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

Prototype for improved decision making in landslide and rockfall risk management

ENGLISH SUMMARY

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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 4.3 of Task 4.3.

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 4.3 is part of the work package 4. This WP is composed by three tasks. On the one hand, in task 4.1 an analysis of existing decision support systems and the operability to include projected climate change impacts identified in previous WP3, is developed. In the second task (4.2), a description of the risk attributes and data requirements to be included into the DSS to address climate change impacts on multi-hazards risk management is done. Finally, the taks 4.3 includes a set of support tools for civil protection which will serve to address a specific need, taking into account all the work done in the previous WP.

As expected, each support tool will be edited in the local language of the territory of applicability (Italian, Catalan, German and Portuguese), and will be also a summary in english available, which is this document.

2. Prototype for improved decision making in landslide and rockfall risk management

2.1 Objectives and scope

A prototype of a dynamic risk assessment approach is introduced, which allows considering climate change effects in risk-based decision –making. This Decision Support System (DSS) focusses on applied civil protection against spontaneous landslides in the loose material layer and rockfall with volumes <100 m³.

In Austria, the local stakeholders play a central role in risk management. The municipality (mayor) as the first instance on a local level, is responsible for spatial and construction planning, the implementation of mitigation measures and immediate incident management. Thus, communities are the primary addressee of this publication.

Figure 1 shows an overview of the chosen approach, which is described in detail below.

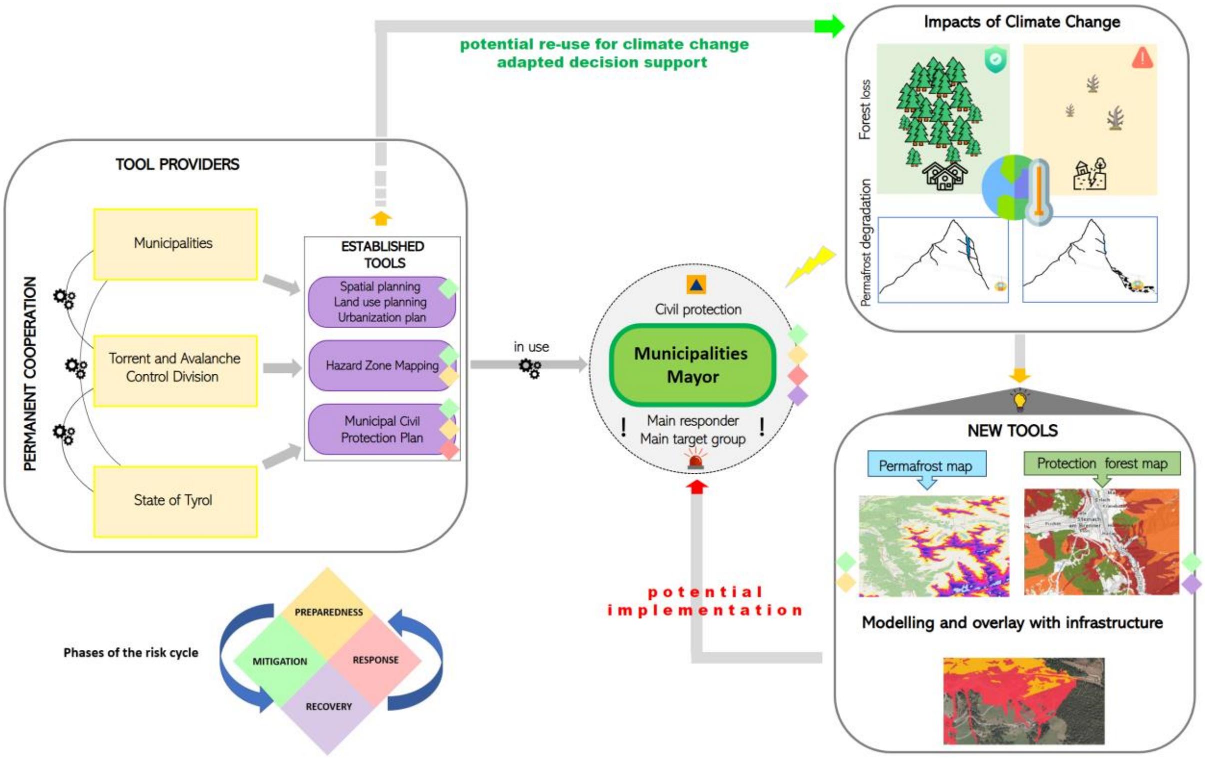

Fig. 1: Main elements, interconnections and workflow of the RECIPE DSS approach, highlighting current providers of established tools on the one hand and newly developed routines, tools and processes on the other; each tools is linked to a phase in the risk cycle (coloured rhombi).

Existing planning fundamentals

Both landslides and rockfall typically effect only relatively small areas, compared to other types of natural hazards (e.g. floods, earth quakes). In the context of natural hazard management on a national scale they have only moderate importance in Austria. As a result, there are gaps regarding data, practical approaches and planning tools. Furthermore, clear regulations of responsibilities in the assessment of these processes and damage prevention are partly missing.

At the national level, the following data are available for the development and implementation of risk-based approaches:

- Geological maps of Austria
- Databases of rockfall and landslide events
- Digital soil maps for agricultural areas
- Digital regional maps of forests
- Digital terrain models

Other planning documents (such as hazard index maps) are often only available regionally or locally and vary considerably in terms of scale, information content and interpretability. However, data on the frequency and magnitude of landslide and rockfall events, which are important for a risk analysis, are mostly not available.

Data on the elements at risk, e.g. settlements and infrastructure potentially exposed to natural hazards, are largely available on a provincial level and could be used for a first quick local risk analyses. Taking the province of Tyrol as an example, the following geodata on infrastructure facilities are available as free downloads:

- Transport infrastructure
- Buildings
- Bicycle routes
- Catalogue of lifts

For the RECIPE prototype DSS, these data, which allow only static risk planning, have to be complemented by a dynamic component (considering future changes). This requires forecasts of relevant, variable influencing parameters such as the expected effects of climate change. Due to the uncertainties of future framework conditions, one approach is to generate scenarios of developments and their effects on the occurrence of natural hazards, exposure and vulnerability.

To determine endangerd areas, established simulation programs are available. Usually, the release areas (event triggering) and process paths (range) are modelled separately. Two examples how to implement dynamic risk assessment are shown below.

2.2 Description of the tool

Dynamic risk assessment to consider climate change effects

Parameters, which are directly related to the potential effects of a rise in air temperature on landslides and rockfall include:

- Rise of the permafrost boundary (=permafrost degradation), i.e. the altitude above which the ground is continuously frozen
- Forest changes (e.g. due to altered water balance, bark beetle calamities, wildfire, windthrow) and the associated reduction in the protective effect of the forest.

Permafrost degradation

The rise of the permafrost line is strongly related with the rise of the average annual air temperature (about 150 m/ °C). The loss of permafrost may cause instabilities of rocks or loose material layers, resulting in a rising hazard potential. Infrastructural facilities in ski resorts, but also transport facilities and settlements at lower altitudes could be affected.

Within the framework of the international project PermaNET, an Alpine Permafrost Index Map (APIM) was generated for the entire Alpine region, which shows the probability of the presence of permafrost. The spatial resolution of the APIM allows applications at the local level. The data can be integrated into any standard GIS software.

The below example of a Tyrolean ski area shows, how to realize the assessment of the future hazard potential based on the available information regarding permafrost. General steps:

- Determining the assumed shift of the permafrost line according to the rise of air temperature (Intergovernmental Panel on Climate Change (IPCC) scenarios)
- Determination of new or more unstable areas caused by permafrost degeneration; done by merging the DEM with the APIM map
- Determination of new release areas and process paths (range) with runout-models

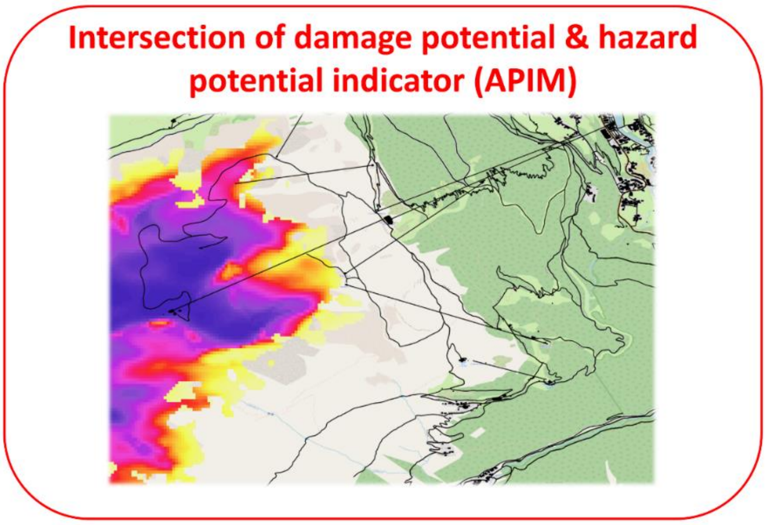

Fig. 2: Infrastructure (black lines) and the potential permafrost area according to the APIM (rainbow coloured area). In the left part of the image, infrastructure intersect with potential permafrost area with a risk of groundfailure to construction there (PermaNET Alpine Space or www.data.gv.at).

Rockfall example:

For the dynamic assessment of a rockfall event, areas with a slope inclination of >50° are assumed to be potential initial areas (heuristic approach). A distinction was made between initial areas above and below the permafrost line. It was assumed, that without climate change these potential rockfall areas would only become active below the permafrost line (see Fig. 3, blue areas). In the IPCC scenario RCP 8.5 (increase in global mean air temperature of 4 °C by 2100 compared to 1986-2005), the permafrost line rises, resulting in additional, potential rockfall areas above the current permafrost line (see Fig. 3, red areas).

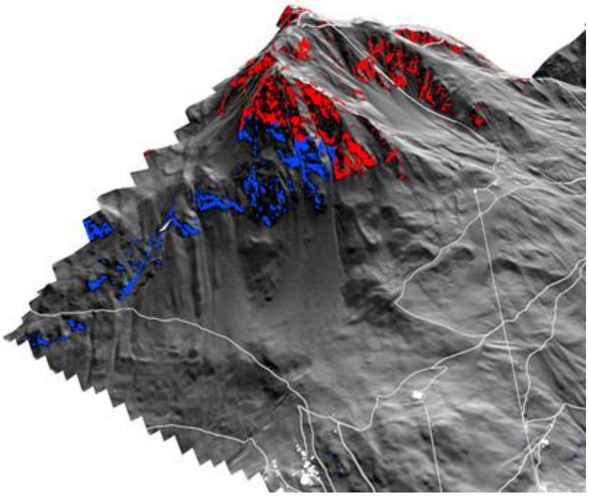

Fig. 3: Terrain model of a Tyrolean ski area; blue areas show current potential rockfall release areas (below the permafrost line); red areas show potential release areas after the climate change-induced rise of the permafrost line.

Based on this information, the spread and range of the rockfall processes were modelled with the Flow-Py (https://www.alpine-space.eu/projects/greenrisk4alps/en/home) model developed at the BFW and merged with the infrastructure information. Figure 4 shows the strong increase of the hazard and risk areas when considering the RCP 8.5 climate change scenario.

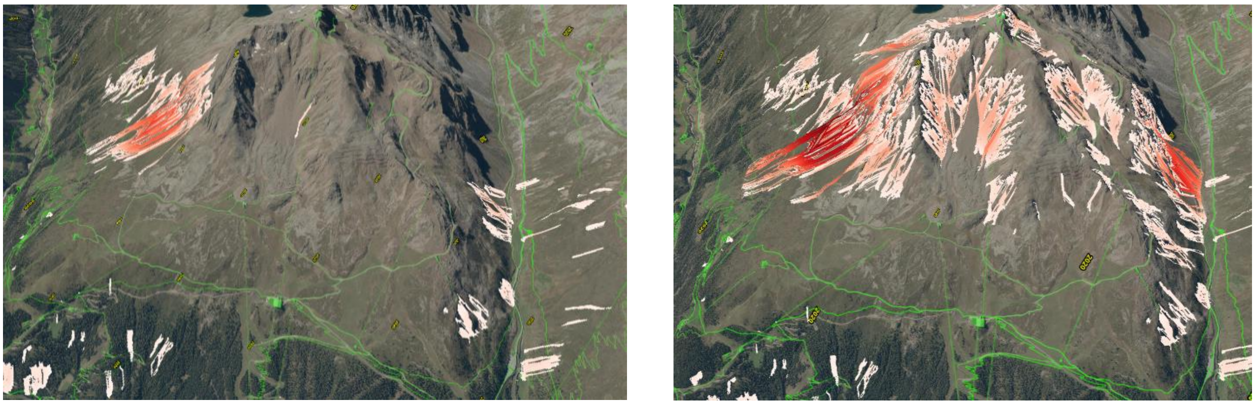

Fig. 4: Rockfall process distribution; before permafrost degradation (left); considering a rise of the permafrost line (RCP 8.5 climate change scenario) (right).

Forest changes as a result of climate change - impacts on the protective effect

Climate change may affect forests in various ways. For the hazard assessment in the frame of risk management, the identification of future areas with reduced protection function is essential. The below example of a windthrow area in Eastern Tyrol shows which general steps are necessary to determine the future hazard potential:

- Estimation of the reduction of the protective effect of forests
- Identification of areas of potentially endangered forests (not adapted to future climate conditions)
- Identification of areas with potential loss of forests; realized by merging the DEM with the data on forest loss
- Determination of the new release areas and process path´s (range) with runout-models

Landslide example:

Flow-Py, a model that can serve as a decision-making tool in the risk management of gravitational mass movements, was used for this scenario. The starting point are windthrow areas in Eastern Tyrol, caused by the storm Vaia in 2018.

Assuming that landslides in vital forest are triggered at steep slopes, areas with terrain inclination between 45° and 50° were identified as potential landslide failures (turquoise) and the corresponding landslide trajectories (blue) were calculated (Fig. 5, left). For forest sites affected by windthrow, landslide initiation zones were defined for slope inclinations between 35° and 50° (yellow areas), the corresponding trajectories are shown in red (Fig. 5 right).

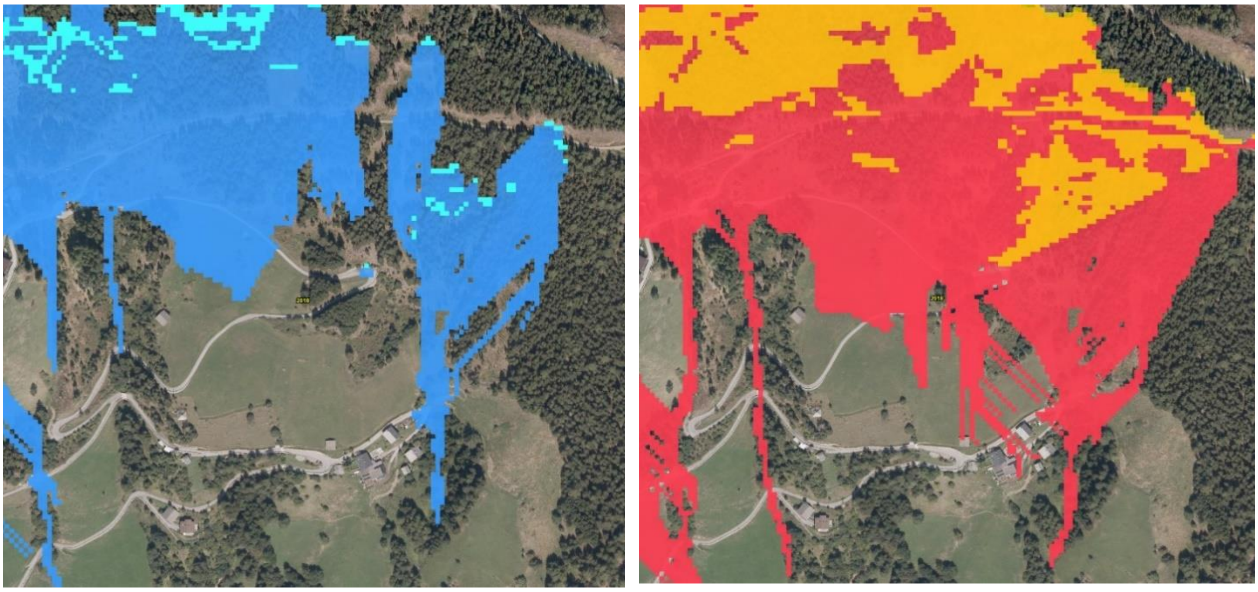

Fig. 5: Potential landslide initiation areas (turquoise) and their trajectories (blue) in vital forest (left); Potential landslide initiation areas (yellow) and their trajectories (red) in forest areas damaged by windthrow (right).

Since the triggering areas with vital forests (slope inclination 45° to 50°) are often directly above the areas with a loss of forest, the modelled landslide trajectories often follow similar paths. However, the extent of infrastructure endangered by the landslides has clearly increased in the scenario considering the damaged forest.

3. Recommendations for the EU scalability of the support tool

The prototype presented in the frame of this deliverable shows, which fundamental information and data are already available for landslide and rockfall risk assessment. Using the province of Tyrol in Austria as an example, we show how these can be linked to new tools for improved decision making in civil protection and disaster management.

Two scenarios were chosen to consider possible effects of climate change on landslide and rockfall hazards, directly related to an increase in the annual mean temperature: i) a rise of the permafrost boundary and increasing mobilization of rock and sediments in high-alpine terrain; ii) changes in the protective effect of forests, due to the alteration of water balance conditions, bark beetle calamities, windthrow, and forest fires.

For the assessment of these two effects on landslides and rockfall, the prototype of a DSS (Decision Support System) was described in detail. This prototype can - depending on the availability of the presented data - also be used in other countries, without any problems. For example, the Alpine Permafrost Index Map (APIM) is the most important data basis for an assessment of the permafrost degradation in the entire Alpine region. Its spatial resolution also allows an application on a local level. The possible integration of the APIM into any standardized GIS is the basis for further calculations of the runout lengths of gravitational mass movements and thus for the estimation of areas at risk under consideration of climate change e. g. by including different RCP scenarios and their consequences. The model Flow-Py used for this purpose is also an open-source model developed within the framework of the Interreg Alpine Space project "GreenRisk4Alps".

However, the basic knowledge of existing data and models is crucial for the use of this prototype. The risk management of landslide and rockfall hazard is predominantly conducted at the local level (municipalities); here lie the responsibility for land use planning and construction planning, as well as the implementation of preventive measures and the immediate incident management. However, knowledge about planning basics and data is best located at supra-regional institutions (national level).

A well-developed networking of the individual organizational units at different levels and a structured, consolidated and standardized processing of information sources can/will thus enable the locally responsible stakeholders for civil protection to perform their tasks even more efficiently.