the UP will have underperformed.

By analysing the performance of the UP in the pilots with the KPIs, it can be found out what UP are performing weakly and what are performing properly. In addition, if some KPIs are reached while other are not, it is possible to identify the features that are underperforming in the UP, and once identified they can be improved. It is highly possible that for some KPI there may not be a link with any feature of the UP, in this case, further analysis to understand why the UP failed to achieve the KPIs is needed. For this reason, it is necessary to gather basic information concerning where, when and by who the pilot activities are carried out. Acknowledging this factor can be a key factor to determine the cause that led to the UP to underperform and can be helpful to understand potential weak points that were not considered during the development stage. E.g., a UP may perform greatly during tests carried out during the day but be highly underperforming during night test, this can be discovered only by analysing the single cases and by knowing the conditions in which the pilot activities have been carried out.

The above-mentioned example may be used as well to make the following reflection. It is possible that a UP reaches all the set KPIs but still be underperforming in certain conditions (e.g., night pilot activities), this can be caused by a poorly decided number of KPIs, a poor number of tests, a poor number of test location and time or by a combination of these factors and eventually by statistic influence. For this reason, reports about pilot activities must be generated and analysed afterward to find if some conditions that may limit the UP exist.

On the other hand, by analysing the results from the surveys, other considerations can be made. The learning evaluation surveys of UP1 and UP8 can have a similar role as the KPIs for UP2 to UP7, providing feedback about the efficiency of the training programmes, for firefighters from UP1 and for the citizens from UP8. Based on the answers to the surveys from the users, the training programmes can be improved, increasing the efficiency of the programmes to reach their objectives. Analysing in detail all the answers to the surveys can help to determine the strengths and weaknesses of the training programmes, allowing to specifically target the identified weaknesses, increasing the quality of the UPs.

Analysing the user satisfaction surveys will be helpful to better understand how the experience of the users has been while using the UPs. This will be valuable to understand if the UI and UX design of the UPs can be further improved and how it can be achieved. Additionally, checking the suggestions left by the users in the surveys can be used to acknowledge what are the features that they would like to be added in the UP. Recognising what additional features are more requested and pairing them with a feasibility analysis, can lead to incorporating such features in the UP, increasing its value for the stakeholders, thus increasing its market appeal.

5 Conclusions and next steps

Deliverable 2.3 describes which factors have been considered to develop the first version of the impact assessment framework and what are the components that make it up. The **development** considered the UPs that are included in the MVP, as well as the EIs that are set by the Green Deal, and to which SILVANUS must contribute. The first version of the impact assessment framework is made of three different main **components**:

- KPIs for every UP, that must be reached during the pilot activities and measure its performance. At the time of the delivery of D2.3 all the KPIs are finalised for every UP.
- Learning evaluation survey for UP1 and UP8, that will be used to assess the efficiency of the training programmes delivered by the two UPs. As the training programmes have not been finalised at the time of the submission of D2.3, the learning evaluation surveys will be built once the programmes are ready and will be immediately added to the framework.
- User satisfaction survey for every UP, that will be used to evaluate the design of the UP and the feeling of the user while testing it and to gather suggestions on additional features to include in it. As the design of the interface of the UPs has not been defined at the time of the submission of D2.3, the user satisfaction survey will be completed once the interfaces are finalised and will be immediately added to the framework. At the time of delivery of D2.3 only a limited set of questions is available.

The first version of the impact assessment framework will be finalised once the UP interfaces and the training programme for UP1 and UP8 are ready, as well as the respective surveys. In addition, once the set-up of the first round of pilot scenarios is prepared, the framework will be completed by specifying the data that must be gathered to verify the KPIs and the data that must be collected to be able to properly carry out the surveys, e.g., location, date and time, user, number of the test, etc…

The results coming out from the assessment of the MVP during the pilot activities will be used to evaluate the performance of each UP included it, verifying that the expected performance and quality are achieved. The UPs will then be adjusted based on their evaluation, and an additional one will be included in the SILVANUS platform. At the same time, the impact assessment framework will be updated based to include the new versions of the UPs and the new UPs that will be included. New KPIs and questions to the surveys will be added as well, based on the feedback coming from the participants in the pilot demonstrations and from the developers of the UPs.

The SILVANUS project will eventually deliver an integrated platform, that will be made of several UPs that will be working jointly to help manage wildfires. It is then necessary to assess how the UPs interconnect with one another and work jointly to achieve the scope of the platform. To do so it is necessary to create cross-UP KPIs, specifically built to measure how the UP interconnects to reach a common objective. E.g., the different systems used to detect the ignition of a wildfire could be used jointly to further decrease detection time, in this case, a cross-UP KPI could be: "detection of any wildfire using all fire-detecting UPs to be lower than 6 hours". These KPIs will be helpful to determine how the overall platform is performing and not just its individual component and will eventually help to better address the Green Deal EIs.

The collaboration with Firelogue and the other IA projects, TREEADS and FIRE-RES, will continue to define a common impact assessment framework that will allow measuring the contribution that the three IA projects have towards reaching the EIs set by the Green Deal. The common impact assessment framework will be different from the SILVANUS individual one, as they have different objectives. The common one must measure the impact that the three IAs jointly have towards the reaching of the EI, while the SILVANUS one must verify that the SILVANUS platform is performing as designed being thus linked to the EIs indirectly. This is an important difference as it is required that the three IAs contribute to the EIs **jointly**, meaning that an IA project may contribute more to reaching certain EIs while another project may contribute more to other EIs, what is crucial is that the contribution of the project jointly targets all the EIs. In addition, as these impacts refers to the EU level it will be needed to consider the market spread of the projects to estimate the adoption of their solution in Europe.

Table 31: Overview of the activities carried out during the submission period of D2.3 and next steps.

Activity	Status
SILVANUS impact assessment framework	
Analysis of SILVANUS' User Products include in the MVP and of the Expected Impacts set by the call for proposal.	Completed.
Identification of the contribution that the UPs can bring to the different EIs, allowing to indirectly demonstrate that the UP can contribute to the EI.	Completed.
Identification of a set of KPIs for each UPs to evaluate the performance of UPs during pilot trials.	Completed.
Creation of learning evaluation survey to assess the efficiency of the training programs that are developed as part of UP1 and UP8.	A first draft has been developed; full version will be released once the training programs are finalised.
Creation of a user satisfaction survey for each UP that will be used to evaluate the experience of the users while operating the UPs in the pilot activities.	A first draft has been developed; full version will be released once the Interface of all the UPs are finalised.
Sharing the Impact assessment framework to T9.6 leader. The framework should be used by T9.6 to create the methodology to evaluate the performance of the UPs in pilot trials.	Partially completed, the set of KPIs has been sent while the questionnaires will be sent upon finalisation.
Identification of the contribution that the new UPs (that will be released in the second version of the platform) can bring to the different EIs.	Will be carried out during the second reporting period, as soon as the new UPs will be decided.
Identification of a new set of KPIs for the UPs included in the MVP, based on the feedback obtained from the pilot trials. Identification of a set of KPI and creation of user evaluation survey for the new UPs.	Will be carried out during the second reporting period.
Release of a final report on SILVANUS formal assessment methodology (D2.5) that will be shared with T9.6 to be used in the second round of pilot activities.	Will be carried out during the second reporting period.
Shared impact assessment framework (cooperation with Firelogue, TREEADS, Fire-res)	
Joint analysis of the EI	Completed
Creation of a common baseline (built on the average yearly value considering the data related to the period 2010-2019) as a starting ground to evaluate the contribution of the projects to the EI. SILVANUS collected data from its pilot sites, and additionally pilot region/country if available, and share it with Firelogue.	Partially completed. Some type of data has been already collected and sent, while some other will be collected during the next reporting period.

Share SILVANUS' (i) technologies, (ii) data format requirements (iii) pilot sites, (iv) stakeholders involved in the pilots, and (v) impact assessment methodology and criteria, with Firelogue (which will aggregate the responses from all the IAs).	Completed.
Creation of a common impact assessment framework to evaluate the contribution to the EI, adapted to the duration of the projects and providing the ground to continue the monitoring of the EI in the upcoming years.	Will be completed during the next reporting periods.

Appendix

User satisfaction surveys

UP3: Fire detection based on social sensing

1) Is the warning you receive for a possible fire-related incident clear?				
1. Very unclear ☐	2. Unclear ☐	3. Neither clear nor unclear ☐	4. Clear ☐	5. Very clear ☐
2) Is the warning useful to your operation?				
1. Very useless ☐	2. Useless ☐	3. Neither useful nor useless ☐	4. Useful ☐	5. Very useful ☐
3) Is it easy to link the warning to a real incident?				
1. Very hard ☐	2. Hard ☐	3. Neither easy nor hard ☐	4. Easy ☐	5. Very easy ☐
4) Are the provided analytics clear?				
1. Very unclear ☐	2. Unclear ☐	3. Neither clear nor unclear ☐	4. Clear ☐	5. Very clear ☐
5) Are the provided analytics useful?				
1. Very useless ☐	2. Useless ☐	3. Neither useful nor useless ☐	4. Useful ☐	5. Very useful ☐
6) What did you expect from UP3 but you didn't find?				
7) Do you have any recommendations to improve the product?				

UP4: Fire detection from IoT devices

1) Are the warning linked to fire incidents?				
1. Clearly not linked ☐	2. Not linked ☐	3. Neither linked nor not linked ☐	4. Linked ☐	5. Clearly linked ☐
2) Do you improve your performance and work efficiency by leveraging fire detection alarms?				
1. Most time use-less ☐	2. Useless ☐	3. Neither useful nor not useful ☐	4. Useful ☐	5. Most times useful ☐
3) Is the prediction rate of the fire incident warning helping you distinguish between false alarms and real detected incidents?				
1. Very useless ☐	2. Useless ☐	3. Neither useful nor useless ☐	4. Useful ☐	5. Very useful ☐
4) Are warning depicted clearly?				
1. Cannot spot any fire event ☐	2. Most of the times cannot spot the event ☐	3. Cannot say ☐	4. Can spot the events most of the times but not all of them ☐	5. Most times clear warnings ☐
5) Do you have issues spotting the fire events?				
1. Cannot spot any fire event ☐	2. Most of the times cannot spot the event ☐	3. Cannot say ☐	4. Can spot the events most of the times but not all of them ☐	5. Most times clear warnings ☐
6) What did you expect from UP4 but you didn't find?				
7) Do you have any recommendations to improve the product?				

UP5: Fire detection from UAV/UGV

UAV

1) Is it useful to have photos or videos from the reported site of a fire?				
1. Very useless ☐	2. Useless ☐	3. Neither useful nor useless ☐	4. Useful ☐	5. Very useful ☐
2) Are the GPS coordinates from the site of a fire a sufficient information?				
1. Not sufficient at all ☐	2. Not sufficient ☐	3. Neither sufficient nor not sufficient ☐	4. Sufficient ☐	5. Very sufficient ☐
3) Is the resolution of the images/videos of the fire sufficient?				
1. Not sufficient at all ☐	2. Not sufficient ☐	3. Neither sufficient nor not sufficient ☐	4. Sufficient ☐	5. Very sufficient ☐
4) Is the image transfer speed from the UAV to the platform sufficient?				
1. Not sufficient at all ☐	2. Not sufficient ☐	3. Neither sufficient nor not sufficient ☐	4. Sufficient ☐	5. Very sufficient ☐
5) What did you expect from UP5 (UAV) but you didn't find?				
6) Do you have any recommendations to improve the product?				

UP6: Fire spread forecast

1) How easy to understand did you found the iteration layer of the fire spread forecasting?				
1. Not easy at all ☐	2. Not easy ☐	3. Neither easy nor not easy ☐	4. Easy ☐	5. Very easy ☐
2) How satisfied are you with the presentation of the result?				
1. Not satisfied at all ☐	2. Not satisfied ☐	3. Neither satisfied nor not satisfied ☐	4. Satisfied ☐	5. Very satisfied ☐
3) How easily recognizable is the burnt area?				
1. Not easily at all ☐	2. Not easily ☐	3. Neither easily nor not easily ☐	4. Easily ☐	5. Very easily ☐
4) How satisfied were you with the processing time of the fire spread model?				
1. Not satisfied at all ☐	2. Not satisfied ☐	3. Neither satisfied nor not satisfied ☐	4. Satisfied ☐	5. Very satisfied ☐
5) How easily did you find the fire spread model to start?				
1. Not easy at all ☐	2. Not easy ☐	3. Neither easy nor not easy ☐	4. Easy ☐	5. Very easy ☐
6) How easy was it to insert the input data to the fire spread model?				
1. Not easy at all ☐	2. Not easy ☐	3. Neither easy nor not easy ☐	4. Easy ☐	5. Very easy ☐
7) What did you expect from UP6 but you didn't find?				
8) Do you have any recommendations to improve the product?				

UP8: Citizen’s engagement programme and mobile apps

Citizen engagement app survey questions

<table>
<tr><td colspan="5">1) It was easy to install and set up the mobile application.</td></tr>
<tr><td>1. Strongly disa-gree
☐</td><td>2. Disagree
☐</td><td>3. Neither agree nor disagree
☐</td><td>4. Agree
☐</td><td>5. Strongly agree
☐</td></tr>
<tr><td colspan="5">2) The app feels fast and responsive.</td></tr>
<tr><td>1. Strongly disa-gree
☐</td><td>2. Disagree
☐</td><td>3. Neither agree nor disagree
☐</td><td>4. Agree
☐</td><td>5. Strongly agree
☐</td></tr>
<tr><td colspan="5">3) It is easy to navigate through the app and find the features that I need.</td></tr>
<tr><td>1. Strongly disa-gree
☐</td><td>2. Disagree
☐</td><td>3. Neither agree nor disagree
☐</td><td>4. Agree
☐</td><td>5. Strongly agree
☐</td></tr>
<tr><td colspan="5">4) The app feels cohesive throughout its different pages.</td></tr>
<tr><td>1. Strongly disa-gree
☐</td><td>2. Disagree
☐</td><td>3. Neither agree nor disagree
☐</td><td>4. Agree
☐</td><td>5. Strongly agree
☐</td></tr>
<tr><td colspan="5">5) The app has all the features that I expected it to have.</td></tr>
<tr><td>1. Strongly disa-gree
☐</td><td>2. Disagree
☐</td><td>3. Neither agree nor disagree
☐</td><td>4. Agree
☐</td><td>5. Strongly agree
☐</td></tr>
<tr><td colspan="5">6) The push notification system is helpful to me.</td></tr>
<tr><td>1. Strongly disa-gree
☐</td><td>2. Disagree
☐</td><td>3. Neither agree nor disagree
☐</td><td>4. Agree
☐</td><td>5. Strongly agree
☐</td></tr>
<tr><td colspan="5">7) The push notification system does not provide irrelevant or unsolicited content.</td></tr>
<tr><td>1. Strongly disa-gree
☐</td><td>2. Disagree
☐</td><td>3. Neither agree nor disagree
☐</td><td>4. Agree
☐</td><td>5. Strongly agree
☐</td></tr>
<tr><td colspan="5">8) I am comfortable with the number of notifications coming from the app.</td></tr>
<tr><td>1. Strongly disa-gree
☐</td><td>2. Disagree
☐</td><td>3. Neither agree nor disagree
☐</td><td>4. Agree
☐</td><td>5. Strongly agree
☐</td></tr>
</table>

9) The app provided me with information & guidelines that were previously unknown to me.				
1. Strongly disa-gree ☐	2. Disagree ☐	3. Neither agree nor disagree ☐	4. Agree ☐	5. Strongly agree ☐
10) The content displayed is useful & easy to understand.				
1. Strongly disa-gree ☐	2. Disagree ☐	3. Neither agree nor disagree ☐	4. Agree ☐	5. Strongly agree ☐
11) I feel like the app helped/made me more qualified to help in a real-life scenario.				
1. Strongly disa-gree ☐	2. Disagree ☐	3. Neither agree nor disagree ☐	4. Agree ☐	5. Strongly agree ☐
12) The app has improved my knowledge regarding forest fires prevention.				
1. Strongly disa-gree ☐	2. Disagree ☐	3. Neither agree nor disagree ☐	4. Agree ☐	5. Strongly agree ☐
13) I only use the app during the fire season.				
1. Strongly disa-gree ☐	2. Disagree ☐	3. Neither agree nor disagree ☐	4. Agree ☐	5. Strongly agree ☐
14) The feature that I am interested in are the ones regarding:				
A. Prevention & Preparedness				
B. Detection & Response				
C. Forest restoration				

UP8: Citizen's engagement programme and mobile apps

Survey questions about the citizen engagement programme in general

1) I have heard about the SILVANUS project.				
1. Strongly disagree ☐	2. Disagree ☐	3. Neither agree nor disagree ☐	4. Agree ☐	5. Strongly agree ☐
2) I know what the project is about.				
1. Strongly disagree ☐	2. Disagree ☐	3. Neither agree nor disagree ☐	4. Agree ☐	5. Strongly agree ☐
3) I have come in contact with the project in some form or shape (e.g., via social media, different events, mobile apps, campaigns, mass media, etc…).				
1. Strongly disagree ☐	2. Disagree ☐	3. Neither agree nor disagree ☐	4. Agree ☐	5. Strongly agree ☐
4) The project, through its different activities and outcomes, has helped me learn more about fire risk and how to help prevent wildfires.				
1. Strongly disagree ☐	2. Disagree ☐	3. Neither agree nor disagree ☐	4. Agree ☐	5. Strongly agree ☐
5) The project, through its different activities and outcomes has helped me learn more about how to act, and steps to take in case of wildfires.				
1. Strongly disagree ☐	2. Disagree ☐	3. Neither agree nor disagree ☐	4. Agree ☐	5. Strongly agree ☐
6) The project, through its different activities and outcomes has helped me learn more about how to help restore an area that has been affected by wildfires.				
1. Strongly disagree ☐	2. Disagree ☐	3. Neither agree nor disagree ☐	4. Agree ☐	5. Strongly agree ☐
7) The project, through its different activities and outcomes has helped me to become more aware of the causes of wildfire and I have therefore changed the way I act or think in order to reduce risks for wildfire.				
1. Strongly disagree ☐	2. Disagree ☐	3. Neither agree nor disagree ☐	4. Agree ☐	5. Strongly agree ☐

Annex: Relationship between biodiversity and forest fire

In the literature, the word forest has been described to represent an area that has many trees. Across the world forest regions have been classified into three categories: temperate, tropical, and boreal. Experts estimate that these forests cover approximately one-third of Earth's surface. Each of the forest region is characterised by the relevant climate and environmental conditions. For instance, temperate forests are found across eastern North America and Eurasia. The temperatures of temperate forests vary throughout the year because of the four distinct seasons at these latitudes. Precipitation is abundant and lends to fertile soil that is able to support diverse flora like maples, oak, and birch. Deer, squirrels, and bears are just a few examples of the fauna that call temperate forests home. Every forest area has its own biodiversity composition which influences the ecological resilience in facing the disturbance. Biodiversity or biological diversity represents the different types of species, genetic, and ecosystem diversity in an area, sometimes including associated abiotic components such us landscape features, drainage systems, and climate [1]. Every area has its own biodiversity, which is consist of living biotic component and the other abiotic component such as environment and climate that support the living. Pressures constantly threaten the sustainability of biodiversity. Certain compositions of biodiversity elements will create an amount of resilience that will support a forest and faster its recovery.

Biodiversity consists of biotic (species, genetic, and ecosystem diversity) [2, 1, 3, 4] and abiotic component (landscape features, drainage systems, and climate) of ecosystems. Biodiversity defines as a forest ecosystem consisting of composition, structure, and function [2, 5]. Noss et. al [2] defines the indicator variable of biodiversity at four organization levels (regional landscape, community-ecosystem, population-species, and genetic). Every organization consists of several indicators grouped into composition, structure, and function. Composition refers to the vegetation and animal species in the ecosystem. In some literature the term species richness [3, 6, 7] has been adopted. In other documentation, the term species distribution [8, 9] has been adopted. In both cases, there is a common agreement among the community to use the term structure that points to the spatial array of diverse ecosystem components, such as tree structure or tree spacing, and function refers to all kinds of ecological processes. The protection of forests against extreme weather events and climate conditions leads to programs that develop ecological resilience.

The term Ecological resilience has been used to refer to systematic impact of animals, trees, the environment, and community based mutual activities. The more those variables effortlessly return to the initial condition (to the pre-industrialisation levels in an ideal scenario), the higher the resilience index they have [10, 11]. Ecological resilience processes have also been identified to assist in improving the quality of biodiversity to sustain itself with short- and long-term stress. However, the adoption of ecological resilience practice within the forest management policies have resulted in many concerns. The first concern is the tree. Tree indicator of resilience is forest structure. Forest structure consists of tree density [3, 5, 12], stand density [13], Diameter at Breast Height (DBH) [12, 14], tree population [15], tree age [3], and tree height [3, 5, 14]. Other indicators are tree mortality [16], non-tree vegetation [15], forest ecosystem type [14, 17]. Fernández-Guisuraga et al., 2021 [18] mentioned leaf model and canopy model as indicator affecting the forest landscape management. The second concern is the environment. The environment indicators are soils [19]. Other indicators are Topographic, Wind speed, Snow load, Lightning, and Anthropogenic [14]. The third is animals. Indicator in an animal is about animal population [15]. The other literature does not mention it, but it implies a biodiversity indicator [19]. The fourth is communities. Relating indicators to communities are forest related social ecological system [14], the level of infrastructure development, GDP /km2 of land, the value of ecosystem service functions, and community resource [21]. As a complex and living ecosystem, forests are subjected to extreme pressures to maintain sufficient balance to maintain ecological resilience due to external extreme weather and climate events.

One of the methodologies that has been adopted by the forest landscape management community is the use of tree density metric, which measures the number of trees per unit area to evaluate and build ecological resilience and sustain biodiversity. The quantification of tree density measure can be obtained from the computation of canopy cover. In the literature, several authors have proposed the computation of canopy cover to be generated using satellite imagery [22]. It has been empirically observed that tree density generally increases with temperature (mean annual temperature and temperature seasonality) and moisture availability (precipitation regimes, evapotranspiration, or aridity). In complementary to the tree density, tree population refers to the number of trees in each area. Forest management can consider tree population, such as encouraging sustainable land management by planting large trees to increase tree population numbers. Increasing tree population numbers affects the sustainable forest. By modelling the information of tree assets present in the forest, the landscape owners and managers can build a better insight into the need for the development of ecological resilience programme, which includes introducing higher resilient trees (from Mediterranean region) into the European forests. Additional improvements could include creating enough space or gap between the trees that are being planted in the post-restoration period to minimize the spread of wildfire.

The tree density and population parameters affect the fire-resistant quality of the forests. This is due to the fact, that when properly cared for, a fire-resistant tree will not ignite as quickly or burn with as much intensity as other vegetation. Characteristics of Fire-Resistant Trees[15]:

- High water content in bark and leaves.
- Annually sheds leaves in winter (Deciduous).
- Thick and large leaves.
- Produces less wax, resin, or oil.
- The sap is thinner or water-like and does not smell strongly.

There are several tree species that exhibit such characteristics, but it is important to recognize that those trees which are fire resistant can still be damaged or killed by a wildfire, but their bark and foliage burn slower and can reduce the speed at which a fire grows. The following list of tree species have been identified to offer higher resistance to the fire spread:

- The Coast Live Oak is an evergreen tree native to California. This Oak species has thick dark green leaves. It produces flowers in the spring and acorns in the fall. They require plenty of room to fully mature and can reach 20ft – 70ft in height and width.
- The Mountain Ash is a deciduous tree with dark green leaves that can grow up to 12 inches long. The Mountain Ash tree grows slowly up to 20ft – 30ft tall and 15ft – 20ft wide. They grow best in full sun to lightly shaded areas and require low to medium amounts of water.
- Beech trees have glossy dark green leaves that change to a bronze colour and produce edible beechnuts in the fall time. It is an ornamental tree that is also great for providing shade. The Beech tree requires low to medium amounts of water and is slow growing. They can get up to 50ft – 70ft tall and spread 35ft – 40ft wide
- The Chinese Pistache tree is an ornamental favorite in many urban areas. It features lustrous dark green leaves that turn a beautiful bright red and orange color. The Chinese pistache tree can grow 25ft –35ft

[15] https://www.vintagetreecare.com/fire-resistant-trees-to-create-a-defensible-space

tall and spread 25ft – 35ft when fully matured. They require low-watering and full sun exposure, making them very drought and heat tolerant.

- The Mediterranean cypress is not fireproof[16], but it may be as close as a tree can get. Researchers have found in a lab that the Mediterranean cypress can withstand fire conditions for up to seven times as long as other trees before it ignites. This is largely due to the tree's thick, scale-like leaves. They retain water extremely well and keep the Mediterranean cypress moist when other plants and trees would have already dried out. Their fallen leaves retain water too, forming a closely packed carpet on the floor of the forest, a bit like a sponge.

Additionally, some tree species have been identified to be prevalent across specific regions of the world which are briefly summarized below.

- In Australia, fire-resistant trees include:
    - Salt River gum (Eucalyptus sargentii)
    - Lilly Pilly (Syzygium smithii or Acmena smithii)
    - Silver Banksia (Banksia marginata)
    - Coastal Wattle (Acacia cyclops)
    - Swamp Sheoak (Casuarina obesa)
- In California, trees planted to resist forest fires might include:
    - Coast live oak (Quercus agrifolia)
    - Blue oak (Quercus douglasii)
    - Vine maple (Acer circinatum)
    - Desert-willow (Chilopsis linearis)
    - Western redbud (Cercis occidentalis)
    - Pacific wax myrtle (Myrica californica)
    - Fruit trees in general are often thought to be fire-resistant, and orchards are sometimes used by firefighting crews as natural firebreaks.
    - Golden rain tree (Koelreuteria paniculata)
    - Gingko (Gingko biloba)
    - Various species of ash (Fraxinus spp.)

The following trees are more commonly seen across the world forests offering higher resistance to fire spread.

- Oak (Quercus spp.)
- Mulberry, specifically White mulberry (Morus alba)
- Chestnut (Castanea spp.)
- Olive (Olea spp.)
- Elderberry (Sambucus spp.)
- Chinese pistache (Pistacia chinensis)
- Carob (Ceratonia siliqua)
- Citrus, including lemon and orange (Citrus spp.)
- Loquat (Eriobotrya japonica)
- Macadamia (Macadamia integrifolia)

[16] https://treevitalize.com/fire-resistant-tree-species/

- Sycamore (Plantanus spp.)
- Walnut (Juglans spp.)
- Poplar (Populus spp.)
- Big leaf maple (Acer macrophyllum)
- Alder (Alnus spp.)
- Beech (Fagus sylvatica)
- Strawberry tree (Arbutus unedo)
- Bay Laurel (Laurus nobilis)
- Magnolia, although possibly not all varieties (Magnolia spp.)
- Fruit trees in general — apple, pear, stone fruit, etc.,

Generally, it is observed that trees with leaves (deciduous) do not burn nearly as fast or as intense as trees with needles (coniferous). Coniferous trees have a large amount of sap in their branches[17]. This sap burns very quickly and supports fast-moving wildfires. These types of trees also tend to grow much closer together than deciduous trees. Being more tightly packed makes it easier for fire to burn effortlessly through an area of coniferous forest by simply moving from treetop to treetop. Over time, dead branches and needles accumulate on the forest floor. This debris can provide fuel for wildfires. Since many coniferous trees have low-lying branches, wildfires can easily move from the forest floor to the forest canopy. Evergreen species like lodgepole pine, black spruce, white spruce, and balsam fir burn anywhere from five to 10 times faster than other species of leafy trees.

Fire behaves differently in different forest cover types. Deciduous stands often act as natural fuel breaks. In the boreal forest, crown fires typically drop to the ground when they enter an aspen stand. Fire spread is dependent on the amount and type of understory plants and shrubs. Because of the usual absence of ladder fuels in deciduous stands, fire does not get carried to the high crowns of these trees. The physical properties of aspen also resist intense fire behavior, high crown base height, higher moisture content of the leaves and stems, and tight, smooth bark. In coniferous stands, the rough, loose bark can act as a ladder allowing fire to climb into the canopy. It can also produce embers that are carried ahead of the fire front.

[17] https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/formain15744/$FILE/tree-species-impact-wildfire-aug03-2012.pdf

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