TREEADS Project: A Holistic Fire Management Ecosystem for Prevention, Detection and Restoration of Environmental Disasters

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Abstract. Considering the socio-ecological transition of Europe 2030, and towards a more resilient and informed community, focusing on the forests that are near wildfire risk, TREEADS project aims to build upon state-of-the-art high TRL (Technology Readiness Level) products and unite them in a Holistic Fire Management Platform that optimize and reuse per phase the available socio-technological resources in all three main phases of wildfires. For the prevention and preparedness, TREEADS project proposes the use of a real-time risk evaluation tool that can receive multiple classification inputs and work with a new proposed neural network-powered Risk Factor Indicator. To create a model of Fire Adapted Communities (FAC) in parallel to insurance incentives, TREEADS will use Alkali Activated Construction Materials (AAM) integrating Post-wildfires Wood Ashes (PWA) for fire-resilient buildings and infrastructure. TREEADS also uses a variety of technological solutions such as the Copernicus infrastructure, and a swarm of small drones customized for accurate forest supervision. In the area of detection, TREEADS propose a variety of toolsets that will accommodate most needs, stemming from virtual reality for the training, wearables for the protective equipment of the emergency responders to UAV (drones), UAG and airships for improving capacity in temporal and spatial analysis as well as to increase the inspected area coverage. Last, TREEADS will build a new land and field-based restoration initiative that will use all modern techniques such as agroforestry, drones for seed spread, Internet of Things sensors that will be able to adapt the seeding process based on the ground needs and on the same time with the help of AI to determine post-fire risks factors. TREEADS solution will be demonstrated and validated under real operating conditions. Demonstration will involve eight complex pilot implementations executed in seven EU countries and in Taiwan.

Keywords: wild fires; prevention & preparedness; detection & response; restoration & adaptation.

1 Introduction

TREEADS (https://treeads-project.eu) is a Horizon 2020 Green Deal project (Grant Agreement: 101036926, H2020-LC-GD-2020/H2020-LC-GD-2020-3), with main objective to increase environmental sustainability and urban / rural ecosystems safety, through redefining and reinforcing forests' protection and management. TREEADS pursues this goal by developing and validating an innovative, sustainable, applied, and holistic wildfire management approach.

TREEADS project ecosystem develops a holistic solution with advanced capabilities for before (prevention and preparedness), during (monitoring and real-time management) and after (impact mitigation) the extreme event of a wildfire, as it is schematically represented in Fig. 1.

Figure 1. TREEADS holistic solution

The core of TREEADS system is an advanced computational system based on Artificial Intelligence (AI), that provides a risk analysis tool, an evacuation route plan, a fire ignition detector, a fire and smoke propagation tool as well as an adaptive forest restoration decision support system DSS along with mapping services. TREEADS will also use a fleet of UAVs and airships (in three different altitude levels), as well as satellite images to create a four layer surveillance platform for faster fire ignition detection and accurate image processing. Finally, TREEADS also proposes new fire resilient materials, insurance models, health monitoring and AR tools for fire responders, a mobile app that will bring the power of the computational system on the go and drone seeding technology by using special made seed capsules.

2. Objectives

The TREEADS system has the following objectives:

1. Contributing to major societal challenges by:
   - Gradually transform forest and fire management into a “management by inclusion” paradigm.
   - Build wildfire resilience and strengthen disaster response and recovery.
   - Bring together expert knowledge, complex adaptive systems, climate change adaptation understanding and artificial intelligence into an adaptive and transparent management context of increasingly informed decisions for ecological restoration.
2. Improving the efficiency of current fire-fighting operations by:
   - Identifying and preventing threats and abnormal events with validated levels of accuracy along with analyzing fire behavior and employing a real-time and 24/7 integrated wildfire detection and strategic surveillance system.
3. Advancing operational reaction and mitigation algorithms by:
   - Developing a novel emergency & disaster response system.
   - Enabling a distributed and resilient event-driven wildfire management system allowing real-time analysis and processing of complex event streams.
   - Providing a multi-response engine offering usable real-time information during a wildfire event.
   - Offering a Common Operational Graphical & Interactive interface with system users
   - enhancing the preparedness and planning capacity of firefighting stakeholders.
4. Deploying, validating and testing the solution in realistic live demonstrations over 8 different climate scenarios, bio-geographical/socio-economic contexts.
5. Protecting human lives, the environment, and the property.
6. Delivering a strong impact, by:
   - Developing an integrated wildfire management ecosystem.
   - Disseminating the project results to accelerate adoption within the forest value chain.
   - Communicating with local communities and the public about wildfire and forest management system.

Figure 2 provides a schematic representation of TREEADS approach.

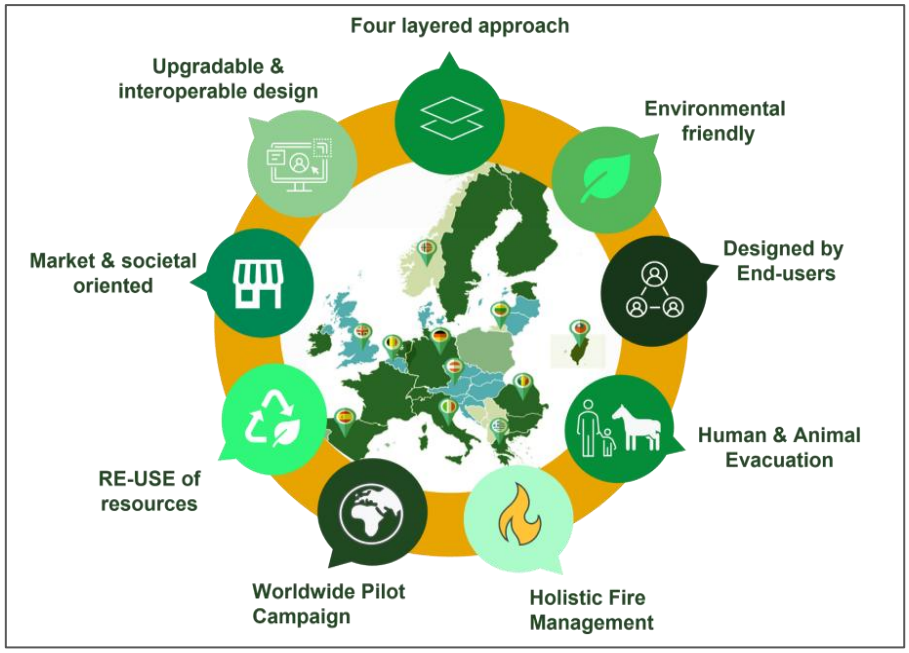

Figure 2. TREEADS approach

3. Challenge and mission

Wildfires are a severe threat across Europe, causing significant environmental and economic damage. They are becoming more intense and widespread as a result of climate change, particular forestry practices, ecosystem deterioration, and rural depopulation. Extreme wildfire events, in addition to their devastating ecological impact, have an unparalleled social cost in terms of both human life and economic losses.

TREEADS project mission is to reduce the effectiveness of the damage caused by wildfires, while maximizing the benefits of restoration and managing the impact of wildfires on local communities. Under a constantly changing socio-ecological context, TREEADS consortium is establishing a unified Technological ecosystem for integrated fire management and adaptive forest restoration. The TREEADS project will adopt a holistic forest fire management and an adaptive, collaborative governance approach based on the deployment of a new systemic and technological framework covering all three interconnected fire management stages.

The TREEADS project has been designed with a positive impact on society in mind. It contributes to major societal challenges by:

- Improving the efficiency of current fire-fighting operations and,
- advancing operational reaction and mitigation algorithms,

by deploying, validating, and testing the solution in realistic live demonstrations over eight different climate scenarios, bio-geographical and socio-economic contexts.

4. Pilot campaigns

The TREEADS ecosystem will be demonstrated and validated in realistic environments under realistic operating conditions with the involvement of different end-users (environmental and nature management organizations, firefighters, local and regional authorities, etc.) from Member States and Associated Countries. Demonstration will involve complex pilot implementations, executed in eight different countries (Norway, Germany, Spain, Italy, Austria, Romania, Greece, Taiwan) under different case scenarios in different environments (as pilot cases will be in southern, central, and northern Europe), testing prototype and demonstrating to meet different first responders' needs. Fig. 3 provides an overview of the TREEADS pilots.

Figure 3. Pilot campaigns and their targets

4.1 Norwegian Pilot Case

Norwegian forests cover 38% of the land area in the country. Many residential buildings in Norway are in the proximity to wildland vegetation. Besides, a large number of such houses were built using wooden construction materials, posing a great wildland-Urban Interface (WUI) fire risk. Due to the long and narrow territory of Norway, a large population in northern Norway relies heavily on the infrastructures in the forest, such as power grids and telecommunication towers.

Therefore, it is crucial for Norway to reliably detect forest fire in the early stage and to protect the key infrastructures in the forest. To improve prevention and preparedness for the wildland fire, several field exercises on forest fires are carried out each year in Norway by local firefighters, Norwegian Fire School (NBSK), and Norwegian Directorate for Civil Protection (DSB). The Norwegian pilot use case connects to such exercises. Measurements obtained from the field exercises will be used as the inputs to test the passive fire protection technologies provided by partners.

4.2 Italian Pilot Case

The pilot case is related to a very important touristic area in Southern Italy, including high density urban settlements and very dense wooded areas on the slopes. The ridge of the Sorrento Peninsula in the proposed area rises up to 390 m above sea level and the slopes are often subjected to extreme wildfires (both natural or malicious); in 2017 a very big fire involved different areas in Campania Region but in particular around the Vesuvius, causing also interruption in public transportation services.

A cable car system will be built to connect a sea level location to the ridge of the Sorrento Peninsula, to integrate the regional rail transport system with connection to remote areas only reachable by car. An ongoing feasibility study promoted by the Regional Transportation Agency, will define the optimal solutions. The final design activities will take place during the project lifetime. The pilot activities could use the available data for the infrastructure design and the fire propagation modelling could support both the feasibility analysis and the final design solutions.

4.3 Romanian Pilot Case

At national level, there are on average 166 forest fires per year, with a total affected surface area of approx. 50kHa (data over the last 60 years). However, the average surface of forest fires has increased by 53% and their frequency has doubled in the last decade. National statistics show that 61% of forest fires start by human negligence and 35% are due to unknown causes, most likely also due to human error. The pilot is set in Macin Mountains National Park's. Its available natural potential is making it accessible to a wide range of tourists, interested in hiking, landscapes, flora, local fauna, studies and documentaries (documentations). Among the identified vulnerabilities of the area are uncontrolled tourism, poaching, scattered grazing, illegal logging leading to the suppression of habitats, burning of vegetation, destruction of specimens of spontaneous flora, illegal capture of Dobrogean land turtles (Testudo graeca), extension of farms, extreme sports that disturb the tranquility of the area. Due to this abundance of visitors, human negligence is an important factor to consider in the prevention and mitigation of forest fires.

4.4 Spanish Pilot Case

Tiétar Valley, in the south of the province of Ávila is the Spanish pilot location. The southern area of Ávila is the most important forest area in terms of forest surface, with the massive presence of Pinus species and mixed forests. This area together with all its municipalities is considered as "High Risk Zone" according to the regional and national administration. The application of the holistic fire management approach proposed in TREEADS project will be narrowed to some municipalities or forest owners surface, according to the potential application of the foreseen technologies, which will be tested and validated in the Tiétar Valley.
The demonstration sites will be strategic points in the southern of Ávila province covering all the types of forest lands existing in the area, regarding different criteria, such as: proximity to urban areas, available infrastructures, the potential input data collection, forest land ownership and type of trees. Regarding the available infrastructures, there are regional infrastructure where can be located and coordinated the activities, like an extinction base, and there are infrastructures provided by the municipalities that will be collected and standardized in a database to offer accurate information to extinction resources.

4.5 Austrian Pilot Case

In Austria forest fires are of main concern and these threats are continually increasing. Long drought periods and more and more heat days together with human induced fire sources are resulting in forest fires which are also threatening the villages and cities often very closely situated to the forests. At the outskirts of Vienna, areas like Stammersdorf are directly located next to woods and vineyards. During dry times in the summer, the risk for a wild fire is extremely high. Since the last years, the area is growing fast and population is increasing. It also resembles a recreational area for a lot of Viennese inhabitants and is an important agricultural and touristic area. Stammersdorf is a prototype of suburban area in Vienna with an existing risk to wildfires.

4.6 German Pilot Case

A direct consequence of climate change is longer drier periods of drought, even in countries which traditionally had a lot of rain. In Germany about 32 % of the surface area is covered by forests. The dryness monitor for Germany shows that Saxony-Anhalt and Brandenburg are some of the driest parts of Germany. Most fires in both provinces have been ground fires which are dependent on dryness and dead organic material. Experiments in medium and large scale are undertaken using ground specimen up to several square meters, to evaluate the dependence of the fire spread on various kinds of vegetation as well as different amounts of organic mass in the ground and dryness. Better understanding of fire and smoke development mechanisms allows for more precise prediction of fire and smoke development which is crucial for assessing and improving firefighting tactics. Smoke production of these fires is a health risk for fire fighters as well as for inhabitants of villages close to forest areas. Extinguishment methods need to be water-saving, eco-friendly and efficient. Each fire scenario has different challenges and wildfires can happen in industrial areas as is the case in many areas of Brandenburg. This presents a great danger of pollutants being introduced into the environment together with the water-based extinguish agents, therefore optimal use and delivery of extinguishing liquids, other extinguishing agents and firefighting methods is of high importance.

4.7 Greek Pilot Case

It is a fine and warm summer day in the touristic area of Samaria Canyon, with temperatures between 35-40 degrees Celsius. Suddenly an explosion takes place in the middle of the day, and smoke, from the forest of Samaria, is covering the area around the forest. On the edge of the canyon is a sea-side touristic village (Agia Roumeli), with a number of hotels and villas. The only way to evacuate this area is by sea as the road is blocked from the fire. This demonstration will be led by Technical University of Crete and Mediterranean Agronomic Institute of Chania at their premises in the island of Crete, Greece capitalising on the data sets obtained by several devastating fires burst out in the island. Notably, the governance authority of Crete will contribute with regional medical emergency services, fire brigade and law enforcement units as well as the civil protection command and control centre. In this demo, cross organisational collaboration at regional, national and international level will be sought. The scenario will highlight the difficulties encountered in prioritising the employment of resources to different sub-scenarios (e.g., where to allocate available assets in handling heterogeneous causes of crises).

4.8 Taiwanese Pilot Case

The pilot case is a house with a dimension of 2mx2mx2m for the length, width and height, respectively. This house will use the alkali-activated material (AAM) concrete, which is produced by post wildfire ash incorporating by-products such ash slag and fly ash. The demo site is located at National Taiwan University Experimental Forest, in Nantou county, Taiwan. There is an existing small house which was utilized for security purpose. The small house will be expected to be rebuilt or refurbished using AAM-based concrete. There are available measurement devices in the demo site, including temperature, humidity, smoke concentration and air pressure. These available data refer to forest. The further measurement devices related to the house are planned to be set up in the demo site.

5. Response and results

TREEADS project will tackle a number of major challenges that wildfires pose by building upon state-of-the-art high TRL products and unite them in a holistic Fire Management Ecosystem consisting of various innovative technologies and systems to optimize and reuse the available socio-technological resources in all three main phases of wildfires. By adopting a multi-stakeholder, multi-actor approach at its core, the TREEADS solutions will contribute to sustainable development as an inclusive societal process and secure sustainability and resilience of natural environment, as well as local human societies. Fig. 4 summarizes the main aspects of TREEADS impact.

Figure 4. Expected impact

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