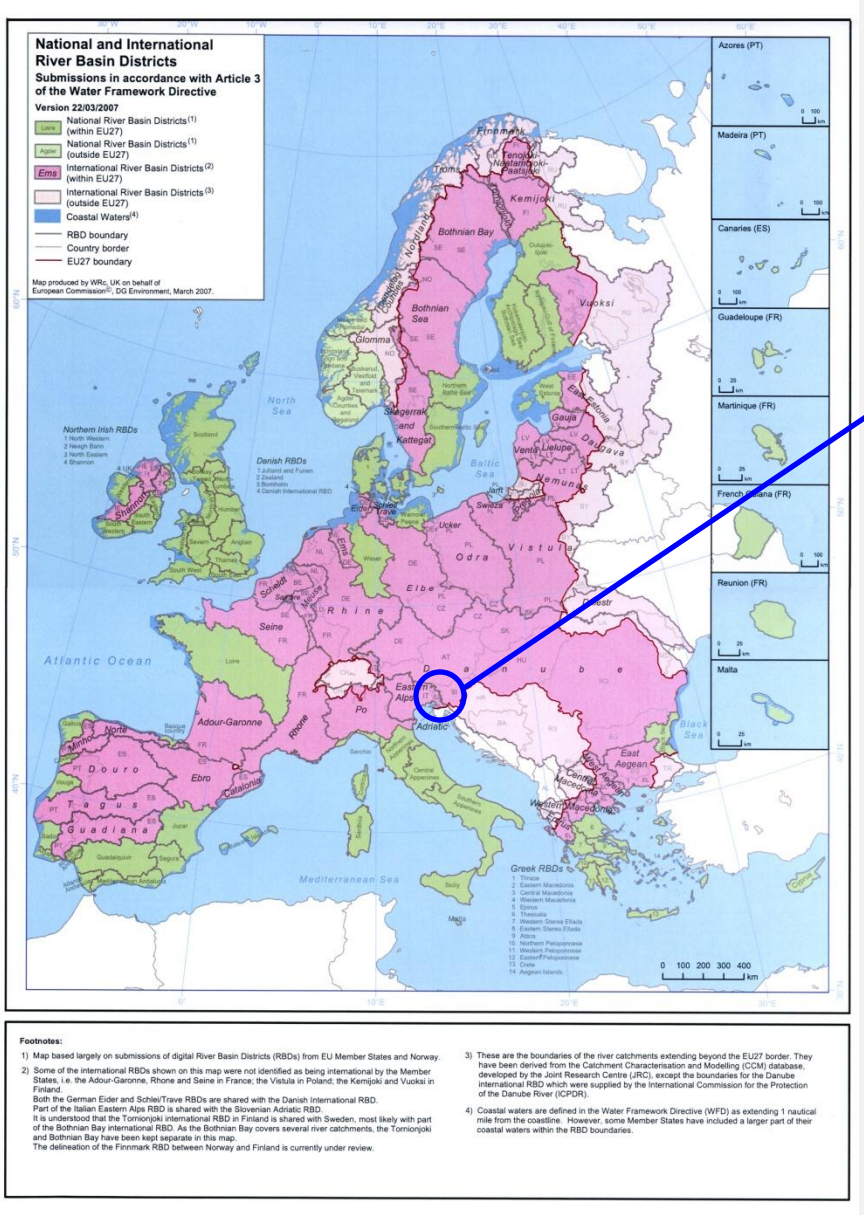
DISTRETTO IDROGRAFICO
DELLE ALPI ORIENTALI

Flood hazard and risk mapping in the Vipacco case study

M. Ferri

Venice, 19-20 September 2013
KULTURisk WORKSHOP

VIPACCO RIVER BASIN



Footnotes:

1) Map based largely on submissions of digital River Basin Districts (RBDs) from EU Member States and Norway.

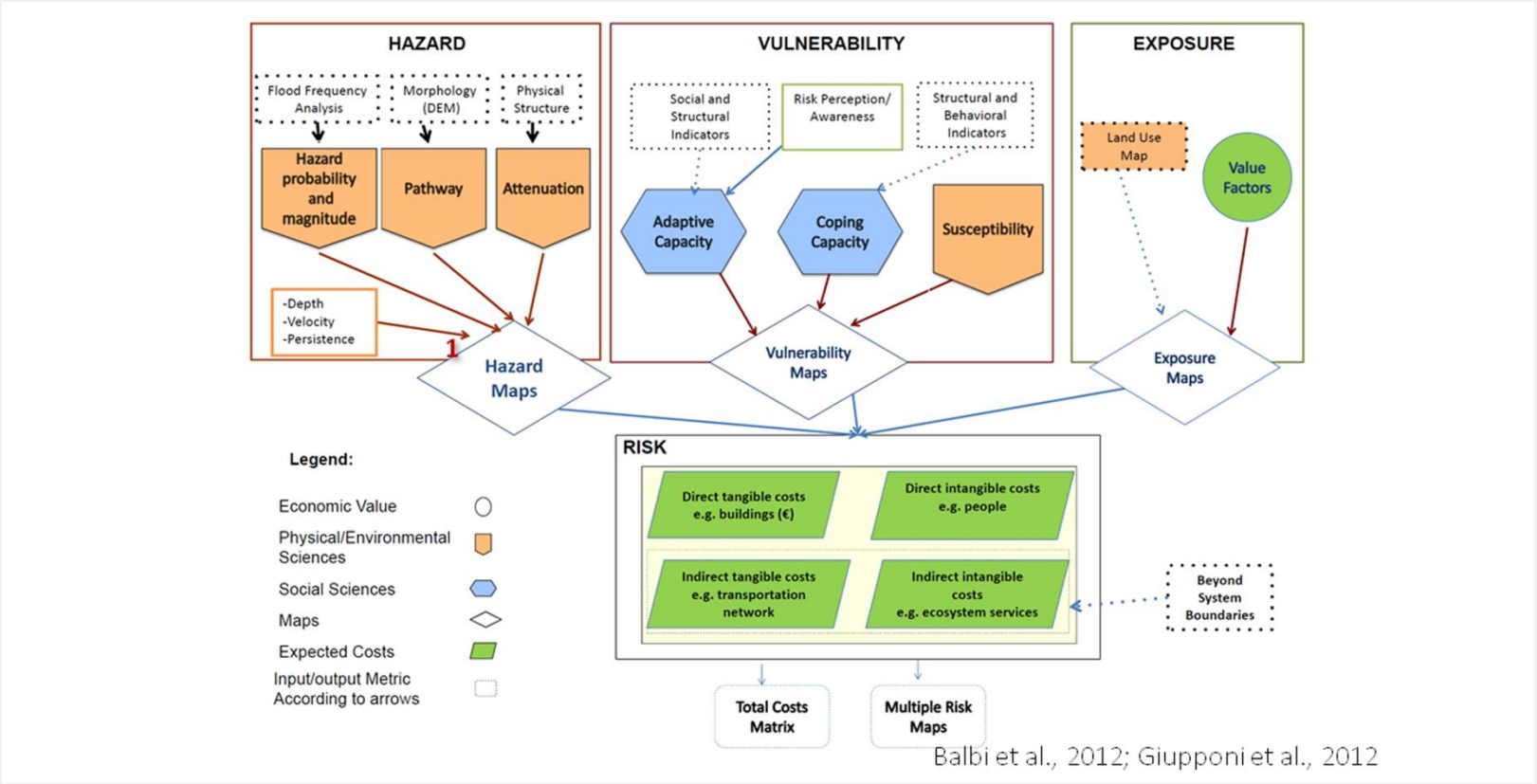
2) Some of the international RBDs shown on this map were not identified as being international by the Member States, i.e. the Adour-Garonne, Rhone and Seine in France; the Vistula in Poland; the Kemijoki and Vuoksi in Finland.
Both the German Eider and Schlei/Trave RBDs are shared with the Danish International RBD.
Part of the Italian Eastern Alps RBD is shared with the Slovenian Adriatic RBD.
It is understood that the Tornionjoki international RBD in Finland is shared with Sweden, most likely with part of the Bothnian Bay international RBD. As the Bothnian Bay covers several river catchments, the Tornionjoki and Bothnian Bay have been kept separate in this map.
The delineation of the Finnmark RBD between Norway and Finland is currently under review.

3) These are the boundaries of the river catchments extending beyond the EU27 border. They have been derived from the Catchment Characterisation and Modelling (CCM) database, developed by the Joint Research Centre (JRC), except the boundaries for the Danube international RBD which were supplied by the International Commission for the Protection of the Danube River (ICPDR).

4) Coastal waters are defined in the Water Framework Directive (WFD) as extending 1 nautical mile from the coastline. However, some Member States have included a larger part of their coastal waters within the RBD boundaries.

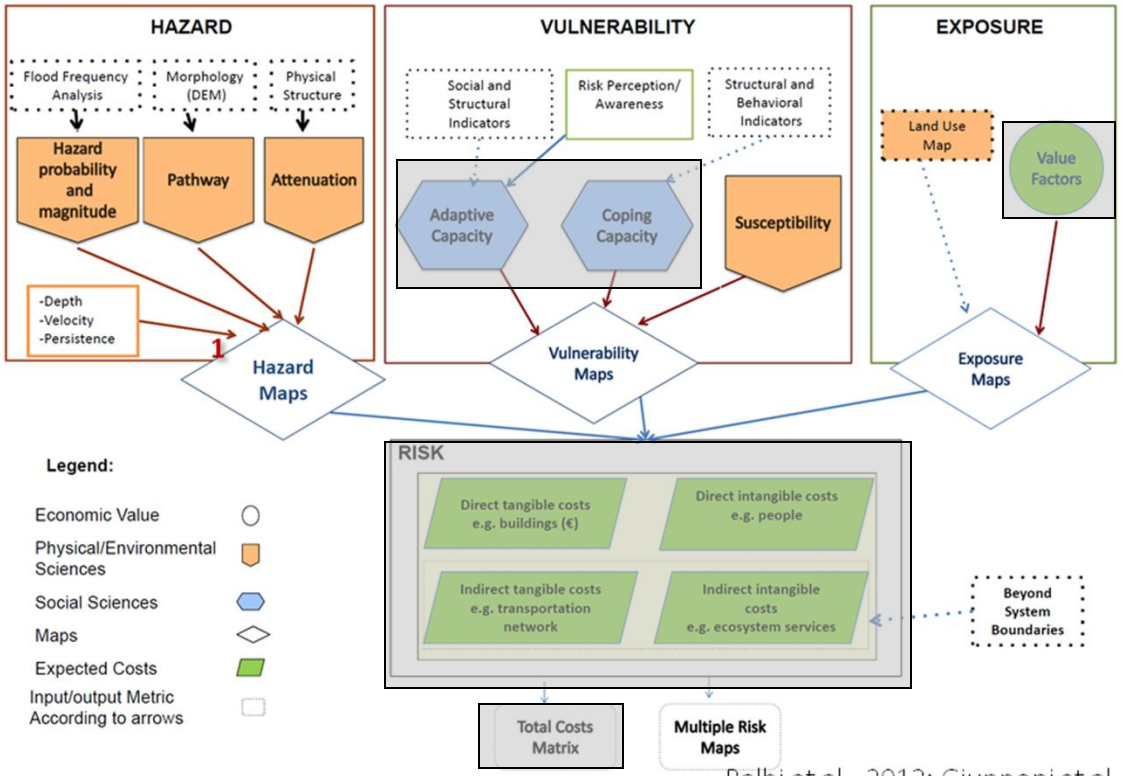
Vipacco is 45 km in length with a watershed of nearly 600 km^2

September, 2009



According to the EC Flood Directive, flood risk results as "the combination of the probability of a flood event and of the potential adverse consequences". Such general statement often finds its operational implementation for producing flood risk maps both in the literature and in national regulations and guidelines as the product of hazard, vulnerability and exposure.

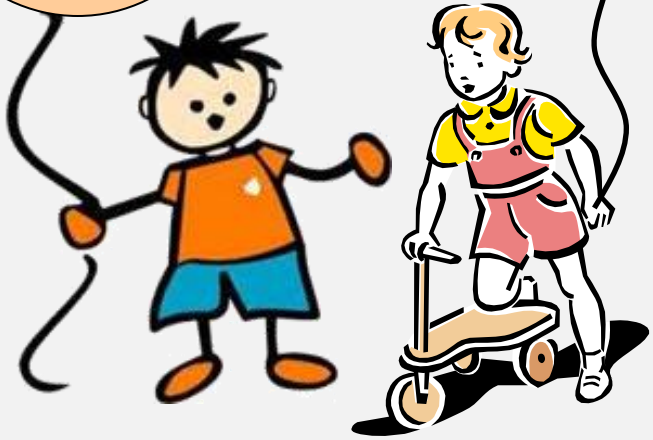
$$\mathbf{R = H \times V \times E = H \times D}$$



Risk quantification is expressed in relative terms (the risk of one exposed element corresponds to a a value between 0 and 1 where 0 represents the case where there's no risk and 1 the maximum risk for the exposed element)

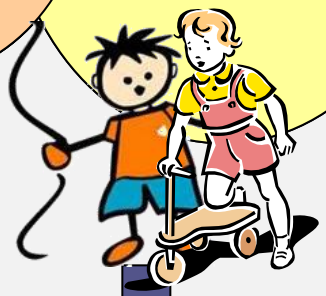
2007/60/EC

D.Lgs. 49/2010



2007/60/EC

D.Lgs. 49/2010



Eastern Alps Hydrographic District Plan

RECEPTORS

- **People (*P*) (2007/60/CE-art.6.5.a)**, (D.Lgs.23.02.2010 - art.6.5.a);

- **Economical activities (*A*) (2007/60/CE-art.6.5.b)**: buildings. agriculture, natural and semi-natural areas (D.Lgs. 23.02.2010-art.6.5.d), infrastructure and strategical structure (D.Lgs. 23.02.2010-art.6.5.b);

- **Cultural** (D.Lgs.23.02.2010-art.6.5.c) and **environmental heritage (*E*) (2007/60/CE (art.6-5.c)**, including the installations described in the attached I of DLgs n°59/2005 and the protected area described in DLgs 152/2006

COD	DESCRIPTION
1	Residential
2	Hospital, social assistence strctures
3	Public buildings
4	Commercial and craft
5	Industrial
6	Agricultural
7	Agricultural not defined such as forest, grassland, grazing land, cemeteries, urban parks.
8	Touristic-entertaining
9	Unproductive
10	Skiing area, Golf camp, Riding stables
11	Camping
12	Transport and communication network: primary road
13	Transport and communication network: secondary road
14	Railway zone
15	Touristic area; Collective equipment area; Collective equipment area over municipality, Collective equipment in the subsoil.
16	Technologic and service infrastructures
17	Structure to support communication and transport network (airports, harbours, service area., parking)
18	Energy production area
19	Landfills, Waste treatment plants. Extractive areas, Waste water treatment plant
20	Area with installation all'allegato I del decreto legislativo 18 febbraio 2005, n. 59
21	Cultural-historical and archaeological relevant area.
22	Environmental heritages
23	Military zone.

The three macro-categories find their descriptors in the land use classes that are identified considering also the reporting sheet of November 2010

Weights related to different receptor-related risks, land use classes and score for Hazard, Vulnerability and Exposure classes are defined on the basis of existing and already approved Eastern Alps Hydrographic District Plans and National guide line

Regional dataset (MOLAND) was used for land use identification

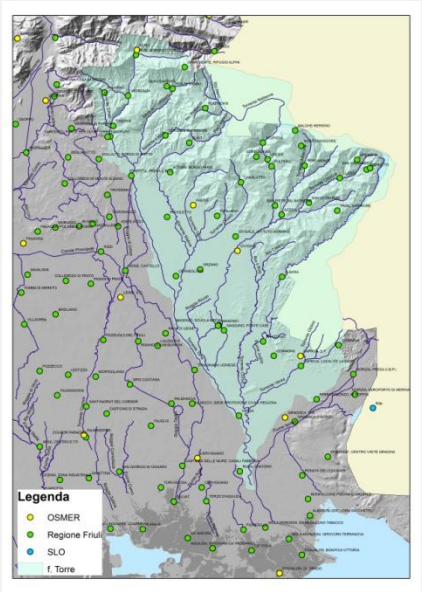
2007/60/EC DIRECTIVE (Article 6)

"Member States shall…prepare flood Hazard maps …that shall cover the geographical areas which could be flooded according to the following scenarios:

1. Floods with a low probability → Tr = 30 years
2. Floods with a medium probability → Tr = 100 years
3. Floods with a high probability where appropriate → Tr = 300 years

For each scenario the following elements shall be shown:
1. The flood extent
2. Water depths
3. Where appropriate, the flow velocity or the relevant water flow"

RAINFALL DATA



$$h_T^{\,i}(d) = a_1 \cdot \left\{1 - \frac{V \cdot \sqrt{6}}{\pi} \cdot [\varepsilon + y_T]\right\} \cdot d^n$$

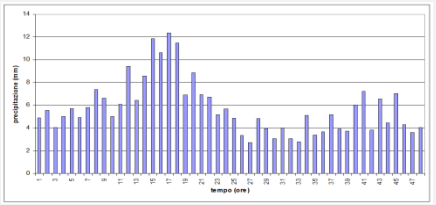
i= 1,…$n_{rainfall\_stations}$

(*Burlando et Rosso,* 1991; 1996).

DESIGN PRECIPITATION

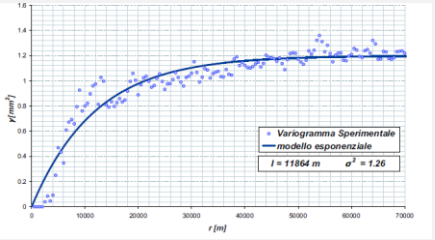
Rainfall time distribution (using geometric forms and a random cascade)

(*Gupta et al,* 1993)

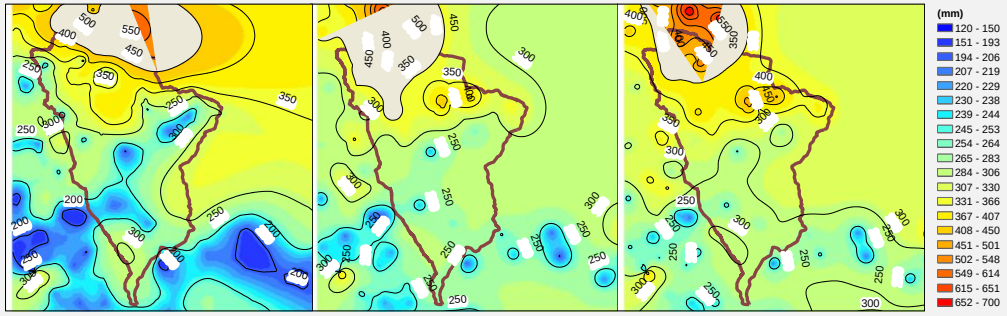


Rainfall space distribution (using a geostatistical interpolation - kriging)

(*Boni et al.*, 2008; *Zanetti et al.*, 2008)



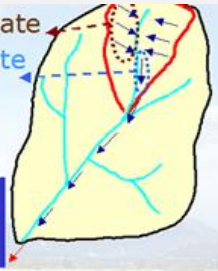
RESULTS: $h_T(x, y, t)$



time

Residence time distribution along a single path:

Hill state
Channel state



$$f_{\gamma_1}(t) = f_{v_1}(t) * f_{c_1}(t) * f_{c_3}(t) * f_{c_5}(t)$$

$f_c(t)$ INVERSE GAUSSIAN DISTRIBUTION
$f_v(t)$ EXPONENTIAL DISTRIBUTION

RIVER BASIN RESPONSE (GIUH):

$$Q(t) = \int_0^t dt_0 \sum_{\gamma_i \in \Gamma} j_{A_i}(t_0) f_{\gamma_i}(t - t_0)$$

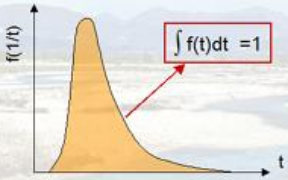
[Rinaldo et al., 2006]

Residence time probability density – CHANNEL STATE

$$f_\gamma(t) = \frac{L_\gamma}{(4\pi D_h t^3)^{1/2}} e^{\left(-\frac{(L_\gamma - at)^2}{4D_h t}\right)}$$

Advective-diffusive formulation of transport

Rinormalization of the $f_\gamma(t)$ in order to conserve mass in the basin



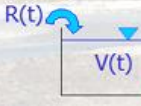
Residence time probability density – HILL STATE

$$f_v(t) = k_v e^{-k_v t}$$

Exponential distribution

k_v [1/t] time constant

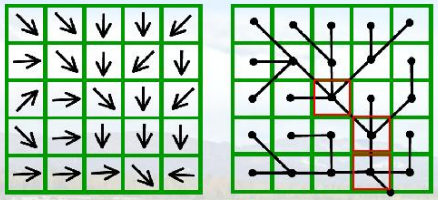
The use of the exponential distribution for residence times is the same as the application of linear reservoir equations



k time constant calculation differentiated by the various types of transport (superficial, subsuperficial, in-depth)

Geomorphoclimatic formulation

Residence time in the hill state

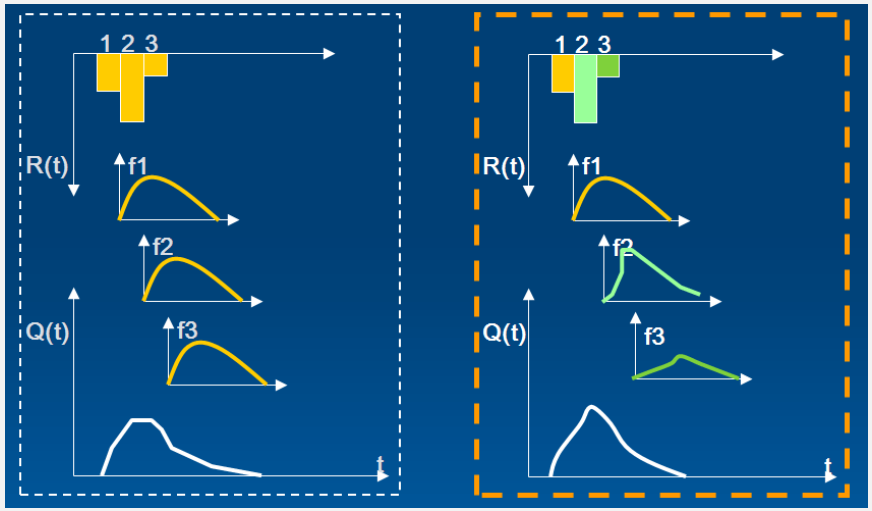


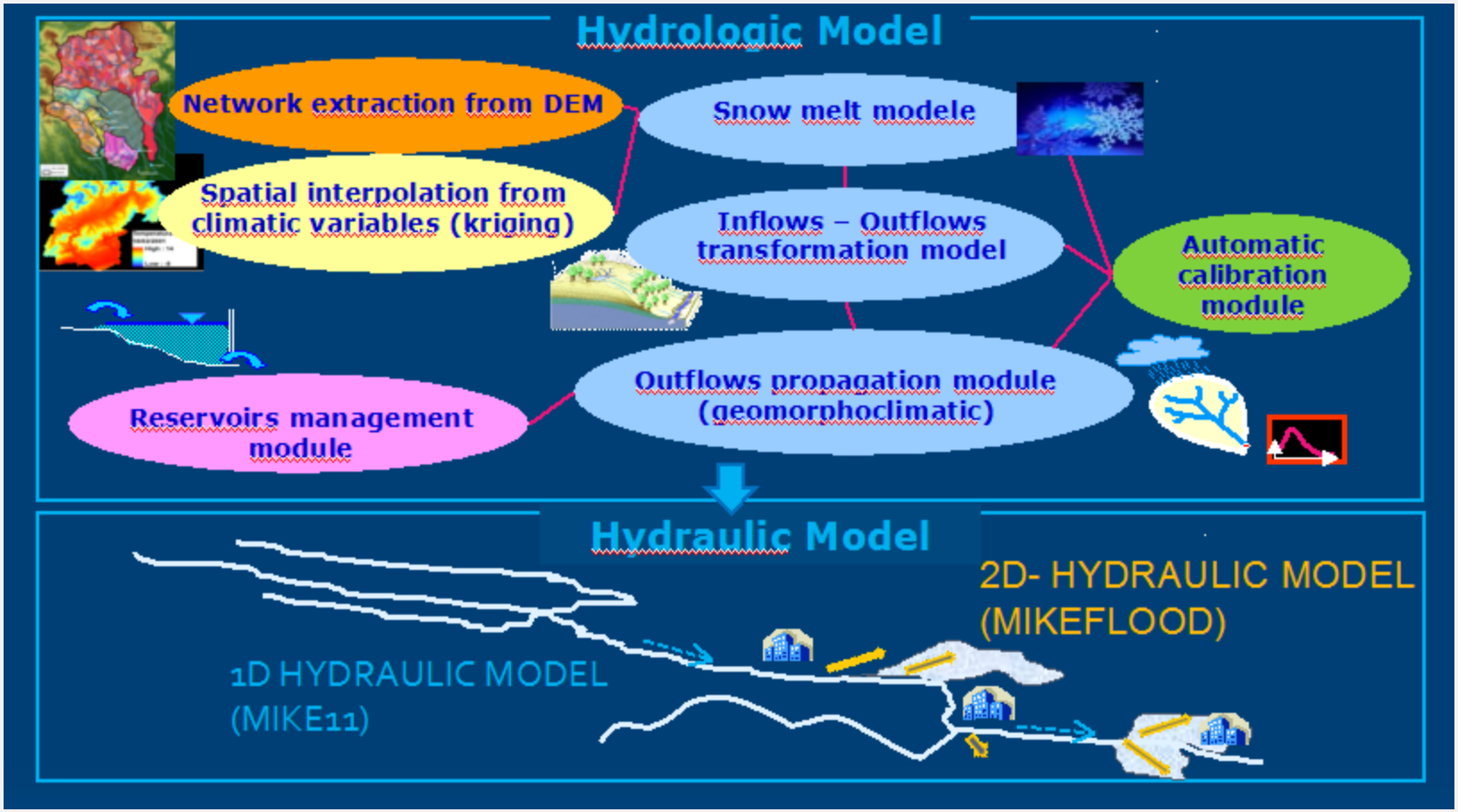
Drainage directions channelled cells

Path length calculation from every hill cell to the first channelled cell (L_v)

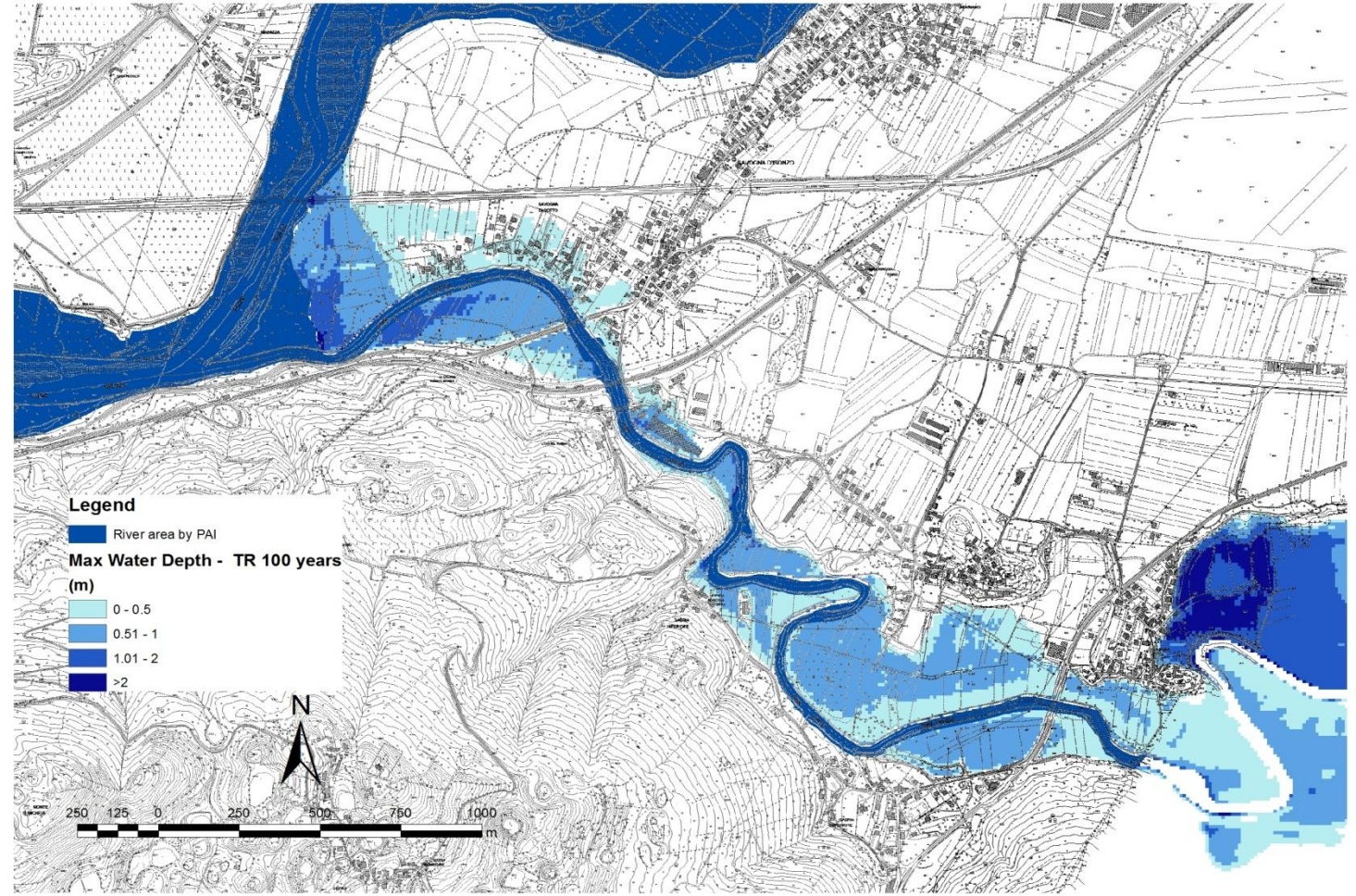
Time varied velocity in relation to precipitation intensity

$$u_v(t) = k_s \sqrt{S} \cdot y(t)^{2/3}$$

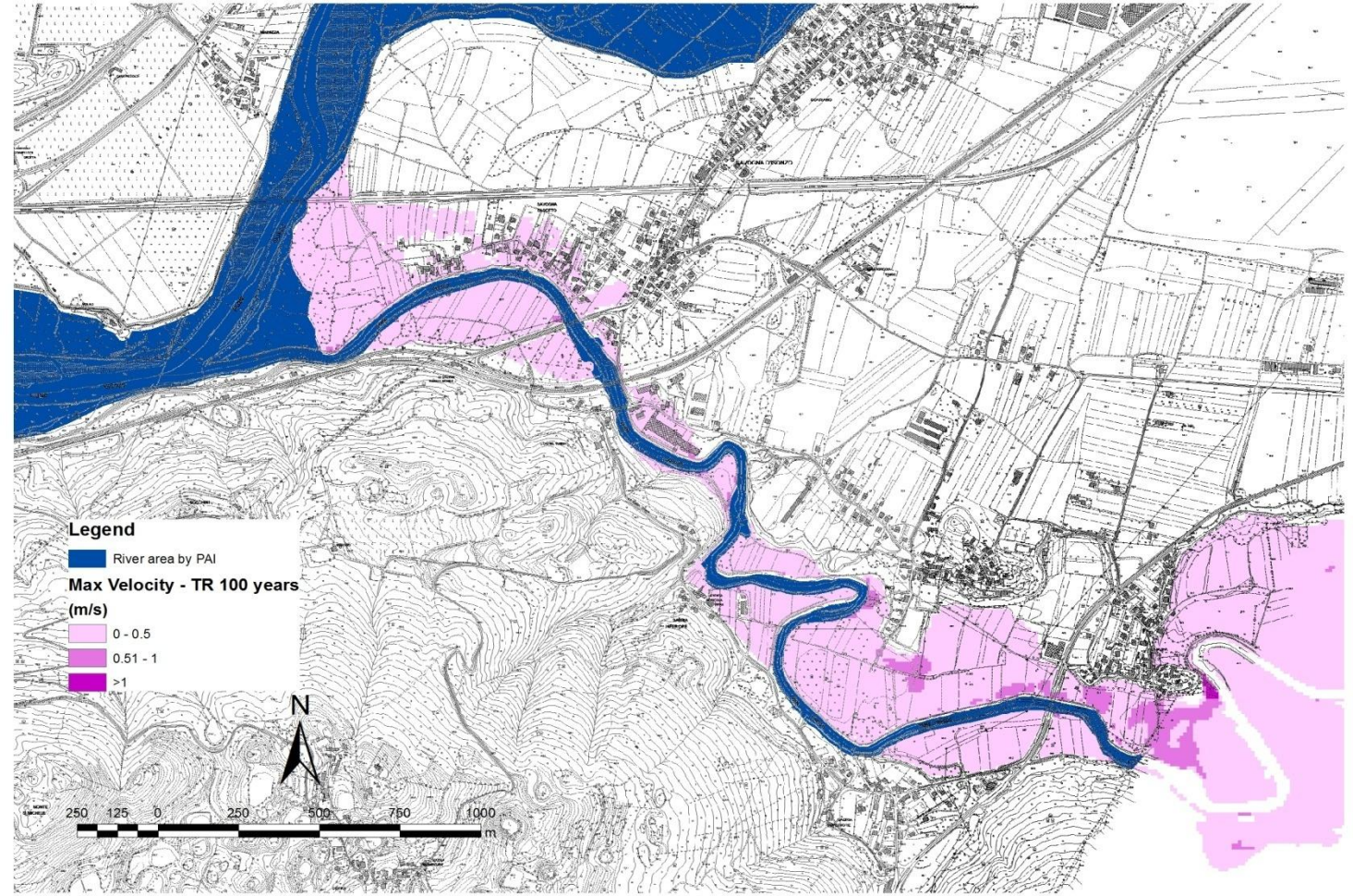



Hydrologic Model
Network extraction from DEM
Snow melt modele
Spatial interpolation from climatic variables (kriging)
Inflows – Outflows transformation model
Automatic calibration module
Outflows propagation module (geomorphoclimatic)
Reservoirs management module
Hydraulic Model
2D- HYDRAULIC MODEL (MIKEFLOOD)
1D HYDRAULIC MODEL (MIKE11)

Water depth – Tr 100 years



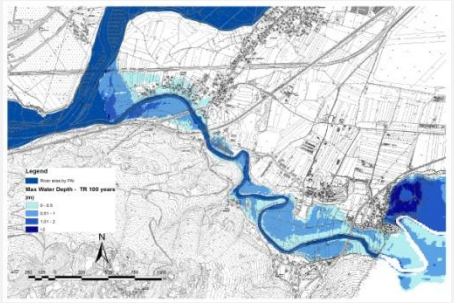
Water Speed – Tr 100 years



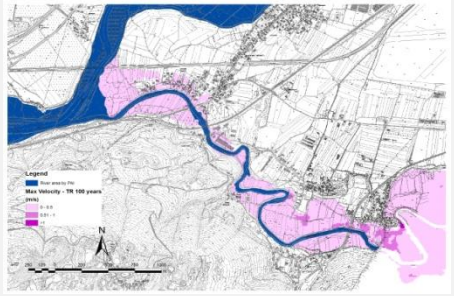
R = H x V x E

(WH, WS) → **I**(WH,WS) → **H**(I)

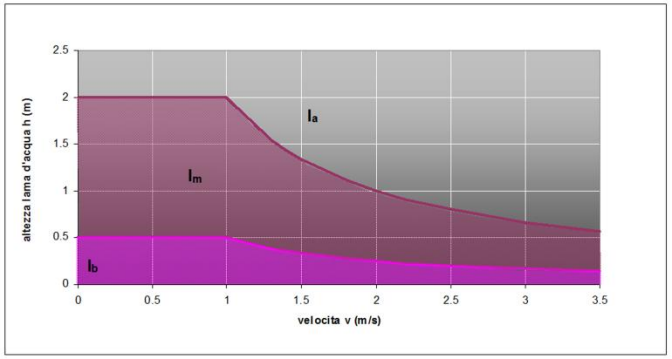
Water heigth – Tr 100 years



Water Speed – Tr 100 years



Intensity Function and Hazard score

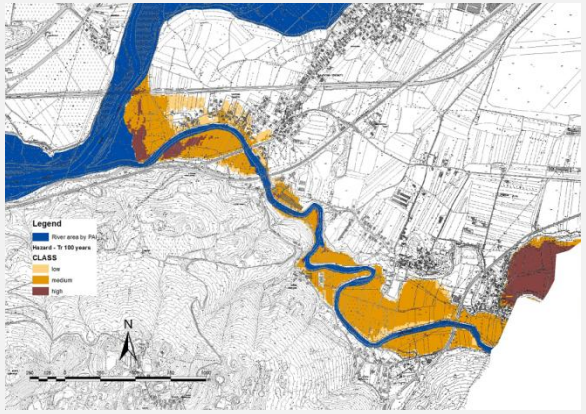


DESCRIPTION	I CLASSES	H SCORE
Low intensity (I_b): flooded areas by low depth water	I_l	0.4
Medium intensity (I_m): flooded areas by significant water depth and/or relevant flow velocity.	I_m	0.8
High intensity (I_a): flooded areas by deep water and/or high flow velocity	I_h	1.0

PAT, *Piano Generale di Utilizzazione delle Acque Pubbliche,* 2006

Provincia Autonoma di Bolzano, Direttive per la redazione dei Piani PZP e CRS, 2008

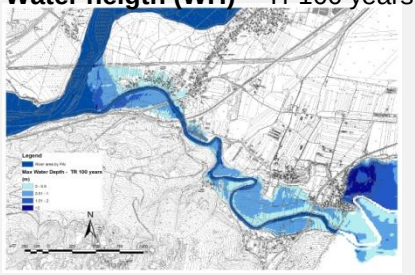
Hazard Intensity – Tr 100 years



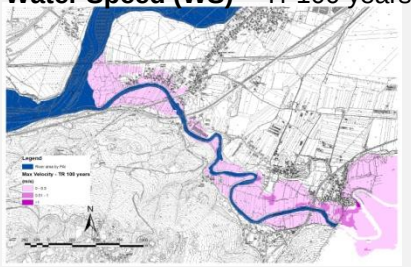
R = H x V x E

(WH, WS, L) → $\mathbf{V}_{\text{RECEPTORS}}$(WH,WS,L) → **V**(WH,WS,L)

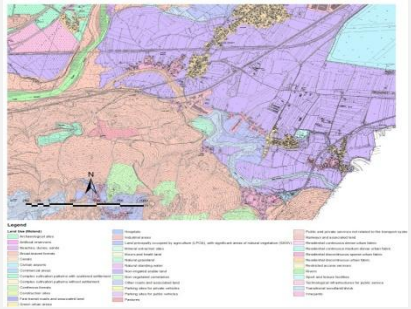
Water heigth (WH) – Tr 100 years



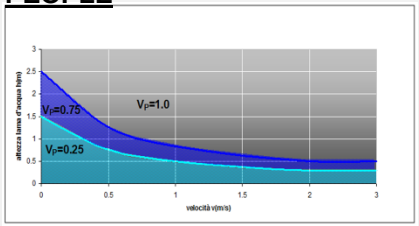
Water Speed (WS) – Tr 100 years



Land use (L)



PEOPLE

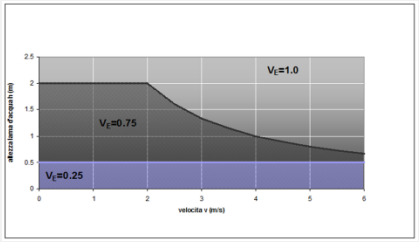


DESCRIPTION	V_E Class	V_E Score
Caution: "flooded area by flowing water with low depth or stable but deep water"	Low	0.25
Hazard for someone (child): "flooded area by deep water or high velocity flow."	Medium	0.75
Hazard for everyone: "flooded area by deep water or with high velocity flow"	High	1

(DEFRA, 2006)

ECONOMICAL ACTIVITIES

E.g. - Buildings

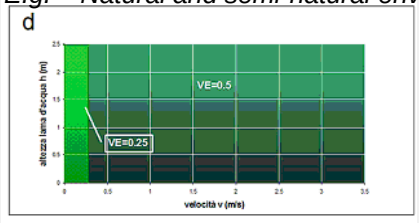


DESCRIPTION	V_E Class	V_E Score
Damages similar to that produced by a natural low depth flood.	Low	0.25
Moderate damages, as doors and windows thrown to the ground, partial damages to "internal goods" and small damages to the main structural elements of buildings.	Medium	0.75
Total collapse or major damages to buildings that need demolition and rebuilding.	High	1

(Clausen et Clark, 1990; Risk-Frontiers, 2001)

CULTURAL AND ENVIRONMENTAL HERITAGE

E.g. – Natural and semi-natural environment



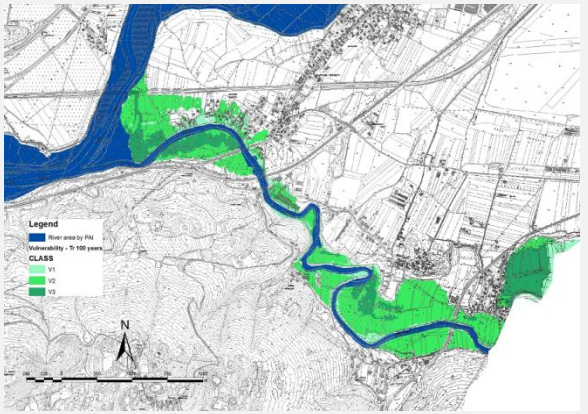
DESCRIPTION	V_E Class	V_E Score
Tolerable height and velocity for a specific environment	Low	0.25
Not tolerable height and velocity for a specific environment	High	1

(Citeau, 2003)

$$V = \frac{w_1 \cdot V_P + w_2 \cdot V_A + w_3 \cdot V_E}{w_1 + w_2 + w_3}$$

w_1=10; w_2=1; w_3=1

Vulnerability map – Tr 100 years



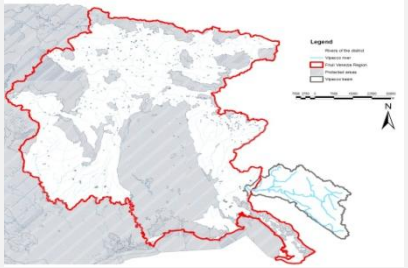
$R = H \times V \times E$

(FE, L, PA, P, CH) ⇒ $E_P(FE, L)$, $E_A(FE, L)$, $E_E(FE, L, PA, P, CH)$ ⇒ $E(FE, L, PA, P, CH)$

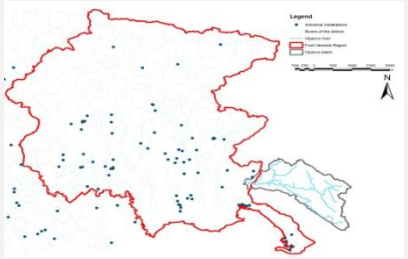
$$E = \frac{w_1 \cdot E_P + w_2 \cdot E_A + w_3 \cdot E_E}{w_1 + w_2 + w_3}$$

w_1=10; w_2=1; w_3=1

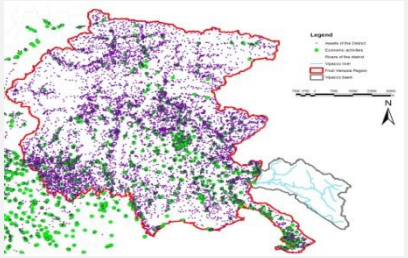
Protected areas (PA)



Plants (P)



Cultural Heritage (CH)



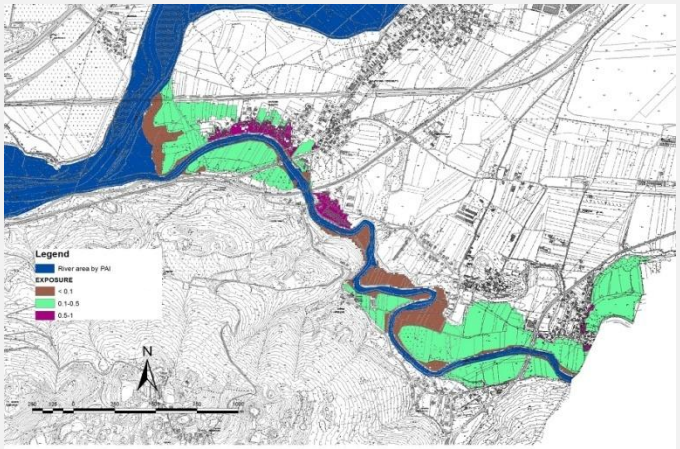
E.G. PEOPLE

NUMBER OF PEOPLE	F_d
1 ÷ 50	0.90
51 ÷ 100	0.95
101 ÷ 500	0.98
> 500	1

$$E_P = F_d \cdot F_t$$

COD	DESCRIPTION	F_t
1	Residential	1
2	Hospital, social assistence structure	1
3	Public buildings	1
4	Commercial and craft	0.5 ÷ 1
5	Industrial	0.5 ÷ 1
6	Agricultural	0.1 ÷ 0.5
7	Agricultural not defined such as forest, grassland, grazing land, cemeteries, urban parks.	0.1 ÷ 0.5
8	Touristic-entertaining	0.4 ÷ 0.5
9	Unproductive	0.1
10	Skiing area, Golf camp, Riding stables	0.3 ÷ 0.5
11	Camping	1
12	Transport and communication network: primary road	0.5
13	Transport and communication network: secondary road	0.5
14	Railway zone	0.7 ÷ 1
15	Touristic area; Collective equipment area; Collective equipment area over municipality, Collective equipment in the subsoil.	1
16	Network infrastructure, Communication infrastructure.	0.3 ÷ 0.5
17	Structure to support communication and transport network (airports, harbours, service area., parking)	0.7 ÷ 1
18	Energy production area	0.4
19	Landfills, Waste treatment plants. Extractive areas, Waste water treatment plant	0.3
20	Area with installation all'allegato I del decreto legislativo 18 febbraio 2005, n. 59	0.9
21	Cultural-historical and archaeological relevant area.	0.5 ÷ 1
22	Environmental heritages	0.5 ÷ 1
23	Military zone.	0.1 ÷ 1

Exposure map – Tr 100 years



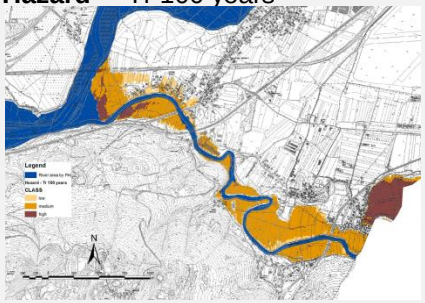
PAT, *Piano Generale di Utilizzazione delle Acque Pubbliche,* 2006
Provincia Autonoma di Bolzano, Direttive per la redazione dei Piani PZP e CRS, 2008

R = H x V x E

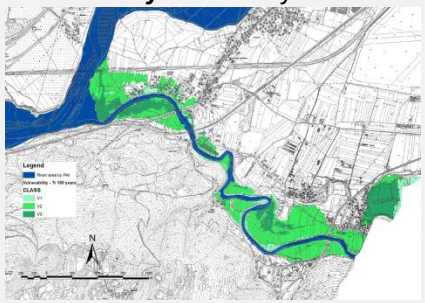
(H,V,E) → $\mathbf{R}_{\text{RECEPTORS}}(H;V,E)$ → $\mathbf{R}(H,V,E)$

$$R = H \cdot V \cdot E = H \cdot D$$

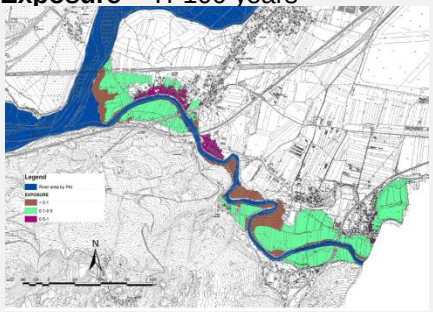
Hazard – Tr 100 years



Vulnerability – Tr 100 years



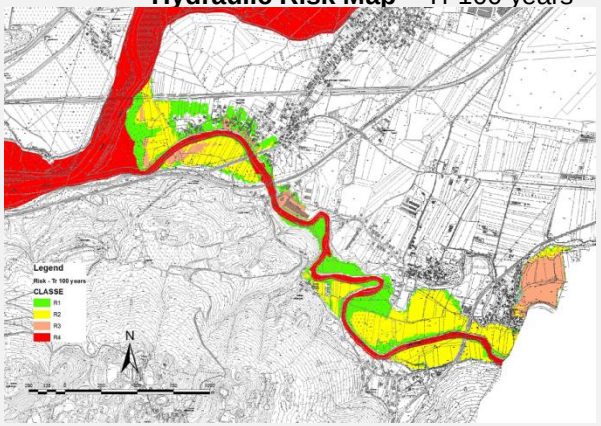
Exposure – Tr 100 years

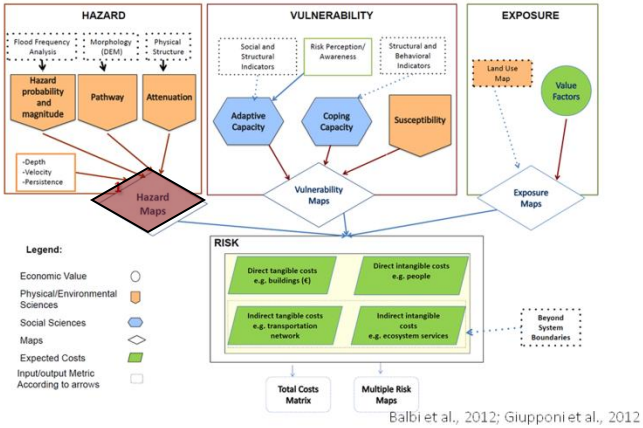


RISK CLASSES	HAZARD CLASSES P3	HAZARD CLASSES P2	HAZARD CLASSES P1
DAMAGE CLASSES D4	R4	R4 / R3	R2
DAMAGE CLASSES D3	R4 / R3	R3	R2 / R1
DAMAGE CLASSES D2	R3 / R2	R2	R1
DAMAGE CLASSES D1	R1	R1	R1

R INTERVALS	DESCRIPTION	Risk category
$0.1 < R \leq 0.2$	Moderate Risk for which relative social economic and environmental damages are negligible or nulls.	R1
$0.2 < R \leq 0.5$	Medium Risk for which are possible minor damage to buildings, infrastructures and environmental heritage that do not compromise people safety, buildings use and economic activities functionality.	R2
$0.5 < R \leq 9$	High Risk for which are possible problems for people safety, functional damages to buildings and infrastructures , interruption of socio economic activities and damages to environmental heritage.	R3
$0.9 < R \leq 1$	Very High Risk for which there are possible loss of human lives and serious injuries to people, serious damages to buildings, infrastructures and environmental heritage and the destruction of socio economic activities.	R4

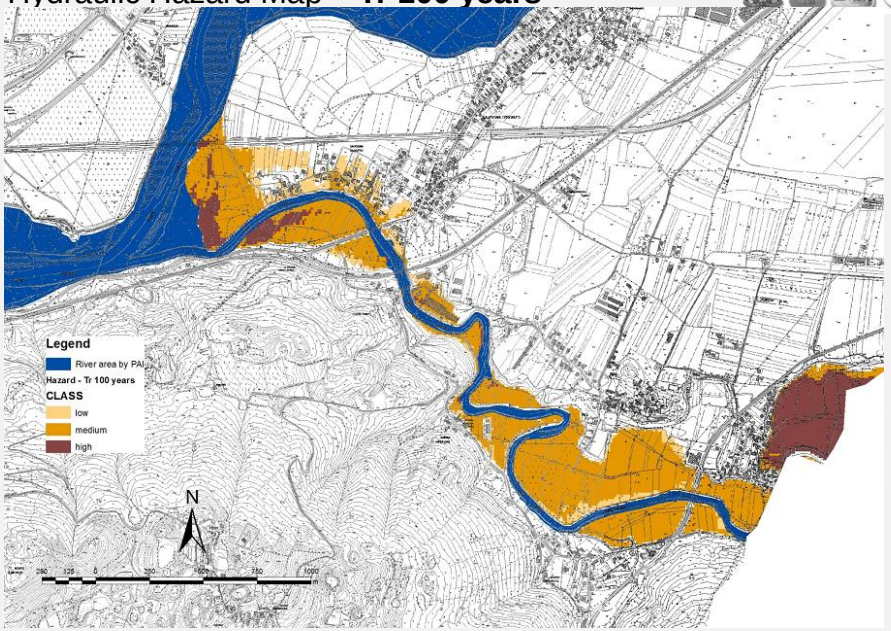
Hydraulic Risk Map – Tr 100 years



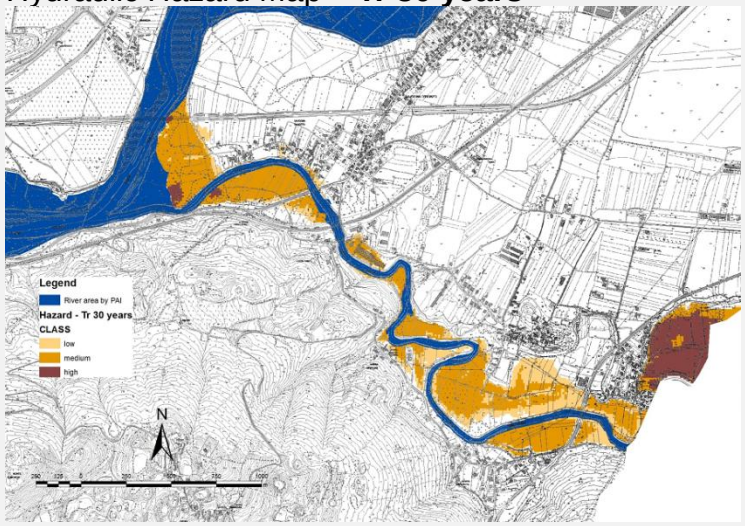


Balbi et al., 2012; Giupponi et al., 2012

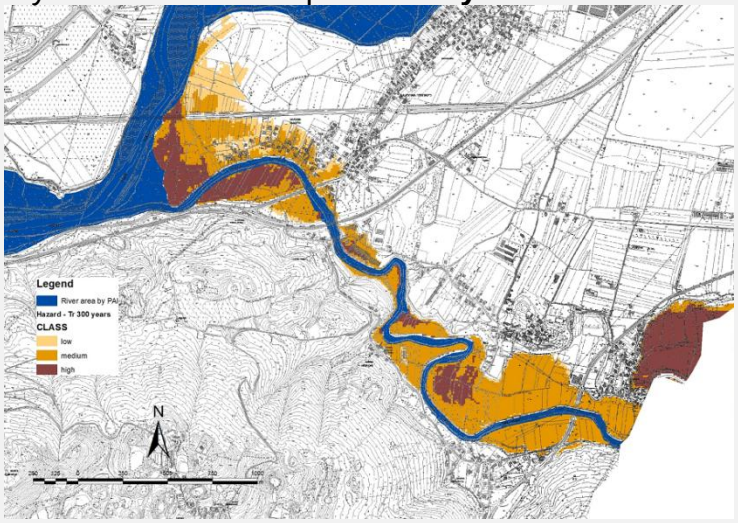
Hydraulic Hazard Map – **Tr 100 years**

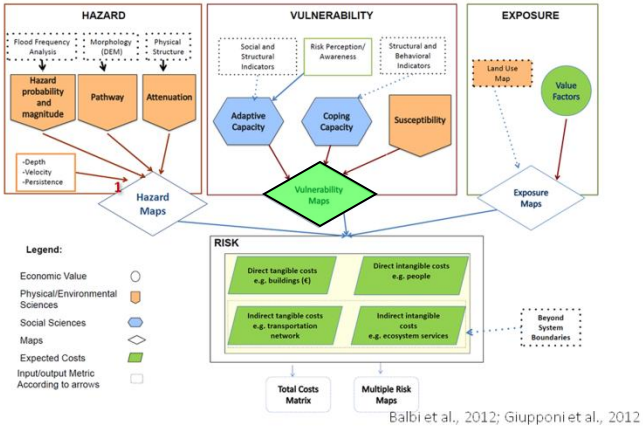


Hydraulic Hazard Map – **Tr 30 years**



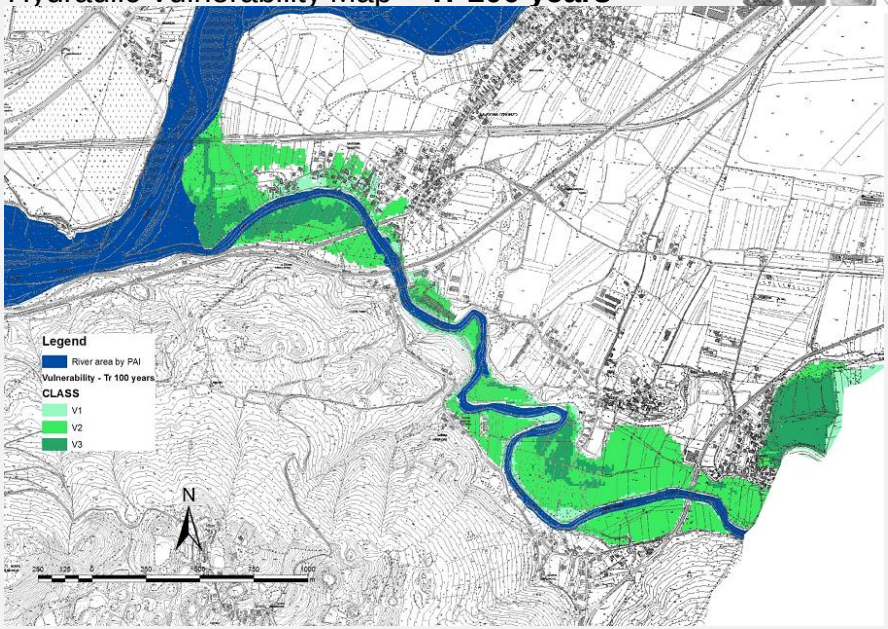
Hydraulic Hazard Map – **Tr 300 years**



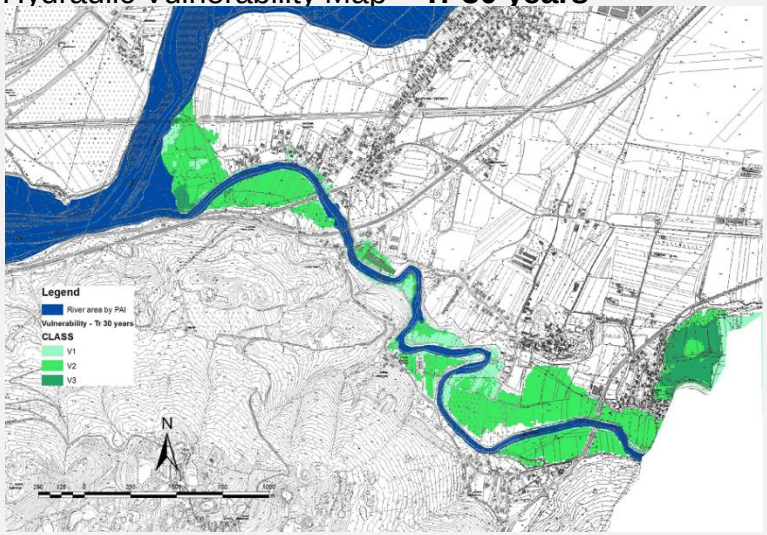


Balbi et al., 2012; Giupponi et al., 2012

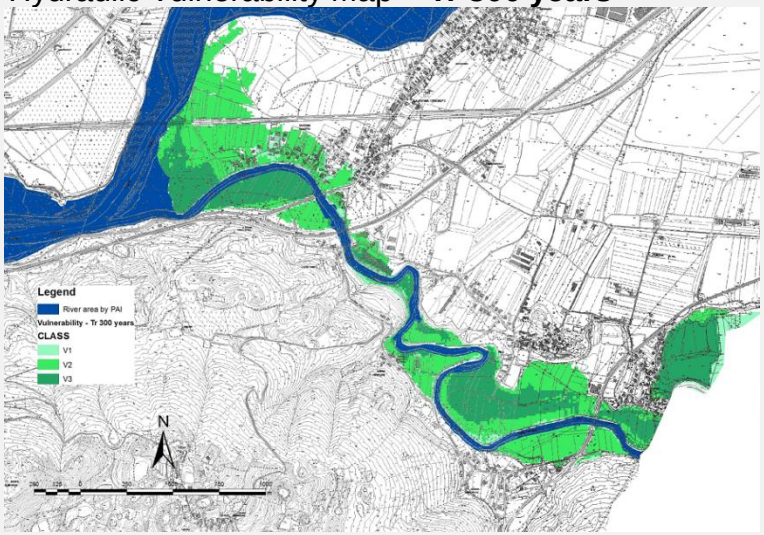
Hydraulic Vulnerability Map – **Tr 100 years**

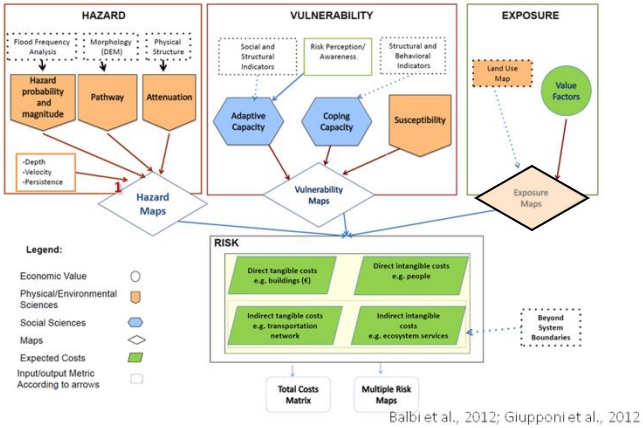


Hydraulic Vulnerability Map – **Tr 30 years**



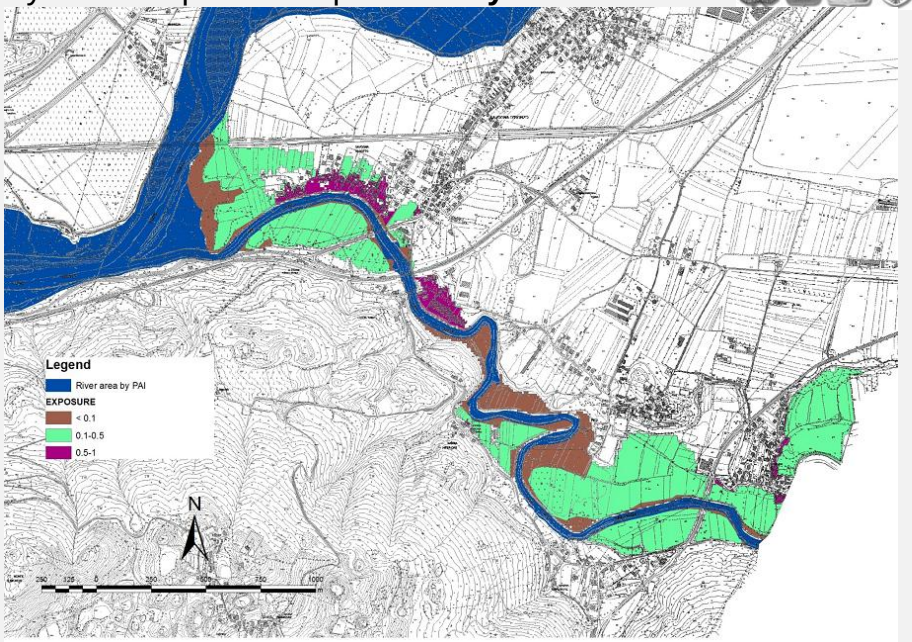
Hydraulic Vulnerability Map – **Tr 300 years**



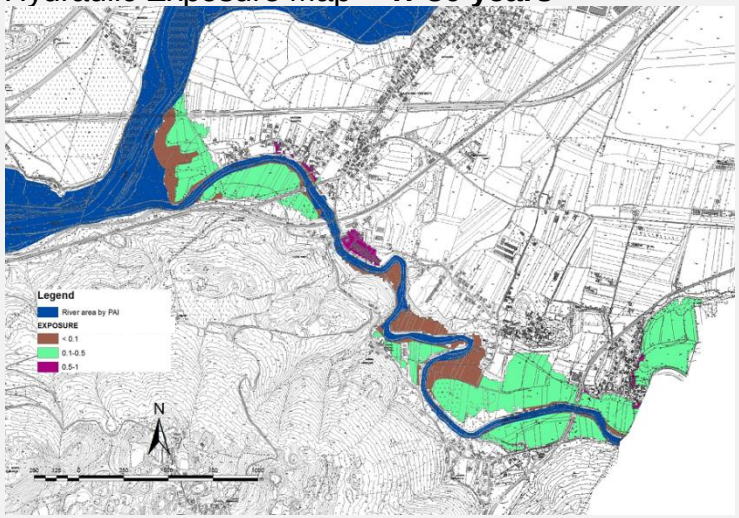


Balbi et al., 2012; Giupponi et al., 2012

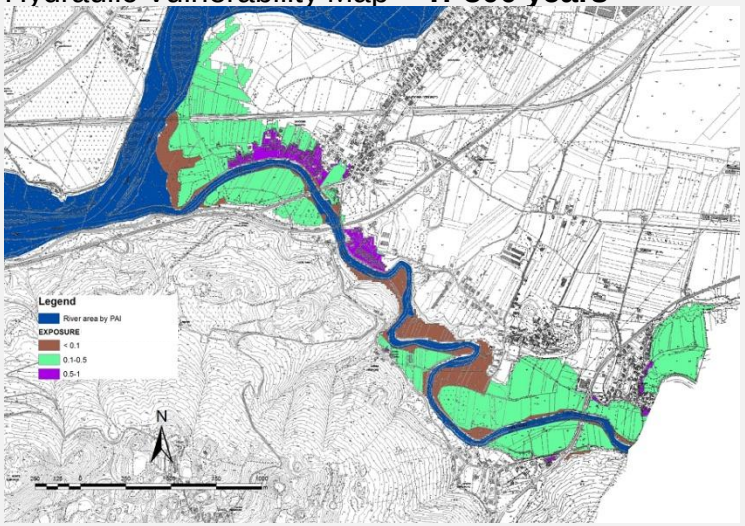
Hydraulic Exposure Map – **Tr 100 years**

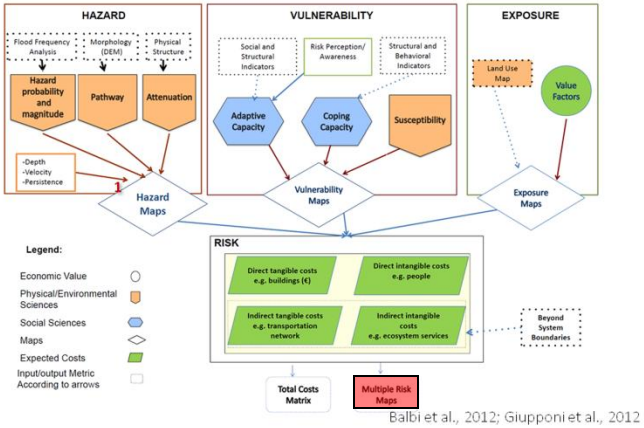


Hydraulic Exposure Map – **Tr 30 years**



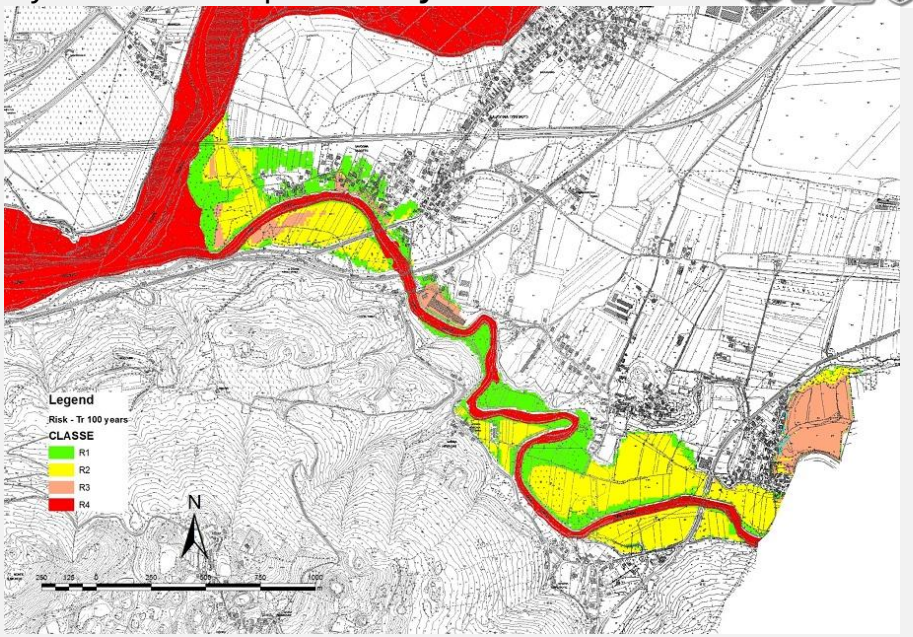
Hydraulic Vulnerability Map – **Tr 300 years**



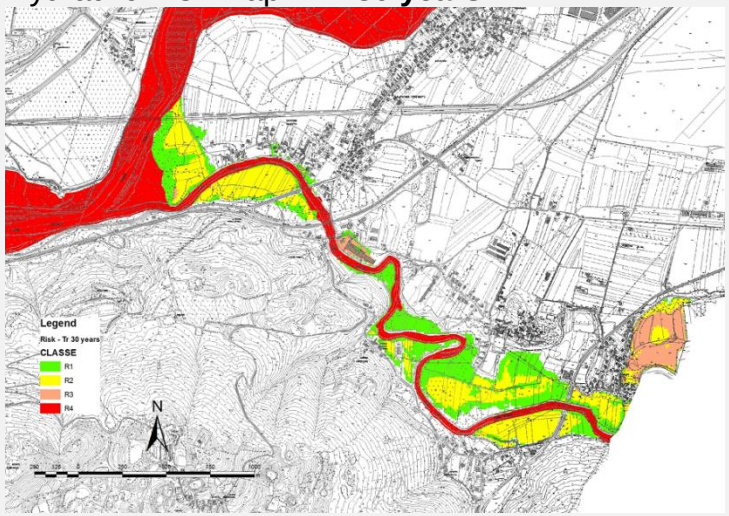


Balbi et al., 2012; Giupponi et al., 2012

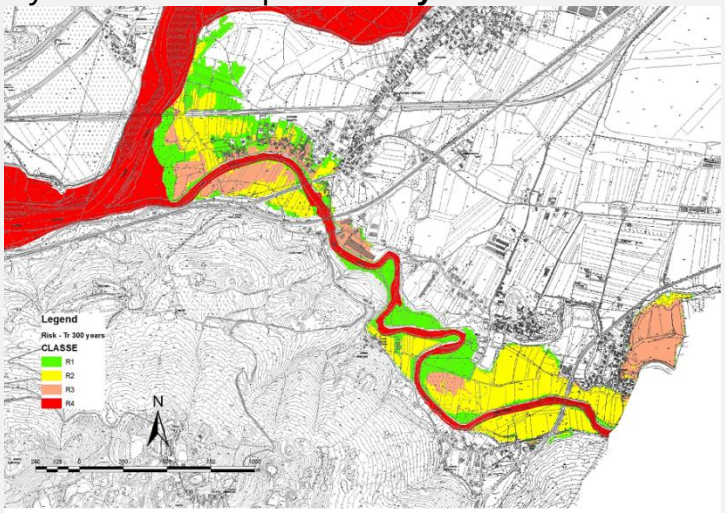
Hydraulic Risk Map – **Tr 100 years**



Hydraulic Risk Map – **Tr 30 years**



Hydraulic Risk Map – **Tr 300 years**



The activities of informatics and preparation of data required by the Floods Directive, are compliant with documentation, schemas, GIS Guidance and tools made available by the European Commission (http://icm.eionet.europa.eu/schemas/dir200760ec/resources/).
In particular, in order to ensure the consistency of Directive 2007/60/EC with the WFD 2000/60/EC, the encoding of the areas of flooding has been constructed in order to contain the information of the Unit of Management (UoM), the scenario and the water body that determines the flood area. Data required for each UoM meet technical specifications relating in particular to the name and format, the criteria of topological consistency, the reference system of coordinates, the metadata, the management of transboundary basins, the attention to compliance with the European WISE and the INSPIRE Directive. Last May reporting activities required by the Directive 2007/60/EC have been tested successfully with the European Commission.
Information obtained from geoprocessing are directly linked to European reference database tables

HERO ver 0.1.2

Generale

Gestione Pericolo | Gestione rischio | Gestione tematismi | Dati progetto | Gis Tools | Archivi di base

Principale

HERO

A. T. SOFT

Coordinate | Scala 1: | Gis Ready | | Server

HERO ver 0.1.2 - [Gestione Pericolo]

Generale | Gestione Pericolo

Ricarica progetto | Upload raster | Aggiungi Quadrante | Esegui modello | Converti in shape | Visualizza File | Aggiungi scenario | Elimina Scenario | Genera Mappe di Pericolo

Operatività pericolo

- ITI017-Lemene
- ITI026-Fissero, Tartaro, Canalbianco
- ITN001-Adige
- ITN003-Brenta-Bacchiglione
- ITN004-Isonzo
- ITN006-Livenza
- ITN007-Piave
- ITN009-Tagliamento
- ITR051-Regionale Veneto
- ITR061-Regionale Friuli

OK | Cancel

Edit

Scala 1:

HERO ver 0.1.2

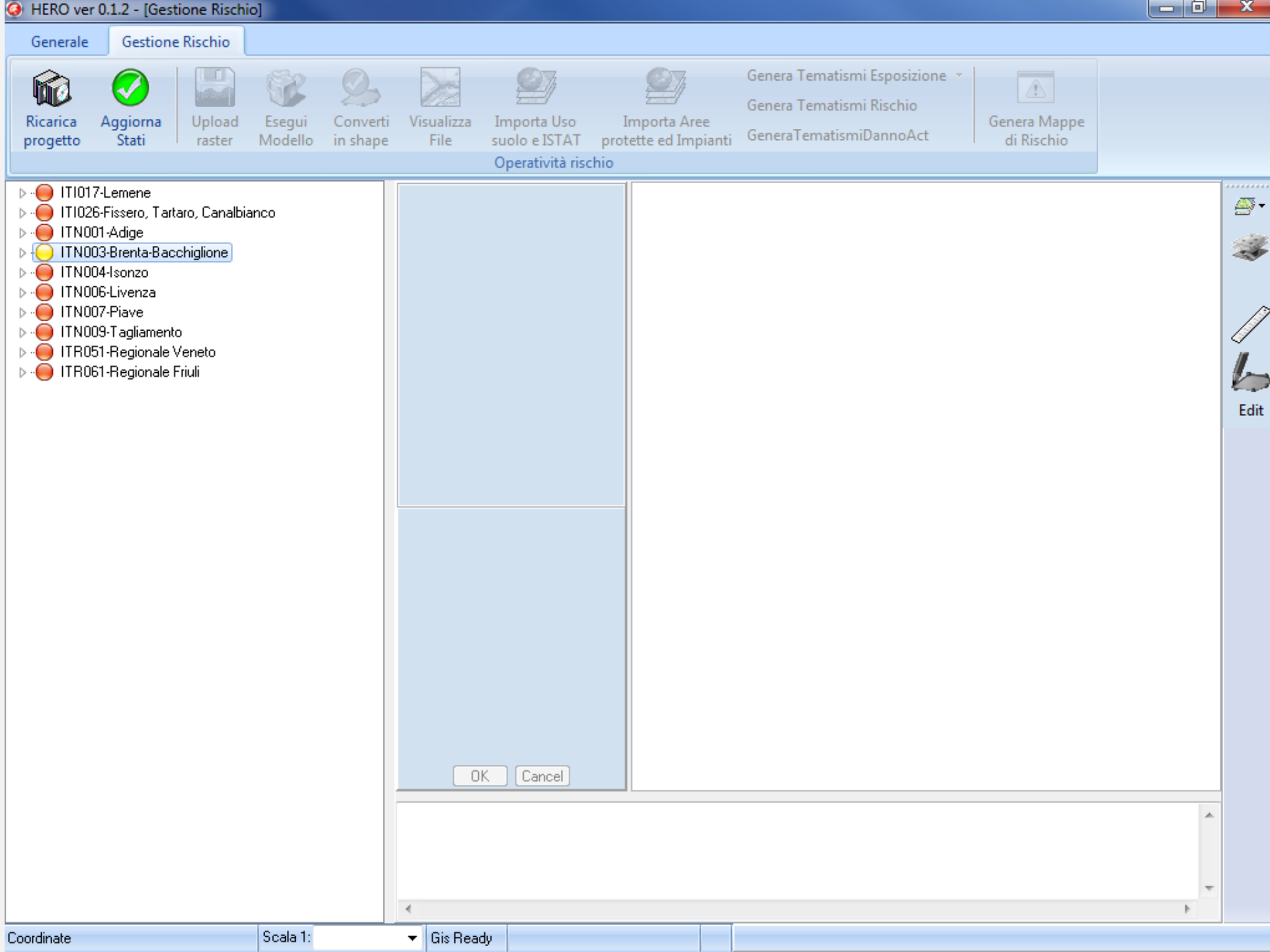
Generale

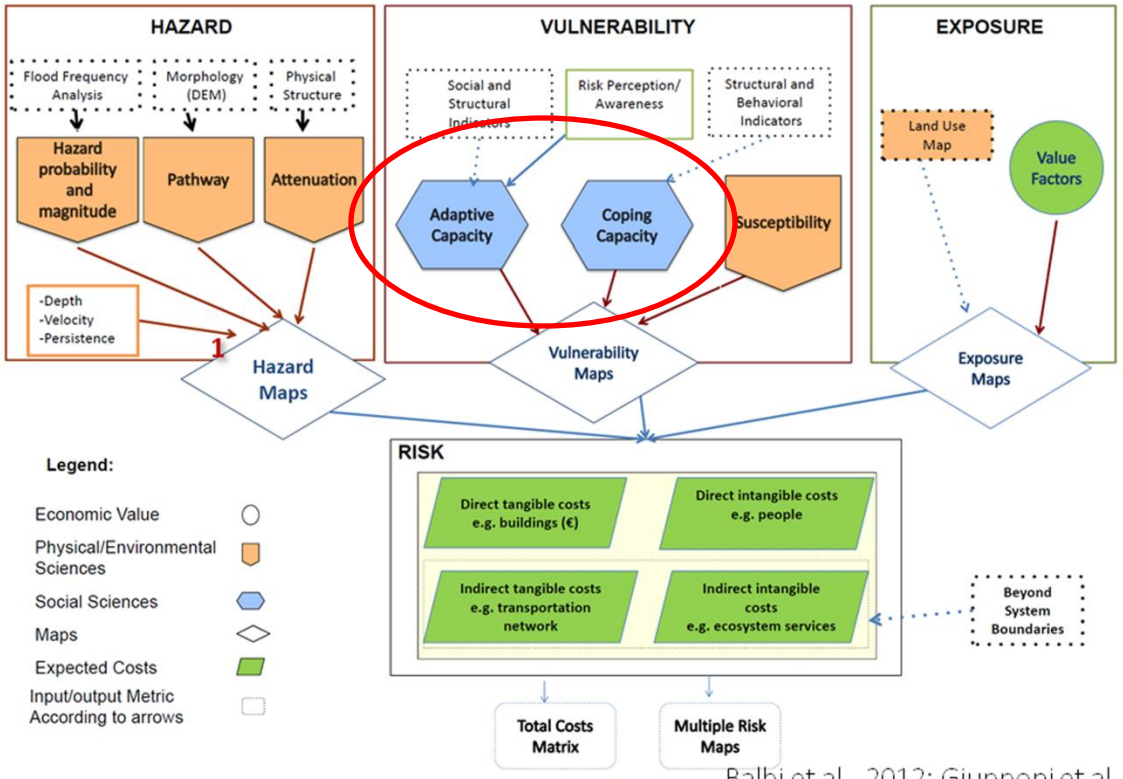
Gestione Pericolo | Gestione rischio | Gestione tematismi | Dati progetto | Gis Tools | Archivi di base

Principale

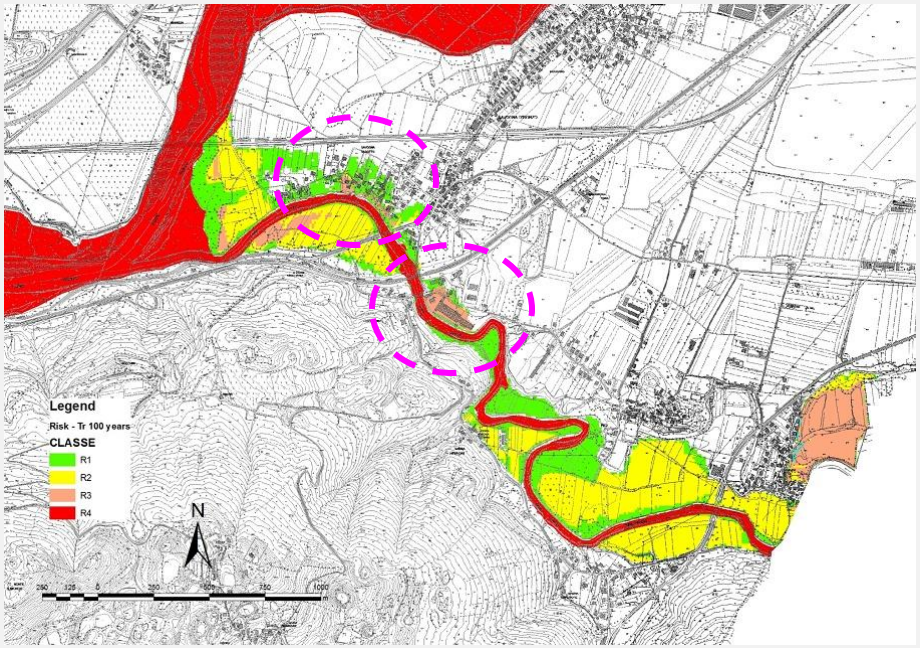
A.T. SOFT

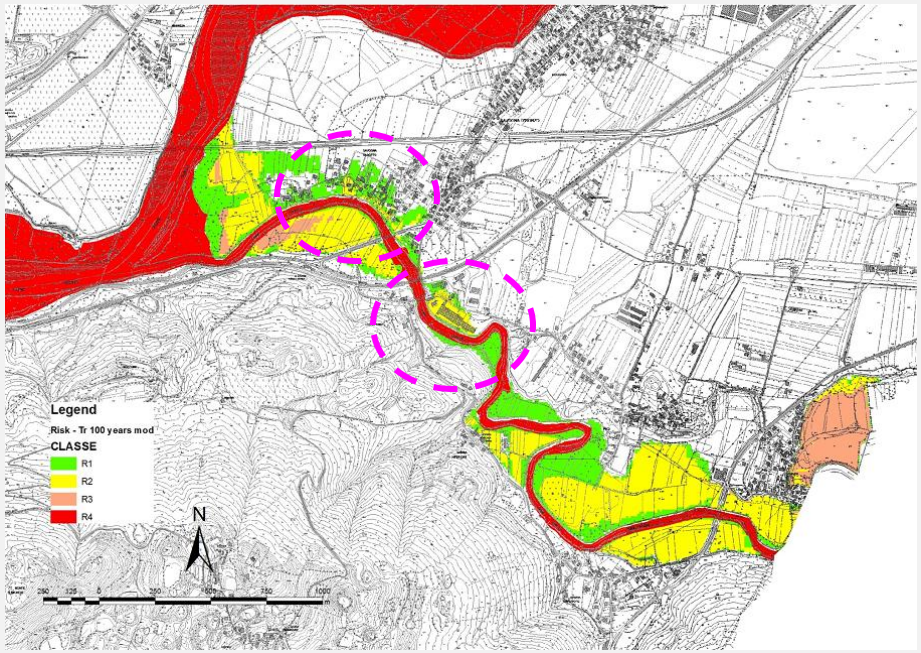
Coordinate | Scala 1: | Gis Ready | | Server


HERO ver 0.1.2 - [Gestione Rischio]
Generale
Gestione Rischio
Ricarica progetto
Aggiorna Stati
Upload raster
Esegui Modello
Converti in shape
Visualizza File
Importa Uso suolo e ISTAT
Importa Aree protette ed Impianti
Genera Tematismi Esposizione
Genera Tematismi Rischio
GeneraTematismiDannoAct
Genera Mappe di Rischio
Operatività rischio
ITI017-Lemene
ITI026-Fissero, Tartaro, Canalbianco
ITN001-Adige
ITN003-Brenta-Bacchiglione
ITN004-Isonzo
ITN006-Livenza
ITN007-Piave
ITN009-Tagliamento
ITR051-Regionale Veneto
ITR061-Regionale Friuli
OK
Cancel
Edit
Coordinate
Scala 1:
Gis Ready



Balbi et al., 2012; Giupponi et al., 2012


Legend
Risk - Tr 100 years
CLASSE
R1
R2
R3
R4
N


Legend
Risk - Tr 100 years mod
CLASSE
R1
R2
R3
R4
N


Amico
SISTEMA PREVISIONALE MODELLISTICO IDROLOGICO E IDRAULICO

Thanks for your attention

MAIN HYDROLOGICAL ASPECTS

1. how to define the probability of a flood EVENT?
2. how to consider rainfall spatial and temporal variability?
3. how to consider snow melt phenomena related to 1)
4. how to consider the initial soil condition related to 1)
5. which kind of hydrological model has to be adopted to determinate discharges? What about ungauged catchments?
6. what discharges have to be used to generate hazard maps (rainfall duration, pick values, shape)