RECIPE

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

Guidelines to incorporate projected climate change impacts into Decision Support Systems and platforms

DELIVERABLE Nº 4.1

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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 D4.1 of task 4.1 and 4.2.

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-Wuerttemberg (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 of 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 for integrate climate scenarios into risk assessment and planning.
- WP5 Publicity and project outcomes transference.

Task 4.1 consist of existing decision support systems and IT resources, and the operability to incorporate operational emergency requirements identified to face climate change scenarios into risk assessment and planning. Main focus is laid on tools used by the regional/national emergency management bodies. The objective is to identify potentials and constrains in terms of resolution, data quality and type, data analysis under operational queries during the case of emergency, etc. Each partner participated in the assessment from their own regional/national experience in the corresponding natural risk through the necessary face-to-face meetings with the emergency bodies (oriented focus assessment of DSS IT tools). Other European projects related with the topic have been included (HEIMDALL, ANYWHERE, etc.), as well as meetings with other associations representing fire and rescue services.

Task 4.2 is done according to the operability of the available platforms (task 4.1) and the risk components and data requirements re-evaluated in the risk situations analyzed under climate scenarios (task 3.2). The description of the risk attributes and data requirements to be included into DSS to address climate change impacts on multi-hazards risk management is done. Climate change impacts on multi-hazard can require new data integration into DSS, which cannot be identified from a single risk approach. Nevertheless, the feasibility and the protocol to integrate them depends on the data quality and the operability of existing platforms. The guidelines will be reviewed in an interactive manner with the specific supporting tools developed in task 4.3 according to own regional/national context, which will contribute to the EU scaled-up multi-hazard final version. This task includes desk work and face-to- face meetings with emergency bodies.

1.1 DSS IT TOOL definition

In the framework of RECIPE project, a Decision Support System (DSS) refers to any information tool that enhance the decision process made by an emergency body during any of the risk phases: prevention, preparedness, response and recovery. A DSS can improve the management, operations and planning levels of a civil protection by giving information and reducing uncertainty to risks that may be in constant change. DSS can be either:

- Fully computerized or human-based
- Dynamic or static
- Commercialized or specifically made for an organization.
- Local, regional, national or international.
- Single risk or multi risk.

A DSS can include any of layers displayed in *Figure 1*.

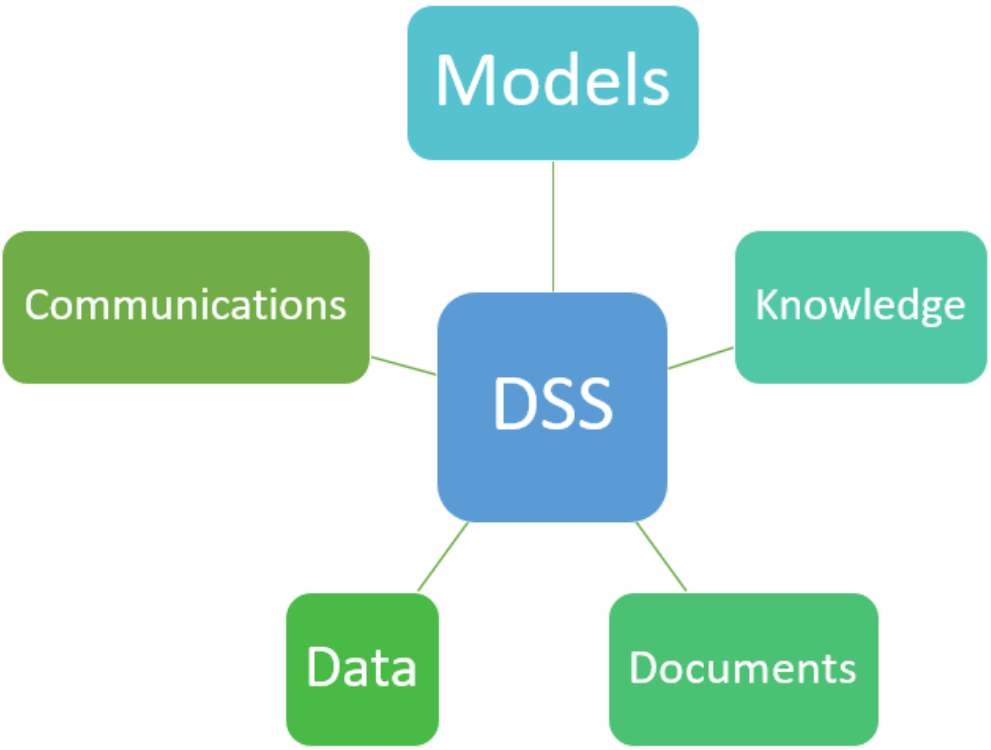

Figure 1. Layers of information.

1. Objectives

The aims of task 4.1 is to make an analysis of existing Decision Support Systems and the operability to include projected climate change impacts on them. In addition, task 4.2 is focused on defining guidelines to incorporate projected climate change impacts into DSS and platforms.

Deliverable 4.1 is the main output of task 4.1 and 4.2. Therefore, the current document, called 'Guidelines to incorporate projected climate change impacts into Decision Support Systems and platforms', is to define Decision Support Systems data requirements according to risk management under climate change context and the current and future capabilities highlighted during DSS analysis.

The document is mainly based on three inputs:

- Interviews that all partners did to Civil Protection to discuss about their DSS tools. Each interview provides a detailed description of the DSS, current capabilities, future needs and DSS assessment. Consequently, after interviewing a large number of civil protection staff, the deliverable provides an extensive and variate overview of current DSS tools that European Civil Protection bodies are using to face different natural disasters.
- Lessons learned during the development of the operational tools (Task 4.3) in regard to DSS enhancement.
- Main findings of WP3 in regard to climate change impacts to face new single and multi-risk scenarios.

At the end of the document, the reader should be able to better understand key information and data requirements to address scenarios posed by climate change according to the experience of civil protection bodies. In addition, topics such as the enhancement of risk management through improving existing DSS and DSS capabilities that reinforce Civil Protection objectives under climate change context are also addressed in this document.

2. Methodology

Deliverable 4.1 is structured in different sections that contribute to define how climate change impacts on risk management should influence DSS IT tools.

Each DSS tools has a section called general description of the DSS, that provides a detailed overview of the DSS, particularly in terms of hazards covered by the tool, the main use in each of the risk management phases (Prevention, preparedness, response and recovery), their operability in multi-risk scenarios and the implementation scale (local, regional, national, international or cross-border).

For each tool, current features and capabilities of the analyzed DSS are provided. Information that can be found in this part is the following: Data sources and resolution, simulations, communication between First Responders and Forward Command Post, alerting First Responders and citizens, situation assessment, decision support and data sharing, scenario matching and climate change/extreme events new capabilities to improve risk management.

An overview of DSS future capabilities to overcome challenges posed by climate change and subsequent multi-risk scenarios has been done for each DSS. In this sections, additional capabilities for each DSS according to current limitations and development of a new tool is provided.

Finally, there is a SWOT analysis for each DSS to find all the positive and negative points both, currently and in the near future.

As mentioned, the current report is based on interviews to civil protection experts as well as the feedback provided by RECIPE partners after completing the different tasks of the project related to civil protection operative tools and risk analysis under current and future climate. The following sections summarize the working process.

The methodology proposed to understand Decision Support Systems data requirements according to risk management under climate change context and the current and future capabilities highlighted during DSS analysis is based on the conduction of a series of interviews to the different organisms involved in the Civil Protection and emergency management itself that are developing or using DSS systems. Through this strategy, staff directly involved with the DSS could provide very useful feedback about their tools.

All the interviews were carried out following the same questions and template (see annex I). Each partner was the responsible for the interviews in its region or country. Afterwards, each partner filled a questionnaire to review the main points of the interviews they performed as a tool to help in the preparation of this report. Each partner has different risks of expertise, so their contributions are benchmarked in their field.

The objective of the questionnaire was to understand the capabilities and potentialities of the DSS under current and future challenges. For that reason, the questionnaire was built under a co-creation process were all RECIPE partners provided inputs in order to address the interview template according to the project objectives. The template has a first section where a description of the Civil Protection body is provided in order to put a context of the DSS and understand the main duties of people using it. Next sections are to generally describe the DSS, to understand the current capacities and to understand future capacities that the DSS should has. Finally, there is a DSS SWOT analysis that pretends to be a final summary of the interview highlighting positive and negative points of the tool.

2.1. Interviews

Interviews (ANNEX I. DSS interviews template) seek to identify and analyze the existing DSS and IT resources, and the operability to incorporate operational emergency requirements, to face risk scenarios posed by climate change into risk assessment and planning. The main objective is to identify potentials and constrains in terms of resolution, data quality, and type (quantitative and qualitative), data analysis under operational queries during the case of emergency, etc., aimed at reinforcing civil protection capabilities within the risk management.

An interview template was initially designed as a guideline to carry out homogeneous interviews with civil protection experts. The interview is available in ANNEX I. The template is divided into three different sections:

- Questions about the civil protection body that is being interviewed.
- General description of the DSS IT Tool
- DSS IT Tools assessment

The interviews were performed through individual online meetings between June 2020 and November 2020. Each RECIPE partner contacted both users or developers of DSS IT Tools (mainly fire services, risk managers and other civil protection bodies) with the aim to better understand their capabilities and possibilities for improvement.

In this point there is a general description of the interviewees as a base to support the comprehension of the next chapters.

The overall number of DSS assessed is 18 as can be seen at Table 1.

Table 1. Number of DSS analyzed according to countries involved in RECIPE project and natural hazards.

Country	Partners	Risk analysis developed within RECIPE	Nº of DSS analyzed
Germany	FVA	Storms	2
Austria	BWF	Landslides, rockfalls, avalanches	2
Italy	CIMA	Floods and forest fires	3
Spain	CTFC, ICGC, DGPC, PCF	Forest fires, floods and avalanches	8
Portugal	ISA	Forest fires	3

In Germany 2 DSS have been analysed by FVA:

- **TREE SPECIES SUITABILITY MAPS**: Interview done to a researcher of the Forest Research Institute Baden-Württemberg, Germany (FVA-BW), a research institution working at national level that provide and disseminate information on risk and crisis management in the forestry sector and provide scientifically backed information on how to re-establish damaged forests (e.g., choice of tree species for planting).
- **VULNERABILITY MAPS:** Interview done to a researcher of the Forest Research Institute Baden-Württemberg, Germany (FVA-BW), a research institution working at national level that provide and disseminate information on risk and crisis management in the forestry sector and provide scientifically backed information on how to re-establish damaged forests (e.g., choice of tree species for planting).

In Austria, the study focused on 2 different DSS tools:

- **HAZARD MAP OF THE TORRENT AND AVALANCHE CONTROL (GZP)- AUSTRIA**: Interview done to a research institution working in cross-border scenarios across the European Union, the torrent and avalanche control (WLV) as a subordinate unit of the BMLRT (Austria). The role of this organization is to provide and disseminate information for protection against floods and gravitational natural hazards as well as provision of scientific basis for hazard and risk assessment.
- **R.A.G.N.A.R - RISK ANALYSIS OF GRAVITATIONAL NATURAL HAZARDS IN THE ALPINE SPACE**: Interview done to the Office of the Tyrolean State Government (department of landscape services & division of sports) & Austrian Alpine Club (division huts and mountain trails). It is a research institution working at cross-border scale across the European Union. The role of this organization is to provide and disseminate information for protection against floods and gravitational natural hazards as well as provision of scientific basis for hazard and risk assessment.

In Italy, CIMA carried out 3 interviews to discuss about DSS:

- **A4LIG:** The interviewed organization using the DSS was the municipality of Genoa, particularly to an expert on emergency planning. It is a public body working at regional and local scale. Their main tasks are territorial and urban planning considering the risks and civil protection plans including risk scenarios, strategies and action plans for different emergencies, information about safety areas and evacuation procedures.
- **HEIMDALL**: Interviewed carried out with the Italian Red Cross, a non-profit organization that was involved in HEIMDALL project, that developed the DSS, as End-User organization. Italian Red Cross works in emergency planning at national level. The Italian Red Cross contribution to risk assessment and planning is structured as following: analysis of vulnerable population and its vulnerabilities; sharing emergency capacities; integration of standard operating procedures; training of personnel; exercises; Pre-positioning of assets, enhancement of local, regional and national capacities for both planning, training and response management; Research and innovation focused to support planning, preparedness and response; Medical emergency services providers; and identification of early recovery and rehabilitation programmes.
- **Prevenzione Comune**: Interviewed carried out to CIMA and to the head of civil protection office of the Municipality of Arenzano. The last one is a public body working at local level. Among their main

actions we can find: territorial and urban planning considering risks; risk scenarios and assessment; strategies set up by the Mayor for possible emergencies within the municipal territory; information regarding the safe areas to get to within the municipality in case of an emergency; and evacuation procedures.

In Spain, partners have performed nine different DSS analysis:

- **Avalanche Hazard Map (AHM):** Interview done to an ICGC technician of Avalanche Warning Services. It is a public body working at regional scale. The main function is the spatial and temporal prediction of the degree of danger of snow avalanches in the Catalan Pyrenees. Raise awareness and train actors involved in snow avalanche risk (civil protection and emergency bodies, risk management agencies, the population, etc.). The forecasting unit provides information on the danger of avalanches in emergency situations (civil protection plan ALLAUCAT). Local forecast (ski resorts that depend on the administration). Assess and report on whether spatial planning considers the risk of snow avalanches.
- **Avalanche Database of Catalonia (BDAC)**: Interview done to an ICGC technician of Avalanche Warning Services.
- **Avalanche Danger Information Platform (PIPA):** Interview done to an ICGC technician of Avalanche Warning Services.
- **ATES-Avalanche Terrain Exposure Scale (mapping)**: Interview done to the head of the Avalanche Warning Services of the Conselh Generau d'Aran (CGA), a Catalan County located at the northwest of the Catalan Pyrenees. CGA is a public body that works at sub-regional scale. Its main civil protection duties are public avalanche prediction and development of support tools for individual and group decision-making.
- **Civil Protection Map**: Interview done to DGPC, the head of the technology service. It is a public body working at regional scale. The main tasks done in terms of risk management are: (1) The civil protection functions are assessment, planning, preparedness and response for risks (natural, technological, …) and anticipate the actions to be taken to minimise the effects of emergencies generated by risks. (2) Among other things, communication, awareness-raising and organising drills to the population. (3) Civil Protection acts as coordinator. Civil Protection carries out communication and monitoring tasks both from the Operational Coordination Centre of Catalonia, the Municipal Coordination Centres and in the field through the Advanced Command Centre, and (4) the management of psychosocial risks, monitoring the situation to overcome the emergency and to have logistical tools available.
- **ANYWHERE**: Interview done to a Technician in the Emergency Management Service of the Catalan General Directorate of Civil Protection, who was involved in ANYWHERE project. Civil Protection management in the region of Catalonia. This person is in charge of the Catalan emergency management room (CECAT, Operative Coordination Centre of Catalonia).
- **Special Plan for Avalanche Emergencies in Catalonia (ALLAUCAT)**: Interview done to the head of Risk Management and Planning Service of the General Directorate for Civil Protection of Catalonia.
- **Emergencies Operational Cartography of the Catalan Fire and Rescue Service**: Interview done to two different representatives of the Catalan Fire and Rescue Service, the Operational Emergencies Cartography responsible (technical view) and a sub inspector of the wildfire analysis unit

(operational view). It is a regional and public body. Their main tasks are planification of strategic areas against wildfires, prescribed burns, maintenance of forest roads and water points, fire suppression as well as response in other type of disasters (floods, landslides, oil spills, car accidents…).

In Portugal, three more DSS were assessed:

- **FlamMap/Behave Plus/Fire Chart, WindNinja, ErMIT:** Interview to a fire expert and consultant of Alto Minho that uses a fire behaviour and propagation software developed by the US Forest Service. It is an organization working at regional, national, international and cross-border whose main actions are planning for forest fire prevention, implementation of structured measures, elaboration of strategic analysis and support in the theatre of operations with tactical analysis and scientific research about forest recovery.
- **SADfLOR - A Web-Based Forest and Natural Resources Decision Support System**: Interview to a researcher specialized in ecosystem services assessment, fire behaviour modelling and sustainable forest management working at the University of Lisbon. Working at national and international levels, its main field of expertise are forest management plans to prevent risk.
- Interview not focusing to any particular DSS. The objective was to talk about a general overview of the means that the Civil Protection Service from Mafra County (Portugal) is using to manage the risk. This organisation work in the 4 phases of the emergency, risk evaluation, preparedness, Education, Emergency Management and Recovery at local (county) level.

As a conclusion, the number of DSS analysis is high and it is enough to draw a general picture of the current capabilities, future needs, weaknesses and potentialities, always related to Civil Protection requirements under climate change scenarios. The territorial distribution is variate, and despite not being an exhaustive compilation of DSS, it is considered to be enough to discuss about Decision Support Systems data requirements according to risk management under climate change context and the current and future capabilities highlighted during DSS analysis.

2.2. Feedback

Lessons learned during the development of the operational tools (Task 4.3) in regard to DSS enhancement are also added at the end of the document considering partners feedback from their use cases.

Information such as data requirements to address scenarios posed by climate change have been provided with the objective to understand to what extend risk/multi-risk management can be enhanced by improving or designing new DSS with the capabilities and Data seen during the interviews and DSS capabilities that reinforce Civil Protection objectives under Climate Change context.

3. DSS Analysis

3.1. Tree species suitability maps

Description

DSS IT TOOL	Natural disasters	Operational scope
Tree Species Suitability maps	Forest fires, Floods, Rock falls, Landslides, Storms, Strong winds, Biotic Hazards. Multi-risk scenario: Floods, Rock falls and Landslides.	Regional (At Germany states level)
https://www.fva-bw.de/daten-und-tools/geodaten/klimakarten		

Tree species suitability maps is a DSS tool used in Germany that can be used at prevention phase for the selection of tree species against the backdrop of climate change. Future hazards can be mitigated by selecting suitable and adapted tree species. At recovery stage, maps provide scientific basis for tree species selection and preventive risk management decisions which is openly available for everybody in the respective region. It is a freely accessible tool implemented since 2019 that help forest managers during tree selection for climate change adaptation. The current Model 2.0 is a further development of the maps that were created in 2010.

Current capabilities adapted to current scenarios

In the case of **tree species suitability**, the maps are based 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 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 likeability and yield. These maps map at 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 climate change projections are based on the IPCC scenario B2 and cover the situation today (2010) and in the future (2050). The maps are a decision support on local or stand level in order to fill the gap between global climate projections and forest or risk management on the local level.

Current capabilities to adapt the DSS to climate change scenarios

Tree species suitability	
Capabilities	**Clarifications**
Ability to add new needs (e.g., decision-making scenarios, new decision-making schemes, new planning approaches, etc)	Allows obtaining information and a rough indication on the growth conditions of forests in 2050. This contributes to landscape planning.
Ability to include generated information into urban planning	The obtained information can be used also for urban planning (i.e., selecting tree species in cities) but also urban forests and parks.
Climate change projections (temperature, radiation, rainfall, etc) to predict future risk scenarios	Extrapolates and visualizes the effects of climate change on future forest composition.
Species redistribution according to climate projections (Flora)	Indicated the suitability of tree species under climate change.
Landscape composition and configuration changes according to climate change projections	Indicated the suitability of tree species under climate change. It also indicates areas, where commercial forestry may not be possible and other environmental services become more important.
Forests vulnerability to climate change impacts according to projections	Indicated the suitability of tree species under climate change. By comparing the current status with the projection, it is possible to detect the vulnerable spots.

Future Capabilities

Tree species suitability maps can only depict predictions for the four main tree species with economic relevance in pure and/or dominated stands. In future, it would be nice to have the maps for more tree species and simulations for mixed stands. New tree species and influencing factors shall be added and a focus on climate change “hot spots” is planned. It is also planned to provide the maps on electronic devices of forest managers so that they are accessible in the field. It would be interesting to provide and extend the information to other authorities, such as emergency services.

Assessment

Tree species suitability maps	
Weaknesses	**Threats**
Information only for state and communal forest areas available (data source). Maps not interactive and not (yet) available on handheld devices in the field.	Due to the long-life span of trees, the predictions of the maps may turn out differently. Too much reliance on information provided by maps when taking decisions and local ground knowledge is not considered.

	As the tool is available only for public forests this may lead to favouring of publicly managed forest and disadvantage of private forest owners.
Strengths	**Opportunities**
Latest findings from forest research as base of the maps. Objective and unbiased information source. Freely accessible.	Possibility to take better informed decisions and include general trends in planning and risk mitigation. Include climate change into forest planning. Facilitate recovery after major disasters (i.e., winter storm) and 'built back better.

3.2. Vulnerability maps

Description

DSS IT TOOL	Natural disasters	Operational scope
Vulnerability Maps	Forest fires, Floods, Rock falls, Landslides, Storms, Strong winds, Biotic Hazards. Multi-risk scenario: Floods, Rock falls and Landslides.	Regional (At Germany states level)
https://www.fva-bw.de/daten-und-tools/geodaten/klimakarten		

Vulnerability Maps are also used in Germany since 2019. The vulnerability maps are free accessible and classify current forest stands in terms of their exposure to mortality risks typical of climate change. At the Preparedness phase, tree species suitability maps are a decision support tool during the selection of tree species against the backdrop of climate change. Forested areas with vulnerable stands can be identified (e.g., during risk assessment) and treated to mitigate risk. In regard to response, the DSS identify vulnerable stands to better coordinate response activities. At recovery phase the maps form an objective basis for tree species selection and preventive risk management decisions which is openly available for everybody in the respective region.

Current capabilities adapted to current scenarios

The **vulnerability maps** are designed as a multi-criteria procedure, so that the vulnerability to climate change is calculated not only on the basis of individual risks but also on the basis of several risks. Data source is based on forest inventory data and site mapping with a resolution of 20m. The maps depict the present situation of forest stands and allow to indicate particularly vulnerable areas.

Current capabilities to adapt the DSS to climate change scenarios

Vulnerability Maps	
Capabilities	**Clarifications**
Ability to add multi-hazard scenarios	The maps show multi-hazard scenarios as they are designed as a multi-criterial procedure, so that the vulnerability to climate change is calculated not only on the basis of individual risks but also on the basis of several risks.
Ability to include generated information into urban planning	The obtained information can be used also for urban planning (i.e., selecting tree species in cities) but also urban forests and parks.
Supports evacuation management	Not directly, but vulnerable stands along roads can be detected.
Landscape composition and configuration changes according to climate change projections	The maps indicate the areas of forest that are most vulnerable to natural hazards.
Forests vulnerability to climate change impacts according to projections	Indicated the vulnerability of present forest stands.
Storms impacts according to climate change projections	To generate the vulnerability level, storm risk is included as one driver of risk.

Future Capabilities

Vulnerability maps can only depict predictions for the four main tree species with economic relevance in pure and/or dominated stands. In future, it would be nice to have the maps for more tree species and simulations for mixed stands. New tree species and influencing factors shall be added and a focus on climate change “hot spots” is planned. It is also planned to provide the maps on electronic devices of forest managers so that they are accessible in the field. It would be interesting to provide and extend the information to other authorities, such as emergency services.

Assessment

Vulnerability maps	
Weaknesses	**Threats**
Information only for state and communal forest areas available (data source). Maps not interactive and not (yet) available on handheld devices in the field.	Due to the long-life span of trees, the predictions of the maps may turn out differently. Too much reliance on information provided by maps when taking decisions and local ground knowledge is not considered.

	As the tool is available only for public forests this may lead to favouring of publicly managed forest and disadvantage of private forest owners.
Strengths	**Opportunities**
Latest findings from forest research as base of the maps. Objective and unbiased information source. Freely accessible.	Possibility to take better informed decisions and include general trends in planning and risk mitigation. Include climate change into forest planning. Facilitate recovery after major disasters (i.e., winter storm) and 'built back better.

3.3. Hazard map of the torrent and avalanche control (GZP)-Austria

Description

DSS IT TOOL	Natural disasters	Operational scope
Hazard map of the torrent and avalanche control (GZP)	Floods, Rock falls, Landslides, Avalanches.	National (Austria)
https://www.bmlrt.gv.at/forst/oesterreich-wald/raumplanung/gefahrenzonenplan/Gefahrenzonenplan.html		

Hazard map of torrent and avalanche control (GZP) is a DSS used in Austria. Maps are freely accessible at the communities, partially already implemented in the Federal State-GIS. The tool has been used since 1970 with regular updates to keep the tool up to date. It is a decision support tool for spatial planning (communities, authorities in Austria), only available for torrential hazards and avalanches around settlement areas. At prevention phase, hazard maps of the torrent and avalanche control are – due to state legislation legally - binding for spatial planning in Austria. Settlement development is regulated according to the type and degree of endangerment. Future endangerments can be mitigated by keeping settlements and infrastructure away from endangered zones or reduce vulnerability due to constructional adaptions. However, they are not available area-wide and not for all kinds of natural hazards. At preparedness phase, hazard maps are a basis for decisions of emergency services as they indicate different degrees of danger and thus the need of measures (nature and urgency, e.g., evacuation). Finally, at recovery stage, the tool is the basis for adapted rebuilding after natural hazard events.

Current capabilities adapted to current scenarios

The **hazard maps (GZP)** are based on event chronicles and -documentations, field surveys (silent witnesses) and increasingly on event modelling. Experts turn all these sources into the final GZP. The maps are available in at slope scale (at least 1:5000) for relevant areas around settlements in Austria. Areas endangered by avalanches and torrential processes (flooding, sediment transport, debris and mudflows in channels) are identified either as “yellow zones” (settlement development with restrictions) and “red zones” (building prohibited). Other hazard as landslides and rockfall are shown as “brown zones”, indicating the need for further investigations. As a static planning tool, changes (as caused by climate change) are not considered in the GZP. GZPs are from the conceptual point of view static plans designed for spatial planning. However, they offer helpful information for emergency services as well.

Current capabilities to adapt the DSS to climate change scenarios

Hazard Maps GZP	
Capabilities	**Clarifications**
Ability to include generated information into urban planning	The generated maps are already obligatory to consider for spatial planning of settlements in Austria.
Ability to include urban planning as an input	Partly: The effects of e.g., soil sealing is considered when determining water discharges.
Ability to calculate economic losses	GZP might be the basis for those calculations.
Supports evacuation management	Information on potential endangered areas.
Supports confinement management	Spatial planning: Classification of certain hazard (e.g., “yellow zone”: construction requirements, “red zone”: building ban).
Ability to include improvements at the DSS (e.g., better communication tools, forecasting tools, geographic information, etc)	Event documentation, use of improved assessment methods and more accurate spatial information can further develop the hazard maps. Changes in hazard zones can have significant socio-economic impacts and therefore lead to serious conflicts of interests.
Landscape composition and configuration changes according to climate change projections	
Forests vulnerability to climate change impacts according to projections	

Future Capabilities

Hazard map of the torrent and avalanche control (GZP) is a proven instrument that has been generally accepted, implemented and used after decades of effort. However, information provided for landslides and rockfall is limited. An extension according to torrential hazards would be helpful for spatial prevention measures. Anyhow, this would require a great deal of effort and would hardly achieve comparable quality. Due to the well-established status of the GZP as planning tool, a lot of actors show little interest on introducing "new instruments" (such as e.g., risk planning). The GZPs are designed as static, spatial planning

information. Thus, it is not the intention to consider changes (climate change, land use changes) or draw scenarios. However, additional modules to extend the hazard focused maps by information on risks scenarios (as e.g., climate change) are interesting in terms of providing additional information for decision-makers.

Assessment

Hazard map of the torrent and avalanche control (GZP)	
Weaknesses	**Threats**
Challenging to keep status up to date not area wide available. Not available for all-natural hazards. No consideration or multi- hazards. Elements of risk estimation are largely missing/ in transparent. Costly creation.	Risk of decreasing timeliness with changing conditions (changing hazards/ hazard zones). No consideration of possible/probable developments. Settlement-development in areas which require. the maintenance and functioning of protective measures.
Strengths	**Opportunities**
Well approved and widely accepted basis for spial planning. Large scale information, high accuracy. Simple design, understandable for laymen. Creation with the involvement of local decision-makers.	Keeping endangered areas free form unsuitable use. Establishment of hazard-awareness by local population.

3.4. R.A.G.N.A.R - risk analysis of gravitational natural hazards in the alpine space

Description

DSS IT TOOL	Natural disasters	Operational scope
R.A.G.N.A.R - risk analysis of gravitational natural hazards in the alpine space:	Rock falls, debris flows, mud flows Multi-risk: Combination of rock falls and debris flow/mud flow	Cross-border EU, Tyrol (Austria), South Tyrol (Italy), Bavaria (Germany).
https://www.bergundsteigen.blog/r-a-g-n-a-r/		

R.A.G.N.A.R - risk analysis of gravitational natural hazards in the alpine space is a semi-open DSS. A rough precalculation can be carried out online free of charge. A complete risk analysis, supported by technical and local experts ending in a report, which costs a one-time fee. The tool was launched in 2019 and does not include the investigation of geotechnical parameters. The main focus is on the frequency of events, the

frequency of the number of visitors (who are passing danger spots) and the average duration of visitors' stay in the danger spots. RAGNAR is used in prevention and preparedness emergency phases. The tool is used to objectively assess the risk of gravitational natural hazards for users of the alpine road & trail network. As a preventive tool, it is intended to help trail maintainers to make decisions regarding the management of the trails and roads (trail closures, construction measures, no measures, etc.). The risk estimation is done in 7 steps, including a protection goal definition (desired level of safety), a risk analysis, the collection of empirical data and a risk calculation. The tool is basically used preventively. If it is used on mountain trails with e.g., currently high rockfall probability the result could be the closure of the trail. Thus, the instrument also has a role in the preparation phase.

Current capabilities adapted to current scenarios

RAGNAR is limited to de facto known "problem trails". The input data / sources for the tool are provided by various actors: The danger spots are defined by experienced local people (e.g., mountain guides, sections of the Alpine clubs, hut owners etc.) and inspected by qualified R.A.G.N.A.R experts. The model input includes the frequency of the events, the visitor frequencies of the affected trails and the average length of stay of the visitors at the critical locations. No geotechnical, lithological or hydrological parameters are considered. A full analysis / expert opinion may refer to one hazard site or include several hazard sites along a hiking trail (then combined with a summation of the risk).

There is no process modelling. Depending on the category of path (forest road, difficulty of the trail, high alpine path), an acceptable risk (what "may" happen?) and a calculated risk of death (and depending on the hazard-event and visitor frequency) are compared with each other.

The intention of the tool is to provide a traceable decision support. Until now, hiking trails that were subjectively perceived as dangerous were closed by the respective trail operators as a precautionary measure ("inflationary road closures") for fear of the responsibility to be borne. With this tool, a decision can be made in a structured and comprehensible way based on defined protection goals and the calculated risk, supported from the public prosecutor's office of Innsbruck.

In the process of determining risk, various scenarios should be calculated, based on the assumption of different event frequencies, event duration, visitor frequencies and their length of stay. The framework conditions can also be selected as a "worst case" scenario (very high event frequency & high visitor numbers) in order to ensure that decisions are made “on the safe side”.

Current capabilities to adapt the DSS to climate change scenarios

RAGNAR	
Capabilities	**Clarifications**
Ability to add multi-hazard scenarios	Multihazard scenarios are considered by no explicit distinction between rockfall and debris flow. Only the fact that a gravitational natural hazard occurs at the site of interest is considered. It can therefore also be a process combination of a primary landslide with secondary rockfall phenomena.
Ability to predict cascading effects/risk interactions	There is no possibility to predict cascading effects.

Ability to add new needs (e.g., decision-making scenarios, new decision-making schemes, new planning approaches, etc)	The implementation of new decision-making scenarios or new decision-making schemes is the main outcome advantage of the tool (described in point 2e.)
Ability to include generated information into urban planning	The generated information offers decision making for alpine space planning, not for urban planning (settlements) per se.
Integrates information on the degree of exposure/vulnerability of human lives and properties	The exposure of human life is considered by comparing an acceptable death rate with a calculated death rate. If the calculation reveals (protection) deficits, there is a need for action. The degree of exposure is indicated by the average time a hiker spends in area of danger. If the hiker has to climb up a rockfall endangered gully in several serpentines, the exposure is relatively high.
Other (please describe)	Objective, legally arguable risk analysis for the alpine space for rockfall events effecting forest roads and mountain trails (instead of inflationary road and trail closures basing on subjective influenced precautions).

Future Capabilities

RAGNAR is currently only used in the alpine area, i.e., exclusively outside settlements and spatially relevant infrastructure. In this area, visitors of e.g., mountain trails expose themselves to an individual risk, which in Austria is still basically borne by each individual. The risk in the institutional sector - i.e., on public transport routes or in settlements - is largely supported by the state. In terms of the development of a modern risk culture, the application for infrastructure facilities and settlement areas should be tested. The limitation of the tool with regard to extreme events is that the determination of the risk is in not related to the rock fall magnitude (and inherent forces) but only to the frequency. According to the developers of this tool, this goal is also not pursued, because there are no geological or geotechnical evaluations. At the moment it is too early for suggestions for improvement. The tool is only available since 2019 and has been used or commissioned by around 25 clients (municipalities, Alpine clubs, tourism associations, etc.).

Assessment

RAGNAR	
Weaknesses	**Threats**
Not yet accepted / recognized in a wide area of experts / responsible persons / stakeholders. Does not fully replace the expertise of the state geology. Applicability depending on event documentation (at least reporting of location and kind). The assessment of the event frequency is subject to uncertainties.	The tool could be used as a business model by the R.A.G.N.A.R evaluators who are necessary for the full analysis (high risk potential could be propagated on many trails). The tool could be misunderstood as a substitute for expert opinions of geologists. In subjective perceptions, hikers could lose awareness of their own responsibility following

The assessment of visitor numbers is subject to uncertainties.	tool-based results and the resulting measures (signage etc.).
Strengths	**Opportunities**
Objective risk analysis / taking the "risk culture" into account. Important decision support for trail maintainers. Avoidance of subjective based forest road and hiking trail closures triggered by fear of liability. Relief for geologists which had to assess the dangers along trails affordable. Legally viable (in the case of liability issues caused by misjudgement (no negligence)).	A decline in inflationary road and trail closures due to hasty precautionary measures. Uniform and harmonized, Alpine-wide approach to problematic hiking trails (the instrument has already been implemented in Tyrol, South Tyrol and Bavaria).

3.5. A4Lig

Description

DSS IT TOOL	Natural disasters	Operational scope
A4Lig	Floods and Wildfires	Regional and local in Italy
http://anywhere-h2020.eu/services/multi-hazard-early-warning-platforms/a4eu/pilot-sites/a4lig/		

A4Lig is a DSS used in Italy since 2014 to deal with floods and forest fires. It has a per-user license and provides the capacity of early-warning detection and proactive decision-making when facing extreme weather-related emergencies. At the preparedness phase, A4Lig allows global forecasting models downscaled to the local level and a combination with regional layers of exposure and vulnerability. During response, the tool tracks potential evolution of events and the identification of impacts of the events.

Current capabilities adapted to current scenarios

A4Lig allows local resolution. The platform provides connection to data available from different sources (from local to European). The Platform uses the data deriving from forecasting model and nowcasting models, used by Centro funzionale the data deriving from regional layer (vulnerability and exposure). The platform is designed to help predict the immediate evolution of extreme climate and weather events and the specific impact on a territory. This tool is able to simulate flood and fire risk simultaneously and to translate meteorological forecasts into quantitative and measurable impacts. The platform is able to put together fire risk scenarios and flood risk scenarios.

Current capabilities to adapt the DSS to climate change scenarios

A4Lig	
Capabilities	**Clarifications**
Ability to add multi-hazard scenarios	
Ability to predict cascading effects/risk interactions	
Ability to add new needs (e.g., decision-making scenarios, new decision-making schemes, new planning approaches, etc)	An integration of landslides scenarios is currently being studied
Ability to include urban planning as an input	
Integrates information on the degree of exposure/vulnerability of human lives and properties	
Ability to calculate economic losses	
Ability to include improvements at the DSS (e.g., better communication tools, forecasting tools, geographic information, etc)	
Ability to include triggering patterns	

Future Capabilities

To improve **A4Lig**, the interviewed user highlighted that:

- In the preparedness phase, automating the change of the operational phase, using the data coming from the sensors present on the territory and from the signals coming from the territory.
- In the response phase, dynamically evaluating the exposed elements.
- In the recovery, integrating the geolocalised data related to the damages of the event, produced by another platform that collect the disaster loss data.

Assessment

A4Lig	
Weaknesses	**Threats**
Ability of interpreting the data is needed.	Underestimate climate change effects. excessive use of data computerization.
Strengths	**Opportunities**
Collect information about hazards, exposure and vulnerability. Use forecasting models for an early-warning detection. Use nowcasting model for developing proactive decision-making.	Anticipate the actions of Civil Protection (from early warning to early actions).

3.6. HEIMDALL

Description

DSS IT TOOL	Natural disasters	Operational scope
HEIMDALL	Rockslides, Landslides, mass movements, surface collapses, debris or mud flows, floods, wildfires.	Regional
https://heimdall-h2020.eu/		

In the case of **HEIMDALL**, a DSS developed under an H2020 EU Funded project, the system is not in use, is in the prototype / pre-industrialization phase. The tool offers an integrated risk management covering all the emergency phases. At prevention phase there is the possibility to create ideal scenarios, test them and identify areas where to organize preventive actions. At preparedness level, the DSS is able to train staff in both coordination and response. In regard to response, it allows a quick identification of the impact, information exchange, liaise with incidents plans and compare with previous similar events to support decision making. Finally, at recovery stage HEIMDALL can quickly identify areas where to activate a recovery program.

Current capabilities adapted to current scenarios

HEIMDALL is based on Earth Observation (SAT imagery and drones) with a variable resolution depending on EO source. It allows two kinds of simulations: running a scenario to forecast the impact of hazards during response operations and the creation of real and potential situation for exercises. The DSS allows data exchange between different users and the integration of data coming from assessment to the ongoing scenario. There is the possibility to make a scenario matching with both real and training scenarios.

Current capabilities to adapt the DSS to climate change scenarios

HEIMDALL
Capabilities
Ability to add multi-hazard scenarios
Ability to predict cascading effects/risk interactions
Ability to add new needs (e.g., decision-making scenarios, new decision-making schemes, new planning approaches, etc)
Ability to include generated information into urban planning
Ability to include urban planning as an input
Ability to calculate economic losses
Supports evacuation management
Supports confinement management
Ability to include improvements at the DSS (e.g., better communication tools, forecasting tools, geographic information, etc)

Climate change projections (temperature, radiation, rainfall, etc) to predict future risk scenarios
New fire regimes impact according to climate projections
New flood regimes impact according to climate projections
Species redistribution according to climate projections (Fauna)
Landslides impacts according to climate change projections
Rock falls impacts according to climate change projections

Future Capabilities

For **HEIMDALL** there is the need to have a DSS that support the definition (before) and the implementation of the emergency plan, step by step, including administrative and political act. Heimdall is very focused on OPERATIONS management, but LOGISTICS, PLANNING, ADMIN and FINANCE are not part of the tool.

Assessment

HEIMDALL	
Weaknesses	**Threats**
Not open source. Not localised (is not harmonised with local procedures). Limited to some specific risks. Limited multi-risk, multi-hazard approach.	Use of the software as a SaaS. The need to integrate it with other software for different risks reduces its possibility to be effectively used.
Strengths	**Opportunities**
Multi-purpose (training, exercise, response). Scenario matching. Joint tool.	Develop specific modules to support emergency and contingency planning. Integrate other hazards. Possibility to be used as EOC-Management software's and distance training platform.

3.7. Prevenzione Comune

Description

DSS IT TOOL	Natural disasters	Operational scope

Prevenzione Comune	Floods	Local
http://www.proterina.info/progetto-proterina2/		

About **Prevenzione Comune**, it is a tool focused on the municipal level and on the flood risk for the municipalities of Liguria Region. It has been developed in the framework of the Proterina2 project (INTERREG Marittimo IT-FR). It requires a per-user license to use it. At preparedness phase, the tool gives support to the definition of static risk scenarios for schools, health services and strategic buildings; support to the definitions of civil protection actions; support to the definition of the operative functions; definition of instrumental thresholds for the early warning; possibility to define coded messages to the operators in the case of threshold warnings. During response, it allows Early warning messages to operators (app Sentinel) and possibility to deliver early warning messages to the population / Real time track of events on the territory (app Creasy) / Instrumental monitoring / Receive official alert from the regional level.

Current capabilities adapted to current scenarios

Prevenzione commune includes static risk scenarios with regional and local data. There is the possibility to register and track critical issues in the territory. There is the possibility to send SMS and/or email to the citizens and to civil protection operators, also through the definition of different target groups and predefined text. Data locally sharing and situation assessment related only on the local critical issues reported. No data is shared with the other territorial levels activated.

Current capabilities to adapt the DSS to climate change scenarios

Prevenzione Comune
Capabilities
Ability to add new needs (e.g. decision-making scenarios, new decision-making schemes, new planning approaches, etc)
Integrates information on the degree of exposure/vulnerability of human lives and properties
Supports confinement management
Ability to include improvements at the DSS (e.g., better communication tools, forecasting tools, geographic information, etc)
Ability to include triggering patterns

Future Capabilities

Managers of **Prevenzione Comune** wishes the system to have a direct management of the exchange of information and communications between the municipal operation center (COC) and the on-site monitoring teams through the possibility of a communication relating the situation in real time accompanied by photos and comments, directly georeferenced and integrated in the platform (through Telegram or mobile phone). Moreover, they asked for a simplified data export system with the creation of a predefined report. In addition, they highlighted that during the recovery phase, a back analysis of an

event, thanks to an organized tracking of the critical issues, could inform prevention and preparedness actions. One of the limitations reported is that the system in some cases resulted slow.

Assessment

Prevenzione Comune	
Weaknesses	**Threats**
Limited to flood risk. Limited multi-risk, multi-hazard approach. Risk scenario limited to specific exposed elements. Slow. More used in the emergency management rather than in the preparedness phase. Low flexibility of the system.	Only web-based platform.
Strengths	**Opportunities**
Adapted to the local context and capacities. Detailed assessment of the vulnerability of exposed elements. Possibility to track critical issues in the territory. Support the civil protection planning. Integrate the regional and local instrumental monitoring network.	Improve the risk scenario application Improve the registration and tracking of the critical issues in the territory. Reinforce data export. Support decisions during emergency.

3.8. Avalanche Hazard Map (AHM)

Description

DSS IT TOOL	Natural disasters	Operational scope
Avalanche Hazard Map (AHM)	Avalanches and Floods cause by avalanches	Regional
https://www.icgc.cat/Administracio-i-empresa/Descarregues/Cartografia-geologica-i-geotematica/Cartografia-de-riscos-geologics/Mapa-de-zones-d-allaus-de-Catalunya-1-25.000		

The **Avalanche Hazard Map (AHM)** is a map used in Catalonia since 1980 (with regular updates). It is a tool that has to be updated every year with the new snow avalanches observed. The ICGC has a full ownership of the maps. At prevention phase main actions include the identification of areas affected by the danger of snow avalanches, identification of vulnerable areas and it would be useful in territorial planning. In response, the Avalanche Hazard Maps helps Civil Protection to quickly identify vulnerable areas of the territory in relation to the danger of snow avalanches. It helps in the decision-making process.

Current capabilities adapted to current scenarios

Avalanche Hazard Map is able to work at a 1:25000 scale. By means of simulations (impact pressure, the speed of movement, etc.), each avalanche zone could be zoned in three categories: non-buildable, buildable with protections and buildable without protections. It is A tool for detecting vulnerable areas and facilitating decision-making (roadblocks, evacuation, etc.). AHM informs if a certain area is affected by the danger of snow avalanches. The population should be informed if their property is in risk areas. The AHM provides this information. This tool detects vulnerable areas and facilitates decision-making (roadblocks, evacuation, etc.). A continuous update of the activity and the observations of avalanches in the Avalanche Hazard Maps allows to improve the decision making.

Current capabilities to adapt the DSS to climate change scenarios

Avalanche Hazard Map	
Capabilities	**Clarifications**
Ability to add multi-hazard scenarios	
Ability to predict cascading effects/risk interactions	The AHM provides information on whether an avalanche can reach a river, obstruct it and produce a flood.
Ability to add new needs (e.g., decision-making scenarios, new decision-making schemes, new planning approaches, etc)	The AHM provides information on which areas are vulnerable.
Ability to include generated information into urban planning	
Integrates information on the degree of exposure/vulnerability of human lives and properties	Only of the properties and fixed structures.
Ability to calculate economic losses	Because there are some vulnerable elements identified.
Supports evacuation management	
Supports confinement management	
Ability to include improvements at the DSS (e.g., better communication tools, forecasting tools, geographic information, etc)	
Ability to include triggering patterns	The new "visualizer tool" will allow it.

Future Capabilities

The **avalanche hazard map** is the new tool that ICGC is developing within the framework of the RECIPE Project. A visualizer tool that determines the most vulnerable areas where to act in a situation of extreme events. The Avalanche Hazard Maps provide information about the observed activity. The hypothetical maximum arrival areas are often overtaken by extreme avalanches. Therefore, it is necessary to simulate possible extreme events (RAMMS model).

This is the new tool ICGC is developing within the framework of the RECIPE project. Especially in the prevention and response phase. This new visual tool will show the most vulnerable areas in major avalanche situations. This tool is based on the analysis of past events. Therefore, civil protection will be able to decide how, when and where to act in order to minimize the risk if similar situations occur in the future.

Assessment

Avalanche Hazard Map	
Weaknesses	**Threats**
Low confidence of the Maximum Avalanche Zones (potential avalanche zones). Lack of Avalanche Hazard Maps on several mountain ranges away from the Pyrenees Possible low density of avalanche activity observers to map all the events. Lack of Avalanche Risk Zoning cartography.	Not enough human resources to review and update information of the Maximum Avalanche Zones. Possible inability of satisfying an increment of demands on avalanche risk information due to the CC.
Strengths	**Opportunities**
-Completed coverture of Maximum Avalanche Zones cartography in the Pyrenees of Catalonia.	The high demand of avalanche risk information could increase the interest of investing on updating the Avalanche Hazard Maps and starting the Avalanche Risk Zoning.

3.9. Avalanche Database of Catalonia (BDAC)

Description

DSS IT TOOL	Natural disasters	Operational scope
Avalanche Database of Catalonia (BDAC)	Avalanches	Regional and Cross-border
https://www.icgc.cat/Administracio-i-empresa/Eines/Bases-de-dades-i-catalegs/Base-de-dades-d-allaus-de-Catalunya-BDAC		

Avalanche Database of Catalonia (BDAC) is a DSS mainly used in Catalonia that was initially implemented in 2001 with a full ownership of ICGC. On average, 250 snow avalanches are recorded and mapped in the database each year. It takes time to complete. It can be used in all of the emergency phases. At prevention phase it determines the avalanche zones and includes past and present snow avalanches. In preparedness it can identify risk areas that help with preparation. During response, if we analyse the information together with PIPA we know which areas are more problematic. Therefore, it allows a better management of the

emergency. At recovery phase, if a snow avalanche destroys a forest area it is registered in the database. Therefore, it helps with subsequent forest management and recovery.

Current capabilities adapted to current scenarios

The **Avalanche Database of Catalonia** has as main data sources aerial photographs, orthophotographs, ground data, surveys (historical snow avalanches), information from historical records, the "Nivobs" observation network (profiles, snow avalanche activity, ground photographs, ...). In some specific cases of snow avalanches, some simulations have been carried out (AVAL-1D, RAMMS). The objective was to see if it was possible to improve the cartographies through simulations. Modelling the most frequent snow avalanches that can affect populations in a climate change context would be a good test.

The tool is open data. The information can be found on the website. Snow avalanches and weekly snow summaries are communicated. The warning (danger level 5) issued in PIPA with the display of the avalanche zone map (BDAC) and the major recorded avalanches is the “perfect fusion”. This would allow a better assessment of the situation. From a major mapped snow avalanche, we can infer, depending on the snow cover, the weather conditions, the terrain, etc., a similar degree of danger if similar conditions occur.

Current capabilities to adapt the DSS to climate change scenarios

Avalanche Database	
Capabilities	**Clarifications**
Ability to predict cascading effects/risk interactions	Avalanche database can help determine that, if an avalanche comes down to the river, it can cover it and produce a flood.
Integrates information on the degree of exposure/vulnerability of human lives and properties	Indicates if avalanches intersect with villages and roads
Supports evacuation management	The BDAC helps decision-making by identifying risk areas.
Supports confinement management	The BDAC helps decision-making by identifying risk areas.
Ability to include improvements at the DSS (e.g., better communication tools, forecasting tools, geographic information, etc)	

Future Capabilities

The **avalanche database of Catalonia** needs to carry out an avalanche mapping on a more precise scale. Modelling is very important. Analyse avalanches that affect anthropic elements (towns, roads, etc.) and modelling them (RAMMS model). This new information would be added to the BDAC. Ideally, the law should obligate the risk of avalanches to be considered in urban planning.

Tool could be improved: Improve mapping with a more precise scale of analysis. Make simulations, calculate frequencies, impact pressures, local resolution. Especially focused on prevention (territorial planning) and emergency management.

Assessment

Avalanche database of Catalonia	
Weaknesses	**Threats**
The scale of analysis is insufficient to give precise answers. The areas of maximum snow avalanche arrival can be overcome.	The uncertainty of climate change.
Strengths	**Opportunities**
The whole of the Pyrenees is mapped.	Using modelling. It nurtured on knowledge from other sciences (i.e., dendrochronology).

3.10. Avalanche Danger Information Platform (PIPA)

Description

DSS IT TOOL	Natural disasters	Operational scope
Avalanche Danger Information Platform (PIPA)	Avalanches	Regional
https://www.icgc.cat/Administracio-i-empresa/Serveis/Perill-d-allaus-i-informacio-nivologica/Sobre-les-allaus/Sobre-el-servei-de-nivologia-i-prediccio-d-allaus		

The **Avalanche Danger Information Platform (PIPA)** is a DSS used by practitioners in Catalonia since 2018. The steps taken to determine the degree of danger of snow avalanches are registered within the platform. At prevention phase it analyses the snow cover, its layers and evaluate its stability. Determine the main avalanche problem and the distribution of the snow cover on the terrain. Assess the probability and size of avalanches. Issue the daily bulletin on the degree of danger of snow avalanches for Civil Protection and the population. At response, the information generated in PIPA helps Civil Protection and emergency bodies to make decisions (is vital information). Where to act and which areas to avoid.

Current capabilities adapted to current scenarios

The **avalanche danger information platform** works at regional and local data from all possible sources of information. PIPA has an editing part (PEPA) that is used to communicate the results to First Responders/Forward Command Post. The expected improvement in PIPA is the inclusion of warnings in graphic format. If the degree of danger of snow avalanches is 4 or 5 the information generated is sent directly to Civil Protection, the municipalities and those areas at greatest risk. A good cartographic, topographical and planimetric basis facilitates better assessment of snow avalanche risk. PIPA helps to

achieve these objectives. It considers the synoptic situations of the past that have triggered major avalanches. It is important to keep the information updated and to know the different possible scenarios. It is very important to register present situations correctly in order to improve forecasting in the coming decades.

Current capabilities to adapt the DSS to climate change scenarios

Avalanche Danger Information Platform	
Capabilities	**Clarifications**
Ability to add multi-hazard scenarios	The information can be useful for forecasting multi-risk scenarios.
Ability to predict cascading effects/risk interactions	Partially. If we add the maps of the past and see that they affected a bridge or river course. Interaction with floods and forest fires is observed. Flooding due to snow melting processes. Flooding due to a river being blocked by an avalanche. Avalanches can destroy forest areas. If these affected areas are not properly managed, fires could occur in the future. Fires can affect the roughness of the terrain and therefore the future stability of the snow cover.
Ability to add new needs (e.g., decision-making scenarios, new decision-making schemes, new planning approaches, etc)	In local forecasting.
Ability to include generated information into urban planning	In example, the PIDA (Avalanche Intervention Plans)
Supports evacuation management	
Supports confinement management	
Ability to include improvements at the DSS (e.g., better communication tools, forecasting tools, geographic information, etc)	
Ability to include triggering patterns	The weather synoptic patterns that triggered major snow avalanches in the past.

Future Capabilities

The **avalanche danger information platform** must be very visual to facilitate decision making. Currently, the information in PIPA consists of icons and an informative text. The expected improvement in the warnings is to add the situation of the past. Analyse with maps the snow avalanches that have affected anthropic elements (towns, roads, etc). Therefore, we must assume that in critical situations the same or greater snow avalanches could occur. In relation to climate change, the maximum extent of these

avalanches is difficult to determine. The main limitation is that it is a recent tool (2018). It aims to improve the shortcomings that emerged in past seasons.

The modelling of snow avalanches from the thickness of snow in the starting zone. Using the Swiss RAMMS model for this purpose. The modelling of major avalanches would allow us to observe how far they go. Therefore, more effort needs to be invested in prevention.

Assessment

Avalanche danger information platform	
Weaknesses	**Threats**
Visualizing data and summarizing data information is complicated. The predictor must be experienced. The definition of probabilities is very subjective. There is a part of interpretation that depends on the experience of the predictor.	Uncertainty in the weather makes it difficult to forecast snow avalanches.
Strengths	**Opportunities**
It is a very well organised tool. It allows you to detect errors very easily. Briefing meetings generate input from the forecasting team that improves prediction.	Inclusion of the avalanche hazard matrix.

3.11. Avalanche Terrain Exposure Scale (ATES)

Description

DSS IT TOOL	Natural disasters	Operational scope
ATES-Avalanche Terrain Exposure Scale (mapping)	Avalanches	Regional. International (Tool created in Parks Canada (2004). It is currently used in the USA, New Zealand, Spain, Andorra and other European countries).
https://atesmaps.org/en		

ATES-Avalanche Terrain Exposure Scale (mapping) is a public tool (following the standards of the Canadian Avalanche Association) and the Evaluator tool can be used with a temporary license. It has been developed in phases. The whole of the Aran was completed in 2017. During prevention and preparedness phases the tool serves as integrated tool in training (ACNA-Snow and Avalanche knowledge Association) to raise awareness and disseminate. It is a basic tool for preparing a winter outing for mountain groups. It is also useful in response since it is integrated in the avalanche rescue protocols.

Current capabilities adapted to current scenarios

The **Avalanche Terrain Exposure Scale** uses 1:5000 orthophotographs and the 15x15 digital terrain model. Tool integrated in the rescue protocol of the Mountain Rescue Group (Pompiers). This A tool allows the assessment of the terrain and is integrated in the emergency operation. This tool can be used by any group involved in the emergency operation. It is a tool to be considered to compare with other situations. Particularly in operations with a variable type of terrain.

Current capabilities to adapt the DSS to climate change scenarios

Avalanche Terrain Exposure Scale	
Capabilities	**Clarifications**
Ability to add multi-hazard scenarios	**Note 1.** In case climate change implies increased avalanche activity with the capacity to destroy forests it will be necessary to adapt the tool to the new terrain conditions. **Note 2.** One of the parameters used by this tool is the avalanche return period (RP). If climate change changes this RP, the tool will have to adapt to the new parameters.
Supports evacuation management	It is a very useful tool in the management of a rescue operation.
Ability to include improvements at the DSS (e.g., better communication tools, forecasting tools, geographic information, etc)	If the information were more detailed (local prediction, ...) the tool would be more accurate. The existence of panels on the terrain at the most frequented points reinforces the awareness of the users.

Future Capabilities

In extreme conditions (difficult terrain and degree of danger >3) **ATES-Avalanche Terrain Exposure Scale** does not allow a detailed gradation of exposure. In other conditions (class 1 or 2 terrain and degree of danger <3) the tool allows a more precise assessment and decision-making in the rescue operation.

It would be necessary to develop a tool with enough resolution to be useful on the terrain. At present, ATES is designed for the planning of an itinerary and not for action at a particular point in the terrain.

Assessment

ATES-Avalanche Terrain Exposure Scale	
Weaknesses	**Threats**
Knowledge of the avalanche return period throughout the territory. Scale not suitable. For example, to make decisions about the safety of specific points.	Use the tool in a restrictive and inflexible manner. Safety conditions depend not only on the terrain, but also on the stability of the snow and the group factor. It should not be a tool that in itself can be used to judge decisions after the event. Use of the tool by groups without training in snow and avalanches.
Strengths	**Opportunities**
Good tool for planning a rescue operation. Easy to use (both ATES and Avaluator).	Use of ATES for managing access to the natural environment. Useful for making recommendations and restrictions.

3.12. Civil Protection Map

Description

DSS IT TOOL	Natural disasters	Operational scope
Civil Protection Maps	Earthquakes, avalanches, floods, wildfires. Separate layer of information according to risk.	Regional
https://pcivil.icgc.cat/pcivil/v2/index.html#41.71 149,1.75979,3z		

The **Civil Protection Map** of the Catalan Civil Protection department is free of charge, public accessible and gives support to municipal technicians since 2010. It is also useful for citizens. It is only a consultation tool and only the owners can edit and update the map. It is used in prevention and preparedness phases to raise awareness.

Current capabilities adapted to current scenarios

Civil Protection Maps are displayed in a scale between 1:25.000 and 1:50.000. It alerts of dangerous weather situations and danger situations 4 and 5 due to avalanches. Allows an assessment of potential risk (not emergency), data sharing and it helps to decide the response protocol from the prevention point of view. It is a tool to help define the risks in each part of the territory, both as a part of the risk analysis and as part of the forecast. The former maps are static and related to prevention. For example, flooding parts

of the main rivers for each return period (according to the flood risk directive). On the other hand, the latest maps are dynamic and are related to the preparedness stage. For example, areas forecasted for the next hours as high risk of high precipitation or areas forecasted as potentially hazardous for snow avalanches in the next days.

Current capabilities to adapt the DSS to climate change scenarios

Civil Protection Maps	
Capabilities	**Clarifications**
Ability to add multi-hazard scenarios	
Ability to add new needs (e.g., decision-making scenarios, new decision-making schemes, new planning approaches, etc)	This tool visualizes the same as the DSS SICECAT (Information System of the Operational Coordination Centre of Catalonia).
Ability to include generated information into urban planning	
Ability to include urban planning as an input	
Integrates information on the degree of exposure/vulnerability of human lives and properties	Only of the properties and critical structures.

Future Capabilities

Increased use of the maps from the application in emergency situations is detected in the case of **Civil Protection Maps**. Therefore, it would be appropriate to provide relevant information to the population through the application when displaying maps. In this way, the population will know what is occurring in real time. Finally, redirect them using self-protection messages.

A4Cat is the implementation of the A4EU platform for Catalonia. This tool has been locally adapted to the specific needs and requirements of the Catalan civil protection system, emphasizing the risk of floods, forest fires, windstorms and snowfall and SICECAT (Information System of the Operational Coordination Centre of Catalonia) as an internal emergency tool within Civil Protection.

Assessment

Civil Protection Maps	
Weaknesses	**Threats**
It does not provide information on ongoing emergencies. If the application does not use the data from the main source of information, there will be a conflict as we will not have the most recent data. Some cartography needs upgrading, especially in relation to climate change.	If the system of the agency which provides the data fails, it is interpreted that the civil protection map will also fail. If the data is not updated the tool loses credibility. Other similar platforms may be a strong competence (more flexible and more global) and may hide this DSS.

Some map management tools should be included in order to avoid processing the maps in a more specialized environments which need more expertise.	
Strengths	**Opportunities**
When the tool makes use of the main data source, the most correct and up-to-date information is being disseminated. Is the official website for risk analysis in Catalonia.	Emergencies could be integrated into the tool. Vulnerable elements may be included as a layer to assess the exposure to each hazard, both in preparedness and prevention.

3.13. ANYWHERE

Description

DSS IT TOOL	Natural disasters	Operational scope
ANYWHERE	Floods, Coastal storm surges, thunderstorms, extreme temperatures, droughts, wildfires, snowfalls.	Regional
http://anywhere-h2020.eu/		

ANYWHERE is a DSS developed under the framework of an H2020 project in 2018. The ownership is the developing company, but it can be implemented for others using different licenses. It is fitted in the Catalan Civil Protection system. The structure is easy to replicate but with other specific regional data. It is mainly used at preparedness emergency phase. It enhances anticipation and pro-active capacity of Civil Protection through Europe and society as a whole to face extreme weather-induced events. A4Cat is the implementation of the A4EU platform for Catalonia. This tool has been locally adapted to the specific needs and requirements of the Catalan civil protection system, emphasizing the risk of floods, forest fires, windstorms and snowfall. A4Cat provides the capacity of early-warning detection and proactive decision-making when facing extreme weather-related emergencies. This allows the CECAT (Catalunya Civil Protection Emergency Centre) to better manage such events, minimizing losses and saving lives.

Current capabilities adapted to current scenarios

ANYWHERE includes two types of information: It is an integrating platform for numerical data (especially weather forecast and fire forecast), but at the same time, it gathers studies and expertise from the civil protection experts. It uses a database of historic episodes to compare the results of the forecast with the reality (the reported effects, variables, behaviour...).

Current capabilities to adapt the DSS to climate change scenarios

ANYWHERE	
Capabilities	**Clarifications**
Ability to include urban planning as an input	Planning.
Integrates information on the degree of exposure/vulnerability of human lives and properties	It considers vulnerability, but not as a numerical information in terms of human lives and properties. It is not deterministic.
Supports evacuation management	There is not any specific tool, but you can use the results to help in your decision.
Supports confinement management	There is not any specific tool, but you can use the results to help in your decision.
Ability to include improvements at the DSS (e.g., better communication tools, forecasting tools, geographic information, etc)	Its modular nature allows improvements
New fire regimes impact according to climate projections	It has the capability to include new fire regimes through changes in the information and algorithms which feds this module.
New flood regimes impact according to climate projections	It has the capability to include new flood regimes through changes in the information and algorithms which feeds this module.
Landscape composition and configuration changes according to climate change projections	Through changes in the underlying information (static information)

Future Capabilities

ANYWHERE has the potential to be Multihazard. There is no interaction between different hazards. It is possible to overcome this limitation and it is projected in a 2nd step of the project.

Assessment

ANYWHERE	
Weaknesses	**Threats**
Interactions of different hazards not included. Advance forecast (3h in advance). Not multilayer. Uncertainties in weather forecast may be too high and are transferred to other fields (especially hydrological), so better weather forecast are needed and more spatial resolution.	License: price could be important in the spreading of this tool. Maintenance: price and feeding with uploading. Robustness. Low implication of agencies specialized in each hazard.

Strengths	Opportunities
Faster decision making: integration of data, possibility of comparison of the same variable from different sources, pro-active instead of reactive. Better decision making: new tools with impacts. Easy to use. Modular system: easy to improve in the future, all similar but independent from each other.	Improvement capacity. Ability to integrate many other data.

3.14. Special Plan for Avalanche Emergencies in Catalonia (ALLAUCAT)

Description

DSS IT TOOL	Natural disasters	Operational scope
Special Plan for Avalanche Emergencies in Catalonia (ALLAUCAT)	Avalanches	Regional
https://interior.gencat.cat/ca/arees_dactuacio/proteccio_civil/plans_de_proteccio_civil/plans_de_proteccio_civil_a_catalunya/plans-especials/allaucat/#bloc4		

ALLAUCAT is a civil protection action plan of the Catalan civil protection department. It is public and free access that was implemented in 2010. The main use at prevention phase is monitoring the danger of avalanches based on the information provided by the technical bodies responsible for carrying them out. There is a defined technical assessment group that forecasts and communicates the degree of avalanche danger at each moment during the winter season. At preparedness phase it contemplates that the municipalities and vulnerable sectors develop action plans (Municipal Action Plans - MAP). In the case of ski resorts, the Avalanche Intervention Plans (PIDA) are considered. Finally, at response phase the plan determines the organizational structure with an Emergency Committee. It defines the Emergency Committee, the composition and functions of the groups involved.

Current capabilities adapted to current scenarios

ALLAUCAT outputs avalanche zone maps on a scale of 1:25.000. Avalanche forecasts on a regional (Catalonia) and local scale (Vall d' Aran, Port de la Bonaigua, Pla de Beret, Coll de Pal and Vall de Núria). There is also the mapping of vulnerable elements. The plan foresees the communication of the warnings to the municipalities, vulnerable sectors and the Operational Coordination Centre of Catalonia (CECAT). It

contemplates the deployment of an Advanced Command Centre. Pre-alerts are issued in case of danger level 4 and alerts in case of danger level 5. Pre-alerts are also issued in situations with hazard level 3 and high expected exposure (holiday periods). In the Technical Committee the Agencies provide the data to support the decision. The composition and the tasks to be carried out are foreseen in case of an emergency situation. Includes large avalanche patterns that have been registered until now.

Current capabilities to adapt the DSS to climate change scenarios

ALLAUCAT	
Capabilities	**Clarifications**
Ability to add new needs (e.g. decision-making scenarios, new decision-making schemes, new planning approaches, etc)	Revisions and updates are made.
Ability to include generated information into urban planning	Already included. It will be improved in the revisions. It will be included in the detailed mappings.
Ability to include urban planning as an input	Already included. It will be improved in the revisions.
Integrates information on the degree of exposure/vulnerability of human lives and properties	Already included (i.e., roads affected).
Supports evacuation management	
Supports confinement management	
Ability to include improvements at the DSS (e.g. better communication tools, forecasting tools, geographic information, etc)	
Ability to include triggering patterns	

Future Capabilities

ALLAUCAT is working on the creation of a database of equipment, of vulnerable elements classified by categories. Automatically alert according to the degree of danger. Current equipment databases are of poor quality. There is a need for quality control and for them to be reviewed and updated. It would also be necessary to add the mapping of defense structures, Avalanche Intervention Plans (PIDA), resources (i.e. Daisybell). In this way, the risk would be minimized, areas would be protected and "cleaned up" and the emergency would be better organized.

Assessment

ALLAUCAT	
Weaknesses	**Threats**
Weather dependency: lack of precision in weather forecasting. Lack of specialised information to improve information on hazards.	More knowledge about Climate Change is needed. Unpredictable or unexperienced scenarios. Higher exposure (greater presence of people in risk areas). Tourism may increase the risk due to a lack of awareness.
Strengths	**Opportunities**
Simulations can be carried out as has been done for other risks.	Incorporate actions that are already being carried out in the terrain, such as Avalanche Intervention Plans (PIDA). Include climate change scenarios. Include tourism as a part of the exposed population to whom rise awareness and advice.

3.15. Emergencies Operational Cartography of the Catalan Fire and Rescue Service

Description

DSS IT TOOL	Natural disasters	Operational scope
Emergencies Operational Cartography of the Catalan Fire and Rescue Service	Wildfires, floods	Regional

Emergencies Operational Cartography of the Catalan Fire and Rescue Service is a map that displays all the necessary infrastructures and elements that influence the emergencies of the Catalan fire service. Shared with regional police and other regional agencies. It was initially created to face wildfires, but it is currently used in other different disasters. It was initially implemented in 1999 until 2017. It is currently being transferred to an ArcGis environment. At prevention phase, it helps to detect opportunities in advanced as well as critical areas in terms of lack of infrastructures or the high number of population. At preparedness phase the maps offers improved knowledge of the territory, such as water points, forest roads, fuel breaks and maintenance of these infrastructures. The main use of the DSS is on the response phase with real time location of deployed units. Any change done can be automatically viewed by everyone. In field units can give real time information to control rooms, with the status of the fire perimeter, hotspots, etc. Finally, during recovery it can help to show the most affected areas in case recovery actions are needed.

Current capabilities adapted to current scenarios

Emergencies Operational Cartography of the Catalan Fire and Rescue Service has a self-owned database. However, data comes from different providers. It means that there are multiple agencies involved. Catalan Fire Service organize the information internally, but with a permanent contact with providers in case some information changes. Resolution is 1:1000 for urban actions and 1:5000 for forest actions. The DSS do not support simulations, but it prepares the information needed to run simulations using other tools. A didactic communication is used. Field units work with smartphones or tablets (each vehicle has a tablet). Thus, everybody is linked with the control and command post. The DSS allow offline working, and it automatically synchronizes once mobile data is recovered. Cartographic information is very easy to understand, since all figures (points, lines and polygons) are created with a set of attributes (hotspots, road, etc) that facilitates its comprehension. DSS do not send alerts, but since it allows the monitorization of deployed units and the status of the fire in real time, alerts can be sent to this units using other devices. The same happens to citizens. A correct monitorization of the fire facilitate the alerting to citizens using other media. All units in the fire have real time information. That enormously facilitate the decision support. Inputs of first responders in the field, by sharing information through mobile devices (collecting hotspots, perimeters, affectations and so on) allows a better monitorization of the fire and facilitate the situation assessment. The DSS allows the comparison of pre and before disaster images. It is useful to validate affected areas. That capability is used in wildfires and flooding.

Current capabilities to adapt the DSS to climate change scenarios

Operative Cartography
Capabilities
Ability to add multi-hazard scenarios
Ability to add new needs (e.g. decision-making scenarios, new decision-making schemes, new planning approaches, etc)
Ability to include generated information into urban planning
Ability to include urban planning as an input
Integrates information on the degree of exposure/vulnerability of human lives and properties
Ability to calculate economic losses
Supports evacuation management
Supports confinement management
Ability to include improvements at the DSS (e.g. better communication tools, forecasting tools, geographic information, etc)
New fire regimes impacts according to climate projections
New flood regimes impacts according to climate projections

Future Capabilities

For the **emergency operative cartography**, the fire service of Catalonia is preparing to face 6th generation fires (climate change driven) and all the actions to improve the DSS come from this direction and are suggested by operational units that require more DSS capabilities to face new situations. The DSS, despite having 20 years, is still in an initial phase, since there are a lot of improvements to be done, and they must be ready before having 6th generation fires in Catalonia. The DSS allows real time monitorization of the

fire and the units. But a better collaboration with other agencies using the same system is needed in terms of data sharing. Apart from that, an important improvement would be the collaboration of citizens through APPs or social networks by sending georeferenced pictures and defined questionnaires. Isolated edifications are still a challenge for the DSS.

It is currently online, but it is being switched to private servers to solve privacy issues. That would allow an improvement of data management and more efficiency in terms of data sharing. Analysis routines should be implemented to validate information and decision-making through the visualization of past situations.

Assessment

Emergencies operative cartography	
Weaknesses	**Threats**
Cartography is only shared within Catalan emergency bodies. Only useful in Catalonia. To help or receive aid from other regions different tools must be used. To many efforts must be done to keep the cartography updated.	The tool must be operationally implemented. Enough human resources are needed. Enough technical resources are needed.
Strengths	**Opportunities**
I can be applied to a wide range of hazards. Online format and updated paper maps every 2 years. Real time quality data sharing. Linkage of the cartography with forest volunteers associations. Large variety of infrastructures and inputs are showed in the cartography to have a clear operational picture.	Capability to integrate and share information with other agencies. Exchange of data and knowledge with other regions to improve the cooperation capabilities. The tool evolves according to operational requirements detected by units. Any tool that have a geographic scope must be uploaded to the platform.

3.16. FlamMap/Behave Plus/Fire Chart, WindNinja, ErMIT

Description

DSS IT TOOL	Natural disasters	Operational scope
FlamMap/Behave Plus/Fire Chart, WindNinja, ErMIT	Wildfires	Regional, National, International
https://www.firelab.org/project/flammap		

FlamMap is a fire simulator developed in the US by the forest service. It is fully free and can be used for static (FlamMap) or dynamic (Farsite) models by choosing different tools of the simulator. At prevention scale it used for the elaboration of structural prevention plans and reconstruction of the history of major forest fires. At preparedness FlamMap is used to model the fire in the prescribed burning before carrying out the action. During response, the main use is the elaboration of simulations for strategic analysis to support decision making in theaters of operations. Recovery phase is only used at academic level, but no at the operational.

Current capabilities adapted to current scenarios

FlamMap is a fire modelling software able to make simulations through different outputs like weather variables, fuel models and topographic information. The software is able to simulate fire propagation and behaviour.

Current capabilities to adapt the DSS to climate change scenarios

FlamMap
Capabilities
Ability to add new needs (e.g. decision-making scenarios, new decision-making schemes, new planning approaches, etc)
Ability to include generated information into urban planning
Integrates information on the degree of exposure/vulnerability of human lives and properties
Supports evacuation management
Ability to include improvements at the DSS (e.g. better communication tools, forecasting tools, geographic information, etc)

Future Capabilities

FlamMap and fire simulators lack on Interoperability and of rigorous and reliable data on the mapping of burnt areas, fuel models and meteorological data. The limitations are related to the usual scale of these systems. Allow only one DSS to create its own inputs and the integration of external information, as well as the units to be located in it. There is also a need for this tool to be multilingual.

Assessment

FlamMap	
Weaknesses	**Threats**
Reduced processing speed, requiring a lot of time, due to the prior need to prepare inputs. Not a multilingual tool. Lack of universal units. Lack of uniform fuel models in Europe. Lack of a free Open-Source platform.	Lack of special training makes it difficult and / or reduces its use. The complexity of preparing the inputs also reduces the use and the potential for evolution of the tools.
Strengths	**Opportunities**
Free tools. They are very useful tools when used and their results interpreted correctly.	The possibility of creating a European model for the classification of fuels and the integration of geographic (burnt and relief areas) and meteorological data from EU member states. Increase in spatial resolution.

3.17. SADfLOR - A Web-Based Forest and Natural Resources Decision Support System

Description

DSS IT TOOL	Natural disasters	Operational scope
SADfLOR - A Web-Based Forest and Natural Resources Decision Support System	Wildfires, soil erosion, biodiversity loss	Regional
http://www.forestdss.org/wiki/index.php?title=SADfLOR_web-based		

SADfLOR is a Web-Based Forest and Natural Resources Decision Support System. CEF/ISA (Centre for Forest Studies of the School of Agriculture) has developed a forest decision support system toolbox (SADfLOR) that has been used in the framework of several research to integrate and implement scientific know-how in the areas of forest planning, scenario modelling, fire risk and assessment of ecosystem services. SADfLOR is a modular, web-based decision support system for forest management and planning. It includes modules dedicated to simulation, forest management and planning, decision making with a Pareto frontier tool, and a GUI (Graphical User Interface) for relevant data analysis. Its use is mainly at the prevention phase. Forest

management goal: biomass estimation, carbon sequestration, climate change impact, economic evaluation, silvicultural regime, alternative forest management models - species selection, yield prediction, wood supply planning, ecosystem services assessment including regulatory services.

Current capabilities adapted to current scenarios

SADfLOR - A Web-Based Forest and Natural Resources Decision Support System, includes web interfaces with a Geographic Information System module that enables the user to select the management area and check related information (forest inventory, soils, climate, and topological data). A prescription driven stand level forest simulator (stands SIM) is incorporated within SADfLOR (Forest Management Approaches). Simulation results are of two types: Detailed characterization of stands' growth and yield for the planning horizon; Essential information required to run the decision models. Includes several optimization tools to support forest management planning, i.e., to help the user build the management planning model, e. g. decision variables, objective functions, and constraints (including spatial and flow constraints). The user may trigger the execution of the SADfLOR optimization and decision module. The latter includes mathematical programming routines as well as Feasible Goals Methods / Interactive Decision - Interactive decision maps for a decision problem. The involvement and participation of stakeholders on SADfLOR's development was deemed as critical to guarantee the quality and usability of the system.

Current capabilities to adapt the DSS to climate change scenarios

SADfLOR	
Capabilities	**Clarifications**
Ability to add new needs (e.g. decision-making scenarios, new decision-making schemes, new planning approaches, etc)	
Ability to calculate economic losses	
Ability to include improvements at the DSS (e.g. better communication tools, forecasting tools, geographic information, etc)	
Climate change projections (temperature, radiation, rainfall, etc) to predict future risk scenarios	The DSS provides direct output related to wood production, however, difficulties to implement and evaluate alternative Forest Management models, essentially refer to lack of information on process-based models to check the impact of climate change on growth, tree mortality and species suitability. Thus, to overcome this issue we adjusted linearly a percentage in yield under RCPs' climate change scenarios over the planning horizon. In this context, our timber supply projections (standing volume) are made with empirical growth and yield models.

Landscape composition and configuration changes according to climate change projections	
Forests vulnerability to climate change impacts according to projections	

Future Capabilities

SADfLOR - A Web-Based Forest and Natural Resources Decision Support System is looking to the future and based on users' experiences with stakeholder involvement they see collaboration between the academic and the forest decision-making communities as key to the success of the continuing evolution of SADfLOR. Here they have room for the civil protection. The main goal is to facilitate the access of stakeholders to tools that may contribute to enhancing forest management planning with modelling scope such as economic indicators, forest indicators, social indicators, climate change and contribution to instrumental fire-adapted silvicultural strategies.

Update and monitor an advanced risk-smart forest Decision Support System through the existing SADfLOR-DSS to help tackle the challenges raised by the large uncertainties in fire management systems. Future work with SADfLOR should seek to promote recovery (fire effects on soil and biodiversity). A platform tool through existing SADfLOR-DSS should become available to assist in forest management decision-making, which not only calculates the best mitigation investment scenario but also provides information on the applicable laws and recommendations regarding traditional and alternative management practices. Implement a participatory multi-stakeholder process, with decisive participation of local and national forest actors to create the underpinnings of integral wildfire strategies at different scales – climate scenarios, sustainable management strategies and related ecosystem business models. In addition, guideline users for the assessment of post-fire ecosystem recovery and resilient forested landscape.

Assessment

SADfLOR	
Weaknesses	**Threats**
Lack of information on process-based models to check the impact of climate change on growth, tree mortality and species suitability. The use of process-based growth and yield models might provide more accurate projections of timber yield and other ecosystem service under climate change, yet this would require data acquisition and modelling research not supported yet by current research projects. There is always room to improve the user-friendliness of the Pareto frontier tool and the way in which the system presents the results for management plans.	The development of a user guide as well as of further training sessions. Some users were not familiar with Pareto frontiers, but after some training they could better understand this decision tool. Expansion to include more models to address other forest species and other ecosystem services. The web development was done with the web programming languages: HTML, CSS, PHP, JavaScript and with the PostgreSQL as the database.

Interpretation of the optimization, decision, and analysis tools of the DSS by the stakeholders.	
Strengths	**Opportunities**
Use of multiple criteria decisions making (MCDM) methods that integrate wildfire risk in planning contexts characterized by multiple objectives. The visualization of the trade-offs possibilities is an easier way of understanding the impacts of the multiple management options that can be displayed in the form of a Pareto Frontier. This technique encapsulated in the SADfLOR DSS, allows for a visual perception of trade-offs between ecosystem services facilitating the setting and negotiation of management planning targets. This is influential to evaluate the levels of achievement of various objectives to help users build strategic and sustainable forest management plans.	SADfLOR seems to be a real chance for new forest management principles make inroads into the national policy processes planning or market payments for ecosystem services in contexts characterized by multiple Ecosystem Services and multiple stakeholders in participatory approaches.

3.18. Portugal Civil Protection

Description

DSS IT TOOL	Natural disasters	Operational scope
Portugal DSS	Wave action, floods, coastal storms, thunderstorms, extreme temperature, wildfires	Regional

Portugal Civil protection use open data sources. They do not use any dedicated system for the weather forecast. They use several open links to see the weather forecast and make decisions based on that data. This method can be used to study the future impacts in several scenarios, prepare the territory, equipment's, people to prevent the expected impacts, reduce de impacts and how to survive, use the equipment's, crews or systems to reduce the impacts of the expected scenario.

4. Recommendations to include climate change impacts into DSS

Despite not being an exhaustive list of DSS, it is possible to observe that most of the DSS that have been considered in the current report have a regional operational scope. This may be due to the scale of natural disasters, that almost in all cases affect only a particular region or group of municipalities. In addition, a regional scope facilitates tool updates according to landscape and infrastructures changes. In relation to forecast, local DSS are better fitted and show less uncertainty.

The number of hazards covered by the DSSs are high: Forest fires, Floods, Rock falls, Landslides, Storms, Strong winds, Biotic Hazards, wave, thunderstorms, extreme weather, avalanches, snowfalls, coastal storms, biodiversity loss, earthquakes and soil erosion. Despite most of the DSS cover more than one hazard, only a few have the potential to address multi-risk scenarios, therefore, understanding the relationship between hazards. It is clear that under current scenarios multi-risk DSS may not represent an advantage. However, it seems that climate change will pose challenges that will require tools dedicated to deal with different risks simultaneously or cascading.

About emergency phases tackled by the DSSs, almost all of them are useful during prevention, preparedness and particularly response. It seems that the most forgotten phase is the recovery, that should start to be considered in future updates or new DSS to enhance recovery at to find synergies with prevention and preparedness.

After reviewing the opinion of different experts after years of using Decision Support Systems, one of the most shared comments is that we need one dedicated DSS. A tool that combines all emergency/natural disaster categories in only one tool, giving the expected scenario and direct impacts to the country infrastructures and territory.

New DSS should be able to calculate the several emergency/natural disaster categories impacts to this territory and the expected damages and expected conditions during all time of the emergency. And can react (recalculate) to the solutions introduced in the system.

In general terms, through the different interviews to multiple experts the following questions have been answered: Key information and data requirements to address scenarios posed by climate change and risk management enhancement by improving or designing new DSS with new capabilities and operating with new data.

Key information that DSS should start to work on to deal with climate change should be organized using the different emergency phases: that would allow a more accurate treatment of data and address required actions according to the phase. DSS users agree that a key issue is to consider exposed and vulnerable elements that could be threatened according to the hazard. A proper vulnerable and exposed elements monitoring has been always a major issue when taking decisions before, during and after emergencies. However, under climate change context, it is important to rethink how hazards evolve and how will affect that in exposure and vulnerability. It may be possible that future emergencies force civil protection agencies to deal with bigger extreme events, which may mean more information to be processed, especially the number of affected vulnerable elements. An important effect then will be to better monitor vulnerable elements.

Climate change projections are also a key information that DSS must incorporate, particularly when planning preventive actions that must be adapted to mid and long-term scenarios. Firstly, climate change must be incorporated in emergency management, and lately, implemented in DSS. For instance, in the case of flash floods it is necessary to adapt mitigation measures considering new return periods identified in the risk analysis, or for avalanches it will we necessary to understand how climate change will affect synoptic conditions that drive the risk. Observing and studying major emergencies generated by natural hazards of other regions helps to understand the new challenges posed by climate change and to see how decision-making influence on the result of emergency management. This is a valuable information to be included on DSS.

Data gathering methods should be regularly updated. Most of experts coincide that static information is always out of date since risks occur under a dynamic environment. Therefore, it is clear that static DSSs are in process of being replaced by dynamic and easily updated ones. That gives a very appreciated advantage when managing the risk because of the presence of trustable information. However, DSS must include static and dynamic information. Some information is static by nature, or at least, static during some years. For instance, in urbanized areas or vulnerable elements. The process of updating this information is crucial as it has to be done in a proper frequency and in a proper scale, usually bottom up, starting from municipalities. There is also other static information, like flooding areas, that remain static for some years. This information is still very helpful, and it cannot be realistically replaced by dynamic information nowadays. Besides, there is dynamic information, like actual precipitation and actual river's flow or levels, that needs to be included also in the DSS. Both, dynamic and static data, are important and there is a natural movement from static to dynamic.

Apart from the temporal scale, with information updated regularly, it is also important to consider the spatial scale of the information added in the DSS. While large scale resolution information seems to be more trustable but more generic, small-scale resolution usually offers a more detailed information, but with a higher level of uncertainty. For instance, it is easy to have an approximate fire risk map for a specific day and a large piece of land. However, it is very difficult to exactly know the risk of a specific small place, for instance, an isolated house. That is why some of the DSS users highlighted the need to find trustable high-resolution methods and technologies. Some agencies already use an uncertainty category to help understand if the information is more or less trustable. Therefore, it may be an appropriate tool to help moving to higher spatial resolutions.

Another key aspect of future DSS, particularly to enhance data gathering, is to count on citizens. Emergency services are limited and, in most of the cases, they arrive later than citizens in a given incident without knowing too much information of the disaster and the staff and equipment they need to solve the situation. For that reason, it is very important to find strategies to collect information from the people through quick systems such as a smartphone app. This way, citizens could be able to send pictures and short description on the event, an even send alerts in case of being in risk. This is not only useful in the response phase, but also in the other phases, for instance, through sending pictures and location from a forest hit by a major storm or a critical infrastructure in a forested area without the required preventive measures. The possibility to periodically send alerts to citizens (beginning of the fire season, storm alerts, etc) and associated recommendations (fire breaks around urban areas, heat or cold waved recommendations, etc) is an easily deployable requirement to raise risk awareness, not only on response, but also in prevention and preparedness. This interaction with population should include the capacity to influence confinement vs. evacuation.

People engagement is also key and could serve as a good decision support mechanism. That has been done, for instance, in many regions of the USA or South Africa, were Civil Protection bodies perform activities with citizens living in high fire risk areas. During these activities, people and civil protection staff can exchange information and understand each other's needs in order to make decisions together, particularly for the prevention and preparedness phase. This includes, for instance, the identification of values of the land, strategic areas, preventive measures to be undertaken in the Wildland Urban Interface, etc. This co-creation process has been demonstrated to be a good way to make sure that the planned management measures are executed, since all the involved stakeholders agree on them from the beginning.

Another aspect to consider for future DSS is the economic impact of decisions. Consequently, it would be necessary to have DSS able to incorporate the expenses of all the actions done (divided according to the emergency phase) and the economic losses of the place that is suffering the disaster. This way it will be easier to be more cost-efficient when managing the risk. According to experts, despite some DSS include economic inputs, they are still far from having an integrated and detailed picture of the real cost of management actions and losses. Experts coincide that it is especially important during the prevention stage because it shows that prevention is often cheaper than other actions.

Impact on ecosystem is something that DSS start to include, but, just like economic impact, there are no DSS that outputs a detailed picture. Impact on ecosystems can be measured through ecosystem services, that is why gathering Ecosystem Service information could serve to have a better-informed decision, when, for instance, leaving a piece of land to burn to find a better opportunity to control a fire.

In regard to the capacity of new DSS to enhance risk management, a shared comment has been the need to integrate the information obtained from advanced DSS into land planning. Currently, most of European countries consider flood risk into land planning through a return period analysis. However, other risks, like avalanches or forest fires do not seems to be considered when planning new urban areas or when allocating new critical infrastructure on the land. New DSS, particularly those performing reliable simulations, have a great potential to become a basic tool for land planners, that should include risk in their decision-making process. However, it is very important to add the precautionary principal to include an extra, but needed security filter, as simulations are never real.

Scenario matching, that represents the possibility to link the current scenario with a past one to understand how past decisions affected the final result of the emergency, could be enhanced after the incorporation of new information to the DSS. Consequently, data collection procedures of past events should be normalized and homogeneous, at least within a country, to be able to automatically include this data to the DSS and generate scenarios that can later be used. In that sense, it is convenient to have protocols to report the most important decisions and events occurring during a given emergency.

One of the climate changes effects that experts highlight is the possibility to have multi-risk scenarios and cascading effects with more frequency. This is something that DSS are no able to forecast. Despite some DSS are useful when dealing with different risks, none of them is able to deal with multi-risk scenarios. At this point, there is a long way to study cascading effects and patterns that can drive multiple risk at the same time and to be able to mitigate and prevent them thanks to the DSS.

Furthermore, very related to climate change, new DSS should not only be able to add climate change projections and its impacts on risk, but also to include these projections to see their impacts on landscape and forest species. The reason is that the landscape offers both opportunities and weaknesses and modelling landscape changes under climate change will offer the capacity to identify future threats and opportunities.

Real-time positioning of first responders as well as their health monitoring seems to be a very relevant challenge for most of risk manager. A lot of DSS are already offering that after including new technologies, such as health belts or small GPS to deployed units. The challenge relies on two aspects: (1) the capacity to obtain positioning in areas with poor connectivity like indoors and (2) the capacity to cross health and position of staff with short-term simulations in order to rapidly detect the staff that is located in a danger zone.

Cross-border scenarios raise a set of challenges that could be solved through the implementation of common DSS and command systems. However, despite existing DSS are able to output relevant cross-border information, such as simulations or impacts, only a few are ready to enhance coordination and communication between the bodies of the different involved countries, which makes operations more difficult.

In regard to risk management phases, it is clear that recovery an adaptation has been traditionally forgotten. While most of DSS are design to enhance response or preventive actions, the recovery phase is not present in most of the cases. Only a few DSS take recovery into consideration, particularly through mapping the affected area. In the near future, it is going to be necessary to include new functions that able to monitor the affected area of a given disaster, quantify the losses, analyse the effectiveness of the actions done during prevention and response and, finally, to fins synergies between recovery and preventive actions.

According to the interviewed DSS users, a list of relevant improvements for the DSS is provided:

- New tree species and influencing growing factors shall be added and a focus on climate change “hot spots” may be planned. DSS could provide the maps on electronic devices of risk managers so that they are accessible in the field. It would be interesting to provide and extend the information to other authorities to work for a Common Operational Picture independently of the emergency body.
- Modulate the output information to address specific actions depending on the risk management phase and factors.
- In some cases, the risk posed by climate change is not related to magnitude, but to frequency. DSS should be able to understand in which scenarios we face magnitude or frequency or both.
- Automatization of several processes: Data incorporation directly from sensors and data sources, evaluation of data treatment results
- Improve mapping with a more precise scale of analysis. Large scale outputs allow planning, but not particular actions on terrain.
- Include simulations.
- Include Civil Protection Plans and incident command system procedures.
- Analysis routines should be implemented to validate information and decision-making through the visualization of past situations.
- Promote recovery monitorization (i.e., fire effects on vegetation and soil).
- A platform tool through existing SADfLOR-DSS should become available to assist in forest management decision-making, which not only calculates the best mitigation investment scenario but also provides information on the applicable laws and recommendations regarding traditional and alternative management practices.

- Implement a participatory multi-stakeholder process, with decisive participation of local and national risk managers to create the underpinnings of integral risk strategies at different scales – climate scenarios, sustainable management strategies and related business models.

The most common capabilities that DSS currently have to face future scenarios are, from more to less frequency, the following:

- Ability to add new requirements.
- Support evacuation management.
- Ability to include improvements at the DSS.
- Ability to include generated information into urban planning.
- Integrates information on the degree of exposure/vulnerability of human lives and properties.
- Supports confinement management.
- Ability to include urban planning as an input.
- Ability to add multi-hazard scenarios.
- Ability to predict cascading effects/risk interactions.
- Landscape composition and configuration changes according to climate projections.
- Ability to include triggering patterns.
- Forests vulnerability to climate change impacts according to projections.
- Climate change projections to predict future risk scenarios.
- Ability to calculate economic losses.
- New fire regimes impact according to climate projections.
- New flood regimes impact according to climate projections.
- Storms impacts according to climate change projections.
- Species redistribution according to climate projections (Fauna).
- Species redistribution according to climate projections (Flora).
- Landslides impacts according to climate change projections.
- Rock falls impacts according to climate change projections.
- Avalanches impacts according to climate change projections.

ANNEX I. DSS interviews template

TEMPLATE FOR THE DSS IT TOOLS ANALYSIS

This survey seeks to identify and analyse the existing DSS and IT resources, and the operability to incorporate operational emergency requirements, to face risk scenarios posed by climate change into risk assessment and planning. The main objective is to identify potentials and constrains in terms of resolution, data quality, and type (quantitative and qualitative), data analysis under operational queries during the case of emergency, etc., aimed at reinforcing civil protection capabilities within the risk management.

DSS IT tool:
Organization:
Expert / Job title or role:
e-mail:

1. YOUR ORGANISATION…

a) Type of organisation (*please tick*)

☐ Public body/agency	☐ Private Company	
☐ Research institution	☐ Other (specify)	

b) Level (*please tick*)

☐ Regional	☐ National
☐ Cross-border EU	☐ International

c) Organization role (please briefly describe)
Risk assessment and planning:
Actions for preparedness:
Emergency management:
Recovery:

2. DSS IT TOOL DESCRIPTION

a) Main use of the DSS IT tool

Phase	**Uses**

Prevention	
Preparedness	
Response	
Recovery	

b) DSS IT tool level

☐ Regional	☐ National
☐ Cross-border EU	☐ International

c) Can you provide more information about the DSS IT tool?

Access model (*please choose*)	yearly licence/ per-user licence / full ownership		
Was it created by/exclusively for your organisation	Yes/No		
Years of implementation	From_____ to _____. From_____ and currently being used.		
Any other details about the system/tool			

d) Please tick the emergency/natural disaster categories covered by the DSS IT tool (*Tick all that apply*)

Emergency/Natural Disaster Categories by Disaster Risk Management Knowledge Centre (EU) and United Nations Office for Disaster Risk Reduction (UNDRR).		
Geological or Geophysical Risks	**Earthquakes**	
	Tsunamis	

	Rockslides	
	Landslides	
	Volcanic activity and emissions	
	Snow Avalanche	
	Mass movements	
	Surface collapses	
	Debris or mud flows	
Hydrological Risks	**Wave action**	
	Floods	
	Coastal storm surges	
Meteorological and Climatological Risks	**Extra-tropical cyclones or storms**	
	Tropical cyclones	
	Thunderstorms (heavy rain, strong winds, hail, tornadoes)	
	Extreme temperatures	
	Droughts	
	Wildfires	
Biological Risks	**Epidemics and pandemics**	
Multi-risk * (specify risks)		
Others (*please list*)		

**Please, note the difference between DSS able to deal with different hazards at different moments and DSS able to deal with multi-risk scenarios (for instance, flooding followed by landslides).*

e) What features/services are offered by your risk management tool considering the following topics? (Please describe)

Data sources and resolution	

Simulations	
Communication with First Responders/Forward Command Post	
Alerting (First Responders and citizens)	
Situation Assessment, Decision support and Data sharing	
Scenario Matching (refers to the ability to compare the emergency with precedent events or simulations in order to improve decision-making, prediction of the impact of decisions…)	

3. DSS IT TOOL ASSESSMENT

a) What additional capabilities do you wish the system to have to reinforce the civil protection? When facing extreme events, which limitations had the DSS? Is it possible to overcome these limitations by improving the DSS? (*please describe*)

b) Which of the following capabilities in regard to climate change and extreme scenarios requirements does the DSS IT Tool has (Tick all that apply)?

Capabilities	**Yes/No (*Tick if yes*)**	**Comments *(Only if needed)***
Ability to add multi-hazard scenarios		
Ability to predict cascading effects/risk interactions		

Ability to add new needs (e.g. decision-making scenarios, new decision-making schemes, new planning approaches, etc)		
Ability to include generated information into urban planning		
Ability to include urban planning as an input		
Integrates information on the degree of exposure/vulnerability of human lives and properties		
Ability to calculate economic losses		
Supports evacuation management		
Supports confinement management		
Ability to include improvements at the DSS (e.g. better communication tools, forecasting tools, geographic information, etc)		
Ability to include triggering patterns		
Climate change projections (temperature, radiation, rainfall, etc) to predict future risk scenarios		
New fire regimes impacts according to climate projections		
New flood regimes impacts according to climate projections		
Species redistribution according to climate projections (Fauna)		
Species redistribution according to climate projections (Flora)		
Impact of plant invasive species		
Impact of animal invasive species		
Landscape composition and configuration changes according to climate change projections		
Forests vulnerability to climate change impacts according projections		
Landslides impacts according to climate change projections		
Rock falls impacts according to climate change projections		

Avalanches impacts according to climate change projections		
Storms impacts according to climate change projections		
Others (*Please, specify*)		

c) Is the development of new DSS necessary? In what phases of emergency management (prevention, preparedness, response, recovery)? If you have a new DSS in mind, define its general characteristics.

d) Please, fill the following SWOT table considering the capabilities offered by your current DSS IT tool in a context of climate change and extreme scenarios.

Weaknesses	**Threats**
Strengths	**Opportunities**