

### Physical, social and institutional vulnerability assessment in small Alpine communities. Results of the SAMCO-ANR project in the Upper Guil Valley (French Southern Alps)

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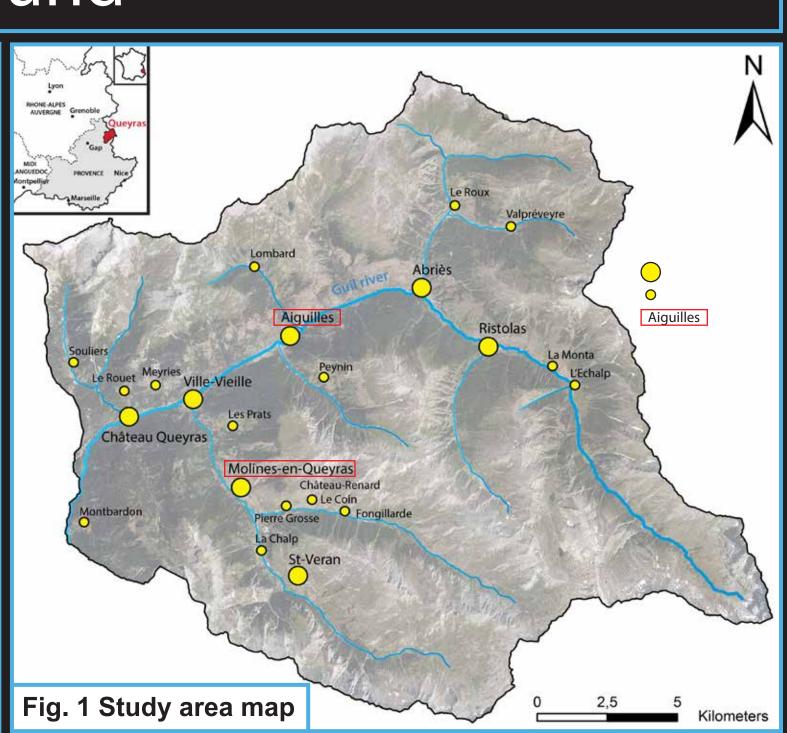
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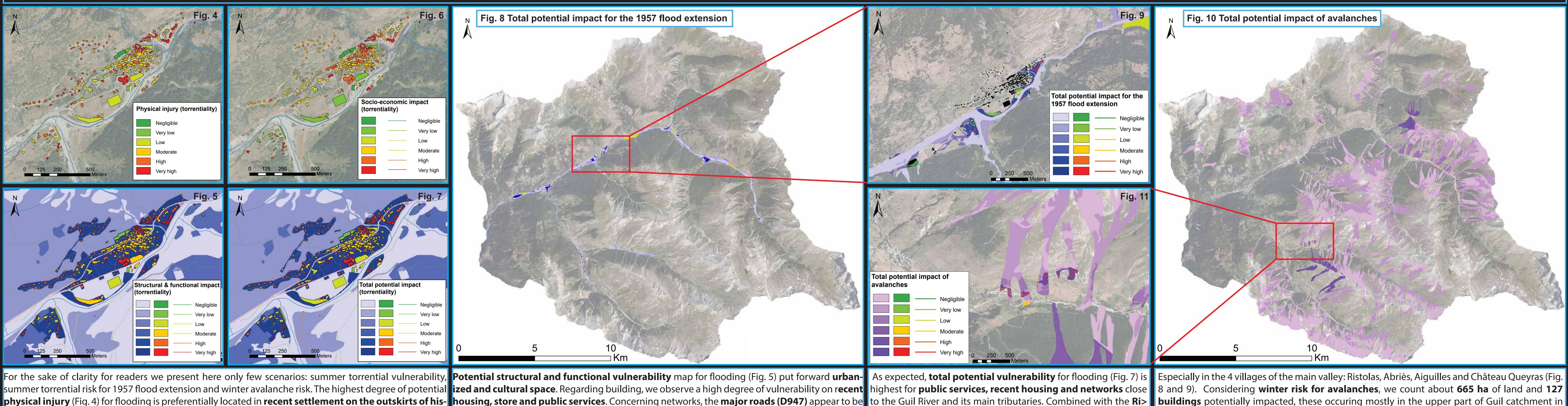


# Physical, social and institutional vulnerability assessment in small Alpine communities. **Results of the SAMCO-ANR project in the Upper Guil Valley (French Southern Alps)**

## 1-Background

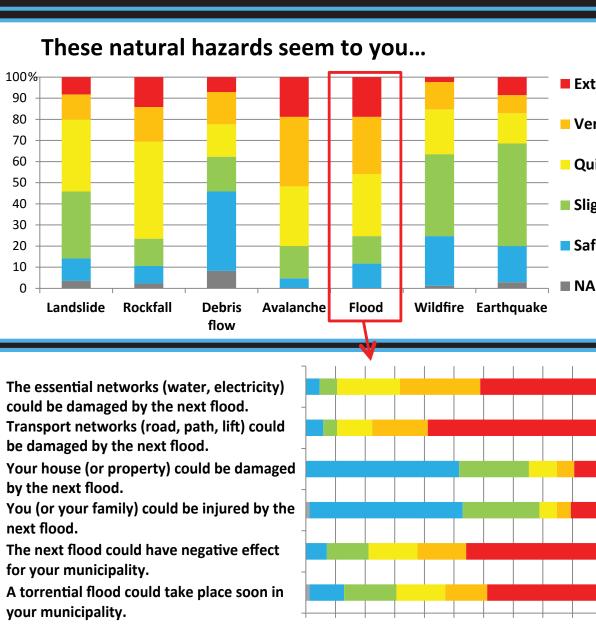
The Guil catchment is particularly prone to torrential and gravitational hazards such as floods, debris flows, landslides or avalanches due to several predisposing factors (bedrock supplying abundant debris, strong hillslope-channel connectivity) in a context of summer Mediterranean rainstorms as triggers. Since the second half of the 20th century, the progressive decline of agropastoralism and the development of tourism activities led to a concentration of human stakes on alluvial cones and valley bottom, therefore an increase of vulnerability for mountainous communities. Following the 1957 and 2000 catastrophic floods and the 1948 and 2008 avalanche episodes, some measures were taken to reduce exposure to risks (engineering works, standards of construction, rescue training...). Nevertheless, in front of urban expansion (land pressures and political pressures) and obsolescence of the existing protective measures, it is essential to reassess the vulnerability of the stakes exposed to hazards. In the frame of the **SAMCO project** designed for mountain risk assessment in a context of global change, we developed a systemic approach to assess three specific components of vulnerability physical, social and institutional – for the six municipalities of the Upper Guil catchment: Ristolas, Abriès, Aiguilles, Château-Ville-Vieille, Molines-en-Queyras and St-Véran (Fig. 1).





torical villages which are often close to torrential rivers. Potential structural and functional vulnera- vulnerable on many points and in the municipalities of Mo**bility** map for flooding (Fig. 5) put forward **urbanized and cultural space**.

Questionnaires and interviews suggest that Queyras inhabitants are **globally aware and well** informed about risk in their municipality (Fig. 12 and 13). According to their response, floods and avalanches are the major risks to consider. Many of them (Fig. 14) have experienced a natural disaster, which suggest a **good memory** of risk. Mind-maps (Figs. 16 and 17) lead in that direction. Nevertheless, just few of them considered that they could be directly and physically affected by risk (Fig. 13); and there is still **7%** of people which are **not informed about risk**. These are often seasonal workers or newcomers such as retired people. Regarding to confidence towards stakeholder we observe a clear next flood preference for local authorities and civil security which are the most visible actors in those isolated regions (Fig. 15).



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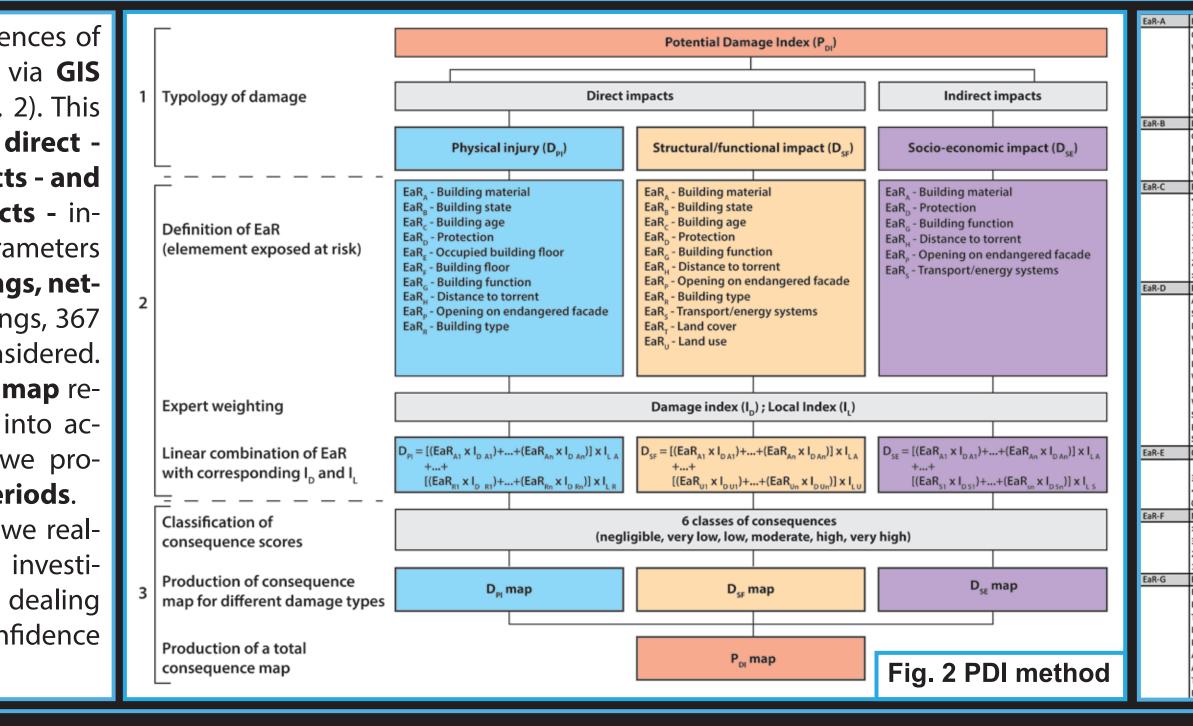
> Physical vulnerability (i.e. total potential consequences of hazards on stakes) was estimated and mapped via **GIS** model from Potential Damage Index (PDI) (Fig. 2). This index allowed us to quantify and describe both direct physical injury, structural and functional impacts - and indirect consequences - socio-economic impacts - in duced by hazards; this by combining weighted parameters reflecting the exposure of elements at risk: **buildings, net**work and land cover (Fig. 3). At least 1890 buildings, 367 km<sup>2</sup> of land cover and 902 km of network were considered. Vulnerability maps were then crossed to hazard map reflecting different scenarios of exposure. To take into account the temporal variability of vulnerability, we produced different maps for summer and winter periods. To assess social and institutional vulnerability we realized questionnaires (5% of the total population investigated), interviews and mind-maps (80 collected) dealing with risk perception, mitigation measures and confidence in the actors of risk management.

### 3- Results : physical vulnerability assessement

maps (Fig. 6) bring to light touristic issues such as shops, camping grounds and lifts.

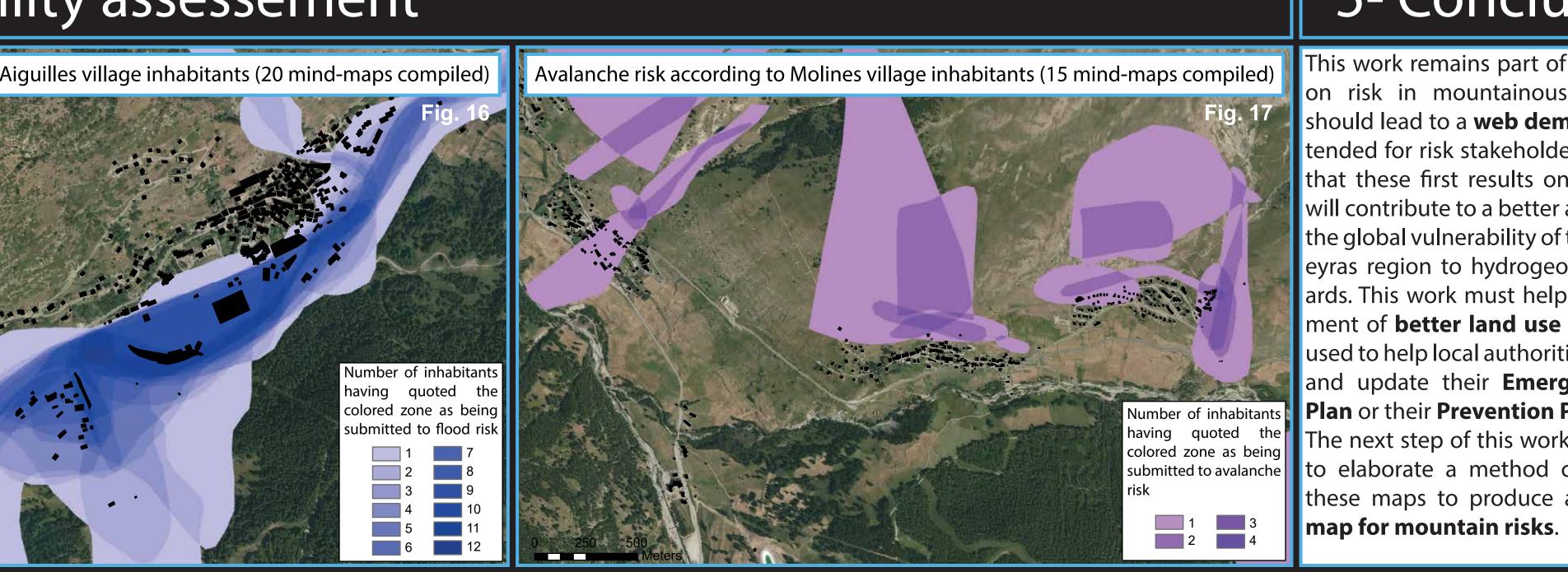
### 4- Results : Social and institutional vulnerability assessement Did you personally experienced a natural disaster? Fig. 14 Torrential risk according to Aiguilles village inhabitants (20 mind-maps compiled) Extremely dangerous Landslid Very dangerous Earthquak Quite dangerou Avalanche Slightly dangerous ) Nb of peo directly affected was in my municipality. personally affected Fig. 12 To what extend do you have confidence in these stakeholder? 1 Unlikel Insurance Company Scientists / experts Medias Firefighter / civil securit State / ministries 2 Region / regional counc 3 Department / department Municipality communiti 5 Likely Local authorities / municipalit 0 10 20 30 40 50 60 70 80 90 100% Fig. 13 Fig. 15

## 2-Methods



**ha** of land and **289 buildings** could be endangered.

**lines-en-Queyras** and **St-Véran** (Figs. 10 and 11).









1970-1990         0,9         0										
Concrete         1         0.8         0.6         1.0m         0.05         1.1           Mature (wood 6 concrete)         1         0.8         0.8         0.00	Building material	Landslides	Torrentiality	Avalanches	FaB-H	Distance to torrent	Landslides	Torrentiality	Avalanches	
whore thetter (word & concrete)         1         0.1         0.03         0.01 to 20m         0.04         0.04         0.04           Mettar (word & concrete)         0.4         0.4         0.4         0.4         30m to 40m         0.2         0.2           Store & word (raditional)         0.4         0.4         0.4         0.4         30m to 40m         0.2         0.2           Natural         0.4 <t< td=""><td></td><td></td><td></td><td></td><td>Lawin</td><td></td><td></td><td></td><td>0</td></t<>					Lawin				0	
Matter Matter Matter Sine Associ (raditional)10.80.80.80.00 <td></td> <td></td> <td>0,0</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>ő</td>			0,0						ő	
Metal         Optimization of the second secon			0.2	- 1 -					ő	
Sone & wood (traditional)         0.6         0.0         0.0         0.1         0.2           Cated, sphalfed surfaces         0.0									ő	
Natural         0.0         0.0         0.0         950m         950m         0         0         0           Building State         Landsides         Torrentality,         Avalanche         Eal+1         Opening on endengered facade         Landsides         Torrentality,         Avalanche           God         0.7         0.7         0.7         Aberoe         0									ő	
Casted, sphalted surfaces         0 <td></td> <td></td> <td></td> <td>-</td> <td></td> <td></td> <td></td> <td></td> <td>ő</td>				-					ő	
Building State         Landallées         Torrentality         Avalanches         EaR-I         Opening on entangered facade         Landslides         Torrentality         Avalanches           God         0,7         0,7         0,7         0,7         1							Ŭ	Ŭ	v	
Good         Initial         Allow         Initial         Allow         Initial         Initia <thinitial< th=""> <thinitia< <="" td=""><td></td><td></td><td></td><td></td><td>EaB-I</td><td>Opening on endangered facade</td><td>Landslides</td><td>Torrentiality</td><td>Avalanches</td></thinitia<></thinitial<>					EaB-I	Opening on endangered facade	Landslides	Torrentiality	Avalanches	
Moderate Bal         0.0         0.0         0				1	convi				0	
Bad $0.2$ $0.2$ $0.2$ $0.4$ $0.6$			_	0.7			-		0,6	
Very bar (min)							, i i i i i i i i i i i i i i i i i i i		0,8	
Building Age         Landsildes         Torrentality         Avalanches         EaR.J         Building type         Landsildes         Torrentality         Avalanches           1300         0.3<								1	1	
C1900         0.3 </td <td></td> <td>-</td> <td>· · · · ·</td> <td></td> <td>FaR-1</td> <td></td> <td>-</td> <td>Torrentiality</td> <td></td>		-	· · · · ·		FaR-1		-	Torrentiality		
1000 19500.050.05Mouing0.10.					contra				1	
1950 1970       0,0							1	1	1	
1970-1990       0,9						÷	0.7 (s) - 0.8 (w)	0.7(s) - 0.8(w)	0,7 (s) - 0,8 (w)	
1999-2000       1									0,7 (3) - 0,8 (47) 0,3	
2000-2010111020101110,5Building protectionLandsildesTorrentialityAvalanchesAbsence0000Sparsel hedge0000Dense hedge00000Urise fince00000Low wall (dry stone)000000Low wall (dry stone)000000Low wall (dry stone)0000000Low wall (dry stone)00000000Low wall (dry stone)00		1		1		Ū.			0,5	
$200$ 110,5 $\mu_{1}$ $0,1$ 0,11,11,11,11,11,11,11,11,11,1<		1	1	1					0,2	
Building protectionLandslidesTorrentialityAvalanchesCemetary00Absence00		1	1	0.5					0,1	
Absence         0 </td <td></td> <td>Landslides</td> <td>Torrentiality</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>0,1</td>		Landslides	Torrentiality						0,1	
Sparsed hedge         0         -0.1         0         Carrow         Main Solid Secting y Stellins         Call Solid         Internating         Valiable           Dense hedge         0         -0.2         0         Main road         0.8         0.9         0.9         0.9         0.9         0.9         0.9         0.9         0.9 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>-</td> <td></td>								-		
Dense hedge         0         0.02         0         0.02         0         Secondary road         0.1         1         1         1           Write fence         0         0.03         0.3				-	EaR-K				Avalanches	
Wire fence         0         -0.2         0         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.3         0.3         -0.4         -0.4         -0.4         -0.4         -0.4         -0.4         -0.4         -0.4         -0.4         -0.4         -0.4         -0.4         -0.4         -0.4         -0.4         -0.5         -0.6				-			-		1	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	-			-					0,8	
Low wall (masonery)         0         -0.3         0.3         0.3         0.1         0.1         0.1         0.1           Wood on fence         0         -0.4         0.2         Ski lift         0.7         0.7         0.7           Mixed (low wall & hedge or fence)         0         -0.5         0.3         Iffak         0.1         1         1           Shutter on opening exposed to hazard         0         -0.4         -0.5         0.4         Urban         0.6         0.6         0.35		-		-					0,6	
Wooden fence         0         -0.4         0.2           Mixed (low wall & hedge or fence)         0         -0.5         0.3           Wall >1,5m         0         -0.7         0.4         High-voltage line         1         1           Shutter on opening exposed to hazard         0         -0.4         -0.5         0         -0.6         -0.6         -0.6         -0.6         -0.6         -0.6         -0.6         -0.7         -0.7         -0.7         -0.7         -0.7         -0.7         -0.6         -0.6         -0.6         -0.6         -0.6         -0.6         -0.6         -0.7		-							0,1	
Mixed (low wall & hedge or fence)00.050.03Imgn voltage inte111Wall >1,5m00.070,4 $\overline{Cast or entiality}$ $\overline{Cast or entiality}$ AvalanchShutter on opening exposed to hazard00.040.05 $\overline{Cast or entiality}$ $Cast or entiality$		-							0,7	
Wall >1,5m00,70,4Ear.LLancoverLandslidesTorrentialityAvalanchShutter on opening exposed to hazard0-0,4-0,5Urban0,60,60,60,6Building protecting other building0-0,60,070,7<						High-voltage line	1	1	1	
Shutter on opening exposed to hazard         0         0.4         0.5         0.4         0.5           Building protecting other building         0         0.6         0.8         Farming/pasture         0.3         0.35           Snow supporting structure         0         0.7         6         0.7         6         0.1         0.15         0.15           >6         0.7(s) - 1(w)         Avalanches         Water surface         0.1         0.1         0.1           0         0         0         0         0         Bare rock & colluvium         0.05         0.05         0.05           3         0.5         0.5         0.7         1		Ť.			EaR-L	Lancover	Landslides	Torrentiality	Avalanches	
Building protecting other building Snow supporting structure0 $-0.6$ 0 $-0.6$ 0 $-0.7$ <th< td=""><td>1 ·</td><td>~</td><td></td><td></td><td></td><td>Urban</td><td>0,6</td><td>0,6</td><td>0,6</td></th<>	1 ·	~				Urban	0,6	0,6	0,6	
Snow supporting structure $\bigcirc$		-				Farming/pasture	0,35	0,35	0,35	
Occupied floors         Landslides         Torrentiality         Avalanches         Grass         0,15         0,15         0,15         0,15           >6         0,7 (s) - 1 (w)         0,05         0,05         0,05         0,05         0,05         0,05         0,05         0,05         0,05         0,05         0,05         0,25         0,15         0,15		-				Forest	0,2	0,2	0,2	
>6         0,7 (s) - 1 (w)		Landslides	Torrentiality			Grass	0,15	0,15	0,15	
3-6 $<3$ $0,07$ $<1$ $0,07$ $<1$ $Alluvium$ $0,05$ $Bare rock & colluvium$ $0,05$ $0,05$ $0,05$ $0,05$ $0$ <td></td> <td></td> <td></td> <td></td> <td></td> <td>Water surface</td> <td>0,1</td> <td>0,1</td> <td>0,1</td>						Water surface	0,1	0,1	0,1	
<3AABare rock & colluvium0,050,050,05000EaR-MLand useLandslidesTorrentialityAvalanchNumber of floorsLandslidesTorrentialityAvalanchesUrban111>30,50,50,5Arable land0,250,250,2530,50,50,7Winter tourist activities0,80,80,820,70,71Summer tourist activities0,50,50,51111Protected area0,150,150,15Building FunctionLandslidesTorrentialityAvalanchesProtected area0,150,15Education11111111Emergency0,950,950,950,951111Trade0,90,90,90,90,91111						Alluvium	0,05	0,05	0,05	
000EaR-MLand useLandslidesTorrentialityAvalanchNumber of floorsLandslidesTorrentialityAvalanchesUrban111>30,00,00,00,0Arable land0,250,250,2530,070,070,071Kinter tourist activities0,80,80,820,070,070,11Summer tourist activities0,50,50,50,51111Protected area0,150,150,150,150,15Building FunctionLandslidesTorrentialityAvalanchesProtected area0,150,150,150,15Education11 <td></td> <td></td> <td></td> <td>1</td> <td></td> <td>Bare rock &amp; colluvium</td> <td>0,05</td> <td>0,05</td> <td>0,05</td>				1		Bare rock & colluvium	0,05	0,05	0,05	
Number of floorsLandslidesTorrentialityAvalanchesUrban11>30,30,50,50,50,250,2530,50,50,70,70,70,720,70,71110,80,80,81111110,150,150,15Building FunctionLandslidesTorrentialityAvalanchesProtected area0,150,15Education11111Emergency0,950,950,950,950,950,95Trade0,90,90,90,90,90,90,9			_	0	EaR-M	Land use	Landslides	Torrentiality	Avalanches	
>3       0,3       0,5       0,5       0,5         3       0,5       0,5       0,7         2       0,7       0,7       0         1       1       1       1         Building Function       Landslides       Torrentiality       Avalanches         Education       1       1       1         Emergency       0,95       0,95       0,95         Trade       0,9       0,9       0,9	-					Urban			1	
3         0.5         0.5         0.7         Winter tourist activities         0.8         0.8           2         0.7         0.7         1         Summer tourist activities         0.5         0.5         0.5           1         1         1         1         Protected area         0,15         0,15         0,15           Building Function         Landslides         Torrentiality         Avalanches         Protected area         0,15         0,15         0,15           Education         1					1	Arable land	0,25	0,25	0,25	
2         0,7         0,7         1           1         1         1         1         1           Building Function         Landslides         Torrentiality         Avalanches         Protected area         0,5         0,5           Education         1         1         1         1         1         1         1           Emergency         0,95         0,95         0,95         0,95         0,15         0,15           Trade         0,9         0,9         0,9         0,9         0,9         0,9         0,9         0,9         0,9						Winter tourist activities	0,8	0,8	0,8	
1111Protected area0,150,15Building FunctionLandslidesTorrentialityAvalanches66666Education1111666 <td< td=""><td>2</td><td></td><td></td><td>1</td><td></td><td>Summer tourist activities</td><td></td><td></td><td>0,5</td></td<>	2			1		Summer tourist activities			0,5	
Education         1         1           Emergency         0,95         0,95           Trade         0,9         0,9	1	1	1	1		Protected area	0,15	0,15	0,15	
Education         1         1           Emergency         0,95         0,95           Trade         0,9         0,9	Building Function	Landslides	Torrentiality	Avalanches						
Trade 0,9 0,9 0,9		1		1	1					
	Emergency	0,95	0,95	0,95						
Industry/Craft 0,9 0,9 0,9 0,9										
Public administration 0,7 0,7 0,7				-						
Accommodation 0.8 0.8 0.8										
	Agricultural							india	atora I	
Agricultural Tourism 0,6 (s) - 0,8 (w) 0,8	1- 1			0,6 (s) - 0,8 (w)			ynted	Indica	αιοίς	
Religious 0,2 0,2 0,2									-	

### 5-Conclusion

This work remains part of a large study on risk in mountainous region that should lead to a **web demonstrator** intended for risk stakeholders. We expect that these first results on vulnerability will contribute to a better assessment of the global vulnerability of the upper Queyras region to hydrogeomorphic hazards. This work must help the development of **better land use** and could be used to help local authorities to improve and update their Emergency Action Number of inhabitants **Plan** or their **Prevention Plan**. The next step of this work will be to try to elaborate a method combining all these maps to produce a global risk