# Rendina study site, Basilicata, Italy

## Highlights of work carried out in the DESIRE Project

## Based on work by University of Basilicata, Italy

## The study site

Large areas of southern Italy are prone to erosion where the soils are formed on soft fine-grained Tertiary and Quaternary sediments. The prevailing climate is characterised by long dry periods with short intensive wet periods, mainly in early spring and late autumn. In the dry periods the soils and sediments shrink, and in the wet periods they swell. These processes reduce stability and increase the likelihood of erosion, and can result in spectacular gullies and other erosion features. Since the soils and sediments are so sensitive, rainstorms and tillage will result in erosion unless agricultural practices are carefully managed. Practices were tested to determine the optimum policies to avoid further degradation.

The Rendina reservoir represents the best water stock of the area and the one that can really mitigate the desertification process in the area itself and in the downstream Ofanto valley. The Rendina reservoir utilization and management is under the responsibility of the Consorzio di Bonifica del Vulture e Alto Bradano. This Consortium has a Council where farmers and farmer unions sit, so that decisions are ultimately taken by farmers. Data available at the moment tells us of a very high rate of sediment trapped in the reservoir each year, corresponding to 10-13 Mg/h/a of specific sediment yield corresponding to a higher erosion rate at plot scale and a unsustainable sedimentation rate in the reservoir (7 $Mm^3$ - stored at present in the reservoir).

The main problems at watershed scale related to soil degradation are highlighted in the intense soil erosion process (diffuse and concentrated in arable land, vineyards and olive orchards), diffuse mass movement and soil slips , river bank erosion, soil erosion by tillage, lost of natural drainage system , large sediment source areas ( soil erosion evidences until 1cm/year in olive orchards for water and tillage erosion and until 2 cm/year in steep slope arable land), and high connectivity between primary source of sediment and drainage network. Land levelling for new vineyard plantations and periodic reshaping of arable land is affected by frequent shallow mass movements.

At present the dam has structural problems and the reservoir is left empty. There is an increase in population: e.g. Melfi has and average population increase rate of about 1.5-2% per year .Data available at the moment show that there is a very high rate of sediment trapped in the reservoir each year, corresponding to 10-13 Mg/hm2/a.

*The Rendina dam*

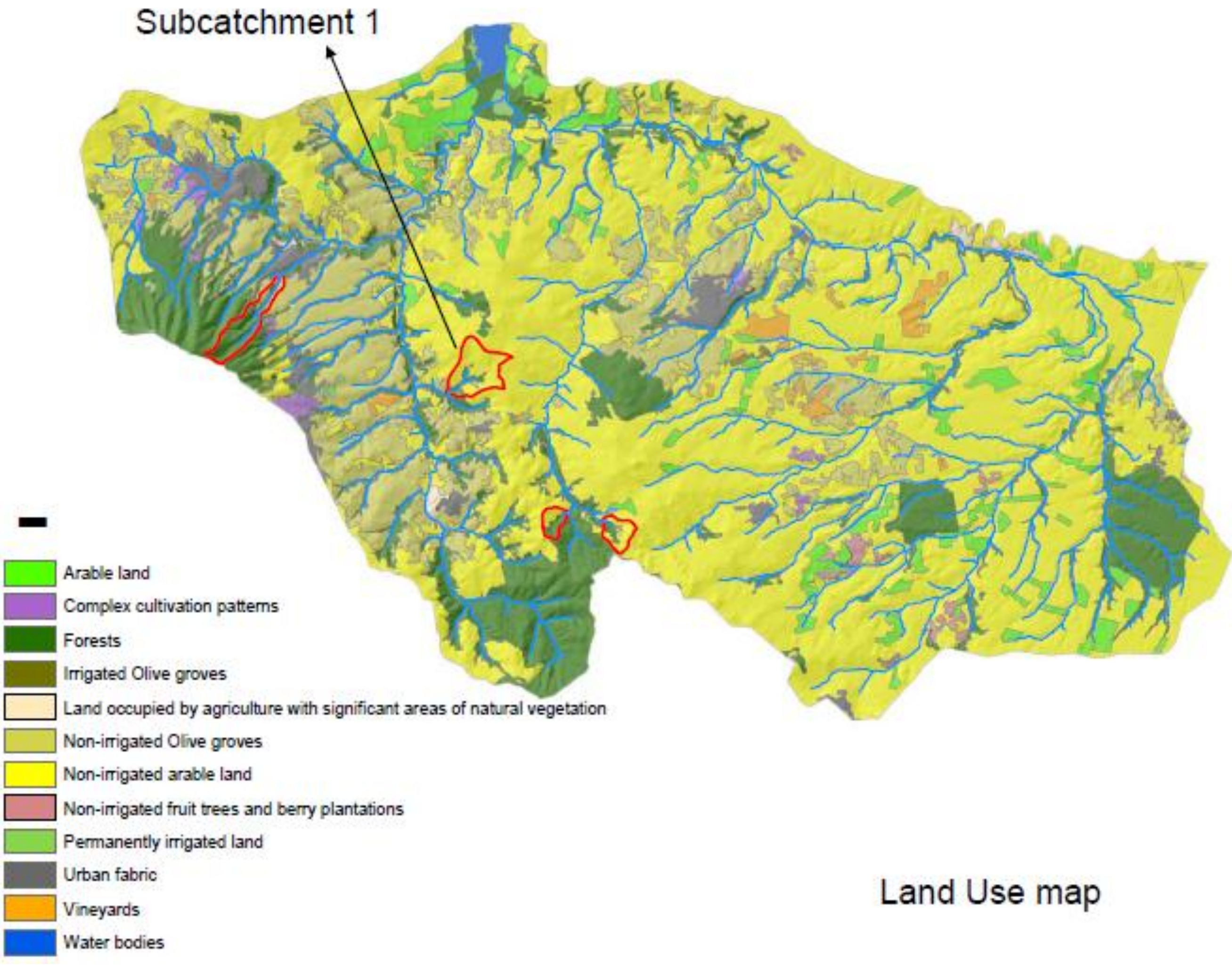
*Ploughing up and down slopes has increased soil erosion, filling the reservoir with sediment*

Some farmers do not help the situation:

1. canals and ditches are often obstructed by agricultural wastes (plastic pipes, plastic containers of tomato plants)
2. bridges over ditches and canals are rarely used while to save time tractors pass over the drains and damage them
3. soil is exported from field during field works because the cultivated part ends at the field border without leaving room for tractors to manoeuvre and soil gets left in ditches, in canals and on roads
4. vegetation is often burned by the farmers , exposing banks to erosion

Farmers know that vineyards and fields should be planted and tilled along contours. Usually farmers follow a rotation where wheat is substituted by fallow every third-forth year or by alfalfa but if wheat prices are high, no fields are left fallow. Rilled and gullied fields are considered normal. The only farming carried out in a sustainable way is sponsored by university research.

*To avoid soil erosion fields such as this one should be ploughed parallel to the contours*




Land Use map

*Clearing land with heavy machinery and burning unwanted vegetation contribute to sever soil erosion*

Detailed monitoring of the environment was carried out to establish the relationships between land use and management to soil erosion,and provided data to test a Connectivity Index. This was used to assess the degree of improvement when new strategies were trialled

**Monitoring activities**

Monitoring started in 2nd year and ended in winter 2010 -2011(end of 4th year), and concentrated on the Connectivity issue as it is correlated with the various type of land use and Land unit systems (**LUS**) and degradation and survey and measurements on the shallow Landslide affected areas (**SLAA**) . The monitoring activity was intended primarily as support of modeling of new tools in order to improve the assessment of degradation processes as soil erosion, soil degradation, mass movement etc.

Connectivity plays a fundamental role in the sediment redistribution inside the hillslope and towards final sinks (e.g. at the Rendina reservoir). Connectivity plays also a relevant role in the sediment yield contribution from shallow landslide-affected areas (connection with PESERA-L new components for the PESERA model). During this phase the field work was structured in 3 main phases:

1) Monitoring rill and ephemeral gullies during the spring 2009 and identification the main affected LUS, with measurements of main geometrical characteristics useful for erodibility analysis by Junction methods (Torri et al. 2006, ; Salvador et al. 2009), and calculation of rill erodibility relative indexes. (activity ended spring 2010)
2) Field connectivity index survey (FIC) (methodology: Borselli et al. 2008) to link with GIS Index of connectivity. (ended spring 2010)
3) Neo-formation **SLAA** (survey spring and autumn winter 2009 and spring –autumn 2010); LUS identification and runout measurements by multi temporal survey based on aerial photos photointerpretation 2003 and 2007 and 2010.

After survey activities in the 4th year a set of analyses were completed in winter2010:
1) Identified of LUS major affected by SLAA and their representation in GIS system
2)Average soil slip run-out length measurement for SLAA (required input parameter for PESERA-L model) by field survey and multi-temporal photointerpretation
3) database creation and Synthesis of the analysis in order to obtain PESERA-L data for its application in the Rendina basin study site.

**Survey for additional shallow landslide component (PESERA-L) for PESERA Model**

In the Rendina study site are relevant Neo-formation shallow Landslide and soil slips that occur mainly during the late winter or early spring. This type of shallow landslides some time behave as planar translational landslides until flow or mudslides. The areas mainly affected are the cereal cropping areas usually deep tilled at end summer and sowed in autumn. The tillage operation in summer sometimes erase the landslide tracks . Some time for the larger landslides the tillage operation only is not enough to remove the landslides and land levelling with bulldozers is needed in order prepare field for new tillage operations. The most shallow Landslide Affected Areas (SLAA) are related to association of cereal crops land use and soil units 7.3 6.3 and survey spring and autumn winter 2009. Google map april 2007 and field survey April –May 2009, spring and winter 2010. often the mayor landslide movement are still visible at the end of cereal harvesting. That's because the disturbed of the field surface s so string that the machines cant' harvest the portion affected form landslides.

The main objectives of this survey were:

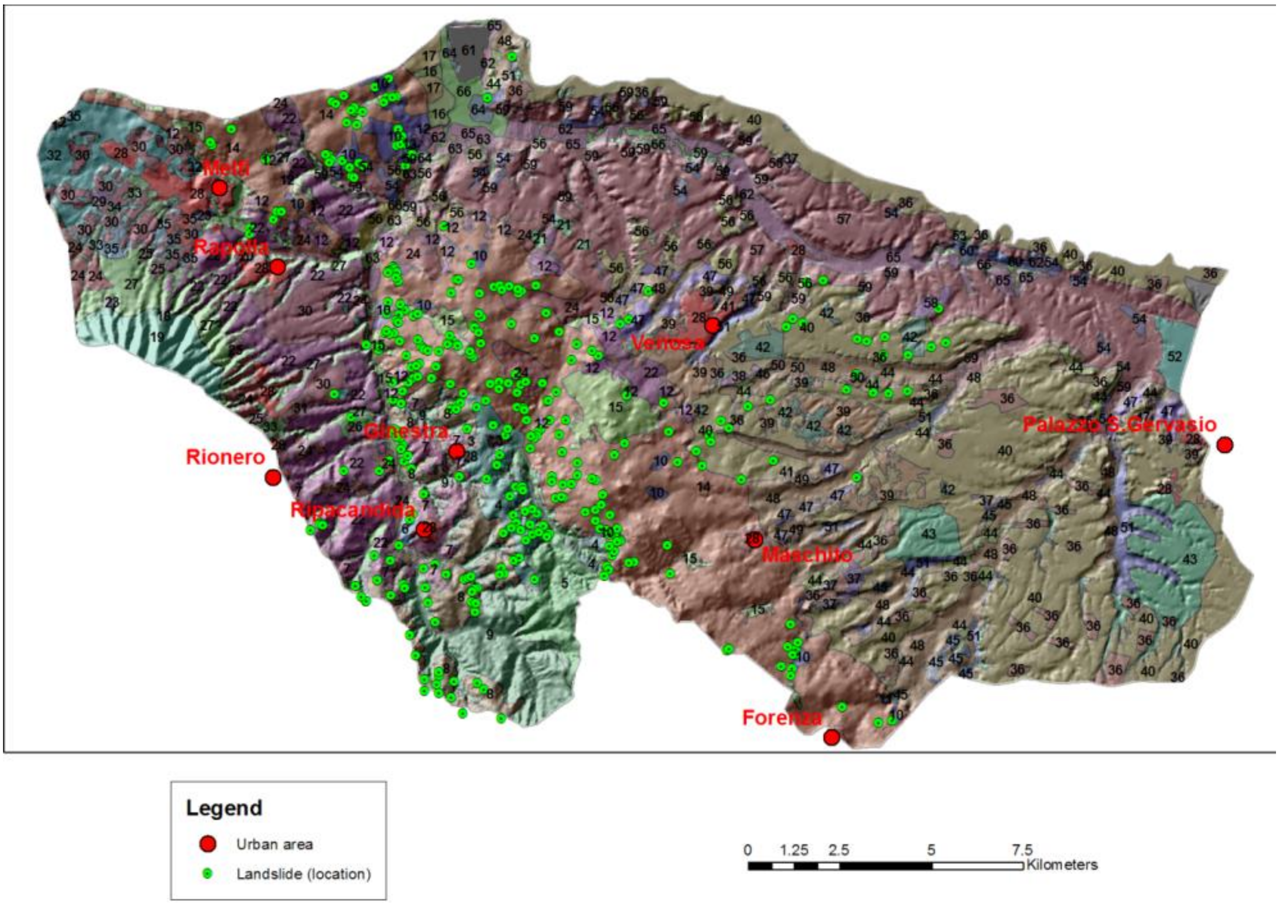
1) Identification of SLAA
2) Identification and positioning on maps statistical significant sample of shallow landslides .
3) Measurement of runout length (m)and surface in each landslide in the sampled areas
4) Determine the mean runout length in each LUS if affected by SLAA.
5) Identification of more relevant morphological – topographic parameter that can affect the probability of mass movement (e.g. slope spectrum associated to each LUS)

This activity was completed in winter 2010 and the main results are summarised :

1) **Definition of LUS**. A total of 66 LUS has been defined in the whole area of study site. The LUS has been defined using the intersection of Soil Units (soil map at scale 1:250.00) and land use class (land use class defined for PESERA model). For cartographic generalization procedure, a minimum threshold for LUS area (< 1ha) and rate area/perimeter (A/P<25) been used eliminate and joined smaller unit to closer larger ones in order to avoid smaller and not representative units, considering working scale of 420 km$^2$.
2) **Identification of SLAA in each LUS** . The main affected LUS are the areas characterised by The most shallow Landslide Affected Areas (SLAA) are related to LUS where exist association of cereal crops land use and soil units 7.3, 6.3 corresponding respectively to Luvi-Vertic Phaeozems and Eutric Cambisols. The same unit are characterised by the following parent materials: 7.3: clayey slate and marls (varicolored clays complex); 6.3: quarzt-arenite with thin clayey layer.
3) **Identification and positioning on maps statistical significant sample of shallow landslides**.

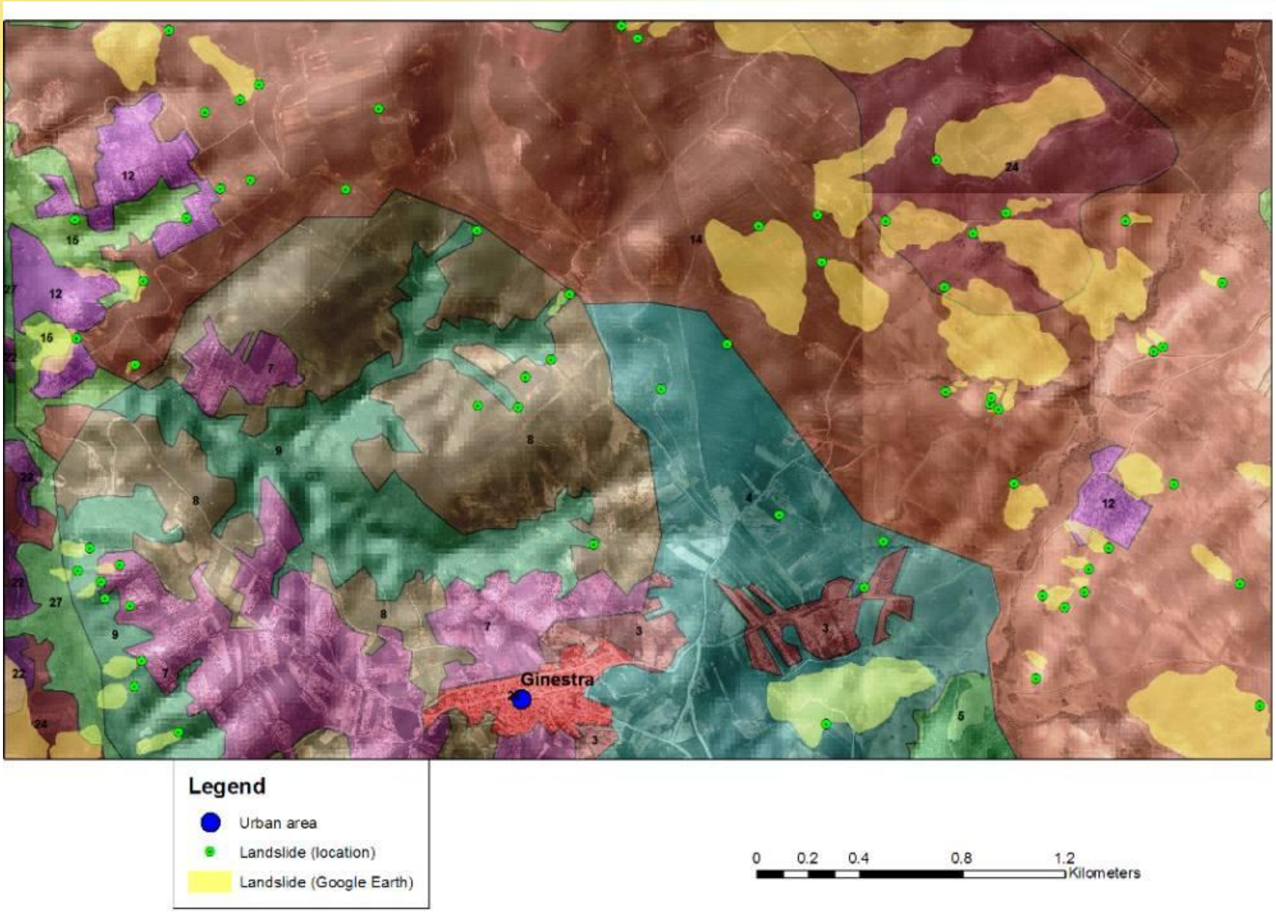
   This is one of the most important step in this kind of survey. The central area of then basin and a belt in direction NW-SE is the most affected my mass movement (fig. 1).. The measured run-out length of

256 shallow landslides (fig. 1) was analysed in details with their total surface and relative percentage of SLAA in each LUS(fig. 2 and 3). In addition the extension of general unstable areas was added to this database for a total 354 SLAA and unstable areas affected..




*Distribution of measurement point of runout length (256 points in green). The number in bold indicates the LUS codes. The area in color indicate the extension of LUS*


*An example of Shallow Landslide Affected Areas*



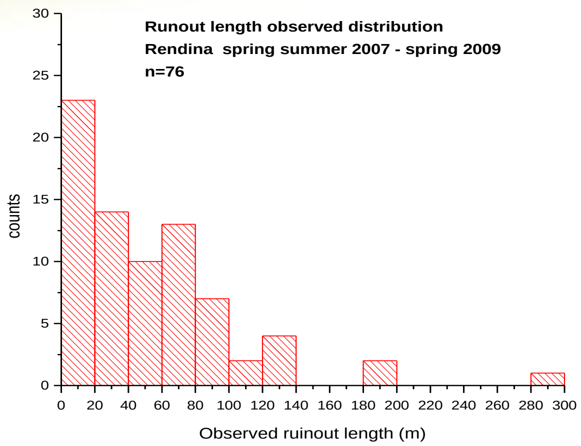

Example of Land Unit Systems and overlapped Shallow Landslide Affected Areas, and unstable area in yellow

**Measurement of runout length (m)**

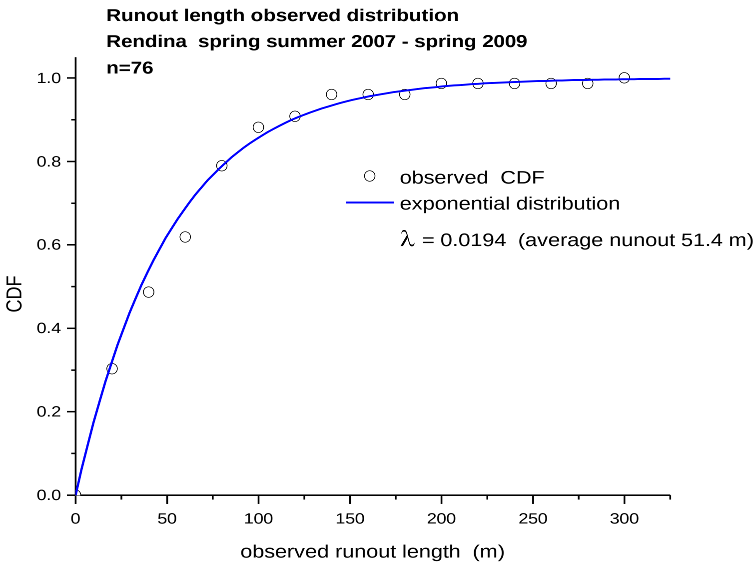
The final measurement of runout length of each LUS was done using the Google map images (April 2007and spring 2010) after that the main affected areas are identified also on 2003 aerial stereo photos and 2009 field survey. Additional data are also recorded as: coordinates, total length of the affected movements and main orientation (azimuth). During the field survey of the 2009 we observed that the main depth of the shallow mass movement was usually in the range 1-1.5m and was controlled mainly by the depth of R horizons. Usually the this type of mass movement is associated with a slope angle varying between 9° to 18° with an average 12°-13°. Most of these landslides are ephemeral because, due to periodic land leveling and tillage they continue to appear always in the same place, year by year. Larger mass movement are also present and historically well known in the watershed (Rio Lapilloso) but this type of deep seated or very deep translational landslide are not considered in the additional component for PESERA and are not considered here.

**Determination the mean runout length**

The determination of average runout length was done according to the methodology proposed from Miller & Burnett, (2008). The average runout length on the observed sample concentrated in soil unit 7.3 and 6.3 in this case is 51.4 m. This value indicate a potential large mobility of the material. Following the model prosed by Miller & Burnett, (2008) the inverse of average runout length is the λ parameter that is the exponent of a exponential type statistical distribution. The observed empirical distribution will fit very well with and exponential distribution with exponent λ=0.0194 ( 0.0.194=1/51.4).




*Example of distribution of runout length*




*Example of calculation of average runout length*

**Conclusions on survey and monitoring**

The SLAA affects only 3.23% of the whole watershed area (13.8 km2 on total surface of 420 km2) . this percentage is probably optimistic because this percentage can be larger in occasion of particularly not favourable climatic condition (wettest years with lager cumulative rainfall during autumn winter spring). But some LUS can be considered severe hot spot for SLAA and as well primary source of sediment yield due to large landslide runout.

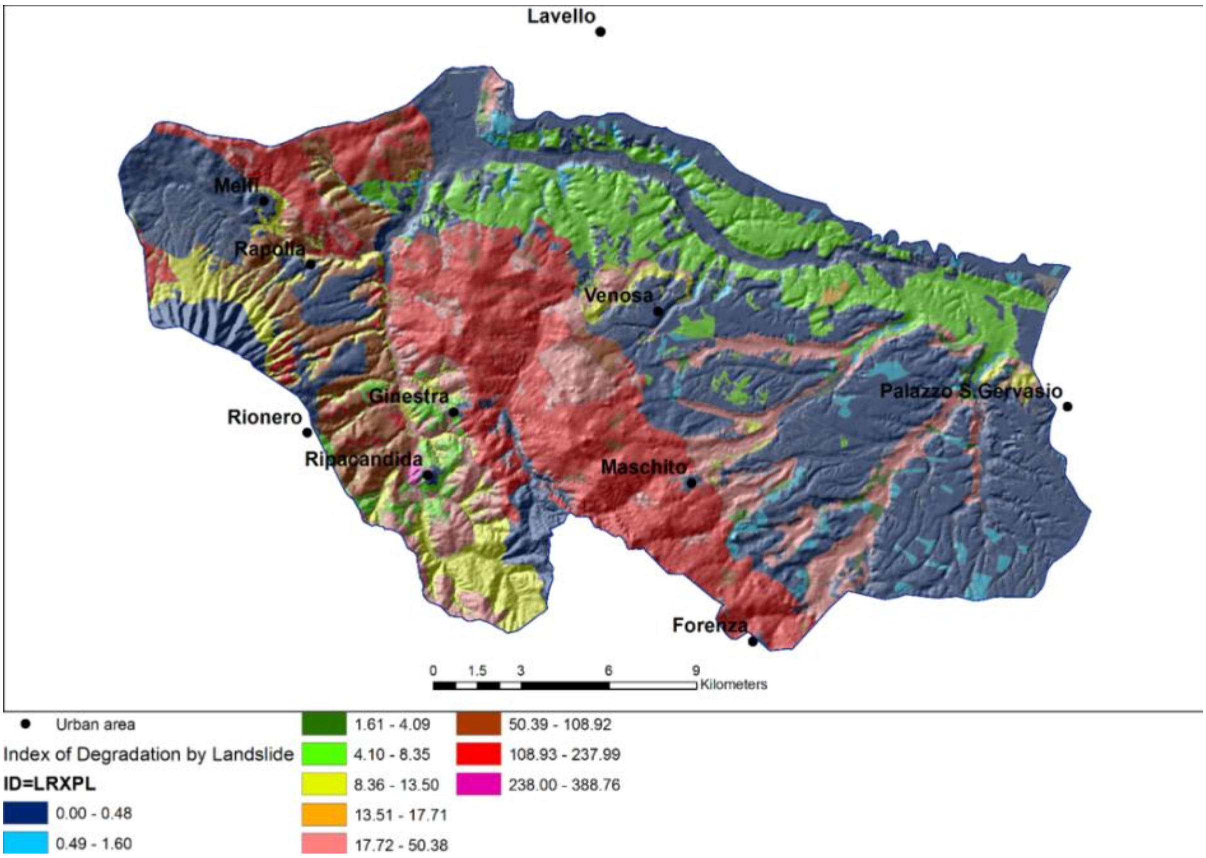
## Testing and improving indicators

The indicators proposed are all directly linked to soil degradation hazard or severe soil degradation conditions :

1. χ, the gulling coefficient, that can explain the relative potential development of deeper incision in arable lands and development of gully system starting from a concentrated rill system . This parameter is dependent mainly of the soil type and profile.

2. FIC (field, index of connectivity): that can classify the on-site connectivity after and erosion event and can be useful to reclassify all the connectivity, by IC index on entire watershed.

3. percentage of landslides affected area and mean run-out length in each LUS are combined in a qualitative indicator , named ***index of degradation from landslides*** (**ID**) that have a promising possibility for an easy field indication of the true areas affected by landslides in a way that the process is effectively responsible of soil degradation. An area may be affected by shallow landslides phenomena but if the runout is negligible this will not produce an effective soil loss.




*Distribution of index of degradation bay landslide (product of average runout length Lr and percentage of area affected by landslides (PL). in brown, red and violet the area most sensitive to land degradation due to landslides*

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