Figure 73: Results of the Post card "Wildfire-resilient landscape" (left) and Train resilient activity (right) carried out in the 1st CWI meeting of PT LL

The Lousã event gathered **35 participants** and **seven FIRE-RES researchers** (ForestWISE, ISA, INESC TEC), representing the four-helix ecosystem. Using the IFM framework (Rego, Morgan, Fernandes & Hoffman, 2021), participants explored the holistic dimensions of wildfire risk: preparedness, prevention, suppression coordination and post-fire recovery.

Figure 74: Creation of the CWI in the PT LL during the 1st CWI meeting (4.11.2023)

The sentences collected from the postcards were clustered into thematic groups, which then informed:

- ✓ the "***Train Through a Resilient Landscape in 2030***" exercise, and
- ✓ the selection of topics and barriers addressed in the afternoon **Challenge**
- ✓ **Design Workshop (CDW)**.

The **CDW** followed the full IFM cycle (Prevention & Preparedness, Detection & Response, Restoration & Adaptation) and resulted in **six challenge frames** (LL PT) and **50 challenge proposals** (all LLs), later synthesized into **[seven themes and seventeen challenges]()**. These became the basis for the **Open Innovation Challenge (OIC)** campaign and for the 2025 **World Café** session.

Figure 75: Challenge Design Workshop (CDW) activities during the 1st CWI meeting, Lousã (4.11.2023)

The 1st CWI Meeting was therefore a cornerstone event: it launched the Portuguese CWI, aligned the two areas of the LL PT around a shared vision (Figure 74), and established the challenges (Figure 75) that would guide the remaining FIRE-RES activities in Portugal.

2nd CWI meeting (November 7-9, 2023 – Porto, Penafiel)

The second CWI event, hosted by ISA and ForestWISE and held in parallel with the **2nd FIRE-RES General Meeting**, brought together more than **130 participants**, including FIRE-RES partners and CWI members.

Day 1 (7 Nov) Plenary sessions connected Living Labs and Work Packages, enriched by keynote speakers and cross-consortium exchanges.

Day 2 (8 Nov) – Travel Lab: Vale do Sousa Field Itinerary Organised by ForestWISE, the Travel Lab explored integrated landscape management through three demonstration stops:

1. **Serra do Porto Parks (REN – Energy company)** – peri-urban risk mitigation and native vegetation conversion under powerlines.

2. **Monte da Pegadinha (Quinta da Aveleda)** – post-fire reconversion of pine stands into vineyard.
3. **Private mixed-forest property (Cristina Silva, a Forest Owner from AVFS)** – biodiversity enhancement and multifunctionality at stand and landscape level.

https://youtu.be/Vygh1lWrsII

The field visit was followed by a **roundtable at Penafiel Museum** (Figure 76), comparing local and national perspectives on challenges to building resilient landscapes. Participants included ENB, ANEPC, AGIF, ICNF (Regional), ALTRI, REN, AFVS, ForestWISE and ISA. The day ended with a networking dinner at the Penafiel SPA Hotel, bringing together CWI members and project partners and providing an opportunity to deepen conversations and consolidate the connections established during the event.

Figure 76: CWI and Partners of the Consortium FIRE-RES during Round table session - activities during the 2nd CWI meeting , Penafiel (9.11.2023)

Day 3 (9 Nov) Parallel WP sessions and networking activities continued, consolidating collaboration between project partners and Portuguese CWI members.

https://www.forestwise.pt/en/fire-res-experts-discuss-to-mitigate-rural-fires/

3rd CWI meeting (October 29 & 30, 2024 – Castelo de Paiva, Penafiel)

Organised by **CoLAB ForestWISE** with the support of **ISA** and the **Vale do Sousa Forest Owners Association (AFVS)**, the two-day event gathered **over 75 participants**, including FIRE-RES partners, Open Innovation Challenge (OIC) winners, and national and regional CWI members.

Day 1 (29 Oct) Field visit and networking in Castelo de Paiva

The programme started with a field visit to **Castelo de Paiva**, focusing on good practices for resilient forest management and value-chain diversification. Participants explored the *Sonae Arauco "Floresta Sonae" demonstration area*, observing post-fire regeneration and sustainable management practices, followed by a presentation by **2BForest** on three years of experience in **ecosystem-services certification** initiatives within the Vale do Sousa region. The day concluded with a **municipal reception at Castelo de Paiva City Hall,** where local authorities highlighted the importance of cooperation among landowners, municipalities, and industries for building fire-resilient territories.

https://www.youtube.com/watch?v=htBqwM_koLI

https://www.forestwise.pt/en/colab-forestwise-launches-1st-innovation-day-series-on-innovative-solutions-for-wildfire-management/

Day 2 (30 Oct) Innovation Showcase and Matchmaking in Penafiel

- The 2nd day took place at the Penafiel Exhibition Pavilion, featuring the official kick-off of the FIRE-RES Innovation Day Series. where **more than 40 innovations between OICs, IAs leaders and active CWI members were showcased**, covering technological, adaptive management, social, and nature-based approaches. The event provided a dynamic setting for knowledge exchange and networking through a matchmaking fair with thematic workstations, showcasing solutions from project partners, CWI members, and OIC winners.
- in the auditorium each of the four main panels opened with a national keynote speaker and reflected one of the typologies of OIC solutions (WP6 innovative campaign). **We bring 9 OICs Pitchers to share their innovative solution.**

Four thematic panels were held:

- Technological innovation for extreme wildfires
- Fire-smart communication and social engagement
- Resilient territories and adaptive management
- Nature-based solutions for prevention and restoration

The event closed with a roundtable on "**Boosting Financially Resilient Landscapes**," moderated by INECS TEC, with representatives from finance, municipalities, entrepreneurship, and forest associations, including Tessa Maurer as keynote invited (Blue Forest).

This closing debate linked innovation with sustainable financing models, reflecting the FIRE-RES ambition to build economically viable, socially engaged, and ecologically resilient landscapes.

Between sessions, participants joined networking moments and exchanged ideas at interactive stands where CWI members presented their ongoing initiatives in prevention, restoration, and community engagement (Figure 77).

Figure 77: Field visit, showcase and OIC pitches during the 3rd CWI meeting, Penafiel (29 & 30.10.2024)

The Innovation Day Series officially began in Portugal and followed in Bulgaria (April 2025) and Spain (July 2025), showcasing the FIRE-RES commitment to upscaling innovation and fostering cross-country learning among Living Labs and CWIs

4th CWI meeting (October 9, 2025 - Lousã)

The fourth and final Portuguese CWI meeting returned to Lousã, symbolically closing the four-year journey with **72 participants**. Beyond celebrating achievements, it provided an opportunity to reflect on the **legacy of FIRE-RES** and evaluate the progress made across the two areas of the LL PT.

The morning sessions featured presentations of outcomes from IAs implemented in Portugal. In the afternoon, national OIC solutions were showcased (REN, 2BForest, AGIF), followed by the dynamic exercise "**Mission FIRE-RES**" - building on the 2022 "*Train through a Resilient Landscape*" activity.

FIRE-RES: Last meeting of the Community of Wildfire Innovation in Portugal - ForestWISE

Participants revisited the themes defined in 2022, scored progress, and identified remaining gaps toward the shared Vision 2030.

The four-year cycle of CWI meetings established a **shared governance culture**, strengthening the link between community engagement, innovation testing, and policy dialogue. The initial "postcard visions" evolved into **measurable pathways** for the 2030 roadmap, shaping a collective strategy for resilient landscapes in Vale do Sousa and Lousã.

Figure 78: Plenary session under 4th CWI meeting, Lousã (9.10.2025)

Between 2022 and 2025, the evolution of priorities in the Portuguese Living Lab areas (Lousã and Vale de Sousa) shows a clear shift from community identity and coexistence with the forest toward practical, ecosystem-based, and collaborative management approaches (Figure 79).

In 2022, participants emphasized cultural and social connections ("The forest is lived by me and the others") and diversity as core dimensions of resilience. By 2025, the focus moved toward landscape diversity, professional forest management, and collaborative approaches, reflecting a growing awareness of the need for coordinated action, innovation, and technical competence to reduce wildfire risk.

The *World Café 2030* exercise thus reveals an **ongoing <u>maturation of local perspectives</u>**: from valuing symbolic and individual relationships with the landscape to **prioritizing collective management, ecosystem services, and multifunctional use** that directly contribute to fewer wildfires and less burned area.

Figure 79: World Caffee Guide.

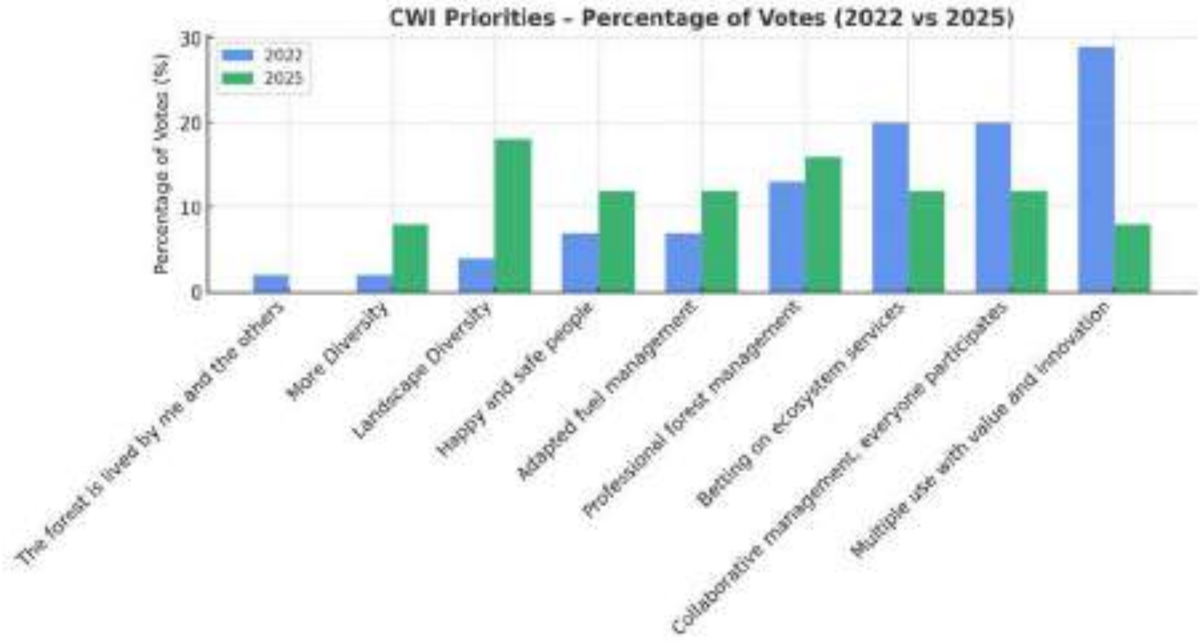

Figure 80: grouped bar chart comparing CWI priorities (%) between 2022 and 2025

We can clearly see the evolution of focus:

- **Landscape diversity**, **professional forest management**, and **adapted fuel management** gained importance in 2025;
- <u>Multiple use with value and innovation</u>, the 2022 leader, <u>lost votes</u>;

- Collaborative management and ecosystem services remain strong but lower.

This collaborative approach reinforces the Living Lab's role as a co-creation ecosystem where science, technology, and community engagement converge toward more resilient fire-adapted landscapes.

World Café - Roadmap 2030: Promoting Fire-Resilient Landscapes

During the 4th CWI Meeting (9 October 2025, Lousã), participants engaged in a World Café exercise titled **Roadmap 2030: Promoting Fire-Resilient Landscapes.** The activity revisited the challenges first identified in 2022, asking a canonical question applicable to all three phases of the fire cycle:
"***Does this 2022 challenge remain relevant in 2025?***"

Figures 82–84 capture the three working tables used in this exercise, where participants assessed the current relevance of the 2022 challenges and identified related **FIRE-RES Innovation Actions (IAs)** and **Open Innovation Challenges (OICs)** that contributed to addressing them.

Prevention & Preparedness | The challenge initially identified in 2022 (*1st CWI Meeting, 4 November 2022*) *"Empowering actions at community and landscape levels: Reversing land abandonment through socioeconomic incentives"* **remains relevant** (≈ 90 %). However, participants noted that it now has a **clear IA/OIC pathway**, notably through **IA4.2**, **IA4.3**, **IA2.x**, and **OIC23/24/41**. CWI members recognised **strong knowledge exchange** and **community engagement** as major advances, while highlighting the need for simpler and more accessible messaging, together with policy and financing mechanisms to scale actions such as residue management, incentive schemes, and timber certification.

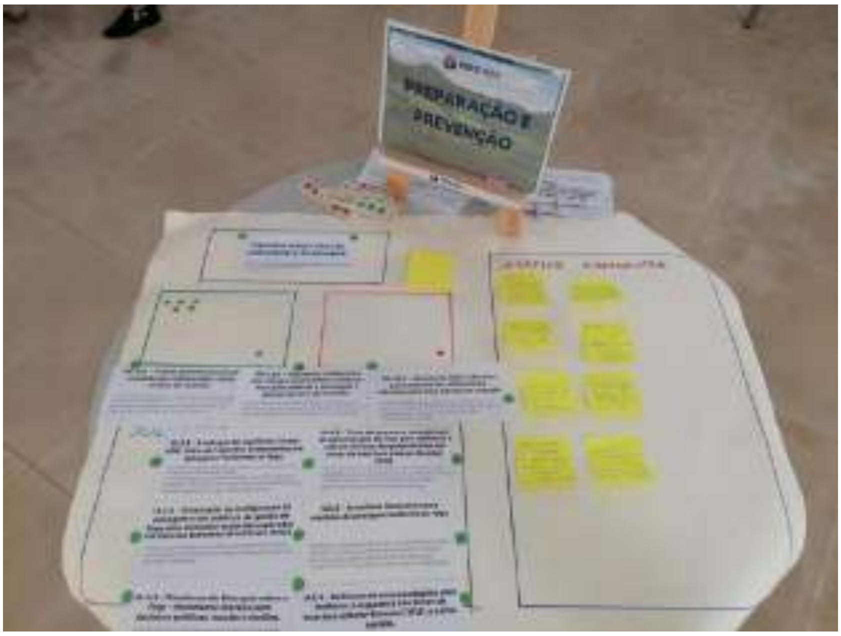

Figure 81: CWI feedback for the Prevention & Preparedness phase - challenge "Empowering actions at community and landscape levels: Reversing land abandonment through socioeconomic incentives" 4th CWI Meeting, 9 October 2025, Lousã

Detection & Response | The 2022 challenge *"Safe and improved early attack and suppression: Modelling fire behaviour under extreme wildfire conditions"* is **still pertinent** in 2025. FIRE-RES delivered a set of **tools and training prototypes** (notably **IA5.1, IA5.2, IA5.8,** and **IA2.5**) supporting operational decision-making and preparedness. Participants nevertheless emphasised the **implementation gap**, stressing the need to formalise training pipelines, standard operating procedures (SOPs), and inter-agency adoption frameworks to ensure that innovations translate into **routine operational practice**.

Figure 82: CWI feedback for the Detection & Response - challenge "Safe and improved early attack and suppression: Modeling fire behavior under extreme wildfire conditions" 4th CWI Meeting, 9 October 2025, Lousã.

Restoration & Adaptation | In this phase, the facilitator's question was phrased as "Is this challenge already solved?". For analytical consistency, **responses marked "NO" were recoded as "YES (still relevant)"**, aligning with the canonical question used for the other phases.

The selected challenge "Smarter post-fire restoration and recovery: Intensifying recovery efforts in rural areas" **remains relevant**. Participants acknowledged tangible progress on **technical guidance and learning** (notably through **IA2.6, IA4.3**, and OIC41). However, issues such as **regulatory clarity** (e.g., debris-burning rules in WUI zones) and **economic viability** (post-fire profitability and crop diversification) continue to lag behind, as they depend on policy and market drivers beyond the scope of the project.

Figure 83: CWI feedback for the Detection & Response - challenge "Smarter post-fire restoration and recovery: Intensifying recovery efforts in rural areas" 4th CWI Meeting, 9 October 2025, Lousã.

Summary of Achievements at CWI Level:

- **Soft impacts consolidated**: stronger knowledge exchange, awareness, and coordination among actors across all fire-cycle phases.
- **Pathways to practice created**: multiple IA/OICs were mapped to 2022 challenges, with several pilots and demonstrations delivered within the PT Living Lab.
- **Remaining gaps**: the main barriers concern policy uptake, institutionalised training, and the creation of economic instruments to sustain action beyond the project.

Table 16: Mapping of 2022 CWI challenges to corresponding FIRE-RES IAs and OICs, including indicative impact levels and progress notes based on feedback from the World Café – Roadmap 2030 exercise.

Fire-cycle phase	Challenge (2022/2025)	Linked IA/OIC	Impact level	Notes
Prevention	More effective risk communication to society	IA4.2 (risk comm. in WUI), IA4.3 (Fire Education Platform), OIC41 (videos)	Community / Individual	Materials exist; wider diffusion still requested

Fire-cycle phase	Challenge (2022/2025)	Linked IA/OIC	Impact level	Notes
Prevention	Incentives to retain/attract people to rural areas; reverse abandonment	IA3.2 (financial incentives), OIC24 (collab. platform)	Territory / Community	Policy/investment dependency; partial pilots
Prevention	Timber certification / baseline values; active management funds	IA2.3/2.4/2.7/2.8 (planning, trade-offs)	Territory	Technical basis improved; policy uptake ongoing
Prevention	Municipal handling of residues (collect / shred on-site)	IA2.4 (strategic networks), OIC23 (DSS for infra resilience)	Territory	Pilots/local ops; needs scaling
Detection	Technical training; anticipation/long-term vision	IA5.8 (training & certification tools), IA5.1/5.2 (real-time risk/simulations)	Individual / Territory	Tools exist; institutionalized training in progress
Detection	In-depth firefighter knowledge aligned with response needs	IA5.1, IA5.2, IA2.5 (strategic managed areas)	Individual / Territory	Good prototypes; operational protocols pending
Restoration	What to do post-fire; training/information	IA2.6 (post-fire strategies), IA4.3, OIC41	Community / Individual	Content available; demand for more practical guides.
Restoration	Define WUI debris (burning) rules	IA4.1 (policy forums), IA2.3 (WUI safety recs)	Territory / Policy	Needs municipal/regional regulation
Restoration	Profitability after fire; diversify crops	IA3.2 (incentives), IA2.8 (trade-offs)	Territory / Community	Economic levers beyond project remit.

12.4.2. The IA demonstration results at LL level

This section synthesizes the implementation and replication of FIRE-RES IAs in the Portuguese LL, with a focus on Lousã and Vale do Sousa. Tables 16 and 17 provide an overview of the main activities carried out during the project, including CWI meetings, training courses, field demonstrations, participatory processes and policy-oriented events. For each activity, we indicate the associated WPs/IAs, location, organiser(s), number of participants and stakeholder profiles, highlighting how the Living Lab has progressively engaged local communities, practitioners and decision-makers in co-developing fire-resilient solutions. The subsequent text details the results of each IA and its contribution to the LL trajectory.

Table 17: Lousã - Activities, IAs implementation and CWI events under FIRE-RES project

Date	WPs/IA	Name	Where	Organizer	Participants (nº)
24/10/2022	**WP8**	**CWI Pre meeting**	Lousã	FWISE & ISA	CWI (17)

Date	WPs/IA	Name	Where	Organizer	Participants [nº)
04/11/2022	WP8	1st CWI meeting	Lousã	FWISE & ISA	CWI & Partners (42)
07/07/2023	WP5/IA5.10	Demonstration Session of GeoCatch App	Lousã	FWISE & ISA	CWI (18)
10/01/2024	WP1/1.4 & 5.7	Presentation session of I.A 1.4 & I.A 5.7 field activities - prescribed fire with sensors testing	Lousã	ENB, INESC TEC & FWISE	CWI & end-users (19)
20/02/2024	WP1/1.4	Fireline delimitation for I.A activities	Lousã	ENB/ICNF Coimbra	End users
19/03/2024	WP1/1.4 & 5.7	I.A 1.4 & I.A 5.7 - Prescribed burn activity	Lousã	ENB	CWI/End-users Partners (34)
11/04/2024	WP1/1.4	I.A 1.4 - Prescribed burn activity	Lousã	ENB	CWI/End-users Partners (31)
31/01/2024 04/02/2024	WP4/4.3	Sinergies Lament & FIRE-RES field activities	Santa Comba Dão	ISA (CEABN) & FWISE	CWI (40)
17/06/2024 18/06/2024	WP4/4.2	Mental Models (participative action)	Lousã	FWISE	CWI (18 +15)
18/06/2024 25/06/2024 26/06/2024	WP4/4.2	Interviews Mental Models	Lousã	FWISE	Rural Communities (16)
30/9/2024 4/10/2024	WP5/IA5.8	Incident commander and fire analyst course	Lousã	ENB	CWI (16)
2/12/2024 5/12/2024	WP4/T4.3.3	Wildfire Occupational Safety Workshop	Lousã	ENB & TIEMS	End Users (16)
09/01/2025	WP4/4.3	Fire Explorer Platform	Vila Real/on-line	ISA (CEABN) & FWISE	FWISE team
16/01/2025	WP4/4.5	Policy Clinics OPERA process	Lousã	FWISE	CWI (12)
18/01/2025	WP4/4.2	Mental Models (participative action)	Lousã- Góis	FWISE	CWI (30)*
19/01/2025	WP4/4.2	Mental Models (participative action)	Lousã-Miranda do Corvo	FWISE	CWI (17)
24/01/2025 12/02/2025 14/02/2025 15/02/2025 17/02/2025	WP4/4.2	Interviews Mental Models	Lousã - Góis & Miranda do Corvo	FWISE	Rural Communities (16+15)
17/02/2025	WP4/4.5	Policy Clinics OPERA process	Gerês	ISA (CEABN) & FWISE	Stakeholders (15)
25/03/2025 - 27/03/2025	WP1/1.2/1.3.1	Fire Manager Training	Lousã	ENB	Stakeholders (16)

Date	WPs/IA	Name	Where	Organizer	Participants [nº)
04/06/2025 - 30/09/2025	WP4/4.2 (debris burning)	Confirmatory Surveys Mental Models	on-line (National)	FWISE	CWI & National traditional burnings practioners (78)
2025	WP4/A4.4	Safe Village	Lousã	ISA (CEABN)	
2024	WP4/IA4.1	Fire Form	Gerês	ISA (CEABN)	Stakeholders (15)
14/07/2025	WP6. OIC Pilot test	1st tecnhical meeting . Demonstração do Sistema de Suporte à Decisão" OIC 23	Biblioteca municipal; Lousã	FWISE & ISA (CEF)	CWI (8), REN (3) & FWISE (1)
28/07/2025	WP6. OIC Pilot test	Webinar : Sessão de Demonstração do Sistema de Suporte à Decisão, OIC23	Online (invite teams)	REN = FWISE & ISA (CEF)	CWI , REN & FWISE (21)
23 & 24/07/2025	WP6. OIC Demo test	Convite participação survey - Plataforma ForestSIM - OIC24 2BForest; divulgação social media	Invite for participate sent by email (> 80)	FWISE	CWI members (CWI 17) & REN, FWISE (2)
09/10/2025	WP8	4th CWI meeting	Lousã	FWISE & ISA	CWI & Partners (80)

Table 18: Vale de Sousa - Activities, IAs implementation and CWI events under FIRE-RES project

Date	WPs/IA	Name	Where	Organizer	Participants (nº)
20/04/2024	WP2/2.5	One online survey	Vale do Sousa	ISA (CEF)	CWI (17)
05/10/2024	WP2/2.5 & 2.6	Collaborative session with stakeholders	Vale do Sousa	ISA (CEF)	CWI(8)
07/09/2024	WP2/2.8	Interviews	Vale do Sousa	ISA (CEF)	CWI Partners
19/06/2024	WP2/2.8	One online survey	Vale do Sousa	ISA (CEF)	CWI (30)
28/11/2024	WP2/2.6	Focus group with stakeholders	Vale do Sousa	ISA (CEF)	CWI/Partners- ICNF, AFVS (15)
29/11/2024	WP2/2.6	Interviews	Vale do Sousa	ISA (CEF)	CWI/Partners- ICNF, AFVS
02/12/2025	WP2/2.6	One online survey	Vale do Sousa	ISA (CEF)	CWI/Partners- ICNF, AFVS (9)
12/06/2022	WP5/IA5.7	Workshop, Innovative Systems to support Team Management in Rural Fires	Vale do Sousa	FWISE, INESC-TEC	CWI & end users (15)
15/09/2023	WP5/IA5.10	Demonstration Session of GeoCatch App	Vale do Sousa	FWISE-ISA	CWI (17)
21/11/2022	WP8	CWI Pre meeting	Vale do Sousa	FWISE-ISA	CWI (17)

Date	WPs/IA	Name	Where	Organizer	Participants (nº)
11/08/2023	WP8-2nd GM	2ºCWI meeting	Vale do Sousa	FWISE-ISA	Total (130) Partners & CWI (40)
28-30/10/2024	WP6 (OICs) & WP8 /all IAs	3º CWI meeting |1st FIRE-RES Innovation Day Series	Vale do Sousa	FWISE-ISA	CWI (25) &OIC winners Partners (total 72)
02/03/2025	WP2/2.5	Online presentation / video	Online	ISA (CEF)	Shared with the forest manager AFVS) for validation & future disemination
23/05/2024	WP2 (several IAs). WP4 (IA4.3). WP5 (IA5.7) & WP6 (OICs) - IAs ongoing & preliminary results	Workshop " Shaping future Fire Resilient-Landscapes and communities" in Pt	Porto	FWISE & ISA (CEF)	CWI/Partners other participants (123)
17/07/2025	WP6. OIC Pilot test	2nd technical meeting . Demonstração do Sistema de Suporte à Decisão" **OIC 23**	Penafiel (CIM Tâmega e Sousa)	FWISE & ISA (CEF)	CWI (16), REN & FWISE
20/06/2024 -15/09/2025	WP4/4.2 *(leisure activities)*	online confirmatory survey	Vale do Sousa	INESC TEC	Vale de Sousa (148), National (600)

IA1.1 Forest Fire Potential Polygons methodology to improve decision making

In Portugal, ENB and CFRS collaborated on a pilot training programme (New training to develop skills and capabilities for Incident Commanders and Fire Analyst to new EWE management challenges') designed to enhance the skills of Incident Commanders and Fire Analysts. This one-week course, held at ENB, incorporated both theoretical and practical elements, preparing participants to use fire potential polygons in managing extreme wildfire scenarios. It brought together experts from several European countries, fostering cross-border knowledge exchange.

IA1.3 Early-warning indicators of EWEs

Accurate and timely warnings are essential to prevent and mitigate the impacts of EWE. In IA1.3 we used advanced probabilistic modelling to forecast the daily occurrence of EWEs at an 8 km resolution across Europe up to 9 days in advance. Our model significantly improved the current estimation of EWE probability while providing key insights into the environmental and climatic drivers of EWEs. Compared to the Fire Weather Index (FWI), our model increased precision by a factor 5 for EWE predictions at the NUTS3 level and by a factor of 10 at 8km resolution. To assess further assess it operational relevance, we evaluated the model's forecasting skill in a test area. Our results demonstrate that EWE forecasts up to nine days in advance outperformed FWI- based nowcasts, emphasizing the model's potential for operational use and its superiority in anticipating EWEs compared to current fire danger rating systems

IA1.4 Integrated fire management model

Prescribed burns were also part of Portugal's IFM implementation. These are expected to complement existing wildfire management strategies, especially in regions susceptible to EWE. In practice, the prescribed burn activities carried out under IA1.4 served the baseline for the IA5.7 wearable device tests, providing the operational context and data foundation to assess the fireline estimation and firefighter safety system developed by ForestWISE and INESC TEC.

The burns were conducted within a Natura 2000 area (20 ha) near Lousã, coordinated by the Escola Nacional de Bombeiros (ENB) with participation from ICNF, ANEPC, ForestWISE, INESC TEC, and several local and volunteer fire brigades.

Activities included plot preparation, manual firebreak construction, and the safe application of prescribed fire (February - April 2024). Real-time monitoring focused on flame behaviour, smoke columns, and post-fire effects such as vegetation regeneration and erosion control.

These operations reduced fuel loads, strengthened firefighter skills through live-fire training, and enhanced interagency coordination. The lessons learned reinforced the value of prescribed burning as a strategic tool for both ecosystem management and firefighter safety innovation.

IA2.1 Data acquisition for landscape design

The main goal of I.A2.1 has been to provide innovative methodologies based on Earth Observation data, to generate scalable key geoinformation to take preventive decisions, about the state and changes of the forestland related to clearcuts, damages, WUI, pathways or fuel:

- Innovative results have been carried out on the use of new LiDAR data and a new model for fuel determination from identification of different forestland morphologies at Portugal living Lab.

IA2.2 Novel management practices - Component 2

Forest management models for the main forest types in Vale do Sousa, Portugal, to prevent EWEs were defined. Site indexes, a set of prescriptions, and a rotation length for each prescription were assigned to each forest type. Then, for each forest type, growth and yield simulations were implemented based on the predefined set of forest management prescriptions. The outputs of these growth and yield models were used to assess the spatially explicit potential behaviour of a wildfire under five different landscape scenarios aimed at maximizing biodiversity, carbon stock, timber supply, and wildfire resistance, and minimizing soil erosion. In order to determine the optimal management alternative for each stand of the landscape under these five scenarios, an optimization model (I Linear) was used. Several fire behaviour metrics were assessed for each of the landscape models analysed.

IA2.3 Recommendations for improving security on WUI - Component 1 (Fire resilient buildings)

The work conducted in the Portugal Living Lab aimed to assess the vulnerability of buildings exposed to wildfire in WUI. The study area was located in Vale do Sousa. Inventories of vegetation and building characteristics were carried out at multiple sites to reflect the range of construction configurations typically found in WUI settings. Large-scale fire exposure tests on the EXPLORII platform evaluated the resistance of different window and shutter types used in the region. Complementary simulations with the WFDS model were performed to assess fire behaviour approaching buildings under both normal and extreme weather conditions, and to test the effectiveness of Portugal's national fuel management regulations. The results showed that preventing fire spread from wildland to structures requires sufficient spacing between trees; for eucalyptus, a 10-meter gap was effective in tested scenarios. A 2-meter vegetation-free zone around buildings also prevented flame contact with façades. To enhance fire resilience, authorities are encouraged to promote the replacement of single-glazed windows and the use of aluminium shutters during renovations. Additional recommendations include maintaining vegetation with high moisture content and avoiding flammable plant species near buildings

IA2.3 Recommendations for improving security on WUI - Component 2 (Creating barriers to fire spread)

Our study was conducted in Vale do Sousa, located in northwestern Portugal about 50 km east of Porto, encompassing both sides of the Douro River. The area includes two forest management zones—Entre-Douro-e-Sousa and Paiva—covering a combined 28,940 hectares, with detailed spatial data represented in 30x30 meter raster grids. To describe fuel types and vegetation structure, we used a forest inventory by Nunes et al. (2022), and for elevation, we relied on data from NASA's Shuttle Radar Topography Mission. Due to differing wind behaviour north and south of the river, we created four weather scenario sets: extreme wildfire event (EWE) and business-as-usual (BAU) conditions for each zone, totalling 400 historical scenarios.

Six equally weighted values at risk were defined based on stakeholder input: biodiversity, economic value of vegetation (cash), wildfire resistance, carbon storage, erosion risk, and standing timber. Each indicator was normalized and combined into a single risk index. We ran 20,000 fire simulations, 3.500 were under BAU conditions and 1.500 under EWE conditions, this was replicated for both North and South regions and before and after the application of treatment strategies, also, we used different fuel moisture levels for EWE (40%) and BAU (66%) conditions, based on the Scott and Burgan classification. Fire ignition points were randomly assigned per scenario, and fire impact was analysed using the Downstream Protection Value (DPV) metric. The evaluation showed a diminution of 33% and 22% on risk loss on South and North region, respectively, using only 1% of the available fuels as firebreaks.

IA2.4 Landscape and fire management policies to minimize expected losses - Component 1 (Vale do Douro Fuel Treatment Study)

The wildfire fuel treatment analysis for the Living Lab Portugal, conducted in the Vale do Douro region, evaluated 495,000 hectares across 66 municipalities to assess the impact of spatially optimized interventions on eight management objectives, including fire risk reduction for communities and protected areas, ignition probability, biomass, and carbon conservation. Initial evaluation (SET0) showed that spatial optimization far outperformed random or road-proximity allocation methods. For example, optimized plans achieved 8% attainment for community exposure reduction and 7% for protected area sources, while non-optimized strategies yielded only around 1%. A 10-year fuel treatment plan (SET1) targeting community exposure sources (90,000 ha) reached 13% attainment for its primary objective by year ten, alongside 10% for biomass and 9% for carbon. Protected area exposure sources plans (27,000 ha) achieved 8% for their main objective, 5% for the Protected area exposure sinks, while other metrics remained below 3%. A third plan focusing on ignition probability (236,000 ha) yielded 15% attainment for that objective and notable co-benefits: biomass (25%), carbon (21%), and wildfire hazard (14%). In total, around 80,000 ha of stands met two of the three key objectives, and 15,000 ha met all three. These overlapping areas enabled efficient multi-objective gains when prioritized. An equity-based scenario (SET2) that evenly distributed treatments across municipalities achieved up to 15% for community exposure, 11% for protected areas sources, and 12% for ignition probability, though results for other objectives were generally lower. Municipalities like Cinfães and Mondim de Basto performed better when projects were targeted. Trade-off analysis (SET3) revealed minor or no trade-offs between some objectives (e.g., protected areas sources vs. sinks), while others (community exposure vs. biomass or sinks) showed clear conflicts in several municipalities.

IA2.4 Landscape and fire management policies to minimize expected losses - Component 2 (Vale do Sousa)

Vale do Sousa, in northern Portugal near Porto, includes two Forest Intervention Zones (ZIFs): Entre-Douro-e-Sousa and Castelo de Paiva. Fieldwork and LIDAR data were used to classify 3,205 stands based on land use, tree height, slope, soil type, and productivity. Forest growth and wood production (thinning, clearcutting) were modelled from 2022 to 2025 using empirical models. Silvicultural options included harvesting, thinning, shrub cleaning, and no management. To assess wildfire risk, a Wildfire Resistance Index (RAit) was developed, incorporating stand structure, slope, shrub cover, and adjacency. The model used Mixed Integer Programming to optimize forest management strategies, balancing wildfire resistance and wood removal. Scenarios with and without harvesting constraints (50 ha rule) were tested. Results show that maximizing wood removal (~271,075 m^3) reduced RAit and increased fire risk. In contrast, maximizing RAit (~0.9977) limited harvest volumes (~126,569 m^3), promoting ecological resilience. Eucalyptus dominates the landscape (52%), with other species like maritime pine, chestnut, oak, and strawberry tree. The most common prescription was "do nothing," covering most stands. This tactical planning approach provides insight into short-term forest management trade-offs between fire mitigation and timber production, supporting adaptive, landscape-level decision-making.

IA2.5 Strategic networks of managed areas

The prioritization of management areas was implemented on Vale de Sousa, involving 19 stakeholders on the different stages of the process. Though the participatory process and data mining, it was considered that 17 criteria, affecting the potential for extreme fires, fuel hazard, suppression drivers, or vulnerability, had to be included on the analysis. From those, fuel hazard and potential fire behaviour were the most important criteria group, and within those groups, either the rate of fire spread, and the accumulation of fuels had the larger impact. Although facilitating firefighter actions was not a strong decision criterion, it was clear that having a good road network to facilitate access to fire trucks, was an issue of concern.

IA2.6 Post-fire restoration strategies

The methodology was implemented for two wildfires that affected eucalyptus forests in the Vale do Sousa region. The prioritization of areas for post-fire restoration was based on three key criteria: erosive potential, the natural recovery capacity of vegetation, and proximity to social areas. Each criterion was further detailed through a set of sub-criteria and specific indicators to facilitate operational implementation. The criteria and sub-criteria were initially identified through a literature review and subsequently discussed with a panel of experts, who validated and selected the most relevant factors. The experts gave weights to each criterion and sub-criterion through an online survey; the final aggregated weights were determined by combining the individual responses using the pairwise comparison method from the Analytical Hierarchy Process (AHP). The maps for each criterion group were created by combining the relevant spatial data layers for each sub-criterion and applying the appropriate weights. These were then combined into a final prioritization map, which was reclassified into four priority categories (low, medium, high, maximum) to facilitate interpretation and practical application of the results.

IA2.7 Landscape design strategies (Vale do Sousa)

The task was conducted for the Vale do LL of Portugal and began by delineating 3,205 forest management units using GIS, LiDAR, field inventory, and national land cover data. Forest growth was simulated with species-specific models from the SIMFLOR platform, and silvicultural prescriptions were developed in collaboration with stakeholders. These included both traditional and species conversion strategies aimed at transitioning eucalyptus and pine stands into native or mixed-species forests. Two scenarios were modelled using mixed-integer optimization: one maximizing biodiversity and another maximizing timber production. The biodiversity scenario promoted ecological complexity and native species, while the timber-focused scenario emphasized productivity through frequent harvesting. Simulator outputs informed fire behaviour analysis using the Cell2Fire model, which assessed burn probability and fire spread under extreme weather conditions. Results showed that the timber-maximizing scenario produced 11.62 million m^3 of wood over 50 years, compared to 3.48 million m^3 under the biodiversity-focused approach. However, biodiversity scores averaged 4.3 versus 2.3, respectively. Fire simulations revealed that biodiversity-oriented management increased burn probability and fire spread due to higher fuel continuity, while timber strategies reduced fire risk through biomass removal. The study highlights the need to balance biodiversity goals with fire resilience in Mediterranean landscapes.

IA2.8 Environmental Services trade-off assessment (Vale do Sousa)

The study area was characterized using GIS, LiDAR, national land cover data, and field inventory, resulting in 3,205 forest management units. Growth simulations were performed using the SIMFLOR platform and other models for key native species such as *Quercus robur* and *Castanea sativa*. A Python-coded spatial optimization algorithm was developed to identify optimal shrub-cleaning interventions for fire prevention. Stakeholder consultation, conducted via online surveys and in-person interviews, provided information on patch size, number, and spatial layout. Ecosystem services- including a novel cultural service index (RAFL)- were successfully quantified for all management alternatives. A peer-reviewed article on this cultural service has already been published. Additionally, the application of Pareto frontier-based interactive decision maps has been demonstrated and disseminated. The current phase focuses on integrating the spatial optimization algorithm with the trade-off analysis framework, enhancing the tool's practical applicability and user relevance.

IA3.3 Parametric solutions for insurance products

A parametric fire insurance scheme, developed as part of Innovation Action 3.3: Parametric Solutions for Insurance Products, was tested in the Portugal Living Lab. This innovative methodology operates through a dynamic trigger system, powered by a stochastic fire probability model trained on historical fire data, with the optional integration of near-real-time satellite observations to enhance accuracy. A dedicated calculation agent complements this framework by estimating potential losses within the forestry sector, ensuring a robust risk assessment mechanism.

For validation, the model retrospectively analysed fire probabilities over recent years, simulating trigger activations across diverse forest assets in Portugal. The findings indicate a strong correlation between the model's triggers and actual recorded losses, underscoring its viability for practical application in forestry insurance. Notably, the region's extensive history of satellite-detected wildfires has enabled precise calibration of triggers, improving the system's reliability. Additionally, the methodology demonstrates adaptability in assessing damages across forest properties of varying sizes - an essential feature for scaling the solution nationwide.

The development and testing process, documented in Deliverables 3.5, 3.6, 3.7, and 3.8. These results highlight the scheme's capacity to enhance resilience in wildfire-prone regions while offering insurers a transparent, data-driven tool for parametric policy design.

IA4.1 Fire forums

The Gerês Fire Forum took place in a National Park with a complex land ownership structure, including public, private, and community-managed lands. The forum facilitated collaborative wildfire risk mapping and integrated local knowledge into decision-making processes. It emphasized proactive planning and helped define fuel management priorities through a jointly developed risk map, later discussed with community land managers.

IA4.2 Methodology for risk communication to improve WUI homeowners' culture of risk

The implementation of IA4.2 in the Portuguese Living Lab focused on improving wildfire risk communication among Wildland-Urban Interface (WUI) homeowners, particularly regarding debris burning and leisure activities. Guided by the Carnegie Mellon University (CMU) Mental Models Approach, the methodology was adapted to the socio-ecological contexts of Lousã and Vale do Sousa. Despite addressing different behaviours, both cases followed a shared logic combining expert knowledge elicitation, community engagement, and survey validation to design locally grounded, evidence-based communication strategies.

In **Lousã**, the focus was on **debris burning practices**. A visual expert model was first developed through literature review and 28 expert interviews in fire prevention, forest management, and civil protection. To integrate community perspectives, five participatory sessions were held to build trust and recruit participants, followed by 47 semi-structured interviews across Lousã, Miranda do Corvo, and Góis. Using NVivo, reasoning patterns and gaps between expert and lay understandings were analysed. A confirmatory survey (76 responses) further quantified knowledge gaps and informed the design of targeted communication messages aligned with local values and behaviours.

In **Vale do Sousa**, the focus shifted to **leisure-related wildfire risks** such as barbecues, off-road driving, and outdoor gatherings. Expert knowledge was systematized through 20 interviews and desk research, followed by 40 community interviews and a survey (148 responses) identifying preferred communication channels and trusted sources.

All activities and community processes are thoroughly described in Deliverable D4.3, including the replication of the methodology in other Living Labs (Sardinia and Aquitaine). The results also informed two policy briefs targeting decision-makers, summarizing key messages and recommendations derived from the Mental Models approach to enhance risk communication and community engagement in fire-prone regions.

IA4.3 Fire Education Platform

communication on the Internet is extensive, with a vast number of credible sources distributing i Wildfire nformation on the topic. However, most of the information available is targeted towards specialists, researchers, and stakeholders, failing to engage wider non-specialized audiences.

Integrated into the FIRE-RES Project, we address this gap by developing a Fire Education Platform: Fire Explorer that aggregates information on the different fire dimensions and directed towards different target audiences: Researchers and technicians, Educators, Teachers and Students.

Our goal is to enhance wildfire knowledge dissemination by integrating scientific information, risk communication strategies, user experience design methodologies, and interactive technologies. The implemented methodology involves the analysis of existing fire platforms and user research methods, including a survey and user-centred design exercises.

The effective communication of fire knowledge is vital for wildfire prevention. Our approach combines a participatory design process combined with the implementation of multimedia techniques such as interactivity and gamification.

Throughout the different sections of the platform, the contents provide scientific information, practical actions to prevent and be more resilient to fire as well as it engages different publics by celebrating the cultural and historical dimension of fire. It is aimed that emotions, empathy, curiosity, fun and knowledge, all are risen by working with the platform creating a more resilient European society.

The Fire Education Platform is accessible and tailored to its user needs and expectations, in both content and interaction, making essential fire information more engaging and intuitive for all audiences.

IA4.4 Fire-safe villages

It is crucial that communities are better prepared to cope with wildfires. In Portugal it already exists the safe-villages, safe people programme. The work to be carried in the LL Pt includes giving technical and scientific support to the Galicia LL, participating in seminars (e.g., SEDEXPO 2025; Field visit to Trelle in August 2023) and preparing a field visit in Portugal for Trelle community to better understand the Portuguese Safe Villages model. Although there was an attempt to visit in the Lousã region (May 2024) it had to be cancelled since it was a very long travel for the elder villagers of Trelle. A new attempt is being made for a closer to the border village. Probably it can happen in October 2025.

Simultaneously, a survey on a village in Portugal that is going to implement the programme safe villages, safe people was done. This survey aimed to better understand the knowledge of the citizen about fire preparedness, fire prevention and risk perception. With this survey it was possible to be more effective in the community preparedness training considering their knowledge, their pre-conceptions and their willing to act.

IA4.5 Policy clinics

Gerês

The policy clinic in Peneda-Gerês National Park identified structural failures in the governance of rural and forest territories, where the lack of coordination between decision-making levels—local, regional, and national—undermines the effectiveness of fire prevention and sustainable landscape management. The overlapping of regulations, the rigidity of the Forestry Regime, outdated fire risk mapping, and the absence of a truly participatory co-management model hinder the implementation of solutions adapted to local realities. Policies that should foster territorial resilience instead create bureaucratic obstacles, discouraging essential practices such as preventive grazing, while land-use planning fails to reflect actual fire risks, negatively impacting socioeconomic development and community safety.

To address these challenges, it is crucial to reform the governance model, ensuring that municipalities, community land councils, and local populations play an active role in defining and implementing territorial policies. Urgent measures include re-evaluate and update the Forest Regime, making fire management and fuel reduction legislation more flexible, and revising risk assessment models to better align fire prevention strategies with the real needs of the territory. Additionally, recognizing grazing as a strategic tool requires a more stable and coherent incentive policy, aligned with conservation objectives and active landscape management.

The European Union and national government must ensure that environmental and agricultural policies do not contradict each other, promoting an integrated approach that combines sustainable development, territorial security, and adaptation to new climate dynamics.

Lousã

The socio-economic profile of rural landowners plays a critical role in their ability to comply with wildfire prevention obligations defined under Decree-Laws 82/2021 and 124/2006. Financial hardship remains a key obstacle, particularly in areas with low land productivity and fragmented ownership. Therefore, many stakeholders proposed to focus on the need for targeted funding mechanisms for fuel management to cover the costs associated with vegetation clearance and wildfire prevention, ultimately making legal compliance more attainable. Some participants also suggested that revaluing and reinforcing the forest ranger programme could complement this measure by offering technical support on the ground. A second-priority proposal focused on introducing tax incentives to promote sustainable practices, such as selective fuel reduction or agroforestry systems. Fiscal tools could increase landowner engagement by rewarding compliance through financial relief.

The challenges associated with the constraints imposed by Natura 2000 regulations on fuel management stem not from the existence of conservation laws themselves, but from the need to better align wildfire risk reduction efforts with biodiversity protection mandates under Natura 2000. The identified top-priority solution was to disseminate best practices and technical knowledge to private landowners, enabling compliant and ecologically sensitive fuel management operations. This includes translating scientific knowledge into practical field guidance. Other high-priority and complementary proposals include compensate landowners for income loss related to legal or environmental constraints, encourage fuel management during ecologically low-impact periods, support non-wood forest product value chains to diversify income sources, remunerate ecosystem services, and strengthen value chains for sustainable forest production.

IA4.6 Firewise planning platform and conceptualization tool

The IA4.6 Fire-Smart Risk Governance and Planning Legal Framework and Tools introduced three instruments aimed at enhancing the integration of wildfire risk into spatial and urban planning across European landscapes. These tools are: (1) the FireXplorer platform, which provides both citizens and professionals with accessible, up-to-date knowledge and information related to wildfire risk; (2) the Guide for Planners, which outlines a structured methodology for incorporating wildfire risk management into landscape and urban planning; and (3) the Risk Assessment and Planning Application, a digital tool designed to facilitate the integration of wildfire risk assessments into planning processes.

In the context of the Portuguese Living Lab, these tools have been tailored to support local needs. Firstly, the FireXplorer platform includes a wide range of Portuguese-language resources—such as guides, technical documents and articles—targeted at land and urban planners, landowners, inhabitants, businesses, and public authorities. It also features materials from other regions and countries, offering Portuguese users' valuable insights into diverse territorial approaches to wildfire risk management.

Secondly, the Guide for Planners contains key terms, wildfire landscape assessment, planning strategies and case studies which can be applied, or act as a support tool, for wildfire landscape planning in Portugal.

Finally, the Risk Assessment and Planning Application can include Portuguese cases, supporting their management and governance processes. The tool can also be translated to Portuguese, facilitating the use for local stakeholders.

IA5.1 Integrative umbrella system for estimating EWE risk and impact

The ISS application's main page highlights different LLs, including Portugal LL. By clicking on this area, you access the implemented solutions and services for the LL. These include:

EUMETSAT and Copernicus services into the ISS to provide users with EWE conditions forecasts.

Weather layers from the SPIRE weather forecast (IA 5.5) from the Basic, Upper-Air and Thunderstorm bundles.

A pyroconvective simulation system (IA 5.2) from CNRS that includes two simulation tools, i) FOREFIRE wildfire surface spread model and ii) Meso-NH. FOREFIRE addresses the simulation of the fire and smoke behaviour of fires with high potential of EWE. It runs in the LL and has been tested on real wildfire scenarios in the LL.

INESCTEC exposure sensors application (IA 5.7) displays and allows to download the exposure data obtained from vehicles sensors and firefighters wearables sensors. It displays variables related to temperature, air quality and heartbeat frequency.

Daily wildfire risk simulation solution (FireRisk) and an operational wildfire simulator adapted to EWE conditions (FireSim) in the approach of IA 5.2. The first, it provides a daily risk assessment forecast for each 3 hours, for a total of 96h of risk.

Daily creation of high-resolution weather data solution for the LL, a 96h high-resolution weather forecast (1-2 km spatial resolution) for 45 variables.

The Volatile Organic Compounds application from ISA displays for the LL the concentration of VOCs (Alpha and Beta-Pinene, and Eucalyptol) and the concentration of CO, CH4, O3 and SO2 for a given location, day and time.

IA5.2 Real-time EWE simulation and smoke spread

A daily wildfire risk simulation solution, and an operational wildfire simulator adapted to EWE conditions have been developed in the approach of IA5.2 and implemented in the ISS, both implemented by TSYLVA. The first provides a daily risk assessment forecast for each 3 hours, for a total of 96h of risk forecast. The operational simulator FireSim features a fire propagation mode and a probabilistic simulation mode. It includes an EWE adjustment factor based on the inclusion of the Lifted Index weather variable provided by SPIRE.

Both solutions make use of base data such as vegetation fuel maps, boundary maps, population and buildings data that have been provided by the LL. Furthermore, it makes use of high-resolution weather forecast data that is created daily for the LL, a 96h high-resolution weather forecast (1-2 km spatial resolution) for 45 variables.

Besides, the ISS integrates the pyroconvective simulation system from CNRS that includes two simulation tools, i) FOREFIRE wildfire surface spread model and ii) Meso-NH. FOREFIRE addresses the simulation of the fire and smoke behaviour of fires with high potential of EWE. It runs in the LL and has been tested on real wildfire scenarios in the LL.

Furthermore, CNRS worked with the LL on the reanalysis of real fires that occurred in this region—extreme fires with significant impacts selected by the LL - CNRS worked with them to determine what simulation results information were most useful for them in crisis situations. CNRS used this information to select the set of results to be displayed through the ISS when a simulation is run for the LL.

IA5.6 High Altitude Pseudo Satellites (HAPS)

In the HAPS simulation, Portugal implements a strategic HAPS deployment with two HAPS units in May, June, and September, increasing to three units during the peak months of July and August. In addition, there were up to 2 HAPS at Pan-European level to cover the peaks in the Southern Living Labs. This optimized approach achieves 96.7% of the burnt area monitored, maintains HAPS arrival times a bit under 3 hours and a half, and successfully keeps the average burnt area of unmonitored fires below 100 hectares.

IA5.7 Impacts of exposure to air pollutants

The IA5.7 builds on the prescribed burn activities conducted under IA1.4 – Integrated Fire Management Model, which provided the operational baseline for testing wearable sensors in Portugal. During the controlled burns in Lousã (Natura 2000 area between february and April 2024), firefighter crews from ANEPC and local brigades were equipped with INESCTEC's wearable monitoring system, capable of collecting physiological and environmental data in real time.

The system recorded over twenty variables, including temperature, humidity, CO and CO_2 levels, volatile organic compounds (VOCs), and particulate matter (PM_1–PM_{10}), alongside heart rate, body temperature, and movement. These data allowed the assessment of firefighters' exposure to air pollutants and thermal stress during suppression activities.

The information gathered was integrated into ForestWISE's Fireline Estimation model, which uses geolocation and temperature data to estimate fireline progression, distance to the flame front, thermal exposure (ΔT = Tfrente – Tbody), and escape time. Risk zones (safe, caution, danger) are dynamically updated to enhance situational awareness and decision-making. Together, these tools demonstrate how wearable sensing and modelling can improve firefighter safety, quantify air pollutant exposure, and support risk-informed strategies for managing extreme wildfire events.

IA5.8 Innovative tools for Extreme Wildfire Incident Command System training certificates

The implementation of Innovation Action 5.8 in Living Lab Portugal involved a pilot training course for Incident Commanders (IC) and Fire Analysts (FA) in EWE, held from 30 September to 4 October 2024 at ENB's Specialized Forest Fire Training Centre in Lousã.

The course was collaboratively designed by ENB, CFRS, Technosylva, and ANEPC, with the objective of enhancing trainees' competencies in anticipating fire behaviour, integrating fire analysis into tactical decision-making processes, and improving coordination in the management of complex wildfire scenarios. It combined theoretical sessions with scenario-based exercises using innovative tools, including virtual reality simulations and decision-support systems.

Ten trainees (five ICs and five FAs) from FIRE-RES partners including ANEPC, CFRS, Södertörn Fire and Rescue Service, and Waldbrandteam participated in the course, alongside trainers from ENB, ANEPC, CFRS, Technosylva, and NIPV. The Tuscany Region also participated via D.R.E.Am. Italia due to its recognized expertise in wildfire response.

The pilot course confirmed the relevance of the training approach and generated valuable feedback to refine both content and delivery. It demonstrated how the integration of fire analysis into tactical decision-making can support faster, more informed responses during EWE. The outcomes contribute to shaping future training and certification frameworks for EWE preparedness across Europe, as outlined in Deliverable D5.11.

IA5.10 Pan-European system to define management priorities

The innovation action "Pan-European System to Define Management Priorities for Mitigating Fire Impact" aimed to design a prototype system for identifying strategic fuel management priorities based on multiple criteria.

To develop this system, we began by defining a set of relevant criteria and assessing the need to model and map these variables. Among the most critical variables were fuel accumulation and potential fire behaviour, which, at the start of the project, were not adequately covered by existing information. During the initial years, the University of Padova mapped all fuel-related variables necessary to estimate fuel accumulation and simulate fire behaviour.

To support this objective, the Geo-Catch application was developed as a field tool to collect georeferenced photographs of forest fuels, later used as training and validation data for automatic fuel type classification through machine learning. Two Geo-Catch application training and demonstration sessions were organized in Portugal within the Living Lab PT, in Lousã (July 2023) and Vale do Sousa (September 2023). These sessions gathered multiple stakeholders acting as active members of the Community of Wildfire Innovation (CWI). The exercises promoted hands-on testing of the app and discussion on its usefulness for supporting local and pan-European fuel mapping and decision-making.

This effort resulted in four scientific articles and the development of a server where the information is publicly available for download (https://www.cirgeo.unipd.it/fire-res/app/). Technosylva used this data to simulate high-intensity fire behaviour across the EU. Simultaneously, ISCI developed a multi-criteria decision support system calibrated to the generated data. This system can assign priority scores once the data is harmonized, and criteria are weighted accordingly. Currently, a strategic prioritization exercise is underway for the Iberian Peninsula, demonstrating the supranational capacity of this analysis and illustrating how large-scale, policy-oriented frameworks are most suited for this system. After the Iberian exercise is completed, the multi-criteria system, programmed as a QGIS plugin, will be publicly available.

Looking ahead, we plan to develop a dedicated server where users can easily download relevant data for such analyses. This platform will also store new data, especially concerning values and risk assessments, alongside existing datasets.

12.4.3. Next steps until 2030

The 2030 roadmap for the Portuguese LL outlines a phased trajectory towards risk-aware, fire-resilient territories, integrating landscape management, community preparedness, institutional coordination, and the operational deployment of the innovative solutions tested during FIRE-RES. It reflects the **priorities identified through the CDW (2022), the CWI process (2022-2025)**, and the **implementation of IAs and OICs in Vale do Sousa and Lousã.**

Following the first period, **Phase I (2022-2025)** - dedicated to building a shared vision, testing solutions and measuring progress, while bringing together a broad set of actors to co-create pathways towards resilient landscapes - **the LL now transitions into Phase II (2026-2030)**, focused on scaling up, integrating and sustaining these advances.

As illustrated in Figure 84, institutional integration, operational capacity, WUI protection, community engagement and innovation uptake converge towards resilient territories by 2030.

Figure 84. Roadmap 2025–2030 for the Portugal Living Lab, outlining the phased trajectory from transition to full implementation of Integrated Fire Management (IFM).

The 2030 vision for resilient territories reflects the full consolidation of the IFM approach in Vale do Sousa and Lousã. By this stage, planning, operations and recovery are fully risk-informed; forest landscapes are adaptive, biodiverse and structurally designed to disrupt fire spread; and communities take an active role as co-managers of risk. This mature system is supported by a digital ecosystem embedded in municipal routines, enabling safer, more resilient territories and communities.

Key features by 2030:

- IFM fully embedded in planning, operations and recovery
- Adaptive, biodiverse, fuel-disrupted forest mosaics
- WUI-proofed territories
- Communities engaged as co-managers of risk
- Digital ecosystem fully integrated into local routines
- Safer communities

The ***strategic priorities for resilient territories & communities*** are outlined, highlighting the key actions and expected outcomes for the period 2026–2030 (Table 18).

Table 18. Portuguese Living Lab ROADMAP 2030 – Strategic priorities for resilient territories & communities (2026–2030), summarising key actions and expected outcomes across the six transformation themes.

THEME	KEY ACTIONS (2026-2030)	EXPECTED OUTCOMES 2030
Integrated Fire Management	• Institutionalize IFM at municipal scale and regional planning • Align Forest operations with risk and recovery zones	• Consistent IFM protocols across Vale do Sousa & Lousã • risk-based forest operations
Landscape Resilience	• Expand fuel-management mosaics •adaptive silviculture • Promote species and structural diversity	• adaptive forest mosaics that limit fire spread • 25–30% increase in heterogeneous, biodiverse stands
Community Empowerment	• Extend risk awareness strategies to all CWI municipalities • Regular joint training and participatory planning • Empowered CWI network co-managing risk • Opportunity fostering shared responsibility and long-term stewardship	• Active CWI chapters with ongoing engagement • Institutional integration of early-warning tools

THEME	KEY ACTIONS (2026-2030)	EXPECTED OUTCOMES 2030
Innovation & Digital Tools	• Operationalize IAs 5.x (DSS, sensors, AI-based monitoring) • Scale OIC solutions with national partners •Testing of IA5.7 system & interoperability exercises	• Technology embedded in routine operations - prevention and response • Coordinated multi-agency response tested annually
Circular Bioeconomy	• Pilot new forest-based business models • Post-fire restoration pilot projects in Lousã & Vale do Sousa; • creation of a circular biomass network • Build ecosystem-service & biomass markets	• Fire-resilient green economy creating local employment • Landscape restoration guidelines adopted at regional scale •Sustainable forest economy
Governance & Learning	• Maintain CWI as permanent co-creation platform • Disseminate FIRE-RES methods nationally • Risk communication platform (IA4.2, IA4.3); training modules for local managers	• LL PT as reference "learning landscape" for integrated fire governance in Europe • Institutional integration of early-warning tools

This roadmap represents an **ideal trajectory co-defined by the multiple actors engaged in the PT Living Lab and by the FIRE-RES partners** who envision these measures being fully deployed on the ground. It outlines a solid and realistic path, but its consolidation requires continuity: i) bringing the voices of the Living Labs into decision-making arenas, ii) securing long-term funding, and iii) enabling upscaling at regional and national levels. The FIRE-RES legacy has allowed us to reach this level of shared vision and operational maturity, now we aim to move forward, deepen this transformation, and turn resilient landscapes and empowered communities into a concrete reality by 2030.

12.5. CWI feedback

The CWI Meetings have progressively consolidated a broad and diverse network of organizations. Over the years, participation has increased both in number and representativeness, bringing together actors from research, public administration, industry, and civil society (Table 19).

Between 2022 and 2025, the Portuguese LL played an active and mobilising role within FIRE-RES, engaging multiple actors across the territory and consistently driving collaboration, field implementation and innovation. Over this period, it carried out more than **60 activities**, tested over **25 implemented and replicated IAs**, and mobilised over **300 participants** representing **70 organisations** from across the fire-resilience ecosystem. The number of participating organizations nearly tripled during this period (from around 25 in 2022 to 70 in 2025), reflecting a growing and more integrated ecosystem of wildfire-resilience stakeholders within the Portuguese Living Lab.

This evolution demonstrates:

- **Strengthened collaboration** between science, policy, and practice;
- **Increased involvement of private actors** (forestry, energy, and pulp & paper sectors);
- Active participation of **municipalities and intermunicipal communities**;
- Inclusion of **civil protection agencies and community-based organizations**.

The **CWI platform has thus become a key space for dialogue, co-creation, and knowledge exchange**, linking local innovation with European-scale resilience strategies under FIRE-RES.

Table 19: Description of the CWI in Portuguese LL - CWI Annual Meetings

Entity name	Stakeholder type	Description & Web	CWI Preliminary Meetings Lousa 24/10/2022	CWI Preliminary Meetings Vale de Sousa 21/10/202	1st CWI meeting [Lousã] 4/11/2022	2nd CWI meeting [2nd GM] [Porto, Penafiel] 7 - 9/11/2023	3rd CWI meeting [1st Innovation Day series] [Castelo de Paiva, Penafiel] 29 & 30/10/2022	4th CWI meeting [Lousã] 9/10/2025
IPLeiria	Academy/science	Polytechnic Institute of Leiria school of technology and management– School of Technology and Management. [Politécnico de Leiria]			2			2
Cascais Ambiente	Public sector	municipal department for environment, Cascais Municipality. [Cascais Ambiente]			1			
AGIF	Public sector	Portuguese Agency for Integrated Rural Fire Management [AGIF | Homepage]	1		1	3	1	3
2bforest	Private sector	Experts in sustainable forest management [2bforest]	1		1	2	2	1
ANP /WWF	NGO / Society	Associação Natureza Portugal [WWF Portugal | WWF]	1		1			
CBE	Private sector	Biomass Center for Energy - promoting renewable energy from forest biomass. [Centro da Biomassa para a Energia]	1		1	1		
E-REDES	Private sector	Portuguese NElectricity distribution https://www.e-redes.pt/pt-pt	1	1	1			
REN	Private sector	Portuguese National Energy Networks https://www.ren.pt/	1	1	1	2	3	1

The NAVIGATOR company	Private sector	Leading pulp and paper company https://www.thenavigatorcompany.com/	2		1	1		1
ALTRI	Private sector	Eucalyptus Fibers and pulp production company Altri				1		2
CELPA/ BIOND	Private sector	Portuguese association representing the pulp, paper and cardboard industries and related activities.). Biond - Biond		1	1	2		
Bombeiros Porto de Mós	Public sector	Volunteers Firefigthers of Porto de Mós Notícias				3		
CIM Viseu Dão e Lafões	Public sector	Intermunicipal Community of Viseu Dão e Lafões					1	
CIM Tâmega e Sousa	Public sector	Intermunicipal Community of Tâmega and Sousa Comunidade Intermunicipal do Tâmega e Sousa			1	2	1	1
AIGP	Public sector	Integrated Landscape Management Areas https://www.dgterritorio.gov.pt/paisagem/ptp/a				2		
ICNF.IP.	Public sector	Institute for Nature Conservation and Forests ICNF - Instituto da Conservação da Natureza e das Florestas	1	1	3	2	2	4
Câmara Municipal de Penafiel	Public sector	Penafiel Municipality CM Penafiel		1	1	2	3	
Câmara Municipal de Paredes	Public sector	Paredes Municipality Câmara Municipal de Paredes		1	1	1		
Câmara Municipal de Castelo de Paiva	Public sector	Castelo de Paiva Municipality					1	
AFVS	Private sector	Forest Owners Association of the Sousa Valley AFVS - Associação Florestal do Vale do Sousa		3	1	5	1	1

Municipio de Figueiró dos Vinhos	Public sector	Figueiró dos Vinhos municipality Município de Figueiró dos Vinhos			1			
ISA	Academy/science	School of Agricultue/ University of Lisbon. Instituto Superior de Agronomia | Conhecimento e Inovação				1	2	1
Quinta da Aveleda	Private Sector	Aveleda Vineyards in the heart of the Vinho Verde Wine Region, Unique Experience at Quinta da Aveleda | Aveleda		1		1		
AFEDT	Private Sector	Forest Association of the Douro and Tamega Valley https://www.facebook.com/afedt/		1	1			
AFEDV	Private Sector	Forest association of the Douro e Vouga Valley Associação Florestal Entre Douro e Vouga - Início		1	1			
ACHLI	ONG/Private sector	Iberian Wolf Habitat Conservation Association ACHLI - Associação de Conservação do Habitat do Lobo Ibérico					2	2
BALADI	Private Sector	National Common lands Federation Baladi - Federação Nacional dos Baldios - Website Oficial		1				
CEABN	Academy/science	Centre for Applied Ecology "Professor Baeta Neves", School of Agriculture, University of Lisbon. Centro Ecologia Aplicada	4	3	3	5	3	4
CEF	Academy/science	Forest Research centre, School of Agriculture, University of Lisbon. O Centro - CEF	2	2	1	7	5	2
CoLAB ForestWISE	ONG/ / R&D	Collaborative Laboratory for integrated Forest & Fire Management Principal - ForestWISE	2	2	3	6	12	9
Camara Municipal da Lousã	Public sector	Lousã municipality Home - Portal Institucional	2		2		4	4
Centro PINUS	Private Sector/Association	Association for the Valorization of Pine Forests Centro PINUS		1				