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FIREURISK - DEVELOPING A HOLISTIC, RISK-WISE STRATEGY FOR EUROPEAN WILDFIRE MANAGEMENT

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Executive Summary

Document in a nutshell

This document presents a Roadmap for the definition of a Framework for integrated wildfire risk management in Europe, taking into account all its processes, components, scales and stakeholders. It is built around the following pillars: (i) Strategy; (ii) Framework; (iii) Governance.

Summary

This document addresses the main objective of FirEURisk Project: to develop, test and disseminate an Integrated and Science-Based Strategy for wildfire risk management in Europe, encompassing various specific objectives of the Project (namely Obj1, Obj11 and Obj16), which were developed mainly in WP4 (activity 4.2.1: integrating risk assessment, risk reduction and risk adaptation). The FirEURisk Integrated Wildfire Risk Management System (IWRMS) is composed of three parts: (1) the risk management Strategy, based on sound scientific principles, such as those developed in the Project to characterise the risk of wildfire; (2) the Framework to structure and organise the principles, goals and guidelines to manage the risk; and (3) the Governance structure that puts in practice the risk management guidelines, defining the laws and managing the assets, including the financial resources. Part 1 of the IWRMS is the object of D4.4; Parts 2 and 3 are the main object of the present Deliverable.

Some key definitions are introduced, including our interpretation of the concept of integrated risk management which also encompasses a holistic management perspective. A literature review based on research papers and on the major framework reports for fire risk management at different scales, is performed, complemented by a series of interviews and discussions held in dedicated webinars on the management of wildfire risk in various countries represented in FirEURisk.

The governance of wildfire risk management in Europe is recognized as being fragmented among various bodies and agencies, and there is a lack of a common and integrated approach to managing the risk of wildfire through the various policies, programs and governance entities. To overcome this situation, we propose the creation of a unified, cross-sectorial agency to ensure and coordinate the implementation of a holistic and integrated system for wildfire risk management for Europe.

Based on the experience and consensus created by the various Framework documents, we paved the roadmap for the creation of a Framework for the IWRM to be developed and applied in Europe at different scales, from Regional to National and to the entire European territory.

Dissemination:

This document is the result from multiples interactions with key stakeholders, namely through webinars and dedicated meetings. A journal paper is also under development.

Objectives not achieved:

Considering the deadline, the document lacks contributions from external parties like other EU projects and experts. This will be accomplished in the near future.

Key take away messages:

a. Europe is composed by a large set of countries with a very diverse geography, vegetation, climate and socio-economic levels, in which the problem of wildfire, and the perception of their risk are far from being uniform. Given the growing concern with the wildfire risk, we propose as a vision: “Develop and manage forested and rural areas, recognizing the role of fire, assessing its risk, promoting safer conditions for citizens in Europe, in the present and in the future”.

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b. Avoid a partisan approach to problem-solving and instead build on multi-parties' consensus to develop long-term programs and plans that provide stability to the system.
c. Move away from a silo mindset, which only considers their sectorial vision and mandates, and instead adopt an integrated approach where responsibilities, resources, budgets, and good practices are shared.
d. All actions implemented in IWRM should be oriented above all for the benefit of the citizens. Communities should be empowered and engaged in local solutions and decision-making processes to enhance wildfire resistance and resilience.
e. Base all activities on a sound science-based risk assessment strategy, including all aspects, and their evaluation should consider the uncertainties of future conditions and therefore be adaptative to incorporate diverse future scenarios

Graphical abstract

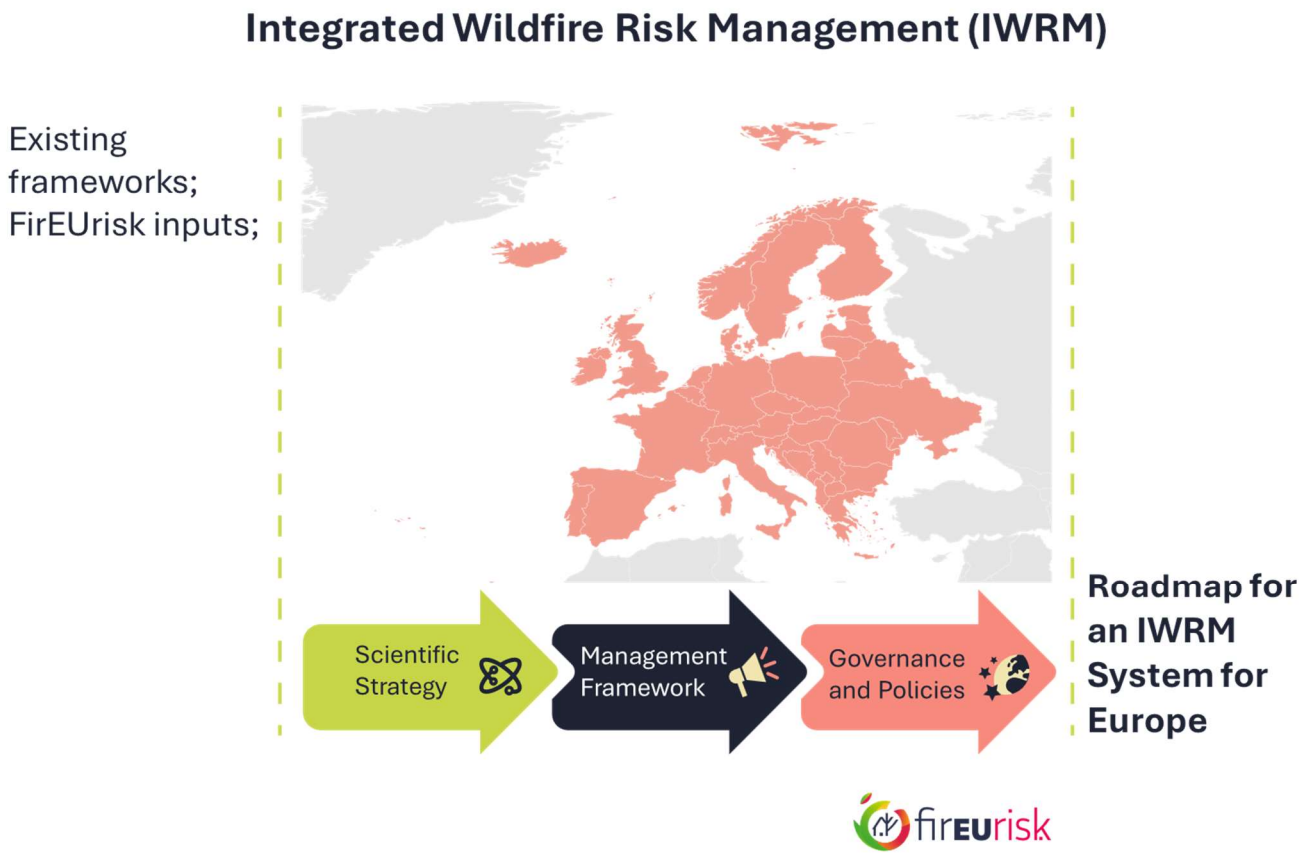


Figure 1 - Graphical abstract on the FirEURisk's proposal for the roadmap for an IWRM for EU

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Contents

1. Introduction 9
1.1. Definition of the Wildfire Risk Management System 9
1.2. Literature Review 10
1.3. Definition of Integrated Wildfire Risk Management 13
1.4. Contribution of FirEUrisk to promote a Roadmap for the integrated risk of wildfire in Europe 15
2. Overview of existing Frameworks 16
2.1. International Frameworks and Guidelines 16
2.1.1. Fire Management Voluntary Guidelines (UN – FAO) 16
2.1.2. Wildfires - a growing concern for sustainable development (UN) 17
2.1.3. Landscape Fire Governance Framework (LFGF) 17
2.1.4. DG ECHO Framework for Peer Review 19
2.1.5. National Strategy for Cohesive Wildland Fire Management (USDA) 19
2.1.6. Canadian Wildland Fire Strategy (Canada) 21
2.1.7. National Bushfire management Policy Statement for Forest and Rangelands (Australia) 21
2.1.8. National Plan for Integrated Rural Fire Management (Portugal) 23
2.1.9. Strategic Guidelines for Wildland Fire Management in Spain (Spain) 23
2.2. Meetings and webinars on WRM 24
2.3. Components of Existing Frameworks 24
2.3.1. Gaps and Limitations 25
2.3.2. Foundation for Change/Cross sectoral issues 25
2.3.3. Vision 26
2.3.4. Mission/Principles 26
2.3.5. Strategic objectives 27
2.3.6. Processes 28
3. Action Plan and Roadmap 29
3.1. Overview 29
3.2. Management Strategy 30
3.3. Integrated Wildland Fire Management Framework for Europe 30
3.3.1. Introduction 30
3.3.2. Cross-sectoral issues 31
3.3.3. Vision 33
3.3.4. Principles 33
3.3.5. Objectives and Goals 36
3.3.6. Integrated Management Plan 37
3.3.7. Key Performance Indicators and Activities 40
3.3.8. Monitoring and evaluation 40
3.3.9. Conclusion 40

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3.3.10. Glossary 40
3.4. Wildfire Risk Governance 41
3.4.1 Current Fragmentation in EU Wildfire Risk Management 41
3.4.2 Integrated Wildfire Risk Governance 42
3.4.3 A Conceptual EU Framework on Wildfire Risk Governance 43
3.4.4 Multi-Level Governance and Collaboration 44
3.4.5 Adaptive Governance and Technological Innovation 45
3.4.6 Performance Indicators and Policy Instruments 46
4. Conclusions and Recommendations 48
Acknowledgements 48
References 49
5. Appendices 52
5.1. WRM in Portugal 52
5.2. WRM in Germany 52
5.3. WRM in Spain 52
5.4. WRM in Greece 53
5.5. WRM in Croatia 53
5.6. RISE Workshop 53

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List of Figures

Figure 1 - Graphical abstract on the FirEURisk's proposal for the roadmap for an IWRM for EU 4
Figure 2 - Components of the System for Integrated and Holistic WRM and segments of the Society addressed.....9
Figure 3 - Diagram of classical (left) and of integrated fire management (right), according to Myers (2006). 12
Figure 4 - Holistic and Integrated Wildfire Management perspectives with the respective components. 14
Figure 5 - FirEURisk proposal for the ROADMAP for an IWRM strategy for Europe.....29
Figure 6 – Structure of the integrated fire management plan (IWMP) for Europe.....30
Figure 7 - Cross-sectoral issues.....32
Figure 8 - Guidelines of the IWMP for EU.....34
Figure 9 - Integrated Management Plan 37
Figure 10 - The EU Civil Protection Mechanism. Source: https://civil-protection-humanitarian-aid.ec.europa.eu/ 41
Figure 11 - Framework of Wildfire Management Governance: Spatial Levels, Roles, and Coordination Aspects.....44

List of Acronyms

DG ECHO	Directorate-General for European Civil Protection and Humanitarian Aid Operations
ET	European territory
FRO	FirEURisk Observatory
IRFMS	Integrated Rural Fire Management System
IWRM	Integrated wildfire risk management
IWRMS	Integrated wildfire risk management system
JRC	Joint Research Center
KPI	Key performance indicators
LFGF	Landscape fire governance framework
NGO	Non-governmental organizations
P&G	Principles & guidelines
PC	Project coordinator
POD	Potential operational delineations
PT	Portugal
RM	Risk management
SC	Steering committee
SP	Spain
UN-FAO	Food and Agriculture Organization - United Nations
USDA	United States Department of Agricultural
WFM	Wildfire risk management
WP	Work package

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1. Introduction

1.1. Definition of the Wildfire Risk Management System

In the FirEUrisk Project, we are committed to developing a "Conceptual framework for integrating risk assessment, reduction and adaptation", that will be tested and applied at local, regional, national and/or EU levels.
We understand that there is no one-size-fits-all solution to this problem. Many countries and regions around the world have successfully implemented different structures of Wildfire Risk Management (WRM). In FirEUrisk, we understand that effective wildfire risk management depends on a solid foundation of scientific knowledge and good practices, as well as well-organised fire management agencies that adhere to sound principles and are supported by established legislation and governance. To address and manage the risk of wildfires, we are developing science-based knowledge that will enable us to assess and mitigate risks in current and future conditions. Our goal is to transform this knowledge into practical guidelines and principles that can be applied across the EU regions, countries, and Europe as a whole.

We consider that in order to adequately manage the wildland fire risk in an organised and integrated form, at different levels, such as global, international, national, regional, or local, it is required what we design an integrated wildfire risk management **System** (IWRMS) (**Erro! A origem da referência não foi encontrada.**). The following components or pillars are essential for the IWRMS:

f. A comprehensive **Strategy** that encompasses all relevant factors and components involved in assessing risk;
g. A well-established **Framework** with clear principles and objectives for reducing and adapting to future changes in risk.
h. An effective **Governance** system that can implement the strategy, follow the framework's guidelines, and enable the society to prevent, suppress, and recover from wildfires - including defining legislation and funding the necessary actions.

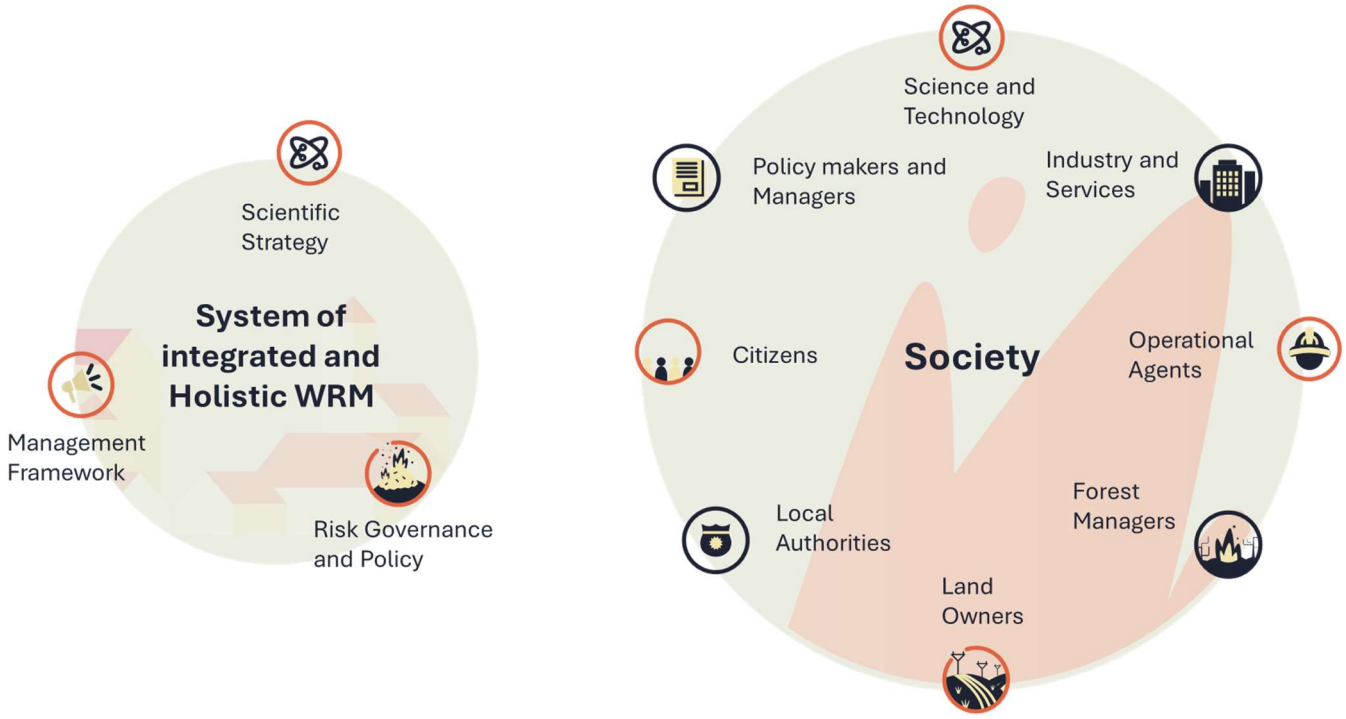


Figure 2 - Components of the System for Integrated and Holistic WRM and segments of the Society addressed.

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In **Erro! A origem da referência não foi encontrada.Erro! A origem da referência não foi encontrada.** the Integrated Wildfire Risk Management System (IWRMS) is represented as three interconnected parts. This depiction aligns with the principle of 'integrated management,' signifying that these parts are interdependent though should not be viewed as isolated or enclosed domains. Their arrangement in the diagram does not indicate a hierarchical order but rather a chronological one. As depicted in **Erro! A origem da referência não foi encontrada.**, the IWRMS structure is closely linked to those people in society who will implement it and/or benefit from it, commonly referred to as stakeholders, each with distinct roles and significance within the system. It is important to clarify that these classifications are not meant to suggest that stakeholders operate within rigid or exclusive groups or institutions. Instead, they are expected to engage collaboratively among them, with each member understanding and fulfilling their specific role within the overall system. This collaborative effort is crucial for the benefit of citizens, the environment, and socio-economic structure on a global scale.

Corresponding to the three main components of the IWFMS, there are three groups of stakeholders that are highlighted:

1. Science and technology providers – including the scientific research institutions and scientists, technology developers, and instructors.
2. Operational and Field Practitioners – the public and private institutions like NGOs, and agents that deal with all operational activities, including resource planning and management, surveillance, monitoring, suppression, civil protection, medical support, and environmental and socio-economic recovery.
3. Policy-makers and managers – including local and national policy-makers responsible for formulating and implementing relevant legislation. They also play a crucial role in allocating financial assets necessary for effective resource management.

The diagram also identifies additional groups, providing a non-exhaustive illustration of the roles linked to key activities within the system. It is crucial to recognise the integral role of all citizens in this system as they are not only beneficiaries but active participants in the decision-making and operational processes. It's essential that they are kept informed about the strategies and actions being developed and implemented, ensuring that the system ultimately serves their interests and needs.

The effective operation of the system hinges on the involvement and alignment of individuals across all its activities and phases. Therefore, it is imperative that everyone involved is attuned to the overarching strategy and objectives of the management processes. To achieve this, it is necessary to equip each system member with appropriate qualifications, training, tools and information tailored to their specific role and responsibilities. For the public, this might involve targeted educational programs aimed at increasing awareness and sensitivity to the issues at hand. Such initiatives are vital in fostering an informed and engaged citizenry, crucial for the system's success.

1.2. Literature Review

The presence of fire in the natural world is recognised as being part of the natural system. For millennia the interaction between natural processes, including fire, kept a balance between the periodic burning of part of the landscape by fire with its regeneration and recovery, maintaining an ecological equilibrium. The use of fire by humanity, attempting to master it and to confine it to processes and systems under full human control, promoted a tendency to exclude fire from the natural world. According to Pyne (2022), this has led to the “Pyrocene age”, a period marked by challenging conditions for re-establishing the lost equilibrium between fire, climate, and the broader relationship between humanity and nature. This era is characterised by more frequent and intense wildfires, altering the natural fire regimes and impacting ecosystems globally (Pyne, 2022; Pyne et al., 1996).

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The common perception of fire in natural settings, particularly in forested or vegetated landscapes, as an inherent hazard and a threat, demanding not just prevention but also complete exclusion through rigorous efforts has narrowed the scope of wildfire risk management (WRM). Traditionally, WRM has been viewed as a linear progression of prevention and suppression activities, often perceived as distinct, unconnected tasks, typically undertaken by different agencies in a sequential manner. The inclusion of fire as a management tool, both in prevention and suppression, represents a significant paradigm shift towards a more holistic approach to fire risk management. This perspective, that was followed in the EU funded Fire Paradox project (Sande Silva et al., 2010) and several other research and operational initiatives attempting to reintroduce the use of prescribed fire, echoes the historical practices of many indigenous and local communities, who utilised fire as a practical tool for landscape management and as a strategic element in combating wildfires (Fernandes et al., 2013a; Moritz et al., 2014). This is particularly useful in scenarios where other powerful tools or resources are unavailable or ineffective (Moreira et al., 2020a; Moritz et al., 2014).

With the advent of advanced technologies, the capacity to suppress wildfires increased to the point that the complete exclusion of unwanted fires became an accepted objective in wildfire risk management. Historically this has not been always possible, and in certain conditions extreme fire events could not be contained causing much greater impacts than low-intensity fires burning in the same areas, as prescribed fires. Besides, a growing recognition has emerged of the necessity of fire in supporting certain ecological processes, along with an awareness of the extensive impact of wildfires on society and the environment. Factors such as climate change and socio-economic shifts have led to land abandonment, changing landscapes, with higher fuel loads available, contributed to an increase in the intensity and frequency of certain fires, designated as extreme fires that cannot be contained. It is often observed that these extreme fires modify their behaviour when reaching areas already burned by previous fires or by prescribed burnings. This recognition has spurred the development of a more comprehensive approach to wildfire risk. It is within this context that the concept of integrated fire management has thus evolved, aiming to encompass all facets and implications of wildfire risk across its various regimes, phases, and scales of manifestation. This evolution is illustrated schematically in **Erro! A origem da referência não foi encontrada.** (Myers, 2006) in which the classical fire management perspective, of prevention versus suppression, in this case including the use of fire, is contrasted with the modern concept of integrated fire management, that includes socio-economic needs and impacts as well as ecological aspects related to wildfires.

In Moore (2019) an overall perspective of the global wildland fire management is provided. Although the scope of that paper was the identification of research needs, it provides a historical background of the introduction of the concept of “Integrated Forest Fire Management” and on how it evolved from the plain fire suppression and fire exclusion policies to more holistic and integrated approaches, including the consideration of various factors namely (i) People, (ii) Fire in the landscape and (iii) Activities, all of which are listed with some detail, to consider all things in context (Food and Agriculture Organization of the United Nations, 2007; P. F. Moore, 2019; Myers, 2006).

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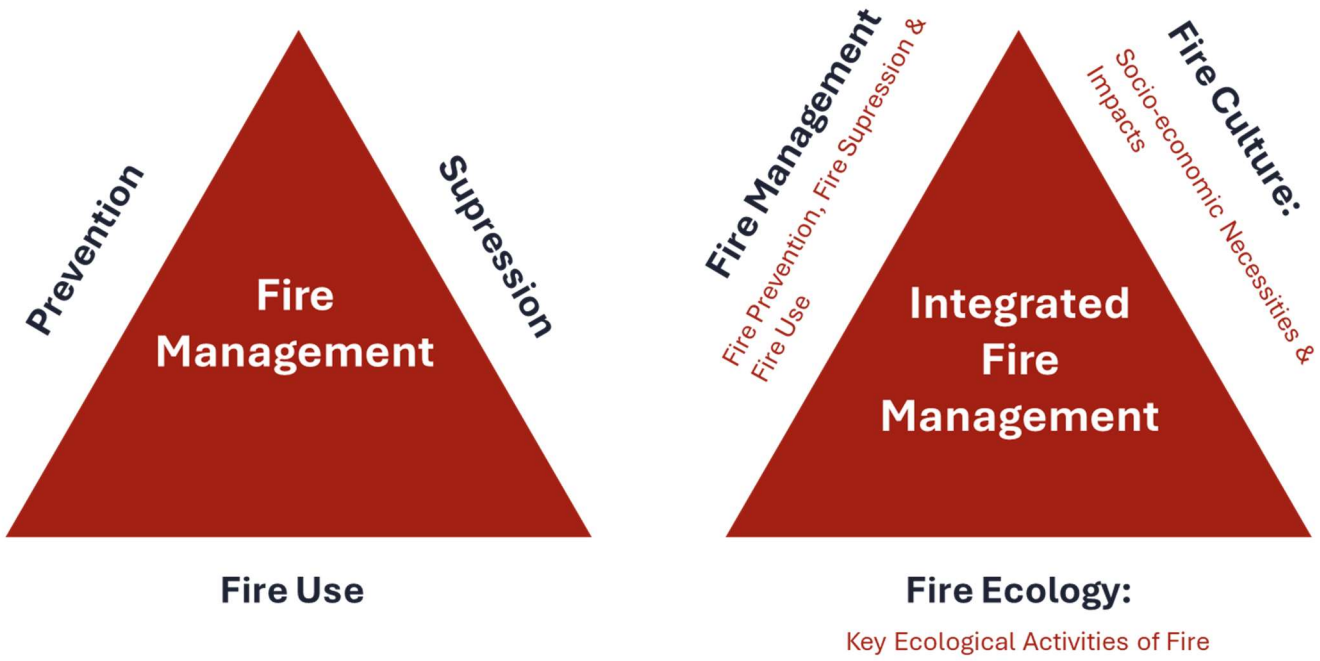


Figure 3 - Diagram of classical (left) and of integrated fire management (right), according to Myers (2006).

In Thompson et al. (2018) a new form of considering the Wildland Fire Management System focusing on the response phase of the process is proposed, recommending that some fires in fire prone areas are not suppressed to avoid the worsening conditions of ever-increasing risks to responders and communities. This is actually a strategy of risk management that, although being centered in the fire response phase, advocates that by changing responses, important opportunities can be provided to restore local landscape conditions and reduce future hazard and risk. The authors claim that their approach would lead to the recognition that increasing the costs of suppression and degrading forest condition poses risks in the long term to the core mission of sustaining the forest cover itself (Thompson et al., 2018).

In Thompson et al. (2019), the previous concepts are extended, proposing the use of analytics concepts related to wildfire response to support response decisions and organizational learning, and to outline an analytics strategy for the future, ranging from full suppression, to manage the fire for ecosystem benefit, balancing between various factors like fire impacts, suppression costs, citizen and responder safety. The authors aim to develop a broader analytics strategy for wildfire management including planning, decision and learning processes to align actions with management objectives, enhance transparency and accountability and improve response safety and effectiveness (Thompson et al., 2019).

Thompson et al. (2022) presented the potential operational delineations (POD) as and adaptative framework for cross boundary and collaborative land and fire management planning. This concept aligns strategically with advanced fire analytics and risk analyses, integrate with forest operations, to provide a platform for a range of decision support applications, and can enhance the design of fuels reduction and forest restoration treatments. Three broad categories of POD are defined: (i) Protect, (ii) Maintain and (iii) Restore, according to the main management objectives considering the boundary conditions of each POD and the properties of potential fire control locations. POD can be used to learn from the past, to improve performance and to better prepare the future, namely in climate mitigation and adaptation, allocation of suppression resources and in risk-informed performance measurement (Thompson et al., 2022).

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The set of three papers that were cited above provide an example of the definition of a wildfire risk management strategy from a perspective of fire response but one that considers all other phases of the process and includes other agents and stakeholders in a truly integrated approach.

1.3. Definition of Integrated Wildfire Risk Management

We started the reflection on this subject early in the life of the Project as the Revision History of the document illustrates, as this was a central goal of the project. In the step-by-step approach that we followed we involved a large number of partners and also members of the FirEUrisk Observatory and several experts and managers outside of the Project, including researchers from other EU projects with whom our perspectives and points of view were discussed.

In this document, we extend the foundational objectives of the FirEUrisk project to present a comprehensive overview of existing frameworks that govern WRM globally. This overview is derived from a careful literature review and stakeholder engagement, aligning with our work program's directive to critically assess the 'current state of fire and fire risk management in Europe and responses to it, both political and practical and at different geographic scales'.

To achieve this, we have conducted a thorough analysis of existing frameworks, focusing on their constituent elements, guiding principles, and overarching goals. This analysis serves a dual purpose: firstly, to identify commonalities that can inform a universally applicable framework, and secondly, to recognise unique, region-specific strategies that have proven effective in localised contexts.

In addition to the literature review, we have organised a series of interactive sessions, including webinars and in-person meetings, with key institutional representatives from Portugal, Germany, Spain, Croatia and Greece. These sessions aimed to garner real-world insights into the state of WRM in these countries, thereby enriching our research with practical perspectives.

Based on our comprehensive research, we propose an integrated framework for WRM that is both scalable and adaptable. This framework is designed to be compatible with the FirEUrisk project's three-fold approach to risk management, encompassing:

- **Risk Assessment**: Comprehensive evaluation of wildfire risk factors, including hazard, exposure, and vulnerability, along with their quantifiable parameters.
- **Risk Reduction**: Identification and implementation of effective strategies to mitigate the identified risks based on empirical data and predictive modelling.
- **Risk Adaptation**: Development of adaptive measures to prepare communities and ecosystems for future changes in wildfire patterns, considering climate change projections and land-use alterations.

Our framework aims to serve as a blueprint for IWRM that can be customised to fit various geographic scales and stakeholder needs, from local communities to national governments and EU-level organisations. It is structured to facilitate multi-disciplinary collaboration and to accommodate the sometimes-conflicting interests of diverse stakeholders, all while striving for the overarching goal of minimising both present and future wildfire risks.

In recent documents, namely in the Commission's White Paper on Adaptation to Climate Change issued and other documents by the EC, the concept of “Holistic Landscape Fire management” is used as a possible complementary or alternative approach, in relation to the commonly used “Integrated Wildfire Management” approach. Although they seem both to mean the same thing, in some texts they appear like two different approaches, possibly coming from different sectors of fire management specialists (European Commission, 2009, 2013).

We can find the following descriptions of each of them:

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- The **Holistic Landscape Fire Management (HLFM)** approach is described as combining wildfire management with broader landscape management objectives. It recognises that wildfires are a natural process that can benefit ecosystems and biodiversity, and that managing them holistically requires understanding the whole landscape and its ecological dynamics. HLFM is based on four core principles: ecological restoration, fire prevention, management, and community engagement.
- The **Integrated Wildfire Management (IWM)** approach is described as aiming to reduce wildfires' negative impact on people and the environment. It involves collaboration among landowners, firefighters, policy-makers, and the public to integrate risk-reduction strategies into land-use planning. The approach focuses on prevention, preparedness, and response.

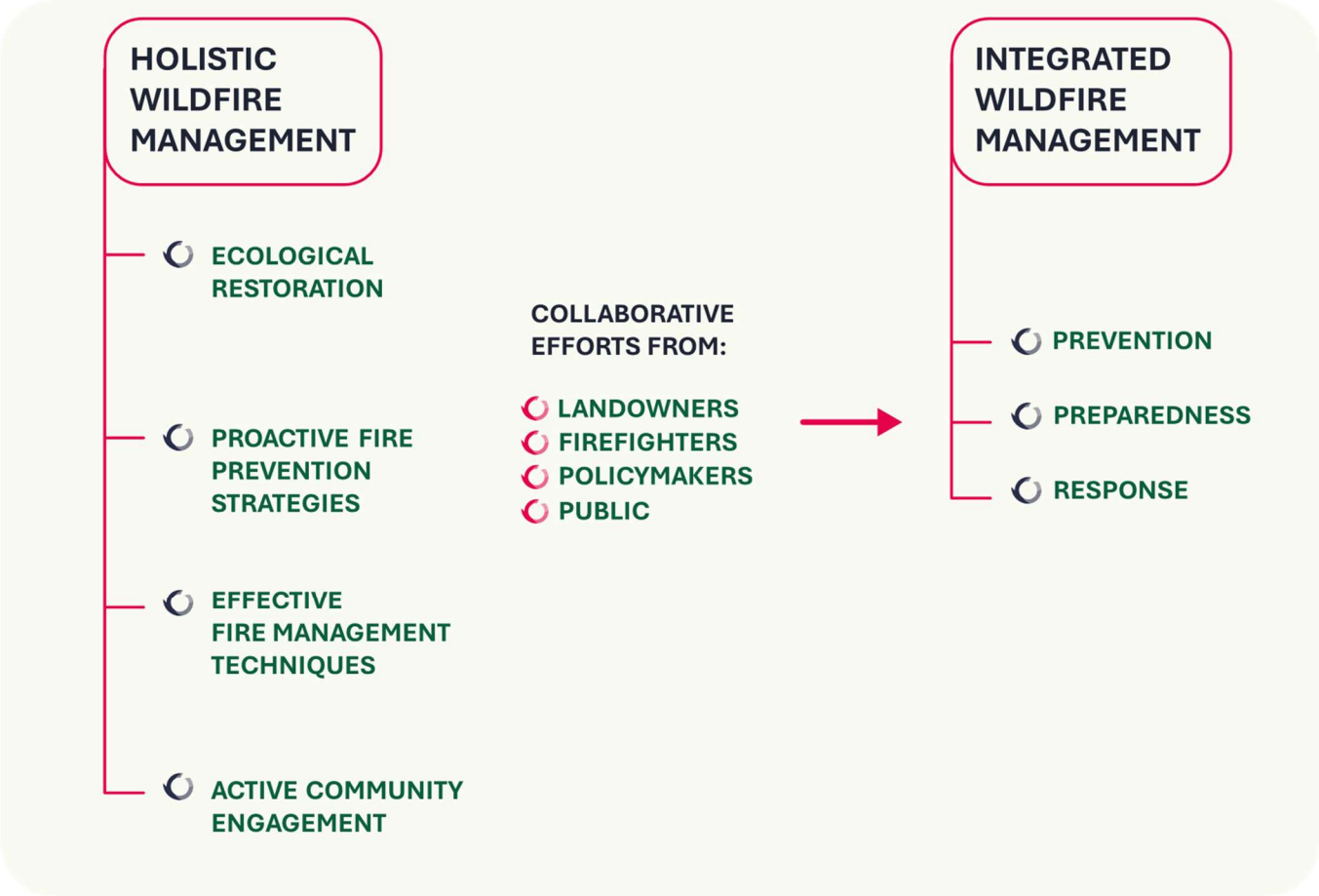


Figure 4 - Holistic and Integrated Wildfire Management perspectives with the respective components.

In **Erro! A origem da referência não foi encontrada.Erro! A origem da referência não foi encontrada.** the two perspectives of Holistic and Integrated Management are illustrated, with their specific components represented schematically as being separate activities.

In FirEUrisk we use the concept of Integrated Wildfire Risk Management (IWRM) in the sense of involving all aspects, components, scales and phases of the overall process. In our perspective it encompasses also the term “holistic” as we are looking at the various aspects as a “whole”, considering the various components that are included in the above definitions, namely those that are mentioned in one of them but not in the other, such as ecological dynamics and restoration, beneficial use of fire, community engagement, reduction of wildfires, negative impacts and firefighters, for example.

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For this reason, we proposed to define our approach and our effort as a **Roadmap for a holistic and integrated fire risk management strategy for Europe**, ensuring we recommend an approach that includes all the processes and all the perspectives and all of society.

1.4. Contribution of FirEURisk to promote a Roadmap for the integrated risk of wildfire in Europe

Developing an integrated framework for managing wildfire risk has been addressed by several agencies across the world in the past few decades. However, existing frameworks reflect the specific viewpoints, historical approaches, terminology, and perspectives of each organisation, country or region. Despite this, recent frameworks do share common objectives, visions, and goals, making them suitable for adoption by different countries, whether they have an existing framework in place or not.

In FirEURisk, we took a step-by-step approach to investigating the three components of wildfire management that we view as part of a larger integrated system. In Work Package (WP) 1, we focused on studying the critical variables for fire risk assessment. These include hazard (or danger), exposure, vulnerability (including resilience), which are also the basis for risk reduction and adaptation. Our findings were published in a paper titled "Towards an Integrated Approach to Wildfire Risk Assessment: When, Where, and How May the Landscape Burn" by (Chuvieco et al., 2023). In WP2, we are researching the mechanisms that link these processes and recommending measures to reduce risk. WP3 focuses on adapting our systems to future conditions.

In WP4 we address the issue of IWRM in two further steps: one is developed in A4.2.1 and is reported in this document (D4.5) describing the components of the IWRM System and in particular its Framework; the other is developed in A4.2.2 and is reported in D4.4, describing a strategy proposed by FirEURisk for IWRM in Europe.

The third step is addressed in WP6's Task 6.4, where we examine the governance system. Specifically, we are looking at the risk governance systems that exist in EU countries and at the EU level. Preliminary results of this work were published in Deliverable D6.4.

In Activity A4.2.1, we focus on the second part of managing the risk of wildfires. This involves creating a framework for organising the principles, goals, and objectives of the different stakeholders. We establish a method to address the various phases of the risk management process while respecting the sometimes-conflicting interests to achieve the overall goal of minimising present and future fire risks.

Together with the elaboration of a Roadmap for the preparation of the Framework, FirEURisk is also integrating other relevant perspectives and outcomes to facilitate its use by multiple end-users, namely EU Member States. These efforts are devoted to improving wildfire risk management in the EU. Key deliverables are illustrative of this effort, i.e., the open platform (D4.8) that is composed by open data that may be used or viewed through a dedicated viewer by interested end-users. On the pillar of science strategy, D4.4 will develop additional integration efforts to demonstrate the contributions from different WPs on the simulations raised to test the methodologies. In addition, results for fire risk assessment, reduction and adaption are going to be identified in D5.12. The pillar of governance and policy integration with the Roadmap is addressed in Section 3.3 of this document and will be also developed in D6.15.

In sum, it is expected that the integration of these different FirEURisk outputs contribute to improving integrated wildfire risk management in EU, namely through their respective use by interested stakeholders.

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2. Overview of existing Frameworks

There are numerous frameworks for WRM proposed at international, national, or regional levels. Therefore, it's reasonable to explore the most relevant ones to comprehend their similarities, which can be utilised by FirEUrisk. Then, we can propose our own structure and develop it further.

2.1. International Frameworks and Guidelines

In this Section we review a selection of documents produced by different agencies at international or national levels that are designated as Reports, each containing a Framework for WRM in the sense that is considered here is analysed. However, they sometimes include other components such as Governance elements, that can be constructive in the preparation of a roadmap to define a WRM Framework for Europe.

2.1.1. Fire Management Voluntary Guidelines (UN – FAO)

The Food and Agriculture Organization (FAO) released a report in (Food and Agriculture Organization of the United Nations, 2007) that is a significant contribution to the field of wildfire management. The report serves as a comprehensive framework to guide policy formulation, legal frameworks, and strategic actions in the realm of fire management. It covers both planned and unplanned vegetation burning outside urban or structural environments, allowing the guidelines to address a wide array of fire management activities, ranging from traditional agricultural burns to modern wildfire suppression techniques.

The Fire Management Voluntary Guidelines aim to establish responsible fire management activities and articulate a series of objectives. These objectives are multi-faceted, extending from the development of national and subnational policies to the facilitation of international cooperation and mutual assistance between various agencies. The guidelines also aim to disseminate best practices in community-based fire management and advocate for sustainable land and resource management programs. This aligns well with the FAO's broader mission to achieve food security and promote sustainable agricultural practices since fire management can be integral to both.

The report has 11 cross-sectoral issues linked to Wildfire Risk Management, covering socio-economic aspects, environmental concerns, and technological dimensions. Each issue is treated as a critical component that contributes to the complexity of fire management, necessitating a multi-disciplinary approach for effective WRM.

The guidelines define principles in five key areas: Social and Cultural, Economic, Environmental, Institutional, and Enhanced Fire Management Capacity. These principles serve as the ethical and operational backbone for fire management activities, ensuring alignment with broader societal, economic, and environmental goals.

Finally, the report proposes a comprehensive set of 15 strategic actions or processes that cover the entire spectrum of fire management. These range from pre-fire planning activities like 'Fire and Resource Management Planning' and 'Fire Awareness and Education,' to real-time response strategies such as 'Initial Attack/Action' and 'Large-Fire Suppression and Management.' It also includes post-fire activities like 'Burned Area Restoration and Rehabilitation' and ongoing efforts like 'Monitoring and Assessment.'

In conclusion, the Fire Management Voluntary Guidelines offer a robust, multi-disciplinary framework for wildfire management and serves as a valuable resource for policy-makers, practitioners, and researchers. Given the increasing frequency and intensity of wildfires due to climate change such comprehensive guidelines are more relevant than ever for establishing effective and sustainable fire management practices (Food and Agriculture Organization of the United Nations, 2007).

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2.1.2. Wildfires - a growing concern for sustainable development (UN)

In 2021, the UN created a Policy Brief titled "Wildfires - a growing concern for sustainable development" (Yan et al., 2021). The document discusses the impact of wildfires on sustainable development in terms of the environmental, economic, and social dimensions. The Policy Brief analyses the current trends and the effects of wildfires on the economy, society, and the environment. It identifies climate change and human activities as the primary drivers of wildfires and suggests ways to mitigate them. These measures include developing comprehensive strategies for wildfire management, using scientific and traditional knowledge, promoting a collaborative agenda for climate and forests, taking effective action at the national level, engaging all stakeholders and promoting international cooperation.

2.1.3. Landscape Fire Governance Framework (LFGF)

During the 8th International Wildland Fire Conference held in Porto, Portugal, in May 2023, a Landscape Fire Governance Framework (LFGF), was presented and after an extensive process of discussion was widely accepted and approved by a large number of international agencies, national and non-governmental organisations, making it one of the latest and most widely supported frameworks, at present (Verde et al., 2023).
This document, that is also known as the “Porto Framework”, has the subtitle of “Guiding Principles for Adjusting Strategies, Policies, and Management to Global Change”, it therefore covers all elements of an integrated framework incorporating the consensual proposals of previous documents, namely, some of those reviewed here The document has a Preamble, Goals and Expected Outcomes, Guiding Principles, Priorities for Action, Governance and Moving Forward.
In the first ten points of the Goals chapter the present scenario of wildfires in the world and its future trends are traced. The increasing relevance of the problem, the magnifying negative effect of fire exclusion policies and land abandonment trend, the role that climate change has on the increasing occurrence of wildfires of high intensity and severity, resulting in greater loss of biodiversity and socio-economic impact, including the loss of lives is also covered. The variety of drivers of the problem, and the different **stakeholders** involved require the development of governance modes to integrate fire management capabilities from local, to national and international levels to assure that wildfires do not contribute to deforestation and to impact negatively on the climate. One example of this is the need to conserve forest and other natural vegetation areas as carbon stores to mitigate climate change creates conflicting balances with the need to reduce accumulation of fuels and protect the environment. It is recognised that some countries are addressing the fire management problem with sectorial perspectives, without considering the vulnerability of the society and neglecting the need of long-term planning, the investment in integrated fire management. As a result of this it advocates a governance system based on multi-tiered systems, involving different actors, with different expectations, perceptions, knowledge, values and **interests**, to collaboratively build an integrated landscape fire management. The exchange of experiences on management approaches between countries will benefit from guiding principles to set the way to enhanced governance and promote international cooperation. The international Landscape Fire Governance Framework (LFGF) is therefore proposed to help the countries to develop policies and governance using existing knowledge and techniques to develop adequate legal provisions, establish financial support programs, build institutional structures and promote the active participation of the society.

Goals and Outcomes

In the first Goal the dual role of fire in the landscape is considered. Its presence in ancestral practices and its role in ecological processes contrast with its suppression, which increases the vulnerability of both land and people. Given the need to balance between the positive and negative impacts of fire on the landscape it is proposed, as an overall goal of the Framework, to manage lands and fire in a preventive way to increase the resilience of rural landscapes

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against wildfires, to maintain or restore sustainable, productive, safe and disturbance resilient land for people to live in. The inclusion of community-based fire management approaches is recommended. IWRM is essential to promote an exchange of both traditional and advanced knowledge between countries, supported by binding agreements. It is noted that the proposed goals align with the Sendai Framework, the Convention on Climate Change and other International Agreements.

The expected outcome of the proposed framework is a significant reduction of losses by wildfires. In order to achieve this the following is required: expertise is incorporated in each component, the latest research and knowledge are integrated into risk governance, responsibilities and accountability are clearly defined for each stakeholder, risks are assessed and evaluated, institutional cooperation is established, communities are actively involved and communications are transparent.

Strengthened interoperability is expected to result in a more effective and efficient international response to wildfire emergencies through the application of the LFGF.

In LFGF Report the expression Integrated Fire Management (IFM) is used with the same meaning as the IWRM that is used in the present document, which we maintain to be consistent with the definitions given above.

Guiding Principles

The LFGF proposes two guiding principles and 15 guidelines. As we are going to propose the adoption of these principles and guidelines in the EC Framework, in 3.2.3, to avoid repetitions they are not detailed here. Then five priorities for action are proposed:

1. Strengthening the governance model – the WRM requires governance composed of bodies that exist at different levels and somehow represent and involve all the relevant interests and consider the range of factors that affect the wildfires development, without gaps and in dialogue among the various areas of expertise.
2. Valuing rural areas – rural areas that are the ground where wildfires develop must be valued to encourage and support their active management, promoting their potential to develop a green, low carbon emission, circular bioeconomy.
3. Actively managing rural areas – related to the previous priority, it is recommended to support the communities involved in the management of rural areas, to better prepare the land for the occurrence of fire and reduce its impact.
4. Changing attitude and behaviour – citizens should adopt different attitudes and behaviour in face of the increasing risk of wildfire, in the management of flammable fuels, in being informed and in keeping themselves safer.
5. Training and qualification – training and qualification of all agents under a common qualification program is required to increase the level of specialization and professionalism of the multiple actors involved.

Governance

In this comprehensive section, a structured approach to navigate the complexities of fire management is offered, aiming to reconcile ecological necessities with societal and environmental safety concerns. The guidance is organized into the following key areas: (1) Fire risk assessment; (2) Wildfire risk tolerance; (3) Wildfire risk management; (4) The Value Chain; (5) Adaptative management; (6) Stakeholder engagement; (7) Communication; (8) International cooperation; (9) Governance bodies. These are detailed in 4.2.6.

Moving forward

To put the IWRM into practice, governments and agencies should measure their own progress in integrated landscape management, focusing on applying the guiding principles. They should then encourage policies

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recommended by the IWRM, such as cross-sectoral dialogue and coordination, inclusion in national policies, and strengthening international efforts and networks to reach a wider community of practitioners. Additionally, the UN should help establish a global fire management program as per the framework, to support integrated fire management actions worldwide.

2.1.4. DG ECHO Framework for Peer Review

In May 2023, the Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG ECHO) released its seminal Wildfire Peer Review Assessment Framework (Casartelli & Mysiak, 2023). This document aims to serve as a comprehensive guideline for evaluating the capabilities of national EU Civil Protection agencies in managing wildfire risks, together with other relevant documents (Oom et al., 2022). The framework is meticulously organized into seven thematic areas, each further divided into six activities, thereby providing a multi-dimensional approach to wildfire risk management (WRM) (Casartelli & Mysiak, 2023).

1. **Governance of WRM**: This area focuses on the overarching structures that guide WRM. It includes the governance framework, which outlines the legal and institutional mechanisms in place. The wildfire risk management strategy is scrutinised to align with broader national and EU objectives. The institutional framework examines the roles and responsibilities of various agencies, while coordination and partnership assess inter-agency collaboration. Wildfire risk planning delves into the tactical aspects, and systemic resilience evaluates the robustness of the entire system to withstand and recover from wildfires.
2. **Wildfire Risk Assessment**: This segment is dedicated to the methodologies and processes used for risk assessment. It starts with the framework and process, which should be transparent and replicable. Identification of risks involves cataloguing potential wildfire hazards, while risk analysis quantifies these hazards in terms of their likelihood and impact. Risk evaluation prioritizes these risks, and risk communication ensures that these evaluations are disseminated to all stakeholders. Capabilities assess the resources available for risk mitigation.
3. **Wildfire Risk Management Planning**: This area focuses on the strategic planning required for effective WRM. It includes the framework and process for planning and the role of stakeholders in this process. Prioritization of measures ensures that resources are allocated efficiently, and monitoring and evaluation assess the effectiveness of these measures. Policy coherence checks for alignment with other national and international policies, and capabilities evaluate the resources available for implementing the plan.
4. **Wildfire Prevention**: This thematic area is concerned with proactive measures to prevent the occurrence of wildfires, including public awareness campaigns, land management practices, and early warning systems.
5. **Wildfire Preparedness**: This involves planning and resource allocation to ensure readiness for wildfire events, including training, equipment, and emergency plans.
6. **Wildfire Emergency Response**: This area focuses on the immediate actions taken to combat active wildfires, including coordination among different agencies and rapid deployment of resources.
7. **Recovery and Lessons Learned**: This final area is concerned with post-wildfire activities, including restoration efforts and the extraction of lessons learned for future preparedness.

The DG ECHO's framework is a robust tool that provides a comprehensive, structured approach for peer review assessments, thereby contributing to the enhancement of wildfire risk management across the EU.

2.1.5. National Strategy for Cohesive Wildland Fire Management (USDA)

In 2014 the USDA proposed “The National Strategy – The Final Phase in the Development of the National Cohesive Wildland Fire Management Strategy” (Wildland Fire Executive Council, 2014). In 2022 an overview of their National Strategy is presented with the purpose of helping decision-makers to understand the risks and consequences of

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decisions and how these decisions fit into the broader goals of the Cohesive Strategy: (i) restore and maintain landscapes, (ii) fire-adapted communities, and (iii) wildfire response (USDA Forest Service, 2022).
It presents several management options for each goal.
Starting with the **vegetation and fuels management options**, it considers (i) prescribed fire, (ii) manage wildfire for resource objectives, and (iii) fuel treatments using mechanical, biological and other non-fire methods. Then it addresses the **management options for homes, communities and assets at risk**, considering (i) Home and community action, and (ii) Building codes.
Regarding the **management of human-caused ignitions options** it addresses (i) the reduction of accidental ignitions and (ii) the reduction of intentional ignitions.
On the **effective and efficient wildfire response management options** it considers: (i) Prepare for large, long duration wildfires, and (ii) Protect structures and target landscape fuels.
For each one of the above topics a general guidance to improve the management is provided.
Then the risk trade-offs are analysed, proposing a path of risk management that marginally increases risk in the short- term, but begins paying long-term benefits relatively quickly and keeps risk at manageable levels. Three key assumptions or premises to underlie meaningful reductions in risk are presented: (i) Prioritisation of investment and use of resources, (ii) Acceptance of increased short-term risk, and (iii) Greater collective investment.
A summary of the management options in relation to the national goals and challenges are presented in a Table and National priority maps are also presented illustrating how multiple management options can be employed in the same location for similar purposes.
Finally, a set of three basic elements to achieve a successful implementation of the plan are proposed: (i) Strategic alignment, (ii) Communication and collaborative engagement, and (iii) Programmatic alignment.
In a two page leaflet the National Cohesive WF Management Strategy is defined as: "To safely and effectively extinguish fire when needed; use fire where allowable; manage our natural resources; and as a Nation, live with wildland fire." It identifies four major challenges: (i) Vegetation and Fuels Management, (ii) Homes, Communities, and Values at Risk Management, (iii) Human-caused ignitions, and (iv) Effective and Efficient Wildfire Response.
In a later document (USDA Forest Service, 2022) entitled "Confronting the Wildfire Crisis", the USDA presents the Wildfire Crisis Strategy and where they stand regarding its effort to reduce wildland fire risk, to face accumulation of fuels, a warming climate and expanding development of fire prone landscapes. The Forest Service identified 'firesheds', that are large landscapes and rangelands that have a high likelihood of having ignitions that can threaten homes, communities and infrastructure, that are prioritised to have increased management activities to reduce fuels and restore forest health, in a ten-year implementation plan. This is done also working together to achieve strategic goals, promoting round tables and meetings, promoting partnerships between government and private agencies to support fuels work and to monitor to reduce fire risk. Investments are being made at the landscape scale using mechanical thinning and prescribed fire to reduce fuel and health treatments, in ten selected firesheds. It is expected that this plan will promote safer communities, the forest ecosystems will support natural fire regimes, with improved biodiversity and less risk of wildfires. This will also support forest industries and strengthen local economies.

In 2023 the USDA produced and Addendum Update to the National Cohesive Wildland Fire Management Strategy (USDA- Wildland Fire Leadership Council, 2023), to spotlight critical areas and challenges that were not identified or addressed in depth in the 2014 Cohesive Strategy framework. Critical areas included: (i) climate change, (ii) the workforce capacity, (iii) health and well-being, community resilience (preparation, response and recovery) and (iv) diversity, equity, inclusion and environmental justice. The following implementation challenges were identified: (i) the present WFRM system has not kept pace with demands, (ii) there is a need to increase the proactive use of fire (both prescribed and managed wildfire) in the landscape; (iii) science, data and technology has not been fully integrated in the decision making process; (iv) resource capacity to utilize biomass from ecosystem management

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or fuel treatments is inadequate, and (v) education, communication and marketing are not sufficient to inform stakeholders about the Cohesive Strategy implementation.

A modified vision was proposed, defined as "To safely and effectively extinguish fire, when needed; use fire where allowable; manage our natural resources; and collectively, learn to live with wildland fire".

The following updated Goals were proposed:

Resilient Landscapes – Landscapes, regardless of jurisdictional boundaries are resilient to fire, insect, disease, invasive species and climate change disturbances, in accordance with management objectives.
Fire Adapted Communities – Human populations and infrastructure are as prepared as possible to receive, respond to, and recover from wildland fire.
Safe, Effective, Risk-based Wildfire Response – All jurisdictions participate in making and implementing safe, effective, efficient risk-based wildfire management decisions.

As a result of extensive reflection on the newly identified critical areas and challenges, 15 new management options were added to the existing 19 proposed in 2014. The new options refer mainly to fire adapted communities and to safety and risk-based wildfire response.

The document reinforces the relevance of the three pillars already identified in 2014, defined as (i) planning efforts, (ii) collaborative engagement and (iii) programmatic alignment, together with increased urgency and work at greater scales as being essential for the Cohesive Strategy framework success.

2.1.6. Canadian Wildland Fire Strategy (Canada)

In the document entitled "Canadian Wildland fire Strategy – a 10-year review and renewed call to Action", the Canadian Council of Forest Ministers, in 2016 proposes a ten-year upgrade of the progress and challenges, to serve as renewed call to action, to reengage senior officials, identify priorities for a renewed emphasis on implementation and enhance horizontal integration plus collaboration so as to invigorate the strategy and further realize its goals and objectives (Canadian Council of Forest Ministers Wildland Fire Management Working Group, 2016). It started from the then current state, considering the (i) Background, (ii) The Progress in Canadian Wildfire Research in the last ten years, (iii) the Extent and impact of WF in Canada, and (iv) Challenges and Risks. Among the challenges and risks the following factors are mentioned: (i) Changing climatic conditions, (ii) Workforce, (iii) Public risk and concern, (iv) Wildland fire costs.
Progress towards the desired future state is designed around four strategic objectives: (i) Public education/awareness and policy/risk analysis, (ii) Canadian FireSmart initiative, (iii) Preparedness and response capacity, and (iv) Innovation.
Then a set of six specific actions are proposed as next steps: (i) Recommit to the strategy, (ii) Enhance horizontal collaboration and integration, (iii) Increase investment in innovation, (iv) Enhance prevention and mitigation capability, (v) Enhance commitment to FireSmart, and (vi) Increase preparedness capacity.
In the first of two Annexes the Goals of the CWFS are defined as (i) Resilient communities and an empowered public and (ii) Healthy and productive forest ecosystems, and (iii) Modern business practices. In the second Annex the main challenges identified for the implementation of the CWFS are identified around the following points: (i) Definition of strategic priorities and needs to promote the partnership of wildland fire agencies; (ii) Preparedness for a major fire event, (iii) Budget pressures and constraints.

2.1.7. National Bushfire management Policy Statement for Forest and Rangelands (Australia)

In the "National Bushfire management Policy Statement for Forest and Rangelands" prepared in 2014 by the Forest Fire Management Group for the Council of Australian Governments, a policy statement and supporting strategies developed by the Australian Governments to guide the evolution of effective and ecologically sustainable fire

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regimes within Australia (The Forest Fire Management Group, 2014). The statement is not a policy on regional growth or land use but advocates for mechanisms that can influence better development outcomes and aims to establish the necessary knowledge and decision-making framework needed by managers to reduce bushfire risk and implement appropriate fire regimes.

The document identifies three **levels of governance** in the country, in relation to hierarchy and of territorial scale: (1) National level, (2) State and Territory governments, and (3) Local Governments.

In the Policy Scope the international dimension of the problem is dealt with and the **community values and expectations** are defined as (i) community protection; (ii) the conservation of natural biodiversity (plant and animal species, habitat), (iii) the production of water, carbon, and timber, (iv) the provision of tourism and recreation opportunities. The **eight objectives for the land managers** of the statement are defined as: (i) using planned fire to reduce fuel and maintain productive and healthy ecosystems; (ii) reducing the occurrence of unplanned and unwanted fires; (iii) preparing for, and rapidly responding to, unplanned fires on or near their lands; (iv) managing bushfires, where possible, to contribute to the achievement of positive outcomes; (v) leading and supporting emergency efforts as appropriate; (vi) working closely with communities, stakeholders and partners; (vii) learning through research, monitoring and adaptive management; and (viii) applying best practice by developing and adapting their agencies' codes of practice to deliver on the principles and policies that lie within the NBMPSFR.

The following **Vision** is proposed: "Fire regimes are effectively managed to maintain and enhance the protection of human life and property, and the health, biodiversity, tourism, recreation and production benefits derived from Australia's forests and rangelands".

The following **principles** are proposed: (i) Learning to Live with Fire – Bushfires are Understood, Accepted and Respected, (ii) Shared and Individual Responsibility, (iii) Protection of Lives as the Highest Consideration, (iv Consistency of Purpose and Unity of Command, (v) Manage Fire According to the Landscape Objectives, (vi) Decisions within a Risk Management Framework, (vii) Integration of Learning and Knowledge (vii) Monitoring Performance.

The following four **Strategic Objectives** and the corresponding 14 National Goals are defined:

A. Effectively Managing the Land with Fire: (1) Maintain Appropriate Fire Regimes in Australia's Forests and Rangelands; (2) Balance the Environmental Impacts of Fire; (3) Promote Indigenous Australians' Use of Fire.

B. Involved and Capable Communities: (4) Community Engagement; (5) Public Awareness and Education.

C. Strong Land, Fire and Emergency Partnerships and Capability: (6) Integrated and Coordinated Decision Making and Management; (7) Employment, Workforce Education and Training; (8) Bushfire Risk Mitigation; (9) Bushfire Response; (10) Safety in Fire Operations; (11) Bushfire Recovery; (12) International Responsibilities

D. Actively and Adaptively Managing Risk: (13) Risk Management, and (14) Investing in and Managing Knowledge.

There is a chapter on Implementation and Reporting that summarizes the key objectives and goals to drive Australia towards the desired vision and proposes a collaborative pathway to implement the political and administrative measures to reach it. A consistent reporting mechanism with annual assessment of the priorities, progress and availability of resources to share and validate information to support business case development and investment.

In Volume 2 characterisation of Fire in Australia is provided, based on the history and geography of wildland fires in Australia. A Glossary based on the Australian knowledge web is provided to clarify the meaning of some words and concepts in the context of the document.

Recently, a relevant paper highlighted that Australia needs a National monitoring agency (Bowman et al., 2020). The Australian Forest Fire Management Committee of Forestry together with the Forest Fire management group issued a new policy statement turning the goals of the National Bushfire Management Policy Statement into objectives and key performance indicators (The Forest Fire Management Committee of Forestry Australia & The Forest Fire Management Group, 2022)

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2.1.8. National Plan for Integrated Rural Fire Management (Portugal)

In the aftermath of the grave fires of 2017, the Portuguese Government created an Agency for the Integrated Management of Rural Fires (AGIF) under the Presidency of the Council of Ministers, expressing the interministerial challenge of wildfire risk governance, creating a disruption with previous legislation and practice, promoting a more integrated and systematic approach to fire management. In a widely participated process a strategy and process chain documents were proposed. In 2018 AGIF produced the National Plan for Integrated Management of Rural Fires (Agency for Integrated Rural Fire Management, 2018). This document is divided in eight chapters: (1) Introduction; (2) Vision Mission and Principles; (3) The foundation for change; (4) The Strategy; (5) Strategic guidelines and targets; (6) Main legislative impacts; (7) Monitoring and evaluation, and (8) Major processes.

In Chapter 2, the proposed **vision** is expressed in a single phrase: *Portugal protected from severe rural fires*. This vision is translated into the following **mission**: *protect people and property from rural fires and develop wild land, ensuring ecosystems are properly tended to.*

Then a set of nine **principles** are defined, along the following keywords: (1) Clarity of purpose; (2) Awareness of the complexity of the mission; (3) Accountability; (4) Subsidiarity; (5) Cooperation; (6) Competence; (7) Experience; (8) Flexibility, and (9) Balance.

In Chapter 3 the **foundations for change** are presented under the following subtitles: (1) National forest protection system; (2) 2017 lessons learned; (3) Understanding the root causes of the problem; (4) Challenges ahead; (5) Socio-economic dynamics; (6) Risk governance evolution, and (7) Integrated with new public policies.

In Chapter 4 the Strategy to develop the National Plan is presented, starting with the proposal of (1) the Integrated Rural Fire Management System (IRFMS), with (2) The Process Chain and (3) The Enablers. In the IRFMS the vision for the system is proposed and then a questionable division or specialisation of the fire suppression activities in a Rural Fire Management and a Rural Fire Protection is proposed, in our opinion introducing and artificial division between the protection of rural spaces from those occupied by people and property. The different temporal levels or Stages of risk management activities, designated as: (1) Planning, (2) Preparation, (3) Prevention, (4) Pre-suppression, (5) Suppression and Relief, and (6) Post fire, are described in detail with the responsibilities of the various involved agencies. According to our concept this role description falls in the area of Governance. The so-designated Process Chain, including the above-mentioned Stages plus the roles of Governance, Qualification and Information and Communication Systems, is described.

In Chapter 5 four Strategic Guidelines are defined: (i) Valuing rural areas [subdivided in 3 sub-Guidelines], (ii) Active management of rural areas [3], (iii) Change behaviours [2], and (iv) Efficient risk management [4]. A set of four targets is proposed to assess the achievement of the goals of the National Plan.

Chapter 6 addresses the required legislation changes to implement the Plan, and in Chapter 7 the process of Monitoring and Evaluation is designed with some principles and the allocation of roles putting emphasis on the qualification of the human resources.

In Chapter 8 an elaborate system of assigning the responsibilities and roles of each agency, and private stakeholders, in the development of the processes and the execution of the various Projects that were defined to implement the 12 guidelines of the Strategy, is presented. The report is also supported by a glossary of 30 terms.

2.1.9. Strategic Guidelines for Wildland Fire Management in Spain (Spain)

In 2019 the Government of Spain, through its Ministry for the Ecological Transition and Demographic Challenge issued a bilingual (in Spanish and in English) document entitled Strategic Guidelines for Wildland Fire Management in Spain, that was prepared by the National Wildland Fire Committee (National Wildland Firefighting Committee, 2019).

This document has four chapters and defines seven main objectives that are presented as priority lines of action.

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In the first chapter the need of a strategy for managing wildfires is addressed, based on the past and recent history of wildfires in Spain and the different legislative, regulatory and research efforts performed, the need of a strategy is justified on the basis of the following facts:

- Wildland fires are a cross-cutting problem, requiring multi-sector approach
- Wildfire have been present naturally in the landscape but many are generated by human action as a land management tool but it is not possible to eliminate wildfires but try to use them as land management tools and learn to live with the risk of fires.
- The global changes that we are facing will lead to increased risk.
- Depopulation and abandonment of traditional land use contribute to transform the landscape into more fire prone structures.
- It is necessary to anticipate fire management to be adapted to future conditions.
- It is crucial to reduce the threat of wildfires to civil populations.

Lessons learned from previous experience should be capitalised to better manage wildfires.

Fire investments are very high cost but there is a lack of balance between expenditure in prevention and suppression, assuring that the restoration efforts contribute to increase resistance and resilience to wildfires.

- There is a need to improve the capacity and safety of the very good human assets that Spain has and extend them to the European scale.

In Chapter 2 the governing principles of the strategic guidelines are presented. These are: (1) Comprehensive management; (2) Social interest in wildland fire management; (3) Land sustainability; (4) Co-responsibility; (5) Adaptation and mitigation, and (6) Operative safety.

In Chapter 3 the objectives of the strategy are presented. A general objective is expressed as: reduce the impacts generated by wildland fires' social, economic and environmental effects.

In Chapter 4 the priority lines of action are presented as seven objectives, each one detailed into several points that cover virtually all sectors of the society, with explicit involvement of the scientific community:

1 – Manage the rural geography to achieve sustainability in the face of wildland fire
2 - Reduce the risk of wildland fires, adapting ecosystems and preparing society for their occurrence
3 – Involve other strategic sectoral policies in wildland fire risk management
4 – Adapt wildland firefighting organisations to the new scenarios and strengthen cooperation
5 – Further knowledge about wildland fires and their impact on ecosystems
6 - Foster society's participation and awareness raising in wildland fire management
7 - Incorporate technological improvements in prevention and suppression of wildland fires.

2.2. Meetings and webinars on WRM

Following the principle advocated by the EU of using the "citizen science" approach the FirEUrisk organised a set of meetings and webinars with relevant stakeholders of some countries and regions. At present, several meetings and webinars with representatives of the following countries were carried out, namely: Portugal, Germany, Spain and Greece. Key aspects were included in the proposed framework. More details on each meeting are given in the Annex.

2.3. Components of Existing Frameworks

In this Section we summarise in a schematic form the main components of existing Frameworks in order to highlight their commonalities and differences with the objective of selecting and proposing the more adequate elements to be included in a European Framework.

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2.3.1. Gaps and Limitations

As could be expected, the main topics or contents that are considered by the various Frameworks differ, given the range of countries, agencies and period of time considered in their preparation and issue. There are nevertheless some commonalities, as the mere description of their contents given above, indicates, highlighting the importance of some subjects and also the consensus that is created around the need to consider them.

As expected, all Framework documents have an introductory chapter that in some cases is designated as a preamble (LFGF), an overview (USDA), or just a justification for the need of strategic guidelines (SP). The UN-FAO presents a chapter with cross-sectoral issues which in the PT report corresponds to the foundation for change, in which the cross-sectoral nature of the wildfire risk management problem is addressed and, on the basis of past history and expected evolution, a need for structuring or modifying the WRM approach is justified. The Canadian report includes also a chapter on the current state of WRM and the need for a change.

Most of them have a chapter dedicated to Goals (LFGF) and Principles (UN-FAO, LFGF, PT, SP). The Australian report defines the policy scope and has a policy statement. Some reports define strategic actions (UN-FAO), priorities for action (LFGF) or priority action lines (SP). The Portuguese report defines a strategy and proposes the corresponding strategic guidelines and targets. The USDA framework presents management options and the corresponding risk trade-offs. The Canadian report addresses the progress toward the desired future state and addresses the steps required to achieve them.

Practically all reports consider the various phases of the RM process and include a chapter dedicated to the implementation of the strategy, the need to monitor and improve it, in processes to define priorities and evaluation of the processes and methods.

As was explained above, the DGECHO report follows a different approach considering each phase of the RM process as a thematic area.

2.3.2. Foundation for Change/Cross sectoral issues

Going more in detail on some of the topics mentioned above, we summarise the contents of the various reports on each topic, starting with the Foundation for Change or on Cross Sectoral Issues.

The **UN-FAO** report considers the following cross sectoral issues to justify and support its proposition of voluntary set of guidelines for WRM: (i) Livelihoods and Poverty; (ii) Fire as a Tool in Sustainable Land Use and Resource Management; (iii) Impacts on Human Health and Security; (iv) Safety Considerations for Firefighters and Civilians; (v) Sustainable Ecosystems and Environmental Impacts; (vi) Carbon and Climate Change; (vii) Knowledge Management; (vii) Science and Technology; (viii) Education, Training and Public Awareness; (ix) Legal, Policy, Institutional and Financial Frameworks; (x) Cooperation and Partnerships.

The **LFGF** report considers the following items in its preamble: (i) Increasingly extreme characteristics of wildfires; (ii) Role of socio-economic dynamics and public policies; (iii) Diversity of causes and growing number of stakeholders; (iv) Need of a more robust framework capable of addressing the complexity and uncertainty of the problem.

In its Introduction the **Australian** report addresses previous legislation and policy statements related to bushfire mitigation and management, paying great attention to biodiversity and ecological sustainability of the environment and the promotion of the cultural and traditional values of the country. Considering the three levels of government and the landowners, the responsibilities and role that each of them has in managing the land and fire are described. It is recognised that rural activities are very important for the economy and social life, but it can be impacted by fire regimes that predispose the landscape to catastrophic fires. The management of fire requires policies and practices that suit regional needs and can be adapted to face future changes in climate, community attitudes and land use and land settlement patterns. It is recognised that fire can be damaging in some circumstances and essential for maintenance in others, the risk of adverse impacts is increasing due to climate change, settlement

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development and other socioeconomic factors, and also that community values are changing with increasing expectations in transparency of decision making.

The **Canadian** Report in its Introduction chapter recognised the existence of an increase in extreme wildland fire behaviour and of wildland urban interface events, leading to the fact that the suppression resources have reached their limits, requiring an equivalent focus and commitment on prevention, mitigation and preparedness. The increasing effects of climate change and limitations in response capacity require a faster progress on the various aspects of fire management than was originally envisioned.

The **Portuguese** Report in its introduction describes the process of creation of the National Plan for the Integrated Management of Forest Fires, in the aftermath of the dramatic fires of 2017. A 2020-2030 Strategy proposing the vision and values, identifying the context, defining the strategic guidelines and goals, setting targets, introducing new governance and management models was presented. This was followed by the National Action Plan that sets the priorities and the course of action materialised in projects to be implemented. In the foundations for change the Report analyses the evolution of the fire management system since its major organisation, recalls the lessons of the 2017 fires and the limitations that they exposed and then sets to identify the roots of the problems. These are associated to extensive socioeconomic and land use changes, to the abandonment of rural areas, to insufficient forest management, and to an increase of the urban settlements exposed to fire. The challenges ahead and the need to promote an evolution is risk governance in harmony with other more general legislation or agreements are presented and discussed.

As can be seen there are several commonalities in the identification of the need for change and the description of the cross-sectoral issues, associated to the proposal, adoption and implementation of a Framework for WRM, or even a whole IWRMS. In section 3.2.2 we will synthesize the items that we consider more relevant.

2.3.3. Vision

We compile the formulation of the Vision proposed by four of the Frameworks consulted.

The LPFG proposes the following Vision: "*A significant reduction of losses driven by added expertise on each component of the value chain, enhanced risk governance incorporating the latest research and scientific knowledge, and a defined set of responsibilities and accountability with each stakeholder having a clear view of their scope of action, where the risk is adequately accessed and evaluated, institutional cooperation is agreed upon, communities are involved and have active voices in the process, and communication is clearer, objective, and transparent*."

The USA report has the following formulation: "*To safely and effectively extinguish fire when needed; use fire where allowable; manage our natural resources; and as a Nation, live with wildland fire*".

The Australian Framework proposes that: "*Fire regimes are effectively managed to maintain and enhance the protection of human life and property, and the health, biodiversity, tourism, recreation and production benefits derived from Australia's forests and rangelands*".

Finally, the Portuguese Program aims to have: "*Portugal protected from severe rural fires".*

2.3.4. Mission/Principles

Some frameworks present a set of ideas that are expressed as a Mission or main goal of the WRM system, but most of them list a series of Principles that should be adopted and followed by all involved in the WRM in all its activities. Some of them are summarised here.

The **UN-FAO** proposes the following thematic principles: (i) Social and cultural; (ii) Human health and security; (iii) Traditional uses of fire; (iv) Protecting lives and assets; (v) Economic impact; (vi) Interactions between climate change and fire; (vii) Fire effects on ecosystems; (viii) Legislation and governance; (ix) Multi stakeholder approach; (x) Cooperation, and (xi) Knowledge transfer.

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The **LGFG** proposes principles on the following ten thematic areas: (i) Impact orientation; (ii) Feed forward strategies; (iii) Bottom-up policies; (iv) Progressive transition; (v) Subsidiarity; (vi) Plural use of resources; (vii) Rational allocation of resources; (viii) Training; (ix) Operational flexibility, and (x) Transparency.

The **Australian** Report propose the following seven principles: (i) Learning to Live with Fire – Bushfires are Understood, Accepted and Respected, (ii) Shared and Individual Responsibility, (iii) Protection of Lives as the Highest Consideration, (iv Consistency of Purpose and Unity of Command, (v) Manage Fire According to the Landscape Objectives, (vi) Decisions within a Risk Management Framework, (vii) Integration of Learning and Knowledge (vii) Monitoring Performance.

The **USDA** report identifies the following major principles: (i) restore and maintain landscapes, (ii) fire-adapted communities, and (iii) wildfire response

The **Portuguese** Plan defines as a Mission the following statement: "*Protect people and property from rural fires and develop wild land, ensuring ecosystems are properly tended to"*.

It proposes also a set of principles along the following topics: (i) Clarity of purpose; (ii) Awareness of the complexity of the mission; (iii) Accountability; (iv) Subsidiarity; (v) Cooperation; (vi) Competence; (vii) Experience; (viii) Flexibility, and (ix) Balance.

Finally, the **Spanish** report proposes a set of principles addressing the following subjects: (i) Comprehensive management; (ii) Social interest in wildland fire management; (iii) Land sustainability; (iv) Co-responsibility; (v) Adaptation and mitigation, and (vi) Operative safety.

2.3.5. Strategic objectives

Some frameworks present a set of objectives, also designated as "strategic objectives", and in some case propose a set of KPI (key performance indicators), to assess the degree of achievement of those objectives, defining the required actions to reach them starting from a certain level of management to reach the next one.

The **LGFG** documents includes two groups, one designated as (1) "Priorities for Action" and the other designated as (2) "Governance". The Priorities for Action include the following topics: (i) Strengthening the governance model; (ii) Valuing rural areas; (iii) Actively managing rural areas; (iv) Changing attitude and behaviour, and (v) Training and qualification. It can be seen that these topics, that are proposed as strategic objectives, are aligned with some of the principles that were found in the previous section.

Similarly, under the title "Governance" the following list of objectives are defined: (i) Fire risk assessment; (ii) Wildfire risk evaluation and tolerance; (iii) Wildfire risk management; (iv) Integrated fire management; (v) Adaptative management; (vi) Stakeholder engagement; (vii) Systemic and public communication, and (viii) International cooperation.

According to the defined principles, the **USDA** framework proposes the following objectives: (i) restore and maintain landscapes, (ii) fire-adapted communities, and (iii) wildfire response.

The **Canadian** framework has the following objectives: (i) Public education/awareness and policy/risk analysis, (ii) Canadian FireSmart initiative, (iii) Preparedness and response capacity, and (iv) Innovation.

The **Australian** system proposes the following four major objectives: A. Effectively Managing the Land with Fire; B. Involved and Capable Communities; C. Strong Land, Fire and Emergency Partnerships and Capability, and D. Actively and Adaptively Managing Risk.

The **Portuguese** program also defines four major objectives that are then detailed in ten sub-objectives.

1. Valuing the rural areas: (1.1) Understand land use and reshape forest management; (1.2) Redesign the forest management model; (1.3) Provide incentives to develop rural areas.
2. Active management of rural areas: (2.1) Design and promote a diverse landscape; (2.2) Reduce the landscape fuel load; (2.3) Increase people and property protection.
3. Change behaviours: (3.1) Reduce fire ignitions; (3.2) Specialise risk communication.

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4. Efficient risk management: (4.1) Implement integrated management; (4.2) Implement risk governance model, and (4.3) Redesign resource management.

From its side, the **Spanish** system proposes to achieve seven objectives that were listed above (2.2.9).
It can be seen that although different terminologies and concepts are used to define the strategic objectives of the WRM System, there are commonalities among them, namely in the recommendation of implementing an integrated wildfire risk management, incorporating risk assessment, reduction and adaptation, developing rural areas, promoting a diverse and more resilient landscape, promote attitude change, involving all stakeholders and the communities, incorporating and valuing scientific knowledge, and protecting the life and property of the communities.

2.3.6. Processes

The complexity and the necessary distribution in time and space of the multiple activities involved in WRM require that they are identified and somehow allocated to specific times and places. These activities are commonly designated as "processes" and receive various designations and sequential arrangements, according to the tradition and culture of each entity that is promoting the framework. In this section the various processes identified by the consulted frameworks are presented to illustrate the variety in their approach. It would be convenient to have an agreement and common designation for the various processes, but more important than that it is the relevance of having clear definitions of the various processes and their operational meaning, even if different names are used to designate them in various international contexts.
The **UN-FAO** Report uses the following designations for the processes: (1) Fire and Resource Management Planning; (2) Fire Management in Natural or Protected Areas and Reserves; (3) Fire Awareness and Education; (4) Fire Prevention; (5) Fire Danger Rating and Early Warning Systems; (6) Fire Preparedness, Including Technical Training; (7) Pre-Fire-Season Activities; (8) Fire Detection, Communications and Dispatching; (9) Initial Attack/Action; (10) Large-Fire Suppression and Management; (11) Managing Multiple Incidents; (12) Fuel Management; (14) Planned Fire; (15) Burned Area Restoration and Rehabilitation, and (15) Monitoring and Assessment.
The **Australian** report identifies the following processes: (1) Maintain Appropriate Fire Regimes in Australia's Forests and Rangelands; (2) Balance the Environmental Impacts of Fire; (3) Promote Indigenous Australians' Use of Fire; (4) Community Engagement; (5) Public Awareness and Education; (6) Integrated and Coordinated Decision Making and Management; (7) Employment, Workforce Education and Training; (8) Bushfire Risk Mitigation; (9) Bushfire Response; (10) Safety in Fire Operations; (11) Bushfire Recovery; (12) International Responsibilities; (13) Risk Management, and (14) Investing in and Managing Knowledge.
The **EU Peer Review Report** is built around seven processes designated as: (1) Governance; (2) Risk assessment; (3) Risk planning; (4) Risk prevention; (5) Preparedness: (6) Emergency response, and (8) Recovery and lessons learned.
The **Portuguese Program** considers nine processes: (1) Planning; (2) Preparedness; (3) Prevention; (4) Pre-suppression; (5) Suppression; (6) Post Fire operations; (7) Governance; (8) Qualification, and (9) Information and Communication.
The **LGFG** proposes six processes: (1) Planning; (2) Preparedness; (3) Prevention; (4) Pre-suppression; (5) Suppression, and (6) Post Fire operations.
Given the importance of this subject, it will be considered again when proposing a common framework for Europe, in Chapter 3 of this Report.

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3. Action Plan and Roadmap

3.1. Overview

In this section we present a proposal of an Integrated Wildfire Risk Management Plan (IWMP) for Europe, as shown in Figure 5.

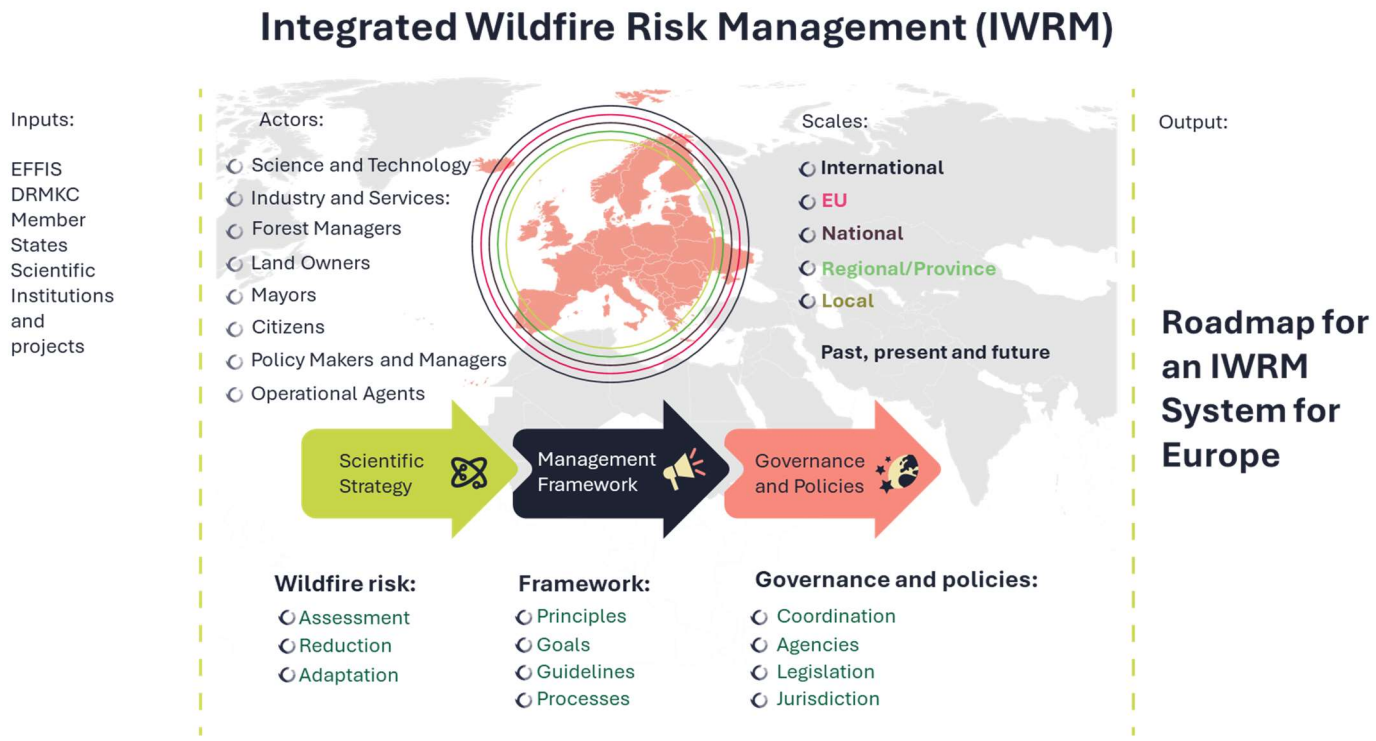


Figure 5 - FirEURisk proposal for the ROADMAP for an IWRM strategy for Europe

It is very clear that each country or region with a problem of WRM must define a Strategy and create a Framework to manage the risk. It would be desirable to have a single IWMP for all countries and regions in Europe and for Europe as a whole, but it is recognized that at this stage this is not the case, therefore we propose a Roadmap to reach this goal.

The existence of a Framework will promote the acceptance of common principles and goals and therefore facilitate collaborative work among the different stakeholders at various levels. As was shown above there are frameworks defined at various levels, from international to local. Fortunately, we can find many commonalities among them, as a consensus around many subjects is being formed in the international WRM community.

As one of the objectives of the present document is to propose a Roadmap for the preparation of a Framework for the Integrated WRM, we will consider the existence of different geographical and administrative levels with their specificities, from the European, to National, Regional and Sub regional scales, knowing that the same framework may not fit well to each one of these situations. We will try nevertheless to propose some guidelines that can be adopted and followed by those Regions and Countries or even Europe as a whole if there is a need and willingness to create or adopt one framework. To facilitate the writing of the text we designate by 'Area' the territory to which this proposal is addressed, regardless of its scale.

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3.2. Management Strategy

The IWFM Strategy is based on scientific and practical knowledge of the processes and factors involved in the whole problem of wildfire risk management, including all its phases and scales of development and application. In FirEUrisk we developed a method to assess the risk of wildfire that encompasses the research program developed in the project to better understand the major processes and the factors that can be modified to reduce the risk and to adapt our society and the landscape to better face future challenges posed by wildfires. This Strategy is presented and developed in D4.4.

3.3. Integrated Wildland Fire Management Framework for Europe



Figure 6 – Structure of the integrated fire management plan (IWMP) for Europe

3.3.1. Introduction

An introduction to the integrated fire management plan (IWMP) should be prepared by the intervening agencies, explaining the purpose of the document, the historical experience in the area with similar documents and plans, justifying its existence, and its purpose.

The contents of the document, to whom it is addressed, its foundations and overall objectives and scope should be described as well.

Europe is composed by a large set of countries with a very diverse geography, vegetation cover, climate and varying degrees of socio-economic development, in which the problem of wildfire, the perceptions of their risk are far from

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being uniform. In the past, the countries of Southern Europe were the most affected by wildfires, but with climate change and other land use and socio-economic changes, in the recent years the problem of wildfires has become of greater concern in more European regions, namely those at higher latitude and altitude, therefore there is a need to have a more uniform and common approach to the problem of wildfire risk management. As mentioned above, we are not so concerned about the Governance system and about the procedures that are adopted in each country. Provided that the proposed strategy and framework are accepted and adopted, in principle, any governing system respecting the democratic and organisational rules that are implied by the concept of "integration" that means that all stages, processes and agents must be considered in the system, should be adequate to govern the system. There are nevertheless lessons to be learned in terms of good practices to follow and errors to avoid that will be the subject of a separate document dedicated to the Governance of the System.

Current status, gaps and challenges

The dimension and complexity of the wildfires problem requires an international cooperation to cope with its seasonality and recurrence in regions in which risk may not be easily anticipated. Europe is already working in this direction with the rescEU mechanism supporting collaboration in fire suppression activities. Although this is a very important step, we know that the risk of wildfire must be managed in an integrated way, considering all its phases and processes.

In spite of the differences that may exist in the impact and dimension of the problem in the various countries, it is important that a common strategy and framework is adopted throughout the EC, with similar principles and goals, with compatible or interchangeable concepts and objectives, involving all stakeholders and facilitating international collaboration within and outside Europe.

Europe is lacking a strategy to better understand and address the problem of wildfire risk. This is reflected in the intermittent development of research programs in the field and the lack of sustained and effective international mechanisms to promote interaction and collaboration between policy makers, scientists, operational agents and citizens. Several programs and policies to promote agricultural and forestry activities, and other economic and social development, have been developed in the past without considering the risk of wildfires. The lack of an integrated European strategy is also notorious.

Regarding WRM principles and goals, we can now benefit from the work developed internationally that helped to create several consensuses, to build a European Framework, adopting what is relevant and adding some guidelines required by the European specificities.

3.3.2. Cross-sectoral issues

It is important to recognise that the problem of wildfires is transversal with implications across various sectors of natural, social, economic, industrial and administrative activities, some related to historical background, with present challenges but also looking at future or emerging changes and perspectives. We give a list of topics that should be addressed, as shown in - Cross-sectoral issues.

1. As a first step the characterisation of the problem in the Area, with some historical background, supported by statistics quantifying the occurrence, extension and impact of wildfires in the geography of the Area.

   In FirEUrisk project we studied extensively the problem of wildfire occurrence in Europe in general and in some countries with more detail, in terms of number, extension and impact of wildfires, including their natural or human related causes; the existence of such databases with consistent and homogeneous data in each country or region is a requirement to characterize the problem.

2. The existence of a strategy to assess and manage WR or, in its absence, the intention to adopt some strategy should be expressed.

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In FirEUrisk we developed a strategy to characterize wildfire risk in all its components and scales, based on the scientific analysis of its processes, which is proposed as a tool that can be adopted by Europe. The knowledge of the various natural and human processes linking the occurrence of fire danger, and its impact is a key to justify and guide the management activities required to reduce the risk and to adapt the systems for future conditions.

3. Socio-economic aspects of the problem, related to changes in demography, population distribution or mobility, aging, changes in touristic, commercial and industrial activities potentially affected by wildfires.

   In general, Europe faces an aging and decreasing population that is less capable of managing the land and of dealing with wildfires; the flux of tourists or the presence of immigrants in rural and fire prone areas require the special attention of fire management agencies. In some regions the poor economic development, the small added value associated to agro-silvicultural activities, land abandonment and an aging population limit the capacity of landowners to perform risk reduction activities, requiring the intervention of the Society. The presence of historical assets, industrial or commercial buildings and other relevant infrastructure should be considered in fire protection plans. Specially trained and equipped agents, supported by a good surveillance and coordination structure, must be provided to help the citizens to manage wildfire risk in all its phases.

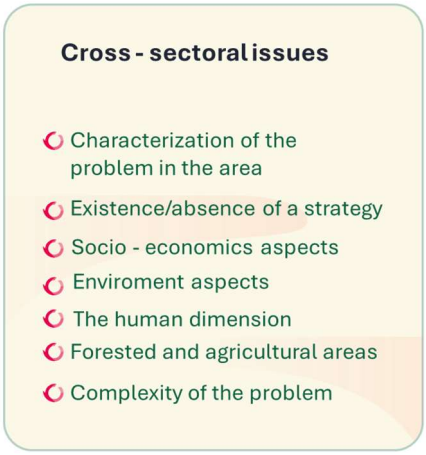


Figure 7 - Cross-sectoral issues

i. Environmental aspects, associated to climate change, reduction of greenhouse gases, preservation of biodiversity, soil and water quality.

   The ongoing change in the climate enhanced by the emission of greenhouse gases is creating longer periods of weather conducive to wildfire outbreaks warmer weather conditions, and longer periods of weather conducive to wildfire outbreaks, that increase the possibility of having more frequent and more intense fires in larger areas of the EU territory. On the other hand, wildfires cause harm to human and natural life, to biodiversity, to soil, water and air quality, contributing to damage the climate equilibrium. Therefore, the reduction of the risk of wildfires must be a global concern for EU Countries and measures must be taken at all levels and considering all the phases of risk reduction.

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4. The human dimension of wildfires, from their origin to their impact, involving the traditional use of fire, the limitations or obstacles to its eventual reintroduction in rural activities. The impact of the wildfires on the communities particularly in built-up areas.
   In Europe most fires are caused by human action, persons are involved in their prevention and suppression and, very often, are the victims of their effects, due to the impact of heat or smoke on their lives or their properties. Fire is a useful tool, required to perform several rural activities and to preserve several ecological processes, its use must be respected and preserved, but considering ecosystem properties and fire danger conditions, to avoid unwanted damage. There is an increasing tendency to have urban communities encroaching rural and fire prone areas. This leads to more frequent processes of accidental fires or to episodes of fires reaching built-up areas, sometimes with great loss of lives. Great care has to be used to plan and manage these areas to avoid and limit such accidents.

   The need to balance the use of forested spaces between nature conservation and production for economic exploitation of forest products. The need to compromise forest plantation and exploitation, in terms of use and layout of species and management practices with the mitigation of wildfires, namely, to avoid the occurrence of extreme wildfire events.
   The planning and maintenance of forested and agricultural areas has to carried out balancing the needs and requirements of nature conservation with economic exploitation and the creation of vegetated areas with less flammable species, with mosaics of uneven aged plants and with fire breaks to reduce the spread of extreme fires.

5. Recognition of the complexity of problem of wildfires and the need of a multi-institutional and multidisciplinary approach in its management, in a collaborative and participated form, considering all their dimensions and components, that may be conflicting in some cases.
   Given the complexity of the problem of wildfires in face of the capacity of single individuals, institutions or agencies, there is a need to promote a multi-disciplinary and multi-institutional approach to their management, in a long-term multiyear and stable program. This must be performed in a collaborative and participated form, considering all dimensions and components of the problem, and all phases of the processes involved, knowing that there may be conflicting interest in some cases.

3.3.3. Vision

Selecting from the previous examples of Vision as an ultimate goal for the process of IWRM in Europe we propose the following statement:

"*Develop and manage forested and rural areas, recognising the role of fire, assessing its risk, promoting safer conditions for citizens in Europe, in the present and in the future*".

3.3.4. Principles

As mentioned above an essential part of the Framework is a set of agreed and accepted Principles from which a series of consensual Guidelines are derived that should form the long-term backbone of WRM in the Area. The Principles and Guidelines (P&G) should be adopted at different scales, for example by the different regions of the same country or even at a continental or international scale.

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For this reason, it is recommended that Principles and Guidelines (P&G) adopted by international bodies should be imbedded in smaller scale frameworks. These should be stable in time and should not be changed, for example, due to a major fire disaster or a modification in the governance component of the System. They can of course be improved, benefitting from the evaluation and lessons learned process. Selecting from the LFGF which is the most recent and widely accepted Framework, we list the following two **main principles** that support the full concept of an Integrated WRM:

(1) Move away from a silo mindset, which only considers their sectorial vision and mandates, and instead adopt an integrated approach where responsibilities, resources, budgets, and good practices are shared.

(2) Avoid a partisan approach to problem-solving and instead build on multi-parties' consensus to develop long-term programs and plans that provide stability to the system.



Figure 8 - Guidelines of the IWMP for EU

From the same document, and derived from the above principles, we select and adapt its **guidelines** (

For this reason, it is recommended that Principles and Guidelines (P&G) adopted by international bodies should be imbedded in smaller scale frameworks. These should be stable in time and should not be changed, for example, due to a major fire disaster or a modification in the governance component of the System. They can of course be improved, benefitting from the evaluation and lessons learned process. Selecting from the LFGF which is the most recent and widely accepted Framework, we list the following two **main principles** that support the full concept of an Integrated WRM:

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(2) Avoid a partisan approach to problem-solving and instead build on multi-parties' consensus to develop long-term programs and plans that provide stability to the system.



Figure 8 - Guidelines of the IWMP for EU

). We added some recommendations (highlighted in blue) derived from the USDA Cohesive Strategy and from the work performed in the FirEURisk Project:

a. Impact orientation – it is proposed that the actions implemented in IWRM should be oriented above all for the benefit of the citizens. A corollary of this Guideline is that the protection of Human life is above all priorities. As a second priority, the life and well-being of animals (both domestic and wild) should be protected and preserved from wildfires.

Provide for the health and well-being of all those involved or present in the areas affected by fires, including the citizens and operational agents. Limit and control as far as possible exposure to heat and smoke and avoid actions that can threaten the life of people.

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b. Feed forward strategies – Base all activities on a sound science-based risk assessment strategy, including all aspects, and evaluation should consider the uncertainties of future conditions and therefore be adaptative to incorporate diverse future scenarios.

We assessed some risk reduction activities aimed to reduce the amount of biomass available to support the spread of fires, like grazing, mechanical cutting and prescribed fire, considering their suitability according to various factors, to be applied in various territories of Europe. It was found that prescribed fire is an adequate option in many areas, including in some countries that do not have yet legislation to incorporate it.

c. Bottom-up policies – the implementation of policies should be holistic, including the mandates of all relevant stakeholders, the contribution of the civil society, involve the knowledge of local communities the scientists and the citizens.

Communities should be empowered and engaged in local solutions and decision-making processes to enhance wildfire resistance.

d. Progressive transition – the transformation of existing frameworks to new frameworks should be gradual preparing the existing skills to the change.
e. Subsidiarity – actions implemented should respect the capacity of existing levels of intervention, with upper levels acting only when the lower levels have exhausted their capacity, respecting the capacity and jurisdiction of all existing levels of intervention.
f. Plural use of resources – all activities in the process should have the same level of access to existing resources and conditions, with priority to prevention when there are no fires and to suppression only when there are fires that are required to be suppressed.
g. Rational allocation of resources – the use of resources should be made in proportion to the prevailing conditions, having in mind their cost-benefit evaluation both in economic and environmental aspects.

Consider equity and inclusivity in budgets, budgeting, and contracting. Increase the range of local roles, and access to training and equipment.

h. Training – all agents involved in actions should have the necessary qualifications, training, health and psychological support and have access to the material resources required at all levels to perform their activities.

Create local collaboratives, forums and/or governance for communities to learn about, share and complete this work. We proposed guidelines to train fire suppression agents in the face of extreme fires, particularly those that threaten WUI areas and endanger citizens.

i. Operational flexibility – the resources available should be proportional and adequate to the risk conditions, considering the meteorological conditions, rather than on a predefined plan or be dependent on the socio-economic level of the area.
j. Transparency – all procedures are performed according to established rules, clearly justifiable and subject to public reporting and scrutiny.

Data on fire events should be recorded and made available to agencies, researchers and citizens.

k. Monitoring and evaluation – a lessons-learned capacity should be embedded in the System, therefore all actions should be subject to an evaluation process, in principle by external and independent institutions, to evaluate and improve the System.
l. Memory – the action should be developed according to the past history of the country, including its previous disasters. (This implies that an auditable record is kept of all actions).

We developed studies on some of the major fires that occurred in Europe in 2021, 2022 and 2023, that were published as JRC Reports and will remain as a repository of data about this sort of extreme wildfire events.

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m. Innovation – considering the traditional knowledge and existing practices in the country, actions should be based on sound multi-disciplinary scientific knowledge and updated technological solutions.

Outcomes of science and technology should be involved in all stages of WFRM, through a permanent collaboration between researchers and operational agents, not neglecting the traditional knowledge and the experience and practice of local citizens.

n. Coherence – the fire management activities should be harmonized with the overarching fire management policy.
o. Coordination – the implementation of all WRM actions should be monitored and coordinated in all steps.

3.3.5. Objectives and Goals

The definition of objectives and goals is very much dependent on the stage of implementation of IWRM program in a given area is, as some countries or regions may be more advanced than others and may have different objectives to set. Therefore, it is more difficult to propose general objectives that can be applied to a given area but based on the objectives and goals that are expressed in existing frameworks, namely those of the LFGF we propose the following five Priorities for Action.

1. The implementation of an IWRM System needs the creation and maintenance of a good governance model, as it is an integral part of the system. It may then be necessary to define some priorities to make sure that the system is governed to the benefit of all relevant parties without allowing one to overcome or to dismiss the others.

A Governance structure to guide and manage the System must be defined and built in each Area, involving representatives of all relevant agencies with a role to develop in the System, including common citizens. In a hierarchical and democratic form, the Governance structure will define and control the roles performed by each agency, allocate the respective human and material resources and facilitate the efficient operation of the entire system, from the decision-making process to the operations and the evaluation of the System as a whole and its components in particular.

Rural areas must be developed and valued, as they are the landscape in which the majority of wildfires occurr in the EU.

Due to lack of recognition of their role and value and of insufficient support for the required management activities, the needed conditions for a sustainable transition to a green, low carbon, and circular economy, with a better protected and more resilient environment in relation to wildfires are often not achieved.

2. Support rural communities and help them to reduce the risk and to be better prepared to face it.

Based on the risk assessment of each Area it is proposed that the adequate risk reduction methods are adopted, namely the following:
Promote the adequate management of the landscape using less flammable species, creating mosaics of vegetation with fire breaks, including whenever possible non-even aged plantations or agriculture and cropland plantations.
Promote the use of prescribed fire, herbivorous animals or mechanical tools to reduce the biomass accumulation, especially in the vicinity of houses, settlings and infrastructure.
Promote the improvement of the resistance of the houses and settlings to fire impact, avoiding construction in high-risk zones, using better construction rules and materials and, when necessary, using complementary protective systems, such as sprinklers.

4. Promote the changing of attitudes of the entire population – including politicians – in relation to the increased risk of fire that is a matter of concern to everyone and not only from those that live in or close the rural areas.

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Reduce the human caused ignitions related to carelessness, or the inappropriate use of fire.
Work with the communities to prepare them to collaborate with the authorities in the case of a fire, evacuating the area when required, sheltering in place if possible, or supporting fire suppression if prepared and equipped.

5. Provide a common and adequate qualification and training to all personnel involved, to facilitate their involvement in the common effort of managing the risk of fire, sharing the same concepts and goals.

Create a common qualification and training program applicable to all agents working in the various tasks and activities associated to IWRM, defining the corresponding tasks, levels, contents and evaluation methods, to allow a transparent recognition of the qualification and capacities of each agent, to facilitate its transfer to another agency or country and to encourage his/her promotion in the system.

Create common training materials, sharing the same concepts and goals, at all levels of operation and management, to facilitate exchange and collaboration.
Work with the scientific community to improve and update the contents of the training material and on the overall assessment of the training system.
Promote the concern of safety in all types of operations, monitoring the physical and mental fitness of all the agents, as well as their socioeconomic status and recognition by the Society.

3.3.6. Integrated Management Plan

The IMWR recognises that there are different processes or stages that are performed at different times and possibly by different actors, given the specialisation that they require. Typically, some are performed before, during or after the occurrence of an actual fire. In some cases, these unsynchronised activities, require specialised capacities that may be a source for breaking the integrated perspective that is advocated here.



Figure 9 - Integrated Management Plan

A typical example is the traditional separation between “Prevention”, “Suppression” and “Recovery”, the first being the hold of foresters, the second of fire fighters and the last of the ecologists, in the best cases. The recognition of the existence of a diversity of actions performed at successive times illustrates the complexity of the problem of IWRM, highlighting the need to have an integrated approach and cannot be an excuse to fail the need to consider them as a whole, as they are all related and connected. Clearly the lack of prevention affects suppression and the lack of recovery will only promote a less resilient landscape.

There are several points of view in identifying and classifying the sequence of activities that are designated as “Chain Value” in the LFGF. Once again, we will follow its recommendation to propose a common and consensual designation of the processes that make part of the Integrated Management Plan, and consider the following set of six processes, that were already mentioned above:

We fully endorse the IMP that is proposed in the LFGF in its section designated “Governance” which is broader that the present concept of Governance.

Therefore, we include here its key elements:

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a. Integrated Wildfire risk assessment – it is recognised that risk characterisation, including hazard identification, exposure and vulnerability are required to assess wildfire risk for all fire management activities. Risk perception by different social groups should be assessed to formulate the required alert and early warning mechanisms. The methodologies to assess wildfire risk should be clear, consensual, coherent, and properly communicated.

We developed a methodology to assess the wildfire risk in an integrated form, including all its components, namely hazard (danger), exposure and vulnerability, and the various factors and processes associated to them, to estimate a daily value of fire risk in a given area of Europe. We recommend its application at the EU and at country levels.

b. Wildfire risk tolerance – risk tolerance depends on communities and their culture so community driven solutions should be built to characterize the severity of the events.

More research is needed in Europe to assess the wildfire risk tolerance of some areas in order to allow that in well-defined conditions, fires spread on them in a controlled form, provided that beneficial ecological or fire protection effects are obtained, with minimal chances of having detrimental effects.

c. Wildfire risk management – it is recommended that risk governance is performed in an integrated form to promote the cooperation of all public and private sectors on all stages of the so-called fire management value chain.

Involve all agents, persons and institutions associated to some aspect of wildfire risk management, in all phases, without excluding any valid contribution.

d. The Value Chain – the IWM recognises the existence of a series of actions or activities that occur typically before, during or after the fire, which require competent and accountable actors to perform them. The following components of the Value Chain of fire management processes are identified

Planning – the interventions and resources required to implement the actions to achieve the fire management objectives must be planned, guiding principles at all levels and fire management budgets are required with anticipation for all actors.

Plan the landscape to include mosaics of diverse vegetation, including where possible less flammable and fire-resistant species, avoiding large extensions or mono species or even aged extensions of potential fuels

Preparation – involve above all the sensibilisation and preparedness of the citizens to follow good practices and build capacities, understand and follow the risk communication actions and avoid exposure to fires or use adequate self-protection measures.

Adopt good construction practices, avoiding building in high fire risk areas, employing when required protective systems. Work with the communities to be prepared to face fires - even long duration and intense fires – to adopt the right decisions to avoid exposure to smoke or fire, leaving the threatened areas with sufficient time, or to follow the orders of the authorities to stay or to leave.

Prevention – involve actions to reduce exposure and vulnerability of the elements to fire, in particular houses and infrastructures, to reduce or even cancel their risk.

Promote the use of prescribed fire and the management of wildfires for resource objectives, grazing animals or mechanical tools, when adequate, to reduce the biomass in rural areas, especially in the wildland urban interface and in water catchment basins.

Pre-suppression – is part of preparedness to intervene in the presence of high fire risk when it is assessed. It involves the increase of response capacity, information to population, surveillance and pre-positioning of suppression forces in predefined areas.

Work with the communities to avoid and limit human caused ignitions, including those caused by the electrical system infrastructure.

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Suppression – actions to suppress the fire and relief operations to those who are affected by the spreading fire and mitigate its consequences.

Fire suppression should be performed considering the safety of the personnel above all priorities, using the required and sufficient resources according to the present and predicted situation, assessing the various components of risk and judging the pertinency of each intervention. Consider that in some cases it may be possible and recommended to let a wildfire spread in some landscape areas in order to meet risk reduction objectives.

Post-fire operations – these take place during or after the fire to investigate its causes, to promote the restoration of the land and the recovery of the communities, in a process of lessons learned, to create more resilient landscapes and communities.

Emergency intervention to assess the potential effects of heavy rainfall after the fires should be performed with urgency to minimize loss of soil, landslides or water catchment contamination. Mulching and erosion barriers can be used to mitigate the transport of ash and soil erosion (Nunes et al., 2018) *in the short term while seeding and planting may be needed in the long term to restore burned ecosystems.*

In some documents a different list of processes or other names are used to designate those mentioned above. In Moore (2019) the "five Rs" are proposed to designate five essential elements of WFRM, in parallel to the globally adopted characterization used in dealing with disaster management: (1) Review, (2) Risk Reduction, (3) Readiness (or preparedness), (4) Response, and (5) Recovery, and provides a framework with examples of system tools and process components for each one of them (P. Moore et al., 2003; P. F. Moore, 2019).
It is important to use precise and clear definitions of the concepts, to avoid confusion or to apparently add other activities to an already extensive list of actions. We recommend that the above designations proposed by the LFGF and their respective descriptions, given above, be adopted by all Frameworks to organise their Management Plans.

e. Adaptive management – the uncertainty under which wildfire management is implemented – due to changing scenarios, lack of information and knowledge, and the latitude of some guidelines – requires that the program is monitored, evaluated and adapted to new goals. Results achieved and evaluation of the plans should be done and published periodically.

Use predicted future conditions under climate change as potential reference conditions for the proactive use of wildland fire and manage landscapes and fuels for fire regimes altered by climate change, fire and other concurrent and cascading factors

f. Stakeholder engagement – the process of decision making in wildfire management should include absolutely all relevant stakeholders, to cope with the complexity, uncertainty, multi scale and multi-level impact of wildfires and promote cooperation along common goals. Local communities, scientists, professionals and enterprises of different backgrounds, should be involved also in the development of public policies.
g. Communication – clear communication strategies on all stages to share risk assessment and risk perception is required to develop a common understanding of the tasks and responsibilities allocated to each agency. The communication strategy should consider the social and physical environment of the population addressed and should involve the media as a partner in this process. The communication should be clear and address all stakeholders to give them a full view of the situation and therefore strengthening their commitment.
h. International cooperation – the principles for stakeholder engagement should go beyond the national level and support international cooperation, promoting international qualification and training programs, platforms to share scientific knowledge and mechanisms to assure cross-sectoral approach to WRM, namely by data sharing between countries, particularly between those that have common borders.

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i. Governance bodies – adapting the national governance system for WRM, to acknowledge the complexity of risk management and the need to have a solid body of governance, intermediate bodies, with political power, should be created with representatives of the following groups: political representatives, forest and civil protection authorities, environmental, security and law enforcing agencies, scientific community, local communities, non-governmental organisations and other sectoral policy stakeholders.

3.3.7. Key Performance Indicators and Activities

It is important that the various P&G and the derived management processes be expressed in well-defined objectives that can convert the vision and goals into reality that can be verified and assessed. The above-mentioned report produced in Australia is a good example of assigning Key Performance Indicators (KPI) to each objective and goal and defining the activities that should be performed to reach that objective and the KPI to check, if possible, in a quantified way if it was achieved.

3.3.8. Monitoring and evaluation

There are no perfect frameworks and even the application of a good one can always be continuously improved, therefore the function of evaluation and improvement should always be an integral part of the System and planned in the framework. In some countries it is observed that after a major disaster a revision of the entire IWFM System is made, questioned and sometimes drastic changes are made. This is an indication of a lack of strategy and of accepted and stable principles and guidelines. To avoid this situation a provision should be made for periodic evaluations of the entire System initiated by self-assessment exercises, complemented by an external evaluation, with the objective of finding good practices and points that can be improved.
Such an exercise, if performed at national or international levels, cannot be a process of imposing goals and methods from one area to another, but should serve to disseminate and promote the adoption of common perspectives and standards and therefore facilitate international cooperation.

3.3.9. Conclusion

A chapter summarising the main components of the proposed management structure, principles and guidelines should be provided as a conclusion to the document. If it is appropriate a proposed period of application, evaluation and revision can be proposed.

3.3.10. Glossary

If necessary, a glossary of the acronyms and concepts used in the document should be presented in order to make sure that the meaning of all terms used is unequivocally understood by all involved. As far as possible existing glossaries, especially those proposed by international agencies, should be adopted and followed.
If applicable a sort of dictionary showing the correspondence of terms used internationally or in some regions or local dialects, should be provided.
In FirEUrisk we produced a Glossary of terms used in WFRM containing some 1200 concepts, including their definition or meaning in English and its translation in 8 languages used in Europe.

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3.4. Wildfire Risk Governance

3.4.1 Current Fragmentation in EU Wildfire Risk Management

Before delving into an integrated wildfire risk governance framework, it is crucial to address the current fragmented state of wildfire management at the EU level. Despite the increasing frequency and severity of wildfires across Europe, the EU's approach to wildfire risk management remains disjointed, with multiple agencies and policies operating in relative isolation (Tedim et al., 2019).

Currently, various EU bodies and directives touch upon aspects of wildfire management, but there is a lack of cohesive strategy and inter-agency communication. For instance, the Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG ECHO) plays a significant role in emergency response, but its focus on civil protection may inadvertently narrow the scope of holistic wildfire management to reactive measures, emphasizing firefighting resources over prevention and long-term resilience strategies (Bento-Gonçalves & Vieira, 2020).

At the European level, the EU Civil Protection Mechanism play a critical role in supporting civil protection activities, as shown in Figure 10.



Figure 10 - The EU Civil Protection Mechanism. Source: *https://civil-protection-humanitarian-aid.ec.europa.eu/*

The following are the main EU entities relevant to wildfire management issues. It's important to note that there are several other entities that deal with partial aspects of wildfire management, alongside other objectives they may have, or in the case of relative or ad hoc policy measures.

- The Directorate-General for Environment (DG ENV), which oversees forest protection policies.
- The Directorate-General for Agriculture and Rural Development (DG AGRI), responsible for the Common Agricultural Policy, which influences land use and, consequently, wildfire risk.
- The Directorate-General for Climate Action (DG CLIMA), addressing the broader climate change context that exacerbates wildfire risks.
- The Joint Research Centre (JRC), which manages the European Forest Fire Information System (EFFIS) but may have limited influence on policy implementation.

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- The European Environment Agency (EEA), which provides independent information on the environment, including assessments related to forest fires and their impacts on ecosystems and air quality.
- The Directorate-General for Migration and Home Affairs (DG HOME), which is responsible for EU-level policies on security, border management, and disaster management, including aspects of civil protection that intersect with wildfire response and prevention

j. The European Union Civil Protection Mechanism (EUCPM), coordinated by DG ECHO, which facilitates cooperation in disaster response, prevention, and preparedness between EU Member States and six Participating States. While it plays a crucial role in coordinating responses to wildfires, its broad mandate covering all types of natural and man-made disasters may limit its capacity to develop specialized, long-term wildfire management strategies.

This fragmentation leads to several issues, which are briefly listed and summarised here next:

k. Lack of a holistic approach: The compartmentalisation of wildfire-related responsibilities across different agencies often results in a focus on specific aspects (e.g., emergency response) at the expense of a holistic risk management strategy (Moreira et al., 2020b).

- Policy inconsistencies: Policies developed by different DGs may sometimes conflict or fail to complement each other effectively in addressing wildfire risks (Paton et al., 2014).
- Inefficient resource allocation: Without a unified strategy, there's a risk of duplicating efforts in some areas while neglecting others, leading to suboptimal use of available resources.
- Reactive rather than proactive approach: The current structure, with its emphasis on DG ECHO's role, may inadvertently prioritize response capabilities (e.g., more firefighting aircraft) over investments in prevention and landscape and communities' resilience.
- Communication gaps: The lack of systematic inter-agency communication and the need to involve national agencies can lead to delays in information sharing and coordinated action, crucial during wildfire events that often cross administrative boundaries.

Addressing this fragmentation is a critical first step towards developing a more effective, integrated EU-wide approach to wildfire risk management. As proposed in section 3.4.2, there is a need for "an agency working at the same hierarchical level as the others – civil protection, forestry, agriculture, environment, etc. – but having a special role of promoting interagency articulation and coordination". This inter-agency structure could play a crucial role in overcoming the current fragmentation.

The subsequent sections outline a framework for such an integrated approach, emphasising the need for improved coordination, a balance between prevention and response, and the incorporation of wildfire risk considerations across all relevant EU policies and agencies. This framework will build upon the idea of an inter-agency coordinating body, detailing how it could function to bring together the various entities involved in wildfire management at the EU level.

3.4.2 Integrated Wildfire Risk Governance

The Governance of wildfire risk has several implications as it involves a large number of agencies and institutions, including the legislative, the executive power, and the judicial power, the civil administration, governmental and non-governmental agencies dealing with the governance of various aspects of the problem of wildfire risk, such as forestry, agriculture, civil protection, environment, infrastructure, climate, tourism, science and the citizens.

In each country the governance of WFRM is organized according to the historical practices, with varying levels of coordination among the various stakeholders, sometimes assigning more important roles to one agency and type of operation in relation to the others.

The relevance of the problem of wildfires and their impact on various aspects of our lives has led to the realisation that the issue of wildfires should be present on the agenda the whole time and not only when a crisis occurs.

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Historically major fire crises impacted politics, causing reforms and sometimes major changes in the governance system.
This would not be the case if there is a strategy and framework for crisis management that is accepted and adopted by all agents. Normally, after an evaluation process, adjustments or corrections to the work programs should be made to update and maintain the strategy and the principles of management.
At all levels it is important that the agencies that govern wildfire risk maintain positive and transparent communication with citizens, both building and promoting the trust and willingness needed to be active participants in the task of risk management.
We support the principle that in each country there should be an agency working at the same hierarchical level as the others – civil protection, forestry, agriculture, environment, etc. – but having a special role of promoting interagency articulation and coordination, at the level of planning, defining regulations and laws, allocating funds and resources and developing operations, in an integrated form paying attention to the roles and objectives of each agency and trying to find a balance between them in the interest of the public.
At the European level the management of wildfire risk is distributed amongst different bodies that operate at various levels and sometimes in specialized fields, addressing the risk of wildfire from their own perspectives. It is required that the prevalence of the wildfire risk is felt in all related agencies and at all levels in a coordinated way.
Similarly, to what is proposed for each Country, it is desirable that at the EU level, an Agency should fulfil this role of an Inter-Agency, coordinating and articulating all efforts related with wildfire risk management in an integrated way, considering all aspects of risk in its assessment, reduction and adaptation.

3.4.3 A Conceptual EU Framework on Wildfire Risk Governance

The increasing intensity and frequency of wildfires across Europe, exacerbated by climate change, socio-economic developments, and shifting land-use patterns, calls for a comprehensive and integrated wildfire risk governance approach (de Rigo et al., 2017; European Environment Agency, 2020; Report, 2022). In this section, we present a high-level conceptual framework for wildfire risk governance in the EU, which is based on FirEUrisk principles and is structured upon three key pillars: Multi-Level Governance and Collaboration, Adaptive Governance and Technological Innovation, and Performance Indicators and Policy Instruments. This framework could contribute to standardizing, coordinating, and harmonizing a comprehensive approach to wildfire management across all EU member states, ensuring a unified and effective response to the growing risks of wildfire.
To further illustrate the complex and multi-faceted nature of wildfire risk governance, **Erro! A origem da referência não foi encontrada.** presents a comprehensive overview of the Wildfire Management Governance framework. This diagram encapsulates the key components discussed in this section, including the various spatial levels of governance, the different roles involved, and the crucial aspects of coordination.
The management of wildfires is governed across various spatial levels, from local community councils to international organisations, as shown in the following Figure 11.

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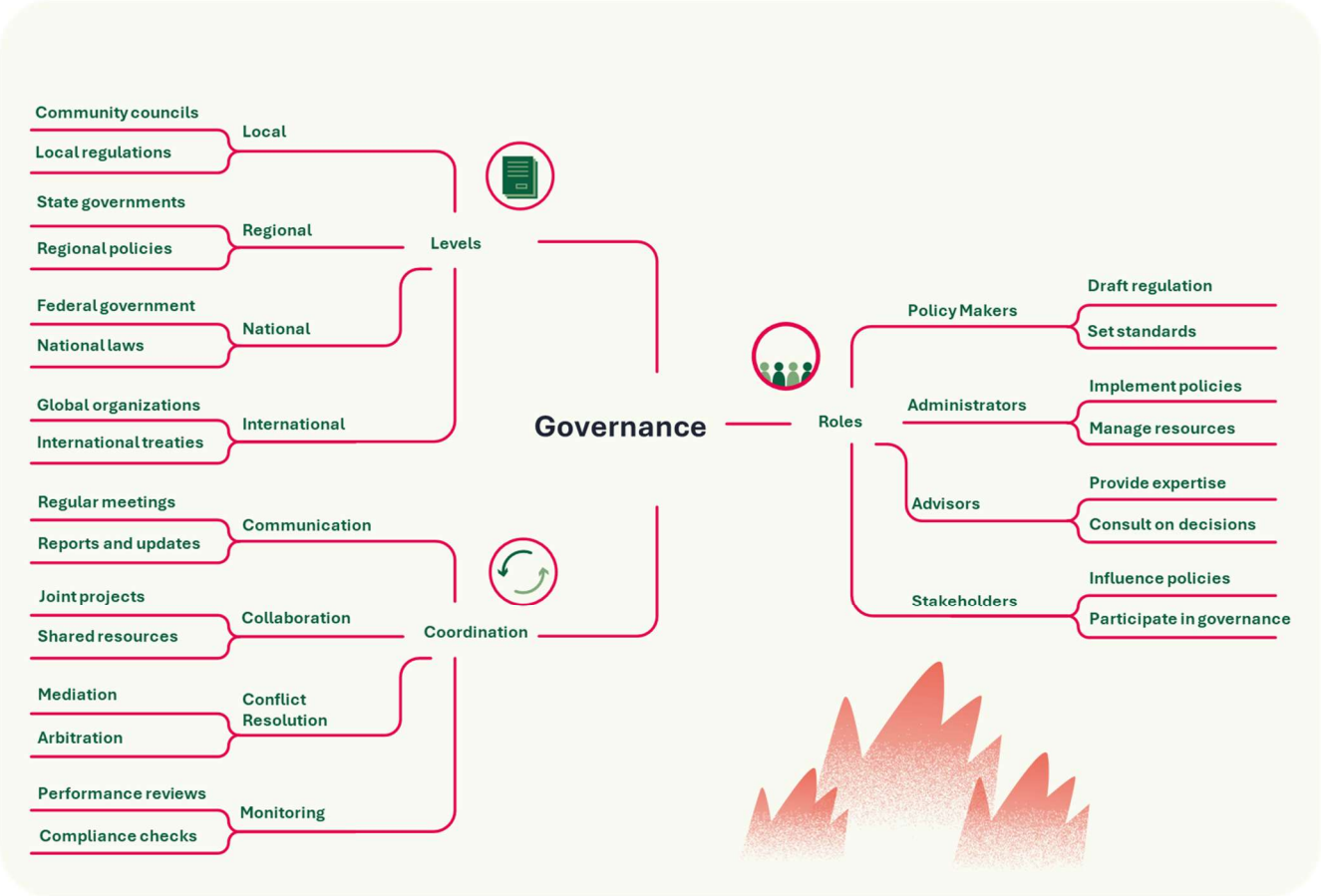


Figure 11 - Framework of Wildfire Management Governance: Spatial Levels, Roles, and Coordination Aspects

The diagram above illustrates the various roles of policymakers, administrators, advisors, and stakeholders. It highlights the important role of coordination, which involves communication, collaboration, conflict resolution, and monitoring activities. This visual representation emphasizes the need for an integrated approach to wildfire risk governance, as discussed throughout this section.

3.4.4 Multi-Level Governance and Collaboration

Effective wildfire risk management requires integrated efforts at the local, national, and EU levels, ensuring that actors at each level fulfil their roles while coordinating efforts to address wildfire risks holistically (European Comission, 2021; European Environment Agency, 2020). The proposed governance model supports local, national, and EU-level actors in their specific roles while ensuring collaboration across these levels, based on the principles of subsidiarity (European Parliament, 2021).

A key recommendation is the establishment of a European Wildfire Management Directive to mandate harmonized policies for wildfire risk assessment, resource allocation, technological investments, and coordination between member states. This Directive would serve as a comprehensive risk governance instrument, providing a common framework for action.

National governments should align their wildfire risk governance strategies with this EU directive, ensuring that legal frameworks reflect integrated fire management approaches, including climate adaptation and land-use policies. The Peer Review Assessment Framework (PRAFF) initiative should be expanded to enhance coordination, address capacity gaps, and strengthen operational readiness across member states working beyond the “Civil Protection” component of WFRM.

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Regional and local authorities are responsible for implementing risk assessments, land-use planning, and fire prevention measures. Local governments should be encouraged adopt community-based fire management practices and engage stakeholders such as local fire services, community organizations, and residents in wildfire risk reduction initiatives (Bento-Gonçalves & Vieira, 2020).

Cross-sectoral collaboration is crucial and should extend beyond traditional sectors like forestry and civil protection, requiring a multi-sectoral approach that includes agriculture, infrastructure, tourism, science, health, local administration, justice and environmental conservation. EU-wide policies, such as the Common Agricultural Policy (CAP) and the Cohesion Policy, must be more closely integrated with broader wildfire risk management strategies.

To enhance effectiveness, the framework incorporates a social-ecological systems (SES) approach, recognizing the complex interactions between human activities, land-use changes, and wildfire risks. SES modelling can provide valuable insights into the dynamics of wildfire-prone landscapes and inform more holistic management strategies (Fischer et al., 2016).

As part of this approach, ecosystem-based wildfire management should be explored, including the use of prescribed burns and natural fire regimes in landscape management. These practices can effectively reduce fuel loads and create more fire-resistant landscapes when implemented correctly (Fernandes et al., 2013b), but their application must be carefully tailored to local ecological and social contexts.

Community engagement is crucial for building local resilience and improving prevention and response efforts. The framework promotes community-based fire management (CBFiM), which has demonstrated potential to reduce wildfire risks while empowering local communities (Tedim et al., 2016). It encourages research into innovative CBFiM approaches adaptable to different social, cultural, and ecological contexts across Europe, including ways to integrate local and traditional knowledge into formal wildfire risk governance frameworks (Otero & Nielsen, 2017).

To ensure the complementarity of various organizations towards integrated wildfire management, clear roles and responsibilities should be defined for all levels of governance and sectors:

At the EU level, the European Commission would oversee the implementation of the European Wildfire Management Directive, with EFFIS providing centralized data and risk assessment support. The EU Civil Protection Mechanism would coordinate cross-border response efforts.

At the national level, governments would be responsible for adapting EU directives into national legislation, coordinating with regional authorities, and ensuring adequate resource allocation. National forest and fire management agencies would lead in implementing strategies and coordinating with local and regional authorities.

At the regional and local levels, authorities would be tasked with on-the-ground implementation of fire prevention and management strategies, community engagement, and local risk assessments, supported by national or international resources and funds. They would also be the first line of response in wildfire incidents.

Building upon a wealth of knowledge from across the globe research institutions and universities would play a crucial role across all levels, providing scientific input to inform policy decisions and improve management practices.

This multi-tiered approach ensures that each organization's strengths are leveraged while maintaining a cohesive, integrated approach to wildfire management across the EU. Regular communication and coordination mechanisms, such as annual conferences and joint training exercises, would be established to maintain alignment and share best practices among all levels.

3.4.5 Adaptive Governance and Technological Innovation

As wildfire patterns become increasingly unpredictable and more frequent, due to climate change, adaptive governance systems are critical. The framework proposes leveraging cutting-edge technologies such as satellite remote sensing data, artificial intelligence-driven fire prediction models, internet of things-based early warning

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systems, drones, robots, advanced sensors and communication technologies to enhance fire monitoring and risk assessment and reduction. A key measure will be the upgrade of EFFIS to integrate these technologies, improving its capability to provide real-time data and predictive analytics.

To support this technological integration, the framework recommends developing standardized data formats and protocols to ensure seamless integration of various data sources (satellite, ground sensors, weather stations) across different EU member states. This data interoperability is crucial for creating a unified European wildfire information system supporting real-time decision-making and resource allocation.

The framework encourages the exploration of advanced AI and machine learning applications for improving fire prediction models, resource allocation, and real-time decision support systems. Recent studies have shown promising results in using deep learning algorithms for wildfire detection and spread prediction (Jain et al., 2020), which could significantly enhance the EU's capacity to respond to wildfire threats proactively.

Continuous monitoring and evaluation are essential for adaptive governance. The framework proposes expanding the peer review assessment framework (PRAF process to include regular assessments of national and EU-level governance performance, ensuring that wildfire management systems evolve in response to emerging risks and technological advances.

Given the significant impact of climate change on wildfire patterns, the framework emphasises the development of more sophisticated climate and socioeconomic change scenario analyses to inform long-term wildfire risk governance strategies and adaptation measures. These analyses should incorporate the latest climate models and consider a range of possible future scenarios to ensure that governance frameworks remain robust and adaptable (Turco et al., 2018, 2019).

Adaptation strategies should focus on creating fire-resilient landscapes and communities. The framework recommends promoting fire-resistant settlement planning, implementing stringent building codes in wildfire-prone areas, and developing green firebreaks. These measures can significantly reduce the vulnerability of communities to wildfires (Calkin et al., 2014).

3.4.6 Performance Indicators and Policy Instruments

To effectively monitor and evaluate wildfire risk governance performance, the framework proposes adopting specific governance performance indicators at both national and EU levels. Such indicators would help measure the effectiveness of governance structures, coordination mechanisms, and stakeholder engagement efforts. Potential performance indicators include burned area reduction, response time, preparedness levels, cross-border collaboration, community resilience, and technological integration. These Key Performance Indicators (KPIs) form a crucial part of the European Risk Governance Framework, providing a standardised means of assessing and comparing wildfire management effectiveness across different member states. This allows for the identification of best practices and areas needing improvement, fostering a culture of progressive and continuous enhancement in EU-wide wildfire risk governance. A word of caution should be made about the interpretation of some of the performance indicators as being success cases. One example is the percentage of initial attack success that is given as a measure of good performance, but this may be misleading in the long term, as the exclusion of fire in all cases may be creating problems in the future (Thompson et al., 2019), so a better reflection is required about the definition of some KPI.

The framework emphasizes the need for robust methodologies to evaluate the effectiveness of wildfire policies and governance structures across different EU member states. This evaluation should include comprehensive economic impact assessments of wildfires and cost-benefit analyses of various prevention and mitigation strategies to inform policy decisions (Molina-Terrén et al., 2019). Such analyses can provide valuable insights into the most effective allocation of resources and the long-term economic benefits of investing in wildfire prevention and management.

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A key policy instrument proposed in this framework is the European Wildfire Management Directive. This Directive would mandate harmonized wildfire management policies across the EU and enhance coordination between member states. Key components of the Directive would include harmonised risk assessment frameworks, operational coordination protocols, technological investment mandates, and funding provisions.

The framework also recommends addressing the need for innovative cross-border coordination mechanisms and decision-making protocols for managing transboundary wildfire events. This could include the establishment of a European Wildfire Response Unit, capable of rapid deployment across borders and equipped with advanced firefighting technologies (Tedim et al., 2015).

By implementing these recommendations, the EU can build a more robust, adaptable, and efficient wildfire risk governance system that is well-equipped to handle the escalating challenges posed by climate change. The integration of the European Wildfire Management Directive, alongside performance monitoring through risk governance indicators, will ensure that Europe is not only prepared to prevent and mitigate wildfires but is also capable of recovering swiftly from wildfire disasters.

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4. Conclusions and Recommendations

The need to consider all aspects and components of wildfire risk and to involve all those that have a role to play in its management is now commonly accepted, in what is defined as an integrated or holistic approach to WFRM. Given the exchange of methods and experience among scientists, practitioners and policy makers, during the past years, a consensus around this need was fortunately, built. There may be of course different opinions about some details, like the hierarchy of the objectives and goals, and on how some of them and their KPIs are expressed in particular management systems, but there is a main consensus and convergence over many important points.

In this paper we advocate the existence of a Wildfire Risk Management System with three components, the Strategy, the Framework and the Governance. The high-level Strategy, being based on science and supported by established knowledge and data, should have universal acceptance but at the same time should be open to changes and innovation when new research findings emerge. The build-up of the Framework was the main subject of this paper, as it is fundamental that a set of principles and guidelines are established and accepted by all those that are involved in the System, regardless of their role, status or time or pace or intervention in the management process. The main elements of the Framework are the principles and guidelines and these can be summarised around two basic ideas: consider all aspects scales and components of wildfire risk without disregarding or downplaying any of them and promote collaborative work, involving everyone, including the citizens. Very often they are the first responders and the final targets of fire effects and damage.

If the Strategy and the Framework are well accepted then the Governance structure should work and perform a sound management of wildfire risk, provided that it is served by well trained and qualified people, oriented to provide the best to the service of their fellow citizens, assessing the risk, reducing it and adapting the society and the landscape to face future challenges.

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5. Appendices

More information of the Webinars mentioned in 2.4 is presented in this Annex, as they were part of the work carried out in the scope of the Project. A report on the RISE Workshop is given as well as it was organized and had the participation of members of the FirEUrisk Consortium is included as well.

5.1. WRM in Portugal

This meeting was held online on March 16, 2022. Various key points in the wildfire management system were identified, including unmanaged fire-prone landscapes and unclear responsibilities. A major point mentioned was the importance of valuing rural areas, changing behaviours, and introduce an efficient risk management in addressing this highly demanding issue. The National Rural Fire Plan, a 10-year plan with strategic guidelines aimed at mitigating wildfire risks and promoting active management of rural areas was also briefly described. Several activities related to prevention, suppression, communication, knowledge management, and evaluation were also mentioned. The collaboration between entities and the need for information sharing and coordination was also reinforced as a key aspect for the success. Since 2017, it was observed that there were reduced fire events, increased investment in prevention, and improved knowledge supporting operations. Examples of activities such as communication campaigns, engagement with farmers, and international exchange programs were also described as successful.

The webinar focused the management of wildfires in Portugal, especially the changes that were introduced after the large fires of 2017 The context of Portugal's susceptibility to forest fires due to diverse landscapes, climate, and cultural factors was also described.

The webinar is available in: *An Integrated Program of Wildfire Risk Management – The Case of Portugal - YouTube*

5.2. WRM in Germany

This meeting was held online on October 12, 2022. The Symposium started with an introduction to the situation of the forest fires in Central Europe, namely focusing past trends as well as recent and disturbing events, namely the recent forest fires that occurred in the Saxon and Bohemian Switzerland National Parks. The symposium was also relevant to understand the fire management resources and strategies on each side of the border, as it is shared by three countries (Germany, Czech Republic and Poland). Several participants from FirEUrisk enriched the discussions on land management strategies, integrated fire risk assessment and future climate challenges.

This webinar was not streamed as it occurred in Dresden, during the FirEUrisk plenary meeting, but it was recorded.

5.3. WRM in Spain

This meeting was held online on February 20, 2023. The structure of fire management in Spain is primarily decentralised to autonomous regions, with additional coordination at the national level. Firstly, two different autonomous regions were introduced as well as the National perspective. In Castilla Leon, one of Spain's largest regions, activities include regional forestry law, development of forest policies, and participation in international projects related to forestry, climate change, and fire prevention. The strategic approach in Castilla Leon was presented, to demonstrate how to reduce fire risk through effective response, village protection, and landscape resilience. In the predominantly urban region of Madrid, one of the main concerns is the wildland-urban interface,

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as a significant portion of the region is covered by fire-prone areas. Spain's wildfire management strategy encompasses prevention, preparedness, response, and restoration efforts. The country aims to proactively address risks, ensure the safety and professionalism of response teams, and involve the various stakeholders.

The webinar is available in: *Spanish strategy for fire risk assessment, reduction and adaptation - YouTube*

5.4. WRM in Greece

This meeting was held online on May 8, 2023. The purpose of this meeting was to gain a better understanding of the wildfire organisation in Greece. The FirEUrisk project was briefly introduced, followed by an explanation of the organization of wildfire management in Greece and the coordination role of the General Secretariat of Civil Protection. The Greek Forest Service also discussed fire prevention and restoration measures. The meeting also explored suppression activities, including operational activity and the use of aerial means. The role of local and regional bodies was presented, as well as the newly introduced back-fire program to be used as fire suppression technique. Finally, the meeting concluded with a debate session in which the audience contributed their thoughts and ideas.

This webinar was not streamed, but the recording is available in: https://adaicloud.quickconnect.to/d/s/zLdRk3qls9CZ9jzOgK2ITqOQSwT4L57I/hiGB1x4AjuBPxkf-qLiNpnA5O89dIol-UrJAMwF7hgs

5.5. WRM in Croatia

This meeting was held online on February 9, 2024. Understanding the situation regarding wildfires in different countries helps to build a comprehensive overview of Europe’s approach to wildfire risk management. The event held on the Croatian case, provided practical and country-related methodologies in WRM as well as key examples from regional and local settings. The presentations provided a comprehensive overview of Croatia's approach considering key topics, including weather forecasting, forest management, fire season, information systems and monitoring and surveillance network in place. Wildfire risk management was detailed and together with insightful presentations, the discussion also offered valuable solutions involved in wildfire management.

This webinar was not streamed, but the recording is available *in:* https://adaicloud.quickconnect.to/d/s/zLdYaIV3rsRzzs7LolfuW9baLYr8T3sD/zhNiDOk_S2M2nNPorGn5JEPs_A2zvHWf-J7NAcWV7hgs

5.6. RISE Workshop

In the program of the RISE-SD Wildfire Workshop, held in Rhodes, a Webinar on wildfire risk management and research was held on May 30, 2023. Although it was not strictly an activity of FirEUrisk, it was organised and had the active participation of FirEUrisk members. During the first panel, the importance of a common language for effective communication in wildfire management was emphasised, along with the need for integrated and holistic approaches, multi-stakeholder engagement, and governance. The second panel focused on the Wildfire Prevention Action Plan (WPAP), highlighting the significance of peer reviews, knowledge sharing, and aligning research with the Peer Review Assessment Framework (PRAF). The panel also stressed the need for simplified communication with policymakers and leveraging existing policy frameworks. The third panel discussed technology's role in wildfire risk management, including data sharing, A.I. applications, and collaboration on exploitation activities. It highlighted the necessity of recognising stakeholder diversity, standardising research processes, enhancing communication and training, and developing validated products for effective wildfire management.

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During the workshop, three panels discussed various aspects of wildfire management research:

1st panel:

Common language for smooth communication among researchers, developers, and decision-makers in wildfire management was highlighted. It discussed integrated and holistic wildfire risk management, highlighting the need for agreement on terminology, the interplay between forestry, technology, civil protection, and the significance of governance and multi-stakeholder engagement. Key takeaways included: agreeing on terminology for integrated and holistic wildfire risk management, specifying project applications of integrated management, and holding a digital meeting before the Clustering Event. The panel advocated for a comprehensive approach, considering all phases and factors in wildfire management, fostering shared understanding, exploring IWRM and HLFM strategies, encouraging stakeholder cooperation, prioritizing proactive landscape-level approaches, enhancing communication, balancing risk assessment, reduction, and adaptation, emphasizing landscape management and ecosystem benefits, and incorporating socio-economic aspects and governance in risk modelling.

2nd panel:

The second panel discussed the Wildfire Prevention Action Plan (WPAP) and the call for good practice on wildfire risk awareness. Relevant projects under DG ECHO were also addressed, including PREVAIL and RECIPE. The panel suggested disseminate project results and making recommendations available early to facilitate wildfire risk management implementation. The impact of different suppression strategies was also discussed, and the panel suggested developing a policy recommendation task force. Panel 2 also emphasized the importance of peer reviews, knowledge sharing, and aligning research with the Peer Review Assessment Framework (PRAF) to enhance wildfire management systems. It highlighted the need for simplified communication using multimedia resources and effective presentation methods to engage policymakers. Additionally, the panel recommended leveraging existing policy frameworks, prioritising research on northern region wildfires, and developing practical solutions and policy recommendations through active stakeholder engagement.

3rd panel:

Panel 3 discussed general technology and wildfire risk management, including understanding user needs and defining "operational" aspects. The panel also discussed data and A.I. aspects, including the need for data sharing and interoperability of solutions. The panel suggested collaborating on exploitation activities and facilitating case study exchanges. Overall, the workshop discussed the importance of developing a joint language for wildfire risk management, the need for science-policy-practitioners collaboration, and the contribution of research and technology to address the growing threat of wildfires in Europe. The third panel also emphasized recognizing stakeholder diversity, standardizing research processes, and fostering collaboration and knowledge sharing to improve wildfire management. It recommended enhancing communication and training, aligning research with existing tools and policies, and addressing challenges like data transfer and limited user participation. Additionally, the panel stressed the importance of developing validated products, establishing consistent policies, conducting infield demonstrations, and investing in training for new technologies.

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