GREEN RISK 4 ALPS

WP 3

Responsibility for Deliverable

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Table of Contents

Table of Figures

Table of Tables

Table of Attachments

Introduction

The TEGRAV is an economic model that aims at providing the user with a comparison between alternative protection measures against different natural hazards. Consistently with the objectives of this project research, the considered natural hazards are: avalanches, rockfall and soil slides.
In the present deliverable, the technical information regarding the structure, the assumptions and the data adopted by the TEGRAV tool will be presented, in order to provide an overview on the functioning of the tool.
This deliverable is meant to be coupled with deliverable D.T3.3.1 " TEGRAV analysis: an integrated model to compare risk management strategies" where a broader explanation of the assumptions of the model is presented.

Input data

Different input data are required to use the TEGRAV model. These data can be divided in three main categories:

- data provided by the hazard model (Prot4Net; D.T1.2.5 and 1.3.3);
- standard socioeconomic values collected by the PAR responsible partners, and
- input data provided by the model user.

Input from the hazard model

The economic model is strictly linked to the hazard model, and they are both embedded into the FAT tool (D.T1.6.1). Therefore, many equations require data that have to be pulled from it. The main data pulled from the hazard model are:

- Energy Line Height (ELH) with and without forest, which is used to define the size of the catching dams and the rockfall nets;
- Run-out distance with and without forest, used to assess the assets at risk and the damages avoided adopting the selected protection measures;
- Forest effect indicator: the degree in which the surrounding ("uphill") forest offers natural hazard protection. This can be done by decreasing the likelihood of the hazard reaching the location or decreasing the magnitude of event at this location.

Standard socioeconomic values

The main category of data used for the model concerns the costs of the different measures considered. To gather these values, all PARs have been involved. Data from different regions of the Alpine Space have been collected so that the model calculations can adopt the most suitable value depending on the country in which the chosen profile is placed. (see Attachment 1, 2 and 3 for the complete database of values)

User inputs

Lastly, few inputs have to be provided by the user: these regard mainly the width of the chosen profile and the position of both the protection structures and the exposed assets (houses, roads, etc.). In the Attachment section an example of the form shared among the project partners in order to collect the user input of the profiles of each PAR is provided.

A summary of the three different input data sources and their combination for each protection measure is presented in the following table.

Table 1 - Summary list of input data needed in the model

Protection measure	Model input	Standard value	User input
Afforestation	-	Unitary cost	Slope width; length,

			position
Forest rehabilitation	-	Unitary cost	Slope width, length, position
Snow fences	-	n/ha, Unitary cost	Slope width; length, position
Catching dam	ELH	Unitary cost	Slope width; position
Rockfall net	ELH	Unitary cost	Slope width; position
Artificial release (avalanche)	-	Implementation cost	-
Early warning system	-	Unitary cost, infrastructures repairing cost	Slope width, infrastructures position
Road closure	-	Road repairing cost	Slope width, Road position
Building evacuation	-	Building repairing cost	Building position
Building relocation	-	Building construction cost	Building position

Protection measures

For each kind of hazard, different protection measures have been included in the model.

Avalanches

For avalanches protection measures in the release area, in the transit and in the runout area have been considered.

In particular, in the release area snow fences, afforestation and forest rehabilitation have been included, aiming to prevent avalanches from happening. In the transit and runout area the measures considered are: afforestation, forest rehabilitation, catching dams and all the avoidance measures. In this case the aim of the measures is to limit the outcomes of the events. For example, by choosing road closure as a measure, while the road gets still damaged by the event, it prevents people and cars from being hit by the avalanche.

Rockfall

For rockfall no measures have been considered for the release area, but only for the transit. In the transit area all measures included for avalanches have been implemented, with the addition of rockfall nets. Similarly, all green and avoidance measures (except for the avalanche artificial release systems) are also available for rockfall.

Soil slides

Finally, the most challenging task has been the choice of protection measures against soil slides. Ultimately, the only “structural” measure that has been implemented is the afforestation, considered the only effective one in reducing the probability of an event from happening. Also, for soil slides all the avoidance measures (except for the avalanche artificial release systems) have been included.

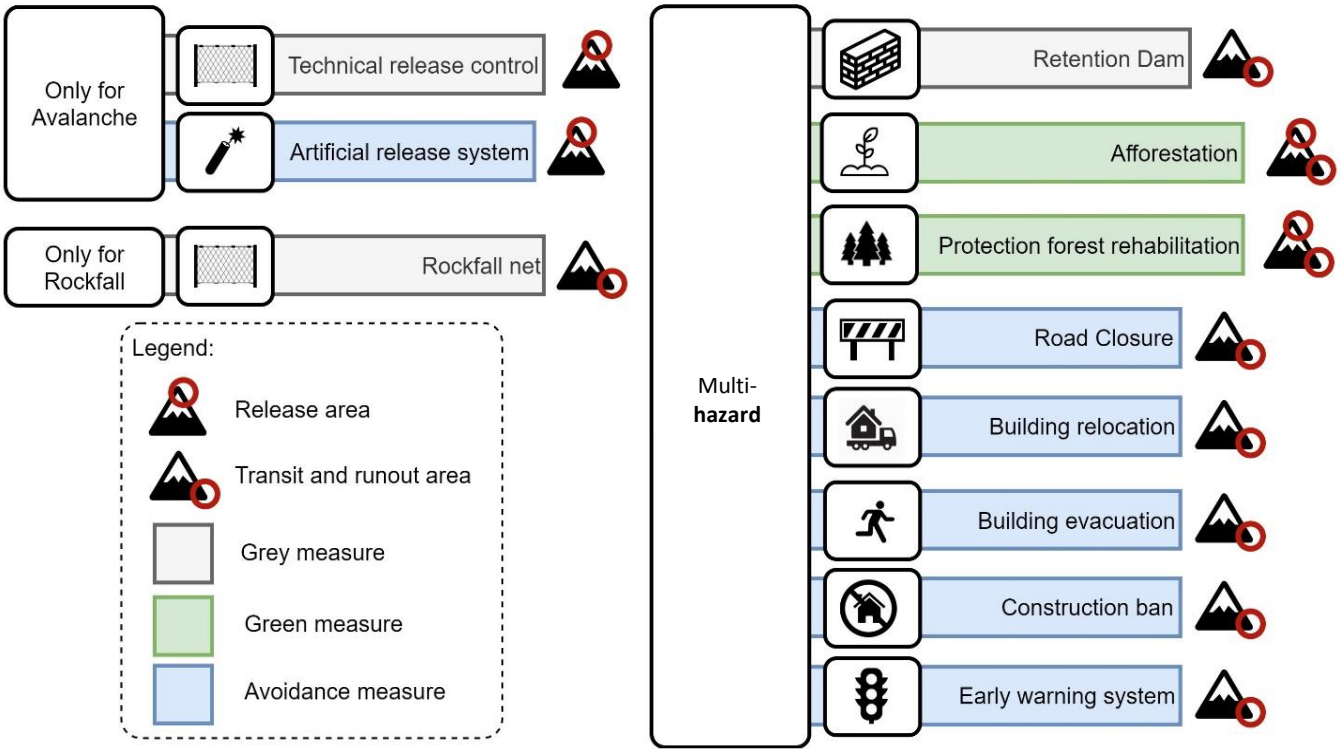

Figure 1 - protection measures included in the TEGRAV model

Calculations

Finally, for each protection measure four economic outputs have been calculated, those being:

- Direct cost: the cost that directly derives from the choice of a measure, it consists of the construction, maintenance and the eventual dismantling cost;
- Indirect cost: for example, if the road closure measure gets chosen, the indirect cost consists in the cost of the de route to reach the same destination avoiding the closed road;
- Avoided damages: the damages that get avoided thanks to the adopted measure;
- Benefits: the net economic benefit provided by the chosen measure, calculated subtracting the indirect costs to the avoided damages.

An example of calculation of these four economic outputs for one of the available protection measures is presented in the following table.

Table 2 - Overview on the components included in the protection measures functions

Protection measure	**Snow fences**
Direct costs	Construction cost + Maintenance cost + Dismantling cost
Indirect costs	- (absent for this measure)
Avoided damages	Total damages * 0.99[(1)]
Benefits	Avoided damages-Indirect cost= Avoided damages

Conclusion

The aim of calculating the aforementioned parameters is to provide the user a useful mean to understand the effective costs and benefits of the different measures. Through the comparison of the outputs derived from the selected protection options, the user can assess the most suitable one from an economic point of view, not only considering its construction cost, but also the avoided damages. As mentioned in D.T3.3.1, this economic analysis has to be considered as a "serious game", and not as a professional tool to design protection measures and/or compute real cost-benefit analysis of risk management strategies. Nonetheless, we believe the results provided are grounded in the socioeconomic conditions of the Alpine Space countries and therefore can provide useful information on the benefits of considering Eco-DRR as alternatives, or complements, of the more common grey and avoidance measures.

[(1)] 0,99 means that even though the chosen measure should avoid the hazard from happening, there is still a small chance (0.01%) that it could be released. Therefore, the damages can not be totally (100%) avoided.

Attachments

Attachment 1 - the values on prices and structure provided by the PARs for avalanche protection measures

AVALANCHES

Measures in the release area

GREY										
	Parameter	**u.m.**	**Austria**	**France**	**Slovenia**	**SudTirol**	**Aosta Valley**	**Piedmont**	**Germany**	**Mean value**
Snow Bridges	Construction cost (2m)	*€/m*	800		500	937		696		733
	4m	*€/m*			700			1272		986
	6m	*€/m*	1300		1200					1250
Snow Nets	Construction cost (2m)	*€/m*	800			585				692
	4m	*€/m*								-
	6m	*€/m*	1300							1300
	Maintenance cost	*% of cc*								-
	Lifetime	*years*	80							80
	Row distance	*m*	25							25
GREEN										
	Parameter	**u.m.**	**Austria**	**France**	**Slovenia**	**SudTirol**	**Aosta Valley**	**Piedmont**	**Germany**	**Mean value**
Afforestation	Afforestation cost	*€/ha*	3780		3885			6275	4000	4485.00
	Maintenance cost	*% or €/ha/year*			67%					0.67
	Lifetime	*years*			25					25.00
Wooden tripods	Construction cost	*€/unit*	245		220			133	500	275
	Maintenance cost	*% or €/ha/year*			15%					0.15
	Lifetime	*years*	30		35					33
	distribution	*n/ha*	900		640					770
Protection forest	forest management cost	*€/ha/year*			69	4100		5123		3098

rehabilitation										
AVOIDANCE										
	Parameter	**u.m.**	**Austria**	**France**	**Slovenia**	**SudTirol**	**Aosta Valley**	**Piedmont**	**Germany**	**Mean value**
Avalanche artificial release system	release system cost	*€*								-
	Maintenance cost	*€/year or %*								-
	Lifetime	*years*								-

Measures in the transit and runout area

GREY										
	Parameter	**u.m.**	**Austria**	**France**	**Slovenia**	**SudTirol**	**Aosta Valley**	**Piedmont**	**Germany**	**Mean value**
Retention dam	Construction cost	*€/m3*				165		184		175
	Maintenance cost	*% of cc*								-
	Lifetime	*years*								-
Avalanche wall	Construction cost	*€/m*	2500						7000	4750
	Maintenance cost	*€ of cc*								-
	Lifetime	*years*								-
GREEN										
- (*already listed above*)										
AVOIDANCE										
	Parameter	**u.m.**	**Austria**	**France**	**Slovenia**	**SudTirol**	**Aosta Valley**	**Piedmont**	**Germany**	**Mean value**
Road closure	Construction cost forest road	*€/m*	100			20		14	100	58
	repairing cost secondary road	*€/m/year*	5			17		167		13
	Construction cost secondary road	*€/m*	1200		300	37				512.19
	repairing cost primary road	*€/m/year*	5							5
	Construction cost primary road	*€/m*	2400		750					1575

	repairing cost highway	*€/m*					4000	4000
	repairing cost railway	*€/m*		3000			300	1650
	repairing cost powerline	*€/m2*		220				220
Building relocation/building evacuation	market value non residential building	*€/m2*		1200	1100		1116	1139
	market value residential bulding	*€/m2*		1900	2750		1800	2150
	market value commercial building	*€/m2*		2600	2700			2650
	market value public building	*€/m2*	182	1750			1900	1277
Construction ban	market value agricultural area	*€/m^2*		13	5000		10	1674
	market value settlement area	*€*		170				170
Early warning system	Warning system cost	*%*						-
	Maintenance cost	*years*						-

Attachment 2 - the values on prices and structure provided by the PARs for rockfall protection measures

ROCKFALL

Measures in the release area

GREY

	Parameter	u.m.	Austria	France	Slovenia	SudTirol	Aosta Valley	Piedmont	Germany	Mean value
Nets	construction cost (light nets)	*€/m2*	65			527		28		207
	construction cost (heavy nets)	*€/m2*	125					78		102
Concrete seals	construction cost	*€/m2*	135			89		76		100

GREEN

- (*already listed above*)

AVOIDANCE

- (*already listed above*)

Measures in the transit and runout area

GREY

	Parameter	u.m.	Austria	France	Slovenia	SudTirol	Aosta Valley	Piedmont	Germany	Mean value
Rockfall net	Construction cost (1000 kJ)	*€/m*	1250	750	950	829		2312		802
	Construction cost (2000 kJ)	*€/m*		850	1400	1004		304		889
	Construction cost (3000 kJ)	*€/m*		1000	1800	1385		428		1153
	Construction cost (5000 kJ)	*€/m*		1200	2700	1944		469		1578
	Maintenance cost	*% of Cc*[2]		30						30
	Lifetime	*years*		25	40			25		30

GREEN

[2] Cc = construction cost

- (*already listed above*)

AVOIDANCE

- (*already listed above*)

Attachment 3 - the values on prices and structure provided by the PARs for slope failures protection measures

SOIL / SLOPE FAILURES

Measures in the release area

GREY

	Parameter	u.m.	Austria	France	Slovenia	SudTirol	Aosta Valley	Piedmont	Germany	Mean value
Cribwall	Construction cost (debris volume 10m^3)	*€/m2*	400		120	143		200		216
	50 m^3	*€/m2*								-
	100 m^3	*€/m2*								-
	Maintenance cost	*% of cc*								-
	Lifetime	*years*			20					20
Concrete seals	construction cost	*€/m*	135			89		756		100

GREEN

- (*already listed above*)

AVOIDANCE

- (*already listed above*)

Measures in the transit and runout area

GREY

	Parameter	u.m.	Austria	France	Slovenia	SudTirol	Aosta Valley	Piedmont	Germany	Mean value
Debris net	Construction cost (1000 kJ)	*€/m*		750		829		2312		604
	Construction cost (2000 kJ)	*€/m*		850		1004		304		719
	Construction cost (3000 kJ)	*€/m*		1000		1385		428		9378

Maintenance cost	*% of cc*	30	1944	987
Lifetime	*years*	25		25
GREEN				
- (*already listed above*)				
AVOIDANCE				
- (*already listed above*)				

Dear GR4A partner, the present form is meant to be used to collect all the necessary data of the profiles you selected for your PAR to be analysed with the FAT tool. Please fill in the table and make sure you collected all the listed information before sending this document to the DISAFA for carrying out the valuation.

Here below the complete list of necessary data is presented:

1) Location info: country, location name;
2) The profile characteristics, expressed as .txt file;
3) The information on the profile width, the exposed assets and the chosen protection measure, resumed in the following tables (please fill the empty cells)

Data typology	Position along the profile (m)
Profile width	…
Forest start	…
Forest end	…
Forest type	

Protection Measure*[1]	Position along the profile (m)
Catching dam	…
Rockfall net	…
Afforestation start	…
Afforestation end	…

*[1] These data have to be provided if said measure has been chosen

Asset type	Type*[2]	Value (€)	Position along the profile (m)
Linear infrastructure	…	…	…
Building (repeat the lines above if more assets are present)	…	…	…

*[2]Linear infrastructure: (1) forest road, (2) secondary road, (3) primary road, (4) highway, (5) railway, (6) powerline.
Building: (1) non-residential building, (2) residential bulding, (4) commercial building, (5) public building.