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Florence HeriTech 2020. 14-16 October

RESEARCH
REMOTE SENSING FOR ARCHAEOLOGY

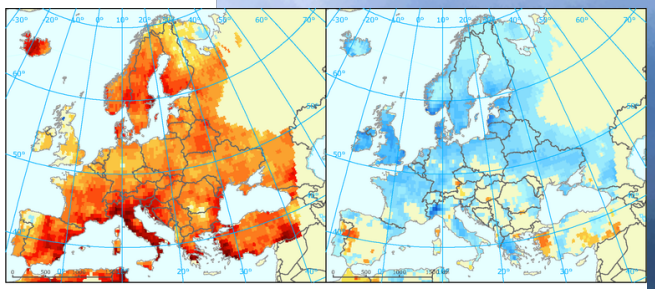
The RESEARCH project. Soil-related hazards and archaeological heritage in the challenge of climate change

Stefano De Angeli (1), Fabiana Battistin (1),

Matteo Serpetti (2), Alessio Di Iorio (2),

Federico Valerio Moresi (1)

1. Università degli Studi della Tuscia, p.le dell'Università s.n.c., 01100 Viterbo, Italy
2. ALMA SISTEMI Srl, via della tenuta del Cavaliere 1, Building B, ooo12 Guidonia, Roma, Italy



Archaeological Heritage, naturally endangered by environmental processes and anthropogenic pressures, is today increasingly at risk, because of intense human activities and climate change, and their impact on atmosphere and soil.

Example of flood in Sibary, Calabria, Italy (source: La Repubblica, February 2014).

Example of urban sprawl in Nea Paphos, Cyprus (April 2017).

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In 2008, after a 2-year consultation process with experts in both fields of natural and cultural heritage, the World Heritage Committee adopted a standard list of factors affecting the Outstanding Universal Value of World Heritage Properties.

(source: https://whc.unesco.org/en/factors/)
See also:
UNESCO, World Heritage Reports n°22- Climate Change and World Heritage, May 2007).

PRIMARY FACTORS	SECONDARY FACTORS
Buildings and Development	Housing Commercial development Industrial areas Major visitor accommodation and associated infrastructure Interpretative and visitation facilities
Transportation Infrastructure	Ground transport infrastructure Air transport infrastructure Marine transport infrastructure Effects arising from use of transportation infrastructure Underground transport infrastructure
Utilities or Service Infrastructure	Water infrastructure Renewable energy facilities Non-renewable energy facilities Localised utilities Major linear utilities
Pollution	Pollution of marine waters Ground water pollution Surface water pollution Air pollution Solid waste Input of excess energy
Biological resource use/modification	Fishing/collecting aquatic resources Aquaculture Land conversion Livestock farming/grazing of domesticated animals Crop production Commercial wild plant collection Subsistence wild plant collection Commercial hunting Subsistence hunting Forestry /wood production
Physical resource extraction	Mining/ Quarrying Oil and gas / Water extraction

PRIMARY FACTORS	SECONDARY FACTORS
Local conditions affecting physical fabric	Wind Relative humidity Temperature Radiation/light Dust Water (Rain/Water table) Pests Micro-organisms
Social/cultural uses of heritage	Ritual/spiritual/religious and associative uses Society's valuing of heritage Indigenous hunting, gathering and collecting Changes in traditional ways of life and knowledge system Identity, social cohesion, changes in local population and community Impacts of tourism/visitor/recreation

PRIMARY FACTORS	SECONDARY FACTORS
Other human activities	Illegal activities Deliberate destruction of heritage Military training War Terrorism Civil unrest
Climate change and severe weather events	Storms Flooding Drought Desertification Changes to oceanic waters Temperature change Other climate change impacts
Sudden ecological or geological events	Volcanic eruption Earthquake Tsunami/tidal wave Avalanche / landslide Erosion and siltation/deposition Fire (wildfires)
Invasive/alien species or hyper-abundant species	Translocated species Invasive/alien terrestrial species Invasive / alien freshwater species Invasive/alien marine species Hyper-abundant species Modified genetic material
Management and institutional factors	Management System/Management Plan Legal framework Low impact research/monitoring activities Governance High impact research/monitoring activities Management activities Financial resources Human resources
Other factor(s)	

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Official web-site: *www.re-se-arch.eu*

Facebook: *https://www.facebook.com/Research-Remote-Sensing-techniques-for-Archaeology*

Project RESEARCH (*REmote SEnsing techniques for ARCHaeology,* 2018-2022) developed a risk assessment procedure for monitoring and evaluating risk for archaeological heritage coming from:

- Land movement
- Soil erosion
- Land use/cover change

The assessment will be possible by combining different types of environmental and archaeological data, mostly produced by remote sensing technologies.

The methodology will be applied by a specifically designed WebGIS Platform.

The project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie

(H2020-MSCA-RISE grant agreement No 823987).

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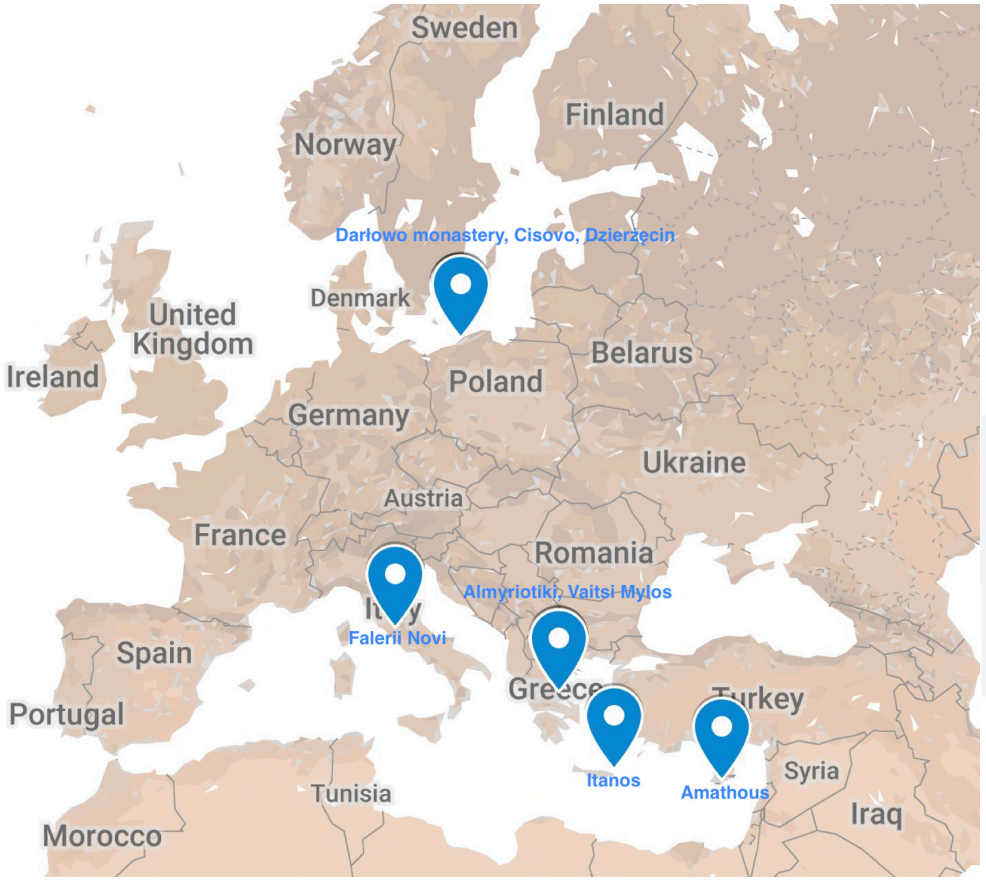
RESEARCH case studies

Case Study		Land Movement	Soil Erosion	Land Use Change
ITALY	Falerii Novi	X	X	X
CYPRUS	Amathous	X	X	X
GREECE	Almiriotiki		X	
	Vaitsi Mill			X
	Itanos	X		
POLAND	Darłowo – monastery			X
	Cisowo		X	X
	Dzierżęcin		X	X



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Project consortium

RESEARCH will coordinate the existing expertise and research efforts of seven beneficiaries into a synergetic plan of collaborations and exchanges of personnel (PhD students and research staff), to offer a comprehensive transfer of knowledge and training environment for the researchers in the specific area.

Università degli Studi della Tuscia (UNITUS, Viterbo, It)
coordinator

Alma Sistemi Srl
(ALMA, Roma, It)

Technologiko Panepistimio Kyprou (CUT, Lemesos, Cy)

Geosystems Hellas it kai Efarmogesgeopliroforiakon Systimaton Anonimietaireia (GSH, Athina, Gr)

Foundation for Research and Technology Hellas
(FORTH, Heraklion, Gr)

Space Systems Solutions Ltd
(S3, Nicosia, Cy)

Uniwersytet Im. Adama Mickiewicza W Poznaniu
(AMU, Poznan, PL)

First year project activities

- Definition of risk assessment methodology
- State of the art of land movement data processing chain (WP1)
- State of the art of soil erosion data processing chain (WP2)
- State of the art of land use/change data processing chain (WP3)
- Selection of case studies
- Definition of scientific requirements of the Platform (WP7)
- Definition of user requirements of the Platform (WP7)

The activities have been conducted in synergy with all the Partners and were supported by the possibility of staff exchange allowed by the funding frame MSCA-RISE

Risk assessment methodology

RESEARCH risk assessment methodology take its moves from the definition of risk as a product of hazard, vulnerability, and exposure.

$$R = H * V * E$$

Hazards: anything (tangible or intangible) that can cause harm to some assets, considered in its magnitude and spatial and temporal aspects (it is the same of risk source, every element which alone or in combination has the intrinsic potential to give rise to risk).

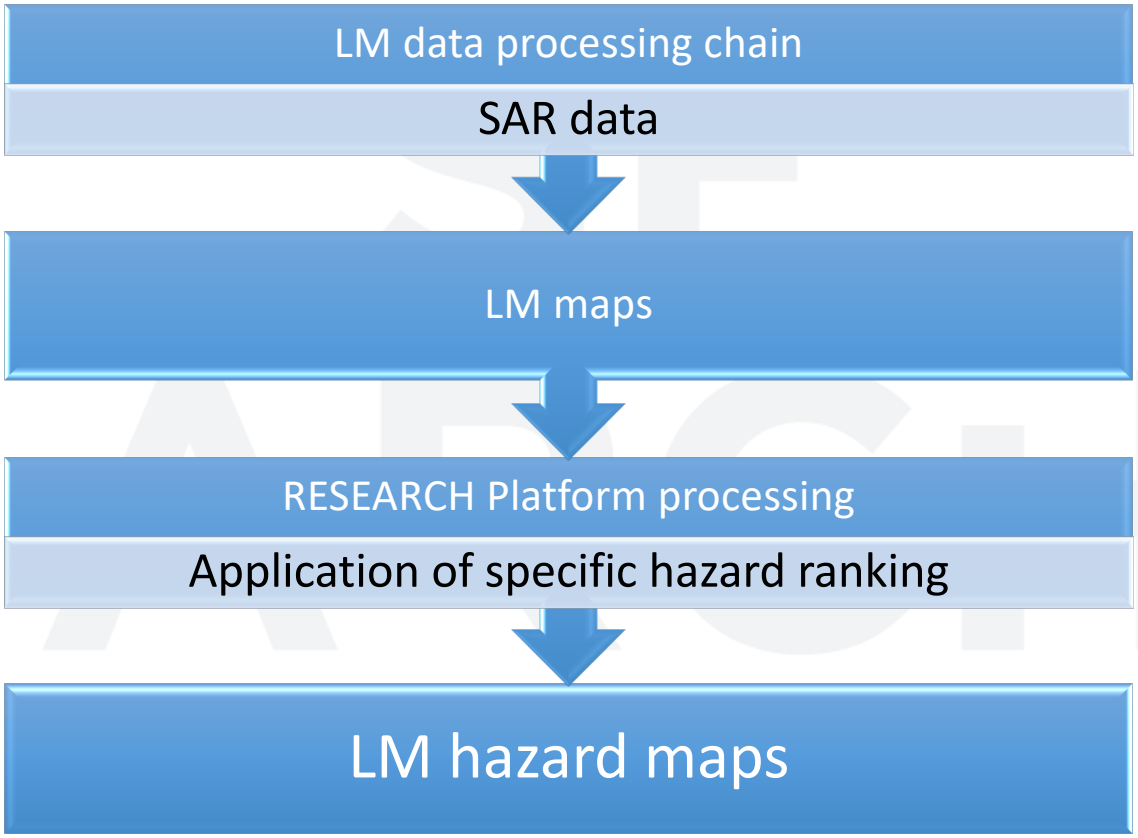
Exposure: what is exposed to a given hazard (asset=something we value and want to preserve. Important types of assets are humans, the environment, material or financial assets, cultural heritage).

Vulnerability: the intrinsic properties of something resulting in susceptibility to a risk source that can lead to an event with a consequence. the aspects of the exposed elements that made them vulnerable to a given hazard.

Land movement hazard assessment

Land movements are natural phenomena influenced by geological and environmental conditions. They typically occur along hillsides and mountains and can naturally happen or being the consequence of human actions. The phenomena can occur suddenly or very slowly, depending on the characteristics of both the area and the hazardous event. Land movements can impact on AH by damaging and destroying standing and buried structures, as well as archaeological stratigraphy.

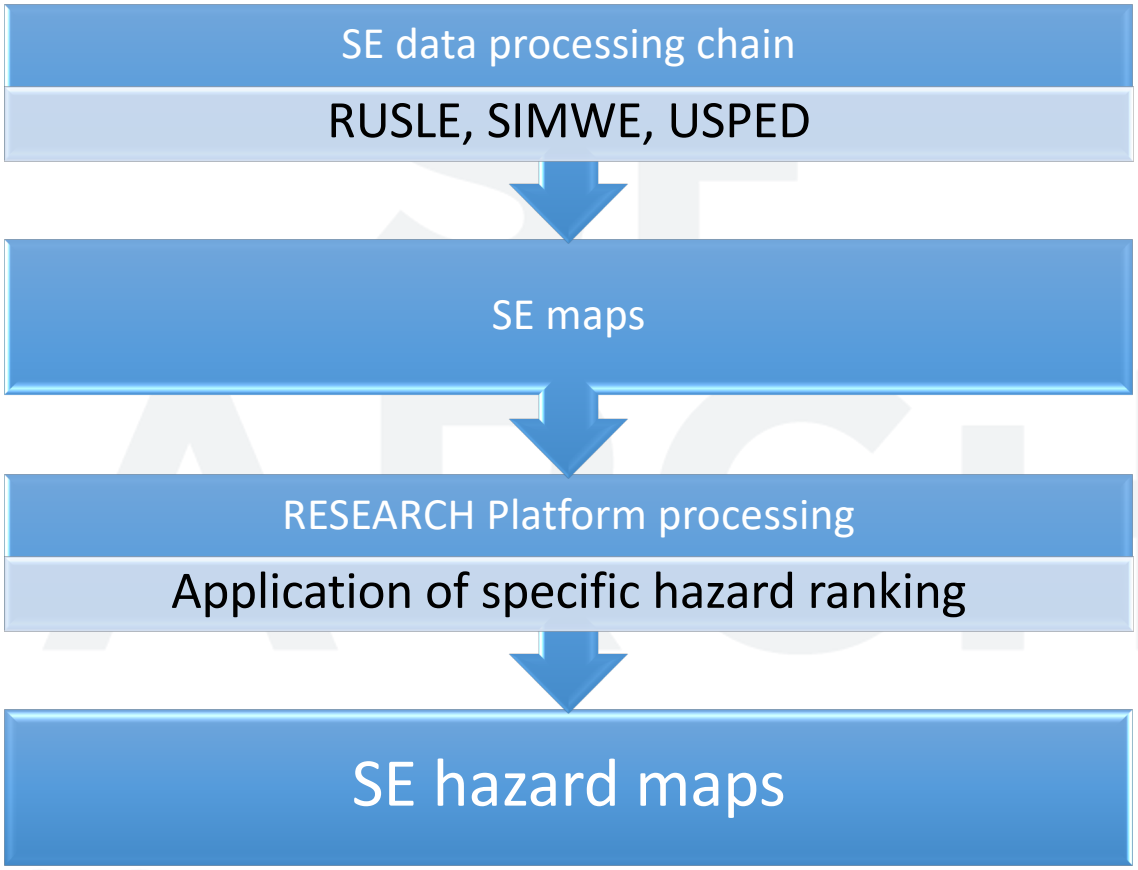
Differential SAR interferometry (D-InSAR) and Persistent Scatterer Interferometry (PSI) methods are used to assess the stability of the ground and identify ground motion caused by processes as subsidence and landslides at, and near, archaeological sites.



Soil erosion hazard assessment

Soil erosion is the natural phenomenon of soil loss manly due to water runoff and wind. The process can be accelerated and intensified by climate change and human activities. Soil erosion can impact in different ways on the archaeological features exposed to it, in particular archaeological deposits because, when soil is eroded, the effective soil thickness above them, that represent a protection, is reduced.

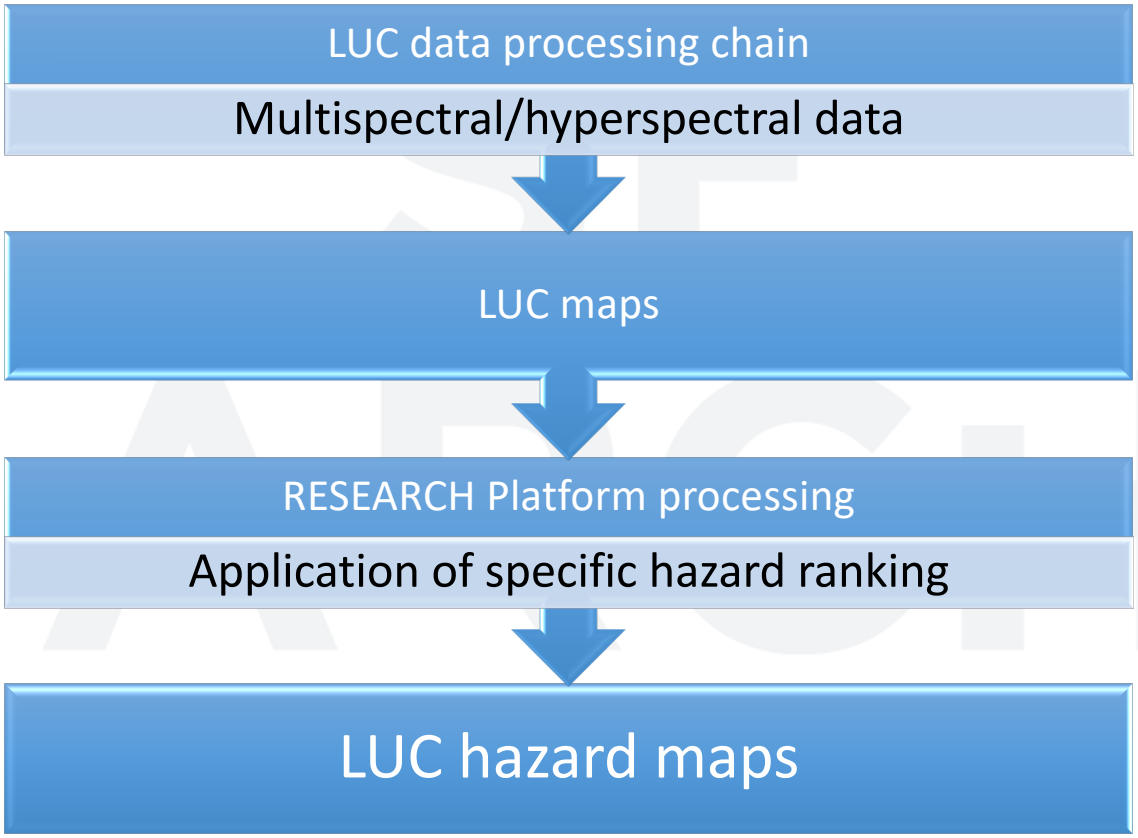
SE estimation models (RUSLE, SIMWE, USPED) will be applied, by taking into account specific parameters such as rainfall factor, topography and land cover management. Multispectral satellite images of high spatial resolution will be analysed simultaneously with high resolution Digital Elevation Model (DEM). Remote Sensing and GIS will be integrated in order to estimate long-term average annual soil loss and accumulation.



Land use/cover change hazard assessment

Beside local environmental conditions and climate change, most of the factors potentially dangerous for AH are related to intensive land use and **land use changes**. AH preservation can be threatened, in fact, by urban sprawl, building and mining activities, pollution, agriculture and pasture related activities, which all imply physical impacts influencing the preservation of archaeological records.

Categories of land use/land cover, defined specifically for each test case, will be studied for the monitoring of important changes in a given span of time. In order to conduct these analyses, satellite and aerial images (multispectral and hyperspectral), terrain attributes, and data collected in field investigation will be used.



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Vulnerability and exposure of AH

VULNERABILITY (CONCEPT)

AH can be said to be vulnerable by definition. The vulnerability ranking is based on the more or less ascertained archaeological value of detected features.

EXPOSURE (CONCEPT)

In theory, the presence of archaeological features, effective or supposed, implies always a high exposure level.
(standard value assigned = 1)

RESEARCH VULERABILITY (RANKING)

Archaeological feature type	Description	Method of identification	Vulnerability Rating
No evidence	--	--	None
Soil/Crop/Shadow marks	Visible differencies/anomalies on the soil surface (colour/vegetation growth/topography), possibly corresponding to buried, superficial or also disappeared archaeological features not yet verified through other techniques)	Aerial/satellite observation	**Low**
Surface archaeological material (in association or not with Soil/Crop/Shadow marks)	Areas presenting dispersion of archaeological material on soil surface (possibly corresponding to buried arch. features not yet verified)	Field walking survey	**Medium**
Buried/unburied structures, including earthworks (in association or not with Surface archaeological material)	Visible structures and buried structures and stratigraphy.	Visible or identifiable through geophysical survey or archaeological excavation	**High**

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Exposure of buiried AH to soil erosion

EXPOSURE (CONCEPT)

In respect to soil erosion, the exposure of buried features follows the principle that as much as a preserved archaeological context is buried deep, the more it is protected from superficial erosion of soil.
Wherever the burial depth of the archaeological deposit is known, it can be applied a coefficient able to represent the differences in the exposure of the features, that reduce the final risk level.
Given a maximum exposure 1, the gradient will be comprised between, 0.01 (corresponding to the deeper structures surveyed using geophysics) and 0.99 (indicating the structures visible on the surface or very close to it).

EXPOSURE INDEX

Burial depth of structure	Reduction Index	First vulnerability rating class of index application	Vulnerability rating in respect to Soil Erosion
≥ 0 cm	1	3	3
-10 cm	0,97	3	2,91
-20 cm	0,94	3	2,82
-30 cm	0,91	3	2,73
-40 cm	0,88	3	2,64
-50 cm	0,85	3	2,55
-60 cm	0,82	3	2,46
-70 cm	0,79	3	2,37
-80 cm	0,76	3	2,28
-90 cm	0,73	3	2,19
-100 cm	0,70	3	2,10

First draft of RESEARCH exposure index (February 2020).

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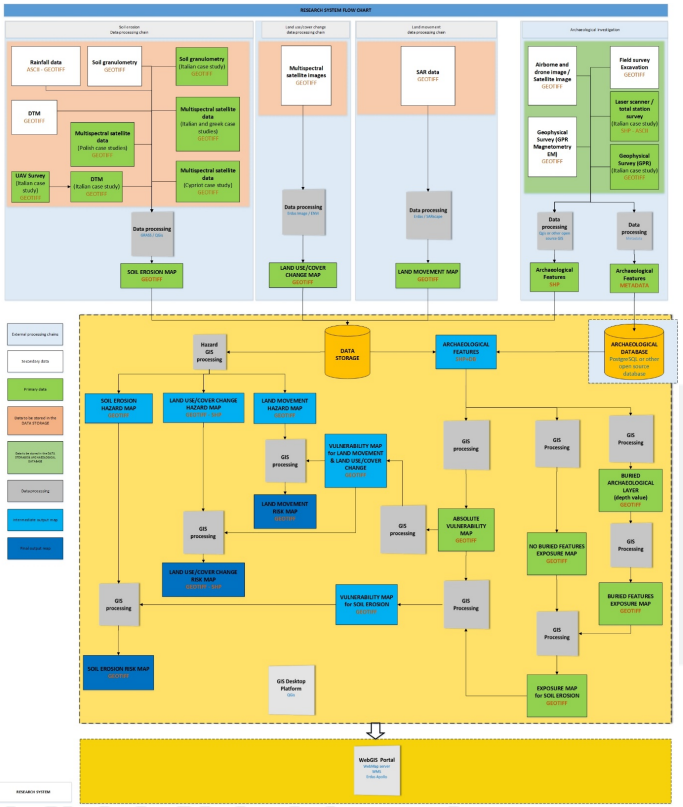
RESEARCH (Web)GIS Platform

The **RESEARCH System** is intended as the combination of the external data processing chains for soil- related threats assessment and archaeological features mapping, the archaeological database, and the **WebGIS Platform**, composed by the GIS Desktop Platform and the WebGIS Portal. The System has been designed on the base of the methodology adopted, elaborated by the authors of this contribution and described above. In particular the GIS Desktop Platform is thought to be used to transform the products of external data processing chains first in hazard, vulnerability and exposure maps (intermediate products), and then in risk maps (final products), by combining hazard and vulnerability maps.

The Platform is at the moment under development.

The processes synthetized in the scheme on the right exemplify the scientific requirements of the Platform, while on a technical base, the aim is to increase process automation as much as possible.

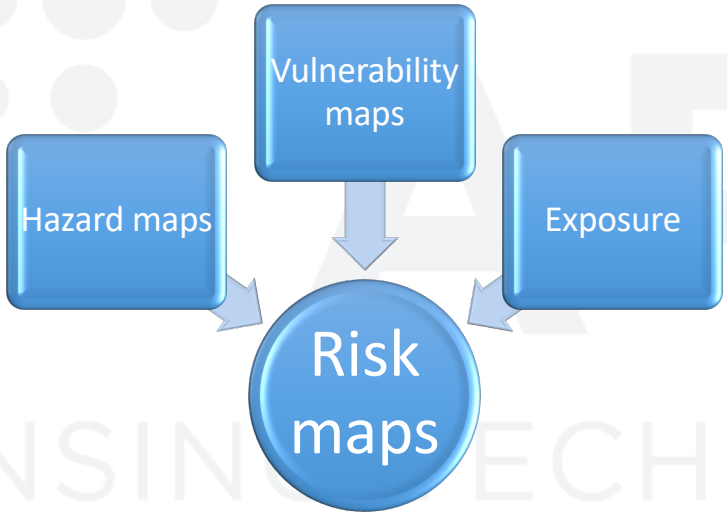


First draft of RESEARCH system:work flow and platform (February 2020).

Risk assessment

The GIS Desktop Platform will transform maps of archaeological features in Vulnerability maps by the application of the vulnerability ranking.

The GIS Desktop Platform will transform land movement, soil erosion, and land use/cover change maps in proper Hazard maps (*Land Movement, Soil Erosion*, and *Land use/cover Change Hazard Maps*) through the application of specific hazard values.



The GIS Desktop Platform will apply to any archaeological features an exposure value = 1. In the case of Archaeological deposits, wherever depth realted information will be available (i.e. GPR data), the exposure index will be applied (0,01⇢ 0,99)

The WebGIS Portal will showcase:

- the opensource input data used in data processing chains and related intermediate output data (*Land Movement Maps, Soil Erosion Maps, Land use/cover Change Maps*, and *Archaeological Features Maps*);
- the primary data produced by the GIS Desktop Platform for the elaboration of *Exposure Map for Soil Erosion* (*Buried Archaeological Layer*, *Buried Features Exposure Maps*);
- the intermediate products (*Land Movement Hazard Maps, Soil Erosion Hazard Maps*, *Land use/cover Change Hazard Maps*, the related *Archaeological Vulnerability Maps*, and the *Exposure Map for Soil Erosion*) produced by the GIS Desktop Platform;
- final products (*Land Movement Risk Maps, Soil Erosion Risk Maps*, *Land use/cover Change Risk Maps*) produced by the GIS Desktop Platform.

Final remarks

This contribution aimed at presenting the results of the first year of Project RESEARCH, in particular:

- definition of the risk assessment methodology, and the related requirements of the RESEARCH GIS Platform;
- the study of the state of the art about soil related threats and their assessment, and the design of data processing chains.

Future activities

- completing data collection, partners will proceed with the application of hazards assement (data processing chains) and production of intermediate output data
- mapping and cataloguing of archaeological features
- Completing and testing the Platform
- Field validation activites

All these activities will be carried on as much as possible through secondments.

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Thank you for your interest.

If you want to know more about RESEARCH project, please visit our web-site

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