# D10.5 – Report on forest landscape management services

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**List of acronyms and abbreviations**

| ACRONYM | Description |
|---|---|
| AI | Artificial Intelligence |
| AG | Augmented Reality |
| CAGR | Compound annual growth rate |
| CCTV | Closed circuit television |
| DL | Deep learning |
| EEA | Euroepna Environment Agency |
| EERC | European Emergency Response Capacity |
| EFFIS | European Forest Fire Information System |
| EFI | Euroean Forest Institute |
| ESG | Environmental, Social, and Governance |
| ETS | Emissions Trading System |
| EU | European Union |
| FAC | Food and Agriculture Organization |
| FSC | Forest Stewardship Council |
| GDPR | General Data Protection Regulation |
| GIS | Geographic Information Systems |
| IFM | Integrated Fire Management |
| IPRs | Intellectual Property Rights |
| IoT | Internet of Things |
| JRC | Joint Research Centre |
| LiDAR | Light Detection and Ranging |
| ML | Machine Learning |
| MVP | Minimum Viable Product |
| NDCs | Nationally Determined Contributions |
| NGOs | Non-Governmental Organisations |
| PEFC | Programme for the Endorsement of Forest Certification |
| PESTEL | Political, Economic, Social, Technological, Environmental, and Legal |
| RAR | Resource allocation of response teams |
| R&D | Research & development |
| R&I | Research & Innovation |
| SAL | Storage Abstraction Layer |
| SDGs | Sustainable Development Goals |
| SME | Small and Medium-sized Enterprises |
| SWOT | Strengths, Weaknesses, Opportunities and Threats |
| TRL | Technology Readiness Level |
| UAV | Unmanned Aerial Vehicle |
| UGV | Unmanned Ground Vehicle |

| ACRONYM | Description |
|---|---|
| UP | User Product |
| UX /UI | User Experience / User Interface |
| VR | Virtual Reality |
| WP | Work Package |
| WUI | Wildland-Urban Interface |

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**Executive Summary**

The deliverable focuses on providing an extensive market analysis, aiming to understand the ecosystem in which the solutions are working, validate their value, and compare with other offerings allowing learnings and evaluating risks to ensure targeted stakeholders have their problem areas covered. It provides an overview of the global situation, trends and players that may influence and affect the outcomes of SILVANUS.

It delves into a detailed stakeholder analysis, identifying and understanding the varied needs and expectations of different user groups to tailor solutions effectively. The analysis also includes a key competitor benchmarking exercise, highlighting SILVANUS's strengths and areas for improvement compared to existing solutions, thereby underscoring its competitive advantages.

Furthermore, the SWOT analysis evaluates the project's internal strengths and weaknesses while identifying external opportunities and threats. This is complemented by a PESTEL analysis that examines the macro-environmental factors impacting the market, including political, economic, social, technological, environmental, and legal aspects. Additionally, insights into current market trends and future outlooks are provided, forecasting the evolution of wildfire management technologies, and identifying potential growth opportunities for SILVANUS.

The key findings indicate a significant and growing market demand for advanced wildfire management solutions, driven by the increasing incidence and severity of wildfires. SILVANUS distinguishes itself through its integrated approach and the breadth of its technological offerings, positioning it strongly within the competitive landscape. The project's strengths lie in leveraging cutting-edge technology and a comprehensive approach, with identified opportunities for collaboration and regional expansion. However, potential challenges include the complexities of technological integration and competition from established solutions, which can be mitigated through strategic partnerships and continuous innovation.

Strategic recommendations emphasize the importance of stakeholder engagement, continuous improvement of technological capabilities, and forming strategic partnerships to enhance market penetration and scalability. By aligning with the European Union's goals of enhancing environmental protection, promoting sustainable development, and increasing resilience against natural disasters, SILVANUS contributes significantly to the EU's objectives of reducing disaster risk, protecting ecosystems, and ensuring the safety and well-being of its citizens.

# 1 Introduction

Wildfires represent a significant threat to ecosystems, human lives, and property. With the increasing frequency and intensity of these events due to climate change and its interactions with land use changes, there is a pressing need for advanced solutions to manage and mitigate wildfire risks effectively. The SILVANUS project is focused on delivering innovative technological solutions for wildfire management across three main phases: **Prevention and Preparedness (Phase A)**, **Detection and Response (Phase B)**, and **Restoration and Adaptation (Phase C)**. These phases are supported by various User Products (UPs) that address the needs of stakeholders across different stages of wildfire management.

- **Phase A (Prevention and Preparedness)** includes tools such as Augmented Reality (AR) and Virtual Reality (VR) training for firefighters, fire danger assessment, and citizen engagement mobile apps to raise awareness. These tools enhance readiness and prevention capabilities through advanced simulations and community involvement.
- **Phase B (Detection and Response)** features sophisticated technologies like AI-based fire spread forecast, fire detection systems that integrate data from social sensing, IoT devices, drones (UAVs), and ground robots (UGVs). These technologies optimize the early detection of fires and improve response coordination, including resource allocation and evacuation planning.
- **Phase C (Restoration and Adaptation)** focuses on long-term recovery after wildfires. It includes decision support systems that calculate biodiversity, ecological resilience, and soil erosion indices. These tools help determine the best strategies for restoring affected ecosystems and adapting to future fire risks.

Each phase integrates cutting-edge technology such as deep learning, multispectral video processing, and wireless communication systems to create a comprehensive platform for wildfire management.

SILVANUS project integrates a key approach known as the **Integrated Fire Management (IFM)** that promotes the use of fire in different phases of the cycle of disaster management. This hub combines environmental data, advanced technologies, and decision-making tools to support wildfire management and sustainable forest restoration. The IFM provides a centralized hub for integrating different technologies such as sensors, drones, and IoT devices. These are crucial for monitoring forest conditions, early fire detection, and assessing post-fire restoration needs. It also incorporates big data analytics and AI-driven models to generate actionable insights for stakeholders, ranging from firefighters to environmental planners.

The SILVANUS platform incorporates cutting-edge technologies and innovative approaches to create a comprehensive wildfire management system. Key features or solutions analyzed include tools and developments related to AI based fire solutions, UGV and UAV, fire prediction assets, fire spread forecast, Multilingual Forest Fire Alert System, Biodiversity index, and citizen apps, among many others.

This deliverable aims to provide a comprehensive market overview and analysis of the SILVANUS project, highlighting its potential impact and value proposition. The document includes a detailed stakeholder analysis to identify and understand the needs and expectations of various user groups. Additionally, key competitor analysis will benchmark SILVANUS against existing solutions, identifying strengths and areas for improvement. The SWOT analysis will further dissect the project's internal strengths and weaknesses, as well as external opportunities and threats.

Moreover, a PESTEL analysis will examine the macro-environmental factors affecting the market, encompassing Political, Economic, Social, Technological, Environmental, and Legal aspects. Finally, the document will offer insights into current market trends and provide an outlook, forecasting the evolution of wildfire management technologies and identifying potential growth opportunities for SILVANUS.

By leveraging an integrated approach and state-of-the-art technologies, the SILVANUS project stands poised to revolutionize wildfire risk management, delivering enhanced safety, efficiency, and resilience for all stakeholders involved.

### 1.1 Background and objectives

Regarding exploitation purposes, previous insights were delivered, first in deliverable D10.2 Annual Report on SILVANUS Dissemination Activities v1 (M12) where the initial exploitation plan was drawn, accompanied by the provision of the first templates to collect partners' contributions on individual exploitation of their project results, and the based for IPR agreements.

The D10.3 Annual report on SILVANUS dissemination activities v2 (M24) represented the next milestone on exploitation activities, jointly with dissemination. In mentioned deliverable D10.3, the first exploitation items were identified and classified based on their commercialization purposes, and their maturity level (TRL). On top of this, the first contributions on individual exploitation plans are reported as well as a first look into the IPR situation, considering joint exploitation strategy. Here, the base for the market analysis was delivered, considering the general SWOT already provided in the proposal stage.

This deliverable D10.5 Report on forest landscape management services represents a third pillar of exploitation activities, jointly with deliverable D10.4 Annual report on SILVANUS dissemination activities v3, both from M36, complementing individual and joint exploitation plans as well as market analysis respectively.

### 1.2 Structure of the document

The document is structured into seven main sections divided like this:

1. Introduction: The current chapter provides the general idea of the deliverable, its objectives and relations.
2. Market overview: Provides information on the wildfire management ecosystem based on research and previous knowledge.
3. Demand side: An analysis of the internal side of the offering, which investigates the stakeholders and their segmentation.
4. Offering side: Considers the competitor framework and analyzes differences and advantages compared with SILVANUS solutions.
5. Strategic market analysis: Includes SWOT analysis of each SILVANUS component as well as a general PESTEL analysis.
6. Market trends: Forecasts and trends of the market.
7. Conclusions: General conclusions for the deliverable and positive learnings.

### 1.3 Relation with other WP/Tasks

The D10.5 is related to D10.2 and D10.3 as mentioned in this chapter, but also has dependencies with the D10.4 due to the shared or common subjects on exploitation, and market strategy.

This deliverable has also reviewed and monitored the results of WP9 as it works around pilot demonstrations, which involved different User products. This deliverable also supports its inputs, with information from WP7 deliverables, which gather relevant insights about stakeholders. This helps to keep consistency among all work packages of the project. but also take inputs from WP7 because of their inputs from stakeholders.

## 2 Market Overview

### 2.1 Global Fire Protection, Suppression and Forest Land Management Market

In order to summarize the fire prevention and protection services market, one should elaborate on the types of products that are currently available. Within the **global fire protection system market**, the following table shows the market segments by type, product, service and end-user (one should note these include fire systems included in buildings, referring to structural fires), as defined by Data Bridge (2023)

| Type | Product | Service | End-user |
|---|---|---|---|
| Active Fire Protection System | Fire Detection | Installation and Design | Commercial |
| Passive Fire Protection System | Fire Sprinkler System | Engineering | Residential |
| Passive Fire Protection Area | Fire Response | Management | Energy and Power |
| | Fire Analysis | Maintenance | Government |
| | | | Manufacturing |
| | | | Oil, Gas and Mining |
| | | | Transportation and Logistics |

**Table 1 Fire Protection Market Segments (Bridge, 2023)**

The active fire protection system refers to the dormant system that needs to be activated in the case of a fire to perform its function, such as water spray systems, deluge systems, sprinkler systems, fire water monitors, and steam rings around flanges. The passive protection systems are related to the features of the construction itself, such as evacuation procedures, compartmentalization, smoke extraction, fire-resistant doors and floors, etc. (Wang, 2022)

The global fire protection, suppression, and sustainable forest landscape management services market is experiencing a significant increase. In 2022, the global fire protection system market was valued at USD 69.66 billion in 2022 (approx. EUR 64 million) and is expected to reach USD 128.24 million (approximately EUR 117.17 million) by 2030, registering a compound annual growth rate (CAGR) of 7.98% during the forecast period of 2023-2030 (Bridge, 2023)

According to a market research study published by Verified Market Reports (2024), **forest land management market** size is expected to develop revenue and exponential market growth at a remarkable CAGR during the forecast period from 2024–2030. This is due to the rise in interest and regulation on managing forests in a sustainable manner, maintaining ecological integrity and social advantages. The market for forest land management includes a wide range of products and services. These could involve managing invasive species, managing forests, reducing the danger of wildfires, monitoring and inventorying forests, restoring ecosystems, managing silviculture, managing wildlife habitats, and promoting community involvement. To improve management results and support decision-making, it also entails the implementation of cutting-edge technology like Geographic Information Systems (GIS), remote sensing, and predictive modelling (Reports, 2024).

The forest land management market is witnessing dynamic shifts in response to increasing environmental concerns and sustainability goals. With a growing focus on carbon sequestration, biodiversity conservation, protection of water bodies, and ecosystem restoration, stakeholders are adopting innovative technologies

and practices. Furthermore, the rise of digital solutions and collaborative approaches is reshaping how forests are managed and utilized worldwide (Reports, 2024).

The market is also taking into account “precision forestry”, made possible by the advancement of technological products such as drones and LiDAR systems. Machine learning can facilitate and evaluate big-data sources and information to forecast fire risk. Forest growth, restoration and resource allocation can therefore be optimised through better decision on the basis of more reliable data.

Forests are also becoming more valuable as carbon sinks in climate change mitigation and adaptation and can generate new revenue streams through carbon credits, while improving biodiversity if well-managed. Certification programmes for sustainability and carbon sequestration such as the Forest Stewardship Council (FSC) are becoming more popular and prominent. (FSC, 2020)

As innovation and advancement of technology are progressing and changing forest management methods, automation is becoming more prevalent, not only in harvesting, energy and construction industry, but also in the fact that demand growth in forest management has been bolstered by deforestation, wildfire, and other human-induced activities.

The major factor for forest land management growth is therefore environmental, as there is an increasing urge to preserve forests and maintain or increase biodiversity. Forests are also important to protect as they provide ecosystem services such as provision of food and biomass (timber) and acting as a buffer against extreme weather and climate change. As climate change can cause prolonged heat waves and extended droughts, increasing the accumulation of excessive fuel loads, there is a higher risk of permanent and large-scale damage to forests due to extreme wildfire events (Reports, 2024).

Furthermore, growing concerns regarding the impact of deforestation and forest loss due to wildfires on global climate change is expected to drive the market growth as governments are introducing various policies to promote sustainable forest management practices. In addition, the increasing investments by governments and private organizations in the forest land management sector is expected to drive the market growth. The increasing demand for forest land management services in emerging economies such as India, China and Brazil are expected to boost the growth of the market (Reports, 2024).

As wildfire management is an essential tool in forest maintenance and sustainability, the technological innovation and products offered by SILVANUS project have a market potential, where the key exploitable results may have a significant impact that will have an influence not only on the fire prevention market alone, but on overall forest and building maintenance markets.

### 2.2 European Fire Prevention and Management market

According to the study “Europe Fire Protection Market Size, Share & Industry Trends Analysis Report by Offering, by Application (Commercial, Industrial and Residential), by Country and Growth Forecast 2023-2030)”, in 2017, the 28 Member States of the European Union (EU) spent €31,2 billion on "fire protection services," and in 2017 and 2018, nearly 300,000 firefighters were employed in the EU.

Through the technological development, such as the advancement in wireless sensor networks and the growing adoption of wireless fire-sensing devices, the market is expected to grow further. The Europe Fire Protection System Market would witness market growth of 6.1% CAGR during the forecast period (2023-2030).

The Germany market dominated the Europe Fire Protection System Market by Country in 2022 and would continue to be a dominant market till 2030; thereby, achieving a market value of $7,800.3 million by 2030.

The UK market is anticipated to grow at a CAGR of 5.2% during (2023 - 2030). Additionally, The France market would register a CAGR of 6.9% during (2023 - 2030). (Research K. , 2024)

Since the fire protection and the forest management markets are booming with new technological developments, in the midst of EU-based policies that are supporting sustainable forest and wildfire management, there is an established market potential for key exploitable results of the SILVANUS platform.

### 2.3 Key Market Drivers and Restraints

Demand for wireless connected safety systems, advancement in technologies & demand for residential fire safety are the growth drivers of the fire protection system market. Key market drivers in forest land management market are timber industry, increasing urbanisation and infrastructure, and environment-driven factors such as the threat of deforestation and extreme wildfire events (Reports, 2024)). Other drivers that should be mentioned are sustainable forest management and certification.

In 2022, the fire detection segment held the highest revenue share in the fire protection system market. The fire detection segment comprises several equipment that works collectively to detect fires, smoke, carbon monoxide, and other crises and to alert people using audio and video appliances.

The major factor for forest land management growth is therefore environmental, as there is an increasing urge to preserve forests and maintain or increase biodiversity. Forests are also important to protect as they provide ecological services such as provision of food and fuel and acting as a buffer against extreme weather and climate change. As climate change can cause prolonged heat waves and extended droughts, increasing the accumulation of excessive fuel loads, there is a higher risk of permanent and large-scale damage to forests due to extreme wildfire events.

Limited availability of capital and resources, along with unstable market trends, high operational costs and environmental degradation of forests, can serve as key market restraints in the forest land management market.

Through the development of the SILVANUS platform and the identification of key exploitable results, the platform components can utilize the trends of key market drivers, along with the recognition of restraints, to find and establish their position of the fire prevention, protection, and forest land management market.

# 3 Demand side analysis

## 3.1 Market Segmentation

Our approach at segmenting the SILVANUS market follows a systematic process to categorize the potential customers into distinct groups based on their shared characteristics.[1] We have mostly leveraged secondary data sources such as industry reports, market studies, and databases to identify broad market trends and potential segments. Under this frame, the SILVANUS market is segmented into two primary dimensions: the type of organization (of the customers) and the geographical area where our fire prevention and management solutions would be most effectively deployed. Initially, we segmented potential customers based on their organizational type, differentiating between private companies and public organizations. For private companies, we further segmented them by their operational scope, recognizing the distinct needs and challenges faced by SMEs compared to large enterprises. In the public sector, we focused on municipal bodies, regional authorities, national emergency services, and forestry departments, each of which plays an important role in fire management. The second dimension of our market segmentation targeted the geographical areas within the EU where our fire management solutions would have the highest potential for effective deployment. We conducted a regional analysis, evaluating factors such as fire incidence rates, regional climate conditions, and geographical terrain. By doing so, we were able to determine regions where our solutions would be most needed and could be better adopted. This mostly includes (among others) southern European countries with high wildfire incidence, such as Spain, Portugal, Greece, and Italy, as well as regions with advanced technological infrastructures capable of supporting innovative fire management solutions This allows the project to tailor its results to meet the requirements and operational frameworks of each customer segment, enabling higher impact. (ACCA, 2018) The exploitable results of SILVANUS could be also marketized in regions outside the EU, and especially in areas in Australia, Brazil and Indonesia, where the SILVANUS innovations have already been tested.

### *3.1.1 By Geographic Region*

The geographical segmentation of the SILVANUS market reveals diverse needs and opportunities across various regions in the European Union. Using as a starting point the project's pilot cases, each site presents unique characteristics and requirements for fire management solutions. With that in mind, to effectively classify the areas involved in the SILVANUS project, we can categorize them based on their key characteristics. This classification focuses on factors such as the type of ecosystem, the nature of fire risks, and the specific needs for fire management technologies. Below is a classification based on these characteristics.

#### *3.1.1.1 Analysis of Market Segmentation for SILVANUS Pilot Areas*

The project involves a range of pilot demonstrations across various geographical and environmental contexts. Each site presents unique challenges and opportunities for advanced fire management technologies, as presented in the Table 2: Geographical Segmentation of the SILVANUS Pilot Areas

[1] https://www.qualtrics.com/en-au/experience-management/brand/customer-segmentation/

**Table 2: Geographical Segmentation of the SILVANUS Pilot Areas**

| Category | Area | Key Characteristics | Specific Needs |
|---|---|---|---|
| **Urban and Industrial Risk Areas** | France | Industrial area near forests; high risk of industrial accidents | Integration with industrial response; advanced mapping |
| **Protected Natural Areas** | Italy | National Park with high biodiversity | Conservation-friendly fire management |
| | Romania | Biosphere reserve with high biodiversity | Biodiversity preservation and fire monitoring |
| | Croatia | Nature Park with diverse ecosystems | Training and simulation tools for varied terrains |
| **Rural and Agricultural Areas** | Greece | High frequency of forest fires; agricultural impact | Agricultural fire management; regional integration |
| | Portugal | Agriculture and forestry; infrastructure risks | Rural and iInfrastructure fire management |
| | Slovakia | Rural, economically disadvantaged area | Forest restoration and rural development |
| **Climate and weather-related risk areas** | Czech Republic | Tourist destination; weather-related emergencies | Fire risk management in tourist areas |

#### *3.1.1.2 Expansion to an EU-level Geographical Segmentation*

The EU market for fire prevention and management technologies can be segmented based on the distinct needs and characteristics of different regions, as illustrated by the SILVANUS pilot sites. These segments include:

- **Industrial and urban risk areas,**
- **Protected natural areas,**
- **Rural and agricultural areas,**
- **High-density and diverse terrain areas,** and
- **Climate and weather-related risk areas.**

Fire patterns in Europe have evolved significantly over the past two decades. Major fire seasons have occurred in 2003, 2007, 2012, 2017, and 2022, burning between 700,000 and 1.2 million hectares annually[2]. This increase in wildfire frequency is driven by climate change, which exacerbates dry conditions, and land use changes due to rural depopulation and abandonment. The changing landscape, characterized by a resurgence of unmanaged land, has led to a higher vulnerability to fires, particularly in areas where land use has become less regulated and more susceptible to natural processes. (Gil, 2023)

[2] https://www.europeandatajournalism.eu/cp_data_news/depopulation-is-changing-the-fire-map-of-europe/

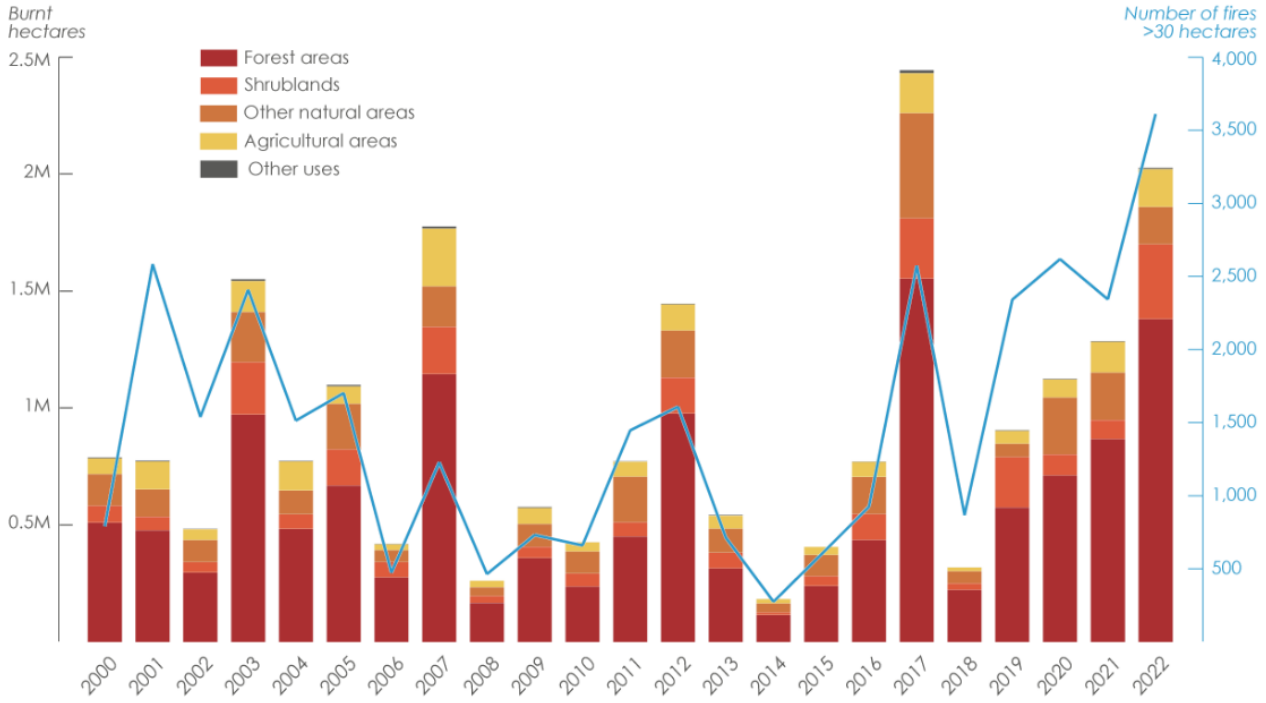


Figure 1 Evolution of Fires in Europe based on area's geographical characteristics **(Gil, 2023)**

In **industrial and urban areas,** for example Germany's Ruhr area, the fire safety equipment market is projected to grow due to stringent regulations and the need for advanced fire suppression systems. The integration of smart technologies in fire management systems is a notable trend, enhancing response times and overall safety. **Protected natural areas**, particularly in Sweden, Finland, and Spain, face significant wildfire risks. The forest wildfire detection system market in Europe is expected to grow significantly, with a projected market size of USD 247 million (almost one third of the global market) in 2023, growing at a CAGR of 6.3% by 2032. Enhanced satellite surveillance and early warning systems are becoming increasingly critical in these regions. (Analytica, 2024)

**Rural and agricultural areas,** such as Italy's Tuscany and the Po Valley, and Portugal's central and northern regions, face risks from agricultural practices and wildfires. The market for fire management technologies in agricultural areas is driven by the need for fire prevention systems. Investment in firebreaks and controlled burns is becoming more common to manage fire risks effectively. According to EFFIS data, in the EU, Greece saw approximately 174,773 hectares of land burned in 2023, with the damage costs estimated at over €1.8 billion. Italy ranked second, with around 97,382 hectares burned, incurring estimated costs of over €1 billion. Spain followed, with 88,444 hectares of land affected, and the damage costs were estimated to be approximately €913 million. (Meier, J.R. Elliott, & Strobl, 2023) An average wildfire season in Southern Europe could lead to yearly production loss of 13–21 billion euros. (Meier, J.R. Elliott, & Strobl, 2023)

Figure 2 Fires mainly in forest areas in the EU. (Gil, 2023)

**High-density and diverse terrain areas possess** complex landscapes. The use of drones and AI technologies for monitoring and early detection of fires is becoming prominent in these terrains. **Climate and weather-related risk areas** are increasingly facing extreme weather patterns that exacerbate fire risks. Therefore, there is a growing focus on developing adaptive fire management strategies that consider changing climate conditions.

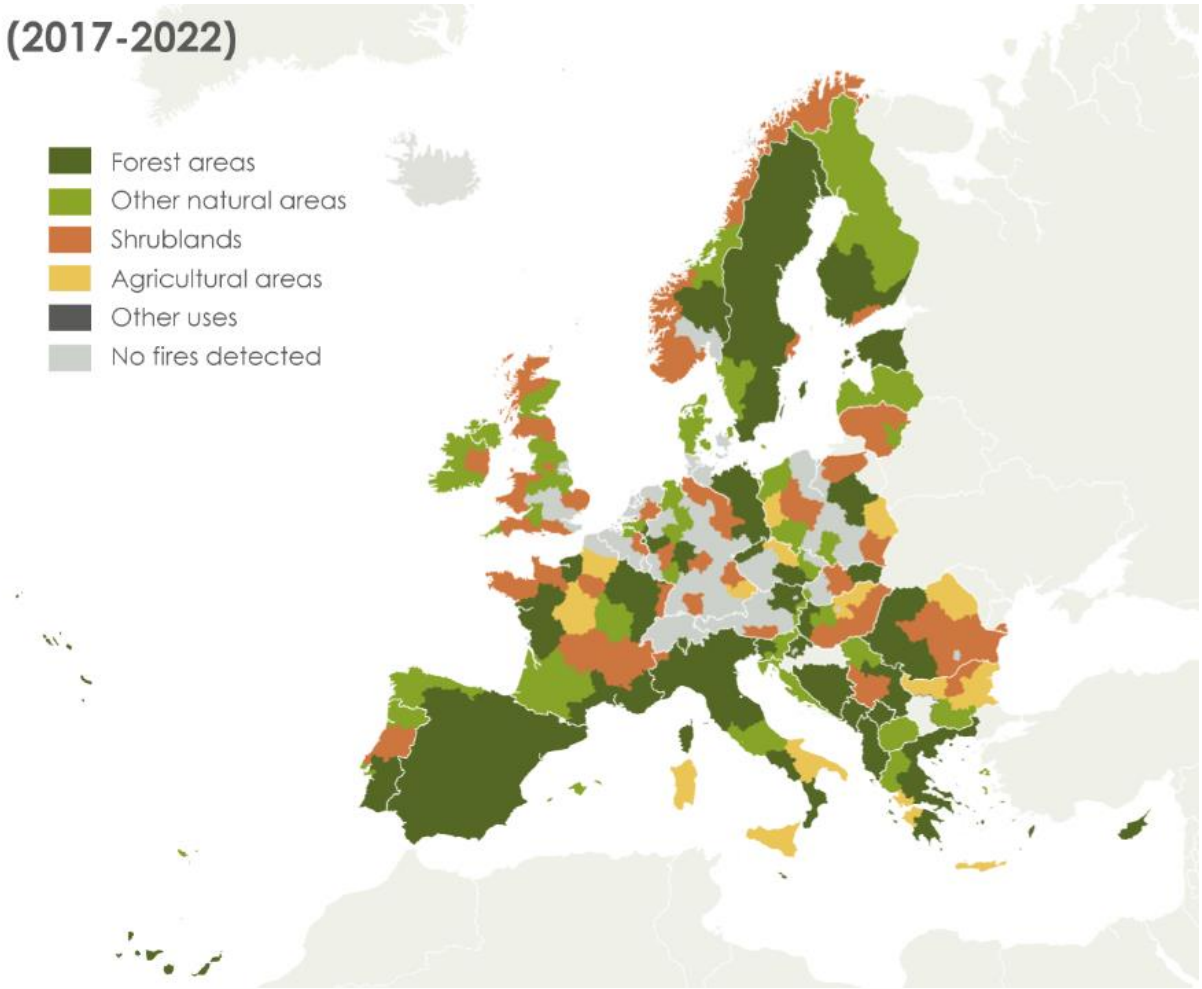

Figure 3 Most common burnt area in the EU for the period 2017-2022 (Gil, 2023)

Based on our analysis, and the geographical segmentation of the SILVANUS Market, we observe that different regions in Europe face varying fire risks based on their development status and land use changes. (Agency E. E., 2023) Therefore, instead of using a country-wise segmentation of our market, we focused on making a regional segmentation, respecting the geographical attributes and specific needs of each region. For instance, in Italy, a North-South divide reflects this concept, with the northern regions experiencing doubled burned areas in recent years, primarily affecting forests. In contrast, the central areas face fires in natural landscapes, while the southern regions, including mountainous areas like Campania and Calabria, see more agricultural fires (Agency E. E., 2023). This underscores the need for firefighting teams to adapt to new and evolving fire patterns in previously unfamiliar environments.

### *3.1.2 By Customer Type*

Focusing on the EU fire prevention and management market, we segment the market in three main types of potential customers, namely, organisations stemming from the public sector, the private/ commercial sector, and we also analyse potential use of the SILVANUS innovations by non-governmental organisations (NGOs). The eTable 3depicts the market segmentation of SILVANUS per customer type.

**Table 3: SILVANUS Market Segmentation per Customer Type**

| Sector | Categories | Subcategories |
|---|---|---|
| **Public Sector** | **Government Authorities** | Civil protection authorities, local authorities, municipalities, Civilian protection (Ministry), national/regional public authorities, forest governance authorities, national governments |
| | **Safety and Emergency Services** | Firefighters, , emergency organisations/volunteer teams, Law Enforcement Agencies (LEAs), , medical emergency sector |
| | **Forest and Wildlife Management** | Foresters/wildlife-forest conservation organisations, forest rangers, land Managers |
| | **Research and Policy** | Safety policy-makers, researchers, academia |
| **Private Sector** | **Forest owners** | Families, farms, rural commons, churches, and aristocratic estates, companies owning forests / Private Sector |
| | **Technology and Service Providers** | Technology providers, services providers in the spectrum of both large enterprises and SMEs |
| **Non-Governmental Organizations** | **NGOs and Community Services** | Non-Governmental Organisations (NGOs), Communities, Volunteer Teams, Volunteer firefighters |

One important aspect that needs to be considered when segmenting the market per customer type, is the ownerships status of the forests. This is because knowing the ownership status will enable us to better formulate selling strategies to potential customer segments (different selling models if we refer to private ownership compared to public ownership). EU forests are owned by approximately 16 million private and public entities. **About 60% of the forested areas in EU is privately owned, while 40% is public**. Forest

property sizes range from less than one hectare to several million hectares. Notably, almost 90% of private forest holdings are smaller than 10 hectares, many of which are much smaller. **Public forests are managed by municipalities, regional, or national governments. Private forests include various types of ownership, such as families, rural commons, churches, and forest industry companies**. Additionally, some forests are held in unique ownership forms, such as communal ownership by local citizens. (Weiss , Wolfslehner, & Zivojinovic , EFI)

Ownership patterns vary across Europe due to historical, legal, and social factors. For example, around 70% of forests in Northern Europe are privately owned, whereas about 90% in Southeast Europe are public. Western Europe predominantly features private ownership, while Eastern Europe has more public ownership. The extent of property rights and freedom in forest management also differs, with Western Europe offering more freedom and Eastern Europe imposing more legal restrictions.

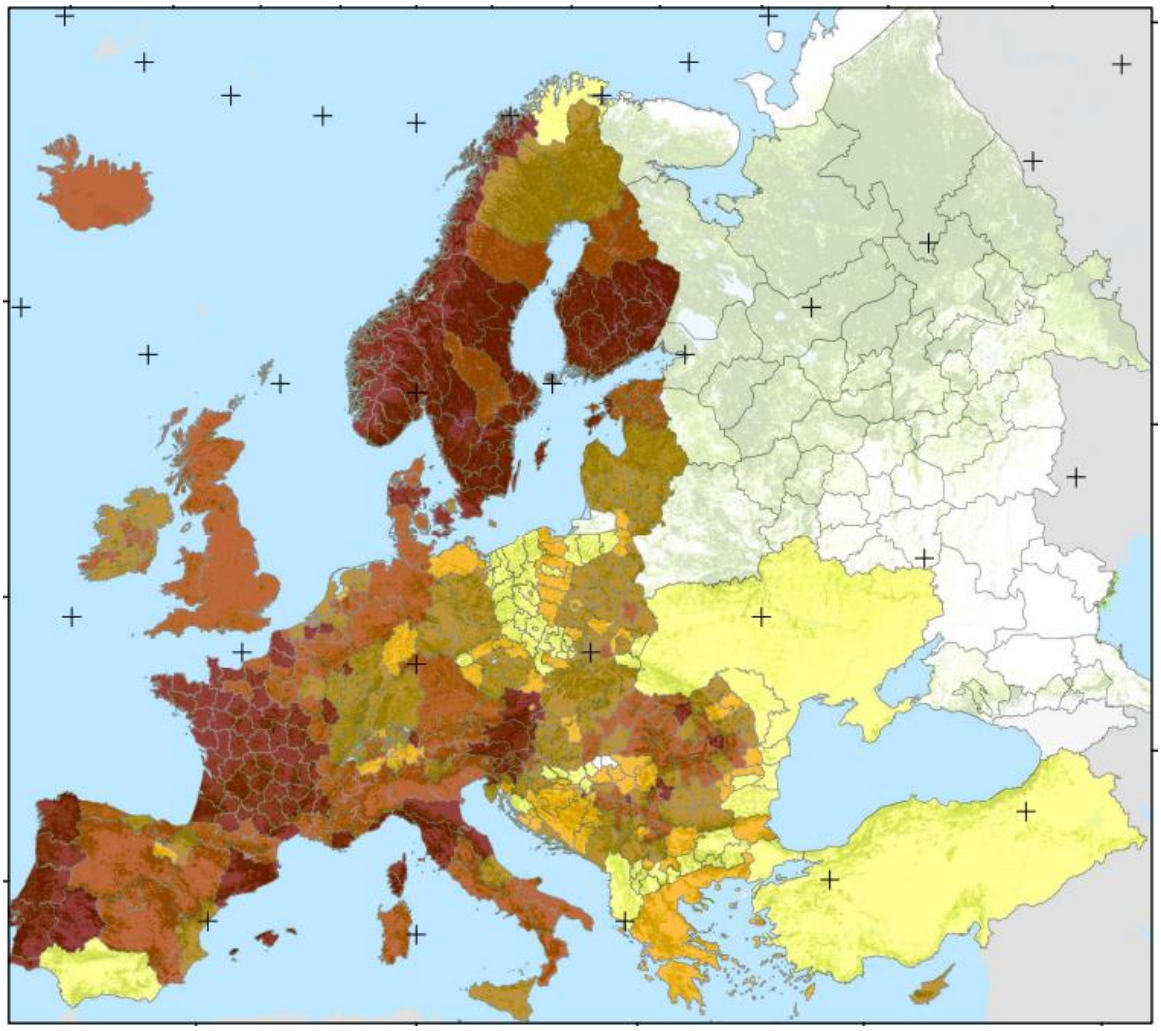

Figure 4 Distribution of private and public ownership across Europe (Weiss, Wolfslehner, & Zivojinovic, EFI)

*3.1.2.1 Market segment of the public sector organisations*

For the public sector, we identified four primary categories:

- **Government authorities** (which include local, regional, and national government bodies, safety and security governance agencies - ministries, and forest governance authorities).

- **Emergency services** (which involves first responders like firefighters, fire brigades, mountain rescue teams, law enforcement agencies, fire departments, who require robust, real-time solutions).
- **Forest and wildlife management and conservation bodies,** (such as foresters, conservation organizations, forest fire management bodies, forest rangers, and land managers, who focus on proactive fire prevention and sustainable land management) and;
- **Research and policy organisations** that target safety policymakers, researchers, and academia, essential for advancing fire management knowledge and shaping future policies.

**Government authorities**

These authorities need real-time data, predictive analytics, and strategic planning tools to prevent and manage forest fires effectively. They also need solutions that ensure compliance with national and international environmental regulations. The European Union has been proactive in wildfire management. For instance, the EU Civil Protection Mechanism has been instrumental in coordinating responses to natural disasters, including forest fires.

**Safety and emergency services**

Firefighting services in the EU are well-organized, with countries like Germany and France having some of the largest and most advanced fire services. The EU also has specialized firefighting units, such as the European Emergency Response Capacity (EERC), which includes resources for cross-border assistance. The European Forest Fire Information System (EFFIS) reports that fire departments across the EU respond to tens of thousands of forests' fires each year, highlighting the critical need for effective firefighting solutions. They need tools for rapid detection, situational awareness, resource allocation, and coordination during fire incidents. Technologies like UAVs (drones), thermal imaging, real-time communication systems, and predictive modelling are critical for these services. Moreover, there is a significant demand for advanced firefighting equipment, training programs, and integrated communication systems.

**Forest and wildlife management and conservation bodies**

The EU is home to some of the world's most extensive forested areas, with countries like Finland, Sweden, and Germany having significant forest cover. According to Eurostat, the EU has around 182 million hectares of forests, which account for 43% of its land area. (eurostat, 2019). Thus, forest and wildlife management bodies need tools for monitoring forest health, assessing fire risks, planning management actions, such as thinning or controlled burns, and managing biodiversity. Advanced technologies like satellite monitoring, AI-based risk assessment, and ecosystem modelling are essential for these bodies.

**Research and policy organizations**

Europe has a strong network of research institutions and policy think tanks focused on environmental and wildfire research. Organizations such as the European Forest Institute (EFI), the Joint Research Centre (JRC), and various universities are at the forefront of wildfire research. The European Environment Agency (EEA) provides valuable data and policy recommendations on forest fire management. According to EFFIS, research and policy efforts have significantly contributed to reducing the number and severity of forest fires in recent years through improved understanding and management practices. The EU has funded over 60 research projects on fire management (more than €100 million), highlighting the sector's significance in addressing wildfire risks. (Agency E. R., 2024) (European Commission)

#### *3.1.2.2 Market segment of the private sector organisations*

We segment the SILVANUS market of the private sector organisations in two dimensions, namely:

- **Forest owners (in case of private ownership)** who require/ demand solutions for fire management and monitoring, as well as forest owners and associations.
- **Technology and service providers/ Businesses (large and SMEs)**.

**Forest owners** in the European Union face significant risks from wildfires, necessitating the development of robust risk management strategies and the adoption of advanced technologies to enhance resilience. The European Forest area is increasingly vulnerable to wildfires due to climate change and land-use changes. Therefore, forest owners require solutions that integrate early detection systems, such as satellite-based monitoring and ground sensors, with predictive tools that use AI to model fire behaviour and spread.

**Technology and service providers** develop and implement innovative solutions for wildfire management. Technology providers, including companies developing hardware and software solutions for wildfire detection, monitoring, and management, need to create scalable, reliable, and cost-effective products that meet the specific needs of various stakeholders involved in wildfire management. These include real-time sensors, AI-driven predictive analytics, and advanced communication systems that enhance situational awareness and decision-making capabilities. Service providers (organisations who offer consultancy, maintenance, and operational support) need to ensure that their services are tailored to the dynamic needs of wildfire management, including rapid deployment, training, and ongoing support.

#### *3.1.2.3 Market segment of the non-governmental organisations*

NGOs, particularly those focused on environmental conservation, disaster response, and community development are important in wildfire management and mitigation. Their profile includes organizations that operate at local, national, and international levels, leveraging their expertise, resources, and networks to address the multifaceted challenges posed by wildfires. Key needs for NGOs in this sector include access to accurate and timely data on wildfire risks, funding for their projects and initiatives, and robust partnerships with other stakeholders to enhance their impact and reach.

## 3.2 Stakeholder's analysis

On previous deliverables reported within the WP10 activities, a stakeholder analysis was conducted based on the SILVANUS framework. The D10.1 Dissemination and Community Engagement Strategy detailed the relevant target groups, including research organizations, forest associations, and policymakers, and provided a brief description for each. The analysis also categorized the stakeholders based on their interests and degree of influence, analyzing how to engage with them.

The D10.3 Annual Report on SILVANUS Dissemination Activities v2 followed the mentioned stakeholder's analysis providing the number of stakeholders per previously identified types (figure 94 SILVANUS External Stakeholders Divided by Target Groups on said deliverable), identifying if they had a strong or weak relationship towards SILVANUS main areas of interest and so, supported how to effectively engage with each of them.

In this report, the stakeholder analysis is complemented by focusing on the target groups of each UP concretely, analyzing how they are relevant to the components/solutions, and how to focus on go-to-market strategies. As previous deliverables mentioned, the D10.5 showcases the list of stakeholders found, highlighting the most common types of users. This list of stakeholders comes from the learnings from the previous deliverable D10.3 but takes its main insight from the results of the exploitation workshop done

during the face-to-face GA meeting in Italy (April 2024) where results from SWOT and Business Model Canvas analysis took place.

Figure 5 Stakeholders from User Products

As the Figure 5 Stakeholders from User Products shows, the most recurrent group of stakeholders involved in UP activities are emergency agencies (fire depart., firefighters org., policy force - first responders), followed by Local or public authorities (including government as Ministry, Municipalities), meaning that communication and engaging activities as well as the channels used to connect with the users must adapt to their needs. In most cases, various strategies have already been implemented or are ongoing activities focused on achieving a wider community interested in the SILVANUS component's benefits and efficiency.

Considering the different stakeholders involved, two identified groups can be mentioned:

- **Internal Stakeholders:** Project team members, EU funding bodies, and research institutions.

- **External Stakeholders:** Local communities, government agencies, environmental organizations, technology partners, end-users (e.g., forest managers, and policymakers), and civil protection agencies, among others.

As the next step, the stakeholders are categorized, ensuring their importance level is known towards the different components within SILVANUS.

The categorization proposed is as follows:

- **Core stakeholders:** Most interested parties towards SILVANUS components (e.g., firefighters)
- **Key Stakeholders:** Directly involved or influenced by the project (e.g., local and national authorities).
- **Primary Stakeholders:** They are important and have been engaged in different dynamics throughout the course of the project. (e.g., civil end users, environmentalists)
- **Secondary Stakeholders:** Indirectly involved or affected (e.g., media, industry).

To highlight the division of the different stakeholders an onion diagram is displayed (Figure 6). An onion diagram visually represents the different layers of stakeholders based on their relationship and proximity to the project, highlighting those who are directly involved, those who have significant influence, and those who are indirectly impacted. As the circles get wider, the distance from the center of the diagram is bigger meaning that the players in the largest circle are secondary stakeholders, while the core ones are in the smallest circle.


Figure 6 Stakeholders onion diagram

# 4 Offering side analysis: Competitor benchmarking

## 4.1 Overview of key competitors' analysis and methodology

The competitor analysis of SILVANUS focused on the User Products (UPs), which are the project's main assets, and utilized two major research techniques. The first technique evaluated a general competitor framework using a common set of variables applicable to all UPs competitors. The second technique assessed how each competitor differed from SILVANUS components by considering variables related to the key features of each User Product.

Initial inputs were derived from exploitation fiches provided by consortium partners. This information was supplemented by desk research into each UP's description and benefits to identify additional competitors in their respective fields. Once the competitors were identified, nine variables were used to compare each UP to similar solutions. These variables analyzed the scope of SILVANUS across different topics, which will be detailed in the next section.

On average, four competitors were analyzed per User Product. Some UPs had few or no competitors, while others operated in highly competitive environments. The competitors were primarily based in Europe and from the United States, but solutions and companies from America and Asia were also considered. To analyse the different competitors, their websites, papers about them, and social media channels were searched for a better understanding of each solution and company.

All the competitors that have been analysed are reported in Annex 8.1.2 along with a reference to their website.

## 4.2 Comparison framework for SILVANUS' User Products competition

The competitor analysis based on different variables pretends to understand how the market behaves in comparison with SILVANUS' assets and based on this, where there can be opportunities or threats and how the different User Products can stand out from the other solutions. Next, the different variables chosen for the comparison are described:

1. **Forest management practices:** Analyse how the competitors manage forest conservation, through different strategies and techniques. This can include sustainable logging, reforestation efforts, and adherence to best practices for maintaining forest health and biodiversity.

2. **Environmental impact:** Assesses the effect of the company's products/solutions on the environment, including carbon footprint, pollution, and overall sustainability.

3. **Innovation and technology:** Measures the level of innovation and the use of advanced technologies in the company's operations. This includes the adoption of new tools for forest monitoring, data analysis, and the implementation of cutting-edge solutions for forest management.

4. **Certification and compliance:** Evaluate which are the certifications and compliance data that can be found on each competitor on the website and how they manage regulations and standards, which may also be related to their dissemination channels.

5. **Features variety /accuracy:** Evaluate what characteristics each solution offers and the variety of their portfolio, to cover stakeholder's needs.

6. **Stakeholder engagement:** Assesses how well the company interacts with and involves its stakeholders, including local communities, customers, partners, and regulatory bodies. Engage activities in social media and events were considered.

7. **Analytics/database:** The quality and scope of the analytics and database capabilities provided by the company. This includes the depth of data collection, the sophistication of analysis tools, and the accessibility of the information to users.

8. **Competitive pricing:** The prices established by a company on their services and products are manageable by users and offer a good balance between content and its quality. It may be provided in packaged solutions, as open sources, or in other revenue streams.

9. **Friendly UX/UI /website:** user experience and interface design of the company's website and digital tools. This includes the ease of navigation, aesthetic appeal, responsiveness, and overall user-friendliness, ensuring that users can efficiently access and utilize the company's offerings.

A table (reported in Annex 8.1.1) was created for each User Product's competitors. The competitors are listed in the left-hand column, while the nine variables are displayed across the top. At the end of the table, the total score of these variables is provided to indicate the overall relevance of each competitor.

The figure below illustrates a generic example of the analysis table. The variables were scored from 1 (lower score) to 3 (higher score), representing the level of importance of each competitor concerning the variable. To visually represent this, three different types of circles are used: a full solid circle indicates a score of 3, a half-filled circle indicates a score of 2, and an empty circle indicates a score of 1. In the cases where the variable does not apply to a specific competitor, a circle with XXX in the middle is shown. This may appear in the Annex section. [3]

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| Competitor 1 | ○ | ○ | ◐ | ○ | ◐ | ● | ● | ● | High | **16** |
| Competitor 2 | ○ | ○ | ● | ○ | ● | ● | ◐ | ● | N/A | **17** |
| Competitor 3 | ◐ | ● | ● | ● | ○ | ● | ● | ◐ | Low | **20** |

**Figure 7 Generic comparison table of Ups competitors based on 9 variables**

Next, each of the UP competitors is analyzed based on the variables mentioned with a general conclusion at the end of the subsection. The different figures, representing the comparison framework can be found in the Annex 8.1.

**UP1: AR/VR training toolkit for trainers**: The highest total score among the competitors is 19, achieved by 4Experience, WE/AR Studio, and Delta Reality. These competitors exhibit strong performance across most variables, indicating comprehensive solutions and a clear "good practice" path for UP1. The lowest scores

3

are held by Crystal Apps and Scotty, with totals of 10 and 11 respectively, showing areas where they lack strengths.

About the pricing strategy, there's a mix of low-cost plans, medium plans, and some with no data on pricing. Free trial plans (WE/AR Studio) could be an attractive offering for users exploring options.

This is the User Product with more competitors in its ecosystem so is important to analyse where this asset can exceed. **UP1: AR/VR training toolkit for trainers** can focus on innovation, environmental impact, comprehensive feature sets, and strong stakeholder engagement to stand out. Is important to maintain a high UX-friendly experience since competitors are stronger on this point.

**UP2a: Fire ignition models:** UP2a demonstrates a strong competitive position across multiple dimensions. While exhibiting comparable performance to other solutions, a focused effort is required to surpass Wildfire analyst pocket in terms of feature breadth, accuracy, and analytical depth. Opportunities exist to enhance stakeholder engagement and alignment with industry benchmarks. While competitors may fall short in these areas, UP2a can differentiate itself by addressing these gaps.

Leveraging the SILVANUS project can broaden UP2a's reach and technological relevance. Coupled with a competitive pricing strategy, this presents substantial growth potential.

**UP2b: Fire danger index:** While competitor scores are modest, the UP2 component offers limited room for significant improvement. To differentiate itself, the Fire Danger Index should prioritize innovation, environmental impact, comprehensive features, and robust stakeholder engagement. Particular focus should be placed on forest management, a highly competitive area and in providing differentiation on the pricing strategy since most of similar solutions don't apply, since offer their solution for free.

Additionally, the Fire Danger Index can learn from established players like EFFIS, known for its strong core functionalities.

**UP3: Fire detection based on social sensing:** To position SILVANUS UP3 as a leading solution in the market for fire detection based on social sensing, it is essential to emphasize several strengths and address key areas for improvement. The component should harness the latest technology, real-time data analysis, and machine learning to improve fire detection. It's essential to minimize the environmental impact by using sustainable methods. Building a strong feature set with diverse data sources and customizable detection options will solidify its market position. A user-friendly and engaging interface is key to a great user experience.

To enhance trust and credibility, SILVANUS UP3 should meet industry standards and obtain relevant certifications. Improving communication and collaboration tools will foster stronger relationships with stakeholders. Offering flexible pricing options, like memberships or tiered plans, will appeal to a wider customer base.

**UP4a: Fire detection from IoT devices:** Based on competitors UP4a's main focus can be on elevating its innovative capabilities, especially in fire detection technology, to keep pace with leading competitors like OPGAL and Piperaris. Developing AI-driven fire prediction systems and integrating Internet of Things (IoT) solutions could position UP4a at the top. The environmental impact is another crucial area where UP4a can distinguish itself from AVIOTEC and Early Fire Detection, who score lower in this domain.

A differentiated pricing strategy could also be a key competitive advantage. Many competitors, such as Piperaris, offer robust solutions but lack cost-effectiveness. Flexible pricing models (subscription options based on framework customization) can broaden the UP4a market, particularly in regions where funding for fire detection systems is limited. Stakeholder engagement is another area of focus. Building strong

relationships with forest management authorities and local communities will not only boost the credibility of the solution but also ensure its adoption in key areas. Competitors like Novo Technologies have demonstrated the importance of collaboration.

Simplifying the user experience, particularly in remote and rural forest areas, can give an edge over competitors like Novo Technologies and AA Alarm. By making its solution intuitive and easy to deploy, Fire detection from IoT device components is already ensuring a broader adoption and positioning as the go-to fire detection system for diverse environments.

**UP4b: Fire detection at the edge - from UAV data:** To establish UP4b as a top solution in fire detection at the edge using UAV data, it is crucial to harness advanced technology and innovative approaches, such as real-time data processing and machine learning, to enhance detection capabilities. By leveraging energy-efficient UAVs and eco-friendly data processing methods, SILVANUS UP4b can distinguish itself through its strong commitment to environmental sustainability. Additionally, a comprehensive and precise feature set, including high-resolution imaging and customizable alert systems, will ensure it meets or exceeds competitor offerings. Emphasizing a user-friendly interface that simplifies operations for diverse user groups will further enhance its appeal.

By continually monitoring advancements in UAV technology and adjusting strategies to incorporate cutting-edge innovations, UP4b can maintain its competitive edge and deliver unparalleled fire detection solutions.

**UP5a: UGV monitoring of wildfire behaviour:** For SILVANUS UP5a: UGV Monitoring of Wildfire Behaviour, the market landscape is competitive with advanced players like DeepRobotics (X30) and Shark Robotics excelling in innovation, technology, and feature accuracy. Given this competitive environment, reaching users and stakeholders effectively will be crucial. Moreover, emphasizing the breadth and precision of features will be key. Ensuring comprehensive functionality, such as high-resolution imaging, precise detection algorithms, and customizable alert systems, will align SILVANUS UP5a with or surpass the capabilities of top competitors.

Interaction between state-of-the-art technological resources (UAV-UGV) to demonstrate and depict the area efficiently and accurately is one of its value proposition statements. Additionally, a focus on environmental sustainability, leveraging eco-friendly UGVs and data processing methods, can set SILVANUS UP5a apart by aligning with global sustainability goals. Not much information on pricing strategy to analyse.

**UP6: Fire spread forecast – modelling:** The UP owner identified two main competitors and the other three were searched and analyzed. One of them is BehavePlus, which is also a competitor for the UP2a Fire Danger index. Is important to understand the correlation between the two components and possibly address similar strategies when analyzing the market.

It has strong competitors such as Intterra but also similar improved solutions since are based on a mathematical model of fire behaviour; like BehavePLus and FlamMap with FARSITE. Moreover, focusing on improving its TRL (Technology Readiness Level) to provide more realistic scenarios for end users will further solidify its market position and appeal.

**UP7: Biodiversity profile mobile application:** The Woode App of Silvanus excels in various aspects compared to its competitors, particularly in environmental impact, innovation and technology, and stakeholder engagement. Its superior environmental impact is evident as it has been designed with sustainability in mind, aligning with the need for eco-friendly solutions. The integration of advanced technologies in UP7 facilitates more accurate and reliable identification of plant species, an area where some competitors like LeafSnap and iNaturalist also perform well but not as comprehensively. Furthermore, UP7 stands out in stakeholder engagement, ensuring a collaborative approach that enhances the app's

credibility and user involvement. This aspect is somewhat lacking in competitors like Google Lens and TreeID, where engagement strategies are less pronounced.

However, there are areas where UP7 can improve. Notably, the variety and accuracy of features, certification and compliance, and competitive pricing could be enhanced to compete more effectively against top performers such as PlantNet. PlantNet's higher ranking is attributable to its extensive feature set, high accuracy, and competitive pricing. While UP7 offers robust functionality, enhancing its range of features and ensuring compliance with more certifications could further solidify its position. Additionally, addressing competitive pricing strategies and providing a more user-friendly interface could bridge the gap between UP7 and leading competitors.

**UP8a: Citizen engagement application:** The Citizen engagement application is a powerful tool that serves as educational and training material, creating a social community and like that, awareness of wildfire prevention. There are only a few direct competitors, as most similar solutions primarily emphasize forest management practices and the particular features available in their apps, rather than the broader or different focus of the solution. Most competitors rely on open-source strategies to offer their services, so, it would be interesting to see which strategies may come into practice when trying to get more users. Dissemination activities are crucial to achieve this, but also is very important to monitor and continue to improve the interface, which may have a bigger impact on all stakeholders.

**UP8b: Citizen application for situational awareness and information sharing (Fire Reporting and Fire Warnings):** The competitors of this component are mostly tools and local solutions that the government and local authorities have put to the disposition of citizens such as Citizen App and My 112, which may fulfil the same objective as in SILVANUS, but don't exceed in the overall score since they don't have interactive map and cannot report events. The main threat may be their continued efforts to engage with stakeholders, so further improvements in this area may be considered, with the help of the broad vision of the SILVANUS platform.

**UP9b: Health impact assessment (DSS-HIA):** To enhance its competitive standing, UP9b of the SILVANUS project should focus on minimizing environmental impact and advancing innovation and technology to match leaders like Met One Instruments. Strengthening certification compliance, feature variety, and stakeholder engagement will also be crucial. Investing in robust analytics, a user-friendly UX/UI and comprehensive forest management practices can further differentiate UP9b. The overall score of competitors is not that high and there are not many competitors that manage the same benefits as the Health Impact Assessment, which implies room for growth without much pressure.

**UP9c: Evacuation route planning (DSS-ERP):** To make the DSS-ERP component from the SILVANUS project more competitive, is important to focus on advances in areas like forest management practices, environmental impact, and innovation. Ensuring compliance with relevant standards, enhancing feature variety and accuracy, and engaging stakeholders effectively. Robust analytics is the stronger factor compared to other competitors, so it is important to continue improving the calculation of evacuation routes with new features.

**UP9d: Ecological resilience index (DSS-ERI):** There are not many competitors for this User product, but there are similar solutions. Some solutions to mention are BERI v2 offer global coverage which gives them an advantage, but on the other hand have limited temporal resolution, where the SILVANUS component can excel. All competitors focus on fire management practices, and most of them, care about making a positive difference regarding environmental impact, so real opportunities can rely on better engagement with end users, by disseminating activities, participating in events, and reaching the audience to multiple channels.

**UP9e: Continuous monitoring of rehabilitation strategy index (DSS-CMRSI):** is a decision-support tool that analyzes forest conditions over time, leveraging earth observation data and stakeholder input. It provides a spatial-temporal analysis of forests before, during, and after fires, incorporating information on climate, policies, and societal factors.

UP9e really stands out in a few key areas: it's innovative, uses cutting-edge technology, offers a wide range of accurate features, and is great at involving people who care about forests. Plus, it's strong on data analysis and protecting the environment. This makes it a well-rounded tool for managing and restoring forests. By using advanced technology and working closely with people, UP9e sets itself apart from other tools that might not do everything as well.

While Global Forest Watch leads in areas such as worldwide coverage, interactive maps, and real-time updates, the DSS-CMRSI system of UP9e offers distinct advantages that focus on tailored solutions and specialized features. Although Global Forest Watch may have a broader reach, SILVANUS system prioritizes precision and actionable insights for specific user needs, positioning DSS-CMRSI as a powerful, targeted tool rather than a generalized platform.

**UP9f: Biodiversity Index Calculation (DSS-BIC):** The Woode – Biodiversity Profile Mobile App enables users to tag and analyse biodiversity using a vast database with crowd-sourced and augmented data. It utilizes deep-learning classification and recognition to enhance environmental awareness and support biodiversity management efforts. The UP9f component potentially offers more advanced and specialized functionalities for biodiversity analysis, (spatial and temporal resolution, landscape biodiversity calculation, etc) particularly for forest management and real-time monitoring, which can address some of the weaknesses identified in the UNEP-WCMC indicators, like lack of spatial and temporal resolution or data limitations (only competitor identified). However, UNEP-WCMC's strengths in innovation, feature variety, and user experience remain significant competitive advantages.

**UP9h: Integrated Data Insights:** Each competitor demonstrates strengths in various areas, with Dryad Networks leading with a total score of 20, indicating robust performance across most variables, although its pricing information is not available. Spire Global follows closely with a total score of 18, showing balanced strengths, particularly in different features and stakeholder engagement. EOS GmbH, scoring 16, also shows commendable performance but lags slightly in areas like certification and stakeholder engagement. Kinéis, with a total score of 15, has strong points in innovation and technology but falls short in other critical areas such as stakeholder engagement and features variety. Overall, Dryad Networks stands out as the most comprehensive competitor.

Integrated Data Insights integrates a variety of data sources which helps users to check past trends and allows better decision-making. That and the combination of human insights and automated processes when analyzing the data is where its strengths come handy in front of the market.

**UP9i: Priority Resource Allocation based on Forest Fire Probability (DSS):** UP9i seems to have a well-rounded feature set compared to its competitors. While the specific ranking within the figure doesn't reveal an overall winner, UP9i's ability to consider 14 forest characteristics (including human-related aspects) suggests a potentially more comprehensive approach to fire probability prediction. Additionally, UP9i directly addresses resource allocation based on these factors, which isn't explicitly mentioned for the competitor systems. A strong selling point is that competitors focus on other markets and have not expanded, and their data is not always updated which makes DSS-PRA a better alternative. Is important to provide reinforcement in standardizing the data which may help users to interpret the information more easily (as is the case for competitors such as Landfire).

**UP9j: Multilingual Forest Fire Alert System:** Compared to other tools like Firewatch (provides aerial imaging and data for wildfire preparedness, conservation, and urban forestry using multispectral imaging and GIS technology. It focuses on vegetation health monitoring, fuel load assessments, and post-fire impact analysis, supporting proactive resource management rather than early smoke detection or alerting), which are good at getting people involved and are easy to use, UP9j stands out by predicting the chances of a fire in a more complete way. 14 different variables/characteristics were analyzed about a forest, including how people use it, and then understand the best way to use firefighting resources. This makes it a smarter tool for managing fires. That said, what's most important it can adopt depending on the project. Sometimes, a tool like FireCast which is cheaper, or Firewatch which is better at getting people involved, might be a better fit. And we can't forget that almost everyone offers a free version of their tool.

UP2b and UP9i are not directly related to multilingual forest fire alert systems. However, they likely share some of the same competitors because they all address aspects of forest fire management. UP9i focuses on priority resource allocation based on forest fire probability, while UP2b concentrates on early detection and monitoring through UAVs. Multilingual forest fire alert systems, on the other hand, disseminate information about fires once they've been detected.

**UP9k: DSS Deep Learning Model for Wildfire Severity Prediction using EO4Wildfires:** There is not a wide range of competitors, but the few that exist have powerful characteristics and are strong mainly in innovation and technology aspects, analytic capabilities, and experience in Forest management practices. most effective competitor in all aspects is Firemaps but is closely followed by the others. SILVANUS UP9k asset will exceed due to its deep learning modelling which allows better accuracy on predictions and is available for a wider community by being an open-source resource, contrary to its competitors.

**UP10: SILVANUS forward command centre:** Four competitors are identified in the market ecosystem which scored a high number when comparing with the variables, which means, in an overall analysis, they are strong solutions to battle with., especially when referring to their Features variety offering, the positive impact on the environment and the advance technology used. They offer high customization and integration with existing systems, like EMIS, but also have the restriction of applying only for the competitor's network, which may be an opportunity for the FCC to reach new audiences that are not being attended. The FCC has a strong value proposition for fire commanders and other emergency personnel working in remote locations and can use this to make improvements on stakeholder engagement and its UX/IU experience, where competitors may lack.

**UP11: SILVANUS platform and dashboard - Geographical information system:** The analysis involves three key competitors: Forestry - The Sanborn Map, Wildfire Analyst Technosylva MXSYS, and CPS Wildfire Management Tool EMXSYS. CPS Wildfire Management Tool EMXSYS leads with a total score of 20, indicating exceptional performance across most evaluated variables, particularly excelling in forest management practices, innovation, and stakeholder engagement. Wildfire Analyst Technosylva MXSYS follows closely with a score of 19, demonstrating strengths in environmental impact, innovation, and analytics/database capabilities. Forestry - The Sanborn Map, with a score of 16, shows solid performance but lags in areas such as certification and feature variety. Both CPS Wildfire Management Tool EMXSYS and Wildfire Analyst Technosylva MXSYS lack pricing data, which may impact decision-making. Overall, CPS Wildfire Management Tool EMXSYS stands out as the most comprehensive competitor, closely followed by Wildfire Analyst Technosylva MXSYS, with Forestry - The Sanborn Map as a viable but less robust alternative. Not much data was found about their price since most required a specialized meeting and demo to know their pricing strategy.

**UP12: MESH in the sky:** Most of the competitors identified for the MESH in the sky solution are robust and well known in the market but their main weakness is the high price to acquire the service, and also that the equipment (drones) due to their heavy weight. Although the technology and innovation are advanced, but steel are too heavy to use for several use cases. On the other hand, SILVANUS UP12 works with flexible and light drones. Analytics and visibility towards stakeholders can be improved to get higher in the market ranking.

For UP9a: DSS - Resource allocation of response teams (DSS-RAR) and UP9l: DSS SIBYLA did not find any competitors. The UP9g was not considered for exploitation purposes so it was not analysed and for UP5b: UAV monitoring of wildfire inspection, there was not data to be considered and analyse.

### 4.3 Differentiation between competitors and SILVANUS solutions

A second analysis was conducted to compare SILVANUS to its competitors in each market segment. This analysis considered the same competitors as the first analysis but included additional variables for a more in-depth comparison. The goal of this analysis is to identify how SILVANUS differentiates itself from similar solutions based on these chosen variables, which vary from one user product (UP) to another. These variables focus on/exemplify key features of each component within the UPs.

The variables chosen for this market analysis were carefully selected to comprehensively cover the core functionalities of the user products and those offered by their competitors. These variables are integral to assessing both the current market landscape and the unique features of SILVANUS UPs. Each variable directly correlates with the primary areas of work, such as fire risk management assessment, environmental protection, and forest management solutions.

The features identified for comparison between the market and the SILVANUS products/components were determined through a thorough review of existing market offerings, combined with an understanding of the strategic objectives of the project. This involved assessing publicly available information on competitor products, industry reports, and academic literature, as well as aligning these insights with the functionalities that SILVANUS UPs aim to provide.

All variables shown on the left side of the tables (shown below) apply to the user products that are being analyzed, helping to showcase where competitors are meeting their functionalities and where each of the components is excelling.

For component **UP1**, six key features were determined based on its strong capabilities and its value proposition. The strongest competitor appeared to be 4Experience filling out all the variables compared to SILVANUS asset. Following 4Experience are Scotty, YORD, and Delta Reality, followed by the rest matching three variables each. This allows us to see a lot of competitors are similar or offer the same benefits to end users which means UP1: AR/VR training toolkit for trainers must reinforce awareness in front of users, through different channels, including SILVANUS, avoiding them going to the competitors.

Based on the variables, *Simulation of different operational scenarios* and *Intuitive graphic interface* got on top so there is where improvements can be made, but also consider an advantage in the provision of *Real-time information* where not many solutions in the market exceed.

Table 4 Differences between UP1's key features and its competitors

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

| Variables \ Competitors | Glue collaboration | Scotty | ENGAGE | InnoChain | YORD | Crystal Apps | 4 Experience | WE/AR Studio | Delta Reality | Zappar | Khora |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Training in AR/VR | X | X | X | X | X | | X | X | X | X | |
| Simulation of different operational scenarios | X | X | X | X | X | X | X | X | X | X | X |
| Multiplayer training | | X | | | X | X | X | | | | X |
| Intuitive graphic interface | X | X | X | | X | X | X | X | X | X | X |
| Equipment included | | | | X | | | X | | | | |
| Real-time information | | | | | | | X | | X | | |

The capacity to predict the probability and frequency of forest fire ignition, which is the main focus of the **UP2a** is also demonstrated by the competitors analyzed in the field. So, where the component can differentiate is in the dashboard aspect. The solution will be accompanied by maps for easy visualizations of the results, which also demonstrate an advantage, including as well Smart modelling for wildfire prediction.

Wildfire Analyst Pocket and Fire Cast are the stronger competitors so keeping up with their strategies may help to get ahead sooner.

Table 5 Differences between UP2a's key features and its competitors

**UP2a: Fire ignition models**

| Variables \ Competitors | FIRETEC (US Forest Service) | Wildfire analyst pocket | Fire Cast (Wirespring t.) | BehavePlus |
|---|---|---|---|---|
| Probability for fire ignition | X | X | X | X |
| Dashboard with different data | X | X | X | |
| Geolocation | | X | X | |
| Weather,air,temperature with public APIS | X | X | X | |
| High model accuracy | | X | X | X |

Out of the five variables identified and analyzed as key features of the **UP2b**, the User dashboard ranked higher meaning all competitors are strong contestants on that matter. On the contrary, the feature of including data vegetation and human factors in the analysis signifies an advantage in front of some competitors that don't have the same ability, so, when showing it to stakeholders this is one of the features to highlight. Another feature to promote will be its availability through open source making it easier to access the information, also providing fire danger information with high resolution.

Due to its position and experience, EFFIS is the most similar solution on the market. This means having a closer look into their operations and checking how they are successful can help to path our own way into improvements for end users.

Table 6 Differences between UP2b's key features and its competitors

**UP2b: Fire danger index**

| Variables \ Competitors | EFFIS (JRC) | CMS (Copernicus emergency) | ESA | MetGIS |
|---|---|---|---|---|
| Elastic: potential markets | X | | X | X |
| Include vegetation and human factors | X | X | | |
| Map with probability of a fire (forecast) | X | X | | X |
| User dashboard | X | X | X | X |
| Open-source data | X | X | X | |

**UP3:** The primary goal of UP3 Fire Detection based on social sensing is to reduce fire risk by detecting incidents through social sensing, a feature most competitors do not integrate into their solutions. While competitors like SILVANUS offer multilingual capabilities, making their platforms accessible to a broader range of users, SILVANUS also excels by clustering social media posts, giving UP3 a distinct advantage over most similar solutions. The closest competitor is Google Crisis Map, which benefits from its parent brand's visibility but cannot match UP3's offerings. Therefore, it is crucial to maintain communication with stakeholders to gain more market share.

Table 7 Differences between UP3's key features and its competitors

**UP3: Fire detection based on social sensing**

| Variables \ Competitors | Mediatoolkit | PromptCloud | Tweetmap | Google Crisis Map |
|---|---|---|---|---|
| Fire risk reduction | | | | X |
| Multilanguage feature | X | X | X | X |
| Real-time notifications | X | | | X |
| User friendly | X | X | X | X |
| Cluster social media posts | | | X | |

**UP4a:** While many systems offer basic fire detection, real-time updates, and alerts, UP4a has the potential to go beyond the standard features. A game-changer is the integration of a camera network directly in forests. Unlike most competitors, only Piperaris currently offers this, but UP4a could take it further, since it is customizable and effortlessly integrated into any remote application, it can be installed anywhere within an hour and can start sending alarms just after the initiation of the module. Cameras provide a level of monitoring and rapid response that other methods simply can't match.

Another key area is user experience. A system that's easy to use is more likely to be adopted. While Early Fire Detection has made strides in user-friendliness, there's still room for improvement. A well-designed interface can make a huge difference.

Of course, constant monitoring is essential. Most competitors offer this, so it's a baseline requirement. By combining these elements - cameras, a user-friendly platform, and round-the-clock watchfulness - with advanced features like AI-powered predictions and a reliable alert system, UP4a can create a truly exceptional fire detection solution that outperforms the competition.

Table 8 Differences between UP4a's key features and its competitors

**UP4a: Fire detection from IoT devices**

| Variables \ Competitors | AVIOTEC | Early Fire detection | OPGAL | Novo technologies | Piperaris | AA alarm |
|---|---|---|---|---|---|---|
| Fire detection | X | X | | | X | X |
| Notifications by alerts of fire | X | | X | | X | X |
| Real-time data | X | X | X | X | X | X |
| Cameras deploy in forest | | | | | | X |
| 24/7 monitoring | X | | X | | X | X |
| Friendly UI | | X | | | | |

**UP4b:** A lot of other drones can already spot fires and smoke, process information quickly, and have user-friendly controls. But UP4b can stand out in a few keyways. First, it's easy to keep UP4b in top shape. Not many other drones are this low maintenance. Less downtime and lower costs are big pluses for our customers. Second, UP4b is built tough. It can handle extreme weather, which isn't common in this industry. Only AgEagle and ITUR drones can match that. Being able to fly in harsh conditions means UP4b can keep watch the fire front, no matter what the weather's like.

By combining these features with top-notch fire and smoke detection and smart technology that can predict problems, UP4b can be the best fire-fighting drone out there.

Table 9 Differences between UP4b's key features and its competitors

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

| Variables \ Competitors | SmokeD | AgEagle | Garuda Robotics | ITUR drones |
|---|---|---|---|---|
| Fire and smoke detection | X | | | X |
| Real-time analysis | X | | X | |
| Friendly UI | X | X | X | |
| Easy maintenance | X | | | |
| Extreme weather resistance | | X | X | X |

**UP5a:** It is clear that the features of acquiring data in dangerous zones for humans by UGV and having a long battery life in the equipment used are very popular and cover area so, to be different and interesting for users, UP5a: UGV monitoring of wildfire behaviour must focus on other characteristics.

There is a huge opportunity in providing 3D point cloud maps of forest (area mapping) since none of the competitors are providing it but also providing and analyzing ground-level forest graphics is free of competitors. So, by highlighting this aspect and making them a priority within the value proposition, this component can get on top of its market.

Table 10 Differences between UP5a's key features and its competitors

**UP5a: UGV monitoring of wildfire behaviour**

| Variables \ Competitors | RTE Robot | Wolf R1 | Shark Robotics | Howe and Howe | DeepRobotics (X30) | TRACKREITAR FFL |
|---|---|---|---|---|---|---|
| Fire Detection & Monitoring | | X | X | | X (+or-) | X |
| 3D point cloud maps of forest (area mapping) | | | | | | |
| Long battery life | X | X | X | X | X | X |
| Adquire data in dangerous zones for humans | X | X | X | X | X | X |
| Ground level forest graphics | | | | | | |

**UP6:** From the analysis we can conclude that FlamMap is the front-runner when compared with the five characteristics, followed by IBM: Environmental Intelligence Suite and Calfire. So, by reviewing the different scenarios, where SILVANUS component can showcase its strengths as a better solution is on the usage, since is not only easy for end users but also does not need expert support or training to keep the component going. On top of it this component will be able to integrate easily with the SILVANUS platform since is dockerized proving an extra value not just for UP6 itself but for the project and its stakeholders.

Table 11 Differences between UP6's key features and its competitors

**UP6: Fire spread forecast - modelling**

| Variables \ Competitors | FlamMap | BehavePlus | Environmental Intelligence Suite IBM | CalFire | Intterra |
|---|---|---|---|---|---|
| Useful to train firefighters | X | X | | X | |
| 24 hours real-time prediction of firefront | X | | X | | X |
| Estimation of fire spread | X | X | | X | |
| Organize citizen evacuation through safe routes | X | | X | X | X |
| Easy usage, no experts needed | | | X | | |

**UP7:**

For UP7, while there are several competitors, none pose a significant threat to this component. Among the competitors, Forest Diversity (CZU Prague) stands out as a leading solution. However, UP7 has a distinct advantage: it is the only solution that integrates the capability to assess the severity of fire damage in real time.

UP7 not only supports species identification but also assists in evaluating the extent of damage to forest ecosystems, a critical component in post-disturbance assessments. Additionally, the app's identification accuracy plays an essential role in delivering reliable data. Beyond trees, the app also focuses on understory species, including woody shrubs, which are vital indicators of forest ecosystem health. This broader focus on species richness and diversity is particularly valuable in the European context, where tree species richness tends to be low to moderate, and tree composition remains relatively stable, except in cases of severe disturbance.

Also, the UP7 is one of the few to provide realistic yet virtual (AI) videoclips on forest damage, generating more insights for the interested party. And even the stakeholder's engagement efforts have been constant ensuring more and more users in the community benefit from this. In conclusion, the UP7 has a very good position on the market and must continue to mature the solution to keep the leadership.

Table 12 Differences between UP7's key features and its competitors

**UP7: Biodiversity profile mobile application**

| Variables \ Competitors | LeafSnap | iNaturalist | Google Lens | TreeID | Forest Diversity (CZU Prague) |
|---|---|---|---|---|---|
| Identificaton and classification of tree species | X | X | X | X | X |
| Information about severity of fire | | | | | |
| Awareness on risk of fire | | X | | | X |
| Provide realistic yet virtual (AI) videoclips on forest devastation | | | | | X |
| Forecast on forest restoration | X | | | X | X |

**UP8a:** To showcase the competitiveness of UP8a, the Citizen Engagement Application should capitalize on the unique opportunity to build a social community feature, which none of its competitors currently offer.

This feature would foster user interaction and collective knowledge sharing, setting UP8a apart. Additionally, while competitors such as FireFringe and WIFIRE already provide educational material, visually engaging tools, and event notifications, UP8a can differentiate itself by enhancing these features with cutting-edge technology. This includes implementing real-time updates and personalized content through AI and data analytics, and offering dynamic, gamified learning experiences to engage users of all ages. By focusing on these underrepresented yet impactful features, UP8a can surpass existing market offerings and establish a distinctive, competitive edge, generating a wider differentiation from National Interagency Fire which is leading, in front of the other competitors.

Table 13 Differences between UP8a's key features and its competitors

**UP8a: Citizen engagement application**

| Variables \ Competitors | FireFringe | National Interagency Fire | WIFIRE | FIRMS |
|---|---|---|---|---|
| Educational material | X | X | X | X |
| Visually dynamic and engaging tool for all ages | X | X | X | X |
| Awarness of wildfire prevention | | X | | X |
| Creating a social community | | | | |
| Events notifications | X | X | X | |

**UP8b:** Currently, GoAudits, CITIZEN, and My 112 are strong due to their robust event reporting capabilities, easy-to-use interfaces, and comprehensive information-sharing features. UP8b can stand out by enhancing its country-specific content, which is already a notable feature in HZS and GoAudits but not widely covered by all competitors. Moreover, introducing the ability for firefighters to aggregate and disseminate warnings, a feature currently unique to HZS, will significantly enhance UP8b's reliability and appeal.

UP8b's interactive map and default subscription to the fire reporting channel offers an immediate advantage in user engagement and situational awareness. To further strengthen its position, UP8b should focus on continuously improving its user interface to ensure it remains intuitive and user-friendly. Additionally, fostering a robust platform for citizen information sharing can enhance community-driven updates and situational awareness.

Table 14 Differences between UP8b's key features and its competitors

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

| Variables \ Competitors | HZS (Mountain Rescue Service | GoAudits | CITIZEN | My 112 |
|---|---|---|---|---|
| Reporting events | | X | X | X |
| Country-specific content | X | X | | |
| Easy to use UI | X | X | X | X |
| Firefighters can aggregiate warnings for citizens | X | | | |
| Citizens can share information | | X | X | X |

**UP9b:** The UP9b Health impact assessment (DSS-HIA) has huge growth opportunities when talking about the market because is not a very competitor-saturated environment but also because the SILVANUS component offers strong and quality features that others don't have.

In this case, the stronger feature is offering multiple emissions indicators to assess the danger which directly impacts a better solution to improve human health in a wildfire scenario, by also evaluating the condition of the ones affected.

Some other solutions also cover features like real-time information on air quality but is still an important feature to highlight for stakeholders, according to different learnings from engagement activities. Met One Instruments is the competitor that most closely resembles UP8b but covers just over half of the analyzed characteristics, which puts us ahead.

Table 15 Differences between UP9b's key features and its competitors

**UP9b: Health impact assessment (DSS-HIA)**

| Variables \ Competitors | Swiss TPH | Met One Instruments | Tenevia | INERIS |
|---|---|---|---|---|
| Detection and evaluation of health impact | X | | | |
| Continuous monitoring of health impact in fires | X | | | |
| Multiple emissions indicators to assess danger | | X | | |
| Real-time information on air quality | | X | X | X |
| Alerts notifications | | X | X | X |

**UP9c:** is a solid tool for planning evacuation routes. Even if, all the other alternate solutions can figure out the quickest safe exit, but UP9c goes a step further. It can plan escape routes based on where the smoke and fire are, and even figure out the best time to get everyone out safely which is only matched with IBM's.

Another important feature of UP9c is that it's open source and easy to use with other systems. This makes it a flexible choice for different organizations. All in all, UP9c is a strong contender for the best evacuation planning tool.

Table 16 Differences between UP9c's key features and its competitors

**UP9c: Evacuation route planning (DSS-ERP)**

| Variables \ Competitors | Openrouteservice | EscapeWildFire | IBM Evacuation Planner | Zoneheaven |
|---|---|---|---|---|
| Provides fastest evacuation route | X | X | | X |
| Open-source | X | X | | X |
| Easy integration for stakeholders to use | | X | X | X |
| Smoke and fire-based evacuation planning | | X | X | |
| Determine the optimal times for evacuation | | | X | X |

**UP9d:** Based on the analysis, the UP9d: Ecological Resilience Index (DSS-ERI) targets critical aspects of forest health, such as monitoring forest conditions, conducting forestry science research, and assessing recovery rates. Additionally, it provides a user-friendly interface designed for ease of use. In comparison, while all competitors (BERI v2 by CSIRO, EFISCEN, ForestRY, and Tree Metrics) also address ecological resilience, UP9d's approach focuses more specifically on practical and actionable metrics related to immediate forest health management and recovery. This contrasts with competitors who may have a broader scope, integrating long-term climate models, economic factors, or large-scale ecosystem assessments. Therefore, UP9d's focus is narrower since it prioritizes immediate ecological resilience and forest health indicators over broader, long-term, or cross-disciplinary analyses.

Where the UP9d has more room to grow and showcase an advantage in front of competitors is definitively in the user interface feature, since is easy to use which provides an easy entry for users that want to try it. Is important to monitor graphic features to reinforce the advantage.

Table 17 Differences between UP9d's key features and its competitors

**UP9d: Ecological resilience index (DSS-ERI)**

| Variables \ Competitors | BERI v2 (CSIRO) | EFISCEN | ForestRY | Tree Metrics |
|---|---|---|---|---|
| Analysis of forest conditions | X | X | X | X |
| Forestry science research | X | X | X | X |
| Show how quickly can certain forest parts recover | X | X | X | |
| Easy to use interface | | X | | X |

**UP9e:** After reviewing the competitive market for DSS-CMRSI, Global Forest Watch stood out as a strong competitor with a large user base. However, UP9e distinguishes itself by offering unique features that set it apart.

One of the key strengths of UP9e is its ability to analyse and visualize the impacts of climate change on forests, through integrated climate data modelling, Additionally, UP9e can monitor human activities, such as land use changes and illegal logging, which are linked to increased fire risks. Another capability is its ability to track changes in the forest over time, allowing users to assess the extent of damage and monitor recovery efforts. Moreover, UP9e offers continuous monitoring through real-time data feeds from satellites and on-the-ground sensors.

While UP9e is already robust, there is still room for improvement. Future developments can focus on enhancing data accuracy and expanding user access to those in remote or underserved areas. This market is not saturated, which provides an opportunity to further develop the component and enhance its appeal to end users who have limited access to similar solutions.

Table 18 Differences between UP9e's key features and its competitors

**UP9e: Continous monitoring of rehabilitation strategy index (DSS-CMRSI)**

| Variables \ Competitors | Global Forest Watch | EFDAC | IUFRO |
|---|---|---|---|
| Monitor forest conditions throughout a fire event | X | X | |
| Social awareness | X | X | X |
| Continuous monitoring of forest health over time | X | | |
| Allows better decision-making | X | X | X |
| Citizen involvement | X | | X |

**UP9f:** Biodiversity Index Calculation (DSS-BIC) has just one competitor identified, meaning the SILVANUS solutions are unique and have a promising future in the possibilities of improving what has already been developed. The solution solves a gap in the market which users can appreciate. The competitor UNEP-WCMC is similar to UP9f but is not quite the same nor does it have the same features or provide the same benefits as our component, so is important to take care of the points where they can improve as can be the user interface, to offer the best in every single aspect.

Table 19 Differences between UP9f's key features and its competitors

**UP9f: Biodiversity Index Calculation (DSS-BIC)**

| Variables \ Competitors | Biodiversity Index Calculation (DSS-CMRSI) |
|---|---|
| Calculate the landscape biodiversity | X |
| User friendly, easy to use | X |
| Historical data, during observed timeframe | X |
| Spatial and temporal resolution | |
| Single value for representing biodiversity index | |

**UP9h:** Four competitors were identified within the ecosystem of UP9h. The closer to SILVANUS component is Dryad Networks, and in this case, to differentiate, is important to emphasize other key features as the fact that this component allows integration with different systems which makes it easier to scale, and also the fact that it integrates date from social media, meaning a robust information source for end users.

The use of IoT devices that detect fires can be further exploited since is not very common in other competitors, and so is the situation with the real-time feature which showcases another advantage.

The disadvantage relies mainly on the provision of global coverage by other competitors that UP9h can't offer, so the strategy must focus on being the best alternative for local users, at this stage of the development.

Table 20 Differences between UP9h's key features and its competitors

**UP9h: Integrated Data Insights**

| Variables \ Competitors | Kinéis | Dryad Networks | EOS GmbH | Spire global |
|---|---|---|---|---|
| IoT devices that detect forest fires and sensors | X | X | | X |
| Improve decision making | X | X | | X |
| Turn real-time data into quicker action against wildfires | | X | X | X |
| Integrated view from various data sources | | X | X | |
| Custom result based on user's needs | | | X | X |

**UP9i:** The UP9i Priority Resource Allocation based on Forest Fire Probability (DSS) shows a competitive edge in several areas when compared to its competitors. Specifically, it is on par with the best competitors in determining the probability of a fire reaching dangerous levels, a feature shared with the PROMETHEUS Fire Growth Model, FireCast, and FireWeather. Moreover, it excels in utilizing satellite data to analyse environmental features remotely, a capability it shares with FireCast and FireWeather, which indicates a strong emphasis on remote sensing technologies.

However, UP9i DSS lags in a few areas compared to its competitors. Unlike Landfire (USGS) and PROMETHEUS, it does not seem to collect and analyse tweets in a specific time and period, which could be a valuable real-time data source for fire detection and public communication. Additionally, UP9i lacks the feature of real-time wildfire notifications via email, a service provided by Landfire and FireWeather, which is crucial for timely alerts and responses. UP9i DSS could enhance its difference by incorporating real-time data collection from social media, offering email notifications, and allowing for fine-tuning with custom data.

Table 21 Differences between UP9i's key features and its competitors

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

| Variables \ Competitors | Landfire (USGS) | PROMETHEUS Fire Growth Model | FireCast (Conservation Int.) | FireWeather |
|---|---|---|---|---|
| Determine probability of a fire reaching levels of danger | X | X | X | X |
| Satellite data to analyze environmental features remotely | X | | X | X |
| Collect and analyze tweeds in a specific time and period | | | | |
| Real-time wildfire notifications via email | | | X | X |
| Possible to fine-tune with custom data | X | X | X | |

**UP9j:** The UP9j offers comprehensive coverage and real-time monitoring, which is important for timely alerts and effective fire management. This feature is shared with EFFIS, emphasizing the robust monitoring capabilities both systems provide. Furthermore, the UP9j system supports integration and interoperability, akin to MODIS, ensuring it can seamlessly work with various other systems and datasets, thereby enhancing its utility and flexibility. One of the standout features of UP9j is its multilingual support, which is not offered by any of its competitors. This aspect is crucial for global applicability and ensuring that alerts and information are accessible to diverse user groups across different regions. There are areas where UP9j could improve. Unlike EFFIS, Landfire, and MODIS, it lacks in providing a strong detection methodology. Enhancing its detection capabilities could significantly boost its overall performance and reliability.

It is worth mentioning that EFFIS is also a competitor of UP2b, and Landfire is a competitor for both UP9i too. This overlap suggests potential correlations and shared methodologies between these systems.

Table 22 Differences between UP9j's key features and its competitors

**UP9j: Multilingual Forest Fire Alert System**

| Variables \ Competitors | EFFIS | Landfire | FireWatch | MODIS |
|---|---|---|---|---|
| Coverage and Real-time monitoring | X | | | |
| Integration and Interoperability | X | | | X |
| Detection methodology | X | X | X | X |
| Multilingual support | X | | | |
| Provides personal assistance and support | | X | X | X |

**UP9k:** The four competitors analyzed have similar characteristics and relate to the number of characteristics they share with the UP9k, especially FiResponse and FIRE tools. This implies that an overall analysis can be done in terms of how to improve the solution to get ahead of competitors or maybe focus on a good dissemination strategy, also taking advantage of SILVANUS visibility, to gain more users in the community and reach potential future customers. Where UP9k can really shine is in the provision of training for stakeholders on how to use the service. This is not a usual feature in the market and can make a difference in choosing us from other similar solutions.

Table 23 Differences between UP9k's key features and its competitors

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

| Variables \ Competitors | firemaps.net | ArboFiRM | FiResponse | FIRE tool |
|---|---|---|---|---|
| Predict severity of potential wildfires | | X | X | X |
| Customized user interface | X | X | X | |
| Training for stakeholders in how to use the service | X | | | X |
| Integration of Multi-source Data | X | | X | X |
| Helps in emergency response planning | | X | X | X |

**UP10:** SILVANUS forward command centre is a comprehensive system designed to manage fire incidents efficiently. In comparison to its competitors—IRIS (Thales Group), Eurocommand 2020 (GmbH), EMIS (Siemens), and SAFE Command by Hexagon—it matches all key functional features. These features include hosting and running critical mission applications at fire incident sites, robust data transfer and storage capabilities, consistent access to updated information, and integration with various tools.

To differentiate, UP10 can focus on unique value propositions or advanced functionalities not yet offered by these competitors. For example, enhancing user experience through AI-driven decision support, implementing predictive analytics for fire behaviour, or providing augmented reality (AR) interfaces for field operatives. Additionally, offering superior customer support and training programs might also help distinguish UP10 in a competitive market.

Table 24 Differences between UP10's key features and its competitors

**UP10: SILVANUS forward command centre**

| Variables \ Competitors | IRIS (Thales Group) | Eurocommand 2020 (GmbH) | EMIS (Siemens) | SAFE Command by Hexagon) |
|---|---|---|---|---|
| Host & run critical mission applications at fire incident sites | X | X | X | X |
| Robust data transfer & storage capabilities | X | X | X | X |
| Consistent access to updated information | X | X | X | X |
| Access and integration with various tools | X | X | X | X |

**UP11:** The SILVANUS platform and dashboard - Geographical Information System (GIS) stands out in facilitating communications between citizens and firefighters, a feature not offered by its competitors Forestry, Wildfire Analyst, and CPS Wildfire Management Tool. It effectively displays data from multiple sources simultaneously and provides a user-friendly dashboard for timely and easy access, comparable to Wildfire Analyst and CPS Wildfire Management Tool. Also, processes information from multiple sources in one interface, ensuring comprehensive data integration.

One of UP11's unique advantages is its lower learning curve for personnel, making it more accessible and easier to adopt. While it shares several strengths with its competitors, such as robust data display and integration, its standout features in communication and ease of use differentiate it in its ecosystem.

Table 25 Differences between UP11's key features and its competitors

**UP11: SILVANUS platform and dashboard - Geographical information system**

| Variables \ Competitors | Forestry | Wildfire Analyst | CPS Wildfire Management Tool |
|---|---|---|---|
| Facilitate communications between citizens and firefighters | X | | |
| Display data from multiple data sources at same time | X | X | X |
| Dashboard that facilitate timely and easy user access | X | X | X |
| Process information from multiple sources in one interface | X | X | X |
| Lower learning curve for personnel | | X | |

**UP12:** MESH in the Sky user product is a powerful solution with numerous benefits but moves into a competitive environment with known competitors such as Airbus and Indra that offer very similar features to the UP11. Most of these strong competitors include solutions that are military grade produce, giving them strength against our component, but the key feature where UP11 is better is in the lightweight and small products this asset works with, meaning a lot of benefits when working in outside spaces and handling the equipment.

Table 26 Differences between UP12's key features and its competitors

**UP12: MESH in the sky**

| Variables \ Competitors | MIMO - Radio | WAVE-RELAY | Airbus Defense and Space | Indra | A-LINK (DOMO) |
|---|---|---|---|---|---|
| Connection between UAVs and ground robots | X | X | X | X | X |
| Wireless communication infrastructure | X | X | X | X | X |
| Communication channels between forward command centers and field devices | | X | X | X | X |
| Light weight and small physical dimensions | | | | X | |
| Improve response time & coordination for emergencies | X | | X | X | |

From the comparative analysis of SILVANUS UPs against their competitors across different market segments, several key insights emerge.

- **Competitive Strengths and Differentiation:**
    - **Unique Features:** Many SILVANUS products exhibit unique features that set them apart from competitors. For instance, UP3's integration of social sensing for fire detection and UP7's provision of realistic AI-generated videos of forest damage highlights distinctive capabilities that offer substantial competitive advantages.
    - **Technological Innovations:** Advanced technological implementations, such as AI-driven predictive analytics in UP4a and UP4b, and the use of IoT devices for real-time fire detection in UP9h, underscore SILVANUS's edge in leveraging cutting-edge technologies to enhance functionality and user experience.
    - **User Accessibility:** Several SILVANUS components, such as UP6 and UP11, are noted for their ease of use and lower learning curves, which make them more accessible to a broader range of users compared to more complex solutions offered by competitors.
- **Areas for Enhancement:**
    - **Feature expansion and improvement:** For UP1 and UP2b, enhancing features like simulation of operational scenarios and incorporating vegetation and human factors in analyses can fortify their market positions. Similarly, emphasizing the development of 3D point cloud maps in UP5a and robust multilingual support in UP9j can address identified gaps.
    - **Market strategies:** Tailoring strategies to address specific market needs, such as focusing on user-friendly interfaces and easy maintenance for UP4b, and prioritizing local user preferences for UP9h, can enhance market penetration and user adoption.
    - **Integration:** Integrating developments within the UPs with the SILVANUS platform can provide added value to stakeholders, facilitating smoother adoption and broader application.

**Strategic improvements:**

- **Enhanced user engagement:** Continuously improving user interfaces and offering comprehensive training programs can significantly boost user satisfaction and loyalty, making SILVANUS products more attractive in competitive markets.

- **Focus on marketing and dissemination:** Developing targeted marketing strategies that highlight the unique strengths and benefits of each SILVANUS product can effectively differentiate them from competitors and attract a larger user base.

The same as for the previous subsection analysis, UP9a: DSS - Resource allocation of response teams (DSS-RAR) and UP9l: DSS SIBYLA mentioned they did not have competitors, so the differentiation did not apply. The UP9g: Soil erosion index (DSS-SEI) was not considered for exploitation purposes and for UP5b: UAV monitoring of wildfire inspection, no data was reported.

# 5 Strategic Market Analysis

## 5.1 SWOT analysis for SILVANUS components

A SWOT analysis is a strategic planning tool used to identify and analyse the Strengths, Weaknesses, Opportunities, and Threats related to a project or business venture. It involves assessing internal factors (strengths and weaknesses) and external factors (opportunities and threats) to gain a comprehensive understanding of the project's current and potential situation. This analysis helps in strategic decision-making, allowing organizations to capitalize on strengths, mitigate weaknesses, exploit opportunities, and defend against threats (White, 2024).

For the SILVANUS project, conducting a SWOT analysis is crucial. The project involves complex objectives related to sustainability, innovation, and technology related to wildfire management. By identifying strengths, such as strong partnerships, advanced technology, or unique expertise, the project and in this case the different UPs can leverage these assets to achieve its/their goals more effectively. Recognizing weaknesses, like limited resources or potential technical challenges, enables the team to address these issues proactively. Exploring opportunities, such as emerging markets, technological advancements, or regulatory incentives, can help the project expand its impact and reach. Finally, being aware of threats, like competition, regulatory changes, or environmental risks, ensures that the project can develop strategies to mitigate these potential obstacles.

In this section, the SWOT analysis per UP group can be found attached to the image of the SWOT provided during the different workshops that were carried out. Two whole stages of the analysis occurred. The first eight UPs, understood as the first User products or the MVP User products were organized by the T10.2 owner in the application Miro[4], within four different online sessions, allowing all experts to actively contribute to this interactive platform. For the new user products including UP9 group, UP10, UP11, and UP12, The SWOT results were gathered in an open session during the 6th General Assembly in Italy on a face-to-face session where all consortium partners participated in a very effective workshop.

### *5.1.1 SWOT analysis UP1 AR/VR training toolkit for trainers*

The SWOT analysis for UP1 reveals a promising product with significant strengths, including the use of real data, customized scenarios, an intuitive graphic interface, cost-effectiveness, and an open architecture capable of integrating various data types. However, the toolkit faces internal challenges such as dependence on special devices, the need for specialized staff, and a requirement for more focused market analysis. Externally, there are ample opportunities due to the increased demand for training solutions, the potential for user customization, the ability to model new environments, and interest from external providers. Conversely, the toolkit must navigate threats from market competition, the risk of damaged equipment, and the scarcity of specialized personnel.

The AR/VR component can leverage the strengths that differentiate them from competitors that in this case rely on the real-time information feature and the fact that they include the equipment which is not the case for other solutions in the market. This all can be seen in Figure 8.

[4] Business Model Canvas for Silvanus - Miro

| Strengths | Weaknesses |
|---|---|
| • Real data<br>• Cost – effective<br>• Real-time information<br>• Customised scenarios<br>• Intuitive graphic interface<br>• Lower costs for VR training compared to the operational training on the field<br>• Open architecture capable to integrate various types of realistic and simulated data | • Dependence of the special devices (AR glasses...)<br>• Need for specialized staff (specific knowledge, competencies, and AR/VR development)<br>• More effort focused on the market analysis, especially for the competition study (positioning) |
| **Opportunities** | **Threats** |
| • Increased need of training<br>• Support end-users to create own VR scenarios<br>• Capable to model new environments<br>• External providers interest | • Similar solutions existing on the market (growing competition)<br>• Damaged equipment<br>• Lack of specialized personnel |

**Figure 8 UP1 SWOT workshop results[5]**

### *5.1.2 SWOT analysis UP2 Fire ignition models and Fire danger index*

UP2: Fire Danger Assessment highlights a robust and adaptable system capable of early wildfire detection with low competition and a broad potential customer base. Its reliance on open-source data enhances its cost-effectiveness and accessibility. Threats such as licensing conflicts, dependence on data availability, need for specialized staff, and low commercial attractiveness must be addressed, and determine how to turn them into positives. On the external side, the increasing interest from customer segments, solution maturity, public awareness, regional expansion, and potential collaborations present significant growth opportunities. Nonetheless, the need for improved support networks and the impact of climate change poses considerable threats, so, by monitoring the framework of its work, prevention solutions can be established.

| Strengths | Weaknesses |
|---|---|
| • Early detection of wildfires (a&b)<br>• Low competition (a&b)<br>• Large pool of potential clients from many sectors<br>• Model accuracy (depend on amount of data)<br>• Quick adaptability (a&b)<br>• Open-source data (no costs) | • Licensing conflicts (a)<br>• Understanding of operators/end users (minimum expertise) (a&b)<br>• Need for specialized staff (specific knowledge, competencies and software modelling) (a)<br>• Low commercial attractiveness (a&b)<br>• Depend on data availability (a&b) |
| **Opportunities** | **Threats** |
| • Increase interest from customer segments<br>• Solution maturity (a&b)<br>• Public awarness (a&b)<br>• Information about wildfire evolution is difficult to access so the UP2 solution is the answer<br>• Extended to other regions (broader customer base)<br>• Interest of third parties (technological providers) in collab. for developing solutions which incorporate these algorithms (a&b) | • Need for better support networks in EU (prediction, detection, monitoring)<br>• Climate changes |

**Figure 9 UP2a and UP2b SWOT workshop results[6]**

[5] Business Model Canvas for Silvanus - Miro

[6] Business Model Canvas for Silvanus - Miro

### *5.1.3 SWOT analysis UP3 Fire detection based on social sensing*

UP3 sets itself apart from competitors primarily through its innovative approach to fire risk reduction. By leveraging social media to detect fire incidents and combining this with a user-friendly interface, efficient response capabilities, and real-time monitoring, UP3 offers a comprehensive solution. Its ability to help prevent fire spread and assess fire impact, coupled with strong user engagement, positions it as a formidable competitor.

However, challenges exist. The system's reliance on social media data can be influenced by factors such as data quality and data availability, platform changes, and internet connectivity issues in remote areas. Additionally, the underlying technology can be complex, requiring ongoing maintenance and updates. To address these weaknesses, we must prioritize technological advancements, robust data acquisition strategies, and continuous improvement to ensure user satisfaction and system reliability.

To reinforce possible future strengths, the opportunities were considered. Climate-related hazards are on the rise, emphasizing the growing need for products like SILVANUS, so the uniqueness of the SILVANUS components poses an advantage. Also, raising more awareness, by involving stakeholders can be a huge aspect to consider which will also validate the willingness of users to share information. Is important to be aware of threats such as people reporting false information (error margin) or not interacting and reporting at all, as well as regulations and privacy issues that may be considered to avoid future problems.

| **Strengths** | **Weaknesses** |
|---|---|
| • Positive engagement with users<br>• Prevention of future fires<br>• User friendly<br>• Deep learning algorithm<br>• Assistance in preventing fire spread and assessing fire scope<br>• Efficient response/Real time monitoring | • Data disparity<br>• Data reliability<br>• Dependency on Social Media platforms<br>• Technical complexity<br>• Fake news/false notifications<br>• Possible lack of bandwidth / good internet connection in more remote areas<br>• Stable access to Silvanus server |
| **Opportunities** | **Threats** |
| • Raise awareness about wildfires<br>• Citizen intention to share through social media<br>• A more interactive communication with citizens<br>• Higher engagement of citizens to post (reliable!) data on fire incidents<br>• Climate-related hazards are on the rise, emphasizing the growing need for products similar to SILVANUS.<br>• No other product with similar functionality | • Users remain innactive<br>• Long distance of the forest from the settlement<br>• Fake posts<br>• GDPR Data protection<br>• Processing the reliability of data in a timely fashion<br>• Changes in social media terms and conditions on sharing information<br>• Potential security risks due to cyber-attacks/down-time of platform<br>• Regulations/critical informations |

**Figure 10 UP3 SWOT workshop results**[7]

### *5.1.4 SWOT analysis UP4 Fire detection from IoT devices and Fire detection at the edge - from UAV data*

The next SWOT analysis highlights the aspects of both UP4a and UP4b, considering they are complementary user products, specifying their differences or shared aspects by an (a) or (b) inside each post of the image.

[7] Business Model Canvas for Silvanus - Miro

Many strengths came out when going through the analysis with the experts, showcasing its maturity and innovation potential. Some strengths apply to both UP4a and UP4b like the fact that can be used for various purposes depending on the user needs, but also has a friendly user interface, which is flexible enough to allow scalability. Both components can function over extreme weather conditions and due to their functioning can allow a better decision-making process for users for example firefighters and emergency organizations. They each stand out for their reason. UP4a works in real-time smoke detection and offers a 24/7 remote monitoring feature. Also, its design was considered with feedback from end users meaning a huge advantage when marketing the solution,

To understand where the weaknesses are, the analysis was also done for the two solutions. The common pain point was the false positive detections, but also in the case of UP4a, the battery dependency must be considered as its sensor limited range. For UP4b is important to consider that it does not real real-time data.

When analyzing external factors, there are great opportunities because of the wide range of applicability, where different communities can be targeted, and future improvements for fire smoke detection as well as possible future collaborations. On the threats side, external factors such as bad connectivity, weather conditions, animals, or human intervention can be a red alert that needs to be monitored. In any case, the positive side is extensive and can easily mitigate the weak points for both UP4 components.

| **Strengths** | **Weaknesses** |
|---|---|
| • Easy-to-use UI (A&B)<br>• Easy to maintain (B)<br>• Instant processing of data (A)<br>• Scalable and extensible (A&B)<br>• Extreme weather conditions components resistance<br>• 24/7 remote monitoring and documentation (A)<br>• Near real-time fire/smoke detection with ML/AI techniques on the edge (A)<br>• It can be used for various purposes not only for fire detection (e.g., area monitoring, plant growth, etc.)<br>• Support decision making/ fire event handling (A&B)<br>• Design through collaboration with end users (A) | • High end hardware (B)<br>• Sensor limited range/capabilities (A)<br>• False positive detections (A&B)<br>• Not real time analysis (B)<br>• Power Supply Independency (A) |
| **Opportunities** | **Threats** |
| • Post-sale service (A&B)<br>• Limited competition (A)<br>• Applicable on various environments (cityscape, indoors, etc.) (A&B)<br>• Technical support and models updates (A)<br>• High interest of community and authorities in firefighting/early fire detection (A)<br>• Collaboration with other AI tools/ Robotics companies (e.g., UGVs, UAVs) (A&B)<br>• Finetuning state of the art models for fire/smoke detection (A&B)<br>• Extensibility of models (multi detection) (B) | • Bad weather conditions (A)<br>• Technological Competitors (A)<br>• Arsonists/Vandalisms (property destruction) (A)<br>• Fire Spread (fire can destroy the IoT) (A)<br>• Hackers can attack the IoT and prevent alerts sending or send fake alerts (A)<br>• Unpredicted/aggressive animal behavior (A)<br>• UxV unavailability (B)<br>• Model limitations (false positives) (B)<br>• Network connectivity limitations (A) |

**Figure 11 UP4a and UP4b SWOT workshop results**[8]

[8] Business Model Canvas for Silvanus - Miro

### *5.1.5 SWOT analysis UP5 UGV monitoring of wildfire behaviour and UAV monitoring of wildfire inspection*

The SILVANUS project's UP5a UGV and UP5b UAV components offer complementary strengths in wildfire management. UP5a excels in real-time ground monitoring and accessing difficult terrains, while UP5b provides rapid, precise aerial inspection with lidar sensors. Both face challenges like battery limitations, data overload, and weather sensitivity, and they depend on network coverage in remote areas.

Their integration enhances opportunities for ecosystem restoration, evacuation route creation, and improved fire protection. Despite threats from severe weather, regulatory changes, security risks, and competition, their combined use facilitates comprehensive wildfire analysis and faster decision-making.

Concluding, the most important advantage of UP5a is its capability to provide detailed, real-time data in difficult terrains, while its weak point is the battery limitation and sensitivity to weather conditions. For UP5b, the key advantage lies in its rapid and precise aerial inspection capabilities, especially in smoky conditions, with the battery limitation and weather sensitivity being the primary weak points. Together, UP5a and UP5b offer a robust, complementary approach to wildfire monitoring and inspection, enhancing the SILVANUS project's overall effectiveness in wildfire management.

| **Strengths** | **Weaknesses** |
|---|---|
| • Real-time monitoring<br>• Efficient response (a&b)<br>• Energy-efficient (b)<br>• UGVs have long battery life and operate in rain/wind/smoke (a)<br>• UGVs can observe undergrowth, and generate detailed sub-canopy maps (a)<br>• Access to difficult areas<br>• Accurate mapping and forest analysis (a)<br>• Multisensor and multi-tasking (multiple functions)<br>• Forest Analytics uses a mapping sensor, so only one sensor needed (a)<br>• LiDAR sensor is better than a camera for penetrating smoke (a) | • Battery limitations<br>• Sensitivity to weather conditions (b)<br>• UGVs can't travel large distances, or see far in a forest (a)<br>• Data overload<br>• Dependency on network coverage in remote areas<br>• Steep slopes limitation |
| **Opportunities** | **Threats** |
| • Ecosystem restoration<br>• Analysis for faster decision making<br>• Creation of evacuation and escape routes (through the platform)<br>• Efficient interdependency of UGVs and UAVs to establish an accurate mapping of the area in a short amount of time<br>• Better fire protection allows for safer positive fire practices, such as burns for undergrowth management<br>• Climate change means fire management will be a growing area of concern. | • Weather conditions<br>• Security risks<br>• Competitors<br>• Regulations<br>• Damaged or destroyed equipment due to weather conditions.<br>• No work yet on ruggedized sensors or heat-proof vehicles (a) |

**Figure 12 UP5a and UP5b SWOT workshop results[9]**

[9] Business Model Canvas for Silvanus - Miro

### *5.1.6 SWOT analysis UP6 Fire spread forecast - modelling*

The UP6 solution is faster than other options, utilizes modern AI algorithms, and handles missing data well, ensuring robust operation. It provides high spatial resolution and near-real-time predictions, requires no expert knowledge to operate, and is integrated into a holistic fire management platform. As weaknesses, the solution relies on high-resolution training data and FlamMap for generating this data, which can be a limitation if data is outdated or not readily available. It also has dependencies on co-design and can only plan a few hours.

On the external side, there are opportunities to enhance the solution by integrating additional routes and fire barriers, adding components for better decision-making, and incorporating them into firefighter training programs to improve practical application and effectiveness. Finally, as threats, the solution faces risks from its dependency on the SILVANUS platform, potential inaccuracies in input data, the emergence of competing solutions, and dependencies on other utility providers, which could affect its performance and adoption.

Highlighting the most relevant aspects, the UP6 solution offers robust and advanced features which makes it a powerful tool for fire management. Its speed, modern AI algorithms, and ability to handle missing data are significant advantages. But also have various weaknesses. It needs to address its dependencies on specific data sources and tools, improve its planning capabilities, and ensure data accuracy. Exploring opportunities for integration with additional fire management resources and training programs will enhance its practical application and effectiveness.

| **Strengths** | **Weaknesses** |
|---|---|
| • Faster than other solutions<br>• Modern AI algorithms<br>• No experts needed<br>• Within Silvanus platform: holistic fire management approach<br>• Handling of missing data for robust operation<br>• High spatial resolution of prediction<br>• High speed (near real-time) prediction | • Dependencies of co-design<br>• Need for high time resolution training data<br>• Data required to run could be outdated (e.g., if "current fire front" is not updated, the prediction will also be outdated)<br>• Currently relies on FlamMap for generation of training data<br>• Plan in advance for just hours<br>• Dependencies on non-readily available data sources |
| **Opportunities** | **Threats** |
| • Adding routes into the model<br>• Adding fire barriers (e.g., firefighter response efforts)<br>• Crucial component to provide an accurate decision-making process for the deployment of technological resources<br>• Integrate with firefighter training program | • Dependency with Silvanus platform<br>• Inaccurate input data<br>• Alternative solution reaches market first<br>• Dependencies with other UPs |

**Figure 13 UP6 SWOT workshop results[10]**

### *5.1.7 SWOT analysis UP7 Biodiversity profile mobile application (woode app)*

The Biodiversity profile mobile application has various strengths such as strong expertise in building AI products and user-centric mobile designs. This allows the application to be easy to use for people of all ages and skill levels. It also has the potential to share knowledge about trees and raise awareness about the threat of forest fires, as the monitoring recovery. However, some weaknesses need to be addressed. For instance, the lack of a market for the application, meaning poor awareness and visibility, and the challenge

[10] Business Model Canvas for Silvanus - Miro

associated with crowdsourced information collection. There are also some external threats such as the existence of competitors with robust training databases and the evolving climate and forest tree species.

The Biodiversity Profile mobile application has the potential to be a valuable tool for raising awareness about biodiversity. However, to be successful, the application will need to address its weaknesses and take advantage of the available opportunities. Some of the opportunities that the application could pursue include obtaining investment to strengthen its carbon storage capabilities and collaborating with human experts to improve the accuracy of the information collected.

Here are some specific conclusions that can be drawn from the SWOT analysis:

- Strengths: Strong foundation in AI and user-centric design, which makes it easy to use and informative.
- Weaknesses: Challenges associated with crowdsourced information collection.
- Opportunities: Can improve its carbon storage capabilities and collaborate with human experts.
- Threats: The application faces competition from other organizations with robust training databases and the threat of a changing climate.

| **Strengths** | **Weaknesses** |
|---|---|
| • Knowledge about forest<br>• Forecast of fire threat<br>• Social community about trees<br>• Stakeholder engagement<br>• Strong expertise in building AI products and user-centric mobile designs<br>• Share knowledge about trees (also as carbon sinks - carbon storage)<br>• Visual communication on the threat of fire<br>• Forecast on forest restoration | • Lack of market share<br>• Challenge to create awareness<br>• Too many tree species to be automatically annotated<br>• Challenge associated with crowd-sourced information collection<br>• Potential faulty information<br>• Learning curve<br>• Involvement of human experts |
| **Opportunities** | **Threats** |
| • Ecological awareness<br>• ESG investment<br>• Climate threat awareness<br>• Lack of competitors<br>• Need for strengthening carbon storage<br>• Information about the environmental resilience of forests (landscape)<br>• Governmental policies on green initiative<br>• New investment opportunities towards Net zero | • Competitors with robust training database<br>• Large organizations in the field of AI<br>• Lack of uptake among the stakeholders<br>• Evolving climate and forest tree species, changing landscape<br>• How to maintain the app<br>• Bad understanding of app use<br>• New products and services being launched (such as ChatGPT)<br>• Lack of knowledge base (or) misinformation being populated in the knowledge base<br>• Abundance of false information – difficult to moderate |

**Figure 14 UP7 SWOT workshop results**[11]

### *5.1.8 SWOT analysis UP8 Citizen engagement application and Citizen application for situational awareness and information sharing*

Both UP8a and UP8b demonstrate considerable potential as foundational components. Shared strengths include adaptability, collaborative functionality, and direct user involvement in wildfire prevention, thereby enhancing public safety. UP8a's user-friendly interface is particularly well-suited for educational purposes, while UP8b's interactive Vector Map and robust infrastructure are key assets. However, external

[11] Business Model Canvas for Silvanus - Miro

dependencies on network operators and software restrictions, coupled with potential human resource constraints, pose challenges to optimal performance.

To maximize the components' impact, opportunities for growth and engagement should be pursued. These include expanding user outreach, fostering inter-component collaboration, and broadening the event reporting and notification capabilities. A vigilant approach to external threats such as low user engagement, network disruptions, and competitive alternatives is essential. Strategic dissemination and exploitation activities can effectively mitigate these risks and drive adoption.

| **Strengths** | **Weaknesses** |
|---|---|
| • Citizen Safety<br>• Strong collaboration component<br>• Users engaged directly with wildfire prevention<br>• Interactive Vector Map (B)<br>• Get context-based (geo, time) relevant information<br>• User-friendly interface (a)<br>• Visually engaging educational tool (A)<br>• Providing user community channel (B)<br>• Customizable for different uses<br>• UISAV: Own infrastructure to run the backend (i.e., building, data center with high bandwidth) | • Dependencies of co-design<br>• Restrictions in modifying software<br>• Dependency on network operators and providers<br>• Potential unreliability of data from citizens<br>• UISAV: More staff (developers, analysts, etc.) needed to develop further<br>• No official channel for fire reporting |
| **Opportunities** | **Threats** |
| • More citizen engagement<br>• The need for relevant information<br>• Collaboration with other UPs or institutes (A & B)<br>• Prevention of forest fires<br>• Organizing events for better visibility<br>• Discovering the most efficient communication techniques between citizens and firefighters<br>• Expand the model of event reporting and notification to other domains<br>• | • Users remain innactive<br>• New competitors rising<br>• 112 number risk – depends on authorities<br>• The information available potentially dated<br>• The willingness of end users to share data<br>• May depend on SILVANUS services – if provided as part of the SILVANUS platform<br>• Low number of users<br>• Network connectivity limitations<br>• Engagement of users in the long-term<br>• Depends on legislation and politics (b) |

**Figure 15 UP8a and UP8b SWOT workshop results**[12]

### *5.1.9 SWOT analysis UP9*

**As the component UP9 is composed of several very different solutions, a separate SWOT is proposed for each of them,** taking out UP9g (Soil erosion index (DSS-SEI)), which does not have a standalone exploitation strategy.

The UP9a Resource allocation of response teams (DSS-RAR) may not have as many strengths as other components, but the advantages are very powerful. This component can be fully customized to match consumer needs and has been already tested and validated by the users, understanding their needs closely with strong technical support.

The component, however, depends on the availability of the communication network and can lack up-to-date data during the incident, which may affect operations or citizen safety, so a more updated version is being delivered.

[12] Business Model Canvas for Silvanus - Miro

For the external factors, is important to monitor all inputs since a threat can be having wrong input data, but also considering legal aspects which may signify a problem. On the other hand, there are huge opportunities to consider as a higher possible interest from users towards worldwide forest fire, since is a trend, but also the fact that there are no other solutions similar in the market allows us to be leaders and understand better the ecosystem.

| **Strengths** | **Weaknesses** |
|---|---|
| • Fully customized<br>• Supports interoperability<br>• Designed with end-users<br>• Already validated<br>• Technological know-how | • Current version depends on information availability about the positioning of resources<br>• Availability of communication network<br>• Potential lack of up-to-date data during the incident |
| **Opportunities** | **Threats** |
| • No similar product in the market<br>• Worldwide interest in forest fire<br>• High interest in forest fire suppression<br>• Visualization of recommendations<br>• Direct live recommendations | • Users remain innactive<br>• Wrong input data (fire spread, resource positioning)<br>• Legal + operational framework (rather fragmented) |

**Figure 16 UP9a SWOT workshop results[13]**

The Health Impact Assessment (DSS-HIA) - UP9b component demonstrates strong foundational capabilities, including real-time data processing, operational independence for pilot testing, continuous data transmission, and wireless network compatibility. Advanced health monitoring, university-backed research, and open-source licensing further enhance its potential for customization and adaptability.

However, technical challenges such as data integration complexity, scalability limitations, external data dependencies, and specialized personnel requirements must be addressed.

Opportunities for enhancement include the integration of machine learning for air quality prediction, the implementation of federated learning to bolster security, and deeper integration within the SILVANUS platform to expand functionality and user engagement.

Potential external threats encompass challenges related to large-scale implementation, regulatory compliance, stakeholder alignment, and data quality and availability.

| **Strengths** | **Weaknesses** |
|---|---|
| • Real-time<br>• No dependencies for pilot testing<br>• Constant data transmission<br>• Wireless network<br>• Advanced Health Monitoring Capabilities<br>• Open-source licensing<br>• University-backed Research and Development | • Integrating diverse data sources is technically complex<br>• Scalability challenges<br>• Dependency on External Data<br>• Specialized personnel needed |
| **Opportunities** | **Threats** |
| • Implementation of ML algorithms for the predictive analysis of air quality<br>• Incorporation of federated learning for security<br>• Integration with the SILVANUS platform<br>• | • Challenges in extensive implementation<br>• Regulatory and compliance risks<br>• Stakeholder coordination<br>• Data availability and quality<br>• Delays or failures in the technology development process |

**Figure 17 UP9b SWOT workshop results[14]**

[13] Business Model Canvas for Silvanus - Miro

[14] Business Model Canvas for Silvanus - Miro

The Evacuation route planning DSS-ERP component of SILVANUS exhibits various strengths, compared with the rest of the SWOT, that make it a valuable tool in emergencies. It saves time and resources, provides effective and safe routes, and determines optimal departure delays. The communication of outcomes through SAL and RESTful APIs, combined with comprehensive route planning and a smoke dispersion feature, further enhance its utility. Its open-source nature also ensures cost-effectiveness and accessibility. DSS-ERP also faces a few weaknesses. Dependency on external data sources, lack of a multi-model system, and increased complexity due to managing and integrating diverse data types and models may need to be mitigated to get a better market position.

Opportunities include improving the interface, promoting it to reach a wider audience, partnering with other tech providers and research institutions, and expanding its use to other regions and disaster types. Threats to consider are dependencies within SAL, environmental unpredictability, competitors' advantages, and data privacy concerns.

In conclusion, DSS-ERP is a powerful solution for emergency evacuation planning, offering real-time, effective, and safe routing with comprehensive planning features. Addressing its dependencies on external data and enhancing its system complexity management will be crucial.

| **Strengths** | **Weaknesses** |
|---|---|
| • Save time/resources during emergencies<br>• Communication of outcomes through SAL and RESTful APIs<br>• Determination of optimal departure delay<br>• Effective and safe routes<br>• Open-source: cost effective and accessible<br>• Smoke dispersion feature<br>• Comprehensive Route Planning | • Dependency on external sources for data<br>• Not a Multi-model system<br>• Managing and integrating diverse data types and models increases system complexity |
| **Opportunities** | **Threats** |
| • Improvements in interface<br>• Promotion opportunities to reach a wider audience<br>• Partnerships with other tech providers and research institutions<br>• Expand solution for other regions<br>• Broadening its utility for other disasters like floods and earthquakes | • Challenges in extensive implementation<br>• Dependencies with SAL<br>• Environmental unpredictability<br>• Competitors advantages<br>• Data Privacy Concerns |

**Figure 18 UP9c SWOT workshop results[15]**

The UP9d Ecological resilience index (DSS-ERI) user-friendly design, online support, data integration, and cyber resilience are clear strengths. on the other hand, the system may lack customization and incur high infrastructure costs, with additional expenses for in-person assistance.

Opportunities lie in the growing demand for ecological solutions and potential market expansion. Strong customer relationships can be fostered through this valuable tool. Yet, keeping pace with technological advancements and facing competition from established providers are ongoing challenges.

Overall, UP9d need to monitor its dependency on data and try to address the complexity of the system, to avoid other competitors from reaching out to interested users.

[15] Business Model Canvas for Silvanus - Miro

| Strengths | Weaknesses |
|---|---|
| • Online support<br>• Data Integration and Visualization<br>• User-Friendly, with clear and simple charts<br>• Computers resistent to cyber attacks<br>• Convert raw data into desired variables value<br>• Spatio-temporal analysis of forest condition | • Low customization<br>• Personal assistance is costly due to travel<br>• High Infrastructure Costs |
| **Opportunities** | **Threats** |
| • Market expansion<br>• Increased Demand for Ecological Solutions<br>• Enhanced Customer Relationships | • Technological Changes: Rapid advancements in remote sensing and data processing technologies<br>• High operational and infrastructure costs<br>• Competition from established solutions |

**Figure 19 UP9d SWOT workshop results[16]**

The Continuous monitoring of rehabilitation strategy index (UP9e) DSS-CMRSI component exhibits remarkable adaptability, accommodating a diverse spectrum of rehabilitation strategies. This flexibility empowers organizations to tailor monitoring processes to their unique requirements. The system's real-time monitoring capabilities provide timely data and insights, facilitating informed decision-making and adaptive rehabilitation strategies. Moreover, the DSS-CMRSI's global applicability positions it as a potential solution for a wide range of stakeholders.

Nevertheless, successful implementation hinges on the effective deployment and integration of UP9e. The system's performance is intrinsically linked to data quality, necessitating robust data management practices. Additionally, fostering user adoption and a comprehensive understanding of the system's capabilities are critical factors influencing its overall impact.

By acknowledging and addressing potential challenges related to implementation complexity, data dependence, and user training, the DSS-CMRSI can truly stand out as a powerful tool for optimizing rehabilitation strategies.

| Strengths | Weaknesses |
|---|---|
| • Continuous monitoring<br>• Advanced predictive capability<br>• Real-time monitoring<br>• Integration with other systems<br>• Global applicability | • Only available for English-speaking countries<br>• User training requirements<br>• Depends on the quality and availability of meteorological data<br>• High initial setup costs |
| **Opportunities** | **Threats** |
| • Evaluation of the Index in the pilot areas<br>• Collaboration with Meteorological agencies<br>• Considers ecological and socio-economic recovery<br>• Policy integration | • Data privacy and security concerns<br>• Unpredictable climate patterns due to climate change<br>• New competitors |

**Figure 20 UP9e SWOT workshop results[17]**

The UP9f Biodiversity Index Calculation (DSS-BIC) component offers a distinctive solution to calculate the landscape biodiversity. The component stands out by its unique solution, offering a valuable, data-driven tool for biodiversity monitoring that is both easy to use and actively engages stakeholders. This combination positions it well in the market.

[16] Business Model Canvas for Silvanus - Miro
[17] Business Model Canvas for Silvanus - Miro

However, its reliance on data is a potential weakness. The effectiveness of the tool is tied to the availability and quality of data, which could be a risk if data sources are insufficient. Additionally, the cost of personal assistance may hinder broader adoption, particularly for smaller organizations with limited resources.

The opportunities are significant, especially with continuous monitoring and the integration of machine learning to enhance predictive capabilities. Engaging new customers can also drive growth and expand the tool's reach. Yet, threats like data provisioning issues and the need for large-scale storage must be carefully managed to ensure the tool remains viable at scale.

| **Strengths** | **Weaknesses** |
|---|---|
| • Unique solution<br>• Simple and easy to use<br>• Quantitative analysis<br>• Active engagement with stakeholders | • Too dependent on data<br>• Personal assistance is expensive |
| **Opportunities** | **Threats** |
| Continuous monitoring<br>• Machine learning to predict<br>• Causal relationships<br>• Engage with new possible customers | • Data provisioning<br>• Storage (big fields) |

**Figure 21 UP9f SWOT workshop results**[18]

The SWOT for the Integrated Data Insights component reveals both the strengths and areas needing improvement, considering more positives than negatives in the overall framework. UP9h has a user-centered approach and is adaptable to the stakeholder's needs which ensures the tool's relevance and usability.

Nevertheless, is important to mention that the main weakness is its lack of reliable data which may bring broader margin errors when conducting an analysis. Is important to check coming information to avoid false results.

Opportunities come from the hand of the weather conditions and the fire season where the component can be proven but can be also a threat that can't be controlled. As rising technologies and a competitive environment can be another threat is crucial to be aware of last innovations and try to keep up with updates to deliver the best to users.

| **Strengths** | **Weaknesses** |
|---|---|
| • Software proprietary<br>• Adaptability<br>• Explainable easily<br>• User-centered approach<br>• Uniqueness | • Lack of reliable data<br>• Unique point of reference |
| **Opportunities** | **Threats** |
| • Fire season<br>• Climate change | • Changing technologies<br>• Manipulated data |

**Figure 22 UP9h SWOT workshop results**[19]

UP9i component, focused on Priority Resource Allocation based on Forest Fire Probability, highlights its strengths in being easy to use, flexible, and versatile, with broad audience appeal. It effectively integrates remote sensing technology, considering around 14 variables as part of the complete analysis, and provides timely wildfire alerts, enhancing proactive resource management. However, the component's dependence

[18] Business Model Canvas for Silvanus - Miro
[19] Business Model Canvas for Silvanus - Miro

on costly social media subscriptions and data poses financial and reliability challenges, alongside a lack of established customer relationships.

Opportunities lie in providing standardized data models and diversifying revenue streams, which can boost its functionality and financial health. Yet, it faces threats from a competitive market, economic instability, and potential regulatory changes affecting social media data access.

To mitigate these risks, UP9i can diversify its data sources, reduce reliance on social media, and strengthen customer relationships, ensuring resilience and sustained effectiveness.

| **Strengths** | **Weaknesses** |
|---|---|
| • Easy to use<br>• Flexible & versatile<br>• Broad target audience<br>• 14 variables considered<br>• Remote sensing technology<br>• Early information on fire occurrences, facilitating proactive resource allocation<br>• Focus on speed: rapid wildfire email alerts | • Costly subscriptions to social media<br>• Dependencies on social media<br>• Lack of established customer relationships |
| **Opportunities** | **Threats** |
| • To provide standardized data models<br>• Diversification of revenue streams | • Competitive landscape<br>• Economic instability<br>• Regulations for social media |

**Figure 23 UP9i SWOT workshop results[20]**

The multilingual forest fire alert system is a robust and versatile platform with significant strengths. Its ability to send real-time notifications and provide early warnings across multiple languages makes it highly accessible and effective. Advanced detection technology and integration with social media ensure that users receive timely alerts, while the partnership with AWS adds reliability and scalability without requiring additional investment. On the other hand, the system's reliance on internet connectivity and third-party data presents potential weaknesses. Limited fire location data may reduce the accuracy of alerts, and the need for personal assistance could become a cost barrier for broader adoption, particularly in areas with limited resources.

The growth opportunities are considerable. By expanding data sources and integrating new technologies, the system can improve its accuracy and reach. A subscription model could also offer a sustainable revenue stream, ensuring long-term viability. Partnering with organizations that provide fire probability information could further enhance the system's predictive capabilities. Threats such as disruptions on social media platforms and the spread of false information pose risks and undermine the system's credibility if not properly addressed.

| **Strengths** | **Weaknesses** |
|---|---|
| • Notifications to users<br>• Real-time early warning<br>• System supports multi-language<br>• Advanced detection technology<br>• Integration with social media<br>• No additional investment needed<br>• Partnership with AWS | • Depend on internet connection<br>• Personal assistance requirement<br>• Limited fire location data<br>• Third-party data dependency |
| **Opportunities** | **Threats** |
| • Fire probability information from partners<br>• Integration with new technologies<br>• Subscription model implementation<br>• Data source expansion | • Issues with social media platforms<br>• False information in posts/tweets |

[20] Business Model Canvas for Silvanus - Miro

**Figure 24 UP9j SWOT workshop results[21]**

The SWOT analysis for the Deep Learning Model for Wildfire Severity Prediction using EO4Wildfires (UP9k) highlight many strengths related to its user interface which is not only an open-source resource easily accessible via API but also does not require a difficult installation. On the technological part, it helps accurate predictions from its deep learning modelling system, among other powerful tools. On the negative, they need to manage expensive costs and continue to mature is developments since they are at an early stage, which can also be an opportunity for improvements, delivering better Disaster management. External collaborations with government environmental agencies can be an advantage too. Is important to search for funding and monitor the market to get ahead of competitors. And is also key to make efforts to build a user community interest in the solution.

| **Strengths** | **Weaknesses** |
|---|---|
| • Targeted user interface<br>• Accessibility via API<br>• Deep Learning Modeling<br>• Open access license<br>• Improved effectiveness of wildfire prevention measures<br>• Indicator of size & shape of expected damage area<br>• Accessible and usable without complex installation<br>• Accurate predictions | • Early stage of development<br>• Limited customer base<br>• Cost structures can be expensive |
| **Opportunities** | **Threats** |
| • Reduction of damages and costs from wildfires<br>• Improved Disaster Management<br>• Meteo experiment improvements<br>• Continuous Improvement and Integration<br>• Collaboration with Government and Environmental Agencies | • Low awareness<br>• Technological advancements by competitors<br>• Model Accuracy Limitations<br>• Funding Instability |

**Figure 25 UP9k SWOT workshop results[22]**

For the UP9l solution of Sibyla, just a few insights were considered in the SWOT analysis. The strengths represent the robust side of the analysis which means more benefits compared to threats and weaknesses. Most strengths rely on their developments and state of the art technology, which allow analysis and testing of various measures at the same time. It includes various processes as can be tree competition. The solution has laser scanning features as well as 3D mapping and VR outputs. The only weakness to be aware of is that it needs an expert to understand how is used and manual installation onsite, which are not that relevant compared with the various benefits provided.

As external factors, achieving a wider base of trained users and keeping an eye on new competitors are the insights to be analyzed.

| **Strengths** | **Weaknesses** |
|---|---|
| • 3D mapping<br>• Laser scanning feature<br>• Virtual reality output<br>• User can remove objects in VR<br>• Various processes included (e.g., tree competition)<br>• Different modules<br>• Analysis and testing various measures | • Manual installation onsite<br>• Need an expert or training to understand how to use |

[21] Business Model Canvas for Silvanus - Miro
[22] Business Model Canvas for Silvanus - Miro

| Opportunities | Threats |
|---|---|
| • Training for new stakeholders | • New similar solutions may arise |

**Figure 26 UP9l SWOT workshop results[23]**

### *5.1.10 SWOT analysis UP10 SILVANUS forward command centre*

The SILVANUS forward command center component presents a promising foundation with a blend of strengths and challenges. Its user-friendly interface, accessibility, real-time capabilities, scalability, and adaptability are notable assets. These characteristics position the component as a potentially versatile and efficient tool. However, the underlying technological complexity can create barriers to entry for some users and introduce potential vulnerabilities. Moreover, while scalable, the system may encounter limitations when expanding its capacity without compromising performance.

Opportunities for growth lie in strategic partnerships, technological advancements, and market expansion. However, the component faces significant external threats, including cybersecurity risks, stakeholder resistance, and environmental uncertainties. To mitigate these challenges, robust security protocols, comprehensive change management strategies, and continuous monitoring are imperative. By proactively addressing these factors, the SILVANUS forward command center can optimize its performance and achieve its full potential.

| Strengths | Weaknesses |
|---|---|
| • Not reliant on SILVANUS cloud<br>• Easy to use<br>• Access from any device<br>• Real-time data access<br>• Can be tailored to meet the specific needs<br>• Scalability | • Complexity, due to sophisticated technology<br>• Dependence on technology<br>• Scalability issues |
| **Opportunities** | **Threats** |
| • Public-Private Partnerships<br>• Technological advancements<br>• Expansion to new markets | • Cybersecurity risks<br>• Resistance from stakeholders to change<br>• Environmental changes |

**Figure 27 UP10 SWOT workshop results[24]**

### *5.1.11 SWOT analysis UP11 SILVANUS platform and dashboard*

Based on the SWOT analysis for the UP11 SILVANUS platform and dashboard, the strengths of the platform include a user-friendly interface, easy access to specialized and unique SILVANUS datasets, a robust communication system, flexibility for customization, and the possibility of creating instant ad-hoc networks with mesh capability. Overall, these benefits, it also represents a cost-effective solution for users who can find different solutions included in a single space. However, some weaknesses need to be addressed, such as complex deployment architecture and reliance on external data sources, as well as market limitations due to diverse reasons such as geographic location.

An important opportunity to consider is the increasing role of data and data processing, which could lead to increased interest in SILVANUS among potential users. A potential threat is the project ending and users having to look for alternative solutions from different fields of expertise.

In general, the UP11 SILVANUS platform and dashboard are crucial since allow the integration of the different User products/solutions of the project in a single platform to create one unique space where users can find various components and benefits related to wildfire management.

[23] Business Model Canvas for Silvanus - Miro
[24] Business Model Canvas for Silvanus - Miro

| Strengths | Weaknesses |
|---|---|
| • Flexibility<br>• Customization<br>• Access to specialize and unique SILVANUS data set<br>• Low entry level for new users<br>• User-friendly interface - Interactive, easy to use<br>• Targeted communications | • Dependence on UP providers' data<br>• Specialized vs. generic<br>• Complex deployment architecture<br>• Reliance on external data sources<br>• Complex maintenance |
| **Opportunities** | **Threats** |
| • Access to wide variety of potential users<br>• Customization and modular solutions<br>• Increasing role of data and data processing<br>• Increase interest in SILVANUS among potential users<br>• Increasing awareness and training | • Project ending (vs. access to data)<br>• Other, more specialized solutions from different fields of expertise of UPs<br>• Budget constraints<br>• Cybersecurity risks |

**Figure 28 UP11 SWOT workshop results[25]**

### *5.1.12 SWOT analysis UP12 MESH in the sky*

Analyzing the SWOT for UP12, the strengths of the MESH in the Sky component, include robustness due to COFDM modulation with turbo coding, lightweight and small physical dimensions for integration, and flexibility and future-proof solutions through customizable and operational licensed and unlicensed frequency bands. On top of this offers a better cost than competitors meaning a huge advantage.

However, there are also weaknesses to consider. The MESH solution depends on hardware components from external suppliers, which creates a hardware dependency and market limitation.

An opportunity to explore is the expansion to emergency services, which could leverage the existing hardware platform. A potential threat is the emergence of new competitors with better prices, especially during economic downturns. This could be mitigated by staying updated with technological advancements and incorporating new waveforms into the existing hardware platform.

In conclusion, the UP12 component has strengths that make it a robust and future-proof solution. By addressing the hardware dependency and staying updated with technological advancements, it can mitigate potential threats and expand into new markets.

| Strengths | Weaknesses |
|---|---|
| • Robust communications due to use of COFMD modulation with turbo coding<br>• Light weight and small physical dimensions for integration of payload<br>• Flexible, customizable, and futureproof solution<br>• Operational in licensed and unlicensed frequency bands<br>• Create instant ad-hoc networks with mesh capability<br>• Lower cost compared to competition<br>• Proprietary technology<br>• Cost-effective | • Depends on hardware components from external suppliers<br>• Hardware dependency<br>• Market limitation |
| **Opportunities** | **Threats** |
| • Expansion to emergency services<br>• Global market<br>• Future proved as new waveforms could be added to the same hardware platform | • New competitors with better prices<br>• Budget constraints and economic downturns could impact<br>• Technological obsolescence |

[25] Business Model Canvas for Silvanus - Miro

| | |
|---|---|
| • Technological advancements<br>• Feedback from end users for improvements | |

**Figure 29 UP12 SWOT workshop results[26]**

The SILVANUS project's components demonstrate a strong foundation for addressing wildfire risk management challenges. The comprehensive SWOT analysis reveals a collection of solutions characterized by innovation, adaptability, and a user-centric approach. Core strengths include intuitive interfaces, customizable features, and the integration of real-time data to inform decision-making. For instance, components such as UP1 and UP9a excel in tailoring solutions to specific user requirements, while UP10 and UP11 provide accessible platforms for command and control. Additionally, the synergistic combination of aerial and ground-based systems, as exemplified by UP5, offers a comprehensive approach to monitoring and response.

However, the realization of the project's full potential is contingent upon addressing inherent challenges. Dependencies on external data, substantial resource requirements, and technological complexities can hinder scalability and broader adoption. Overcoming these obstacles will be crucial for ensuring the long-term success of the SILVANUS components.

To maximize the project's impact, strategic opportunities must be capitalized upon. Public-private partnerships, market expansion, and technological advancements present avenues for growth and innovation. Components like UP12 and UP9i exemplify the potential for expanding into new domains and enhancing predictive capabilities.

Mitigating external threats such as competition, cybersecurity risks, and regulatory challenges is essential for safeguarding the project's achievements. Implementing robust security measures, fostering strong stakeholder relationships, and adapting to evolving regulatory landscapes are critical to the project's sustainability.

In conclusion, the SILVANUS project offers a promising foundation for addressing wildfire risk management. By leveraging its strengths, addressing weaknesses, seizing opportunities, and mitigating threats, the project can establish a leading position in the field. Continuous improvement, focused on user needs, technological advancements, and market dynamics, will be instrumental in achieving long-term success.

## 5.2 PESTEL Analysis

A PESTEL analysis is a strategic tool used to examine the macro-environmental factors that can significantly influence and impact, in this case, the SILVANUS project. It stands for Political, Economic, Social, Technological, Environmental, and Legal factors (Research A. , 2024).

Conducting a PESTEL analysis is crucial for the SILVANUS project as it provides a comprehensive understanding of the external factors that may influence its success. By leveraging this analysis, SILVANUS can make informed decisions, capitalize on opportunities, mitigate risks, and ultimately, maximize its impact in the market.

- By identifying potential opportunities and threats, SILVANUS can develop effective strategies for exploitation and ensure long-term sustainability.
- SILVANUS can identify emerging trends, market opportunities, and areas for growth. For example, by recognizing increasing end-user awareness of sustainability and care for environmental causes.

[26] Business Model Canvas for Silvanus - Miro

- By aligning its strategies with external opportunities and mitigating risks, SILVANUS can drive innovation and create positive social and environmental outcomes.

### *5.2.1 Political Factors*

- **EU regulations and policies**: The SILVANUS project benefits from favourable EU regulations and policies promoting sustainability and innovation, such as the European Green Deal [27], the Horizon Europe program, the Biodiversity Strategy[28] and the Nature Restoration Law[29]. The European Green Deal outlines the EU's ambition for a climate-neutral future. Wildfire management is a key aspect of achieving this goal. By contributing to reduced wildfire risks and improved forest health, SILVANUS directly aligns with the Green Deal's objectives. This alignment strengthens the project's credibility and demonstrates its positive impact on environmental sustainability. These policies provide funding opportunities and support for projects aligned with EU priorities, enhancing SILVANUS' credibility and impact.

- **Political/government stability** (Group, 2024): For long-term success, the project results require political stability in its operational countries. This ensures continuity in funding and consistent regulatory support. Proactive monitoring of political developments and building partnerships with stable institutions can help mitigate risks associated with political instability. While external factors may exist beyond immediate control, staying informed on political shifts can be crucial.

- **Leveraging trade agreements:** EU trade agreements present opportunities for SILVANUS to expand internationally and foster collaboration. These agreements facilitate market access for SILVANUS's products and services.[30] While navigating trade barriers and tariffs isn't a current focus, understanding these aspects can help capitalize on global opportunities more effectively.

- **Collaborative governance:** Effective wildfire management requires a strong foundation of collaboration among relevant government agencies. This includes fire departments, forestry agencies, emergency management organizations, and environmental protection bodies (Nations, 2024). UP developers may need to continue engaging with these stakeholders to implement comprehensive fire risk management strategies and ensure a unified response during wildfire events.
- **Building community resilience and public awareness**: SILVANUS has demonstrably considered existing government initiatives for community engagement in wildfire prevention and preparedness. Public education campaigns, community outreach programs, and wildfire risk assessment tools are all crucial aspects. Through participation in various events, SILVANUS has actively contributed to enhancing community resilience, raising public awareness about wildfire risks, and promoting sustainable land management practices. (Watch, 2024)

- **Advocating for change:** Assessing and understanding the political will and support for addressing wildfire risks at various levels is key. This includes the commitment of political leadership to allocate resources, implement policy reforms, and support innovative approaches. (Institute, 2023) In

[27] European Green Deal - Consilium (europa.eu)
[28] EU Biodiversity Strategy | Knowledge for policy (europa.eu)
[29] The EU #NatureRestoration Law (europa.eu)
[30] https://www.intracen.org/

building relationships with policymakers and demonstrating the social, economic, and environmental benefits of proactive wildfire management, SILVANUS can advocate for policy changes and investments in wildfire resilience measures.

### *5.2.2 Economic Factors*

- **Capitalizing on market trends**: The growing demand for sustainable solutions presents a significant opportunity for SILVANUS. When closely monitoring market dynamics and adapting offerings to meet evolving consumer needs, the project can maintain a competitive advantage.

- **Balancing innovation and cost-effectiveness:** SILVANUS offers innovative solutions with significant benefits for wildfire management. However, the potential cost compared to traditional methods may be a barrier. Careful pricing is essential to ensure the solutions provide value while remaining competitive.[31] This requires balancing development, implementation, and maintenance costs against the long-term benefits and cost savings SILVANUS can deliver.

- **Market saturation and competitive landscape**: The increasing number of competitors in the wildfire risk management sector[32] creates a competitive environment. Understanding the strengths and weaknesses of rival offerings, including both traditional and emerging technologies, is crucial. SILVANUS must differentiate its solutions to stand out in the market.

- **Increasing economic impacts of wildfires**: Over recent years, the economic impacts of wildfires have dramatically increased. These impacts affect various stakeholders, including insurance companies, individual households, humanitarian organizations, governmental authorities, and investors (Lüthi, Aznar-Siguan, Fairless, & Bresch, 2021). The destruction caused by large fires results in substantial costs for relief, prevention, firefighting, and recovery efforts. This financial strain underscores the need for effective wildfire management solutions like those offered by SILVANUS.

- **Market penetration and commercialization:** While SILVANUS has developed innovative products and solutions for wildfire risk management, there can be more emphasis on market penetration and commercialization strategies. Economic success hinges not only on the development of cutting-edge technologies but also on effectively bringing these products to market and generating revenue.[33] This involves conducting thorough market research, implementing effective marketing strategies, building robust sales channels, and establishing partnerships to increase product adoption.
- **Funding opportunities:** SILVANUS benefits from EU funding sources like Horizon Europe and ESIF. By effectively positioning its solutions to meet funding criteria and demonstrating their economic viability, the project can secure additional financial support to drive growth and impact.

### *5.2.3 Social Factors*

- **Growing market - consumer awareness**: Increasing consumer interest in sustainability and eco-friendly solutions presents a favorable market backdrop for SILVANUS. By effectively

[31] https://www.mckinsey.com/
[32] https://www.grandviewresearch.com/
[33] https://www.cbinsights.com/

communicating the environmental benefits of our products and services, we can stimulate demand. Furthermore, heightened public concern about wildfires can drive increased adoption of advanced wildfire management solutions.

- **Demographic shifts and market segmentation and trends:** Demographic shifts, such as urbanization and population aging, influence market segmentation and product localization for SILVANUS. As populations grow, more people live in or near wildland areas, creating what is known as the Wildland-Urban Interface (WUI) (Hammer, Stewart, & Radeloff, 2009); where human settlements meet wildfire-prone areas - presents both challenges and opportunities. SILVANUS' products address specific demographic needs within this context. Population growth has contributed to the emergence of the WUI, leading to increased wildfire risk in these interface areas.

- **Community engagement**: Strong community engagement is vital for project success and acceptance. SILVANUS fosters open communication and continuously involves stakeholders in decision-making, to build trust and support. This has been done in different dissemination events, involving different consortium partners, resulting in a wider base of interested users in SILVANUS components.

- **Talent development:** A skilled workforce is essential for implementing and scaling SILVANUS solutions. Investing in training and capacity building ensures we have the talent necessary to drive project success. All partners involved have effective representatives, and experts in their fields which makes it easier to ensure knowledge transfer to the community and positive reactions to SILVANUS results.

#### *5.2.4 Technological Factors*

- **Innovation and advancements** (Carta, y otros, 2023)**:** It is important to consider technological innovations and advancements relevant to SILVANUS' user products. Improvements in AR and VR, IoT devices, and UAVs/UGVs leverage remote sensing and improvements in automation, navigation, and data processing. This ultimately helps to improve decision-making.

- **Digital transformation:** By embracing digital transformation and its continuous evolution, we can transition from simply battling wildfires to effectively managing them.
    - Sensor networks, satellite imagery, and real-time data analytics now enable early fire detection, prediction of fire behaviour, and proactive risk assessment.
    - Cloud-based platforms and secure communication networks are essential for efficient wildfire management. These technologies facilitate seamless information sharing among firefighters, emergency responders, and communities, enabling faster decision-making and coordinated responses.

  While challenges such as data integration, cybersecurity, and equitable technology access persist, advancements in artificial intelligence, the Internet of Things, and immersive technologies hold immense potential to enhance wildfire response capabilities.

- **Competitive analysis:** Understanding how competitors leverage technology is crucial for identifying opportunities and threats. By staying abreast of technological advancements in firefighting, emergency response, and citizen engagement, SILVANUS can maintain a competitive edge.

- **Data security and data protection:** As technology collects and processes sensitive data, robust security measures and strict adherence to privacy regulations are paramount. Protecting user data is essential for building trust and ensuring legal compliance.

- **Research and development (R&D) – driving innovation:** EU funding supports SILVANUS' research and development efforts, fostering collaboration among diverse experts. This enables exploration of new technological approaches, prototyping, and real-world testing. By investing in R&D, SILVANUS can develop innovative, scalable solutions with commercial potential.

- **Collaboration and strategic partnerships:** Collaborations with academic institutions, research organizations, technology providers, and industry stakeholders accelerate technology development and enhance project impact. Knowledge sharing and access to specialized expertise through partnerships are key to addressing complex wildfire management challenges.

- **Capacity building and skills development:** SILVANUS offers training programs, workshops, and knowledge-sharing events to empower stakeholders with the skills and knowledge needed to adopt and utilize innovative technologies effectively. Empowering stakeholders with the skills to adopt and utilize innovative technologies is vital for long-term success. Through training programs and knowledge-sharing initiatives, SILVANUS fosters a skilled workforce and supports sustainable development in wildfire-prone regions.

#### *5.2.5 Environmental Factors*

- **Climate change:** The increasing frequency and intensity of wildfires driven by climate change creates a growing demand for advanced fire management solutions. SILVANUS addresses this critical challenge by offering early detection, improved monitoring, data-driven decision-making, and enhanced communication and coordination capabilities. These solutions are essential for mitigating the impacts of wildfires and protecting lives and property.

- **Land use practices:** Changes in land-use practices (e.g., forestry, agriculture) can influence wildfire risks. Historically, land management practices like intensive logging or widespread conversion of forests to agricultural land can lead to increased fire risk. These practices often leave behind flammable debris or create landscapes with reduced vegetation diversity, which can act like fuel and contribute to faster fire spread. (Geographic, 2024) Additionally, practices like fire suppression in certain areas can lead to a buildup of combustible materials, creating a higher risk for catastrophic wildfires when a fire inevitably ignites. However, land-use practices can also play a role in mitigating fire risks. Techniques like prescribed burns can help manage fuel loads by intentionally burning under controlled conditions, reducing the potential for larger, uncontrolled wildfires later. Additionally, sustainable forestry practices that promote healthy and diverse forests can create a more fire-resistant landscape.

- **Impact on protected areas:** Protected areas are vital for safeguarding biodiversity and ecosystem services. It's crucial to minimize disruptions caused by technology deployment within these sensitive environments. By conducting thorough environmental assessments and collaborating with conservation experts, we can ensure that our actions align with regulations and protect vulnerable ecosystems and species. This involves identifying critical conservation areas, evaluating potential environmental impacts, and implementing mitigation measures. By prioritizing

environmental stewardship, SILVANUS can balance wildfire management goals with the preservation of these invaluable natural resources.

- **Data sharing and environmental monitoring:** Effective data sharing and robust environmental monitoring are essential for understanding and responding to wildfires. Sharing real-time information among government agencies, emergency responders, researchers, and communities fosters collaboration and efficient resource allocation. Advanced technologies like sensor networks, satellite imagery, and GIS provide valuable insights into fire behavior, ecosystem health, and air quality. SILVANUS harnesses these tools to collect, analyze, and disseminate data, empowering decision-makers to implement proactive prevention strategies, optimize emergency responses, and minimize environmental impacts.

- **Waste management and circular economy:** SILVANUS is committed to minimizing our environmental footprint throughout the product lifecycle. We prioritize waste reduction, recycling, and circular economy principles in our operations and product design. By working closely with stakeholders and complying with regulations, we strive to implement sustainable waste management practices. This includes exploring opportunities for reusing and recycling materials, reducing waste generation, and promoting resource efficiency. Through these efforts, SILVANUS contributes to a circular economy and demonstrates our dedication to environmental responsibility.

### *5.2.6 Legal Factors*

- **GDPR compliance:** Given the extensive use of data, including environmental sensors, CCTV, and multi-spectral imaging, the SILVANUS project monitors the subject to comply with the General Data Protection Regulation (GDPR) in the EU. Ensuring that all collected data is handled with appropriate consent, security measures, and privacy protections is crucial.

- **IPR:** The development of new technologies and software within SILVANUS necessitates clear agreements on intellectual property rights (IPR). This includes patents for new detection tools, algorithms, and software solutions, ensuring that innovations are legally protected and that ownership rights are clearly defined among the consortium partners. The IPR management is being monitored and the UP owners have ongoing discussions on the ownership of each result to have a clear understanding of IPR.

- **Regulatory compliance for UAVs and ground robots:** The use of unmanned aerial vehicles (UAVs) and ground robots in wildfire management must adhere to strict national aviation and robotics regulations. These include guidelines for airspace usage, safety protocols, and operational restrictions.[34] Ensuring compliance, we guarantee the safe integration of these technologies into emergency response operations and prevent legal issues.

- **Environmental compliance** SILVANUS is committed to sustainable practices. Our activities must align with national and international environmental regulations, including those governing forest

[34] https://www.icao.int/

management, conservation, and restoration. By adhering to these laws, we can ensure that our interventions are environmentally responsible and contribute to long-term sustainability.

- **Navigating international legal frameworks:** SILVANUS operates on an international scale, with partners from Europe, Brazil, Indonesia, and Australia, requiring us to navigate diverse legal systems. The project has to comply with international agreements on climate action and disaster management. A deep understanding of these legal frameworks and bilateral agreements[35] is essential for smooth cross-border collaboration and project execution and has been continuously monitor in the project's lifespan.

### *5.2.7 PESTEL analysis conclusions*

After identifying political, economic, social, technological, environmental, and legal aspects and analyzing the different variables within the PESTEL, the results were categorized considering which are more important to the SILVANUS project and the ones are not that close to its scope. To do so, a table of each variable is provided categorizing each aspect into most relevant (R+), relevant (R), neutral ones (N), irrelevant (I), and most irrelevant (I-), which appears in Table 27

Table 27 PESTEL relevance categorization

| PESTEL CATEGORY | ANALYSIS VARIABLE | CODE | R+ | R | N | I | I- |
|---|---|---|---|---|---|---|---|
| Political | EU Regulations and Policies | P1 | X | | | | |
| | Government Stability | P2 | | | X | | |
| | Trade Agreements | P3 | | X | | | |
| | Joint Coordination | P4 | | X | | | |
| | Community Engagement and Public Awareness | P5 | X | | | | |
| | Political Will and Support | P6 | | | | X | |
| Economic | Market trends | E1 | X | | | | |
| | Cost Considerations | E2 | X | | | | |
| | Market Saturation and Competition | E3 | | | X | | |
| | Increasing Economic Impacts of Wildfires | E4 | X | | | | |
| | Market Penetration and Commercialization | E5 | | | | X | |
| | Funding Opportunities | E6 | X | | | | |
| Social | Consumer Awareness | S1 | X | | | | |
| | Demographic Trends | S2 | | X | | | |
| | Community Engagement | S3 | X | | | | |
| | Workforce Skills | S4 | | X | | | |
| Technological | Innovation and Advancements | T1 | X | | | | |
| | Digital transformation | T2 | | X | | | |
| | Competitive Landscape | T3 | | | X | | |
| | Data Security and Privacy | T4 | | X | | | |
| | Research and Development (R&D) | T5 | | X | | | |
| | Collaboration and Partnerships | T6 | | | X | | |
| | Capacity Building and Skills Development | T7 | X | | | | |
| Environmental | Climate change | EN1 | X | | | | |
| | Land use practices | EN2 | X | | | | |
| | Impact on protected areas | EN3 | | X | | | |

[35] https://unfccc.int/

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Data sharing and Environmental monitoring | EN4 | | | X | | |
| | Waste management | EN5 | | | | | X |
| Legal | GDPR Compliance | L1 | | | X | | |
| | IPR | L2 | X | | | | |
| | Regulatory compliance for UAVs & Ground Robots | L3 | | X | | | |
| | Firefighter Training and Safety | L4 | X | | | | |
| | Sustainable Practices | L5 | X | | | | |
| | Cross-Border Collaboration | L6 | X | | | | |

The table results yielded an interesting overview of all aspects analyzed within the PESTEL matrix. Almost half of the results are positioned as most relevant (R+) for the SILVANUS project which indicates a well-established correlation with the analysis done and the scope of the project, but also let us see that in the economic and legal aspects, market growth and compliance with regulations, analysis of IPR (respectively) are aspects to be continued monitoring.

The relevant aspects also symbolize a very strong part of the results, with nine matches, especially over technology criteria, which indicates the crucial efforts to be continued in digital transformation, innovation, and R&D aspects, overall.

The neutral aspects refer to variables that are not the most important to consider but are still relevant to SILVANUS work and given the situation, may need to be considered and further developed, as is the case of the competitors. The market until now may not be saturated but is a threat that must be monitored, more in some UPs than others, as shown in the Competitor benchmarking section.

There are a few irrelevant (I), (I-) points to consider since they are more far from SILVANUS scope or are not aspects that the project can control or monitor as changes in laws or waste management but is important to consider all the PESTEL ecosystem and be aware of changes and how may the affect positive or negative SILVANUS results. To better showcase the conclusions the PESTEL relevance aspects are shown in Figure 30.

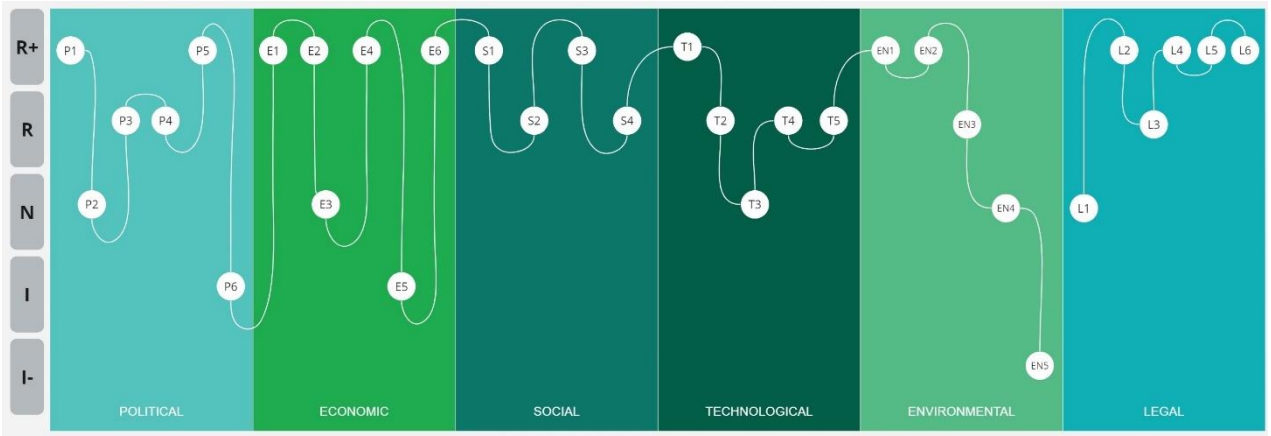


**Figure 30 PESTEL relevance graphic**

# 6 Market trends and future outlook

## 6.1 Environmental and Sustainability trends

### *6.1.1 Environmental and Sustainability Trends at European and Global Levels*

The European Green Deal sets ambitious goals for the continent. By 2050, Europe aims to achieve climate neutrality, significantly reducing its carbon footprint. A key component of this plan is transitioning to a circular economy, which emphasizes reducing waste and enhancing resource efficiency. The deal also includes a comprehensive biodiversity strategy, targeting the restoration of ecosystems and halting biodiversity loss by 2030 (European Environment Agency (EEA), 2019).

Renewable energy is at the forefront of Europe's sustainability efforts. Investments in wind, solar, and bioenergy are ramping up, with a target to source 32% of energy from renewables by 2030. This shift supports sustainable agriculture, with reforms in the Common Agricultural Policy promoting environmentally friendly farming practices. Precision farming, organic methods, and sustainable land use are prioritized to reduce agriculture's environmental impact (Commission, 2020).

To further drive down emissions, the European Union is expanding its Emissions Trading System (ETS) and implementing carbon pricing mechanisms. These initiatives incentivize businesses to lower their greenhouse gas emissions. Green finance is also gaining traction, with the development of green bonds and sustainable investment frameworks. The EU Taxonomy helps guide investors towards sustainable activities, ensuring their investments support environmental goals (European Environment Agency (EEA), 2019).

Globally, the Paris Agreement is a cornerstone of climate action. It commits nations to limit global warming to well below 2°C, ideally 1.5°C, above pre-industrial levels. Each country sets its own Nationally Determined Contributions (NDCs) to reduce greenhouse gas emissions ((IPCC), 2018).

The United Nations Sustainable Development Goals (SDGs) outline 17 targets for achieving sustainable development by 2030. These goals address a wide range of issues, including poverty, inequality, climate change, and environmental degradation. (United Nations, 2020)

Climate adaptation and resilience strategies are crucial for managing the impacts of climate change. Efforts include building resilient infrastructure and protecting vulnerable communities, with a strong emphasis on nature-based solutions and ecosystem-based approaches (IUCN, 2018).

Corporate sustainability is becoming increasingly important, with companies committing to environmental, social, and governance (ESG) criteria. This trend is accompanied by a growing focus on sustainable supply chain management and responsible sourcing.

Technological innovation plays a critical role in these efforts. Advances in clean technology, renewable energy, and energy efficiency are essential for sustainable development. Additionally, the development of smart cities and sustainable urban planning are helping to create more liable and eco-friendly urban environments. (IRENA, 2020)

### *6.1.2 Environmental and Sustainability Trends in the Fire Protection and Forest Land Management Market.*

A major trend in fire prevention and sustainable forest management is the **shift towards Integrated Fire Management (IFM).** This holistic approach includes prevention, suppression, and post-fire restoration, aiming to maintain ecological balance while reducing fire risks effectively. Increasingly, this strategy involves local communities, promoting community-based fire management programs. By engaging local

stakeholders, these programs build capacity and resilience against wildfires, ensuring that fire prevention and response strategies are sustainable and tailored to the specific needs of the area. (World Bank, 2020)

The IFM approach has been adopted by numerous countries around the world. According to various sources, around 30 countries are actively implementing IFM principles within their national policies and practices. (FAO, 2021) For instance, the Food and Agriculture Organization (FAO) supports the development and implementation of IFM through various initiatives and collaborations. This includes capacity-building workshops and the establishment of the Global Fire Management Hub. (FAO, Report on Sustainable Forestry and Fire Management in the Near East and North Africa, 2019)

Sustainable forest management is being reshaped by **climate-smart practices** designed to enhance carbon sequestration and biodiversity. Key practices include promoting species diversity to boost ecosystem resilience, implementing sustainable harvesting techniques that support continuous forest growth and regeneration, and undertaking forest restoration projects such as reforestation, afforestation, and the restoration of degraded areas to improve forest health and increase carbon storage capacity.

The FSC is present in over 80 countries and has certified over 230 million hectares of forest area globally. PEC's certification systems endorsed in over 50 countries and covers over 330 million hectares globally. Major global corporations are increasingly requiring their suppliers to have FSC or PEFC certification. Moreover, various governments and international organizations endorse and support certification schemes as part of broader sustainability and climate goals. (FSC, 2020)

**Technological advancements** are crucial for enhancing the sustainability of forest management and fire prevention. Key innovations include the use of advanced monitoring systems such as drones, satellites, and remote sensing technologies like LiDAR and infrared imaging. These tools provide detailed data on forest health and enable early detection of fire hazards.

Predictive analytics, powered by artificial intelligence (AI) and machine learning models, are being developed to forecast fire risks and behaviours, allowing for proactive management and resource allocation. These predictive tools allow for more effective planning and resource allocation for fire prevention and suppression. Additionally, the integration of big data analytics with forest management practices enables the processing of vast amounts of information from various sources, leading to more informed decision-making and proactive fire management strategies (Global Fire Monitoring Center (GFMC), 2021).

Additionally, automated fire detection systems, featuring early warning sensors and intelligent surveillance cameras, enable timely interventions, significantly reducing the impact of wildfires. The development of advanced firefighting equipment, such as fire-retardant chemicals and high-efficiency water delivery systems, is improving the effectiveness of fire suppression efforts.

These advanced monitoring systems, the predictive analytics and the automated fire detection systems represent a significant and growing portion of the overall forestry technology market. Combined, they might account for around 25-30% of the market value dedicated to forest management technologies.

The market value of the Advanced Monitoring Systems is estimated at around €10-15 billion with a Global Market Percentage of approximately 25-30%. The market value of the Predictive Analytics is estimated at around €10-12 billion with a Global Market Percentage of approximately 15-20%. The market value of the Automated Fire Detection Systems is estimated at around €20 billion with a Global Market Percentage of approximately 25-30% (European Forest Institute (EFI), 2020).

Please find below some more data:

1. **Drones**:
    - Market Value: The global market for drones in various sectors, including forestry, is expected to reach several billion euros by 2025. This includes both hardware and software solutions. (BCC Publishing, 2024)
    - Growth Rate: The compound annual growth rate (CAGR) is significant, often estimated at around 20-25% due to increasing applications in precision forestry, agriculture, and environmental monitoring.
2. **Satellites** (Research and Markets, 2024):
    - Market Value: The satellite remote sensing market is substantial, often estimated in the range of 10-15 billion euros globally.
    - Growth Rate: The market is expected to grow at a CAGR of around 8-10%, driven by advancements in satellite technology and increased demand for real-time data for forest management.
3. **Remote Sensing Technologies (LiDAR, Infrared Imaging)**: ((GMI), 2024)
    - Market Value: The LiDAR market alone is projected to be worth around 5-7 billion euros by the mid-2020s.
    - Growth Rate: With a CAGR of approximately 15-20%, the adoption of LiDAR and infrared imaging is growing rapidly in forestry for applications such as biomass estimation, canopy structure analysis, and fire risk assessment.
4. **Predictive analytics:** (Research G. V., 2018)
    - Market value: The market for predictive analytics is experiencing a high compound annual growth rate (CAGR), often estimated at around 20-25%.
    - Growth Rate: The market for predictive analytics is experiencing a high compound annual growth rate (CAGR), often estimated at around 20-25%. This growth is fueled by the increasing adoption of AI and machine learning across various industries including finance, healthcare, retail, and manufacturing.
5. **Automated fire detection systems** (Research D. B.-M., 2023)
    - **Market Value:** The global market for automated fire detection systems was valued at approximately €20 billion in recent years and is projected to grow significantly. Estimates suggest it could reach around €30 billion by the mid-2020s.
    - **Growth Rate:** The compound annual growth rate (CAGR) for this market is estimated to be around 8-10%, driven by increasing demand for advanced safety systems, technological advancements, and stringent safety regulations.

Governments around the world are implementing **stricter environmental regulations** to promote sustainable forest management and reduce fire risks. These regulations often include financial incentives and support for adopting sustainable forest management techniques, as well as penalties for practices that increase fire risk or degrade forest ecosystems. Green financing initiatives, such as the development of green bonds and sustainable investment frameworks, are providing funding for projects aligned with environmental goals. The EU Taxonomy for sustainable activities, for example, guides investors towards

activities that support environmental sustainability. (Commission, The EU Strategy for Forest Fire Prevention and Climate Change, 2021)

Raising public awareness about the importance of fire prevention and sustainable forest management is a key trend. **Educational programs** are being launched to inform the public, especially in fire-prone areas, about responsible behaviors and practices. Media campaigns and outreach initiatives are highlighting the benefits of sustainable forest management, and the risks associated with forest fires, helping to build a culture of sustainability and proactive fire prevention.

**International collaboration** is vital for addressing the global nature of forest management and fire prevention. Enhanced global cooperation involves sharing knowledge, strategies, and resources across borders to tackle transboundary challenges effectively. Increased funding from international organizations and climate finance mechanisms is supporting sustainable forest management projects, helping to scale up successful initiatives and invest in innovative solutions.

The fire prevention and sustainable forest management market is increasingly shaped by integrated approaches, climate-smart practices, technological advancements, supportive policies, and a growing emphasis on education and global cooperation. These trends are essential for protecting forest ecosystems, enhancing climate resilience, and promoting biodiversity conservation.

**Future Outlook**

The future outlook for the fire prevention and sustainable forest management market is promising, driven by technological innovation, regulatory support, and increasing global awareness of environmental sustainability.

The sustainable forestry market is expected to grow due to rising demand for sustainably sourced timber and forest products. This demand is likely to drive the expansion of certification schemes and encourage more companies to adopt sustainable practices. As consumers and businesses prioritize environmentally friendly products, the market is set to expand (Nations, Economic and Social Council (ECOSOC) , 2019).

Climate change adaptation will become increasingly important. Forest management practices that enhance resilience to climate change, such as promoting species diversity, adaptive management techniques, and focusing on carbon sequestration through forest conservation, will become more prevalent. Increased investment in reforestation, afforestation, and the restoration of degraded forests will play a crucial role in mitigating climate change impacts.

Innovative solutions and ongoing research will continue to drive the sector. Continued research into fire-resistant plant species, new forest management techniques, and advanced firefighting technologies will foster innovation. The development of new materials and products from sustainably managed forests will open up new markets and applications.

Global cooperation and increased funding will support these efforts. Enhanced international collaboration on forest management and fire prevention strategies will be essential for addressing transboundary challenges, with international organizations and climate finance mechanisms providing crucial support. Climate finance and green investment initiatives will increase funding for sustainable forest management projects, supporting both public and private sector efforts.

Enhanced monitoring and data analytics will further improve forest management and fire prediction. The integration of various data sources, including remote sensing, ground-based observations, and climate models, will enable comprehensive forest health monitoring and early warning systems. Data-driven

approaches will improve forest management practices, allowing for more effective and efficient resource allocation and risk management.

Overall, the fire prevention and sustainable forest management market is set to benefit from ongoing technological advancements, supportive regulatory frameworks, and a growing emphasis on sustainability. These trends will help protect forest ecosystems, enhance climate resilience, and promote biodiversity conservation.

### 6.2 Future market predictions

The SILVANUS project has built its framework and technological solutions around the Integrated Fire Management (IFM) approach, aiming to provide a holistic solution for stakeholders addressing all phase of fire management, from prevention and preparedness to detection and response, to restoration and adaptation. Through the technical developments, the project partners have leveraged their scientific expertise and the latest developments in computer science and advanced algorithms to provide tools that support the IFM approach. Briefly, the technological advances of each User Product (UP) are summarized below:

**UP1 – AR/VR training toolkit for responders**: The tool employs augmented reality / virtual reality (AR/VR) to simulate wildfire scenarios for training purposes, thus allowing firefighters to train in a virtual environment that mimics real-world conditions, enhancing their preparedness and response capabilities.

**UP2 – Fire danger tool**: The tool expresses the potential for fire ignition and spread risk through a semi-quantitative index (6 classes from very low to very high risk), calculated based on empirical and data-driven approaches. This is done across different temporal scales (nowcasting, daily, monthly, and seasonal), aiding in strategic planning of firefighters.

**UP3 – Fire detection based on social sensing**: The tool utilizes AI algorithms to process social media posts to detect and locate emerging fire events, enabling rapid notification and response by gathering real-time, crowd-sourced information. Multiple languages are supported.

**UP4 – a) Fire detection from IoT devices**: This tool consists of a deployable IoT Edge Device that can detect fire/smoke. The technological advances include its power independence, and low-latency edge processing for early identification of critical events. **b) Fire detection at the edge**: This tool uses advanced AI computer vision algorithms to analyse georeferenced photos of an area to detect fire and smoke in them. Images can be processed in near real time.

**UP5 – a) UGV Monitoring for risk and wildfire behaviour**: The tool consists of an unmanned ground vehicle capable of autonomous navigation through a forest to and from a fire front. The UGV can also gather georeferenced images and lidar data to estimate local forest characteristics (e.g. leaf/tree density). **b) Wildfire behaviour inspection based on UAVs' deployment**: The tool develops a solution for Unmanned Aerial Vehicle (UAV) deployment and trajectory planning using AI and computational geometry, guaranteeing optimal use of resources and allowing adaptive, on-the-fly mission planning and decision support in the command centre.

**UP6 – Fire Spread Forecast**: The tool uses machine learning to predict the spread of a wildfire over a 24-hour period, based on the current fire front. Several local parameters are considered, such as terrain, forest characteristics and meteorological conditions. Minimal operator intervention is required to initiate the prediction calculation.

**UP7 – Woode Mobile Application**: The tool uses deep-learning based classification and recognition solutions to identify tree species, facilitated by crowdsourced data aggregation. It engages the community in biodiversity conservation efforts. Also is important to highlight the use of AI for assessing fire damage.

**UP8 – a) Citizen engagement mobile application & b) Citizen situational awareness and information sharing**: the tool empowers citizens and provides them with tools to become crucial actors in forest fire management, by providing a holistic toolkit for Citizen Preparation, Response and Recovery through interactive educational and situational awareness modules.

**UP9 – Decision Support System**: a) Resource allocation of response teams (RAR); b) Health impact assessment (HIA); c) Evacuation route planning; d) Ecological resilience index; e) Continuous monitoring of rehabilitation strategy index; f) Biodiversity index calculation; h) Resource allocation using data fusion; g) Multilingual Forest fire alert system; i) Integrated data insights; j) Deep learning model for wildfire severity prediction using EO4Wildfires. This tool integrates multiple components that integrate sophisticated algorithms, data analytics, and real-time monitoring technologies to support firefighters in their decision-making process. The tools leverage several technological advancements, such as dynamic multi-objective optimization, dispersion modelling for evacuation route planning, AI algorithms for processing of earth observation data, data aggregation and classification techniques.

**UP10 – Forward command centre**: This tool links the SILVANUS cloud with the Edge Micro Data Center, providing the capacity to firefighters on the field to oversee operations. It provides the infrastructure to enable local download of necessary data to ensure component functionality with limited connectivity of the edge devices.

The SILVANUS technological advances bring added value to the IFM approach. Although the discussion is separated according to the fire management phases, this distinction is somewhat arbitrary as the tools are interlinked and they all work synergistically to increase wildfire resilience. The developed solutions worked harmoniously together to provide a comprehensive fire management solution.

**Prevention & Preparedness:** The SILVANUS project emphasizes the synergy of community engagement, education and training through technological advancements and community-focused strategies, to create a resilience framework against wildfires. The solutions: i) raise public awareness and communication by educating the public on fire risks and preventive measures to reduce the likelihood of wildfires; ii) engage the community in biodiversity conservation, monitor forest health and support fire-prevention strategies by involving the community in sustainable practices and conservation efforts; iii) enhance training efficiency of firefighters through advanced training tools; and iv) improve citizen situational awareness through communication tools and the knowledge to understand fire risks.

**Detection and response**: Central to SILVANUS' approach on detection and response is the enhancement of situational awareness, achieved through real time monitoring capabilities and delivering of actionable intelligence. The solutions: **i)** provide critical information on the context and extent of a fire incident, allowing for informed decision-making; **ii)** provides real-time monitoring, data, and insights, which are essential for early intervention and mitigating fire impacts; **iii)** support decision making by providing resource optimization for firefighting logistics, ensuring efficient use of resources.

**Restoration and adaptation**: In the aftermath of a wildfire, the project aids in the efficient understanding of the extent of damage and the prioritization of recovery efforts, while also engaging the community. The solutions: i) enable post-fire damage assessment by evaluating the extent of the fire; ii) utilize crowd-sourced data to monitor recovery progress.

**Examples of emerging technologies that could influence the project's domain in the short to medium term.**

This section reflects upon emerging technologies that could influence SILVANUS' market positioning in the short to medium term.

A critical aspect of the project is the speed at which data is received from the various sensors, therefore technologies that can **enhance connectivity** in remote areas (e.g., in a forest) and adverse conditions (e.g., heat from fire, smoke, exposure to natural elements) would greatly influence the application and adoption of SILVANUS solutions. To this end, the rollout of 5G can significantly enhance communication speeds, bandwidth, reliability, and lower latency amongst IoT devices, allowing for larger data volume to be gathered. This would significantly enhance the data gathering ability of UAVs and UGVs, and the transmission speeds of data gathered by these devices, for monitoring and combating wildfires.

The enhanced connectivity can provide larger freedom to hardware developers to create **new unmanned vehicles or IoT devices** that can operate in the harsh environmental conditions of a forest and the temperature extremes of a wildfire.

Aside from IoT devices for in-situ observations and monitoring, SILVANUS also relies on remote Earth Observation data, for example satellite imagery). Improvements in sensors technologies and data processing methods can enable the proliferation of **EO datasets with higher spatial and temporal resolution**. Increased resolution can lead to more accurate predictions, considering local features that can significantly impact the behaviour of a wildfire, such as terrain features creating local weather patterns that are not discernible on a 5×5km weather prediction dataset.

The large volume of data gathered requires advanced methods for processing to extract meaningful information and actionable intelligence. Here, **advancements in AI/ML/DL algorithms** and establishing robust training datasets can help improve the accuracy and precision of the developed software solutions. Further, such algorithms enable predictive analytics to identify potential hotspots, forecast fire spread patterns, and optimize firefighting strategies before a fire even starts, greatly enhancing pre-emptive planning and response efficiency.

As with any project that uses data, appropriate protection and assurance on data provenance must be considered, to prevent malicious actors from altering data. Here, advances in **blockchain technology** can revolutionize data sharing amongst stakeholders by providing a secure, transparent, and tamper-proof platform. Through the use of blockchain, end-user trust is facilitated and collaboration amongst firefighters, first responders, government agencies and the public can take place with ensured integrity.

**How these innovations could impact market dynamics, create new opportunities, or present challenges.**

**Market dynamics**

The increasing frequency and severity of wildfires, exacerbated by climate change, and the increased prevalence of digital solutions in all sectors, are contributing to an increased demand for innovative solutions that contribute to the integrated fire management approach, thus driving the market for innovative solutions relating to fire management. This shift further emphasizes the need for integrated and comprehensive platforms for data and functionalities. SILVANUS partially addresses the growing demand for innovative solutions by offering capabilities to firefighters beyond those traditionally available, such as the AI-driven predictive analytics, IoT real-time monitoring and AR/VR for immersive training. Aside from software solutions, specialized hardware also contributes to data collection, analysis, and simulation,

creating niches for innovation. The growing demand for such solutions encourages both public and private sectors to invest in R&I activities, opening new market pathways for exploration and exploitation.

The increased use of digital tools implies an increased level of interconnectedness and communication amongst various components, services, and organizations. This requires the foundational work of standardizing bodies, as well as an appropriate regulatory and legal framework, to ensure the safety, effectiveness, and ethical use of the new technologies. Therefore, policy changes could significantly impact the emerging market dynamics, influencing the technologies that will be adopted, and how these will be implemented.

**New Opportunities**

The technological innovations introduced through SILVANUS, spanning the development of new services and enhancement of existing practices, pave the way for numerous new opportunities in (wild)fire management, positioning technology providers, software developers and service providers to the disaster management sector to capitalize upon.

A significant opportunity exists in the integration of AR/VR technologies with firefighter training programs, offering a wide range of wildfire scenarios in a virtual environment. This allows trainees to gain valuable experience, skills and muscle memory without the risks associated with real fires.

The successful engagement of the community is paramount for fire management. The involvement of the community in all phases of fire management is critical, from embracing best practices for wildfire prevention, educational material for preparedness and protection, crowdsourcing of intelligence for fire/smoke detection, citizen-scientists for data collection for biodiversity monitoring and restoration effort and fostering a spirit of environmental sensitivity in the community, to name a few. All these aspects provide great opportunities to startups and technology companies to (co-)create community engagement platforms that promote wildfire resilience. Further, they present an opportunity to fire services, who can reinforce their value and benefit to the community through providing online engagement, educational initiatives, etc., which can also serve to ensure public support and continued funding for their activities.

The application of AI/ML for predictive analytics services relating to fire management and operational decision support can enable better decision-making under extreme-duress situations faced by firefighters. Such tools can also help to optimally utilize the available resources to prevent loss of life and more effectively fight wildfires, thus reducing their impacts.

The use of IoT devices, complemented by Earth Observations, offer the potential to monitor forests in unprecedented scales, providing real time information on a wide range of spatial scales. This enables early warning of emerging threats and gives valuable response time to firefighters. Companies and research centres developing such sensors, devices and processing tools can leverage this market need.

All these opportunities, if realized, have the potential to significantly contribute to the resilience of our communities and forests against the threat of wildfires.

**Challenges**

Despite the immense potential of the opportunities presented by the adoption of innovative technologies for fire management described above, several challenges remain on the technological, economic, political and societal fronts. Overcoming these challenges requires a multi-actor approach, bringing together technology developers with wildfire management professionals, policy makers and the community.

On the technological front, connectivity in remote areas can pose a significant hurdle, either due to not being available altogether, or to limited speeds or unreliable connections. These issues may further be

exacerbated due to smoke and high temperatures occurring during wildfires. Aside from connectivity, the integration of multiple complex software components and technologies poses challenges for compatibility and interoperability. Integrating new solutions with existing systems requires careful planning and support to avoid disruptions and ensure seamless operation.

On the financial front, the development, deployment, and maintenance of advanced technologies for wildfire management requires significant investment, and securing funding for these innovations presents a challenge.

On the societal front, the adoption of new technologies may face issues due to the lack of appropriate skills, or the solutions not being user-friendly or adding clear value. Appropriate training of firefighters or disaster managers is critical to understand the full scope and limitations of the technological solutions. Knowledge gaps must be overcome to ensure that all stakeholders have the necessary skills to engage with the new technologies presented to them.

Finally, on the regulatory/ethical front, emerging technologies must be deployed within the bounds of legal, regulatory, and ethical frameworks and respecting data privacy and security constraints.

# 7 Conclusions

The D10.5 presents a comprehensive examination of the wildfire management and forest land management market. It offers in-depth insights into various facets, including market dynamics, stakeholder interactions, and strategic assessments such as SWOT and PESTEL analyses. This analysis serves as a foundational framework for comprehending the market's current state and future trajectory, enabling informed decision-making and strategic planning.

The report provides a global perspective on the fire protection forest Land Management Market, emphasizing the increasing adoption of advanced technologies across multiple sectors. The market is segmented based on fire protection system types (active and passive) and fire response/analysis tools, catering to commercial, residential, and governmental applications. The heightened awareness of environmental sustainability and stringent regulations are driving demand for sophisticated, technology-driven wildfire management solutions. Consequently, precision forestry technologies like drones, satellites, and LiDAR are gaining prominence in enhancing forest landscape management accuracy and efficiency.

A detailed stakeholder analysis illuminates the complex network of entities within this market. Regulatory bodies and environmental organizations are exerting growing influence on the demand side by advocating for sustainable practices and regulatory compliance. On the supply side, companies are differentiating through innovation and environmental commitment in a highly competitive landscape. The report specifically evaluates the SILVANUS project's User Products (UPs) within this context. By comparing UPs to existing market offerings, with a focus on innovation, stakeholder engagement, and environmental sustainability, the analysis reveals their potential to meet market demands. However, ongoing innovation and alignment with evolving environmental standards are essential for sustained competitiveness.

A SWOT analysis offers a balanced assessment of the market's strengths, weaknesses, opportunities, and threats. While technological advancements and a growing sustainability focus are driving market growth, challenges such as high technology costs and substantial R&D investments persist. The market presents significant opportunities, particularly in the context of global climate change mitigation and sustainable development. However, regulatory shifts and economic downturns pose potential threats to market expansion and funding.

The PESTEL analysis further contextualizes the market by examining broader macro-environmental factors. Political factors, including government policies and international agreements like the Paris Agreement, significantly influence market dynamics. Economic conditions, such as funding availability and market growth rates, impact market expansion. Social and environmental factors, driven by increasing public climate change awareness and the demand for sustainable practices, are market drivers. Technological advancements, especially in remote sensing and data analysis, are key enablers of market growth. Legal and environmental regulations provide the framework for market operations and innovation.

Market trends indicate robust growth fuelled by technological advancements and supportive regulatory environments. The global sustainability movement, exemplified by Europe's 2050 climate neutrality goal, will significantly shape market development. The integration of AI and machine learning into wildfire management systems is a key trend with the potential to enhance predictive capabilities and operational efficiency.

In conclusion, continuous innovation and strategic alignment with environmental and regulatory trends are crucial for success in the wildfire management market. The SWOT and PESTEL analyses provide a strategic roadmap for navigating challenges and seizing opportunities. Stakeholders should prioritize innovation, stakeholder engagement, and environmental compliance to drive sustainable market growth. The

SILVANUS project, with its strong innovation and sustainability focus, is well-positioned for market leadership, contingent upon its adaptability to the evolving landscape and responsiveness to stakeholder needs.

# 8 Annexes

## 8.1 Comparison framework figures for each User product and its competitors:

### *8.1.1 Original comparison framework table for all UP competitors*

| | | | Variables | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Forest management practices** | **Environmental impact** | **Innovation and technology** | **Certification and compliance** | **Features variety /accuracy** | **Stakeholder engagement** | **Analytics / database** | **Competitive pricing** | **friendly UX/UI /website** | Total |
| Competitors | UP1 | Glue collaboration | 1 | 2 | 2 | 2 | 2 | 3 | 2 | Plans 0/50/initial | 3 | **17** |
| | | Scotty | 1 | 1 | 2 | 1 | 2 | 1 | 2 | No info | 1 | **11** |
| | | ENGAGE | 2 | 1 | 2 | 2 | 3 | 3 | 2 | Low | 3 | **18** |
| | | InnoChain | 2 | 2 | 3 | 1 | 1 | 2 | 1 | Low | 2 | **14** |
| | | YORD | 2 | 1 | 2 | 1 | 3 | 3 | 1 | High | 3 | **16** |
| | | Crystal Apps | 1 | 1 | 1 | 2 | 1 | 2 | 1 | No info | 1 | **10** |
| | | 4Experience | 3 | 2 | 2 | 1 | 3 | 3 | 2 | Medium | 3 | **19** |
| | | WE/AR Studio | 2 | 2 | 3 | 1 | 2 | 2 | 3 | Plans. Free trial | 2 | **17** |
| | | Delta Reality | 3 | 2 | 3 | 1 | 2 | 3 | 2 | ? | 3 | **19** |
| | | Zappar | 1 | 1 | 2 | 1 | 2 | 2 | 1 | Plans 58/435/enterprise | 2 | **12** |
| | | Khora | 1 | 1 | 2 | 1 | 3 | 2 | 2 | High | 3 | **15** |
| | | Total: | 19 | 16 | 24 | 14 | 24 | 26 | 19 | 0 | 26 | |
| | UP2a | FIRETEC (US Forest Service) | 2 | 3 | 3 | 1 | 3 | 2 | 3 | High | 2 | **19** |
| | | Wildfire analyst pocket | 3 | 2 | 3 | 2 | 3 | 3 | 3 | Medium | 3 | **22** |
| | | Fire Cast (Wiresprin g technologies) | 1 | 3 | 2 | 1 | 2 | 1 | 2 | Packages - medium price | 2 | **14** |
| | | BehavePlus | 3 | 1 | 2 | 3 | 2 | 2 | 2 | n/a | 2 | **17** |
| | | Total: | 9 | 9 | 10 | 7 | 10 | 8 | 10 | 0 | 9 | |
| | UP2b | EFFIS (JRC) | 3 | 3 | 2 | 2 | 2 | 1 | 2 | n/a | 2 | **17** |
| | | CMS (Copernicus | 3 | 3 | 2 | 2 | 2 | 1 | 3 | n/a | 1 | **17** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | emergency ) | | | | | | | | | | |
| | | ESA | 2 | 3 | 3 | 1 | 1 | 2 | 2 | n/a | 1 | **15** |
| | | MetGIS | 3 | 2 | 1 | 1 | 2 | 1 | 2 | Medium | 2 | **14** |
| | | Total: | 11 | 11 | 8 | 6 | 7 | 5 | 9 | 0 | 6 | |
| | UP3 | Mediatoolkit | 1 | 1 | 2 | 1 | 1 | 3 | 3 | Packages | 1 | **13** |
| | UP3 | PromptCloud | 1 | 1 | 2 | 1 | 1 | 1 | 2 | Depends on datasets | 3 | **12** |
| | UP3 | Tweetmap (Heavy AI) | 1 | 1 | 2 | 2 | 1 | 2 | 3 | n/a | 2 | **14** |
| | UP3 | Google Crisis Map | 2 | 3 | 2 | 2 | 2 | 2 | 3 | Free. Low membership | 2 | **18** |
| | UP3 | Total: | 5 | 6 | 8 | 6 | 5 | 8 | 11 | 0 | 8 | |
| | UP4a | AVIOTEC (Bosch) | 2 | 2 | 2 | 2 | 1 | 2 | 1 | ? | 1 | **13** |
| | UP4a | Early Fire Detection (FLIR) | 3 | 3 | 2 | 1 | 2 | 1 | 2 | High | 1 | **15** |
| | UP4a | OPGAL | 2 | 3 | 3 | 3 | 2 | 2 | 1 | High | 1 | **17** |
| | UP4a | Novo technologies | 1 | 3 | 2 | 1 | 3 | 1 | 3 | High | 1 | **15** |
| | UP4a | Piperaris | 1 | 2 | 3 | 3 | 2 | 2 | 1 | Low | 2 | **16** |
| | UP4a | AA alarm | 1 | 3 | 3 | 1 | 3 | 3 | 1 | Medium | 1 | **16** |
| | UP4a | Total: | 10 | 16 | 15 | 11 | 13 | 11 | 9 | 0 | 7 | |
| | UP4b | SmokeD | 3 | 2 | 3 | 1 | 2 | 2 | 1 | ? | 3 | **17** |
| | UP4b | AgEagle (SenseFly) | 1 | 1 | 3 | 3 | 2 | 2 | 2 | ? | 2 | **16** |
| | UP4b | Garuda Robotics | 1 | 1 | 2 | 1 | 2 | 1 | 3 | ? | 3 | **14** |
| | UP4b | Itur drones | 2 | 2 | 2 | 2 | 3 | 1 | 1 | ? | 2 | **15** |
| | UP4b | Total: | 7 | 6 | 10 | 7 | 9 | 6 | 7 | 0 | 10 | |
| | UP5a | RTE Robot (Rosenbauer) | 2 | 2 | 1 | 1 | 2 | 1 | 1 | ? | 3 | **13** |
| | UP5a | Wolf R1 (Magirus) | 3 | 3 | 3 | 1 | 2 | 2 | 1 | ? | 2 | **17** |
| | UP5a | Shark Robotics (Colossus) | 1 | 2 | 3 | 2 | 3 | 3 | 2 | ? | 3 | **19** |
| | UP5a | Howe and Howe (Thermite) | 1 | 2 | 3 | 2 | 3 | 2 | 1 | ? | 1 | **15** |
| | UP5a | DeepRobotics (X30) | 3 | 2 | 3 | 2 | 3 | 3 | 1 | High | 3 | **20** |
| | UP5a | TRACKREITAR FFL | 1 | 3 | 3 | 2 | 3 | 3 | 1 | ? | 2 | **18** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (Leotronics ) | | | | | | | | | | |
| | | Total: | 11 | 14 | 16 | 10 | 16 | 14 | 7 | 0 | 14 | |
| | UP6 | FlamMap (US dept agriculture) | 3 | 2 | 1 | 2 | 3 | 1 | 1 | n/a | 2 | **15** |
| | | BehavePlus | 3 | 1 | 2 | 3 | 2 | 2 | 2 | n/a | 2 | **17** |
| | | Environmental Intelligence Suite (IBM) | 1 | 2 | 3 | 2 | 2 | 2 | 3 | Multiple plans options | 2 | **17** |
| | | CalFire | 3 | 3 | 2 | 2 | 2 | 1 | 3 | n/a | 1 | **17** |
| | | Intterra | 3 | 3 | 3 | 1 | 2 | 2 | 3 | ? | 3 | **20** |
| | | Total: | 13 | 11 | 11 | 10 | 11 | 8 | 12 | 0 | 10 | |
| | UP7 | LeafSnap (Appixi) | 1 | 1 | 2 | 1 | 1 | 1 | 2 | n/a | 2 | **11** |
| | | iNaturalist | 1 | 1 | 1 | 1 | 1 | 1 | 3 | n/a - merch store | 2 | **11** |
| | | Google Lens | 1 | 1 | 2 | 2 | 2 | 3 | 3 | n/a | 2 | **16** |
| | | TreeID (Woodland Trust ) | 1 | 3 | 1 | 1 | 2 | 2 | 2 | Low | 1 | **13** |
| | | Forest Diversity | 2 | 2 | 2 | 2 | 1 | 1 | 1 | Medium | 1 | **12** |
| | | PlantNet | 2 | 3 | 2 | 1 | 3 | 2 | 3 | n/a | 3 | **19** |
| | | Total: | 8 | 11 | 10 | 8 | 10 | 10 | 14 | 0 | 11 | |
| | UP8a | FireFringe | 2 | 2 | 3 | 1 | 2 | 1 | 1 | ? | 2 | **14** |
| | | National Interagency Fire C. | 3 | 2 | n/a | 3 | 2 | 2 | 1 | n/a | n/A | **13** |
| | | WIFIRE | 2 | 2 | 2 | 2 | 3 | 1 | 1 | n/a | 2 | **15** |
| | | FIRMS | 3 | 3 | 1 | 2 | 2 | 1 | 3 | n/a | 2 | **17** |
| | | Total: | 10 | 9 | 6 | 8 | 9 | 5 | 6 | 0 | 6 | |
| | UP8b | HZS (Mountain Rescue Slovakia | 1 | 1 | 2 | 3 | 2 | 3 | 1 | n/a | 1 | **14** |
| | | GoAudits | 2 | 1 | 2 | 3 | 2 | 2 | 3 | Plans - Low | 2 | **17** |
| | | Citizen APP | 1 | 1 | 2 | 2 | 3 | 3 | 2 | n/a | 3 | **17** |
| | | My 112 | 1 | 1 | 2 | 2 | 1 | 3 | 2 | n/a | 2 | **14** |
| | | Total: | 5 | 4 | 8 | 10 | 8 | 11 | 8 | 0 | 8 | |
| | UP9a | NO COMPETITORS | | | | | | | | | | **0** |
| | UP9 | Swiss TPH | 2 | 1 | 1 | 3 | 2 | 3 | n/a | No info | n/a | **12** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Met One instruments | 2 | 1 | 3 | 2 | 3 | 2 | 1 | No info | 3 | **17** |
| | | Tenevia | 1 | 2 | 2 | 1 | 1 | 2 | 2 | No info | 3 | **14** |
| | | INERIS | 2 | 2 | 1 | 3 | 1 | 2 | 1 | ? | 1 | **13** |
| | | Total: | 7 | 6 | 7 | 9 | 7 | 9 | 4 | 0 | 7 | |
| | UP9c | Openroute service (HeiGIT gGmbH) | 1 | 1 | 3 | 2 | 2 | 1 | 3 | n/a | 2 | **15** |
| | | EscapeWild Fire (RISE) | 2 | 1 | 2 | 1 | 2 | 1 | 2 | n/a | 3 | **14** |
| | | IBM Evacuation Planner | 2 | 1 | 2 | 2 | 2 | 2 | 3 | Medium | 2 | **16** |
| | | Zoneheaven (Genasys) | 1 | 2 | 2 | 1 | 3 | 1 | 3 | n/a | 2 | **15** |
| | | Total: | 6 | 5 | 9 | 6 | 9 | 5 | 11 | 0 | 9 | |
| | UP9d | BERI v2 (CSIRO) | 3 | 2 | 2 | 2 | 2 | 1 | 2 | n/a | 2 | **16** |
| | | EFISCEN | 2 | 2 | 2 | 2 | 3 | 1 | 2 | n/a | 2 | **16** |
| | | ForestRY | 3 | 3 | 2 | 3 | 1 | 2 | 1 | n/a | 1 | **16** |
| | | Tree Metrics | 3 | 2 | 3 | 1 | 3 | 1 | 3 | Plans (4 options) | 3 | **19** |
| | | Total: | 11 | 9 | 9 | 8 | 9 | 5 | 8 | 0 | 8 | |
| | UP9e | Global Forest Watch | 2 | 3 | 3 | 2 | 2 | 1 | 3 | n/a | 3 | **19** |
| | | EFDAC | 2 | 1 | 2 | 3 | 1 | 3 | 3 | n/a | 2 | **17** |
| | | IUFRO | 1 | 2 | 2 | 2 | 2 | 3 | 2 | Various programs | 1 | **15** |
| | | Total: | 5 | 6 | 7 | 7 | 5 | 7 | 8 | 0 | 6 | |
| | UP9f | Biodiversity Indicators (UNEP-WCMC) | 1 | 2 | 3 | 2 | 2 | 3 | 2 | ? | 2 | **17** |
| | UP9h | Kinéis | 1 | 1 | 3 | 3 | 2 | 1 | 3 | High | 1 | **15** |
| | | Dryad Networks (Silvanet Suite) | 2 | 3 | 3 | 2 | 3 | 2 | 3 | n/a | 2 | **20** |
| | | EOS GmbH | 1 | 2 | 3 | 2 | 3 | 1 | 2 | Medium | 2 | **16** |
| | | Spire global | 1 | 2 | 3 | 2 | 3 | 2 | 3 | Medium | 2 | **18** |
| | | Total: | 5 | 8 | 12 | 9 | 11 | 6 | 11 | 0 | 7 | |
| | UP9i | Landfire (USGS) | 3 | 2 | 2 | 1 | 3 | 2 | 3 | n/a | 2 | **18** |
| | | Prometheus - fire | 2 | 2 | 3 | 2 | 3 | 2 | 3 | n/a | 1 | **18** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | growth model | | | | | | | | | | |
| | | FireWeather (Canadian Forest Service) | 3 | 2 | 2 | 3 | 2 | 2 | 3 | n/a | 3 | **20** |
| | | FireCast (Conservation International) | 2 | 3 | 3 | 2 | 3 | 3 | 2 | n/a | 3 | **21** |
| | | Total: | 10 | 9 | 10 | 8 | 11 | 9 | 11 | 0 | 9 | |
| | UP9j | EFFIS (JRC) | 3 | 3 | 2 | 2 | 2 | 1 | 2 | n/a | 2 | **17** |
| | | Landfire (USGS) | 3 | 2 | 2 | 1 | 3 | 2 | 3 | n/a | 2 | **18** |
| | | Firewatch | 3 | 3 | 3 | 2 | 3 | 2 | 3 | Medium | 2 | **21** |
| | | MODIS | 2 | 2 | 2 | 3 | 2 | 2 | 2 | n/a | 2 | **17** |
| | | Total: | 11 | 10 | 9 | 8 | 10 | 7 | 10 | 0 | 8 | |
| | UP9K | firemaps.net | 3 | 3 | 3 | 2 | 3 | 2 | 3 | Plans+setup (medium) | 3 | **22** |
| | | ArboFiRM (Arbonaut) | 3 | 2 | 3 | 3 | 2 | 3 | 3 | ? | 2 | **21** |
| | | FiResponse (Technosylva) | 3 | 2 | 3 | 1 | 2 | 2 | 3 | Plans:Lite/professional | 3 | **19** |
| | | FIRE tool (NCEI and NASA) | 3 | 2 | 2 | 2 | 1 | 3 | 3 | n/a | 1 | **17** |
| | | Total: | 12 | 9 | 11 | 8 | 8 | 10 | 12 | 0 | 9 | |
| | UP9L | No competitors | | | | | | | | | | |
| | UP10 | IRIS (Thales Group) | 2 | 2 | 3 | 1 | 3 | 3 | 3 | High | 1 | **18** |
| | | Eurocommand 2020 (GmbH) | 3 | 3 | 2 | 3 | 2 | 2 | 2 | Medium | 2 | **19** |
| | | EMIS (Siemens) | 2 | 3 | 3 | 2 | 3 | 3 | 3 | Medium | 3 | **22** |
| | | SAFE Command by Hexagon | 2 | 3 | 3 | 3 | 3 | 2 | 3 | Medium | 3 | **22** |
| | | Total: | 9 | 11 | 11 | 9 | 11 | 10 | 11 | 0 | 9 | |
| | UP11 | Forestry - The Sanborn Map | 3 | 1 | 2 | 2 | 1 | 2 | 3 | High | 2 | **16** |
| | | Wildfire Analyst - | 3 | 2 | 3 | 1 | 3 | 1 | 3 | ? | 3 | **19** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Technosylva | | | | | | | | | | |
| | | CPS Wildfire Management Tool - EMXSYS | 2 | 3 | 3 | 2 | 3 | 2 | 3 | ? | 2 | **20** |
| | | Total: | 8 | 6 | 8 | 5 | 7 | 5 | 9 | 0 | 7 | |
| | UP12 | MIMO-Radio (SILVUS Technologies) | 1 | 1 | 2 | 2 | 2 | 3 | 3 | High | 3 | **17** |
| | | WAVE-RELAY (PERSISTENT Systems) | 1 | 1 | 3 | 1 | 3 | 3 | 2 | High | 3 | **17** |
| | | Airbus Defence and Space | 2 | 3 | 3 | 3 | 3 | 3 | 3 | High | 2 | **22** |
| | | Indra (Pelicano) | 2 | 2 | 3 | 2 | 3 | 2 | 3 | Medium | 2 | **19** |
| | | Total: | 6 | 7 | 11 | 8 | 11 | 11 | 11 | 0 | 10 | |

### *8.1.2 Comparison framework figure of each UP and competitors*

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| Glue collaboration | ○ | ◑ | ◑ | ◑ | ◑ | ● | ◑ | ● | Plans. Low | **17** |
| Scotty | ○ | ○ | ◑ | ○ | ◑ | ○ | ◑ | ○ | No data | **11** |
| ENGAGE | ◑ | ○ | ◑ | ◑ | ● | ● | ◑ | ● | Low | **18** |
| InnoChain | ◑ | ◑ | ● | ○ | ○ | ◑ | ○ | ◑ | Low | **14** |
| YORD | ◑ | ○ | ◑ | ○ | ● | ● | ○ | ● | High | **16** |
| Crystal Apps | ○ | ○ | ○ | ◑ | ○ | ◑ | ○ | ○ | No data | **10** |
| 4Experience | ● | ◑ | ◑ | ○ | ● | ● | ◑ | ● | Medium | **19** |
| WE/AR Studio | ◑ | ◑ | ● | ○ | ◑ | ◑ | ● | ◑ | Plans. Free trial | **17** |
| Delta Reality | ● | ◑ | ● | ○ | ◑ | ● | ◑ | ● | No data | **19** |
| Zappar | ○ | ○ | ◑ | ○ | ◑ | ◑ | ○ | ◑ | Plans. Medium | **12** |
| Khora | ○ | ○ | ◑ | ○ | ● | ◑ | ◑ | ● | High | **15** |

**Figure 31 Comparison framework UP1.**

**Competitors UP1**: Glue collaboration, Scotty, ENGAGE, InnoChain, YORD, Crystal Apps, 4Experience, WE/AR Studio, Delta Reality, Zappar, Khora

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| FIRETEC - US Forest service | ◑ | ● | ● | ○ | ● | ◑ | ● | ◑ | High | **19** |
| Wildfire analyst pocke | ● | ◑ | ● | ◑ | ● | ● | ● | ● | Medium | **22** |
| Fire Cast (Wirespring t.) | ○ | ● | ◑ | ○ | ◑ | ○ | ◑ | ◑ | Plans. Medium | **14** |
| BehavePlus | ● | ○ | ◑ | ● | ◑ | ◑ | ◑ | ◑ | N/A | **17** |

**Figure 32 Comparison framework UP2a**

**Competitors UP2a**: FIRETEC, Wildfire analyst pocket, Fire Cast (Wirespring technologies, BehavePlus

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| EFFIS (JRC) | ● | ● | ◑ | ◑ | ◑ | ○ | ◑ | ◑ | N/A | **17** |
| CMS (Copernicus E.) | ● | ● | ◑ | ◑ | ◑ | ○ | ● | ○ | N/A | **17** |
| ESA | ◑ | ● | ● | ○ | ○ | ◑ | ◑ | ○ | N/A | **15** |
| MetGIS | ● | ◑ | ○ | ○ | ◑ | ○ | ◑ | ◑ | Medium | **14** |

**Figure 33 Comparison framework UP2b**

**Competitors UP2b**: EFFIS (JRC), CMS (Copernicus emergency), ESA, MetGIS

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| Mediatoolkit | ○ | ○ | ◑ | ○ | ○ | ● | ● | ○ | Plans of all prices | **13** |
| PromptCloud | ○ | ○ | ◑ | ○ | ○ | ○ | ◑ | ● | Different prices. Datasets | **12** |
| Tweetmap (Heavy AI) | ○ | ○ | ◑ | ◑ | ○ | ◑ | ● | ◑ | N/A | **14** |
| Google Crisis Map | ◑ | ● | ◑ | ◑ | ◑ | ◑ | ● | ◑ | Membership | **18** |

**Figure 34 Comparison framework UP3**

**Competitors UP3:** Mediatoolkit, PromptCloud, Tweetmap (Heavy AI), Google Crisis Map

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| AVIOTEC (Bosch) | ◑ | ◑ | ◑ | ◑ | ○ | ◑ | ○ | ○ | No data | **13** |
| Early Fire Detection (FLIR) | ● | ● | ◑ | ○ | ◑ | ○ | ◑ | ○ | High | **15** |
| OPGAL | ◑ | ● | ● | ● | ◑ | ◑ | ○ | ○ | High | **17** |
| Novo technologies | ○ | ● | ◑ | ○ | ● | ○ | ● | ○ | High | **15** |
| Piperaris | ○ | ◑ | ● | ● | ◑ | ◑ | ○ | ◑ | Low | **16** |
| AA alarm | ○ | ● | ● | ○ | ● | ● | ○ | ○ | Medium | **16** |

**Figure 35 Comparison framework UP4a**

**Competitors UP4a:** AVIOTEC (Bosch), Early Fire Detection (FLIR), OPGAL, Novo technologies, Piperaris, AA alarm

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| SmokeD | ● | ◑ | ● | ○ | ◑ | ◑ | ○ | ● | No data | **17** |
| AgEagle (SenseFly) | ○ | ○ | ● | ● | ◑ | ◑ | ◑ | ◑ | No data | **16** |
| Garuda Robotics | ○ | ○ | ◑ | ○ | ◑ | ○ | ● | ● | No data | **14** |
| Itur drones | ◑ | ◑ | ◑ | ◑ | ● | ○ | ○ | ◑ | No data | **15** |

**Figure 36 Comparison framework UP4b**

**Competitors UP4b:** SmokeD, AgEagle (SenseFly), Garuda Robotics, Itur drones

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| RTE Robot (Rosenbauer) | ◑ | ◑ | ○ | ○ | ◑ | ○ | ○ | ◑ | No data | **13** |
| Wolf R1 (Magirus) | ● | ● | ● | ○ | ◑ | ◑ | ○ | ● | No data | **17** |
| Shark Robotics (Colossus) | ○ | ◑ | ● | ◑ | ● | ● | ◑ | ◑ | No data | **19** |
| Howe and Howe (Thermite) | ○ | ◑ | ● | ◑ | ● | ◑ | ○ | ○ | No data | **15** |
| DeepRobotics (X30) | ● | ◑ | ● | ◑ | ● | ● | ○ | ● | High | **20** |
| TRACKREITAR FFL (Leotronics) | ○ | ● | ● | ◑ | ● | ● | ○ | ◑ | No data | **18** |

**Figure 37 Comparison framework UP5a**

**Competitors UP5:** RTE Robot (Rosenbauer), Wolf R1 (Magirus), Shark Robotics (Colossus), Howe and Howe (Thermite), DeepRobotics (X30), TRACKREITAR FFL (Leotronics)

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| FlamMap (US dep agriculture) | ● | ◑ | ○ | ◑ | ● | ○ | ○ | ◑ | N/A | **15** |
| BehavePlus (US Forest Service) | ● | ● | ◑ | ● | ◑ | ◑ | ◑ | ◑ | N/A | **17** |
| Environmental Intelligence Suite (IBM) | ○ | ◑ | ● | ◑ | ◑ | ◑ | ● | ◑ | Multiple plans | **17** |
| CalFire | ● | ● | ◑ | ◑ | ◑ | ○ | ● | ○ | N/A | **17** |
| Intterra | ● | ● | ● | ○ | ◑ | ◑ | ● | ● | No data | **20** |

**Figure 38 Comparison framework UP6**

**Competitors UP6:** FlamMap (US dept agriculture), BehavePlus (US Forest Service), Environmental Intelligence Suite (IBM), CalFire, Intterra

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| LeafSnap (Appixi) | ○ | ○ | ◑ | ○ | ○ | ○ | ◑ | ◑ | N/A | **11** |
| iNaturalist | ○ | ○ | ○ | ○ | ○ | ○ | ● | ◑ | N/A. Merchandising | **11** |
| Google Lens | ○ | ○ | ◑ | ◑ | ◑ | ● | ● | ◑ | N/A | **16** |
| TreeID Woodland Trust | ○ | ● | ○ | ○ | ◑ | ◑ | ◑ | ○ | Low | **13** |
| Forest Diversity (CZU Prague) | ◑ | ◑ | ◑ | ◑ | ○ | ○ | ○ | ○ | Medium | **12** |
| PlantNet | ◑ | ● | ◑ | ○ | ● | ◑ | ● | ● | NA | **19** |

**Figure 39 Comparison framework UP7**

**Competitors UP7**: LeafSnap (Appixi), Google Lens, TreeID (Woodland Trust), Forest Diversity (CZU Prague)

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| FireFringe |  |  |  |  |  |  |  |  | No data | **11** |
| National Interagency Fire C. |  |  |  |  |  |  |  |  | N/A | **11** |
| WIFIRE |  |  |  |  |  |  |  |  | N/A | **16** |
| FIRMS |  |  |  |  |  |  |  |  | N/A | **13** |

**Figure 40 Comparison framework UP8a**

**Competitors UP8a** FireFringe , National Interagency Fire C., WIFIRE, FIRMS

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| HZS (Mountain Rescue Service) |  |  |  |  |  |  |  |  | N/A | **14** |
| GoAudits |  |  |  |  |  |  |  |  | Plans. Low | **17** |
| Citizen APP |  |  |  |  |  |  |  |  | N/A | **17** |
| My 112 |  |  |  |  |  |  |  |  | N/A | **14** |

**Figure 41 Comparison framework UP8b**

**Competitors UP8b:** HZS (Mountain Rescue Service) Slovakia, GoAudits, Citizen APP, My 112

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| Swiss TPH |  |  |  |  |  |  |  |  | No data | **12** |
| Met One instruments |  |  |  |  |  |  |  |  | No data | **17** |
| Tenevia |  |  |  |  |  |  |  |  | No data | **14** |
| INERIS |  |  |  |  |  |  |  |  | No data | **13** |

**Figure 42 Comparison framework UP9b**

**Competitors UP9b:** Swiss TPH, Met One instruments, Tenevia, INERIS

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| Openroute service (HeiGIT) | ○ | ○ | ● | ◑ | ◑ | ○ | ● | ◑ | N/A | **15** |
| EscapeWildFire (RISE) | ◑ | ○ | ◑ | ○ | ◑ | ○ | ◑ | ● | N/A | **14** |
| IBM Evacuation Planner | ◑ | ○ | ◑ | ◑ | ◑ | ◑ | ● | ◑ | Medium | **16** |
| Zoneheaven (Genasys) | ○ | ◑ | ◑ | ○ | ● | ○ | ● | ◑ | N/A | **15** |

**Figure 43 Comparison framework UP9c**

**Competitors UP9c:** Openrouteservice (HeiGIT gGmbH), EscapeWildFire (RISE), IBM Evacuation Planner, Zoneheaven (Genasys)

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| BERI v2 (CSIRO) | ● | ◑ | ◑ | ◑ | ◑ | ○ | ◑ | ◑ | N/A | **16** |
| EFISCEN | ◑ | ◑ | ◑ | ◑ | ● | ○ | ◑ | ◑ | N/A | **16** |
| ForestRY | ● | ● | ◑ | ● | ○ | ◑ | ○ | ○ | N/A | **16** |
| Tree Metrics | ● | ◑ | ● | ○ | ● | ○ | ● | ● | Plans. 4 options | **19** |

**Figure 44 Comparison framework UP9d**

**Competitors UP9d:** BERI v2 (CSIRO), EFISCEN, ForestRY, Tree Metrics

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| Global Forest Watch | ◑ | ● | ● | ◑ | ◑ | ○ | ● | ◑ | N/A | **19** |
| EFDAC | ◑ | ○ | ◑ | ● | ○ | ● | ● | ● | N/A | **17** |
| IUFRO | ○ | ◑ | ◑ | ◑ | ◑ | ● | ◑ | ○ | Various programs | **15** |

**Figure 45 Comparison framework UP9e**

**Competitors UP9e:** Global Forest Watch , EFDAC, IUFRO

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| Biodiversity Indicators (UNEP) | ○ | ◑ | ● | ◑ | ◑ | ● | ◑ | ◑ | No data | **17** |

**Figure 46 Comparison framework UP9f**

**Competitor UP9f:** Biodiversity Indicators (UNEP-WCMC)

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| Kinéis | ○ | ○ | ● | ● | ◑ | ○ | ● | ○ | High | **15** |
| Dryad Networks (Silvanet Suite) | ◑ | ● | ● | ◑ | ● | ◑ | ● | ◑ | N/A | **20** |
| EOS GmbH | ○ | ◑ | ● | ◑ | ● | ○ | ◑ | ◑ | Medium | **16** |
| Spire global | ○ | ◑ | ● | ◑ | ● | ◑ | ● | ◑ | Medium | **18** |

**Figure 47 Comparison framework UP9h**

**Competitor UP9h:** Kinéis, Dryad Networks (Silvanet Suite), EOS GmbH, Spire global

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| Landfire (USGS) | ● | ◑ | ◑ | ○ | ● | ◑ | ● | ◑ | N/A | **18** |
| Prometheus fire growth model | ◑ | ◑ | ● | ◑ | ● | ◑ | ● | ○ | N/A | **18** |
| FireWeather Canada Forest S | ● | ◑ | ◑ | ● | ◑ | ◑ | ● | ● | N/A | **20** |
| FireCast Conservation In. | ◑ | ● | ● | ◑ | ● | ● | ◑ | ● | N/A | **21** |

**Figure 48 Comparison framework UP9i**

**Competitor UP9i:** Landfire (USGS), Prometheus - fire growth model, FireWeather (Canadian Forest Service), FireCast (Conservation International)

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| EFFIS (JRC) | ● | ● | ◑ | ◑ | ◑ | ○ | ◑ | ◑ | N/A | **17** |
| Landfire (USGS) | ● | ◑ | ◑ | ● | ● | ◑ | ● | ◑ | N/A | **18** |
| Firewatch | ● | ● | ● | ◑ | ● | ◑ | ● | ◑ | Medium | **21** |
| MODIS | ◑ | ◑ | ◑ | ● | ◑ | ◑ | ◑ | ◑ | N/A | **17** |

**Figure 49 Comparison framework UP9j**

**Competitor UP9j:** EFFIS (JRC) , Landfire (USGS), Firewatch, MODIS

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| firemaps.net | ● | ● | ● | ◑ | ● | ◑ | ● | ● | Plan + setup Medium | **22** |
| ArboFiRM (Arbonaut) | ● | ◑ | ● | ● | ◑ | ● | ● | ◑ | No data | **21** |
| FiResponse (Technosylva) | ● | ◑ | ● | ○ | ◑ | ◑ | ● | ● | Plans: Lite and pro | **19** |
| FIRE tool NCEI & NASA | ● | ◑ | ◑ | ◑ | ○ | ● | ● | ○ | N/A | **17** |

**Figure 50 Comparison framework UP9k**

**Competitor UP9k:** firemaps.net, ArboFiRM (Arbonaut)., FiResponse (Technosylva), FIRE tool (NCEI and NASA)

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| IRIS (Thales Group) | ◑ | ◑ | ● | ○ | ● | ● | ● | ○ | High | **18** |
| Eurocommand 2020 | ● | ● | ◑ | ● | ◑ | ◑ | ◑ | ◑ | Medium | **19** |
| EMIS (Siemens) | ◑ | ● | ● | ◑ | ● | ● | ● | ● | Medium | **22** |
| SAFE Command - Hexagon | ◑ | ● | ● | ● | ● | ◑ | ● | ● | Medium | **22** |

**Figure 51 Comparison framework UP10**

**Competitor UP10:** IRIS (Thales Group), Eurocommand 2020 (GmbH), EMIS (Siemens), SAFE Command by Hexagon

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| Forestry - The Sanborn Map |  |  |  |  |  |  |  |  | High | **16** |
| Wildfire Analyst Technosylva MXSYS |  |  |  |  |  |  |  |  | No data | **19** |
| CPS Wildfire Management Tool EMXSYS |  |  |  |  |  |  |  |  | No data | **20** |

**Figure 52 Comparison framework UP11**

**Competitor UP11:** Forestry - The Sanborn Map, Wildfire Analyst – Technosylva, CPS Wildfire Management Tool - EMXSYS

| | Forest management practices | Environmental impact | Innovation and technology | Certification and compliance | Features variety /accuracy | Stakeholder engagement | Analytics / database | Friendly UX/UI / website | Pricing | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| MIMO - Radio (SILVUS Tech.) |  |  |  |  |  |  |  |  | High | **17** |
| WAVE-RELAY PERSISTENT S. |  |  |  |  |  |  |  |  | High | **17** |
| Airbus Defence & Space |  |  |  |  |  |  |  |  | High | **22** |
| Indra (Pelicano) |  |  |  |  |  |  |  |  | Medium | **19** |

**Figure 53 Comparison framework UP12**

**Competitor UP12:** MIMO- Radio (SILVUS Technologies), WAVE-RELAY (PERSISTENT Systems), Airbus Defence and Space, Indra (Pelicano)

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