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The Future of Forest Firefighting in Andalucia, Spain

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Living Lab
Forest Fires in Andalusia
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Remotely Piloted Aircraft System, geolocation, communication systems, cloud-based database
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The Andalusian Living Lab (LL) focuses on *How can digitalisation contribute to reduce the damage caused by wildfires and to make more effective firefighting and degraded land restoration by 2030?*

Forest fires are an increasingly recurrent phenomenon with an everchanging and more unpredictable behaviour. They require a significant amount of effort, resources, and coordination from all the organisations and communities involved to minimise their impact. The current context is complex and increases the risk to suffer highly impactful forest fires. Rural depopulation and agriculture land abandonment have increased forest surface in Spain, but many of these areas are not managed, and the local knowledge and values are not passed on. Private-forest owners -accounting for 75% of the Andalusian forests-, see their land profitability reduced due to the high costs of fire preventions measures. They are also affected by unfair competition of resources from public-owned forests (e.g., wood), increasing possibilities to land abandonment. Also, the limits between urban and forests have faded as new communities settle within or in the vicinity of forest areas, changing the way in which fires are managed. Finally, the sector is demanding professional profiles trained on forest management and digital and technological tools that Academia is not yet able to provide.

Whereas technologies have significantly evolved and contributed to faster and better manage forest fires (e.g., use of the use of Remotely Piloted Aircraft System -RPAS- for monitoring, smartphone devices and networks for immediate communication and geolocation), there are still some issues to be addressed for a better performance. Technological advances require a more responsive public administration to provide regulation updates and to establish data protocols and data interoperability mechanisms. Also, technologies could support a better coordination of the public administration with the communities and the private sector for early warning, monitoring and recovery systems.

The LL participants had a valuable chance to interact, which is not always enabled, and to provide hints about the future of digitalisation in forest fires management.

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Context and main needs related to the Living Lab's focal question

The current context is shaped by key socio-economic factors: agriculture land abandonment, increase of forest land and depopulation processes in the rural areas. These factors combined with climate change and the natural dynamic of Mediterranean forest ecosystems to accumulate fuel (especially during the summer draught) increase the possibilities to suffer more severe and impactful forest fires. Moreover, ageing processes and lack of generational shift in traditional farming activities playing a key role in forest fires prevention, such as cattle grazing, contribute to create less resilient forest ecosystem.

Yet the forest fires sector has seen a dramatic technological adoption in the past decade (e.g., fire evolution modelling, use of geographical big data) and it is expecting to incorporate further developments. In return, the rigidity of the public administration hinders regulation updates and the provision of open, interoperable, and up-to-date data protocols and databases. Technology can facilitate public engagement and citizen science for early warning, monitoring and recovery mechanisms. Also, faster, and more accurate technologies -like the High Altitude Pseudo Satellites, HAPS- are expected to significantly control and reduce the impact of forest fires. The main threat is how climate change will impact forest ecosystems and whether the access to future technologies will be granted.

Main digitalisation needs

- *Increased general awareness about forest fires. Awareness campaigns about prevention, risks, and impact of forest fires. Procedures in case of forest fire events, early warning, and monitoring mechanisms for citizens. Technologies to support prevention measures in private forest properties.*
- *Updated and real-time data. Protocols and tools to make updated forests information available including vegetation fuel maps, firebreaks status, accessibility of roads and routes, etc. Protocols and tools to provide real-time information about forest fires evolution and behaviour.*
- *Improved data accessibility. Centralised, organised, easy-to-access and public data in relation to vegetation status, location of water supplies, new roads and routes, private owners fire prevention plans, and previous forest fires episodes.*
- *Frequent regulation updates. Need to accommodate technology developments in regulation faster. Regulation to coordinate RPAS and piloted aircrafts.*
- *Better collaboration and coordination among stakeholders. Communication channels to enable information exchange, collaborations and to share technological innovations. Early warning systems and use of social media.*
- *Interoperable systems to transfer data among stakeholders.*
- *More reliable communication systems, especially in rural and remote areas. Internet connectivity must also be affordable, reliable, stable, possess low latency, and have redundancy.*[1]

[1] Council of Canadian Academies, "Waiting to Connect: The Expert Panel on High-Throughput Networks for Rural and Remote Communities in Canada" (Ottawa, October 2021), https://cca-reports.ca/wp-content/uploads/2021/10/Waiting-to-Connect_FINAL-EN_digital.pdf.

The Socio-Cyber-Physical (SCP) system

Several interactions occur in a complex SCP system due to the population increase within or in the vicinity of forest areas, the shared competencies in land management and the development of strategies for prevention, extinction, and restoration of burnt areas. All these are, at the same time, impacted by progress in research, development, and innovation.

The **social** component of the SCP system comprises citizens, the public administration, and the private sector. Forest owners, people living in forests and forest areas, forest visitors, occasional users and society at large are beneficiaries of the forest ecosystem services. Therefore, they should be involved in the forest maintenance and valorisation to the extent possible, which is not always facilitated. The competencies in forest firefighting and forest management are shared among different areas and levels of the public administration, which can cause overlapping and coordination issues, as well as information flows deficiencies. The staff and technologies required for forest firefighting belong to both the public (firefighters) and the private sectors (piloted aircrafts and their sensors). This may lead to clashes in terms of regulations and standards, slowing down or even preventing the use of certain -unregulated- technologies or the deployment of forest fire brigades. The visions and strategies of the stakeholders within the social dimension of the SCP system differ and can lead to conflicts and coordination issues.

The **physical** aspect of the SCP system shows a great variability and complexity throughout Andalusian forests in terms of vegetation, topography, climate, infrastructure layout, etc. Forests vulnerability to suffer severe wildfires is increased by the existence of patches of homogenous species, the lack of management in many forests (especially in pine forests) and wrong approaches to forest ecology (considering thinning and clearance activities as deforestation). Therefore, modelling techniques based on artificial intelligence could support to design more resilient landscapes.

The **cyber** domain has undergone significant development in the past decade. Remote sensing and spatial techniques provide updated information about the forest and fire status; fast telecommunication systems enable onsite and offsite coordination; and the capacity to quickly process large volumes of information allows to predict forest fires behaviour. The challenge is to establish collaboration and communication protocols among stakeholders and to the increase systems interoperability.

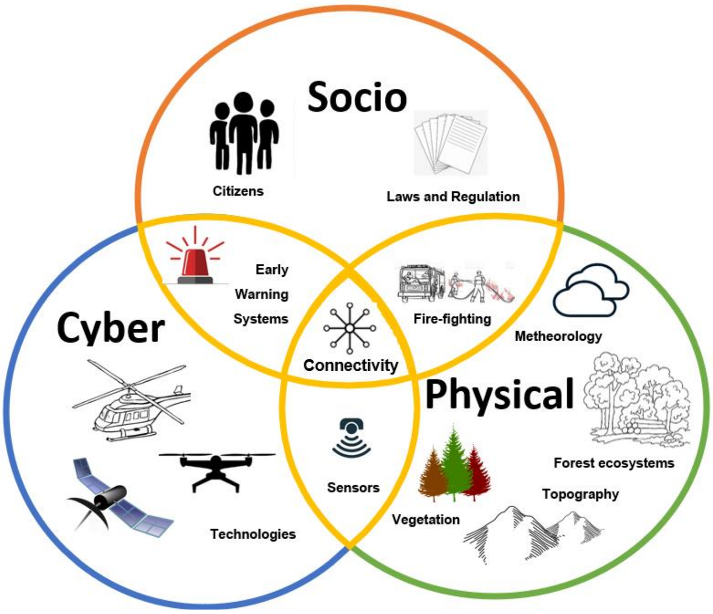

Figure 1 Visualisation of SCP system for forest fires in Andalusia

Impacts of digitalisation

What has been digitalised?		Main impacts (i.e. effects/consequences)	Sustainable Development Goals
• The data acquisition and data processing, thanks to sensors, remote sensing, telecommunication systems and powerful software and hardware.	Direct	• Difficulties in sorting and organising all the data and evidence gathered during wildfires	SDG 9: Build resilient infrastructure, promote sustainable industrialisation and foster innovation SDG 13: Climate action SDG15: Life on land
		• Difficult to find qualified staff	
		• Faster and more informed decision making, in prevention, firefighting and recovery	
		• Increased security for the firefighting brigades (geolocation, faster assistance)	
		• More accurate response and forest recovery thanks to modelling techniques	
	Indirect	• Potential unethical use of the data	
		• Better forest and ecosystem management, reducing fire possibilities	
		• Enhanced transparency in operations	

- **Design of digital technologies:**

Data processing has enabled to make information from different sources accessible. Also, availability of devices, such as smartphones or tablets, and the capacity to process and to consult high volumes of information quickly, have accelerated and improved the response on the field. New technologies pose the challenges of integrating them in a time-sensitive operation and to find the qualified profiles required. Finally, proprietary software and limited interoperability might prevent the use of relevant data.

- **Access:**

Reliable, stable, and fast internet connection is not always available in rural areas, making the firefighting response more difficult, especially in remote places. Besides, the fire often damages infrastructures which are the only source of communications. New technologies require significant investments for their development, testing and full adoption, which is conditioned as well by a general reluctance to change by the public administration and the staff involved in firefighting. Yet access to digital technologies is not limited to availability, but usage. Sometimes the staff lacks the technical skills and abilities to use specific or cutting-edge technologies. The ageing of the rural population restricts the capacity to engage with the local communities via new technologies (e.g. social media).

- **System complexity**:

The fast evolution of technologies has generated a complex system in which standardised training and requirements for staff are missing. This is worsened by the work seasonality for a high percentage of professionals working in forest fires. In general, communication channels, data acquisition and processing during wildfire fighting are not uniform and difficult early warning systems.

Main conclusions and recommendations

The impact of digitalisation in forest fires has been of special relevance in relation to data and communications. New technologies have significantly increased the capacity for data acquisition and processing. Nowadays, it is easier, cheaper, and faster to gather data with remote sensing technologies, cameras, sensors, GPS devices, etc., providing a detailed picture of all the forest fires stages. The capacity to process, integrate, and analyse data has undergone rapid improvements, enabling faster and more informed decision-making processes. Geolocation systems and portable GPS devices allow to track assets and to improve people safety. Progress in communications systems have also contributed to enhance the response capacity during a forest fire episode. Advanced technologies (satellite broadband, digital radio communications networks, etc.) facilitate onsite and offsite communications through a variety of devices, even in challenging conditions and complex topography.

To summarise, digitalisation has improved the analysis, modelling and usability of forest fire scenarios; it has improved the capacity of reaction; it has managed to reduce the impact of forest fires in the whole system -including casualties, ecological and economic losses-; and it has contributed to save time and money.

Some of the recommendations for the future of digitalisation in forest fires are:

- To use the new technologies to design collaborative platforms and to create a framework that facilitates knowledge transference between all stakeholders (public administration, rural communities, academia, and private sector).
- To systematise the experiences with technological advances for efficient and effective learning and implementation processes.
- To boost transversal development, fostering new opportunities for rural development.
- The public administration should adopt these new technologies with the views to:
    - Create more fluid and efficient administrative procedures.
    - Open direct communication channels with the citizens.
    - Develop and improve regulation, e.g. permits required for specific activities in forests, such as camping or bonfires, could be granted based on a risk index calculated from real-time data and not based on a fixed calendar.
    - Design a system to turn administrative process into an opportunity to contribute and to update a centralised database.
    - Ensure the standardisation of data to be easily integrated in different platforms and to be accessed by different stakeholders.

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