RECIPE

REINFORCING CIVIL PROTECTION CAPABILITIES INTO MULTI-HAZARD RISK ASSESSMENT UNDER CLIMATE CHANGE

Report on data attributes for integrated risk assessment and planning of wildfires, floods, storms, avalanches, rockfalls, landslides and their interactions

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1. Introduction

This report is part of the deliverables of the RECIPE Project (**Reinforcing Civil Protection capabilities into multi-hazard risk assessment under climate change**) and corresponds to the Deliverable 2.1 of Task 2.1.

RECIPE is a two-year Prevention Project (January 2020 – November 2021) founded by the Civil Protection Mechanism of the European Commission (call identifier UCPM-2019-PP-AG), with the participation of 8 institutions from 5 EU countries:

- Forest Science and Technology Centre of Catalonia (CTFC), Spain (Project coordinator).
- Pau Costa Foundation (PCF), Spain.
- Civil Protection General Directorate of Catalonia (DGPC CAT), Spain.
- Forest Research Institute Baden-Württemberg (FVA), Germany.
- CIMA Research Foundation (CIMA), Italy.
- Austrian Research Centre for Forest Natural Hazards and Landscape (BFW), Austria.
- Institute of Cartography and Geology of Catalonia (ICGC), Spain.
- Higher Institute of Agronomy (ISA), Portugal.

The RECIPE Project seeks to develop operational recommendations and tools to reinforce Civil Protection capabilities into emergency management and risk planning of different natural hazards across Europe to address climate change impacts, by using an integrated risk management approach and the exchange of lessons learned and best practices.

By means of putting together multi-hazards' expertise from science and practice on **wildfires, floods, storms, avalanches, rockfalls and landslides**, main impacts of climate change in risk management will be identified. The potential scenarios of unprecedented multi-risk events will be considered. The interactions between prevention-preparedness-response-recovery actions in projected climate change scenarios will be analysed with an active participation of practitioners and other users. Accordingly, Civil Protection requirements to face new risk management challenges about climate change impacts will be identified.

Based on the above, transferable guidelines will be edited to incorporate the projected multi-risk impacts of climate change into operational decision support systems (DSS) that are used for risk management. Complementary, specific operational tools will be developed at pilot site level for each natural hazard to reinforce Civil Protection capabilities. Participation of public agencies will be promoted from the beginning to achieve an end-user oriented focus. Results will be actively disseminated into Civil Protection systems.

Furthermore, the project's workshops will promote the knowledge exchange in the existing networks to reinforce European landscapes' resilience to natural hazards.

The project is divided in 5 work packages (WP) as follows:

- WP1 Management and coordination of the action.
- WP2 Framing Civil Protection requirements for integrated multi-hazard risk management.
- WP3 Impacts of climate change projections on multi-hazard risk management.
- WP4 Guidelines and decision support tools to integrate climate scenarios into risk assessment and planning.
- WP5 Publicity and project outcomes transference.

Task 2.1 is part of the work package 2. This WP is composed by two tasks. On the one hand, in task 2.1 a common understanding of risk dimensions of the different natural hazards to address multi-risk integrated and cost-efficient risk management is defined. The risk analysis carried out are explained in the present report. In the second task (2.2), a gap analysis to identify how to best enhance response capabilities into risk assessment and planning process is done.

Along task 2.1, as a previous statge, and taking advantage of the diverse range of institutions, as well as regions and natural hazards represented on the consortium, a common baseline in terms of methodological components towards integrated Prevention-Preparedness-Response-Recovery risk management approach will be stablished. This will be developed under cost-efficient criteria to cope the potential multi-emergency and multi-risk interaction among natural hazards considered within the project. The task also includes a selection of best cases and methodologies about integrated and participatory approaches. This task has only one deliverable which is the present report.

2. Objectives

Task 2.1 seeks to define the risk dimensions (hazard, exposure and vulnerability) per each single natural hazard (wildfires, floods, storms, avalanches, rockfalls and landslides). A common methodological scheme has been developed, identifying the attributes of the territory and infrastructures that increase/reduce the risk. This shared common understanding of risk dimensions should help to undertake a multi-hazard assessment, and to evaluate how new situations posed by climate change can modify the level of risk. By contrasting risk driver factors among hazards, potential multi-risk interactions shall also be identified.

The assessment have been carried out by all partners, according to each one's expertise in the corresponding natural risk. This task included the organization of the 1st RECIPE technical workshop (minutes available in the projecte website, see here), where selected external experts on risk managment were invited.

Moreover, linked with the Civil Protection tools to be developed in WP4, each partner has contributed in a selection of best cases and methodologies about integrated and participatory risk management approaches.

The risk analysis will be used in the next work packages 3 and 4, stablishing a common base to discuss and conform all the activities expected on the project.

In the WP3, a state of the art of climate change impacts on each natural risk and potential multi-hazard cascade effects will be done, focusing on best practical knowledge and transferable guides available at the decision-making level. Data collection will be complemented with a qualitative gap analysis with practitioners, about the challenges for the effective integration of climate change scenarios into risk management strategies (task 3.1). Once the risk situations are defined, results and analysis done in this report about risk factors will be re-evaluated to face the projected climate change impacts (task 3.2).

In the WP4, the present results will be used to develop transferable guidelines for decision support tools to include the climate change scenarios into the risk assessment and planning, evaluating the data managemetn feasiblity regarding the risk factors defined. Moreover, these risk factors will be considered as well along the operational tools' development in each case study[1] planned in the project.

More information about the results of this sequential process can be find in the corresponding deliverables and in the project website. A final Book of Guidelines capitalises the results of the WPs sequence developed through the RECIPE action plan.

[1] CIMA, Italy: Guidelines for flood and fire Civil Protection planning with participatory approach with an operational tool for collecting citizens monitoring observations in emergency situations.
BFW, Austria: Decision support for sustainable multi-hazard risks management.
FVA, Germany: Guidelines for a participatory crisis management plan to manage wind throw along roads.
ICGC, DGPC CAT Spain: Visualizer tool for managing emergency situation in case of high avalanche risk.
CTFC, PCF, ISA, DGPC CAT, Spain-Portugal: Support tool and guidelines for integrated risk assessment and planning for landscape and wild-land urban interface fires.
CTFC, ICGC, BFW, Spain-Austria: Protocol for wildfire and avalanche risk management in mountain areas.

3. Methodology

"Risk" is an abstract concept and many definitions exist, depending on the discipline and field it is used. According to **ISO 31000:2018 – Risk management**, risk is defined as the "effect of uncertainty on objectives". It includes both negative and positive impacts on objectives. Thus, the focus and direction of risk management is clearly determined by predefined goals.

In the context of Civil Protection and emergency management, the objectives are usually to prevent or reduce potential human harm and losses, to mitigate economic damages, and to protect livelihoods, environment and cultural heritage[2]. This sector often applies a concept called disaster risk.

Disaster risk signifies the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community. It derives from the interaction of social and environmental processes and from the combination of physical hazards and the vulnerabilities of exposed elements. The term "crisis" is sometimes used interchangeably for disaster risk.

In RECIPE we imply this concept when utilizing the more general term "risk" and focus in particular on disaster risk related to natural hazards of wildfires, floods, storms, avalanches, rockfalls and landslides.

The objective of the task is to establish a common methodological framework for risk assessment across various natural hazards. This help to set the ground for further analysis in other work packages about the impacts of climate change towards enhanced Civil Protection capabilities.

In order to assess data attributes of risk in various contexts, the underlying driver factors of risk have been analyzed according to the three dimensions of risk proposed by the IPCC Report (2012)[3].

Figure 1. Three dimensions of risk (from IPCC 2012)

[2] Art.2 DECISION No 1313/2013/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 December 2013 on a Union Civil Protection Mechanism.

[3] IPCC, 2012 – Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (Eds.) Available from Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 8RU ENGLAND, 582 pp.

The dynamics and consequences of natural hazard processes vary greatly according to the hazard and the environment and territorial context in which it occurs. Natural hazards are often linked to human interventions in natural ecosystems (e.g. proximity of infrastructure and settlements close to forests, construction in flood plains or avalanche run-off areas). The UNDRR defines hazard as "a process, or phenomenon that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation." The same source, defines **natural hazard** when are "predominantly associated with natural processes and phenomena" distinguishing the **anthropogenic** or human-induced hazards, and adding the category of **socionatural** for those "associated with a combination of natural and anthropogenic factors, including environmental degradation and climate change". [4]

In order to be able to assess the diverse data attributes of risk, a general framework has been established. For this, risk driver factors were identified and grouped according to the three dimensions of risk (i.e. hazard, exposure, vulnerability). The main goal is to identify risk driver factors and compare similarities or distinctions between the analyzed natural hazards. Measures and stakeholders involved for each identified driver are also included, thus displaying risk reduction proceedings associated for each one.

3.1 What is a risk driver factor and how are they identified?

For the dimension **hazard,** a driver factor is a variable which can trigger and/or influence the hazard itself or the outcome of the hazard (e.g. droughts altering the likelihood of wildfires, soil structure determining the likelihood of damaged trees during storms).

For **exposure,** a factor represents a feature/property of an exposed element (not the exposed element itself) that influences the level of risk (i.e. increases or decreases overall risk). E.g. size of population in an affected area, or the presence of critical infrastructure.

For **vulnerability,** a factor is a feature of an exposed element or the protective system which influences the coping capacity of the system/element (e.g. risk awareness of the population or resistance quality of the critical infrastructure).

Each driver factor was further categorized and described. For the dimension hazard, a factor could be either of natural or human origin with an indication if it had triggering properties or not. 'Natural' driver factors are determined for instance by specific site conditions (e.g. topography) or vegetation type. 'Human' driver factors can be determined for example by land use form. For the exposure and vulnerability dimensions the following risk driver categories were established: Population, Infrastructure, Buildings, Critical facilities, Economic activities, and Environmental services.

In a second step, existing and potential risk reduction measures were identified for each factor and marked with the phase within the Risk Management Cycle (i.e. Prevention, Preparedness, Response and Recovery), as well as the cross-sectoral component of risk management commonly present in all Disaster Risk Reduction strategies used in RECIPE Project for risk analysis (see Figure 2 and Table 1). Risk mitigation measures related to forestry were specifically indicated and named.

[4] https://www.undrr.org/terminology/hazard

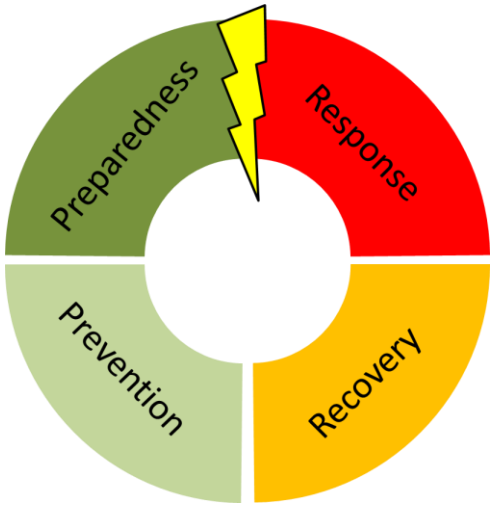

Figure 2. Phases of Risk Management Cycle

Box 1. Phases of Risk Management Cycle and definitions

The RMC is commonly divided into four different phases to manage disasters[5]. The first two applies before the disaster and the other two follow the disaster:

- **Prevention:** activities and measures to avoid existing and new disaster risks.
- **Preparedness:** aims at building the needed capacities to efficiently manage emergencies and achieve orderly transitions from the response to a sustained recovery phase.
- **Response:** actions taken directly before, during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.
- **Recovery:** the restoring or improving of livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and "build back better", to avoid or reduce future disaster risk.

Table 1. Cross-sectoral components of risk management (adapted from Plana et al. 2019[6])

Cross-sectoral component	Description
Risk assessment, mapping, and planning tools	Comprises the assessment of risk level (e.g. through modelling, mapping or qualitative surveys); identification of underlying causes of the driving hazard, exposure and vulnerability; and risk planning tools.
Risk governance and policy	The corresponding regulations and a public-private multi-actor governance framework for regional/national DRR strategies.
Risk culture and communication	Refers to actions promoting risk awareness and participation of exposed population in mitigating risk under the general framework of risk culture.
Technical measures	The corresponding mitigation measures at technical level.
Emergency management and response capacity	Considers all actions related to the protection of people, goods and environmental services, and the organisation of the emergency services during the event.
Recovery	Recovery and post-disaster management initiatives (e.g. from assessment of lessons learned to recovery plans).

[5] https://www.undrr.org/terminology

[6] Plana, E., Font, M., Serra, M., Hörl, J., Hengst-Ehrhart, Y., Hartebrodt, C., Held, A., Clemenceau, A., Giroud, F., Tola, F., Capula, T., Cinus, S., Visani, C., Soi, F., Manca, G., Prat, N., Borràs, M., Vendrell, J., Ballart, H. and Vilalta, O. 2018. Forest risks in a climate change context: trends and risk management challenges of wildfires, floods, storms, avalanches and their interactions in EU landscapes. Networking for the European Forest Risk Facility Initiative (NET RISK WORK ECHO/SUB/2016/740171/PREV10 Project). CTFC Editions.

In a third step, the involved stakeholders and their corresponding actions were stated.

The outcome was a comprehensive set of Assessment Scheme of Risk Driver Factors and Mitigation Measures for each natural hazard (Figure 3, and Figure 4). Risk mitigation measures have been classified according the RMC phase and risk management cross-sectoral component. Moreover, the corresponding stakeholder(s) involved in its implementation has been identified.

All the fields of information are organised in a matrix for risk analysis, included in an Excel template file (Annex I).

From a methodological point of view, the proposed Assessment Scheme implies the typical sequence of risk process resulting from the combination of hazard, exposure, and vulnerability dimensions. In this sequence, if hazard mitigation measures are effective, natural hazard no longer has the capacity to impact on the exposed elements. If hazard cannot be neutralized (e.g., due to natural risk factors such as wind or rainfall intensity), only the absence of exposed elements limits the risk. Finally, if neither hazard nor exposure can be neutralized to acceptable levels of risk, vulnerability of people and values at risk must be reduced.

Therefore, a proper identification of risk driver factors within each dimension should help to address disaster risk reduction in the most effective way. The understanding of risk process sequence facilitate to focus the Civil Protection systems since the general objective is to reduce the social vulnerability from the perspective of integrated risk management, by anticipating risk mitigation actions in the dimensions of exposure and hazard that may become more cost-efficient.

Figure 3. Example of Assessment Scheme of Risk Driver Factors and Mitigation Measures developed in RECIPE Project for the risk analysis of natural hazards

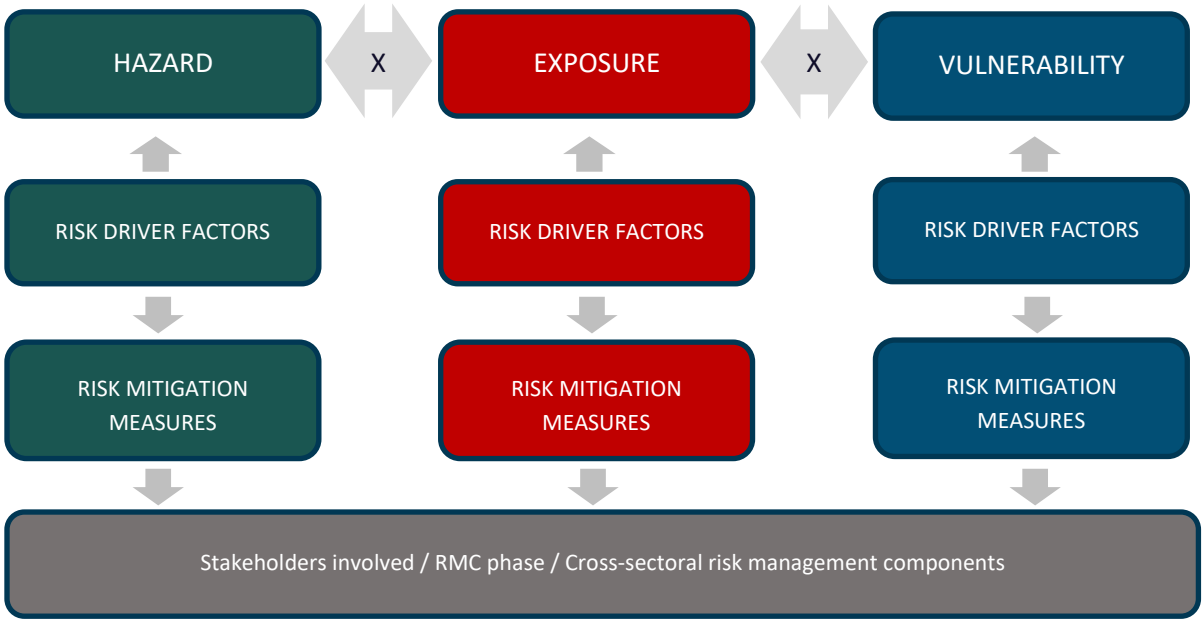

Figure 4. Example of the matrix used for the risk analysis per each natural hazard

Author	CIMA Foundation
Hazard process:	**Forest fire**
Hazard	Impact of Wildland Urban Interface fire front line (high intensity)
Impact relevant for Civil Protection	Human damage (lives, health and livelihoods); interruption of critical infraestructures; loose of forest cover; damages at buildings,

Risk dimension	**Categories**		**Factors**	**Description**	**Measures**													
					Forest Management	**Phase in Disaster Risk Management Cycle**			**Component of Disaster Risk Reduction**	**Other**	**Phase in Disaster Risk Management Cycle**				**Component of Disaster Risk Reduction**	**Forest managers**	**Land planners**	**Risk asses authori**
Hazard	Natural		High Forest stand density and fuel continuity	Fire intensy and spread capacity directly depends on the fuel loads that are influenced by the fuel continuity	Reduction of fuel load continuity				Technical measures	Creation of mosaic landscape					Technical measures	Guides and support tools for preventive silviculture	Guides for resilience landscapes	Spread capa risk assessn and mapping accordingly
	Natural	Triggering	Heat waves	High temperatrues facilitate the fire ignition and spread, because they dry the fuels, becoming more prone to the fires	Choose of species better adapted to climate chance scenarios	Prev.			Technical measures							Guides and support tools for preventive silviculture		Fire risk assessment mapping acc
	Natural	Triggering	Drought	Drought periods facilitate the fire ignition and spread, because they dry the fuels. At mid long period (frome one season to other) pay special attention to drought inertia (a unique rainfall may not compensate a long deficiency) . At daily level, speciall attention to the recovery of humidity during the night, crictial issue related to fire spead capacity	Choose of species better adapted to climate chance scenarios	Prev.			Technical measures							Guides and support tools for preventive silviculture		Fire risk assessment mapping acc
	Natural	Triggering	Wind	Windy weather dry the fuels and spread the flames and secondary fires at longer distances														
	Human		Presence of trees under electric lines	Electric lines can generate ignition because of over demand which sometimes happens together within hot waves (electricity for electrical appliances).						Legal frame that obligates the companies to clean the fuel under the lines	Prev.				Risk governance and policy			
	Human	Triggering	Proximity to agricultural and pastoral practices	Shrub brushing or other agricultural practices can increase the fuels presence and so the hazard intensity						Legal frame that obligates the farmers to do not light fires during the high fire risk season	Prev.				Risk governance and policy			
	Human	Triggering	Proximity to the tourist areas	A little fire in a forest during a piknic can generate a big forest fire if lighted during the high fire risk season						Communication and awareness campaign that inform the forest users on the forest fire risk during the high fire risk season	Prev.				Risk governance and policy			

3.2 How to use these results

Based on the above, the analysis has been developed per each natural hazard (i.e. wildfires, floods, storms, avalanches, rockfalls and landslides), identifying and describing the hazard, exposure, and vulnerability driver factors.

Each partner has contributed with its risk expertise and from its regional/national context. Table 2 summarizes the cases that have been developed across the consortium. In the case of wildfires, three specific cases (Forest fires and fires in wildland urban interface areas, High intensity fires with extreme fire behaviour and High intensity fires in Mediterranean context) were analysed.

Table 2. Risk analysis developed by the consortium

Partner/s	Country/ies	Risk analysis
FVA	Germany	Storms
BFW	Austria	Landslides and Rockfalls
CIMA	Italy	Forest fires and wildland-urban interface fires and Flash foods
PCF	Spain	High intensity fires with extreme fire behaviour
CTFC, DGPC CAT, ISA	Spain and Portugal	High intensity fires in a Mediterranean context
ICGC	Spain	Avalanches

Due to the long extension of the matrix once filled, they have not been added in the present report and each natural hazard file can be found in the project website. For this reason, each partner was asked to carry out a sum-up of the corresponding matrix, to summarize such a complex file. The sum-up tamplate to be filled is available in the Annex II.

Summaries are included in the next Chapter 4, with a detailed and pooled analysis of the risk driver factors, measures and the corresponding stakeholders identified.

Then, Chapter 5 summarize the findings for each risk regarding to risk factors, and a preliminary analysis of the results and the template functioning is also done. The objective is to evaluate the robustness of the risk analysis method, and guide possible adjustments in next project steps, in order to be able to compare risk factors:

- Among natural hazards (in order to evaluate multi-risk and cascade effects).
- With the Civil Protection requirements, expected impacts of climate change and DSS functioning in terms of data management.

3.3 Selection of best cases on integrated risk management

Additionally, along task 2.1, a selection of best cases of integrated risk management approaches and tools has been done following a common template with the next attributes: Basic information (name, promoter, scope, place and risk), General focus (DRM cycle phases) and, Description and complementary information (main category, available languages, short description, complementary information and web link). This selection will be a methodological support for the Civil Protection operational tools design and development in the WP4.

Best cases are summarised in Chapter 6 and collected in Annex III.

4. Description of natural risk processes

4.1 Wildfires

4.1.1 Forest fires and Wildland–Urban Interface Fires

General description of hazard process

Forest fires and Wildland–Urban Interface Fires cause threats to humans, buildings, critical infrastructure, and economical activities that can be burned and damaged in a short time and for long time. The resulting risk needs to be assessed, analyzed, evaluated and managed.

Assessment of risk dimensions

HAZARD - Description of driver factors

1. **Driver factors that influence hazard**

The hazard is influenced by factors of both "natural" and "human" categories. Natural driver factors are determined by specific site conditions (such as topography), vegetation types and growth / density, and characteristics of the meteorological event (i.e. heat waves, drought, and wind). Human driver factors are determined by land use which influences the ignition (e.g. presence of trees under electric lines or tourist area) and the fuels presence (agricultural and pastoral practices).

2. **Climate change impacts**

Driver factors that are influenced by climate change:

- Tree health (decrease of tree health due to effects of drought and pest & disease infestations).
- Degree of species mixture (shift in species composition, first die off of less adapted tree species => increase in risk; then regrowth with more adapted species).
- Tree species composition.
- Heat waves, drought, and wind.

HAZARD - Description of measures (type and phase)

Measures to address those driver factors are predominantly "Technical measures" and "Risk governance and policy" related to land use, but also "Technical measures" related to silviculture and forest management. They all take place in the "Prevention" phase of the Risk Management Cycle (RMC).

HAZARD - Description of stakeholders and actions

- Forest managers are involved in most measures to reduce the hazard and therefore risk.
- Land planners are involved in most measures to reduce the intensity of the hazard and therefore risk, and also, to prevent new risk.
- Risk assessment authorities are involved in most measures to map the hazard.
- Civil protection authorities are involved in the definition of legal framework for handling/ managing the hazard.
- Private sector is involved to support the coherent application of fuels management.

Most of measures aim at integrating the understanding of the local risk situation into different planning (included Civil Protection planning) and at reducing the intensity of the hazard. Local authorities respect and control compliance with existing regulations.

EXPOSURE - Description of driver factors

The overarching objective of this risk assessment is Civil Protection, the driver factors that influence the exposure dimension reflect well the elements at risk and appeared in the following categories: population (2), critical facilities, infrastructure, economic activities and environmental services. The risk is highly influenced by the presence of elements at risk in areas affected by the hazard process (identified by fire risk mapping produced by RISICO, a fire danger rating system).

Generally two types of damages can be discerned: direct damage, which have an immediate impact during or shortly after the hazard event, such as infrastructures and economic activities affected by fires or loss of lives, or secondary damage, resulting from indirect damages due to interruption of the day-to-day functioning of environmental, such as the loss of aesthetic and recreation values, or due to a cascade effect of a wild fire, such as an increasing of pollution, deriving from an affected critical plants.

The presence of people and tourists, settlements, economic activities, cultural heritage, critical facilities, infrastructures etc., in fire prone areas and the amount, value and importance of them influence the level of risk.

EXPOSURE - Description of measures (type and phase)

Non-forest management related measures take place during all phases of the RMC, except the Recovery phase, and almost all of them are aimed at properly assessing and mapping exposure and avoiding the presence of people in case of a forecasted event by safe evacuation / temporary relocation (e.g. high safe places, closing schools, etc.).

Most components of DRR are covered: 1) define, train and implement safe evacuation / temporary relocation protocols activated by early warning (risk assessment, mapping and planning tools & risk culture and communication & emergency management and response capacity); 2) assess and map exposure (risk assessment, mapping and planning tools); 3) land use zone and relocation policy (risk governance and policy).

Forest management related measures to reduce exposure are all 'technical measures', which take place during the Prevention phase. They aim at excluding the hazard, e.g. firebreaks and complementary suppression equipment (water points).

The main stakeholders involved are risk assessment authorities, Civil Protection authorities, exposed population, local authorities, and Civil Protection Volunteers.

EXPOSURE - Description of stakeholders and actions

Analyzing the involved stakeholders and their respective activities shows that for most of the driver factors (e.g. amount of neighbourhoods and population in fire-prone areas or presence and importance of critical facilities, number of mobility infrastructures and essential services) multiple stakeholder groups at different territorial level and with different competencies are involved and active, included the exposed people themselves. This indicates that good collaboration and communication is needed to effectively address this factor as a subsidiary system and that exposed people should be part of the DRR process. Moreover, it is important to explicitly mention the necessary collaboration of stakeholder groups with risk assessment authorities and Civil Protection authorities and exposed people, also to elaborate guidelines for the exposure assessment and mapping and to support the local authorities.

VULNERABILITY - Description of type of driver factors

Driver factors influencing vulnerability reflect well the identified elements at risk, as seen in the categories population (2), critical facilities, infrastructure, economic activities and environmental services.

For all factors, reducing vulnerability includes strengthening Prevention / Preparedness / Response of the Civil Protection system at all the levels, including the capacities of Civil Protection planning and early warning and integrating with other planning.

Moreover:

- For the category population reducing vulnerability is related also to: raising risk awareness and risk culture also in terms of early warning (even considering tourists and visitors).
- For critical facilities and infrastructure it is related to their capacities to withstand direct (response capacity - physical structure of buildings) damages.
- For economic activities and environmental activities, it is related to the existence of protective measures, to maintain operationality and to withstand to secondary damages.

VULNERABILITY - Description of measures (type and phase)

Non-forest management related measures take place during all the phases of the RMC, mostly in Prevention, Preparedness, and Response. The majority are risk assessment, mapping and planning tools, risk culture and communication, technical measures and emergency management and response. Some measures aim at recovery of economic activities and infrastructure and at disaster loss data collection.

The driven idea for all these measures is related to the relevant collaboration between stakeholders and Civil Protection system for mapping risk, co-elaborating protocols, better collecting loss data and other actions that can produce:

- a proactive and "aware" behaviour,
- a better and more adapted Civil Protection planning.

Another important issue is the coordination among the different stakeholders of the RMC.

Apparently, only few driver factors can be related to forest management and they refer to environmental services. All of them should take place during the Recovery phase and focus on technical measures.

VULNERABILITY - Description of stakeholders and actions

Forest managers contribute with local and forest-related knowledge and participate in the development of a crisis management plan and regular trainings of emergency situations.

Most driver factors are addressed by several stakeholder groups at different territorial levels, which makes good coordination, collaboration, and communication crucial. Often, one stakeholder takes a leading role in the development / implementation of the measure and relies on the contribution of others. In other cases, such as for the EWS, the implementation of actions is characterized by a subsidiary and coordinated activation among different stakeholders. Even for vulnerability driver factors, the exposed population itself should have an active role in the implementation of many of the measures identified.

The involved stakeholders are Land planners, Risk assessment authorities, Civil protection authorities, First responders (Fire Service), Exposed population, Local authorities / Municipalities, Private sector (IT Sector, Farmers and agricultural sector) and Universities / Research centres.

4.1.2 High intensity fires with extreme fire behaviour

General description of hazard process

High intensity fires with extreme fire behaviour[7] in mountain rural areas putting under risk human lives (locals and tourists), properties, forest habitats and croplands.

Assessment of risk dimensions

HAZARD - Description of type of driver factors

1. **Driver factors that influence hazard:**

Driver factors influencing the hazard are mainly related to fire behaviour triangle as well as the specific site conditions: weather (i.e. strong winds or unstable atmosphere), fuel (i.e. severe drought periods or high fuel continuity) and topography (steep slopes or S-W aspects). Ignition under electric powerline are also considered.

2. **Climate change impacts**

Climate change mainly influence driver factors related to weather and fuel:

- Heat waves: more and longer heatwaves are expected under several climate change scenarios, which will increase the stress of the vegetation and their burn probabilities, with more ignitions and extreme propagation.
- Drought periods: polarisation of wet and dry periods may be a future normality in the Mediterranean basin. That would increase the availability of fuel to burn.
- Forest continuity: the increase of rainfall periods during wet seasons may facilitate the growth of light fuel, that will easily dry during drought periods making fire behaviour more intense.

HAZARD - Description of measures (type and phase)

Measures to address those factors are predominantly “Technical measures” and are related with forest management (fuel reduction, choosing species better adapted to the climate). There are also measures related to risk assessment and planning (post fire analysis) and risk governance (clean under electric powerlines). They almost all take place in the “Prevention” phase of the RMC.

[7] Even extreme wildfire events (EWE) is a novel concept not fully developed, within this chapter is understood as high intensity fires able to interact with the atmospheric conditions, with high spread ratios and velocities and potential to affect large surfaces and to provoke relevant losses in lives and properties. More information in Tedim, F.; Leone, V.; Amraoui, M.; Bouillon, C.; Coughlan, M.R.; Delogu, G.M.; Fernandes, P.M.; Ferreira, C.; McCaffrey, S.; McGee, T.K.; Parente, J.; Paton, D.; Pereira, M.G.; Ribeiro, L.M.; Viegas, D.X.; Xanthopoulos, G. Defining Extreme Wildfire Events: Difficulties, Challenges, and Impacts. Fire 2018, 1, 9. (https://www.mdpi.com/2571-6255/1/1/9/htm).

HAZARD - Description of stakeholders and actions

Most of the measures depend on forest managers, land planners and risk assessment authorities since they are addressed at forest management. Private sector (electric companies cleaning the understory of electric powerlines) and fire services (weather monitoring) are also involved.

EXPOSURE - Description of driver factors

The main objective of this risk assessment is Civil Protection, the driver factors that influence the exposure dimension reflect well the elements at risk and appeared in the following categories: population (2), infrastructure, economic activities, and environmental services. Factors such as high population size, high affluence of tourists, large number of settlements and the presence of rural activities (livestock, agriculture) are considered. The distance of forests to human settlements as well as croplands influence level of risk, as it does the presence of local people and tourists doing their activities in the area.

EXPOSURE - Description of measures (type and phase)

Measures to address the exposure are mainly focused on risk assessment mapping and planning tools (5), emergency management and response capacity (7) and risk culture and communication (4). These measures are mainly evacuations, early warning systems, communication tools, fire extinction, access roads and communication with population. Most of measures are focused on the Prevention phase of the RMC while a few others focus on Preparedness and Response.

EXPOSURE - Description of stakeholders and actions

Involved stakeholders are land planners (design of prevention plans), risk assessment authorities (assessment of evacuation plans, wildland-urban interface risk and real time risk assessment), Civil Protection (design and implementation of evacuation plans), Fire Services (access routes, fire suppression and prevention as well as implementation of evacuations), police (implementation of evacuation plans and control of ignitions), exposed population (prevention measures and training and implementation of evacuation plans) and local authorities (communication during evacuations).

For example, an extreme fire occurring in a rural area, land planners should have prepared an evacuation plan and an adapted prevention plan together with forest managers and Fire Services. Police should control ignitions, but once the fires are burning, they collaborate in the evacuation phase together with Fire Services and Civil Protection. Fire Services should implement suppression actions while local authorities inform about the evolution of the fire to citizens. Population have the duty to be prepared (25 m strip without fuel, training of evacuations).

VULNERABILITY - Description of type of driver factors

Driver factors influencing vulnerability reflect well the identified elements at risk, as seen in the categories population (2), infrastructure, environmental services and economic activities. Specifically, factors such as high number of inhabitants with little knowledge on fire risk and the low risk-awareness of tourist have an important influence in terms of population category. Other driver factors are critical settlements, priority habitats in risk posed by climate change and high value rural activities may be affected.

VULNERABILITY - Description of measures (type and phase)

Measures addressed at reducing vulnerability are mainly technical measures, risk culture and communication, risk assessment and mapping and risk governance and policies. Most of them are focused on the Preparedness phase, despite there are measures in all phases of the RMC.

VULNERABILITY - Description of stakeholders and actions

Forest managers contribute by providing fuel management codes. Land planners provide building codes. Risk assessment authorities provide real time risk assessment and establish a post burn fast reaction protocol to restore protection function. Civil Protection define protocols, promote training, and organize the confinement, provides territory values and fire prevention plans. Police organize the confinement. Exposed population train and implement confinement protocols and establish smart gardening and insurances. Local authorities promote training and organize the confinement. Private sector also influence vulnerability by providing insurances. Public media inform society about risk.

4.1.3 High intensity fires in a Mediterranean context

General description of hazard process

Impact of wildfire front line (high intensity) in Mediterranean context. Human damage (lives, health and livelihoods); interruption of critical infrastructures; loose of forest cover (environmental services provision); damages at buildings.

Assessment of risk dimensions

HAZARD - Description of type of driver factors

1. **Driver factors that influence hazard**

Wildfire has a particularity within the "natural hazards" since the hazard is heavily human-influenced. In fact, the fire itself is not necessarily a hazard but the conditions that facilitate that an ignition spread fast and fire become intense (the so called high intensity fires behaviours, which overwhelm suppression capacity and collapse the emergency management). Therefore, together the "natural" driver factors (high temperatures, dry fuels, etc.) those resulting from the human action are, at least, very relevant (in terms of 1) how influence on fuel loads structure and distribution at landscape level and, 2) human causes of ignition, which in high risk periods can be determinant generating simultaneous wildfires).

2. **Climate change impacts**

All those environmental factors that affects the so called "fuels availability to burn" as follow should be considered:

- Precipitation: there is not a clear picture of the effects of climate change in precipitation distribution in the Mediterranean area. What it seems clear that this will be more irregular with potential longer drought periods. Drought has two main effects; short term, fuels are drier and facilitate fire ignition and spread. At medium long term (rainfall accumulated deficits) can stress vegetation, increase the dead biomass (easy to burn) and generate cascade effects with biotic diseases and pests' affectations in large forest areas.
- Temperature: the increase of temperatures has two main effects. On one hand accelerate the fuel dehydration and vegetation stress, especially within rainfall deficit periods. On the other hand, the so called "fire risk season" (typically in summer) is extended along the year, in a combination of more dry and hot periods in autumn even winter. Consequently, high intensity fire can appear out of the "season".
- Winds: high uncertainty exist about the influence of climate change in the wind patterns at regional level. In any case, wind increases the spread capacity and dry the vegetation. Special attention should be posed to potential changes in main wind directions, which are determinant regarding to fire behaviour patterns at landscape level on which is based the risk planning in Catalonia (see Best case number 7 – Annex III).

HAZARD - Description of measures (type and phase)

About the "natural" hazard driver factors there is no capacity to influence them directly. Nevertheless, some capacity to mitigate their impact in fuels exist, fundamentally, by two ways: 1) Promoting forest management and reducing the tree competences for the resources (large surface of forest vulnerable to fires in the Mediterranean areas are young trees coming from the land crops abandonment, with high dense forest stands and continuous vegetation strata up to the tree crowns), 2) Tree species selection more adapted to the expected climate change scenarios, especially, on those sites where drier and hotter conditions has been already stated in the last decades. Both measures aim at improving the forest "health" increasing the forests' capacity to stand more sever conditions, limiting potential cascade effects with biotic affectations and proving in general less flammable biomass fuels conditions.

About the human driver factors, ignition control is something already well and successfully established in most of risk management strategies. Nevertheless, attention should be posed about "cultural" uses of fire and fire risk perception (e.g. on tourist and visitors), that needs to be adapted to the changing risk situations posed by climate change (for instance, prescribed burns in mountain areas are becoming more difficult to manage). Nevertheless, the main measures are on those influencing fuels cover structure and distribution mitigating the potential of high intensity fires through forest management. The objective should be to provide forest stands with low "horizontal" (landscape level) and "vertical" (within forest stand layers) fuel continuity which prevent high intensity fires. The maintenance and creation of mosaic landscape decrease the fire spread capacity. Or the above-mentioned tree species selection, basically promoting those existing in the land more adapted to the expected environmental conditions.

HAZARD - Description of stakeholders and actions

According the factors and measures, main stakeholders/actions are described as follow:

- Forest managers, farming sector and land planners: influencing in forest cover structure and distribution, providing the so called "fire-resistant" forests and landscapes with less capacity to generate and spread high intensity fire behaviours.
- Risk planners (most previous stakeholders are also included here): integrating climate change impacts on hazards driver factors to the risk assessment and planning (especially about the influence on environ conditions to fuels' availability to burn), embedding the mitigation measure in the common mid-long-term frame of results of the forest management actions.
- Private companies, citizens, farmers, inhabitants, and visitors in forest/rural areas, etc.: reducing ignition risk with responsibility and common sense. This also includes ignitions coming from urban infrastructures to the forest areas such as electric lines, roads, trains, recreational resorts, etc.

EXPOSURE - Description of driver factors

Three main categories have been described:

- Population in wildland-urban interface and forest areas, describing separately the residents and neighbours from the occasional visitors and tourist.

- Forest environmental services, highlighting two main functions, a) the forest protection regarding to multi-risk cascade effects due to the loss of forest cover and, b) the economic impact on wood and forest products provision.
- Firefighters and other emergency corps exposed directly to the flames impact, which is becoming more and more a tricky issue since more sever and uncertain fire behaviours are being registered aligned together the increasing hazardous conditions.

EXPOSURE - Description of measures (type and phase)

In terms of exposed elements there are two main measures: 1) to avoid the exposure to urban infrastructure to the wildfire impact (typically example, no building houses near to forest areas) and, according the particularity of forest cover "hazard", and 2) reducing the capacity of forests to generate and spread high intensity fires, in forest areas close to urban settlement and infrastructures. In the case this reduction of exposure cannot be ensured (the so called "pre-existing elements" in urban planning, those houses infrastructures coming without proper risk-based planning), measure should be addressed to ensure the evacuation capacity in safety conditions (proper early warning systems, trained protocols, prepared road infrastructures, etc.). Special attention should be posed to occasional visitors (language factor) and to crowed sites like touristic resorts, beaches, recreation sites, etc.

In terms of economic impact, both in infrastructures and environmental services provision, insurances can play an important role since more areas are at risk and actions to reduce the hazard and the exposure cannot reach all the situations.

Regarding to enviroment service provision, most measure to reduce their exposure to fire are similar to those related the reduction of hazard, since low intensity fires in most cases are not going to affect environmental services provision in the Mediterranean landscape (vegetation has several adaptations to fire as a natural component of the ecosystem). Therefore, open and less fuel continuity forest reduce their exposure to high intensity fires (cannot generate them, but overall a high intensity fire cannot be spread across them). Additional attention should be focus in those forest tree species not adapted to fire from an ecological point of view, potentially affected by an extension of fire-prone conditions with the climate change, for instance, beech or spruce forests in mountain areas with thin barks sensitive to the heat of flames.

EXPOSURE - Description of stakeholders and actions

The effective reduction of exposure to wildfire risk result from the combination of actions from several stakeholders:

- Main efforts should be posed in promoting smart urban infrastructures and activities planning, balancing them according the fire-prone conditions (e.g. regulation the access to forest massif without prevention measures in high fire risk season. In fact, this could mean to close most of touristic areas. Or, alternatively, including in the urban projects the operational requirements for safety evacuations in case of emergency). On that sense, land planners, municipalities and private urban developers play a crucial role.
- At individual level, effective evacuation protocols (including early warning systems) should basically be promoted by the Civil Protection system, in collaboration with local authorities, private sector

(e.g. touristic resorts) and Fire Service, for instance. Complementary, residents in fire-prone environs should be trained regularly in emergency procedures (training, drills, etc.).

- The introduction in any business plan the insurance model should be properly considered, in the case the exposure neither the vulnerability to wildfire impact can be reduced at all.
- Both forest managers and generally risk planners, should integrate the evolving risk context, and introduce the changing exposure conditions in the risk assessment and planning, carrying out the corresponding action to mitigate the risk. Land use changes influencing risk together with climate change should be cross-analyzed together. Special emphasis should be posed to the exposure of protection function of forest, and consequently, potential multi-risk situations (e.g. increase the fire prone conditions in mountain areas and cross-links with avalanche and landslides risks).

VULNERABILITY - Description of type of driver factors

Once the exposed elements cannot be removed to the wildfire "run", main driver factors determining the vulnerability are related, on one hand, to the potential damages caused by the fire front line impact on them, and, on the other hand, in a broader scale the impact of the burnt area to the territory. Therefore, those impacts in population, infrastructure and forest environmental services will be strongly related with the intensity of the wildfire and the resilience of the landscape and the economic activity in the territory.

VULNERABILITY - Description of measures (type and phase)

In the Prevention phase, main measures to mitigate wildfire impact damages is to reduce fuels around houses and infrastructures. Complementary, the provision of building codes and gardening guides can help to achieve fewer flammable buildings. In terms of environmental services provision, diversification of species and ecosystem can help to reduce the wildfire impact in the landscape. As was mentioned above, forest management reduce forest exposure to high intensity fires. The extension of this preventive management will affect the landscape vulnerability to wildfire impacts, in terms of landscape beauty, water provision, wood and forest products provision and effects in other farm activities. At this stage, insurance can help to mitigate potential damages of wildfires and increase economic activities resilience. About recreational uses in forest areas, the places/infrastructures adaptation to the emergency management requirements may reduce the vulnerability, for instance, having safe confinement places distributed (see next phase), avoiding the need of limiting the access in high risk periods (mentioned previously as an action to reduce exposure).

Regarding to the Preparedness phase, complementary to evacuation protocols to avoid the exposed elements in the territory when a wildfire happens, the corresponding proper confinement protocol (in infrastructures able to resist the wildfire impact) will reduce the social vulnerability. Those confinement infrastructures can be the own building (with the corresponding fuel management within the defensible space) or new one created or prepared that will serve to meet the people according the protocol.

Within the Response phase, as much as the operational requirements of the emergency services are integrated in the development of infrastructures, more effective (and safe) will be the fire suppression tasks. For instance, including the necessary roundabouts in disseminated wildland-urban interface areas to facilitate the mobility of fire trucks moving in narrow streets and mountain roads.

Regarding Recovery phase, to establish protocols with agile and effective measure to restore the economic activities in the area will decrease the social vulnerability to the wildfire impacts.

VULNERABILITY - Description of stakeholders and actions

Described actions to reduce vulnerability are involving several stakeholders:

- Urban planners should effectively integrate wildfire risk into planning processes and in collaboration with the municipalities, promote the necessary arrangements to reduce the potential damages of a wildfire impact. The reduction of fuel loads around buildings, the preparation of selected infrastructures to be used in case of confinement (access roads and buildings), the implementation of building codes to resist external fire impact, etc., should be inserted in the urban planning as has been done with other natural hazards like floods or earthquakes.
- Inhabitants in wildland-urban interface areas should have carry out the corresponding fuel management around the buildings and have proper knowledge about the emergency procedures in case of wildfire.
- Visitors should be properly informed in case of risk and how to follow the confinement protocol.
- In terms of environmental services provision, forest managers should be able to integrate wildfire risk assessment and planning into forest management practices at massif scale, ensuring the landscape resilience. Synergies with the forest sectors (promoting biomass sector or extensive grazing, for instance, in high fire risk areas) should be integrated in the risk management plans. Additionally, collaborations with private actors that benefit from environmental services (water provision, landscape beauty) could be explored in the sense of adding resource to the risk mitigation measures. Recovery plans and forest and farm insurances can reduce the impact of wildfires in local economies.
- Risk assessment authorities should frame the wildfire risk planning in the sectoral policies such us urban planning (through the corresponding regulations and norms) and standardized the levels of vulnerability affordable.
- Civil Protection system and globally emergency crops in cooperation with local authorities and private actors should define and promote the implementation of confinement protocols. Operational requirements of Fire Service to improve the suppression tasks should be properly be integrated in the urban infrastructures design and maintenance.

4.2 Floods (Flash floods)

General description of hazard process

Flash flood causes threats to humans, buildings, critical infrastructure, and economical activities of being flooded and damaged in a short time. The resulting risk needs to be assessed, analyzed, evaluated and managed.

Assessment of risk dimensions

HAZARD - Description of type of driver factors

1. Driver factors that influence hazard

The hazard is influenced by driver factors of both "natural" and "human" categories. Natural factors determined by specific site conditions (such as topography, soil structure), vegetation types and growth / density, and characteristics of the meteorological event (i.e. heavy intensity rainfall). Human factors determined by land use which influences the discharge rate (e.g. large urbanization reduces flood propagation times and infiltration rates and, consequently, increases peak runoff rates).

2. Climate change impacts

- Precipitation: according to the EEA (2017)[8], extreme weather and climate-related events that result in hazards such as floods and droughts will become more frequent and intense in many regions and impacts related to changes in precipitation, notably heavy precipitation events leading to floods and landslides, are projected to increase further in the future. Pluvial floods and flash floods, which are triggered by intense local precipitation events, are likely to become more frequent throughout Europe, while in regions with projected reduced snow accumulation during winter, the risk of early spring flooding could decrease.
- Tree health (decrease of tree health due to effects of drought and pest and disease infestations).
- Degree of species mixture (shift in species composition, first die off of less adapted tree species => increase in risk; then regrowth with more adapted species).
- Tree species composition.

HAZARD - Description of measures (type and phase)

Measures to address those factors are predominantly "Technical measures" and "Risk governance and policy" related to land use, but also "Technical measures" related to silviculture and forest management. They all take place in the "Prevention" phase of the risk management cycle.

[8] European Environment Agency, 2017. Climate change, impacts and vulnerabilities in Europe 2016: an indicator-based report. ISBN 978-92-9213-835-6 (https://www.eea.europa.eu/publications/climate-change-impacts-and-vulnerability-2016).

HAZARD - Description of stakeholders and actions

Land planners are involved in most measures to reduce the intensity of the hazard and therefore risk and also to prevent new risk. The majority of measures aims at integrating the understanding of the local risk situation into different planning (included Civil Protection planning) and at reducing the intensity of the hazard. Local authorities respect and control compliance with existing regulations.

EXPOSURE - Description of driver factors

The overarching objective of this risk assessment is Civil Protection, the driver factors that influence the dimension exposure reflect well the elements at risk - as well as the elements at risk identified by the EU Floods Directive (2007/60/EC) - and appeared in the following categories: population (2), critical facilities (3), buildings (2), economic activities (3), infrastructure and environmental services (3). The risk is highly influenced by the presence of elements at risk in areas affected by the hazard process (identified by the floods hazard maps for each return period according to the EU Floods Directive plus critical local hot spots).

Generally two types of damages can be discerned: direct damage, which have an immediate impact during or shortly after the hazard event, such as buildings be flooded or loss of lives, or secondary damage, resulting from indirect damages due to interruption of the day-to-day functioning of society, such as the disruption of economic activities due to road damages in the aftermath of a hazard event or such as the disruption of schools activities. Moreover, it has been considered also the possible accidental pollution cascade effect in case of critical plants.

The presence of people and tourists, settlements, economic activities, cultural heritage, critical facilities, infrastructures etc. in flood prone areas and the amount, value, and importance of them influence the level of risk.

EXPOSURE - Description of measures (type and phase)

Non-forest management related measures take place during all phases of the RMC, except the Recovery phase, and almost all of them are aimed at properly assessing and mapping exposure and avoiding the presence of people in case of a forecasted event by safe evacuation / temporary relocation (e.g. high safe places, closing schools, etc.).

Most components of DRR are covered and reached from define, train and implement safe evacuation / temporary relocation protocols activated by early warning (risk assessment, mapping and planning tools, risk culture and communication and emergency management and response capacity), assess and map exposure (risk assessment, mapping and planning tools), to land use zone and relocation policy (risk governance and policy).

No forest management related measures to reduce exposure have been identified.

EXPOSURE - Description of stakeholders and actions

Apart from forest managers, analyzing the involved stakeholders and their respective activities shows that for many driver factors (e.g. amount of neighbourhoods and population in flood-prone areas or presence and importance of critical facilities) multiple stakeholder groups at different territorial level and with different competencies are involved and active, included the exposed people themselves. This indicates that good collaboration and communication is needed to effectively address this factor as a subsidiary system and that exposed people should be part of the DRR process. Moreover, the factor 'importance of facilities' explicitly mentions the necessary collaboration of stakeholder groups with risk assessment authorities and Civil Protection authorities, also to elaborate guidelines for the exposure assessment and mapping.

VULNERABILITY - Description of type of driver factors

Driver factors influencing vulnerability reflect well the identified elements at risk, as seen in the categories population (7), economic activities (5), infrastructure (2), buildings (3), critical facilities (5) and environmental services (1).

Reducing vulnerability in the category population is twofold: raising risk awareness and risk culture also in terms of early warning (even considering tourists and visitors) and strengthening Prevention / Preparedness / Response and Recovery capacities (including "build-back-better" capacity) of the Civil Protection system at all the levels, including the capacities of Civil Protection planning and early warning.

Factors in the other categories describe the properties of the elements and their capacities to withstand direct (physical structure of buildings) damages, also taking into account the existence of protective measures, to maintain operationality and to withstand to secondary damages (financial reserves of businesses).

VULNERABILITY - Description of measures (type and phase)

Non-forest management related measures take place during all the phases of the RMC, mostly in Prevention, Preparedness and Response. The majority are risk assessment, mapping and planning tools, risk culture and communication, technical measures and emergency management and response. Some measures aim at recovery of economic activities and infrastructure and at disaster loss data collection.

Two central measures to reduce the vulnerability of people and critical facilities (such as schools and health care facilities) for floods are related to the co-design of the Civil Protection plan with all the relevant stakeholders and authorities, to be integrated with all the other related protocols and internal emergency plans and to be trained and properly developed and supported by an early warning system effective in all its components of forecasting, monitoring and information dissemination, at all the territorial levels involved. Moreover, another important measure for the Civil Protection purpose is to pointly assess and map vulnerability of all the categories to plan more territorial suited and effective actions.

Apparently, only few driver factors can be related to forest management and they refer to environmental services. All of them should take place during the Prevention phase and focus on technical measures.

VULNERABILITY - Description of stakeholders and actions

Most driver factors are addressed by several stakeholder groups at different territorial levels, which makes good coordination, collaboration, and communication crucial. Often, one stakeholder takes a leading role in the development / implementation of the measure and relies on the contribution of others. In other cases, such as for the EWS, the implementation of actions is characterized by a subsidiary and coordinated activation among different stakeholders. Even for vulnerability driver factors, the exposed population itself should have an active role in the implementation of many of the measures identified.

4.3 Storms

General description of hazard process

Storm causes threat of falling trees on humans and infrastructure. The resulting risk needs to be assessed, analyzed, evaluated and managed.

Assessment of risk dimensions

HAZARD - Description of type of driver factors

1. **Driver factors that influence hazard**

Mostly driver factors of category “natural”, determined by specific site conditions (such as topography, soil structure, degree of usual exposure to wind), forest composition and tree health, and characteristics of the meteorological event (i.e. critical wind speed and precipitation prior to the event).

2. **Climate change impacts**

- Precipitation (more during winter months in form of rain instead of snow).
- Critical wind speeds (increase in maximum wind speeds and increase in frequency of storm days).
- Tree health (decrease of tree health due to effects of drought and pest & disease infestations).
- Degree of species mixture (shift in species composition, first die off of less adapted tree species => increase in risk; than regrowth with more adapted species).
- Tree species composition.

HAZARD - Description of measures (type and phase)

Measures to address those driver factors are predominantly “Technical measures” related to silviculture and forest management. They almost all take place in the “Prevention” phase of the risk management cycle.

HAZARD - Description of stakeholders and actions

Forest managers are involved in most measures to reduce the hazard and therefore risk. The majority of measures aims at integrating the understanding of the local risk situation and preventing the hazard. Local authorities control compliance with existing regulations.

EXPOSURE - Description of driver factors

The overarching objective of this risk assessment is Civil Protection, the driver factors that influence the dimension exposure reflect well the elements at risk and appeared in the following categories: population (3), infrastructure (2), economic activities, buildings, critical facilities, and environmental services. The risk is highly influenced by the presence of elements at risk in areas affected by the hazard process. Generally two types of damages can be discerned: direct damage, which have an immediate impact during or shortly after the hazard event, such as a tree hitting a building, or secondary damage, resulting from indirect

damages due to interruption of the day-to-day functioning of society, such as the disruption of economic activities due to road blockages in the aftermath of a hazard event. The distance of forests and trees to urban areas influence level of risk, e.g. proximity to settlements and highly frequented infrastructure increases risk of direct and indirect damage by falling trees. The presence of persons e.g. recreation/tourism or commute to work have influence on the level of risk as well and is influenced for example by the time of day.

EXPOSURE - Description of measures (type and phase)

Forest management related measures to reduce exposure are all 'technical measures', which take place during the Prevention phase. Either they aim at excluding the exposed element, e.g. through closing off forest roads and putting signs to keep people out of forests or by excluding the hazard e.g. through creating tree free buffer strips along highly frequented roads.

Non-forest management related measures are more diverse and take place during all phases of the RMC, except the Recovery phase. Most components of DRR are covered and reach from media dissemination and official declaration of early warning (risk culture and communication and emergency management and response capacity), insurance of storm damages (technical measures), identification and rating of critical infrastructure (risk assessment, mapping and planning tools), to regulations and building codes (risk governance and policy).

EXPOSURE - Description of stakeholders and actions

Analyzing the involved stakeholders and their respective activities shows that for some driver factors (e.g. number of people in the forests) multiple stakeholder groups are involved and active. This indicates that good collaboration and communication is needed to effectively address this factor. The factor ‘importance of facilities’ explicitly mentions the necessary collaboration of stakeholder groups with risk assessment authorities. In contrary, other factors show that no stakeholder group is actively involved (e.g. time of the day), which means that the factor can hardly be influenced. In general, focus should be put on factors that can be influenced.

VULNERABILITY - Description of type of driver factors

Driver factors influencing vulnerability reflect well the identified elements at risk, as seen in the categories population (5), economic activities (2), infrastructure (2), buildings, critical facilities and environmental services. Reducing vulnerability in the category population is twofold: first, raising risk awareness and information sharing and second, through protective measures and strengthening of response capacities. Factors in the other categories describe the properties of the elements and their capacities to withstand direct (physical structure of buildings) or secondary damages (financial reserves of businesses).

VULNERABILITY - Description of measures (type and phase)

Apparently, only few driver factors are and can be addressed by forest management. Most of them should take place during the preparation phase and focus on emergency management and response capacities.

Non-forest management related measures are more diverse and also take place mostly during the preparation phase of the RMC. The majority are 'emergency management and response capacity' components of DRR that take also place during the Response phase of the RMC. Some measures aim at recovery of economic activities and infrastructure.

VULNERABILITY - Description of stakeholders and actions

Forest managers contribute with local and forest-related knowledge and participate in the development of a crisis management plan and regular trainings of emergency situations.

Obvious is again that most driver factors are addressed by several stakeholder groups, which makes good collaboration and communication crucial. Often, one stakeholder takes a leading role in the development / implementation of the measure and relies on the contribution of others.

4.4 Avalanches

General description of hazard process

Snow avalanches are a natural phenomenon that can affect people, villages, facilities, mountain resorts, properties, the environment, economic services, and infrastructure. Therefore, this natural risk must be evaluated and analyzed for a better understanding of the phenomenon at the spatial and temporal level that allows effective risk management.

Assessment of risk dimensions

HAZARD - Description of type of driver factors

1. Driver factors that influence hazard

The types of driver factors that influence the danger of snow avalanches are those described in the following order of importance: snowpack structure (snow strength, weak layers, internal instability, crystalline bonds, friction between layers among others), terrain (topography, steepness, altitude, aspect, geomorphology, rugosity and vegetation), overloads (people, animals, wind drift, snowfalls, rain, etc.) and weather conditions (precipitation type and intensity, air temperature, wind direction and speed, humidity, sky cover and solar radiation.) and climate change impacts.

2. Climate change impacts

- Snowpack: climate change is expected to affect the duration (days) and thickness (cm) of the snowpack during future winter season.
- Terrain: in a context of global warming, some variations on the prone terrain to avalanches are expected to appear in future. Vegetation helps to fix the snowpack and a more homogeneous distribution, and roughness. In this sense a greater number of forest fires would increase the erosion of the terrain and thus increase the probability of avalanche triggering. Furthermore, the natural forest growth could affect the altitudinal zonation of vegetation and the type of forest. Some species have different behaviour concerning avalanche triggering: some recovers more rapidly than others, some are more flexible when are affected by avalanches while other breaks and “die” and are difficult to grow again.
- Weather: in the context of climate change both the intensity of precipitation and the increase of temperatures affect the probability of extreme events (different return period) and the type of avalanche problems (wet snow and avalanche glides). Other weather driver factors must be also considered and their role in the climate change context.

HAZARD - Description of measures (type and phase)

Forecasting and mapping are the first step for Prevention phase. The most appropriate measures that allows forecasting and mapping is “monitoring”: recording snowpack information, knowledge of prone avalanche terrain and recording weather and snow information. This monitoring can be both manual data as far as automatic data in some specific cases. Avalanche forecasters and cartographers have and important role in these two main issues (forecasting and mapping) as far as the setup of a) observer’s

networks for avalanche works during the winter season, and b) automatic devices and sensor networks to record some data automatically. Forecasting and mapping allow to determine when and where avalanches occur, and networks and specialists allow to monitor all the driver factors influencing the hazard. Deep knowledge on avalanche behaviour as far as high level avalanche data allow avalanche modelling that is also a second step in Prevention. Avalanche protection methods and strategies (that includes protective forest management among others) have also an important role in reducing the level of risk.

HAZARD - Description of stakeholders and actions

Hazard is a dimension of risk that must be assessed and managed through an integrated and interdisciplinary vision. Forest managers, land planners, Civil Protection authorities, risk managers, police, local authorities and private sector play a key role in the snow avalanche risk Prevention phase. Most prevention measures are focused on forest management, assessment, and monitoring of the state of the snowpack, the terrain, weather conditions and possible triggers, and finally, structural measures to protect against snow avalanches.

EXPOSURE - Description of type of driver factors

The exposure determines the elements of the risk territory that are likely to be affected, in this case, by a snow avalanche. The elements exposed to snow avalanche risk are on one hand the population and, on the other hand, infrastructure, buildings, critical facilities, economic activities, and environmental services, which must be managed through appropriate land use and urban planning.

The driver factors that affect population are: the exposure of citizens, workers, tourists and visitors in a risk area, knowledge about the risk and access to information, the day of the week and time of day, the behaviour and attitude towards risk and the existence (or not) of Civil Protection plan (including evacuation). Other factors are the presence of infrastructures (ski resorts, mountain tourism services, communication, meteorological and snow stations), buildings (mountain huts, refuges, cottages, shelter buildings, other buildings or small restaurant inside ski resorts), critical facilities (roads, train, rack railway; electric powers, explosives, water contains, reservoirs), economic activities (hotels, hostels, ski resorts, mountain tourist activities, mountain guiding) and environmental services (forest management, wildlife control and management, hunting, avalanche forecast control, weather and climate measurements). Finally, well-worked and consolidated territorial and urban plans for the management of infrastructures, constructions, critical facilities, economic activities, and environmental services, are crucial to reduce risk exposure (or enlarge it in case of lack of these plans).

EXPOSURE - Description of measures (type and phase)

Measures related to forest management are non-existent in this risk dimension (exposure), since the presence or absence of a forest does not help to reduce the exposure of the population, infrastructure, buildings, and critical facilities. In any case, the presence of a forest area helps to reduce vulnerability.

Instead, we have a diverse set of prevention and preparedness measures that help reduce exposure. These measures are described below: risk governance and policy measures, such as the avalanche safety programs (regulation of access to risk areas, safety signs), risk assessment measures (avalanche terrain assessment

and data, land use restrictions), risk culture and communication measures (public dissemination of snow avalanche forecasting, generating scientific knowledge and information, training and education on snow avalanches and behaviour guidelines) and emergency management measures and response capacity measures (evacuation plan).

EXPOSURE - Description of stakeholders and actions

As in the hazard dimension, in the exposure dimension there must be an integrated and interdisciplinary vision of the actions to be developed, so that many stakeholders are involved in the development of specific actions (forest managers, land planners, risk assessment authorities, Civil Protection authorities, police, exposed population, local authorities/municipalities, private sector, risk managers, etc.). These specific actions are cutting roads, installing signs, preparing hazard maps, behavioural guidelines, training and generating information and knowledge, etc.

VULNERABILITY - Description of type of driver factors

Vulnerability is the third dimension of risk, which analyzes the losses that a certain risk can generate in the system and its resilience. The driver factors that directly influence vulnerability are the following: a) the level of information, knowledge and preparedness of the population (low information, low knowledge and preparation, in relation to avalanche risk, benefit greater vulnerability), b) the speed of response to an emergency situation (a quick identification of the affected area during an emergency benefits efficient management of the situation and reduces vulnerability), c) the general response capacity (vulnerability depends on whether there is an action plan in case of warning and emergency in avalanche situations), d) assistance to those affected during and after the emergency (for victims and relatives), and on the other hand, e) the snow avalanche protection systems that protect population, infrastructures, buildings, critical facilities, economic activities and environmental services. Finally, another factor is surveillance and maintenance during emergency situations of critical facilities (it is important to keep and safeguard critical facilities in emergency situations).

VULNERABILITY - Description of measures (type and phase)

There are various measures to address the vulnerability generated by avalanche danger. Forest management measures (repopulation of the forest with Pinus uncinata), communication measures and risk culture are very important (booklets, education and training, public issue of the bulletin, information panels, etc.), management measures of risk, cartography and planning tools (Civil Protection plans ALLAUCAT in Catalonia, etc.), management measures and emergency response (use of avalanche safety gear), recovery measures (health care and psychology for victims and relatives) and finally technical measures (artificial triggering of avalanches with explosives, engineering works).

VULNERABILITY - Description of stakeholders and actions

Although avalanche risk management is led by the Civil Protection of Catalonia, numerous stakeholders are also involved. As we have seen previously, natural risk affects many elements of the territory: population, infrastructures, buildings, economic activities, etc., and so the participation of all those sectors that are likely to be affected by risk is very important when implementing the measures described above. Thus, forest managers, land planners, risk assessment and Civil Protection authorities, police, exposed population, local authorities, ski resorts, and risk managers have an important role in risk management and actions. Some examples are the following: First Avalanche warning services determine where and when avalanches occur through forecasting and mapping. Risk managers in ski resorts and road safety control evaluate and determine the areas where to trigger avalanches following protocols (i.e. PIDA). Civil Protection authorities disseminate avalanche information (forecasting and mapping) produce special warnings and are responsible to update this information. Other risk managers authorities must review and control the implement and the update (if necessary) of all the actions, protocols, and methods. Finally, local authorities and private sectors (ski resorts) has the local control in their area and disseminate avalanche forecasting. Non-profit organizations are more focused in avalanche training (including self-rescue protocols).

The conclusion is that the diversity of actors involved must provide an integrated view of risk management (from general overview to local managers). Therefore, multiple coordinated actions should be generated to reduce hazard, exposure, and vulnerability and thus the mitigation of the potential impact that a major avalanche event can produce.

4.5 Landslides

General description of hazard process

Within RECIPE Project we focus on spontaneous, rapid mass movements in the loose material layer – we call them spontaneous soil slides-.

Landslides endanger people, buildings, and infrastructure in three ways: firstly, through erosion in the triggering area, secondly through the pressure during the (fast) movement of the mass, and thirdly through burring, both in the transmission and deposition zone. The resulting risk needs to be assessed, analyzed, evaluated and managed.

Assessment of risk dimensions

HAZARD - Description of type of driver factors

1. **Driver factors that influence hazard**

The most important driver factors for triggering landslides are meteorological: heavy precipitation or long lasting (>24h) precipitation events leed to high soil moisture contents (reduced internal friction angle, higher weights) and high pore water pressure. Anyhow the topographical conditions are important for the occurrence-probability of landslides; namely the slope inclination (landslides occurs predominantly between 20° and 45°) and the horizonal and vertical slope structures (influence the disposition and the range). Furthermore, geological conditions (kind and thickness of the loose material layer) and the vegetation (e.g. stabilisation via roots of forests) influence the landslide susceptibility of slopes.

2. **Climate change impacts**

- High altitudes: increased prone of landslides because of thawing permafrost areas due to rising temperature.
- Medium to low altitude areas: more landslides and shift of events to the winter half-year due to increased precipitation events and reduced solid fraction (snow), especially in Central and North Europe.
- South Europe, low to medium altitudes: due to higher temperatures and precipitation sums hazard of landslides tending to decline equal to reduced.
- Generally: unexpected landslides events (time, situation), which differ from past observations or have not been observed so far.

HAZRAD - Description of measures (type and phase)

Measures to reduce the hazards caused by landslides are mainly biological and technical. Biological measures are the adaption of silviculture/forest management that almost covers the Prevention phase of the RMC. Technical Measures like (temporary) protective structures face the Preparedness phase of the risk management cycle.

HAZARD - Description of stakeholders and actions

Forest managers are involved in most biological measures to reduce the hazard and thus the risk. Risk assessment authorities are responsible for the event documentation, analysis and for the creation of hazard index maps, as well as for planning of protective structures. Local authorities control compliance based on existing regulative tools (danger zone plans, spatial planning).

EXPOSURE - Description of driver factors

The overarching objective is Civil Protection. The risk is highly influenced by the presence of elements at risk in areas affected by the hazard process. The driver factors that influence the dimension exposure reflect the elements at risk and appeared in the following categories: population, infrastructure, economic activities, buildings, technical protective structures, critical facilities, and environmental services. Basically, two types of damages can be distinguished: direct damages, which have an immediate impact in or shortly after the hazard event (e.g. damage to buildings due to pressure). And secondary damages, resulting from indirect damages due to interruption of the day-to-day functioning of society, such as the disruption of economic activities due to the destruction of a road section by landslide.

Beside the cubature and the speed of the moving landslides, topographical conditions are responsible for the extent of the transport length as well as the deposit area. The combination with the spatial proximity of infrastructure and the frequency of its use play is very important for risk assessment, the presence of persons strongly influences the level of risk.

EXPOSURE - Description of measures (type and phase)

It is widely recognized that forests can stabilize steep slopes. Field studies and scenario modelling showed that landslide densities were lower in forested terrain than in open land and occurred on steeper slopes. Therefore, protective forest management related measures to reduce exposure are mainly 'biological measures', which take place during the Prevention phase. (e.g. identification of forest areas with important protective effects and adapt management to ensure vital, well-structured, and site-adapted forests, which stabilize the soil and increase the evapotranspiration (reduction of soil-water contents)).

Non-forest management related technical measures take place during all phases of the risk management cycle, except the Recovery phase. Technical measures (e.g. slope stabilization, slope draining, dams) and early warning systems have proven their worth.

Other components of disaster risk reduction are depending on risk culture and communication, emergency management and response capacity, identification, and rating of critical infrastructure (risk assessment, mapping, and planning tools) and regulations and building codes (risk governance and policy).

EXPOSURE - Description of stakeholders and actions

A look at the involved stakeholders and their respective activities shows that for some driver factors (e.g. number of people in endangered areas) multiple stakeholder groups are involved. This indicates that clear responsibilities, good collaboration, and communication are needed. Unfortunately, in Austria there is no

uniform regulation of responsibilities for taking measures against landslide-hazards. That is why some institutions work side by side (geological services, torrent and avalanche control division, road companies).

VULNERABILITY - Description of type of driver factors

Driver factors influencing vulnerability reflect the identified elements at risk, as seen in the categories population, economic activities, infrastructure, buildings, critical facilities and environmental services and technical protective structures.

Reducing vulnerability in the category population means to avoid susceptible areas by use of foresighted settlement development (according to hazard index maps). Raising risk awareness and information sharing (can) improve the situation.

VULNERABILITY - Description of measures (type and phase)

Biological measures are implemented by a specific and small-scale designation of forest management of property protection forests. Hence precise regulations for a suitable forest management of these forest areas are necessary.

Technical protective measures with proper, terrain-adapted constructions and strengthening of response capacities are other important factors.

Improvement and use of well-founded risk assessment methods are important as well as good communication between science, practice, and decision makers. Local authorities have an important role in emergency management and response capacity components of the disaster risk reduction. They must be prepared to manage crisis teams. Periodic updating of the crisis plans and communication with all event-relevant actors and communication with higher-level departments as well as promotion of trainings are needed.

VULNERABILITY - Description of stakeholders and actions

Most driver factors are addressed by several stakeholder groups, which makes good collaboration and communication crucial. Mainly, decisions are made on a case-by-case basis. Various stakeholders are then used to prepare expert opinions. Often, one stakeholder takes a leading role in the implementation of the measures.

Land planners integrate areas with identified protective effects in land-use planning and settlement development projects (according to hazard maps).

Forest managers contribute with local and forest-related knowledge.

4.6 Rockfalls

General description of hazard process

In RECIPE we focus on rockfalls with volume <100 m^3 and negligible interaction between rocks during an event.

Rockfalls often occur “surprising” as single events, they are usually not predictable (temporal occurrence). The endangerment of people (in the Alps) is comparatively high due to the high exposure due to intensive touristic activities and its occurrence even if the weather is nice. The resulting risk needs to be assessed, analyzed, evaluated and managed.

Assessment of risk dimensions

HAZARD - Description of type of driver factors

1. **Driver factors that influence hazard:**

Triggering driver factors of rockfalls are diverse. Earthquake, water, ice, storms, and vegetation growth are the final forces that cause unstable rocks to fall.

2. **Climate change impacts**

Geomorphic responses to climate change are complex and highly variable spatially and temporally. Heavy precipitation, freeze-thaw change, and storms are to be considered. While the rise of temperature and thus the rise of the permafrost line is a fact, the development of the other climatic parameters and its influence on rockfalls is insecure. The change of (climate) conditions usually leads to instabilities of systems. Hence for rockfalls it can be concluded:

- High altitudes: increased prone of rockfalls frequency because of permafrost degradation areas due to rising temperature.
- Other areas: regional differences in the impact of the climate change may occur, but no significant increase of rockfalls frequency overall.
- Generally: shift of rockfalls active zones to higher altitudes and main activities earlier in the year.

In addition, so-called cascade effects triggered by climate change can also play an important role, e.g. wind throws lead to destabilization of rocks due to loosing up the soil and hence increase rockfall frequency.

EXPOSURE - Description of measures (type and phase)

Measures to reduce the hazards caused by rockfalls are mainly biological and technical. Biological measures are the adaption of silviculture/forest management that almost covers the Prevention phase of the risk management cycle. Technical Measures like protective structures face the Preparedness phase of the RMC.

EXPOSURE - Description of stakeholders and actions

Forest managers are involved in most biological measures to reduce the hazard and thus the risk. Risk assessment authorities are responsible for the event documentation, analysis and for the creation of hazard index maps, as well as for planning of protective structures. Local authorities control compliance based on existing regulative tools (danger zone plans, spatial planning).

EXPOSURE - Description of driver factors

The overarching objective is Civil Protection. The risk is highly influenced by the presence of elements at risk in areas affected by the hazard process. The factors that influence the dimension exposure reflect the elements at risk and appeared in the following categories: population, infrastructure, economic activities, buildings, and technical protective structures.

Basically, two types of damages can be distinguished: direct damages, which have an immediate impact during the hazard event (e.g. damage to buildings, injury to hikers). And secondary damages, resulting from indirect damages such as the disruption of economic activities due to the destruction of a road section by deposited rocks.

Beside the total cubature and the cubature of the individual rocks topographical conditions are responsible for the extent of the transport and deposition zone. The overlapping with infrastructure and the frequency of its use is very important for the risk assessment, the presence of persons strongly influences the level of risk.

EXPOSURE - Description of measures (type and phase)

Forests protect against rockfalls or mitigate the consequences. Therefore, protective forest management are mainly 'biological measures', which take place during the Prevention phase (e.g. identification of forest areas with protective effects and adaption of their management to ensure vital, well-structured, and site-adapted forests).

Non-forest management related technical measures take place during all phases of the RMC, except the Recovery phase. Technical measures as rockfall protection barriers, rockfall nets or deflection dams are used.

Other components of DRR are depending on risk culture and communication, emergency management and response capacity, identification, and rating of critical infrastructure (risk assessment, mapping, and planning tools) and regulations and building codes (risk governance and policy).

EXPOSURE - Description of stakeholders and actions

A look at the involved stakeholders and their respective activities shows that for some driver factors (e.g. number of people in endangered areas) multiple stakeholder groups are involved. This indicates that clear responsibilities, good collaboration, and communication are needed, since often different institutions work side by side (geological services, torrent and avalanche control division, road companies).

VULNERABILITY - Description of type of driver factors

Driver factors influencing vulnerability reflect the identified elements at risk, as seen in the categories population, infrastructure, economic activities, buildings and technical protective structures. Reducing vulnerability in the category population means to keep as many people as possible out of endangered areas. This could be done by avoiding susceptible areas by use of foresighted settlement development (according to hazard index maps), and temporal closing of roads, trails, etc.

Raising risk awareness and sharing communication and implementation of evacuation plans are other important components.

VULNERABILITY - Description of measures (type and phase)

Biological measures are implemented by a specific and small-scale designation of forest management of property protection forests. Hence precise regulations for a suitable forest management of these forest areas are necessary.

Technical protective measures with proper, terrain-adapted constructions and strengthening of response capacities are other important factors. Documentation and analysis of events, that have occurred already, and hazard index maps are essential, as well as a good way of communication between science, practice, and decision makers. Local authorities are of great importance in emergency management and response capacity. They must be prepared to manage crisis teams. Periodic updating of the crisis plans and the check of communication with other event-relevant actors, communication with higher-level departments as well as promotion of trainings are needed.

VULNERABILITY - Description of stakeholders and actions

Most driver factors are addressed by several stakeholder groups, which require good collaboration and communication. Mainly, decisions are made on a case-by-case basis. Various stakeholders are then used to prepare expert opinions. Forest managers contribute with local and forest-related knowledge.

5. Summary of risk driver factors of hazard, exposure and vulnerability per each natural risk analysed

In this chapter are listed the risk driver factors of hazard, exposure and vulnerability identified in each natural hazard analysis (Table 3-10).

Results show how in all cases risk driver factors for each dimension have been described according the methodology, with the corresponding risk mitigation measures and related stakeholders. Comparing the results among natural hazards, similarities in terms of risk drivers are found, but also specificities according each natural risk.

Globally, the information compiled in the matrix is a good point of departure to carry out the next project steps regarding how this risk factors interact with Civil Protection system, with the expected impact of climate change and how they can be integrated into platforms for decision-making:

- About Civil Protection system, all risk dimensions are human influenced, overall exposure and vulnerability. Also in the case of wildfire, hazard dimension includes several human risk factors both in terms of ignition risk and, more especially, spread capacity of fire towards high intensity fire behaviours, which indicates the socionatural dimension of the hazard. In all cases have been distinguished the local population from the visitors/tourist, which has relevance in terms of risk culture and emergency management capacity.
- Regarding climate change impacts, all natural hazards are heavily influenced by meteorological phenomena, directly (rainfall or wind intensity) or indirectly (effects of drought in fuel availability to burn). This means that climate change could be also considered as a factor in all risk dimensions since could modify the intensity of the hazard. Regarding the exposure, could include new elements at exposure (e.g. new fire prone areas as North Europe) and in consequence, also could appear new vulnerabilities.
- In most of cases, risk driver factor related to data availability and management are mentioned, especially related to copying capacity, highlighting the importance of DSS into risk management.

From a methodological point of view, results also shows that not in all cases the risk dimensions have been developed at the same level, especially regarding exposure and vulnerability. Within exposure, normally the “exposed element” is highlighted.

In the case of vulnerability, some factors are referred to the attributes of the exposed elements. Nevertheless, other factors are very similar to risk mitigation measures. For instance, in the case of High intensity fires in a Mediterranean context (Table 5), risk factors considered in exposure and vulnerability are the same, developing the riks mitigation measures in each case towards less exposition or vulnerability of the corresponding factor.

These apparently disfunctions of the methodology show the difficulties of achieving a common understanding when dealing with risk analysis, even within the expert community. And it is a result itself as part of the task objectives. According the work plan, matrix and risk analysis method will be fine-tuned in the next project steps, also with the participation of external experts.

Table 3. Hazard, exposure, and vulnerability driver factors for Forest fires and Wildland Urban-Interface fires

Driver factors		
Hazard	**Exposure**	**Vulnerability**
- High Forest stand density and fuel continuity. - Heat waves. - Drought. - Wind. - Presence of trees under electric lines. - Proximity to agricultural and pastoral practices. - Proximity to the tourist areas.	- Presence of houses in WUI areas. - Tourists and visitors in forest/WUI areas/beaches and tourist resorts. - Presence of Schools and Health Care facilities. - Number of Mobility infrastructures and essential services (electricity, water, telephony, ports, airports, roads). - Number of Plants at risk of major accidents. - Presence of Protection function of forest cover. - Presence of aesthetic value and recreational value.	- Existence of non-structural measures for coping. - Risk awareness. - Information dissemination. - Response capacity. - Duration of initial and secondary impacts. - Dependency on intact forest ecosystems.

Table 4. Hazard, exposure, and vulnerability driver factors for High intensity fires with extreme fire behavior

Driver factors		
Hazard	**Exposure**	**Vulnerability**
- Forest stand high density and fuel continuity. - Heat waves. - Long and severe drought periods. - Strong winds. - Ignitions under electric lines. - Unstable atmosphere. - Steep slope. - South and West Orientation of the slope.	- High population size. - High density of settlements. - High affluence of tourists. - Presence of priority habitats. - Presence of rural activities such as agriculture and livestock.	- Presence of priority habitats. - Presence of rural activities such as agriculture and livestock. - High number of inhabitants with little knowledge on fire response. - Critical settlements. - Low risk awareness of tourists.

Table 5. Hazard, exposure. and vulnerability driver factors for High intensity fires in a Mediterranean context

Driver factors		
Hazard	**Exposure**	**Vulnerability**
- Forest stand density and fuel continuity. - Heat waves. - Drought. - Wind. - Ignitions under electric lines. - Other human ignitions. - Ignitions during cereal harvest period.	- Neighbours and homeowners in WUI areas. - Tourists and visitors in forest/WUI areas/beaches and tourist resorts. - Protection function of forest cover. - Provision of forest goods and other Environmental services. - Firefighters.	- Neighbours and homeowners in WUI areas. - Tourists and visitors in forest/WUI areas/beaches and tourist resorts. - Protection function of forest cover. - Provision of forest goods and other Environmental services.

Table 6. Hazard, exposure, and vulnerability driver factors for Flash floods

Driver factors		
Hazard	**Exposure**	**Vulnerability**
- Land use. - Heavy rain fall. - Topography. - Vegetation. - Soil structure. - Climate change.	- Amount of neighbourhoods and homeowners in flood-prone areas. - Number of tourists and visitors in flood prone areas. - Presence and importance of strategic buildings in flood prone areas or exposed to other risks: Municipality Building, Fire Stations, Police Stations and Emergency Operation Centres (EOCs). - Importance of schools and health care facilities. - Presence and value of cultural heritage in flood prone areas. - Amount and values of buildings in flood-prone areas. - Presence and importance of infrastructures such as mobility infrastructures and essential services (electricity, water, telephony, ports, airports, roads). - Presence of plants that could cause accidental pollution in case of flood. - Presence of the agricultural sector in flood-prone areas.	- Early warning capacity of the system. - Existence of an effective Civil Protection plan. - Prevention / Preparedness / Response / Recovery capacities of technicians. - Risk awareness. - "Build back better" capacity. - Response capacity. - Risk awareness of tourists and visitors and information dissemination. - Existence of an effective internal emergency plan in affected areas. - Existence of protective structures. - Financial capacity or securities to recover from negative impact of hazard event. - Operationality maintenance of the Municipality Building, Fire Stations, Police Stations and Emergency Operation Centres (EOCs). - Type and quality of buildings. - Type and quality of infrastructure. - Type of agricultural sector and practice.

	- Presence and importance of the productive sector in flood-prone areas. - Presence of critical environmental services such as biodiversity (vegetation and wildlife). - Presence of critical environmental services such as aesthetic value and recreational value. - Presence of critical environmental services such as water quality and retention.	- Type and quality of environmental service.

Table 7. Hazard, exposure, and vulnerability driver factors for Storms

Driver factors		
Hazard	**Exposure**	**Vulnerability**
- Tree height. - Soil structure. - Topography. - Precipitation. - Degree of usual exposure to wind. - Distance of trees from elements at risk. - Critical Wind Speed (CWS). - Tree health. - Degree of tree species mixture. - Tree species composition.	- Number of people outside in forested areas, places and roads close to trees (e.g. forest visitors / doing recreational activities, commuters. - Proximity to urban areas. - Time of day / day of the week. - Direct and indirect economic impact of disaster. - Direct damages to infrastructure. - Importance of infrastructure. - Amount and value of buildings in hazard prone area. - Importance of facilities. - Presence of critical environmental services.	- Risk awareness in population. - Information dissemination. - Existence and conditions of protective structures along infrastructure (e.g. walls or nets). - Reaction time to identify and secure area of damage. - General response capacity. - Financial capacity or securities to recover from negative impact of hazard event. - Duration of initial and secondary impacts. - Type and quality of infrastructure. - Response capacity. - Type and quality of buildings. - Operationality maintenance. - Dependency on intact forest ecosystems.

Table 8. Hazard, exposure, and vulnerability driver factors for Avalanches

Driver factors		
Hazard	**Exposure**	**Vulnerability**
- Snowpack. - Terrain. - Weather. - Overloading.	- Number of citizens, workers, public workers (forecasters, forestry guards, police, rescue teams, ...), tourists, visitors, mountaineers, climbers and hikers in mountain areas. - Access to information about avalanche risk and knowledge about avalanche risk. - Day of the week and time day. - Risk behaviour/attitude (uncertainty). - Evacuation Plan. - Ski resorts or mountain tourist services have infrastructures in mountain areas. Communication infrastructures. Automatic weather and snowpack monitoring stations in mountain areas. - Urban and land planning. - Mountain huts, refuges, cottages, shelter buildings, other buildings, or small restaurant inside ski resorts. - Hotels, hostels, ski resorts, mountain tourist activities, mountain guiding. - Forest management, wildlife control and management, hunting, avalanche forecast control, weather and climate measurements.	- Information, knowledge and preparation of citizens, workers, public workers (forecasters, forestry guards, police, rescue teams, ...), tourists, visitors, mountaineers, climbers and hikers in mountain areas. - Speed of reaction to an emergency. - General response capacity. - Assistance during and after the emergency. - Avalanche protection systems. - Surveillance and maintenance during emergency crises.

Table 9. Hazard, exposure, and vulnerability driver factors for Landslides

Driver factors		
Hazard	**Exposure**	**Vulnerability**
- Antecedent and intensity of precipitation. - Temperature rise. - Earthquakes. - Deep seated mass movements. - Topography. - Geology, geomorphology, and lithology.	- Local and tourist presence and activity in endangered areas. - Stability and usability of buildings. - Usability and functionality of infrastructures. - Direct and indirect economic impacts of disaster. - Functionality of diverse protective structures (slope protection, drainage system, deflection structures).	- Local and tourist presence and activity in endangered areas. - Rescue workers present in the area. - Types and quality of buildings in affected areas. - Usability and functionality of infrastructures. - Functionality of diverse protective structures (slope protection, drainage system, deflection structures).

- Inadequate constructions. - Starting, transportation and deposition zones.		- Economic activities disrupted (industry, agriculture…).

Table 10. Hazard, exposure, and vulnerability driver factors for Rockfalls

Driver factors		
Hazard	**Exposure**	**Vulnerability**
- Temperature rise. - Storms. - Heavy (intense) precipitation. - Earthquakes. - Inadequate constructions. - Deep seated mass movements. - Starting, transportation and deposition zones.	- Local people and tourist in endangered areas. - Stability and usability of buildings. - Usability and functionality of infrastructure. - Direct and indirect economic impact of disaster. - Functionality of diverse protective structures (rockfall nets, deflection structures).	- Local people and tourist in endangered areas. - Rescue workers present in the area. - Different types and quality of buildings. - Usability and functionality of infrastructure. - Functionality of diverse protective structures (rockfall nets, deflection structures). - Economic activities disrupted (industry, agriculture…).

A cross-analysis among natural hazards shows similar risk driver factors in many cases. They can be grouped in common categories of exposure and vulnerabitliy for risk managmenet.

From the initial categories list (see sub-Chapter 3.1), the following topics has been used to be able to integrate the Coping capacity and Risk cultural/behaviour and information, which were not considered at the beginning, to perform a more coherent classification:

- Life and properties (initial categories of Population and Buildings).
- Infraestructures and Critial facilities.
- Economic activity.
- Environmental services.
- Coping capacity.
- Risk culture/behaviour and information.

Table 11 presents the driver factors of exposure and vulnerability identified in all natural hazards' matrix grouped by the above mentioned categories. Life and properties and Coping capacity are the most represented.

The list of risk factors can potentially be used as a checklist for Civil Protection proposes. They can also be transferred to other natural risk management processes, learning from other natural hazards. At the same time, risk factors can facilitate risk analysis of multi-hazard situations, when two or more risk interacts or they happen as a cascade-effect (for instance, wildfires affecting forest cover and increasing, consequently, the risk of avalanches).

In further project steps, risk factor definition and classification will be fine-tuned, in order to compare them with the Civil Protection requirements, climate change impacts or DSS operability.

Table 11. Driver factors of exposure and vulnerability identified in all natural hazards analyzed grouped per topic

Life and properties
- Amount of neighbours and homeowners in affected areas (risk-prone).
- Tourist and visitors in affected areas (risk-prone).
- Presence of houses in affected areas.
- High population size.
- High density of settlements.
- Proximity to urban areas.
- Time of day/ Day of week.
- Amount and value of buildings in hazard prone area.
- Duration of initial and secondary impact.
- Type and quality of buildings and infrastructure.
- Urban and land planning.
- Stability and usability of buildings.
- Firefighters.
Infrastructures/Critical facilities
- Presence and importance of schools and health care facilities.
- Number of Plants at risk of major accidents.
- Presence of plants that could cause accidental pollution in case of flood (or other risks).
- Presence, number and importance of Mobility infrastructure and essential services (electricity, water, telephony, ports, airports, roads).
- Presence and importance of strategic buildings in risk-prone areas or exposed to other risks: Municipality Building, Fire Stations, Police Stations and Emergency Operation Centres (EOCs). As well as their operational maintenance.
- Importance of facilities.
- Type and quality of buildings and infrastructure.
- Direct impact to infrastructure.
- Duration of initial and secondary impact.
Economic activity
- Presence of rural activities such as agriculture and livestock in risk-prone areas.
- Presence and importance of the productive sector in risk-prone areas.
- Type of agriculture sector and practice.
- Direct and indirect economic impact of disaster (disrupter activities).
- Financial capacity or securities to recover from negative impact of hazard event.
- Duration of initial and secondary impact.
Environmental services
- Presence of Protection function of forest cover.
- Provision of forest goods and other environmental services.
- Presence of aesthetic value and recreational value.

- Dependency on intact forest ecosystems.
- Presence of priority habitats.
- Presence and value of cultural heritage in risk-prone areas.
- Presence of critical environmental services such as biodiversity.
- Presence of critical environmental services such as water quality or retention.
- Type and quality of environmental services.
- Forest management, wildlife control and management, hunting, avalanche forecast control, weather and climate measurements.
- Duration of initial and secondary impact.

Coping capacity

- Rescue workers present in the area.
- General response capacity.
- Early warning capacity of the system.
- Existence of an effective Civil Protection plan.
- Prevention/Preparedness/Response/Recovery capacities of technicians.
- "Build back better" capacity.
- Existence of an effective internal emergency plan in affected areas (risk-prone).
- Financial capacity or securities to recover from negative impact of hazard event.
- Existence and conditions of protective structures along infrastructures.
- Reaction time to identify and secure area of damage in an emergency.
- Evacuation Plan.
- Surveillance and maintenance during emergency crises.
- Existence and functionality of diverse protective systems and structures (slope protection, drainage system, deflection structures, rockfall nets…).
- Duration of initial and secondary impact.

Risk culture/behaviour and information

- Risk awareness in population.
- Information dissemination.
- High number of inhabitants with little knowledge on fire (risk) response.
- Low risk awareness of tourists and visitors.
- Access to information and knowledge about a risk.
- Risk behaviour/attitude (uncertainty).
- Information knowledge and preparation of the population.

6. Best Cases selection

Within RECIPE Project, the different european partners (from 5 different european countries) collected 22 examples of best cases (see Table 12, detailed fact sheets in Annex III).

These cases were analized according to the scope of implementation, the risk (or risks) studied and their focus on the RMC. All cases help to develop good field practices, published guidelines, training or other dissemination mateiral or create mobil app/software to help decision making process.

A total of 22 cases have been identified, including 12 related to wildfires, 7 to floods, 5 to avalanches, 3 to storms and 5 to rockfalls and/or landslides. A majority of the cases (12) were developed at EU scale and almost all of them (21) focused on the Prevention phase.

Table 12. Summary of best cases collected

ID	Best case name	Natural hazard	Category	Place	Brief Description
1	Interreg Sudoe OPEN2PRESERVE: Sustainable management model for the preservation of mountain open areas	Wildfires	R+D Project	Portugal, Spain and South France	The main objective of the OPEN2PRESERVE project is to connect current interdisciplinary scientific knowledge with technology and practical operation, in order to implement and assess combined techniques that guarantee the preservation of the ecosystem services linked to open spaces with high natural value.
2	Democratizing wildfire strategies. Do you realice what it means? Insights from a participatory process in the Montseny region (Catalonia, Spain)	Wildfires	Article	Catalonia, Spain	This paper presents a method to democratize wildfire strategies by incorporating social values about landscape in both suppression and prevention planning. It was done by reporting and critically reflecting on the experience from a pilot participatory process conducted in a region of Catalonia (Spain).
3	HEIMDALL project (Multi-Hazard Cooperative Management Tool for Data Exchnge, Response Planning and Scenario Building)	Wildfires, floods, landslides & rockfalls	R+D Project (Mobile app/web, Software/IT/DSS	Europe	HEIMDALL addresses the challenge of providing integrated tools for emergency planning and management, including the definition and sharing of multi-disciplinary scenarios, and addressing the needs of the involved first responders and relevant stakeholders in terms of interoperability, inter-organisational coordination and information sharing.
4	Trees that don't burn: Women in forest fire prevention	Wildfires	Field best case	Galicia, Spain	The project promotes training in the prevention of fires with an economic and social dynamism in the countryside. Thus, the project team gathered materials of different authors who, in their disciplines, reflect on the role of gender in preventing and fighting forest fires.
5	Toward Integrated Fire Management – Outcomes of the European Project FireParadox and Policy brief on Towards Integrated Fire Management	Wildfires	R+D Project, and Guidelines/training dissemination material	Europe	FireParadox approach was based on the paradox that fire can be both a “bad master and a good servant”. The outcome documents provide science-based knowledge that can assist policy makers to develop the necessary 'common strategies' to elaborate and implement integrated fire management policies.
6	Forest much more than trees (environmental education manual for forests)	Wildfires	Guidelines/training dissemination material	Portugal	Educational Manual about forests, environmental education and how to prevent forest fires. This manual was written to help teachers and educators to enhance on their students from all ages interest in the forest ecosystems.
7	Prevention of large wildfires using the fire types concept	Wildfires	Guidelines/training dissemination material	Europe	The handbook is an attempt to introduce the methodology of the Fire Types Concept as a prevention and pre-suppression tool. The main objective is to provide the knowledge for the integration of fire into forest planning and

					wildfire prevention so that it can be used as a tool to complement and support forest policies.
8	LIFE+Integration cost-effectiveness of the prevention fires in the planning and forest management	Wildfires	R+D Project	Catalonia, Spain	LIFE+DEMORGEST aims to reduce the vulnerability of the forests of Catalonia to large forest fires (GIFs), facilitating the adoption of new models of multifuncional forest management (ORGEST models) that include the production of various goods and services to promote the prevention of GIFs.
9	Forest fires in the alps. State of knowledge, future challenges and options for an integrated fire management	Wildfires	Guidelines/training dissemination material	Alpine areas	In the context of the EUSALP - EU Strategy for the Alpine Region, the Action Group 8 is aiming to improve risk management and adapting governance mechanisms by enhancing and valorizing existing cooperation structures.
10	Proterina C	Wildfires	R+D Project	Italy and France	PROTERINA-C focuses on issues linked to climatic change and its impacts on natural and anthropized environment, with special attention to hazard conditions induced by these changes.
11	PROTERINA3EVOLUTION	Floods	R+D Project (Mobile app/web)	Italy and France	Proterina-3Évolution aims at improving the capacity of institutions to both prevent and manage flood risk. The overall objective is to strengthen the response capacity to flood risk through an awareness-building process of institutions and communities.
12	LIFE PRIMES	Floods	R+D Project (Mobile app/web)	Italy	This project aims at reducing land and population damages caused by events like floods, inundations and sea storms which depend on intense meteorological phenomena that are becoming more and more frequent every day.
13	LIFE FRANCA- Flood Risk ANticipation and Communication in the Alps	Floods	R+D Project (Mobile app/web)	Italy	LIFE FRANCA is a European project that promotes flood risk anticipation and communication in the Alps through the analysis and modification of collective socio-cultural attitudes, decision-making practices and common perceptions of the environmental risks affecting the territory.
14	Avalanche Danger Bulletin (ADB)	Avalanches	Field best case, Guidelines/training dissemination material	Catalonia, Spain	The ADB describes: 1) basic avalanche danger information for the Catalan Pyrenees (showing 7 different nivo-meteorological regions), 2) detailed iconographic information for each nivo-climatic region, 3) detailed text base information for each nivo-climatic region.
15	Avalanche Database (AD) - Geoindex Avalanche Viewer	Avalanches	Field best case, Software/IT/DSS	Catalonia, Spain	The Avalanche data base of Catalonia and its viewer (Geoindex) integrates three shapes of avalanche information: 1) areas that may be affected by avalanches 2) recent avalanches observed since 1986 and 3) events of major

					avalanches coming from historical records and survey to mountain population.
16	PIDA (Intervention Plan for Triggering Avalanches) of Vallter (Catalonia)	Avalanches	Field best case, Guidelines/ training dissemination material	Catalonia, Spain	The PIDA (Avalanche Trigger Intervention Plan) regulates the artificial triggering of avalanches in ski resorts. It consists of triggering small, controlled avalanches deliberately and systematically as a preventive measure. It is carried out in areas prone to avalanches such as snowdrifted terrain or high-risk areas.
17	Tree species suitability maps	Storms	Software/IT/DSS	Baden-Württemberg, Germany	The project "Effect of climate change on forests in Baden-Wuerttemberg" produced tree species suitability maps and are used as a decision support tool to help forest managers during tree selection for climate adaption.
18	Storm Handbook – Coping with Storm Damaged Timber	Storms	Field best case, Guidelines/ training dissemina-tion material, Software/IT/DSS	Baden-Württemberg, Germany	The storm handbook offers a web-based collection of best practices regarding guidelines for coping with storm damaged timber.
19	SURE Project - SUstaining and Enhancing REsilience of European Forests	Multi-risk	R+D Project (Software/IT/DSS)	Baden-Württemberg, Germany	The project SUstaining and Enhancing REsilience of European Forests (short: SURE) is aiming at enhancing forest resilience and addressing disturbance related risks as an integral part of sustainable forest management through facilitating networking, learning and capacity building.
20	GreenRisk4Alps	Avalanches, floods, landslides & rockfalls	R+D Project (Software/IT/DSS)	Alpine areas	The overarching goal of GR4Alps is the development of forest based concepts to support risk management basing on forestry resources with respect to natural hazards and climate impacts.
21	ROCKtheALPS	Landslides & rockfalls	R+D Project (Software/IT/DSS)	Alpine areas	RockTheAlps has been specifically dedicated to the enhancement forest ecosystems service of rock fall protection in risk management and prevention policy.
22	MANFRED – "Management Strategies to adapt Alpine Space forests to climate change risks"	Floods, wildfires, landslides & rockfalls	R+D Project (Software/IT/DSS)	Alpine areas	MANFRED aims to further understanding of climate change impacts in the forestry sector in the Alpine Space region. The project brings together practitioners from neighbouring transnational regions and integrating these key stakeholders into project activities to support their work.

7. Final remarks

- The structured scheme followed for the risk analysis has been shown to be a useful tool to identify risk driver factors influencing hazard, exposure, and vulnerability. Moreover, the proposed scheme offers a correlation between risk drivers and the corresponding mitigation measures as well as the risk "community" understood it as the stakeholders involved in the risk management cycle (i.e., from Prevention to Recovery stages). However, some aspects need to be fine-tuned in order to complete the common understanding of the risk analysis process, especially among exposure and vulnerability risk driver factors.

- The proposed scheme also shows the inherent sequence within the risk dimensions, as avoiding the hazard, no exposed elements exist, or reducing the exposition, no efforts in reducing the vulnerability are necessary. On the contrary, as more sever is the hazard, more exposed elements arise, and bigger efforts in reducing vulnerability become necessary.

- Consequently, a proper identification of the risk driver factors, and the corresponding mitigation measures helps to establish the trade-offs among risk dimensions favouring integrated risk management approaches. By this way, benefits of reducing hazards towards less exposed and vulnerable elements in the territory can be easily highlighted (e.g. in case of snowpack in mountains with high slope, forest management can be integrated as a risk mitigation measure to avoid the impact of avalanches in citizens and infrastructures: the avoided losses in life and properties should make this prevention measure as a pillar of the local Civil Protection system).

- In sum, this risk analysis scheme facilitate the comprehension of how risk dimensions (hazard, exposure and vulnerability) interacts, allowing to increase the Civil Protection capabilities acting on the initial stages of the risk sequence, according the risk mitigation measures identified within the risk management cycle, with the participation of the corresponding stakeholders involved.

- Regarding the results of the analysis, hazard dimension is mostly influenced by natural driver factors (e.g. rainfall in landslides) but has also some human factors (e.g. land-uses in floods). As an exception, the case of wildfires has more human driver factors influencing hazard, since most of fire ignitions are linked to human activities (e.g. electric lines, fire camps or cigarettes) and natural factors as lighting represents a low proportion. On the other hand, other human risk driver factors influence the hazard level since poor fuel management allows high intensity fire behaviours that overwhelm suppression capacity.

- Nevertheless, generally, hazard driver factors are less "modifiable", or have less possible measures to reduce its effects since mostly are linked to natural processes (e.g. wind intensity in storms or rainfall in floods). Thus, the main measures to reduce risk are focused on human driver factors linked with

vulnerability and exposure. This are related to population, infrastructures, buildings, critical facilities, and economic activities, among others.

- Results of the matrix shows how response capacity, risk awareness and existence of emergency plans are often mentioned within the vulnerability driver factors, highlighting the importance of strong preparedness and response capacity in reducing vulnerability, overall, in the social sphere. In parallel, most of prevention actions mentioned are mostly linked with reducing exposure and hazard (obviously, several prevention measures focus on vulnerability reduction as well). This shows the capacity of the prevention stage to influence the initial stages of the risk sequence.

- Climate change could be also considered as a driver factor in all risk dimensions since could modify the intensity of hazard (e.g. rainflow in floods), regarding the exposure, could include new elements at exposure (e.g. new fire prone areas as North Europe), and in consequence, also could appear new vulnerabilities.

- Accordingly, and considering all risks analyzed, they all have weather dependant driver factors of hazard, which will probably be exacerbated by climate change (heat waves, droughts, strong winds, changes in precipitation…). Thus, adaptation measures to deal with climate change effects are a key issue to diminish future potential hazard risks and Civil Protection challenges.

- Vulnerability and exposure driver factors are, in all risks, heavily influenced by the amount of people present in risk areas. Most accurately there is usually a distinction between locals and tourist and their different levels of preparedness and awareness when dealing with risks.

- Good mobility and essential services infrastructure, altogether with resistant buildings and the protection function provided by natural or artificial elements, are key common features to diminish vulnerability and exposure.

- Regarding the stakeholders involved, in most of risk driver factors, multiple groups of actors (at different territorial levels and with different competences) are referred. Therefore, integrated risk management approaches into Disaster Risk Reduction strategies should give them the corresponding role (and capacities). Thus, multi-actor participation and a transversal and holistic perspective are needed since natural hazards are complex phenomena that interacts with different elements in the territory along the process of increase or decrease the hazard, exposure and vulnerability dimensions.

Annex I. Template of Assessment scheme of risk driver factors and mitigation measures

Author	
Hazard	
Hazard	
Impact relevant for Civil Protection	

Risk dimension	Categories	Factors	Description	Measures										Stakeholder and Actions										
				Forest Management	Phase in Disaster Risk Management Cycle				Component of Disaster Risk Reduction	Other	Phase in Disaster Risk Management Cycle				Component of Disaster Risk Reduction	Forest managers	Land planners	Risk assessment authorities	Civil protection authorities	First responders (Fire Service)	Police	Exposed population	Local authorities / Municipalities	Private sector (define which)	Others 1	Other 2	Other 3
					Prev	Prep	Re	Rec																			
Hazard																											

Risk dimension	Categories	Factors	Description	Measures										Stakeholder and Actions										
				Forest Management	Phase in Disaster Risk Management Cycle				Component of Disaster Risk Reduction	Other	Phase in Disaster Risk Management Cycle				Component of Disaster Risk Reduction	Forest managers	Land planners	Risk assessment authorities	Civil protection authorities	First responders (Fire Service)	Police	Exposed population	Local authorities / Municipalities	Private sector (define which)	Others 1	Other 2	Other 3
					Prev	Prep	Re	Rec																			
Exposure (Elements at Risk)																											

Risk dimension	Categories	Factors	Description	Measures										Stakeholder and Actions										
				Forest Management	Phase in Disaster Risk Management Cycle				Component of Disaster Risk Reduction	Other	Phase in Disaster Risk Management Cycle				Component of Disaster Risk Reduction	Forest managers	Land planners	Risk assessment authorities	Civil protection authorities	First responders (Fire Service)	Police	Exposed population	Local authorities / Municipalities	Private sector (define which)	Media	Other 2	Other 3
					Prev	Prep	Re	Rec																			
Vulnerability / Coping capacity (of elements at risk)																											

Annex II. Sum-up template of Risk driver factors and mitigations measures

Hazard process: *(Storm, avalanche, wildfire, flood, rockfall and landslide)*

General description of hazard process

Assessment of risk dimensions

HAZARD - Description of type of driver factors

1. **Driver factors that influence hazard:**
3. **Climate change impacts**

Which factors are influenced by climate change? In which way?

EXPOSURE - Description of measures (type and phase)

EXPOSURE - Description of stakeholders and actions

Look at the involved stakeholders and their actions/roles for a specific factor. Alternatively you can describe the overall involvement of a stakeholder for the whole dimension (i.e. exposure), or report on interesting insights of stakeholder interactions and their respective activities. E.g. it is also noteworthy, if for a factor there is no stakeholder actively involved.

EXPOSURE - Description of driver factors

EXPOSURE - Description of measures (type and phase)

EXPOSURE - Description of stakeholders and actions

VULNERABILITY - Description of type of driver factors

VULNERABILITY - Description of measures (type and phase)

VULNERABILITY - Description of stakeholders and actions

Annex III. Best case selection

III.1 Wildfires

Best cases identification				
Basic information			**ID**	1
Name	**Interreg Sudoe OPEN2PRESERVE: Sustainable management model for the preservation of mountain open areas**			
Promoter	Public University of Navarra / Interreg Sudoe			
Scope	☐Regional/Sub-regional ☐National ☒EU	**Place**	Sudoe area (Portugal, Spain and South France)	
Risk	☐ Avalanche ☐ Flood ☒ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒ **Prevention**	☒**Preparedness**	☐**Response**	☒**Recovery**
Description and complementary information				
Main category	☐ Field best practice	☐ Guidelines / training, dissemination material		
	☐ Mobile app. / portal web	☐ Software / IT / DSSS	☒ Others: R+D Project	
Available languages	English (Also some in Spanish, Portuguese or French)			
Short description	In southern Europe, many mountain valleys are experiencing an intense change in the landscape as a result of rural exodus and changes in production systems. The reduction in grazing by herbivores due to the fall in extensive livestock is especially affecting open spaces and natural pastures in particular, which is manifested in a rapid expansion of bushes and in extensive processes of natural forestation, which cause a loss of biodiversity, a homogenization of the landscape, an accumulation of plant fuel and an increase in the risk of big fires, a high and permanent threat in the current scenario of climate change. European open landscapes evolved under a natural regimen of fires and herbivory, which can today be emulated by sustainable management practices. Controlled burns and guided grazing are presented as key options to reduce the accumulation of fuel, stop the expansion of the wood component and prevent the loss of patchwork landscapes and their associated biodiversity. The main objective of the OPEN2PRESERVE project is to connect current interdisciplinary scientific knowledge with technology and practical operation, in order to implement and assess combined techniques that guarantee the preservation of the ecosystem services linked to open spaces with high natural value. The project proposes starting different regional pilot experiences based on the combination of guided herbivory and initial techniques to reduce fuel through controlled burns. All the experiences seek to offer innovative solutions that guarantee the economic feasibility of the commitment and can serve as an example and training for the execution of similar initiatives at local and regional level.			
Complementary information	Pilot experiences description: https://open2preserve.eu/en/descripcionep/			
Web link	https://open2preserve.eu/en/			

<table>
<tr><th colspan="6">Best cases identification</th></tr>
<tr><td colspan="4">Basic information</td><td>ID</td><td>2</td></tr>
<tr><td>Name</td><td colspan="5">Democratizing wildfire strategies. Do you realize what it means? Insights from a participatory process in the Montseny region (Catalonia, Spain)</td></tr>
<tr><td>Promoter</td><td colspan="5">Otero, I., et al (2018)</td></tr>
<tr><td>Scope</td><td colspan="2">☒Regional/Sub-regional ☐National ☐EU</td><td>Place</td><td colspan="2">Montseny Biosphere Reserve (Catalonia)</td></tr>
<tr><td>Risk</td><td colspan="5">☐ Avalanche ☐ Flood ☒ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others:</td></tr>
<tr><td colspan="6">General focus (mark as much as necessary)</td></tr>
<tr><td>DRM cycle phases</td><td>☒ Prevention</td><td>☒Preparedness</td><td>☐Response</td><td colspan="2">☐Recovery</td></tr>
<tr><td colspan="6">Description and complementary information</td></tr>
<tr><td rowspan="2">Main category</td><td colspan="2">☐ Field best practice</td><td colspan="3">☐ Guidelines / training, dissemination material</td></tr>
<tr><td colspan="2">☐ Mobil app. / portal web</td><td>☐ Software / IT / DSSS</td><td colspan="2">☒ Others: Article</td></tr>
<tr><td>Available languages</td><td colspan="5">English</td></tr>
<tr><td>Short description</td><td colspan="5">Participatory planning networks made of government agencies, stakeholders, citizens and scientists are receiving attention as a potential pathway to build resilient landscapes in the face of increased wildfire impacts due to suppression policies and land-use and climate changes. A key challenge for these networks lies in incorporating local knowledge and social values about landscape into operational wildfire management strategies. As large wildfires overcome the suppression capacity of the fire departments, such strategies entail difficult decisions about intervention priorities among different regions, values and socioeconomic interests. Therefore, there is increasing interest in developing tools that facilitate decision-making during emergencies. In this paper we present a method to democratize wildfire strategies by incorporating social values about landscape in both suppression and prevention planning. We do so by reporting and critically reflecting on the experience from a pilot participatory process conducted in a region of Catalonia (Spain). There, we built a network of researchers, practitioners and citizens across spatial and governance scales. We combined knowledge on expected wildfires, landscape co-valuation by relevant actors, and citizen participation sessions to design a wildfire strategy that minimized the loss of social values. Drawing on insights from political ecology and transformation science, we discuss what the attempt to democratize wildfire strategies entails in terms of power relationships and potential for social-ecological transformation. Based on our experience, we suggest a trade-off between current wildfire risk levels and democratic management in the fire-prone regions of many western countries. In turn, the political negotiation about the landscape effects of wildfire expert knowledge is shown as a potential transformation pathway towards lower risk landscapes that can re-define agency over landscape and foster community re-learning on fire. We conclude that democratizing wildfire strategies ultimately entails co-shaping the landscapes and societies of the future.</td></tr>
<tr><td>Complementary information</td><td colspan="5">Otero I, Castellnou M, Gonzalez I, Arilla E, Castell L, Castellví J, et al. (2018) Democratizing wildfire strategies. Do you realize what it means? Insights from a participatory process in the Montseny region (Catalonia, Spain). PLoS ONE 13 (10): e0204806. https://doi.org/10.1371/journal. pone.0204806</td></tr>
<tr><td>Web link</td><td colspan="5">http://interior.gencat.cat/web/.content/home/030_arees_dactuacio/bombers/foc_forestal/jornades_recerca_cooperacio_internacional/articles_de_recerca_en_foc_forestal/articles_incendis_forestals/2018_OTEROetal_Democratizing-wildfires-strategies_PLOSONE.pdf</td></tr>
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Best cases identification				
Basic information			ID	3
Name	**HEIMDALL project (Multi-Hazard Cooperative Management Tool for Data Exchange, Response Planning and Scenario Building)**			
Promoter	German Aerospace Center (DLR) / Horizon 2020			
Scope	☐Regional/Sub-regional ☐National ☒EU	Place	Europe	
Risk	☐ Avalanche ☒ Flood ☒ Wildfire ☐ Storm ☒ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☐**Prevention**	☒**Preparedness**	☒**Response**	☐**Recovery**
Description and complementary information				
Main category	☐ Field best practice	☐ Guidelines / training, dissemination material		
	☒ Mobil app. / portal web	☒ Software / IT / DSSS	☒ Others: R+D Project	
Available languages	English			
Description	The management of complex crisis situations, with natural, accidental or intentional origin, generally require the participation and coordination of multiple first responders. This heterogeneous group of first responders provide a varied set of expertise to handle crisis situations and pose different requirements in terms of timeliness and relevance of the needed information and interoperability among the organisations. Moreover, communication and information sharing involving additional stakeholders, such as the population at risk, become relevant to increase the overall situation awareness and population involvement. Therefore, efficient response planning, including the development of realistic scenarios, and response coordination shall consider this multi-disciplinary context in order to provide information and tools. In this regard, efficient inter-organisational coordination among first responders is essential for improving preparedness of societies to cope with complex crisis situations. HEIMDALL provides: ▪ Support the already existing operational procedures for inter-organisational coordination, including cross-border scenarios, and implement new ones, if needed; ▪ Provide means to define and share realistic scenarios and the corresponding response plans to be applied, covering the different perspectives of the involved first responders and the different phases of the disaster management cycle. ▪ Integrate monitoring assets, based on satellite and aerial earth observation, in-situ sensors and information provided by first responders, to promptly detect and track any existing risk or ongoing emergency; ▪ Apply available data fusion techniques and modelling algorithms to improve situation and risk assessment and identify the relevant scenarios available and the corresponding response plans to be applied, based on decision support techniques. ▪ Allow information sharing and communication among the relevant stakeholders. HEIMDALL addresses the challenge of providing integrated tools for emergency planning and management, including the definition and sharing of multi-disciplinary scenarios, and addressing the needs of the involved first responders (firefighting units, police departments, medical emergency services, Civil Protection units and command and control centres) and relevant stakeholders in terms of interoperability, inter-organisational coordination and information sharing.			
Complementary information	Events and publications: http://heimdall-h2020.eu/publications/ Deliverables: http://heimdall-h2020.eu/public-deliverables/			

Web link	http://heimdall-h2020.eu/

Best cases identification				
Basic information			ID	4
Name	**Trees that don't burn: Women in forest fire prevention/ Árbores que non arden: As mulleres na prevención de incendios forestais.**			
Promoter	Proxeto Batefogos: previr o lume dinamizando social e economicamente o rural / Batefogos Project: preventing the fire by making social and economically dynamic in rural areas			
Scope	☒Regional/Sub-regional ☐National ☐EU		Place	Galicia, Spain
Risk	☐ Avalanche ☐ Flood ☒ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒**Prevention**	☒**Preparedness**	☐**Response**	☐**Recovery**
Description and complementary information				
Main category	☒ Field best practice	☐ Guidelines / training, dissemination material		
	☐ Mobil app. / portal web	☐ Software / IT / DSSS	☐ Others:	
Available languages	Galician, Spanish (main results)			
Description	Batefogo is a social intervention project that promotes training in the prevention of fires with an economic and social dynamism in the countryside. The main goals of the project are: to reduce the number and the impact of forest fires; to encourage the sustainable use of the forest areas and the economic revitalization of the rural environment; to generate a new forest culture; to value the patrimonial and cultural elements of the territory. At one of the stages of the development of this project, experts asked themselves a question for reflection: "Why is the presence of women almost inexistent in the wildfire world?". In an attempt to answer this question, the Batefogo project team gathered in their book the materials of different authors who, in their disciplines, reflect on the role of gender in preventing and fighting forest fires. The book also addresses the issue of the influence and role of community initiatives in the same topic.			
Complementary information	A preliminary acquaintance with the book and its contents (in Galician) can be done by clicking on the link: https://issuu.com/catroventos.gal/docs/a_rbores_mostra. Buying a book can be done on the publisher's website (https://catroventos.gal/product/arbores-que-non-arden/) or on websites specializing in selling books (e.g. https://www.amazon.com/-/es/Proxecto-Batefogo/dp/8494915460).			
Web link	https://batefogo.wordpress.com/ or https://www.facebook.com/proxectobatefogo/			

Best cases identification				
Basic information			ID	5
Name	**Toward Integrated Fire Management – Outcomes of the European Project FireParadox** and **Policy brief on Towards Integrated Fire Management**			
Promoter	FIRE PARADOX European project - an innovative approach of integrated wildland fire management. A joint European initiative			
Scope	☐Regional/Sub-regional ☒National ☒EU	Place	Portugal (coordination)	
Risk	☐ Avalanche ☐ Flood ☒ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒**Prevention**	☒**Preparedness**	☒**Response**	☒**Recovery**
Description and complementary information				
Main category	☐ Field best practice	☒ Guidelines / training, dissemination material		
	☐ Mobil app. / portal web	☐ Software / IT / DSSS	☒ Others: R+D Project	
Available languages	Portuguese, English (main results)			
Description	FireParadox was an integrated project (2006-2010) funded by the European Commission, including 30 partners from eleven European countries and six from Africa, South-America and Asia. Its approach was based on the paradox that fire can be both a "bad master and a good servant". This required to consider the negative impacts of wildland fire regimes (by understanding fire initiation and propagation), the benefits of using fire as a tool for managing vegetation and treating hazardous fuels (prescribed burning and some traditional fire practices) and combating wildfires by using suppression fire techniques all of which being cornerstones of integrated fire management. The project's philosophy, as well as an overview of its main results and initiatives, was presented in different books and published articles, the most striking of which are: FireParadox White Book and EFI Policy brief on Towards Integrated Fire Management The first document provides science-based knowledge that can assist policy makers to develop the necessary 'common strategies' to elaborate and implement integrated fire management policies. It makes extensive use of the science and technology findings from the FireParadox project, focusing on policies and best management practices, as well as providing guidelines for the future. The project developments may contribute to solve the FireParadox in the context of integrated fire management. Overall, the document provides a comprehensive synopsis of science, technology, products and services resulting from the FireParadox project. In addition, this book presents science-based knowledge and recommendations for changing the paradigm of fire management in Europe and elsewhere. The second one (policy brief) addresses the highlights of the FireParadox philosophy, achievements, conclusions and recommendations and is specifically developed for policy makers, journalists and the general public. The European dimension of the fire issue, together with the diversity of situations in fire management and use, recommends that action is taken within a global but flexible framework. Thus, this document allows for a general approach, according to which the goals are pursued using the means that each of the states considers appropriate.			
Complementary information	Free access to the book "Towards Integrated Fire Management" can be found here: https://www.researchgate.net/publication/304424773_FIRE_PARADOX_White_Book_Towards_integrated_fire_management A short but important addition in the form of EFI Policy Brief can be consulted here. https://www.efi.int/sites/default/files/files/publication-bank/2018/efi_policy_brief_4_en.pdf			
Web link	http://www.isa.ulisboa.pt/ceabn/projecto/2/29/fire-paradox-an-innovative-approach-of-integrated-wildland-fire-management-regulating-the-wildfire-problem-by-the-wise-use-of-fire-solving-the-fire-paradox or http://www.fireparadox.org/			

Best cases identification				
Basic information			ID	6
Name	**Floresta, muito mais que árvores (manual de educação ambiental para a floresta) / Forest much more than trees (environemtal education manual for forests**			
Promoter	Portuguese Forest Authority (ICNF) / Centre for Applied Ecology Baeta Neves - ISA			
Scope	☒Regional/Sub-regional ☒National ☐EU	Place	Portugal	
Risk	☐ Avalanche ☐ Flood ☒ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒ **Prevention**	☐**Preparedness**	☐**Response**	☐**Recovery**
Description and complementary information				
Main category	☐ Field best practice	☒ Guidelines / training, dissemination material		
	☐ Mobil app. / portal web	☐ Software / IT / DSSS	☐ Others:	
Available languages	Portuguese			
Short description	Educational Manual about forests, environmental education and how to prevent forest fires. This manual was written to help teachers and educators to enhance on their students from all ages interest in the forest ecosystems. The purpose was to reach publics of all ages through educational activities that would increase not only the forest ecosystems knowledge but also the sense of wonder. The manual has 3 big chapters: the first where it is possible to find scientific knowledge written in a very simple way; 2nd, about the different methodologies that can be used on environmental education and it role to preserve our forests; the 3rd is a group of activities that explore the forest and fire topic using the different environmental education methodologies previously explored in the 2nd chapter. The methodologies vary from more sensorial and ludic approaches until arts, narratives and scientific. The added value of this book/manual is that encourage different publics to better understand forest and their ecosystems, helping them, through simple activities to decrease risk behaviours and promote these areas management.			
Complementary information	**Colaço, M.C. (Coord)**, 2011, Floresta, muito mais que árvores: Manual de Educação Ambiental para a Floresta, Autoridade Florestal Nacional, Lisboa, 127p. ISBN:978-972-8097-74-5			
Web link	https://www.researchgate.net/publication/281440201_Manual_de_Educacao_Ambiental_para_a_Floresta			

Best cases identification				
Basic information			ID	7
Name	**Prevention of large wildfires using the fire types concept** (Costa, P. et al. 2011)			
Promoter	FireParadox Project			
Scope	☐Regional/Sub-regional ☐National ☒EU	Place	Europe	
Risk	☐ Avalanche ☐ Flood ☒ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒ **Prevention**	☐**Preparedness**	☒**Response**	☐**Recovery**
Description and complementary information				
Main category	☐ Field best practice	☒ Guidelines / training, dissemination material		
	☐ Mobil app. / portal web	☐ Software / IT / DSSS	☐ Others:	
Available languages	Catalan, Spanish and English			
Short description	The handbook is an attempt to introduce the methodology of the Fire Types Concept as a prevention and pre-suppression tool. The scope of the publication includes the integration of fire use into forest planning and the prevention of large wildfires. The main objective is to provide the knowledge for the integration of fire into forest planning and wildfire prevention so that it can be used as a tool to complement and support forest policies. The handbook seeks to provide a European perspective on fire prevention considering the different fire regimes and vegetation structures as well as the heterogeneous socioeconomic conditions in Europe. The specification of a region through the Fire Types Concept with adjustments to particular landscape features is translated into the concept of model fires. A model fire serves as a reference and describes the maximal potential of a fire to become a large wildfire in a particular landscape unit. It provides information and criteria for discussing and placing measures that need to be implemented to provide support to fire management and suppression operations. The model fires concept allows to understand the main characteristics that describe the expected movement of a large wildfire in a particular area, pointing out its spread scheme. Accumulated operational experience and the working system of each suppression force make it possible to determine the most suitable opportunity for each fuel type and relief. It is therefore not necessary to wait for a potential fire to occur to look for suppression opportunities, when the fire front will constrain capacity for analysis. Instead, it is possible to plan in advance, identifying the potential opportunities and adapting them to the requirements of the suppression service. This advance in planning allows to identify the Strategic Management Points (SMPs) - locations throughout a region where the modification of fuel and/or preparation of infrastructures enables the suppression service to carry out safe operations to attack and limit the range of a large wildfire.			
Complementary information	The structure of the publication consists of the main text that describes the context of its field of application and a series of appendices where more technical information can be found. Costa, P. et al. 2011. Prevention of large wildfires using the fire types concept. Cerdanyola del Vallès: Home Affair Ministry of the Government of Catalonia. ISBN: 978-84-694-1457-6			
Web link	English version: https://www.researchgate.net/publication/263923019_Prevention_of_Large_Wildfires_using_the_Fire_Types_Concept/link/0046353c52f1fec358000000/download			

Best cases identification				
Basic information			ID	8
Name	**LIFE+Integration cost-effectiveness of the prevention fires in the planning and forest management (LIFE+DEMORGEST) (LIFE12_ENV_ES_000730)**			
Promoter	The Forest Ownership Centre / The EU LIFE+program			
Scope	☒Regional/Sub-regional ☐National ☐EU	Place	Catalonia, Spain	
Risk	☐ Avalanche ☐ Flood ☒ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒**Prevention**	☒**Preparedness**	☐**Response**	☐**Recovery**
Description and complementary information				
Main category	☐ Field best practice	☐ Guidelines / training, dissemination material		
	☐ Mobil app. / portal web	☐ Software / IT / DSSS	☒ Others: R+D Project	
Available languages	Catalan, Spanish, English (main results)			
Short description	LIFE+DEMORGEST is a European LIFE+project with a duration of five years which aims to reduce the vulnerability of the forests of Catalonia to large forest fires (GIFs), facilitating the adoption of new models of multifuncional forest management (ORGEST models) that include the production of various goods and services to promote the prevention of GIFs; and which raise awareness in the general public of the role of forest management in fire fighting and the conservation of agricultural landscapes.			
Complementary information	Free access publication (in Catalan): *Les Orientacionsde Gestió Forestal Sostenible de Catalunya. Integració del risc de grans incendis forestals (GIF) en les ORGEST* (The Guidelines for Sustainable Forest Management of Catalonia. Integration of the risk of large forest fires (GIF) in ORGEST) http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=DEMORGEST_risk-incendis_leaflet_ES.pdf			
Web link	http://cpf.gencat.cat/en/cpf_03_linies_actuacio/cpf_transferencia_coneixement/cpf_projectes_europeus/cpf_life_demorgest/			

Best cases identification				
Basic information			ID	9
Name	**Forest fires in the alps. State of knowledge, future challenges and options for an integrated fire management**			
Promoter	EUSALP Project (Action Group 8)			
Scope	☐Regional/Sub-regional ☐National ☒EU	Place	Alpine areas	
Risk	☐ Avalanche ☐ Flood ☒ Wildfire ☐ Storm ☐ Landslide / Rockfall ☒ Others: Risk interactions			
General focus (mark as much as necessary)				
DRM cycle phases	☒ **Prevention**	☐**Preparedness**	☒**Response**	☒**Recovery**
Description and complementary information				
Main category	☐ Field best practice	☒ Guidelines / training, dissemination material		
	☐ Mobil app. / portal web	☐ Software / IT / DSSS	☐ Others: White paper	
Available languages	English			
Short description	In the context of the EUSALP - EU Strategy for the Alpine Region, the Action Group 8 is aiming to improve risk management and adapting governance mechanisms by enhancing and valorizing existing cooperation structures. The identification of good practice solutions in tackling climate change is one of the major activities. In this context, the Austrian Federal Ministry of Agriculture, Regions and Tourism (BMLRT) has launched the project "Forest fires in the Alps: State of knowledge and future challenges" in cooperation with the University of Natural Resources and Life Sciences, Vienna (BOKU), and the members of Action Group 8. The publication is a white paper for policy makers that includes a first descriptive part including the definition of forest fire and the characterization of fire regimes in Alpine areas, and the effects of the natural hazard in these territories (reduction of the protection function of mountain forests, increased vulnerability to natural hazards, loss of natural resources and decreased productivity through increased soil erosion, high costs from firefighting and post-fire management, among others). A distinction of fire management actions according fire prevention, suppression and post-fire management, and an identification of legal and governance aspects regarding wildfire are also defined. The second part includes the identification of current and future challenges regarding 4 main drivers: (1) environmental and socio-economic conditions, (2) fire prevention, (3) fire suppression and (4) the post-fire management. Finally, the third part includes different proposals and options for an integrated fire management, following the the scheme: (1) early warning and fire danger rating systems, awareness-raising activities and, measures to increase resistance against fires linked with fire prevention measures; (2) training of specialized action forces and, provision of necessary infrastructure linked with fire suppression measures; (3) monitoring and, reduction of occurrence of natural hazards, linked with post-fire management; and (4) knowledge transfer and exchange.			
Complementary information	EUSALP: EU strategy for alpine region. Action group 8: https://www.alpine-region.eu/action-group-8			
Web link	https://files.constantcontact.com/56858e45101/32b9b95f-c0eb-4b3f-a836-fb49dd219693.pdf			

Best cases identification					
Basic information				ID	10
Name	**Proterina C (Pilot project for sustainable prevention)**				
Promoter	Liguria Region				
Scope	☐Regional/Sub-regional ☐National ☒EU		Place	Italy and France	
Risk	☐ Avalanche ☐ Flood ☒ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others:				
General focus (mark as much as necessary)					
DRM cycle phases	☒ **Prevention**	☐**Preparedness**	☐**Response**	☐**Recovery**	
Description and complementary information					
Main category	☐ Field best practice	☐ Guidelines / training, dissemination material			
	☐ Mobil app. / portal web	☐ Software / IT / DSSS	☐ Others: R+D project		
Available languages	Italian and French				
Short description	PROTERINA-C focuses on issues linked to climatic change and its impacts on natural and anthropized environment, with special attention to hazard conditions induced by these changes. PROTERINA-C involves activities related to deepen the knowledge and to develop models for evaluating forest fires hazard in Liguria, Corsica and Sardinia, in connection to climate variability. Local administrations involved in risk prevention are the final beneficiaries of the project. Some activities directly impact on local organizations (e.g. donors groups) or on population exposed to risks. Moreover, some pilot actions for re-qualification of territories subject to risk, also through the identification of sustainable land use techniques. Key elements of the projects are the formation/information campaigns for population at risk and for local authorities. Finally, results dissemination activities are planned; they will focus on workshops development and on the draft of joint (among the project partners) publications. The Ligurian pilot actions deal with four themes considered to be priorities for risk mitigation: • use of the prescribed fire, i.e. controlled fires to clean and mitigate the risk in vegetated areas and for the renewal of pastures; • development of sustainable prevention practices by small local communities typical of the Ligurian mountain environment (Andagna); • integration of the emergency plans with the management plans of periurban green areas at high risk from fires in the interface areas, to be implemented in Genoa. The project aims to highlight the importance of the collaboration with local authorities, citizens and volunteers of Civil Protection and forest fire prevention.				
Complementary information	https://www.andagna.it/territorio-andagna/proterina-c-andagna/ http://www.maritimeit-fr.net/documents/12943000/12967214/PROTERINA-C_it.pdf/0b10f453-7daa-4185-b4b4-23a2eeca8368				
Web link					

III.2 Floods

Best cases identification				
Basic information			ID	11
Name	**PROTERINA3EVOLUTION (Territory protection to natural risks: the participated evolution)**			
Promoter	Cima Foundation			
Scope	☐Regional/Sub-regional ☐National ☒ EU	Place	Italy and France	
Risk	☐ Avalanche ☒ Flood ☐ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒**Prevention**	☒**Preparedness**	☐**Response**	☐**Recovery**
Description and complementary information				
Main category	☐ Field best practice	☐ Guidelines / training, dissemination material		
	☒ Mobil app. / portal web	☐ Software / IT / DSSS	☒ Others: R+D Project	
Available languages	Italian and French			
Description	Proterina-3Évolution (founded in the framework of the Programme Interreg Italy-France 2014-2020) aims at improving the capacity of institutions to both prevent and manage flood risk. The overall objective is to strengthen the response capacity to flood risk through an awareness-building process of institutions and communities. Specific objectives are: • to improve the effectiveness of (structural and not) prevention measures related to flood risk through a cross-border and trans-regional participation of institutional levels and communities actively involved in a process of risk awareness-building in their own territory • to enhance monitoring networks and to integrate acquired data into early warning models by capitalizing the results of the previous Projects • to increase the cross-border capacity of adaptation to climate change through the development of resilient communities • Beneficiaries (direct or indirect) are the competent Administrations in the field of Civil Protection, Soil and Water Cycle, institutions responsible for forecasting and monitoring activities of meteorological phenomena and citizens actively involved in the decision-making processes. • The keywords that describe the approach and the innovative character of the Project are: • Participated. Participation, inclusion and involvement of people and administrators as a mean for creating resilient communities: objective of PROTERINA-Due, it is becoming a global model • Cross border. Côte d'Azur, Sardinia, Liguria and Tuscany are addressing common challenges: hydrometeorological events can be better managed by sharing and enhancing tools, approaches and procedures • • Consolidation. The Project capitalizes and develops the progress obtained in the previous Programming in order to put in place more effective actions			
Complementary information	http://interreg-maritime.eu/web/proterina-3evolution/checosarealizza			
Web link	http://interreg-maritime.eu/web/proterina-3evolution			

Best cases identification				
Basic information			ID	12
Name	**LIFE PRIMES (Preventing flooding risk by making resilient communities)**			
Promoter	ARPA Emilia Romagna			
Scope	☐Regional/Sub-regional ☒National ☐EU	Place	Italy	
Risk	☐ Avalanche ☒ Flood ☐ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others: sea storms			
General focus (mark as much as necessary)				
DRM cycle phases	☒ **Prevention**	☒**Preparedness**	☐**Response**	☐**Recovery**
Description and complementary information				
Main category	☐ Field best practice	☐ Guidelines / training, dissemination material		
	☒ Mobil app. / portal web	☐ Software / IT / DSSS	☒ Others: R+D Project	
Available languages	Italian and French			
Short description	This project aims at reducing land and population damages caused by events like floods, inundations and sea storms which depend on intense meteorological phenomena that are becoming more and more frequent every day. The LIFE PRIMES project is conceived to respond to the European challenge in the area of adaptation management and in particular of the Early Warning Integrated Systems, through the achievement of the following specific objectives: • To homogenize procedures of risk management and flooding prevention at trans-regional level, moving towards strengthening coordination between different levels of Civil Protection both on a vertical scale (Region – City – Community) and horizontal scale (Region-Region / City-City / Community- Community). • To build a web friendly tool kit where all knowledge and necessary information are collected and organized in order activate voluntary and daily actions for the prevention of risks due to climate change; • To move communities from a passive approach to the risk management, relevant to emergency response, to a pro-active one, supporting the phase of risk prevention through the active participation in implementing soft adaptation measures and actions • To allow the knowledge diffusion and innovative collaboration among Civil Protection and the civil society, raising awareness on adaptation to climate change and on the impact of risk alert patterns; All these objectives will be achieved through a series of activities (as described in section C.0) and they will contribute to the realization of the long term objectives, such as: • To integrate the adaptation in the daily life stile and habits of local communities, stimulating them in implementing soft adaptation actions and risk preventing measures • to improve the awareness-raising by identifying responsibilities, roles and collaborations among organizations and citizens both at national and local levels. The main activities are A.1-Base line scenario and capacity building. C.1-Homogenisation and integration of early warning systems. C.2-Implementation of the primes tool-work and development of the web-portal. C.3-Building resilient communities through local civil adaptation plans.			
Complementary information	http://www.lifeprimes.eu/index.php/piano-di-adattamento/?lang=en http://www.lifeprimes.eu/index.php/docs/prodotti-editoriali/leaflet/			

Web link	http://www.lifeprimes.eu/

Best cases identification					
Basic information				ID	13
Name	LIFE FRANCA- Flood Risk ANticipation and Communication in the Alps				
Promoter					
Scope	☐Regional/Sub-regional ☒National ☐EU		Place	Italy	
Risk	☐ Avalanche ☒ Flood ☐ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others:				
General focus (mark as much as necessary)					
DRM cycle phases	☒ **Prevention**	☐**Preparedness**	☐**Response**	☐**Recovery**	
Description and complementary information					
Main category	☐ Field best practice	☐ Guidelines / training, dissemination material			
	☒ Mobil app. / portal web	☐ Software / IT / DSSS	☒ Others: R+D Project		
Available languages	Italian				
Short description	LIFE FRANCA is a European project that promotes flood risk anticipation and communication in the Alps. It is has been realized with the contribution of the LIFE programme, the European Union's financial instrument supporting environmental, nature conservation and climate action projects. The main objective of LIFE FRANCA was to promote a culture of flood risk anticipation and prevention in the Alps through the analysis and modification of collective socio-cultural attitudes, decision-making practices and common perceptions of the environmental risks affecting the territory. The main actions of the project are: • Data: Collection, analysis and reorganisation of available flood risk data in Trentino. • Scenarios and Focus Groups: Production of strategic scenarios to evaluate the impact of potential flood events, starting in the experimental study areas identified in the Province of Trento. Focus groups will be used to involve the public in preparedness exercises that simulate future flood scenarios. • Portal: Construction of an innovative online flood risk portal that provides a reference for anyone seeking information on hydrogeological conditions in the Trentino region. The portal will be updated by employees of the Autonomous Province of Trento, but any citizen will be able to bring to attention anomalies observed in the region. • Professional training: Organisation of seminars for specialists, administrators and journalists to improve skills relating to handling and communicating regional hazards to the public. • Education and dissemination: Organisation of workshops, activities and educational outings for students and training courses for teachers. Creation of travelling exhibitions, guided tours, conferences and meetings for the public in the informal setting of Science Café events. • Networking: Creation of a network of relationships and collaborations with other stakeholders, organisations and associations that are not project partners but have an interest in its results, like neighbouring regions, different drainage basin authorities, the Ministry of the Environment, environmental associations, insurance companies, etc. Exchange of information with other LIFE projects promoting awareness of climate change-related hazards.				

Complementary information	https://www.lifefranca.eu/wp-content/uploads/2020/06/Guidelines_for_flood_risk_communication_english.pdf https://www.lifefranca.eu/wp-content/uploads/2018/02/alluvioni__come_difendersi__it_logos.pdf https://bacinimontani.provincia.tn.it/
Web link	https://www.lifefranca.eu/en/

III.3 Avalanches

Best cases identification				
Basic information			ID	14
Name	**Avalanche Danger Bulletin (ADB)**			
Promoter	Cartographic and Geological Institute of Catalonia			
Scope	☒Regional/Sub-regional ☐National ☐EU		Place	Catalonia
Risk	☒ Avalanche ☐ Flood ☐ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒ **Prevention**	☐**Preparedness**	☒**Response**	☐**Recovery**
Description and complementary information				
Main category	☒ Field best practice	☒ Guidelines / training, dissemination material		
	☐ Mobil app. / portal web	☐ Software / IT / DSSS	☐ Others:	
Available languages	Catalan, Spanish, English			
Short description	The ADB describes the following sections: 1) **basic avalanche danger information for the Catalan Pyrenees:** general map of the Pyrenees of Catalonia showing 7 different nivo-meteorological regions with its avalanche danger level showed with an icon and a number. The danger level comes from the standard European avalanche danger scale (5 levels). This map shows with a shade background colour the danger of each region. Clicking on this map we will access the detailed information of each one of the nivo-climatic zones), **2) detailed iconographic information for each nivo-climatic region:** each region has a description of the danger level showed with icons: main avalanche problem (5 standard problems can be chosen), its location (aspect and height), size of the avalanche and its origin (natural or triggered) and the trend of the situation for the coming days. **3) detailed text base information for each nivo-climatic region:** sentence summarizing the main problem as far as second or even third problems. The described snowpack conditions and distribution, detailed snowpack data i.e. stability test results, weak layers in the snowpack, prone terrain to avalanches.			
Complementary information	**Explanation of icons :** https://www.icgc.cat/en/Citizens/Explore-Catalonia/Avalanches/Avalanche-Danger-Bulletin/Legend-of-icons-BPA			
Web link	https://www.icgc.cat/Ciutada/Explora-Catalunya/Allaus/Butlleti-de-Perill-d-Allaus-BPA			

Best cases identification				
Basic information			ID	15
Name	**Avalanche Database (AD) - Geoindex Avalanche Viewer**			
Promoter	Cartographic and Geological Institute of Catalonia			
Scope	☒Regional/Sub-regional ☐National ☐EU	Place	Catalonia (Spain)	
Risk	☒ Avalanche ☐ Flood ☐ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒ **Prevention**	☐**Preparedness**	☒**Response**	☐**Recovery**
Description and complementary information				
Main category	☒ Field best practice	☐ Guidelines / training, dissemination material		
	☐ Mobil app. / portal web	☒ Software / IT / DSSS	☐ Others:	
Available languages	Catalan, Spanish			
Short description	The Avalanche data base of Catalonia and its viewer (Geoindex) integrates three shapes of avalanche information: 1) areas that may be affected by avalanches 2) recent avalanches observed since 1986 and 3) events of major avalanches coming from historical records and survey to mountain population. This information is regularly updated with the observations and mapping interpretation of ICGC avalanche specialists, with the observations coming from the network of snow and avalanche observers of the ICGC, (set up by snow and avalanche specialists, police, ski resorts, forestry guards, firefighters, rescue teams and mountain hut attendants) and by observations and mapping interpretation coming from the technicians of the Conselh Generau d'Aran. In addition to the avalanche thematic information, this geoindex also incorporates Avalanche defence structures and protection systems Each winter season there is new information on avalanches that must be updated both avalanche in the avalanche data base and in the Geoindex.			
Complementary information				
Web link	https://www.icgc.cat/Ciutada/Explora-Catalunya/Allaus/Geoindex-Allaus			

Best cases identification				
Basic information			ID	16
Name	**PIDA (Intervention Plan for Triggering Avalanches) of Vallter (Catalonia)**			
Promoter	Vallter sky resort			
Scope	☒Regional/Sub-regional ☐National ☐EU	Place	Catalonia	
Risk	☒ Avalanche ☐ Flood ☐ Wildfire ☐ Storm ☐ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒ **Prevention**	☐**Preparedness**	☒**Response**	☒**Recovery**
Description and complementary information				
Main category	☒ Field best practice	☒ Guidelines / training, dissemination material		
	☐ Mobil app. / portal web	☐ Software / IT / DSSS	☐ Others:	
Available languages	Catalan			
Short description	The PIDA (Avalanche Trigger Intervention Plan) **regulates the artificial triggering of avalanches in ski resorts**. The artificial triggering of avalanches consists of triggering small, controlled ***avalanches*** deliberately and systematically as a **preventive measure using diverse types of explosives and explosion methods. This preventive system is carried out in** areas prone to avalanches such as snowdrifted terrain or high-risk areas (great vulnerability and or great exposure). This plan enables ski resort safety for users, staff and facilities by avoiding the occurrence of large avalanches The PIDA regulates the actions that are carried out in the framework of the **preventive triggering of avalanches and aims to determine the areas where avalanches can be artificially triggered in a preventive way according to a detailed protocol.** It includes the determination of the prone zones and shooting points, the management of the explosives, itineraries and transportation of explosives from the starting point till the detonation points, safety protocols and other indications according to information i.e. ADB and AD.			
Complementary information				
Web link				

III.4 Storms

Best cases identification				
Basic information			ID	17
Name	**Tree species suitability maps – (Baumarteneignungskarten)**			
Promoter	Forest Research Institute (FVA) Baden-Württemberg, Germany. Department of Forest Growth			
Scope	☒Regional/Sub-regional ☐National ☐EU	Place	Baden-Württemberg, Germany	
Risk	☐ Avalanche ☐ Flood ☐ Wildfire ☒ Storm ☐ Landslide / Rockfall ☒ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒ **Prevention**	☒**Preparedness**	☒**Response**	☒**Recovery**
Description and complementary information				
Main category	☐ Field best practice	☐ Guidelines / training, dissemination material		
	☐ Mobil app. / portal web	☒ Software / IT / DSSS	☐ Others:	
Available languages	German			
Short description	Tree species suitability maps are a decision support tool to help forest managers during tree selection for climate adaption. These maps -(scale of 1:50.000) are available for every district of the German federal state of Baden-Württemberg for the tree species Norway spruce, European beech, sessile oak and silver fir. The projections are based on the IPCC scenario B2 and cover the situation today (2010) and in the future (2050). The suitability of the tree species is assessed via four categories: “suitable”, “possible”, “less suitable” and “unsuitable” based on the following criteria: competitive pressure of the species, maintenance intensity, damage likelihood and yield. The maps are relying on statistical models based on tree species distribution, phytosociological backgrounds and the assessment of the respective risk for the species due to climate change. The maps are based on the IPCC SRES-scenario B2 and cover a situation with an assumed annual average temperature increase till 2050 of 1,95°C and a decreased annual precipitation of 25mm. The maps are the outcome of the project “Effect of climate change on forests in Baden-Wuerttemberg” and used as decision support in the state-owned forest stands as well as part of the forestry consultancy by the district foresters as guidelines. The maps are available and in use on a voluntary basis.			
Complementary information	Storm risk of forests is highly influenced by site conditions. Selecting suitable tree species, adapted to these conditions can reduce the storm risk in future.			
Web link	https://www.fva-bw.de/daten-und-tools/geodaten/klimakarten			

Best cases identification					
Basic information				ID	18
Name	**Storm Handbook – Coping with Storm Damaged Timber**				
Promoter	Forest Research Institute (FVA) Baden-Württemberg, Germany. Department of Forest Management and Ecosystem Services Section of Forest Risk- and Crisis Management				
Scope	☐Regional/Sub-regional ☒National ☒EU		Place	Baden-Württemberg, Germany	
Risk	☐ Avalanche ☐ Flood ☐ Wildfire ☒ Storm ☐ Landslide / Rockfall ☐ Others:				
General focus (mark as much as necessary)					
DRM cycle phases	☒ **Prevention**	☒**Preparedness**	☒**Response**	☒**Recovery**	
Description and complementary information					
Main category	☒ Field best practice	☒ Guidelines / training, dissemination material			
	☐ Mobil app. / portal web	☒ Software / IT / DSSS	☐ Others:		
Available languages	German; English				
Short description	The storm handbook offers a web based collection of best practices regarding guidelines for coping with storm damaged timber. It covers the following topics: first measures and survey of damages, strategies and personnel management, salvage logging and work safety, timber storage, forest protection, timber transportation, regeneration and afforestation as well as subsidies and public relations. The collection of instructions, checklists and leaflets encompasses the whole process of coping with storm damaged timber and provides basic information. The handbook therefore creates a basic standard of knowledge, providing staff with a compendium for future storm calamities, enabling them to handle the damage in a well-equipped, calm and efficient manner. Due to an increased likelihood of storm damage under climate change, storm damages can cause severe economic losses, a proper work strategy salvage logging.				
Complementary information					
Web link	https://www.waldwissen.net/waldwirtschaft/schaden/sturm_schnee_eis/fva_sturmhandbuch/index_EN				

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<tr><td colspan="4">Basic information</td><td>ID</td><td>19</td></tr>
<tr><td>Name</td><td colspan="5">SURE Project - SUstaining and Enhancing REsilience of European Forests</td></tr>
<tr><td>Promoter</td><td colspan="5">European Forest Institute (EFI)</td></tr>
<tr><td>Scope</td><td colspan="2">☐Regional/Sub-regional ☐National ☒EU</td><td>Place</td><td colspan="2">Baden-Württemberg, Germany</td></tr>
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<tr><td>DRM cycle phases</td><td>☒ Prevention</td><td>☒Preparedness</td><td>☒Response</td><td colspan="2">☒Recovery</td></tr>
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<tr><td>☐ Mobil app. / portal web</td><td colspan="2">☒ Software / IT / DSSS</td><td colspan="2">☒ Others: R+D Project</td></tr>
<tr><td>Available languages</td><td colspan="5">English</td></tr>
<tr><td>Short description</td><td colspan="5">European forests are affected by different disturbances. They range from pests and insect damages to megafires and transnational storm events and can have profound impacts on forest ecosystem services and livelihoods. As forest disturbance regimes have intensified during the last decades, making forests more resilient has gained in importance. Experiences from both practice and science on how to best cope with risk and respond to disturbance events are crucial for developing and improving response strategies in policymaking and practical management.

The project SUstaining and Enhancing REsilience of European Forests (short: SURE) will tackle these challenges by fostering cross-border exchange and highlighting best practices. Coordinated by European Forest Institute's Bonn Office and funded by the German Federal Ministry for Food and Agriculture, SURE is aiming at enhancing forest resilience and addressing disturbance related risks as an integral part of sustainable forest management through facilitating networking, learning and capacity building.

One of SURE's main objectives is establishing the European Forest Risk Facility, an unbiased platform of exchange and knowledge transfer between science, practice and policy. The Facility aims to facilitate cooperation and exchange between communities, thus providing transnational access to knowledge and experience while incorporating existing expertise in Europe (like the projects KoNeKKTiW and Plurifor). It will collect and distribute data for a better understanding of forest risks to support effective collaboration and coordination of relevant national bodies and facilitate the exchange of good practice, ultimately leading to better-informed political decisions on matters relevant to forests and forestry.</td></tr>
<tr><td>Complementary information</td><td colspan="5">Information on current events, news, activities and more in-depth reports developed in the framework of SURE can be found on the Resilience Blog.</td></tr>
<tr><td>Web link</td><td colspan="5">http://sure.efi.int/</td></tr>
</table>

III.5 Rockfalls & Landslides

Best cases identification				
Basic information			ID	20
Name	**GreenRisk4Alps – Interreg Alpin Space - European Regional Development Fund**			
Promoter	Interreg is one of the two goals of the EU Cohesion Policy in the 2014-2020 period and it is funded by the European Regional Development Fund (ERDF). GreemRisk4Alps Lead Partner: Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW, Austria)			
Scope	☐Regional/Sub-regional ☐National ☒EU	Place	Austria, France, Germany, Italy, Slovenia, Switzerland	
Risk	☒ Avalanche ☒ Flood ☐ Wildfire ☐ Storm ☒ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒ **Prevention**	☒**Preparedness**	☒**Response**	☒**Recovery**
Description and complementary information				
Main category	☐ Field best practice	☐ Guidelines / training, dissemination material		
	☐ Mobil app. / portal web	☒ Software / IT / DSSS	☒ Others: R+D Project	
Available languages	English			
Short description	The overarching goal of GR4Alps is the development of forest based concepts to support risk management basing on forestry resources with respect to natural hazards and climate impacts. GR4Alps promotes forests to be part of a sustainable risk management by balancing green, technical and preventive risk strategies. GR4Alps has a clear strategy to overcome conflicts and resistances in doing eco-system based disaster risk reduction: all relevant actors are involved and provided with new mitigation alternatives and science-based communication support. GR4Alps is partitioned into five work packages: 1. WP1 is dedicated to the development of new tools and new information for sustainable protection forest and risk management 2. WP2 outlines for all partner countries the relevant actors and decision structures. 3. In WP3 the necessary economic and risk assessment will be carried out. 4. In WP4 new strategies for communication of risk mitigation strategies are created. 5. WP5 introduces the results to the municipalities and the strategic governance institutions to enable an effective implementation.			
Complementary information	The consortium includes 12 partners, covering the diversity of the alpine space and its typical problems. All activities will be carried out in the GR4Alps pilot action regions: Brenner region (AUT/ITA), Courmayeur (ITA), Kranjska Gora (SLO), Parc de Baronnie (FRA) and Oberammergau (GER). The authorities of these pilot action regions are active partners in the project. In order to foster the implementation process and to address national and transnational governance institutions, representatives of Eusalp, Alpine Convention and Cipra are part of the consortium. Duration of GreenRisk4Alps: 3 years starting in June 2018			
Web link	https://www.alpine-space.eu/projects/greenrisk4alps/en/home			

Best cases identification				
Basic information			ID	21
Name	**ROCKtheALPS - Interreg Alpin Space - European Regional Development Fund**			
Promoter	Interreg is one of the two goals of the EU Cohesion Policy in the 2014-2020 period. It is funded by the European Regional Development Fund (ERDF). ROCKtheALPS Lead Partner: National research institute of science and technology for environment and agriculture (IRSTEA, France)			
Scope	☐Regional/Sub-regional ☐National ☒EU	Place	Austria, France, Germany, Italy, Slovenia, Switzerland	
Risk	☐ Avalanche ☐ Flood ☐ Wildfire ☐ Storm ☒ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒ **Prevention**	☒**Preparedness**	☐**Response**	☐**Recovery**
Description and complementary information				
Main category	☐ Field best practice	☐ Guidelines / training, dissemination material		
	☐ Mobil app. / portal web	☒ Software / IT / DSSS	☒ Others: R+D Project	
Available languages	English			
Short description	RockTheAlps has been specifically dedicated to the enhancement forest ecosystems service of rockfall protection in risk management and prevention policy. The general approach has been: To share knowledge and data, to develop an innovative common regional rockfall model considering forest effects, to use this model for creating regional maps and transfer them in existing WEBGIS platforms. These maps and associated tools have contributed to improve risk management relating to manage climate change, including major natural risks prevention - of the European strategy for the Alpine region (EUSALP) and the forest ecosystems services mapping and valuing actions of Europe 2020 biodiversity strategy.			
Complementary information	There is a consortium of a total of 15 partners: Austria (2), France (3), Germany (1), Italy (5), Slovenia (3) and Switzerland (1). The partnership is supported by 24 observers which are relevant regional or national actors regarding the natural risks reduction policy. Duration of ROCKtheALPS: 3 years starting in November 2016			
Web link	https://www.alpine-space.eu/projects/rockthealps/en/home			

Best cases identification				
Basic information			ID	23
Name	**MANFRED – "Management Strategies to adapt Alpine Space forests to climate change risks"– Interreg Alpin Space - European Regional Development Fund**			
Promoter	Funded by the European Regional Development Fund (ERDF). MANFRED Lead Partner: Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg (FVA, Germany)			
Scope	☐Regional/Sub-regional ☐National ☒EU	Place	Austria, France, Germany, Italy, Slovenia, Switzerland	
Risk	☐ Avalanche ☒ Flood ☒ Wildfire ☐ Storm ☒ Landslide / Rockfall ☐ Others:			
General focus (mark as much as necessary)				
DRM cycle phases	☒ **Prevention**	☒**Preparedness**	☐**Response**	☐**Recovery**
Description and complementary information				
Main category	☐ Field best practice	☐ Guidelines / training, dissemination material		
	☐ Mobil app. / portal web	☒ Software / IT / DSSS	☒ Others: R+D Project	
Available languages	English			
Short description	MANFRED successfully met it's aims to further understanding of climate change impacts in the forestry sector in the Alpine Space region. The project accomplished this through bringing together practitioners from neighbouring transnational regions and integrating these key stakeholders into project activities to support our work. All of the modelling projections made for natural hazards and species range shifts were carried out based on downscaled climate models for the Alpine Space. The project should develop a better understanding of natural hazard processes like rockfall. Developed tools support policymakers and the forestry sector making better decisions in order to use the forest resource sustainably in the future as well.			
Complementary information	There is a consortium of a total of 14 partners: Austria (3), France (2), Germany (1), Italy (4), Slovenia (2) and Switzerland (2) covering the diversity of the AS space and its typical problems. Duration of MANFRED: 3 years starting in August 2009			
Web link	http://www.alpine-space.org/2007-2013/projects/projects/detail/PARAmount/show/index-2.html			