



# ENSURE E-LEARNING TOOL

F43\_Applying the ENSURE methodology for vulnerability assessment: the case of Vulcano eruptions

## Presentation

Application of the ENSURE framework in a volcanic setting: the case study of Vulcano Island, Italy

by Costanza Bonadonna (UNIGE)  
ENSURE final meeting



# ENSURE PROJECT

## Application of the ENSURE framework in a volcanic setting: the case study of Vulcano Island, Italy

Costanza Bonadonna (UNIGE)



Final ENSURE Project Meeting, Orléans 10-11 May 2011

# ENSURE PROJECT

## Main acknowledgements:

Adriana Galderisi (UNINA)

Floriana Ferrara and Giuseppe Delmonaco (T6)

Sebastien Biass (UNIGE)



Final ENSURE Project Meeting, Orléans 10-11 May 2011

# OUTLINE

- **Geological/socio-economic settings**
- **Hazard assessment** (eruption frequency and hazard curves and maps)
- **Vulnerability assessment** application of the ENSURE framework:
  - Mitigation (Volcanic Risk) → Social system
  - Physical vulnerability to lahars
- **Conclusions (on methodology)**

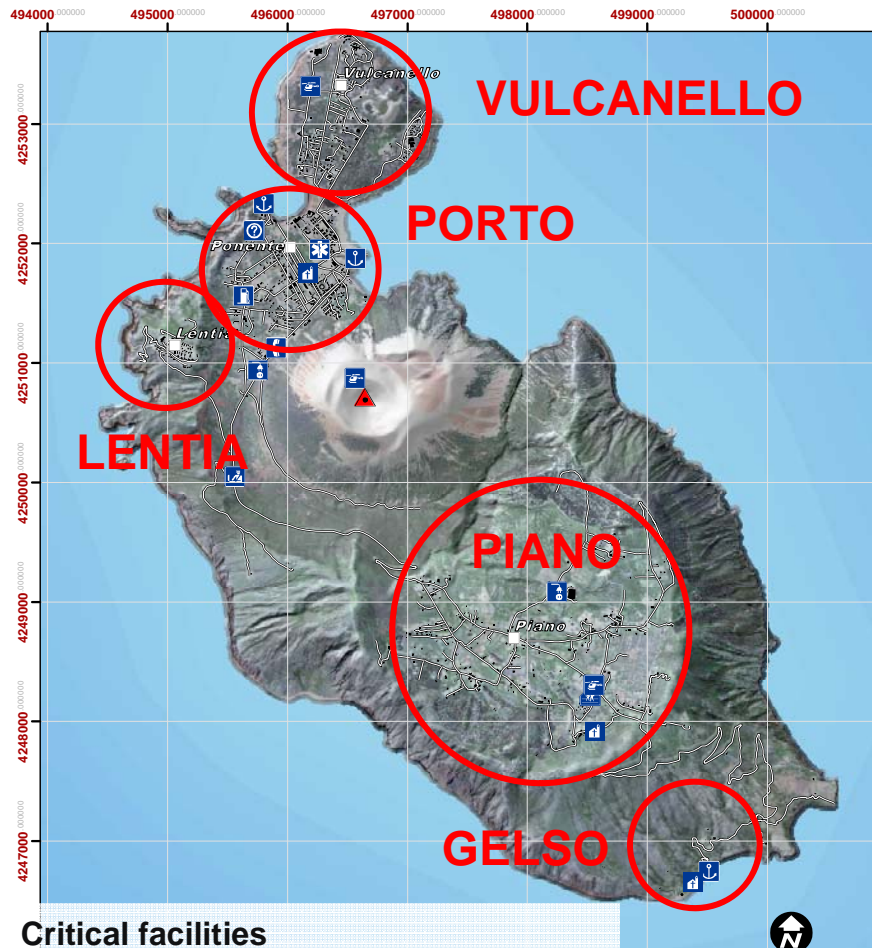


# Vulcano, Italy



**La Fossa** (main volcanic structure) →  
quiescent state with present activity  
consisting of fumarolic gas emissions, weak  
and sporadic seismicity and occasional  
landslides and lahars

**Last eruption** → 1888-1890  
(accumulation up to 5-m thick tephra)



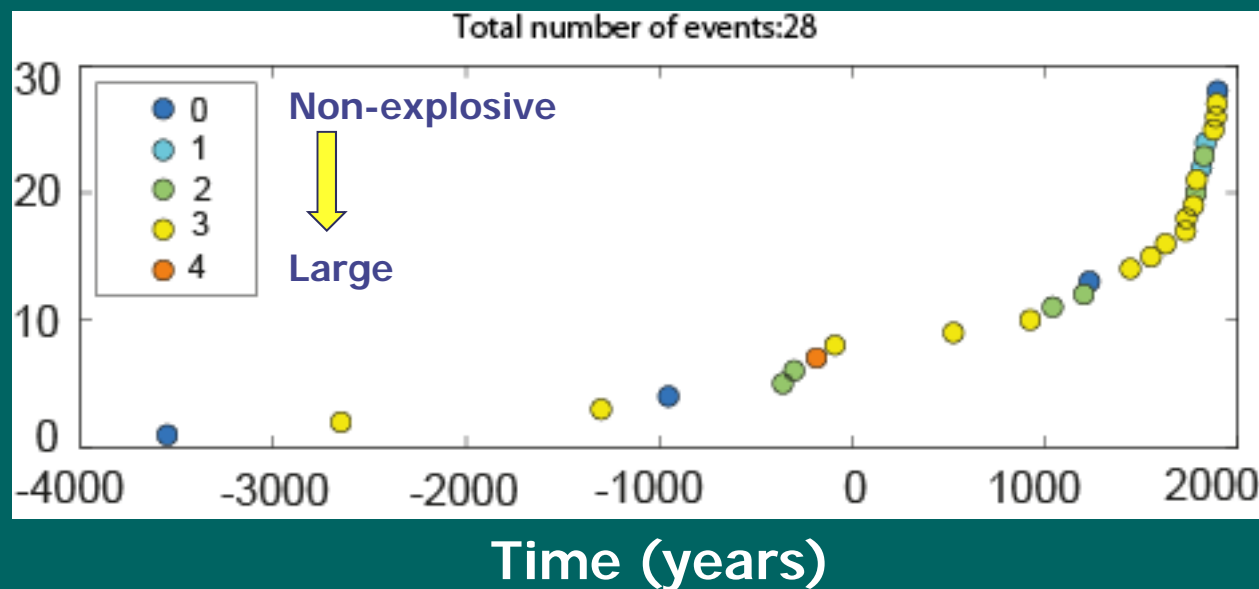
#### Critical facilities

	Church		Heliport
	INGV		Medical center
	Gas station		Police station
	Power Plant		School
	Harbour		Telecommunication

- Area : 21 km<sup>2</sup>
- Official residents : 1080  
...but in reality only 600! (often secondary residence, but officially as first ones due to financial reasons)
- 5-10'000 tourists in summer
- Average local economy but no relevant economic stakeholder.  
Main employment:
  - Summer: tourism
  - Winter: construction (stops in july-aug)
- Existing infrastructures can be considered critical only at local scale

	Residents	Women	Men	Children < 5 years	People > 65 years
Number	1080	492	588	63	180
Percent [%]	100	45.6%	54.4%	5.8%	16.7%

Cumulative no. of events



**Hazard  
Assessment:  
eruption  
frequency**

45% prob. of eruption  
in next 100 yrs

**VEI3:**

**Volume:  $10^7$ - $10^8$  m<sup>3</sup>**

**Plume height: 3-15 km**

**Associated hazards:**

**PRIMARY: Tephra fall**

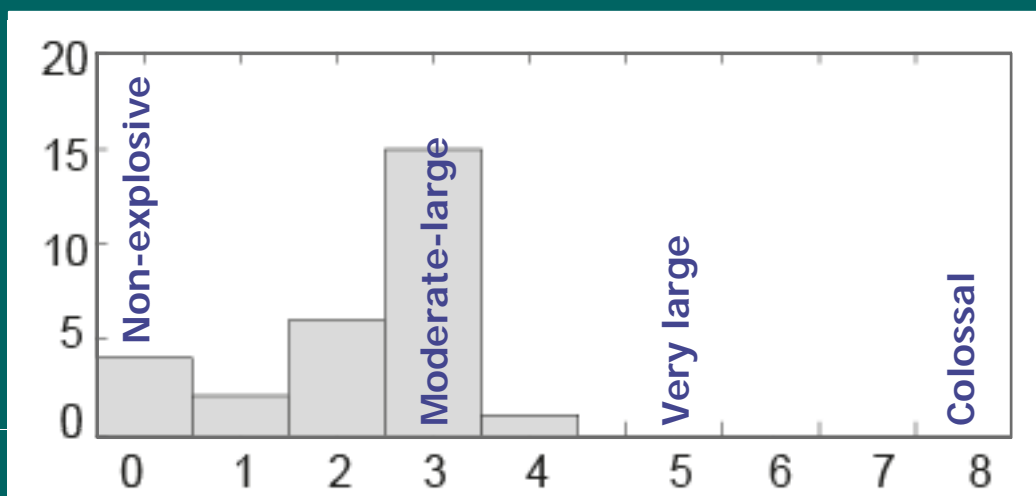
**PRIMARY: Ballistics**

**PRIMARY: PDCs**

**SECONDARY: Lahars**

**SECONDARY: Landslides**

frequency



**Volcanic Explosivity Index**

# Hazard Assessment: tephra fall

## TEPHRA2

Advection-Diffusion-Sedimentation  
model (Bonadonna et al. 2005)

### ➤ Probabilistic approach:

- **Inputs (stochastic  
parameter sampling)**

(i.e. column height; erupted mass;  
grainsize distribution; wind  
profile)

- **Outputs**

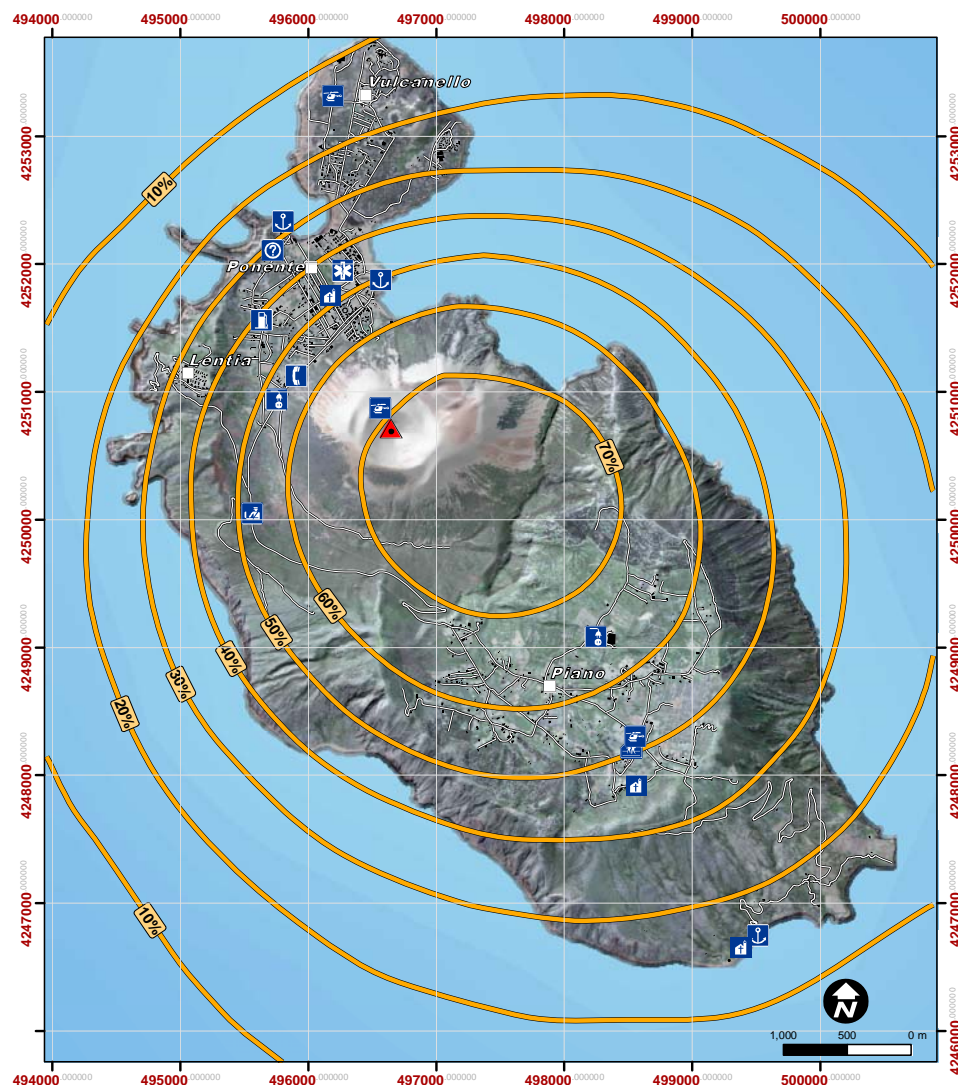
(i.e. probability maps; hazard  
curves)

VEI 3: Probability of reaching 300 kg/m<sup>2</sup> (roof collapse)

## Hazard Assessment: tephra fall

### TEPHRA2

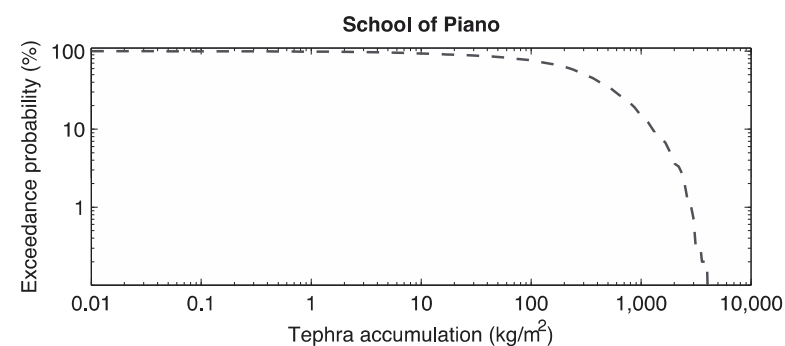
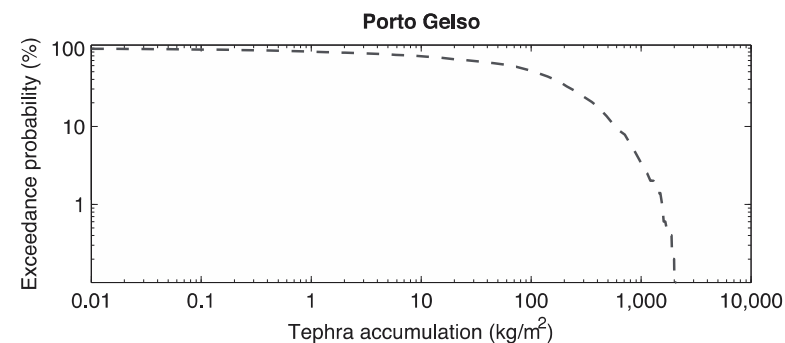
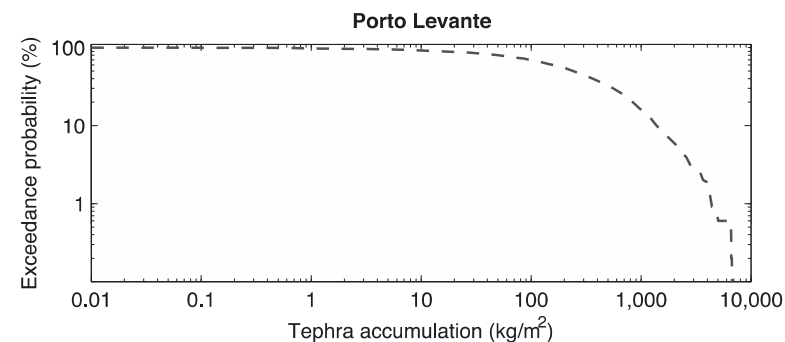
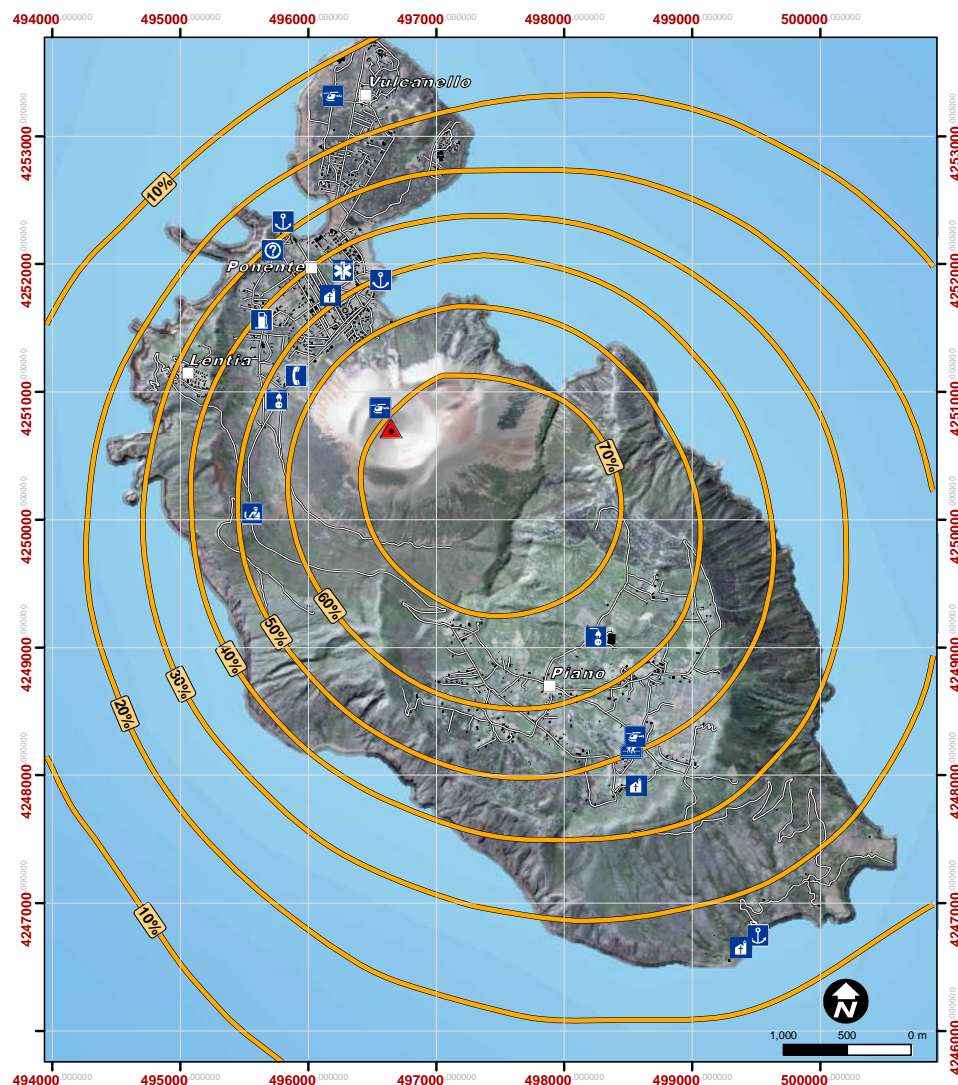
Advection-Diffusion-Sedimentation  
model (Bonadonna et al. 2005)

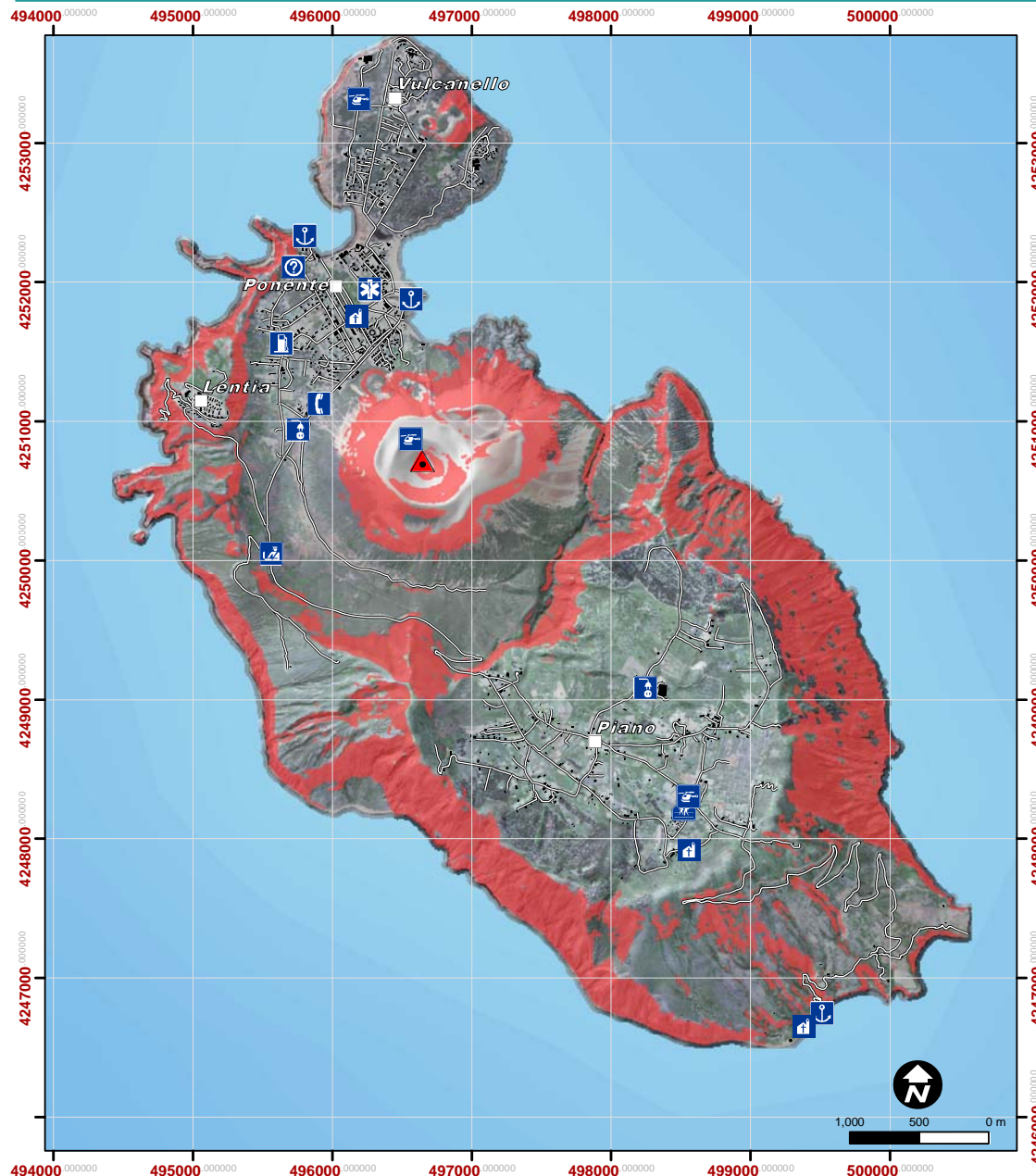


(Physical vulnerability in collaboration  
with EPFL, Switzerland)  
Roof collapse: 300 kg m<sup>-2</sup>

## VEI 3: Probability of reaching 300 kg/m<sup>2</sup> (roof collapse)

## Hazard Assessment: tephra fall





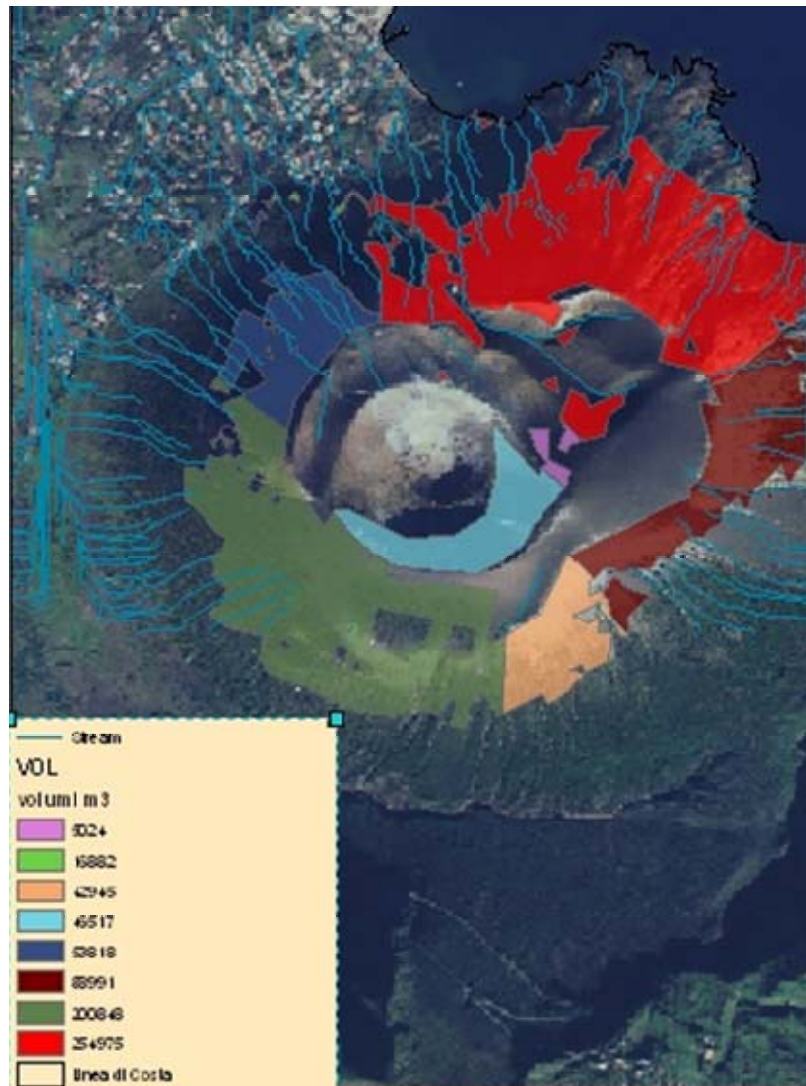
## Hazard assessment: lahars

Four conditions are required for  
lahar generation:

- 1) an adequate water source
- 2) abundant unconsolidated debris
- 3) steep slopes
- 4) a triggering mechanism

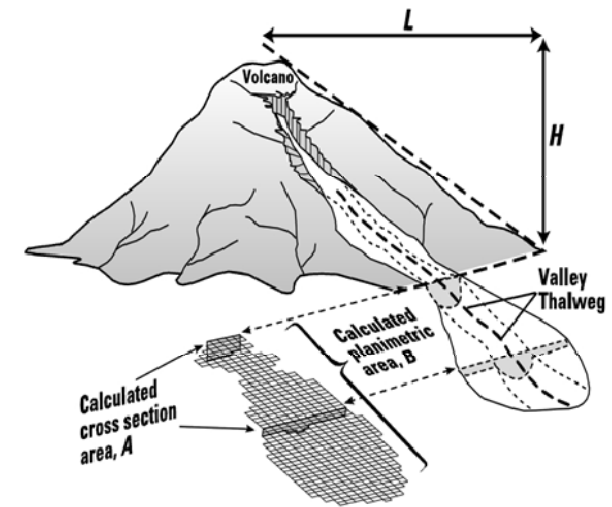


Most of the cone is unstable

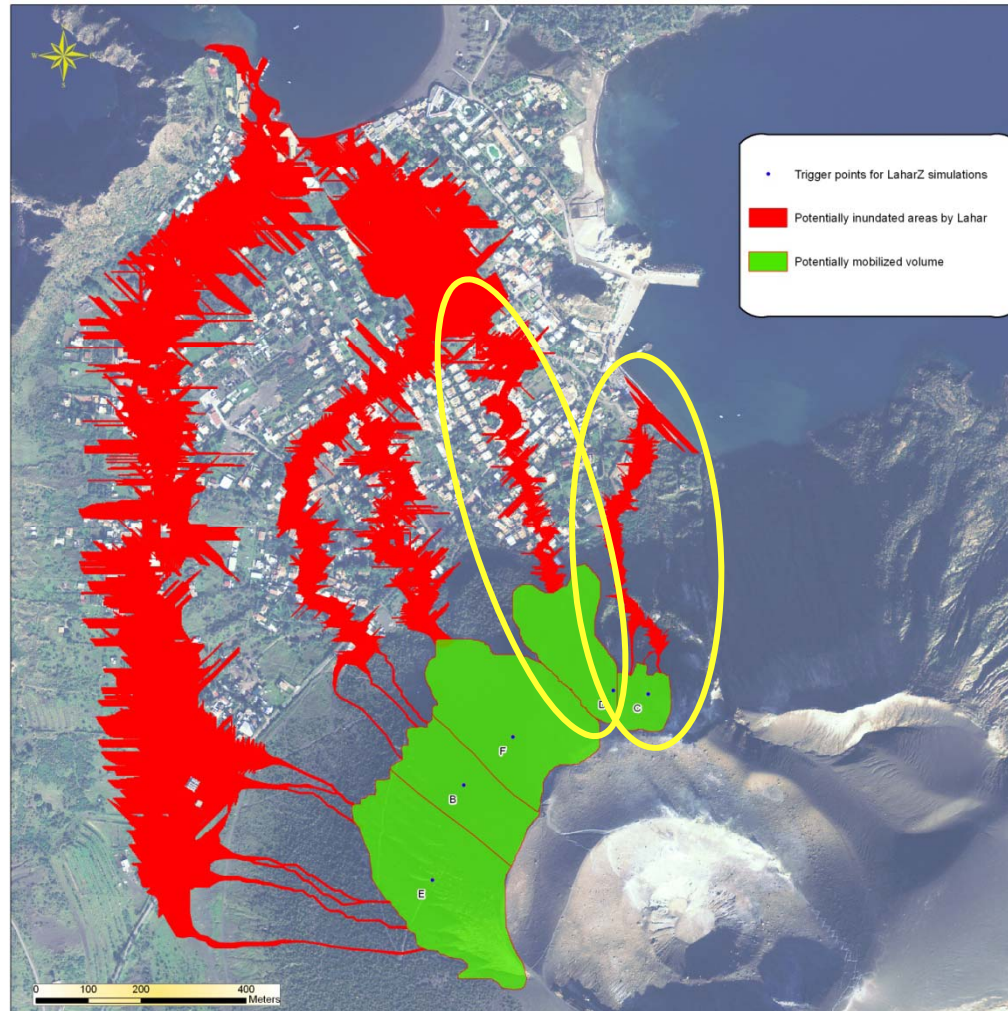


Drainage basins

## Hazard assessment: lahars

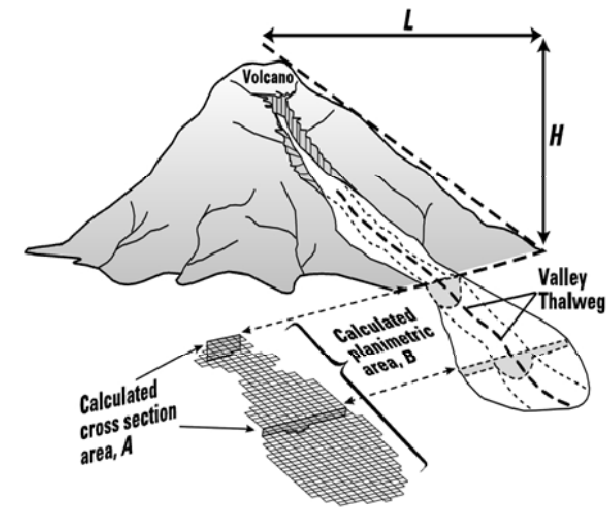


LAHARZ (Iverson et al. 1988;  
Schilling 1998)



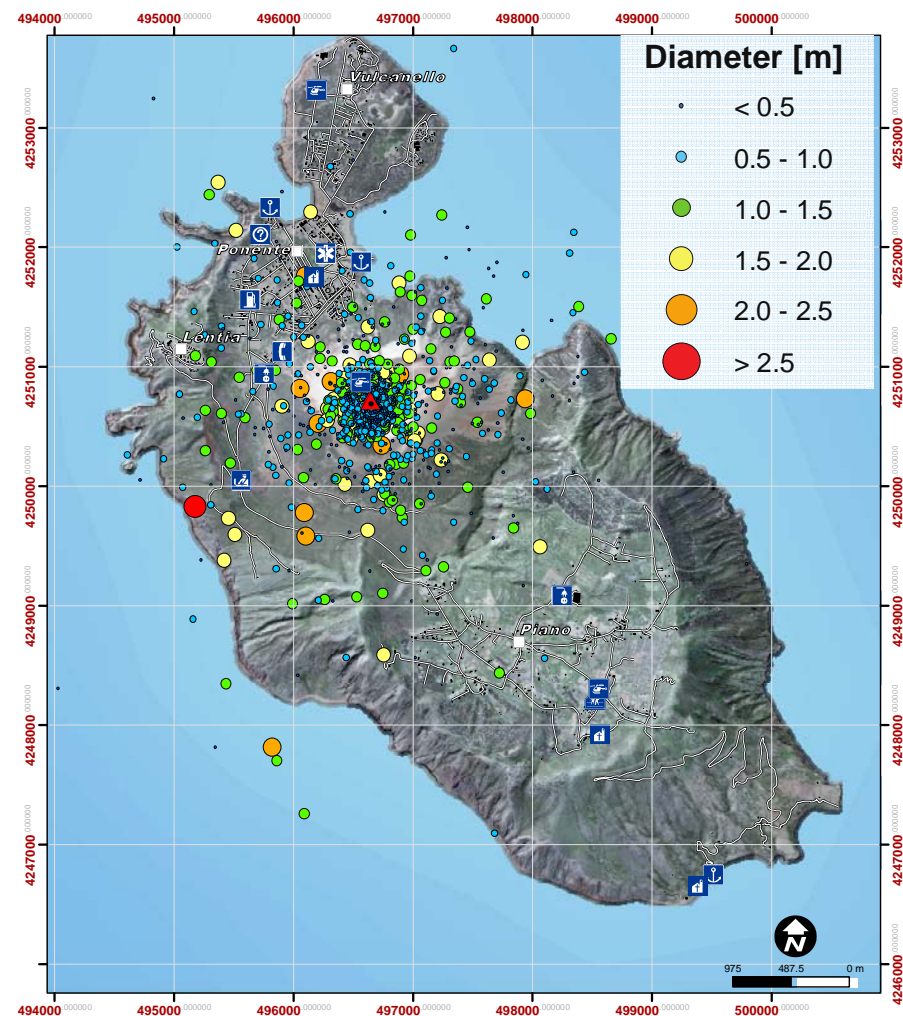
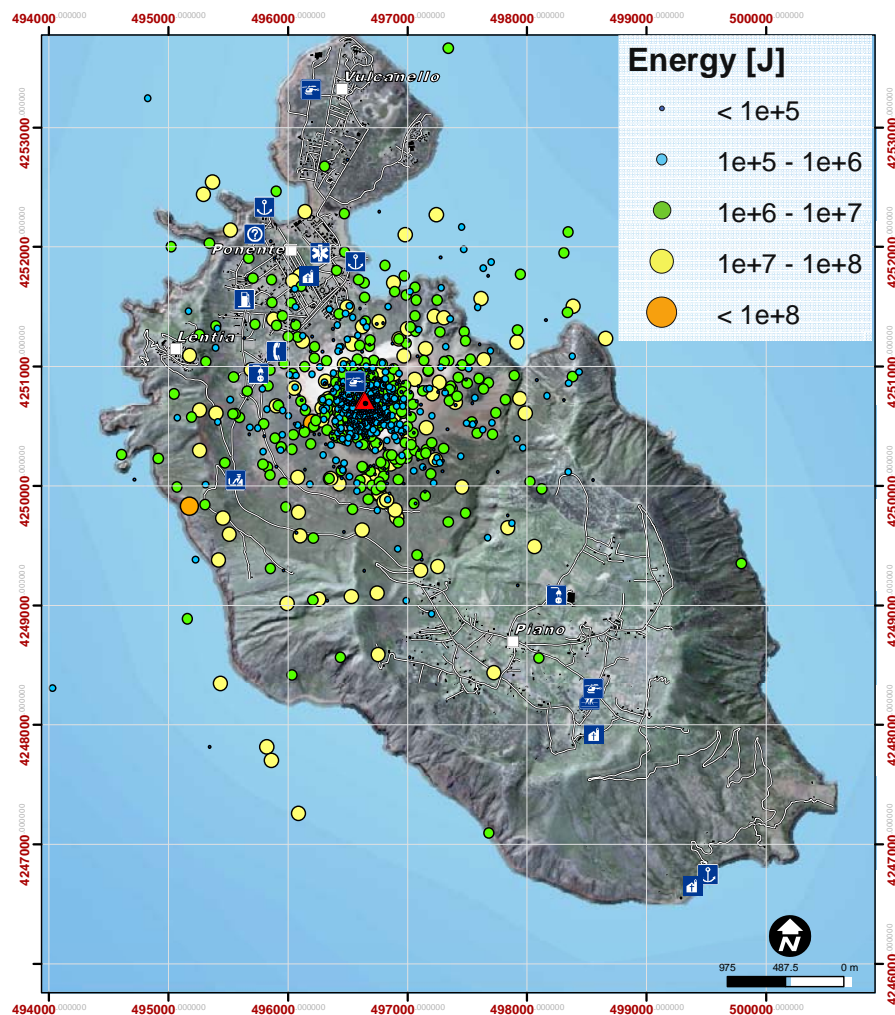
LAHARZ simulations, triggering points, source areas

## Hazard assessment: lahars

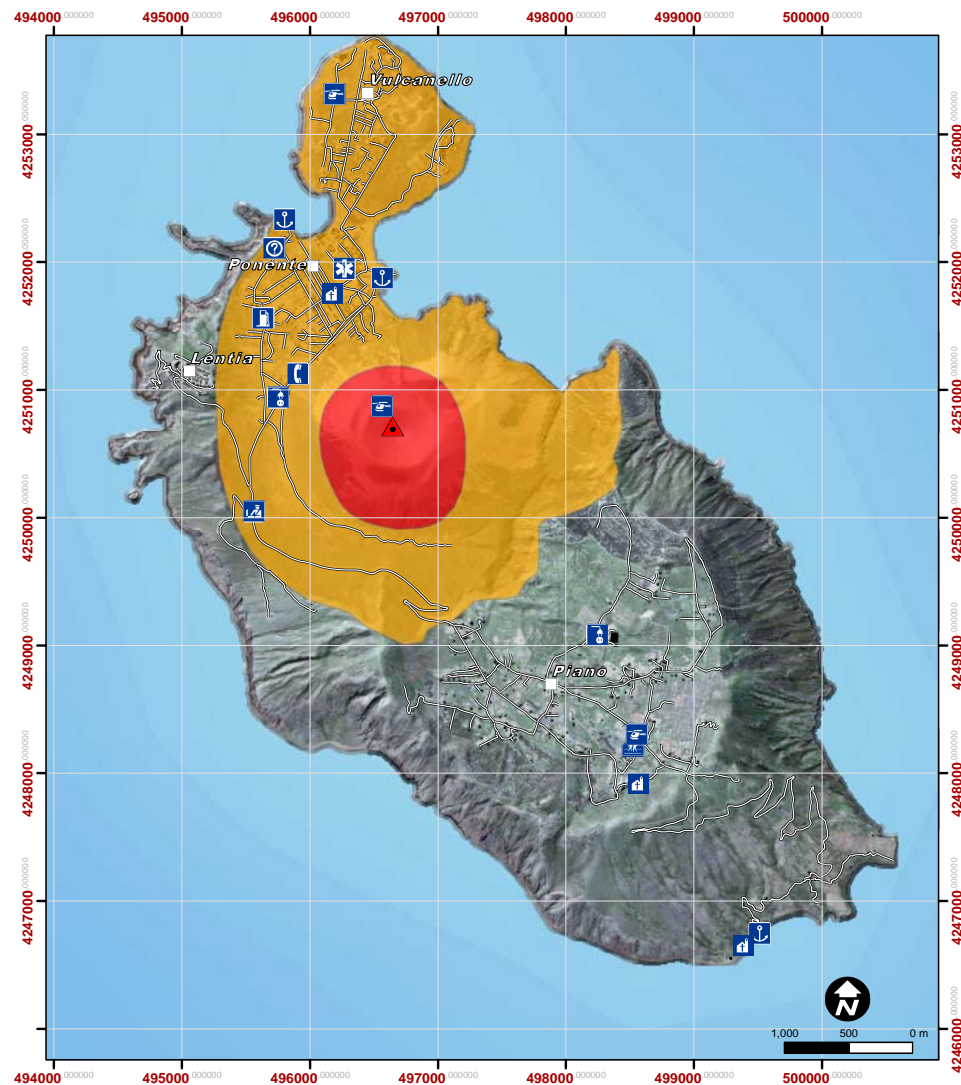


LAHARZ (Iverson et al. 1988;  
Schilling 1998)

# Hazard assessment: ballistics



# Hazard assessment: pyroclastic density currents



Dynamic Pressure [kPa]

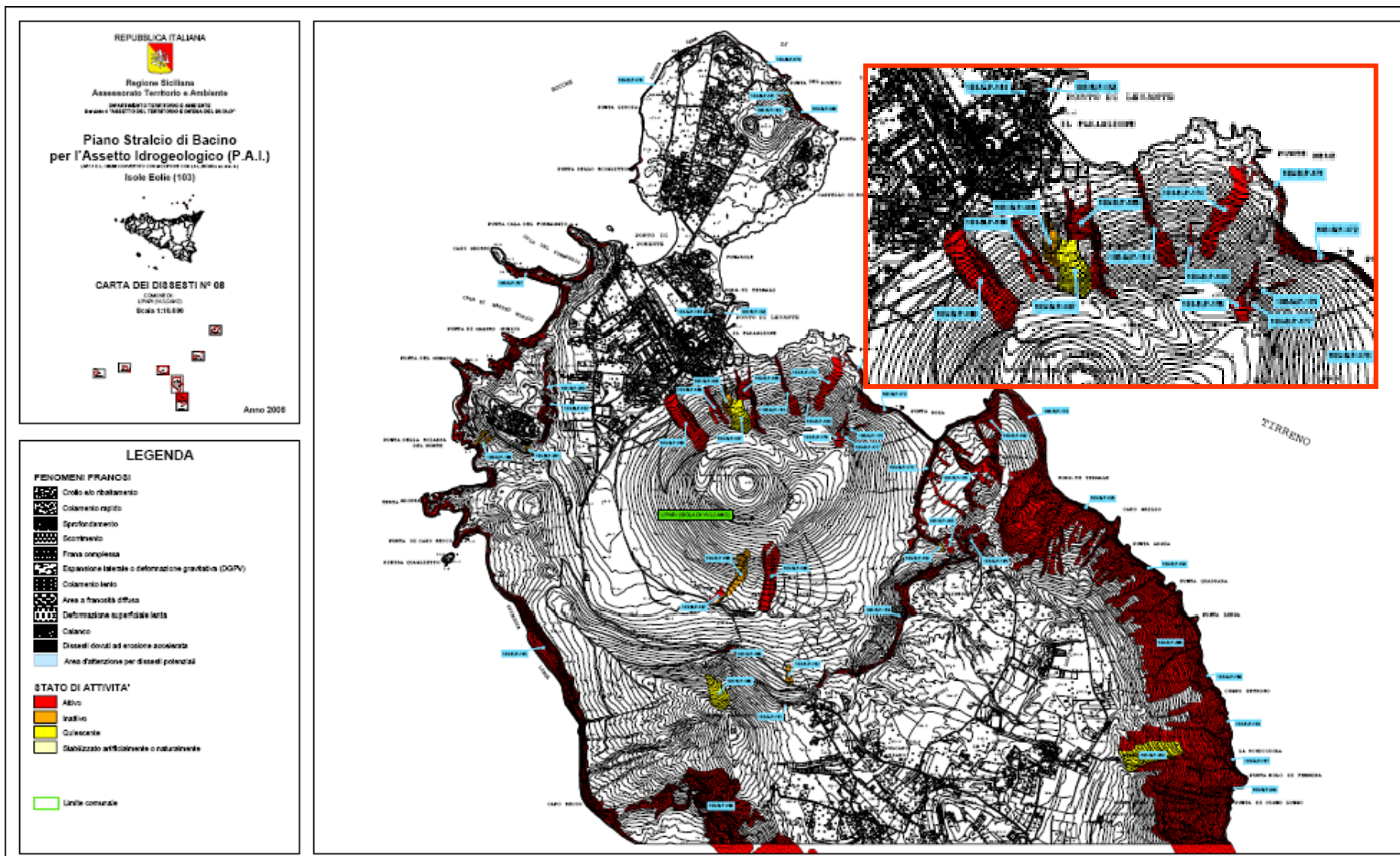
P<sub>dyn</sub>(10m) 2-5 kPa

P<sub>dyn</sub>(10m) > 5 kPa

Dellino et al. 2010



# Hazard assessment: Landslides



## CONCLUSIONS (Hazard)

- 45% prob. eruption in the next 100 yrs (VEI3: most likely scenario)
- The **north** of the island (mainly Porto area) is significantly affected by lahars, pyroclastic density currents, ballistics, landslides
- The **south** of the island is mostly affected by tephra fall (50% prob. of reaching thresholds of roof collapse)



# ENSURE Framework

1) **Mitigation capacities** is used to evaluate whether:

- i) different components of risk (hazard and vulnerability of exposed elements and systems) are currently known and assessed
- ii) mitigation measures have been defined and/or implemented
- iii) different actors (individuals, communities, institutions) are adequately prepared for managing a hazardous event

2) **Physical vulnerability** is necessary to identify the primary factors that make urban area vulnerable to hazards. These factors refer on one hand to features of individual buildings (e.g., roofs, building typology, construction techniques) and on the other hand to features of urban fabric (e.g., morphology, compactness).

3) **Systemic vulnerability** is mainly addressed to evaluate the capacity of critical equipment to continue functioning after some level of physical damage.

4) **Resilience capacities** to recover in the long term

# Mitigation:

## Volcanic, Seismic, Landslides

### 4 Matrices:

- Natural system
- Built environment
- Critical infrastructures
- Social system

### Scale matters!

- Municipality scale (→lowest level on which mitigation policies can be implemented)
- Some key topics and parameters have to be investigated with respect to different geographical scales, since mitigation capacities at local scale depend, in some cases, on legislative framework, policies, decisions taken at wider scales (e.g., building codes in seismic)

# Mitigation: Volcanic Risk (social system)

## System

Social System

## Aspect

People/individuals  
Preparedness

## Key-Topic

Are individuals aware of existing  
risks, informed and prepared in  
case of emergency?

## Parameter

Risk perception/  
awareness

System	Aspect	Aspect weight	Key-topic	Key-topic	Parameters	Criteria for assessment	Descriptors	Assessment	Notes on the Vulcano case-study	Scoring Parameter	Scoring key-topic	Scoring Aspect	Scoring System
Social system (agents)	People/individuals Preparedness	1	Are individuals aware of existing risks, informed and prepared in case of emergency?	1	Risk perception/ awareness	qualitative scale based on questionnaires	low/average/good	AVERAGE	According to surveys developed within the Ensure Project, the awareness of timing of most recent eruption (69%) is good. Expectations of a future eruption in <100 years is also good, but lack of expectation of an eruption in < 12 months suggests that people delay in taking preparedness actions, since the issue is not pressing. Interviewed people were largely split down the middle on the idea of taking actions to increase their ability to respond to the next eruption (e.g., 52% disagreeing they would prepare and 47% agreeing they would).	0.5	0,1 = Very Low	0,1 = Very Low	
					Level of coverage of Early Warning Systems (if EW Systems are available)	quantitative scale based on data collection	% of coverage in respect to the population	—	According to surveys developed within the Ensure Project, concern about lack of information, no provision for elderly and a lack of drills have been expressed by several interviewed.				
					Individual preparedness in terms of availability of masks and shovels	qualitative scale based on questionnaires	low/average/good	LOW	A majority of respondents believe they would have from few minutes to some hours to react before an eruption. But, few people indicated they have an emergency supply kit on hand.	0			
					Known evacuation procedures	binary scale based on questionnaires	yes/no	NO	At present, the Emergency Plan is not available; thus, evacuation procedures are not clearly defined.	0			
	Mitigation capacity of Institutions	1	Are Institutions able to involve communities in mitigation strategies and improve risk awareness? Is the level of cooperation among different institutions in charge of risk prevention/ mitigation satisfactory?	1	Evacuation drill (training) frequency	qualitative scale based on data collection	Regularly (every year)/every few years/occasionally	OCCASIONALLY	The only evacuation drill on the island was done in November 1991. They used one ferry (SIREMAR) in Porto Ponente and one ferry (NGI) in Gelsò. Moreover, according to the surveys developed within the Ensure Project, many people have not a clear idea of where to go and what to do in case of emergency. In detail, the questionnaires reveal that 43% of interviewed, answered that in case of eruption they would have gone to specific meetings points, while 40% declared they don't know what to do.	0	0,1 = Very Low	0,1 = Very Low	0,2 = Very Low
					Participation in development and prevention/mitigation strategies	qualitative scale based on questionnaires and expert judgment	not existant/average/good	NOT EXISTANT		0			
					Media campaigns	binary scale based on data collection	yes/no	NO		0			
					Frequency of media campaigns	qualitative scale based on data collection	every two years/only occasionally	—					
					Education programs embedded in school programs	binary scale based on data collection	yes/no	NO		0			
					Coordination and cooperation among institutions in charge of risk prevention/ mitigation	qualitative scale based on interviews and expert judgement	low/average/high	AVERAGE		0.5			
	Mitigation capacity of economic stakeholders	1	Do local economic stakeholders have sufficient resources for mitigation?	1	GDP; GVA (Gross added value, measure of productivity and size of economy)	qualitative scale based on data collection	rich/average/poor country	AVERAGE	Tourism represents the leading economic activity. Thanks to tourism, local economy is placed at an average level: incomes are surely all above 15000 € per year, most between 15-30 thousand €/year and, according to the surveys developed within the Ensure Project, no one is below the poverty threshold. Nevertheless, the regional economic context is very poor: the value of the GDP pro-capite in Sicily is one of the lowest in Italy. The low level of the regional economy might have relevant repercussions on the local scale in terms of provision of public services, lack of cultural and social activities and strategic development strategies. According to this, it seems possible to state that private stakeholders should have an average capacity to raise funds for mitigation, but public resources would be difficult to raise. National or European funds would be required although the Vulcano island should represent not a priority in the Italian situation where other volcanic areas, like the Vesuvius area for example, would require funds for mitigation activities.	0.5	0,75 = High	0,75 = High	
					dimension of poverty/marginalization	qualitative scale based on data collection	low/average/high	LOW	As mentioned above, no one is below the poverty threshold, almost all inhabitants own a house. More than 30% of inhabitants has at least an other property to rent in the summer.	1			

# Social Study

(in collaboration with East Tennessee State University, USA and University of Salento, Italy)

- Study focused on collecting baseline data among residents of Vulcano island in summer 2010 (sample size = **91 adults**).
- Data were collected through a quasi-census method of key **the Porto area**.



Vulcano full time residents	55 (60.4)
Part-time Vulcano residents	36 (39.6)
Porto	49 (53.8)
Vulcanello	12 (13.2)
Sotto Lentia	5 (5.5)
Vulcano Blu	4 (4.4)
Piano	21 (23.1)

# Summary

Initial descriptive statistics indicate a few key findings:

- Awareness of last volcanic eruption in 1800s is good
- Expectations of a future eruption in <100 years is also good, but lack of expectation of an eruption in < 12 months means **people not likely to prepare**.
- Majority think that eruptions will be bad, but one third think effects of an eruption are exaggerated
- Most think they will only have minutes to hours to a few days of forewarning, but few have taken simple steps to prepare and **people are mixed about CPA advice for eruption**
- Sheltering needs are anticipated both off- and on-island
- Major problems on the island relate to **provision of public services, lack of cultural and social activities and strategic development strategy**.....not fear of the volcano or presence of visitors.
- The most common problem linked to the volcano was effects on quality of water
- Most common first and second reasons for people leaving the island were jobs, lack of entertainment and education.

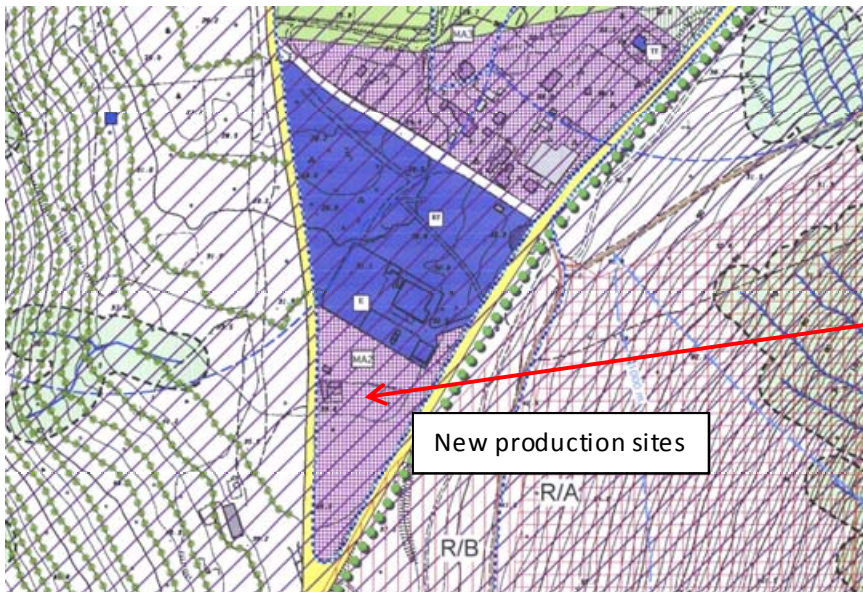
# Some conclusions on social.....

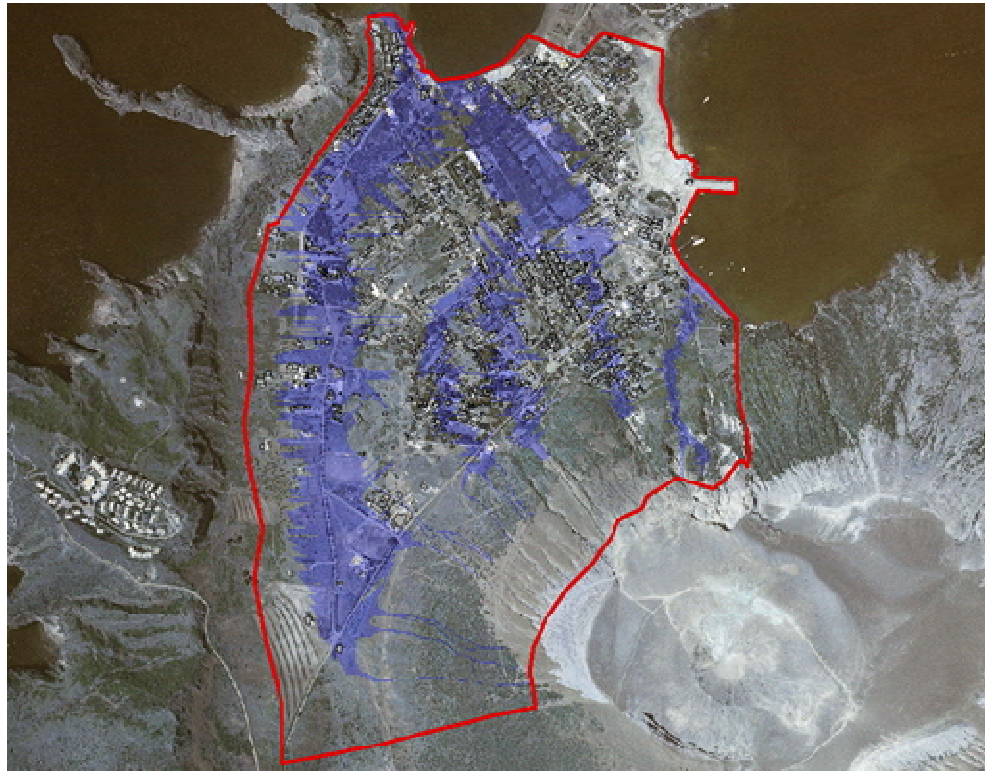
- There is an expectation of a future eruption, but
  - people's attention is focused on concerns about **short-term economic, social and service issues** AND
  - these concerns result in people leaving the island for greener pastures (i.e., lack of jobs, entertainment and education)
- Increasing knowledge of protective actions and preparedness for an eruption or other hazards should focus on **incentives for preparing**:
  - Highlight the economic and social benefits and consequences of preparing
    - A. Benefits are a reduction of risk and increased ability to cope with an eruption and its effects.
    - B. Consequences are an upfront initial investment of time and resources

## CONCLUSIONS (Mitigation capacities)

➤ **Mitigation capacities** have been evaluated for volcanic phenomena, seismic events and landslides.

– The assessment highlights that mitigation policies are still mainly focused on hazard. In fact, hazards are very well known and monitored, whereas exposure and vulnerability analyses are still missing. Consequently, structural defence measures (e.g., water drainage) are generally favoured with respect to the non structural ones (e.g., Master plan).





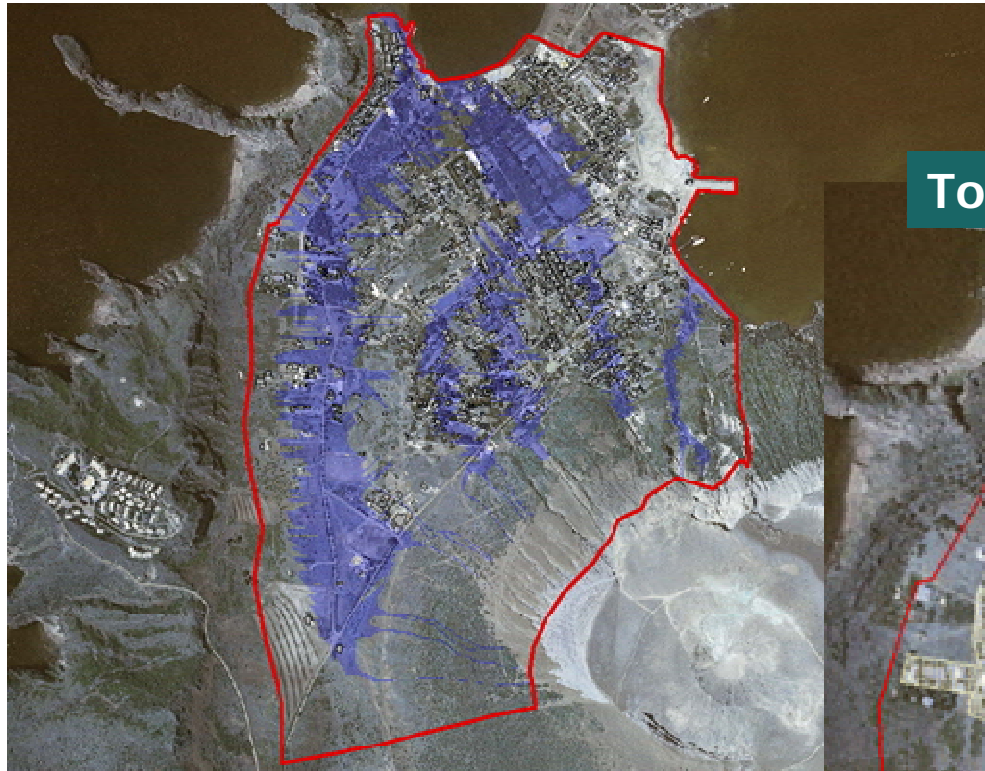
Area investigated

## Physical Vulnerability: Lahars

### 4 Matrices:

- Natural system
- Built environment
- Critical infrastructures
- Social system

## Physical Vulnerability: Lahars

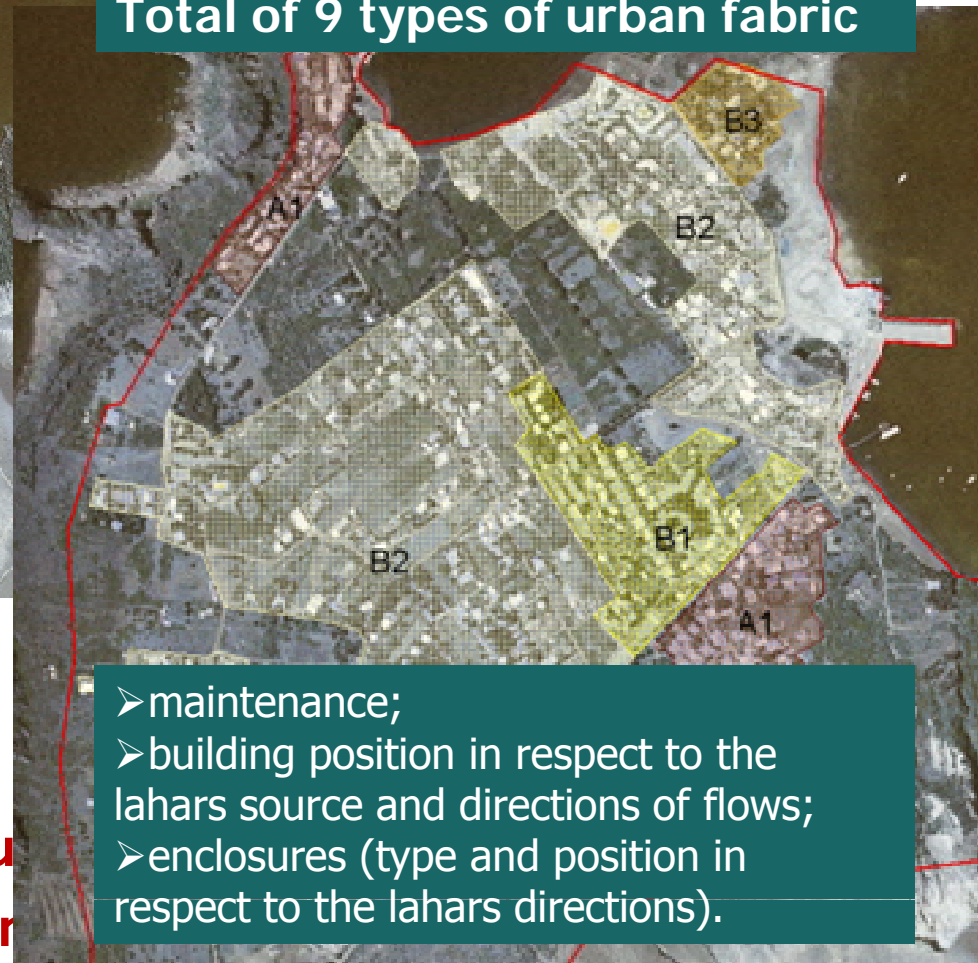


Area investigated

### Classification of:

- individual buildings (e.g., u
- urban fabrics (e.g., regular

Total of 9 types of urban fabric



- maintenance;
- building position in respect to the lahars source and directions of flows;
- enclosures (type and position in respect to the lahars directions).

# Buildings (in situ survey)

Identify from: <Top-most layer>

Identified 1 feature

Field	Value
FID	199
Shape	Polygon
ENTITY	Polyline
LAYER	Buildings
RIGHT_FID	1009
BUILDING_I	H1-1
N_STOREY	4
ROOF_IN	1
ROOF_EN	1
ROOF_ELEME	openings
ROOF_TYPE	flat
B_SHAPEN	2
B_MAT	0
B_MAT_DES	0
B_SLOPE	1
B_QUALITY	1
B_PRESERV	1
B_USEN	2
B_USE	hotel
PICTURE	H1_1_1.JPG

Display Source Selection Favorites Index Search

Drawing

494433.113 4246343.143 Meters

# Physical Vulnerability: Lahars (built environment)

System	Aspect	Aspect weight	Key-topic	Key-topic weight	Key-element	Key-element weight	Parameters	Criteria for assessment	Data Quality	Descriptors	Assessment	Notes on the Vulcano case-study	Scoring parameter	Scoring key-element	Scoring key-topic	Scoring aspect	Scoring System			
Built environment	Exposure and vulnerability of Urban Fabric n. 1	1	What are the factors that make the urban fabric vulnerable to the stress?	1	Factors related to the features of buildings and public facilities of urban fabric	1	roof	connection to structure		good/poor				0,8 = VERY HIGH						
							weight		heavy/light											
							shape		large inclination/plane											
							structure	material	Low	Four classes obtained through the ranking of the index with the natural breaks procedure (iron-wood and mixed, masonry, reinforced concrete)	High	The assessment has been developed grounding on in-situ surveys and photos	0.75							
								homogeneity		large/largely disomogenous										
								type of connection among parts	not available	good/poor										
								floors rigidity		rigid/non rigid										
							foundation	depth and type	not available	non-existent, deep, superficial										
								distance in m.		> 3 mt; < 3 mt (for masonry mainly)										
							shape	openings	not available	number and dimension of windows/doors										
								quality of openings		may be easily sealed/not										
								basement	not available	existant/non existent										
								inflammable objects	not available	existant/non existent										
								sources of radiation or toxic chemicals		existant/non existent										
							maintenance	building conditions	Low	Four classes obtained through the ranking of the index with the natural breaks procedure (poor/medium/ good/very good)	High	The assessment has been developed grounding on in-situ surveys and photos (see fig. 16)	0.5							
								soil on which the building is built (crest, alluvial deposits, etc.)		amplification soils yes/no										
							position	with respect to dangerous channels	High	Four classes obtained through the ranking of the index with the natural breaks procedure (out of the channel/lateral zone/middle zone/central zone)	Very high	The assessment has been developed grounding on cartography and lahars run out analysis (see fig. 18)	1							
								distance from dangerous areas	High	Four classes obtained through the ranking of the index with the natural breaks procedure (low, medium, high, very high)	Very high	The assessment has been developed grounding on cartography and lahars run out analysis (see fig. 17)	1							
					protection	protection provided by enclosures (type and position)	High	Four classes obtained through the ranking of the index with the natural breaks procedure (low, medium, high, very high)	Medium	The assessment has been developed grounding on cartography (see fig. 20-21)	0.75									
						vulnerability assessment of public facilities	not available	yes/no; type of machinery												
					Factors related to the urban fabrics features	1	rainproof level of the settlement	covered surface/surface of urban fabric	High	Four classes obtained through the ranking of the index with the natural breaks procedure (low, medium, high, very high)	Very high	The assessment has been developed grounding on cartography (see fig. 23)	1	0,75 = HIGH						
								rainproof surface /surface of open spaces	Medium	Four classes obtained through the ranking of the index with the natural breaks procedure (low, medium, high, very high)	Medium	The assessment has been developed grounding on cartography and orthophoto (see fig. 23)	0.5							
activities at ground floor	surface of residential building placed at road level/covered surface of the urban fabric	Medium	Four classes obtained through the ranking of the index with the natural breaks procedure (low, medium, high, very high)	High			The assessment has been developed grounding on in-situ surveys and cartography (see fig. 24)	0.75												
	surface of basement/covered surface of the urban fabric	not available																		

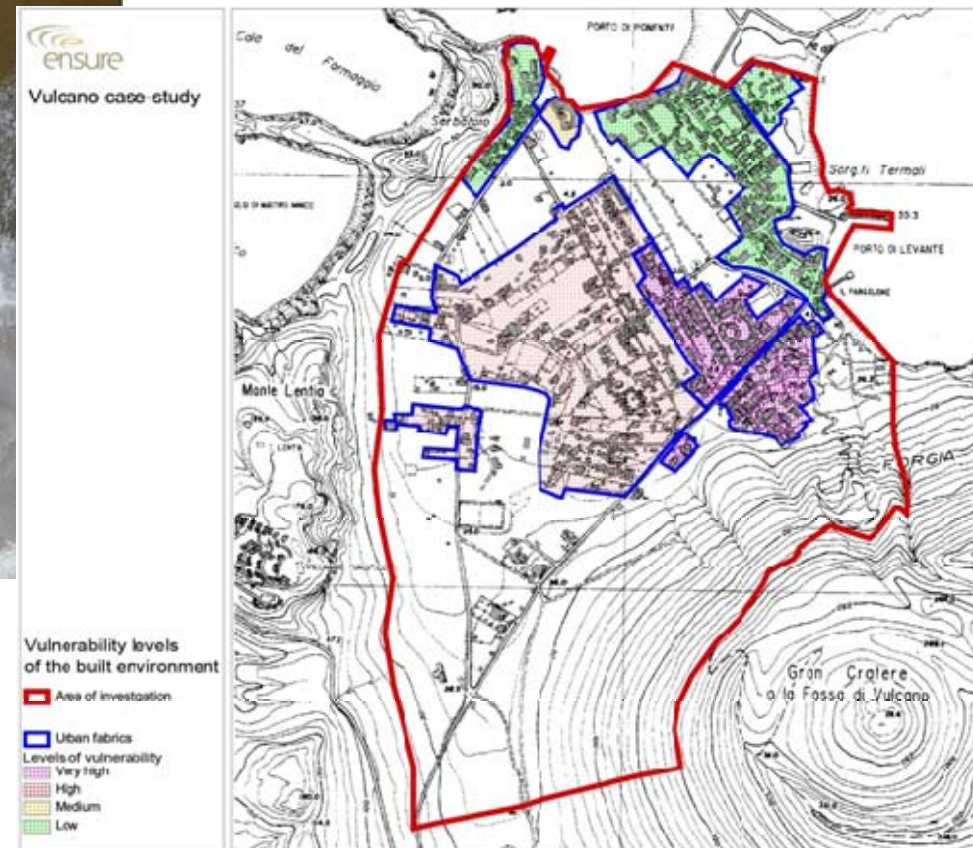
9 matrices (i.e., one for each urban fabric)

## Physical Vulnerability: Lahars (built environment)



### CONCLUSIONS

- The north of the island is the most exposed to lahars (based on hazard assessment)
- The north of the island shows various degrees of vulnerability to lahars from low to very high (based on characteristics of buildings and urban fabrics)



Physical vulnerability assessment of the **built environment**: final ranking of urban fabrics



## CONCLUSIONS (Methodology)

- Volcanic risk is typically characterized by **multiple hazards** (e.g., tephra, ballistics, lahars, pyroclastic density currents, landslides)
  - Each hazard needs to be analyzed separately

## CONCLUSIONS (Methodology)

- Volcanic risk is typically characterized by **multiple hazards** (e.g., tephra, ballistics, lahars, pyroclastic density currents, landslides)
- The large set of key topics and parameters analyzed in the matrices requires a **large amount of data** and the involvement of **different disciplinary fields** (e.g., volcanology, urban planning, engineering, sociology).
  - Some parameters can be evaluated through data easily to collect and to interpret (e.g., availability of hazard map), but some are based on expert judgment (e.g., quality of monitoring systems or adequacy of hazard maps to support mitigation measures).

## CONCLUSIONS (Methodology)

- Volcanic risk is typically characterized by **multiple hazards** (e.g., tephra, ballistics, lahars, pyroclastic density currents, landslides)
- The large set of key topics and parameters analyzed in the matrices requires a **large amount of data** and the involvement of **different disciplinary fields** (e.g., volcanology, urban planning, engineering, sociology).
- Required data have to be collected mostly through **detailed surveys in situ** (e.g., the state of maintenance of buildings) or through **questionnaires** involving local community and local Authorities
- Some key topics and parameters have to be investigated with respect to **different geographical scales** (i.e., local to national)
- Matrices use numerical scoring but are still based on qualitative assessments.
  - e.g., main aim of a mitigation matrix is to highlight the main weaknesses in the mitigation capacities of a given area and, consequently, to identify the main aspects which have to be strengthened for improving the capacities of preventing, mitigating and coping with hazardous events.

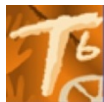
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- Some key topics and parameters have to be investigated with respect to **different geographical scales** (i.e., local to national)
- Matrices use numerical scoring but are still based on qualitative assessments.
  - Scores related to individual parameters are crucial to understand specific weaknesses
  - Aggregate scores can be very useful in order to compare and prioritize different areas or systems



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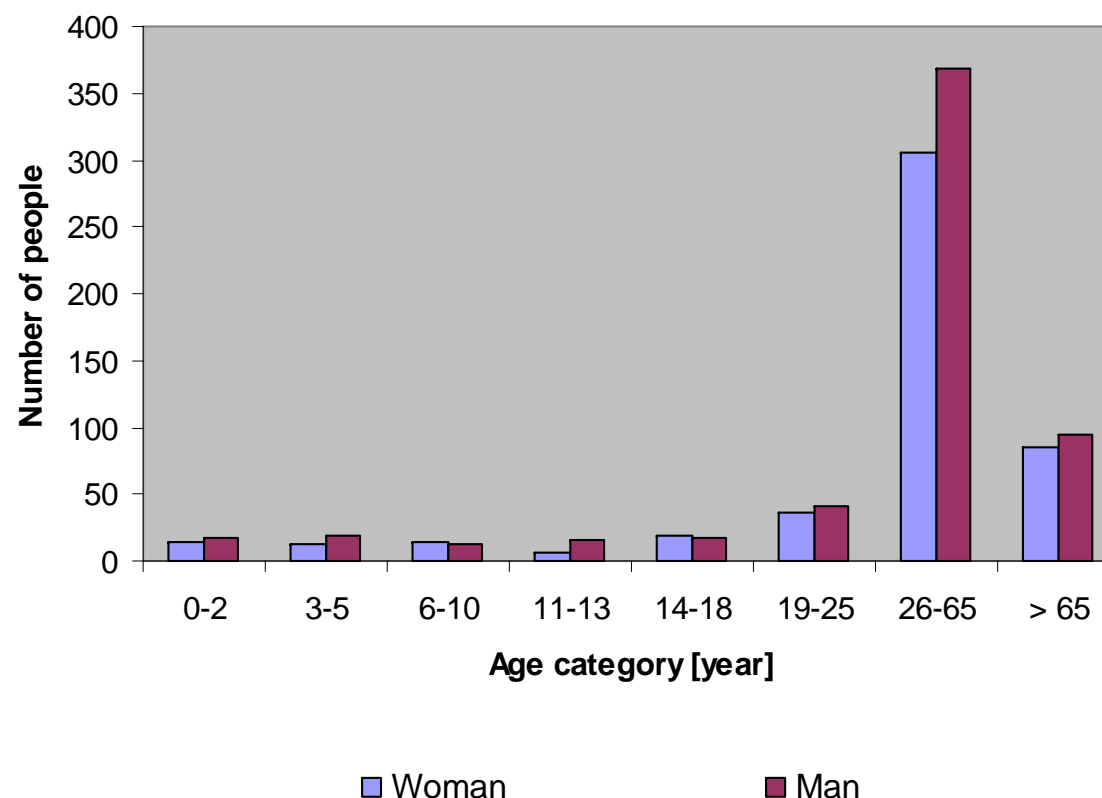


*Thanks!*

# Residential population - 2006

**588 Men and 492 women**

Age category	Woman	Man
0-2	14	17
3-5	13	19
6-10	14	13
11-13	6	16
14-18	19	18
19-25	36	41
26-65	305	369
> 65	85	95
Total	492	588



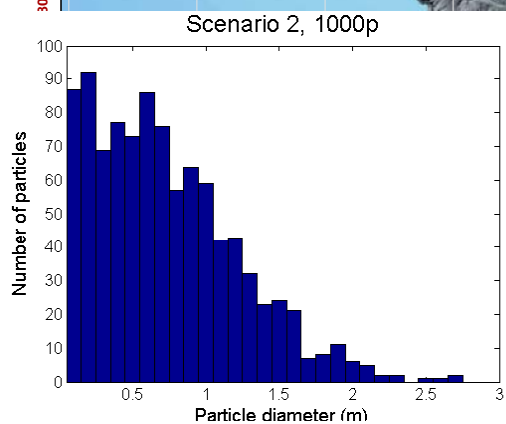
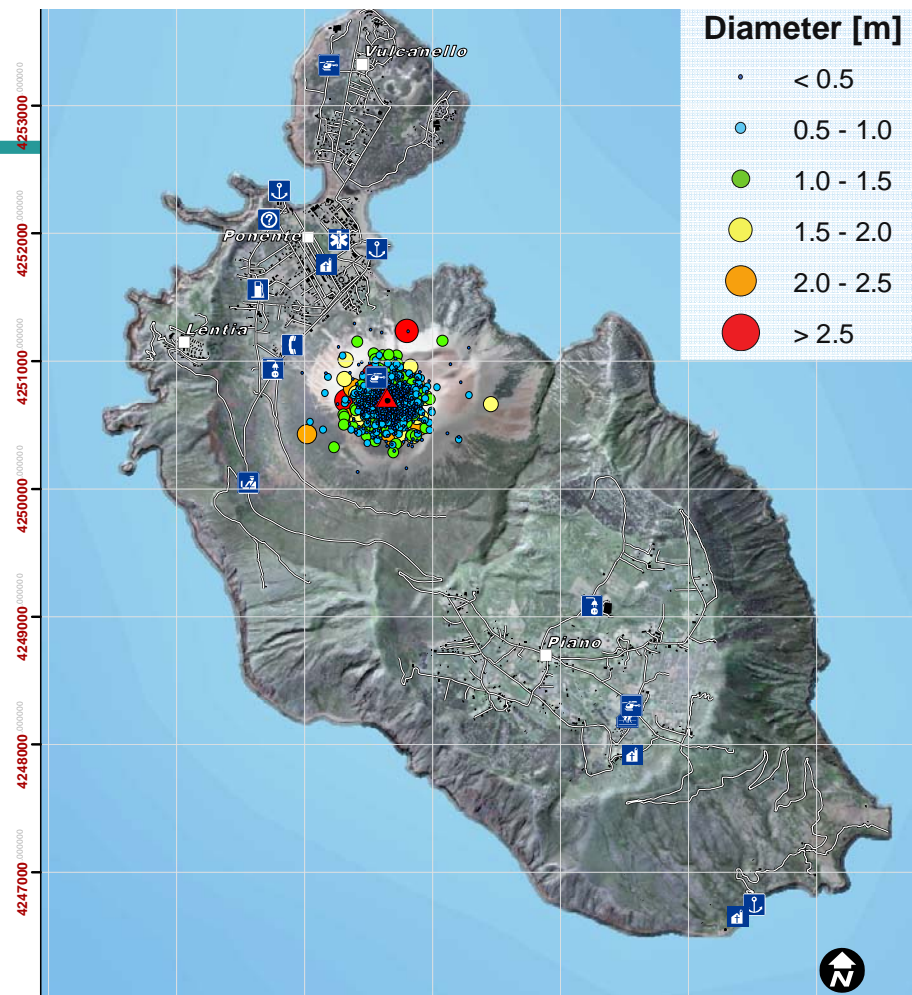
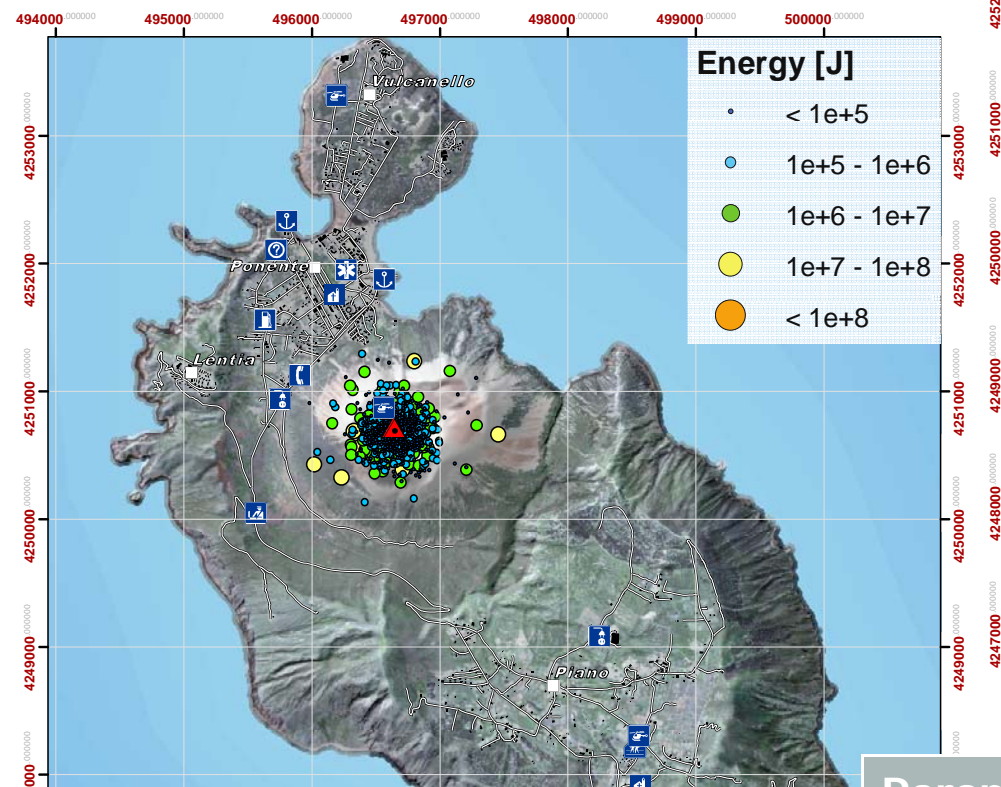
## Hazard assessment: ballistics

Parameter	units	value
Total Particle Number	-	1000
Average of Density	kg/m <sup>3</sup>	2000
Standard deviation of Density	kg/m <sup>3</sup>	500
Average of Particle diameter	cm	20
Standard deviation of Particle Diameter	cm	80
Standard deviation of displacement of ejection point	m	100
Crater altitude	m	350
Radius of crater area	m	400



2 scenarios: varying velocity and ejection angle

# Scenario 2



Parameter	Unit	Value
Average velocity	m/s	50
$\sigma$ velocity	m/s	10
Average ejection angle (from horizontal angle)	degree	90
$\sigma$ ejection angle	degree	75

# Elements on roof



# Mitigation: Volcanic Risk

System

Aspect

Key-Topic

Parameter

Nat. environment

Hazard Knowledge

Are hazards known and mapped?

Maps Availability

System	Aspect	Aspect weight	Key-topic	Key-topic weight	Parameters	Criteria for assessment	Descriptors	Assessment	Notes on the Vulcano case-study	Scoring Parameter	Scoring key-topic	Scoring Aspect	Scoring System
Natural environment	Natural Hazards knowledge	1	Are volcanic hazards known and mapped?	1	Volcanic hazard maps availability	binary scale based on data collection	yes/no	YES	The official hazard map of Vulcano island used by the Italian Civil Protection is by Dellino and La Volpe (1997). The map focuses on the distribution of diluted pyroclastic density currents (Dellino P, Volpe LL (1997) and is the result of a research project developed between 1993 and 1995 by the Italian National Council of Research- National Group for Volcanology and titled "Progetto Vulcano". (see: "Stratigrafia, dinamiche eruttive e deposizionali, scenario eruttivo e valutazioni di pericolosità a La Fossa di Vulcano", Fellici Editore). Furthermore, it has to be considered that the map is not an "official" one, as in the case of Maps provided by Basin Authorities. Finally, it has to be noticed that, although the scale of the hazard assessment seems to be adequate, the lack of a detailed assessment of some of the volcanic phenomena (ashes, lahars...), which clearly depends on the hypothesis on which the assessment has been carried out, might be insufficient for a correct definition of mitigation measures.	1	0,75 = High	0,44 = Low	
					Scale of hazard maps adequate to support prevention and mitigation measures	qualitative scale based on expert judgement	adequate, partially adequate, inadequate	PARTIALLY ADEQUATE		0.5			
			Are spatial and temporal dynamics of volcanic hazards and synergies among them and other natural hazards (e.g. tsunami) considered?	1	Hazard scenarios, taking into account spatial and temporal dynamics of volcanic hazards and including enchainment events, availability	qualitative scale based on data collection	not available, available but not satisfactory, available	NOT AVAILABLE	No hazard scenarios showing potential synergies among different phenomena and the temporal dynamics of volcanic phenomena are currently available.	0	0 = Absent		
					Hazard maps updating	binary scale based on data collection	yes/no	NO	There are recent studies, but they do not represent official maps. The most recent study has been published by Dellino et al. (2010). It accounts for a more detailed stratigraphy and a quantification of potential damage on the built environment (Dellino P, De Astis G, La Volpe L, Mele D, Sulpizio R (2010) Quantitative hazard assessment of phreatomagmatic eruptions at Vulcano (Aeolian Islands, Southern Italy) as obtained by combining stratigraphy, event statistics and physical modelling, Journal of Volcanology and Geothermal Research). New stratigraphic work has been developed in the frame of a PhD project at the University of Pisa (Dr Federico Di Traglia) and the project ENSURE as part of a collaboration with Prof. Mauro Rosi. Associated results have not been published yet but they could highlight fundamental differences with the work of Dellino and colleagues.	0	0 = Absent		
			Is available knowledge updated?	1	Frequency of update	qualitative scale based on data collection	any time new knowledge is available/ any time activity changes/ occasionally	—					
	Tools for prevention	0.5	Are hazards monitored?	1	Availability of volcanic hazards monitoring systems	binary scale based on data collection	yes/no	YES	According to INGV geochemical phenomena are currently monitored: <a href="http://www.pa.ingv.it/orveglianza/elettronica/elettronica.html">http://www.pa.ingv.it/orveglianza/elettronica/elettronica.html</a> ; seismic activity is also monitored by INGV and there are currently 4 permanent seismic stations on the island	1	1 = Very High		
					Quality and density of monitoring systems	qualitative scale based on expert judgement	good, medium, scarce	GOOD		1			
			Are monitoring systems connected to forecasting modelling systems?	1	Availability of volcanic hazards monitoring systems linked to forecasting systems	binary scale based on data collection	yes/no	NO		0	0 = Absent		
					Quality of forecasting models connected to hazard monitoring systems	qualitative scale based on expert judgement upon the quality of forecasting models	good, medium, low	—					
			Are structural defence measures available and effective?	0.5	Existence of early warning systems	binary scale based on data collection	yes/no	NO		0	0 = Absent		
					Existence of structural defence measure	binary scale based on data collection	yes/no	NO		0			
					Effectiveness of existing structural defence measures	qualitative scale based on expert judgement upon the effectiveness of defences	effective, partially effective, ineffective	—	There is a project related to the canalisation of rainwater to collect water from the volcano flanks and mitigate mud and debris flow, but no data related to the quality (extension, features) of the project and information about its implementation are currently available.				
					State of maintenance of defences	qualitative scale based on expert judgement upon the state of maintenance	high, medium, low	—					

# Mitigation: Volcanic Risk

System	Aspect	Aspect weight	Key-topic	Key-topic weight	Parameters	Criteria for assessment	Descriptors	Assessment	Notes on the Vulcano case-study	Scoring Parameter	Scoring key-topic	Scoring Aspect	Scoring System
Built environment	Exposure vulnerability of built environment knowledge	1	Is exposure and vulnerability known and considered in plans?	1	Risk maps and scenarios, including enchainned events availability	binary scale based on data collection	yes/no	NO	The study published by Dellino et al. (2010), providing a quantification of damage on the built environment, should represent a first assessment of risk, although it is not official and exposure and vulnerability assessment has not been explicitly considered.	0	0 = Absent	0 = Absent	0,1 = Very Low
					Vulnerability assessment of exposed built stock availability	binary scale based on data collection	yes/no	NO		0			
					Frequency of update	qualitative scale based on data collection	any time new buildings are built/only occasionally	—					
					Vulnerability and exposure assessment included in ordinary plans (example land use)	binary scale based on data collection	yes/no	NO		0			
	Rules and tools for risk mitigation	1	Do rules for risk mitigation exist? What is their expected efficacy/quality?	1	Building codes/rules availability	binary scale based on data collection	yes/no	NO	The new Master Plan which has been approved only in November 2010 does not include exposure and vulnerability assessment. It only includes, according to the Italian National Law, a geological report. Nevertheless, it has to be noticed that the Sicily Region has a very old law on land use planning. Thus, according to the regional law, local Master Plan are not forced to include risk assessment, whereas in other Italian regions (e.g. Emilia Romagna, exposure and vulnerability assessment are explicitly mentioned as contents of a Master Plan.	0	0,2 = Very Low	0,2 = Very Low	
					Quality and update of building codes/rules	qualitative scale based on expert judgement	taking into account new knowledge and info/only occasionally updated	—					
					Traditional building practice based on hazard knowledge	binary scale based on expert judgment	yes/no	NO		0			
					Land use plans embedding risk mitigation measures	binary scale based on data collection	yes/no	YES	In the Master Plan recently approved a large area has been identified as a volcanic hazard prone area. In detail, this large area is defined as: "Volcanic risk: territorial organization linked to civil protection". This area, which includes not only the Volcano itself but the built up areas of Porto Ponente, Porto Levante e Vulcanello, is superimposed to the functional zoning defined by the Master Plan and no specific limitations are defined. Some constraints have been defined for all the areas affected by "geological risks". In detail, according to the technical norms of the MasterPlan, in these areas the re-building of existing houses in case of collapses or demolitions is not allowed; nevertheless, according to the norms for each functional zone, new buildings are allowed after in-depth geognostic surveys. No rules for reducing exposure and vulnerability of built environment are explicitly provided by the new Master Plan, although it recognizes that existing built up areas are at risk.	1			
					Quality of mitigation measures included in land use plans	qualitative scale based on expert judgement	formal/substantial with limitation and specific requirements for new settlements/substantial with limitation and specific requirements for new and existing settlements	FORMAL		0			
					Integration to other measures (insurance)	binary scale based on data collection	yes/no	NO		0			
Infrastructure and production sites	Exposure and Vulnerability of Critical infrastructures: knowledge and mitigation	1	Is vulnerability of critical infrastructures assessed and acted upon? Particularly with respect to na-techs and enchainned effects on depending systems?	1	Vulnerability assessment of critical infrastructure availability	binary scale based on data collection	yes/no	NO	The most relevant project is the new main road connecting the area of Porto with the safer one of Piano. The project, which at present has not been realized, is clearly based on the available hazard assessment (Dellino, La Volpe 1997). Another relevant project refers to a new square in the area of Porto, as a center for collecting people for civil protection; the latter has been approved but it has not been financed at present. Finally, a medical aid (presidio medico) with hydroambulance for providing first assistance in case of emergency should be established in Volcan starting from this year (2011).	0	0,4 = Low	0,4 = Low	0,3 = Low
					Frequency of updating	qualitative scale based on data collection	each time new projects are drawn/only occasionally	—					
					Current Maintenance Programs embedding mitigation	binary scale based on data collection	yes/no	YES		1			
					Frequency of maintenance activities	qualitative scale based on data collection	regularly/frequently/occasionally	OCCASIONALLY		0			
					New projects based on hazard/risk assessment	binary scale based on data collection	yes/no	YES		1			
					Level of coordination among stakeholders	qualitative scale based on interviews and expert judgement	low/medium/high	LOW		0			
					Vulnerability assessment of production sites availability	binary scale based on data collection	yes/no	NOT RELEVANT FOR THE CASE STUDY					
	Exposure and vulnerability of Production sites: knowledge and mitigation	0.25	Is the vulnerability of production sites assessed and acted upon particularly with respect to potential na-techs?	0.25	Frequency of updating	qualitative scale based on data collection	each time new plants or transformation of existing ones occurs	NOT RELEVANT FOR THE CASE STUDY	New production sites are foreseen by the new Master plan in areas at volcanic risk. According to the detailed hazard assessment developed within the Ensure Project, the new areas for production might be significantly affected by lahars.		0 = Absent	0 = Absent	
					Retrofitting measures for existing production sites	binary scale based on data collection	yes/no	NOT RELEVANT FOR THE CASE STUDY					
					New projects based on risk assessment	binary scale based on data collection	yes/no	NO		0			
					Rules for existing hazardous plants in risky areas aimed at preventing or mitigating na-tech events	qualitative scale based on data collection and expert judgement	special provisions for hazardous plants/generic rules	NOT RELEVANT FOR THE CASE STUDY					
					Na-tech explicitly accounted for in hazardous installations emergency plans	binary scale based on data collection	yes/no	NOT RELEVANT FOR THE CASE STUDY					

# Roof types

