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A standardized GIS-based methodology for assessing water erosion risk in sloping vineyards: a case study in the UNESCO vineyard region of Monferrato (Piedmont, NW Italy)

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Soil erosion by water

is a natural process in **landscape evolution**

is generally a natural «slow» process

but **landscape management** can lead to not tolerable soil erosion rates with onsite and offsite effects

In Europe:
- **62 % of soils is** affected by **some kind of degradation**
- **7.2 % of agricultural soil** is affected by **severe erosion** (**33 % in Italy**!)
- **soil erosion** has annual impact of **1.26 billion in Europe**, **0.6 billion € in Italy**

… in vineyards

…is one of the main soil degradation process affecting vineyards in the Mediterranean area (Prosdocimi et al., 2016), due to the combination of different factors:

Erodible soils
(low organic content, fine textures, poor aggregate stability)

Rainfall regimes
(high rainfall intensity)

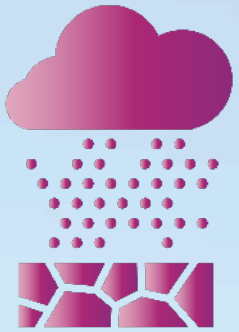
Topography
(slope gradient and lenght)

Vegetation cover and soil management
(soil disturbance and low cover within rows)

→ vine-growers need **awareness, information and reliable evaluation tools** in order to adopt sustainable soil management to prevent soil erosion risk

Revised Universal Soil Loss Equation (RUSLE)

SOIL LOSS (SL)



Rainfall Erosivity
R-Factor

Slope Length and Stepness
LS-Factor

Cover and Management
C-Factor

$$R_x \mid K_x \mid LS_x \mid P_x \mid C$$

Soil Erodibility
K-Factor

Support Practices
P-Factor

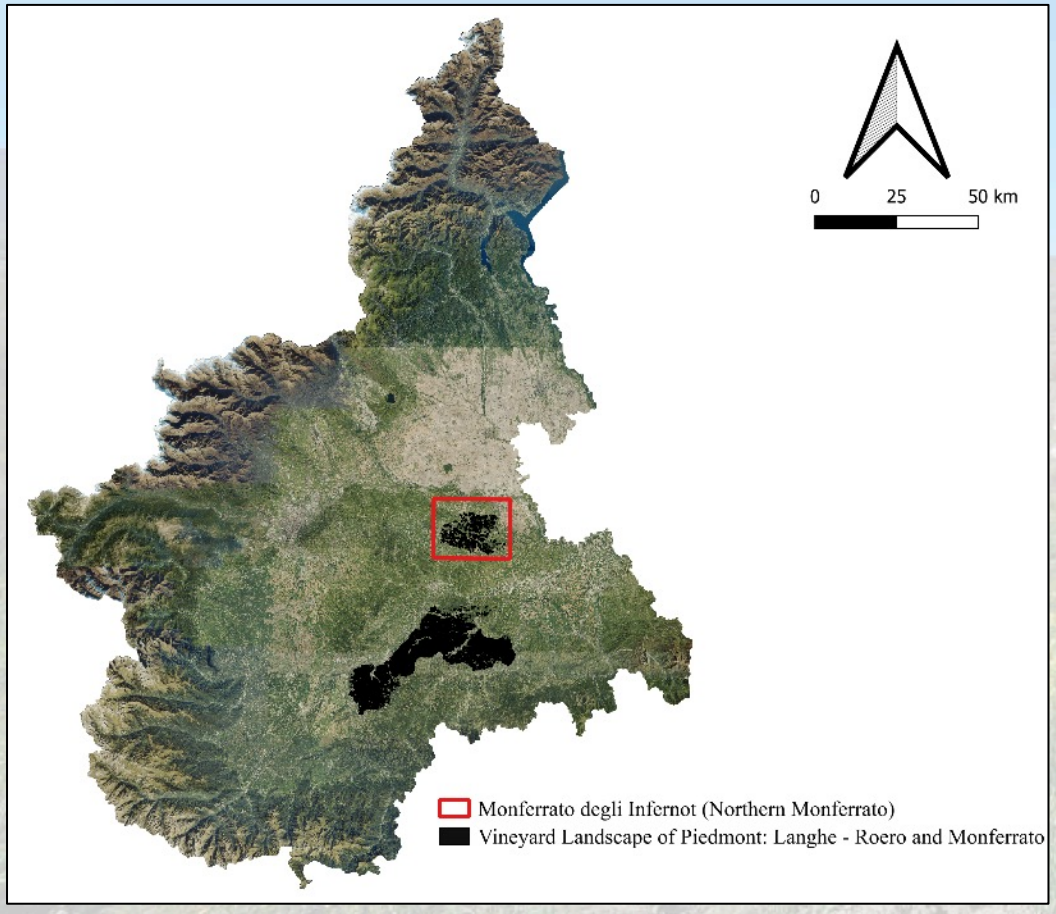
https://esdac.jrc.ec.europa.eu/themes/rusle2015

- Adaption of a methodology based on RUSLE already implemented in olive groves area in Spain (Gómez et al., 2023) to a vine-growing study area in Piemonte (North Italy)
- **AIM:** Estimation of average annual soil erosion rate under different management situations over a study area, to compare different scenarios and evaluate effectiveness of soil protection solutions.
- using **freely available information** from digital databases and remote sensing platforms

Study area

“Monferrato degli Infernot”

Typical hilly vine-growing landscape in the northern part of the “Vineyards Landscape of Piedmont: Langhe-Roero and Monferrato", recognized as a World Heritage Site by UNESCO since 2014.



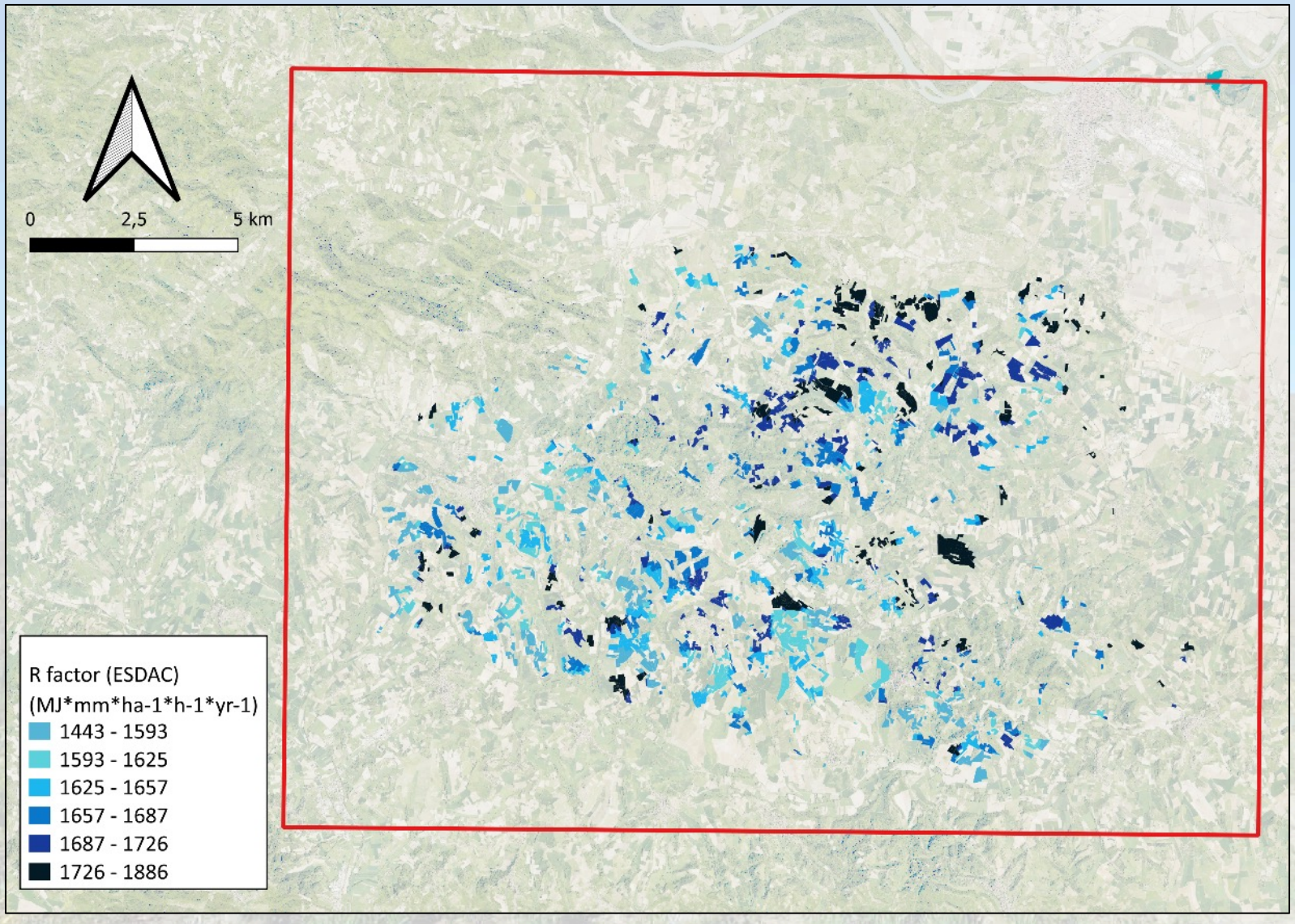
2. Material and methods

Workflow	Information gathering	1 - Parcel information	Shapefile identifying the polygons of the different individual vineyards of the Piemonte region.	(*Regione Piemonte, 2026*).
		2 - Terrain information	Raster file with the DEM at 10 m grid size of the Piemonte region.	(*Regione Piemonte, 2026*).
		3 - Rainfall erosivity	Raster file with the average annnual rainfall erosivity of RUSLE for current climate for Piemonte region.	(*ESDAC, 2026; Panagos et al. 2015*).
		4 - Soil erodibility	Raster file with the soil erodibility of RUSLE for Piemonte region.	(*ESDAC, 2026; Panagos et al., 2014*).
	Information Processing	5 - Determination of LS factor	Filling sinks using Fill sinks (*Wang and Liu, 2006*) function of QGIS. Raster map of LS factors of RUSLE using the LS function of QGIS (*Desmet and Govers, 1996*).	
	Calculation	6 - Determination of baseline erosion at parcel level	Use zonal statistics in QGS to determine R, K, LS values for each vine parcel, export into and excel file and multiply to obtain an average baseline value of RKLS.	
		7 - Determination of C factor at parcel level	Use of ORUSCAL (*Gómez et al, 2020*) to obtain C-factor for three soil managements adopted in the region, according to *Biddoccu et al, 2020*. Calculation of RKLSC for the three soil management scenarios.	
		8 - Determination of P factors at parcel level	Use of P factors for contour lines and terraces, from *Wischmeier and Smith (1978)* based on slope.	
		9 - Determination of water erosion	Calculation of soil loss RKLSCP in excel for different scenarios.	
	Analysis	10 - Mapping and distribution	Analysis of soil erosion rates distribution and mapping in QGIS adding results to table of contents of shapefile with vine plots in QGIS.	

R factor distribution in Northern Monferrato

Data extracted from *ESDAC* https://esdac.jrc.ec.europa.eu/tags/r-factor

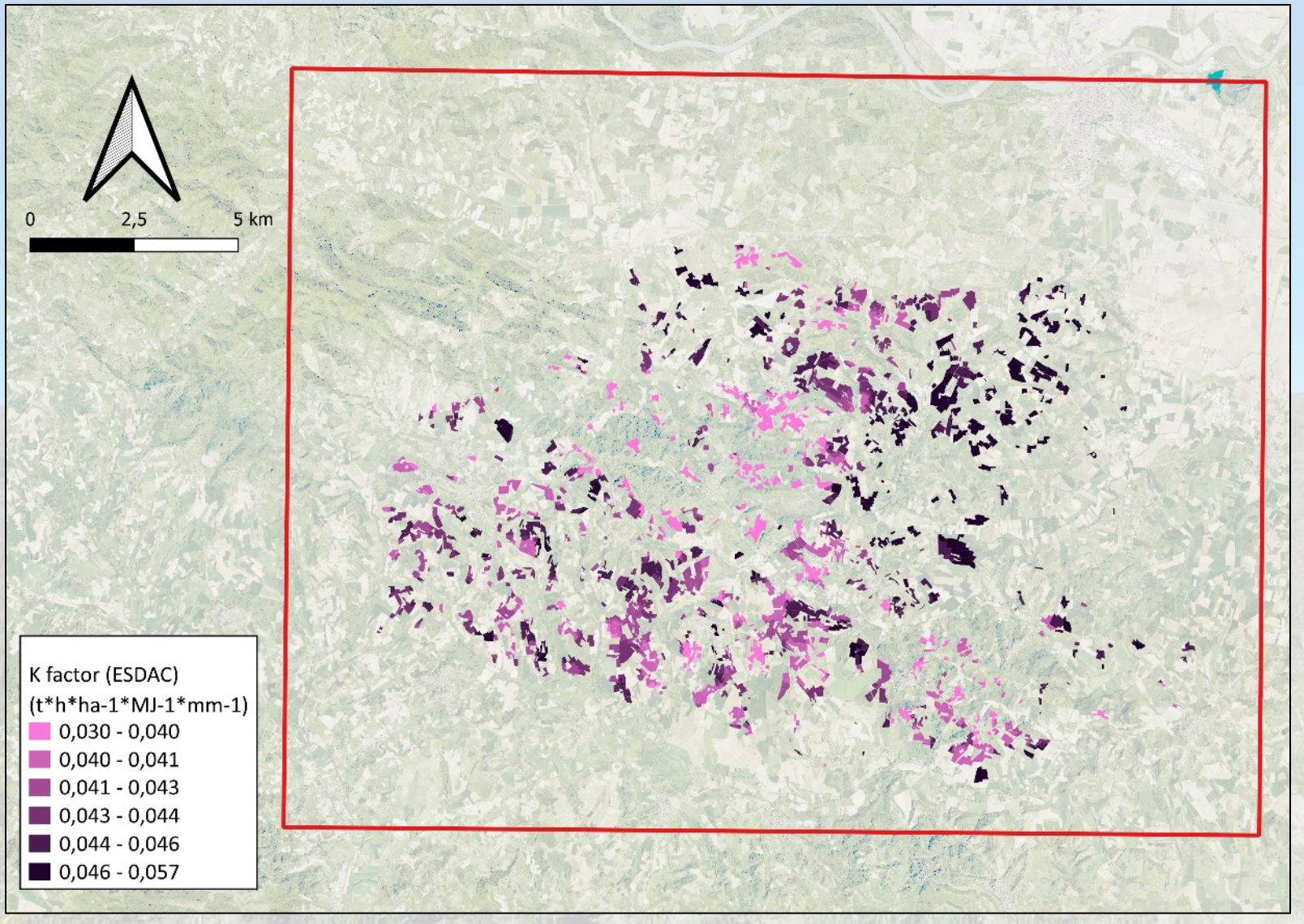
(Panagos et al. 2015).



K factor distribution in Northern Monferrato

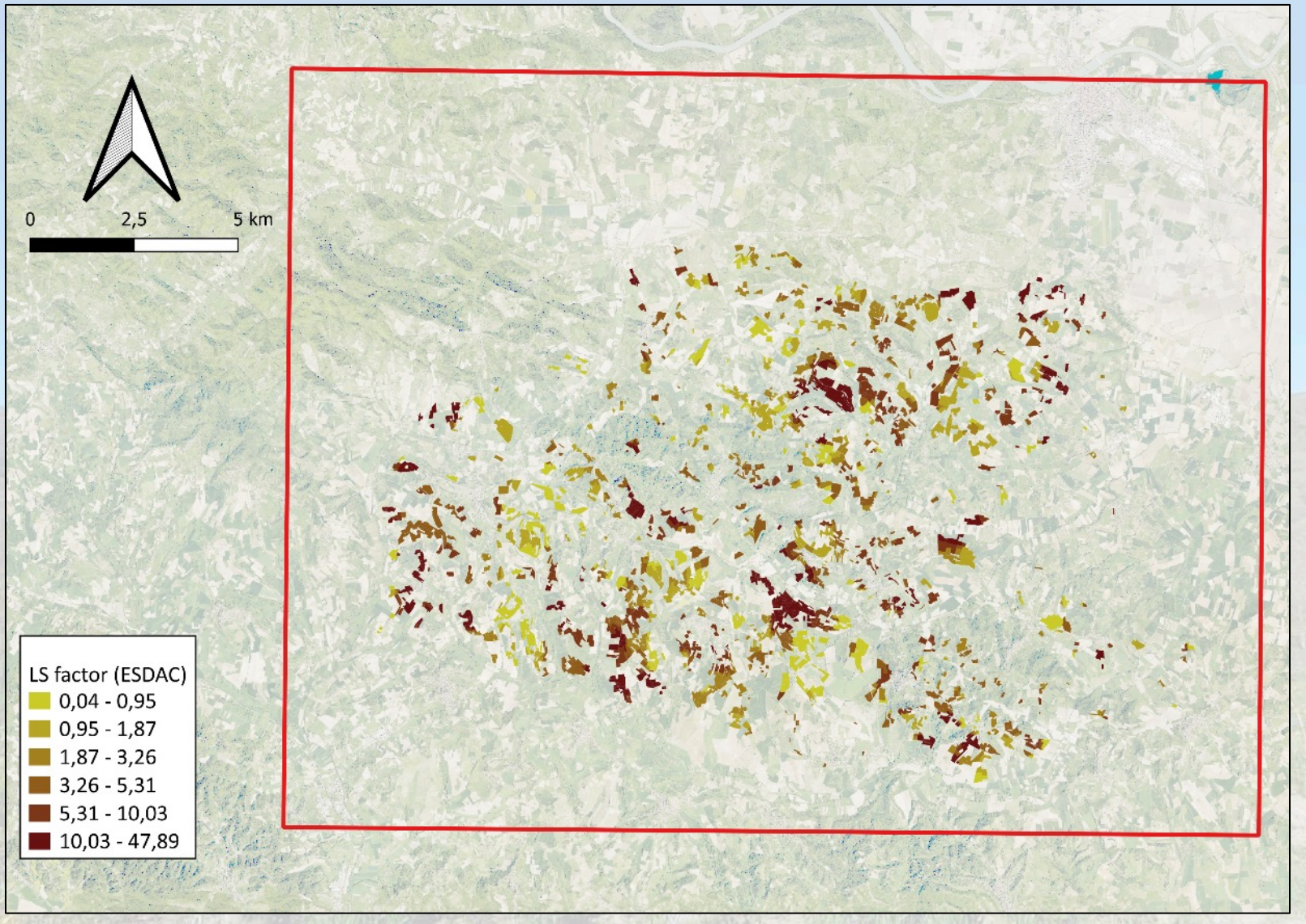
Data extracted from *ESDAC* https://esdac.jrc.ec.europa.eu/content/soil-erodibility-k-factor-high-resolution-dataset-europe

(Panagos et al. 2015).



LS factor distribution in Northern Monferrato

Terrain data extracted from raster file with the DEM at 10 m grid size of the Piemonte region, [Geoportale Piemonte]



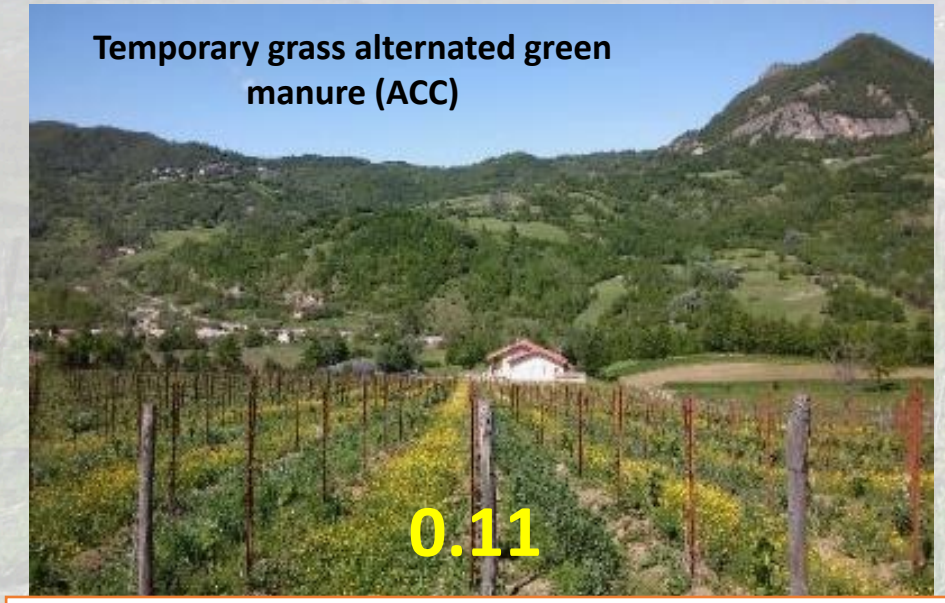
Filling sinks using Fill sinks (*Wang and Liu, 2006*) function of QGIS. Raster map of LS factors of RUSLE using the LS function of QGIS (*Desmet and Govers, 1996*).

2. Material and methods

Cover and management C-factor

Conventional tillage (CT) Permanent grass cover (GC)

Temporary grass alternated green manure (ACC)



Support practices P-factor

Three scenarios:

(i) rows along the slope in all cases,

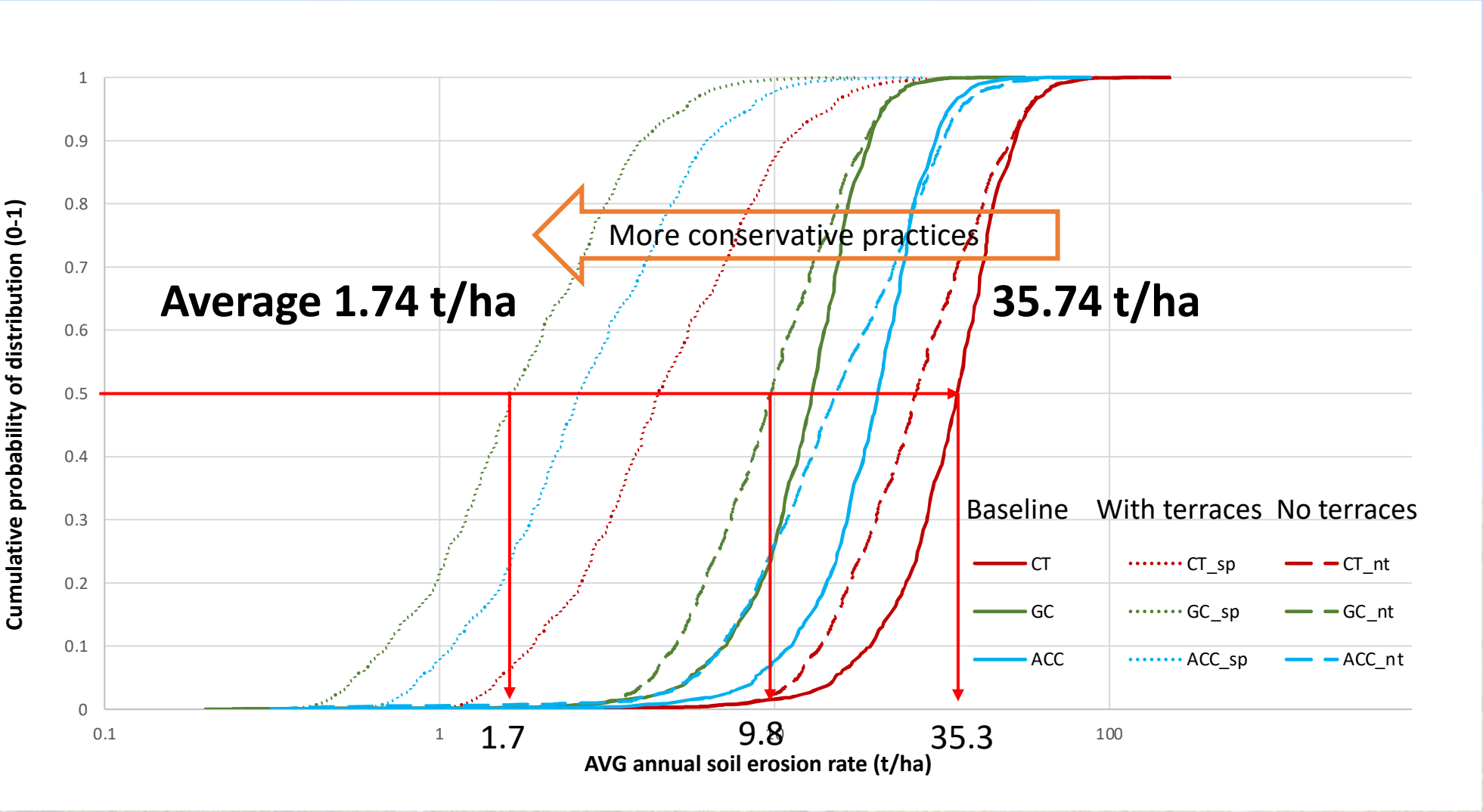
(ii) rows along the slope with gradients less than 10%, and vine rows along contour lines for gradient greater than 10%.

(iii) as (ii), adding the use of terraces where slopes exceed 20%.

		P-factor contour farming	P-factor terraces
Slope (%)	1-2 %	0.6	0.12
	3-5 %	0.5	0.1
	6-8 %	0.5	0.1
	9-12 %	0.6	0.12
	13 - 16 %	0.7	0.14
	17 - 20 %	0.8	0.16
	21 - 25 %	1	0.18

ORUSCAL (Orchards Rusle CALibration) (Gómez et al., 2020; Biddoccu et al., 2020)

3. Results



Best scenarios (with terraces)

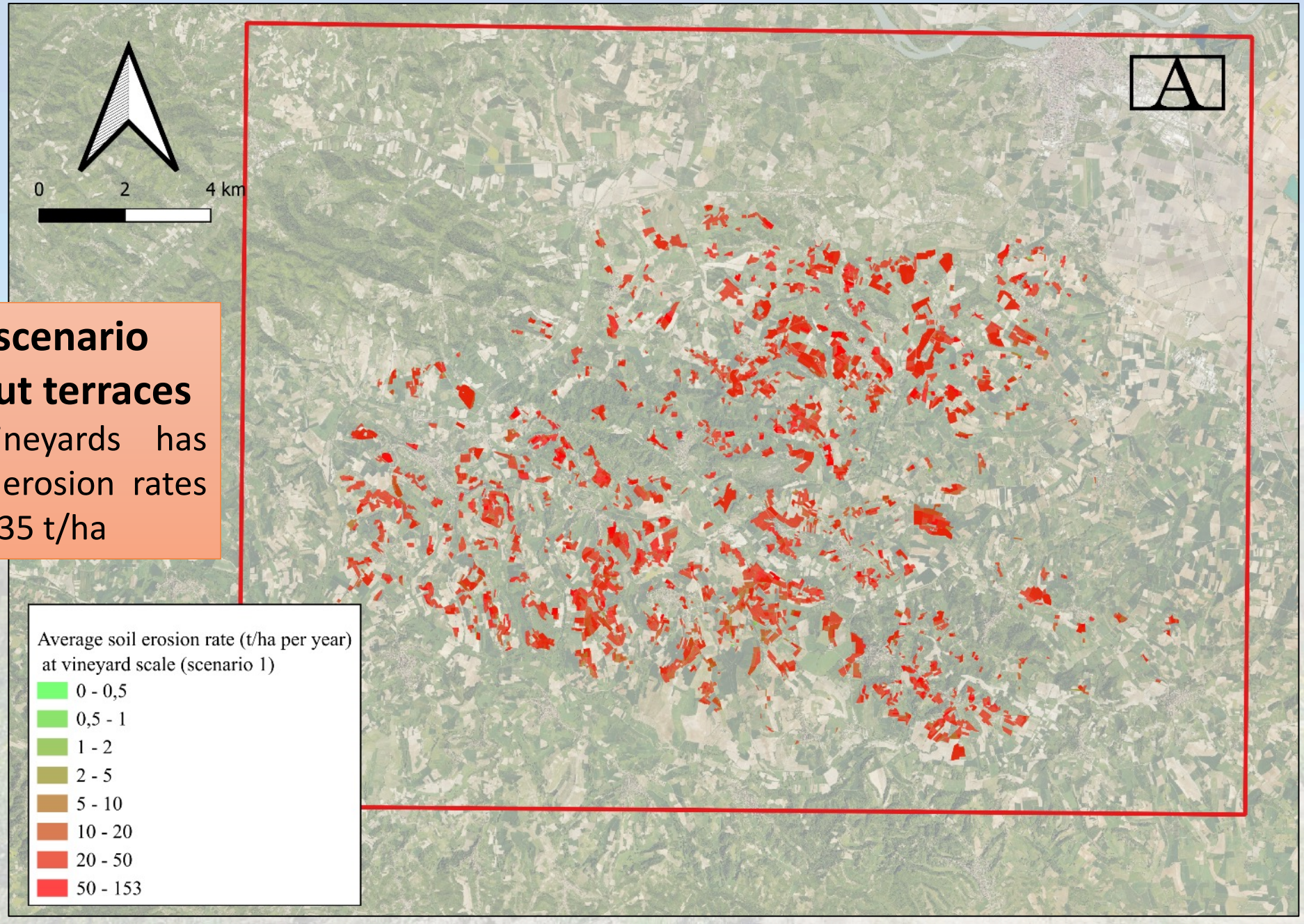
More than 90% of vineyards is expected to have average soil erosion rates lower than 10 t/ha

Scenarios without terraces

At least 50% of vineyards have soil erosion rates higher than 10 t/ha

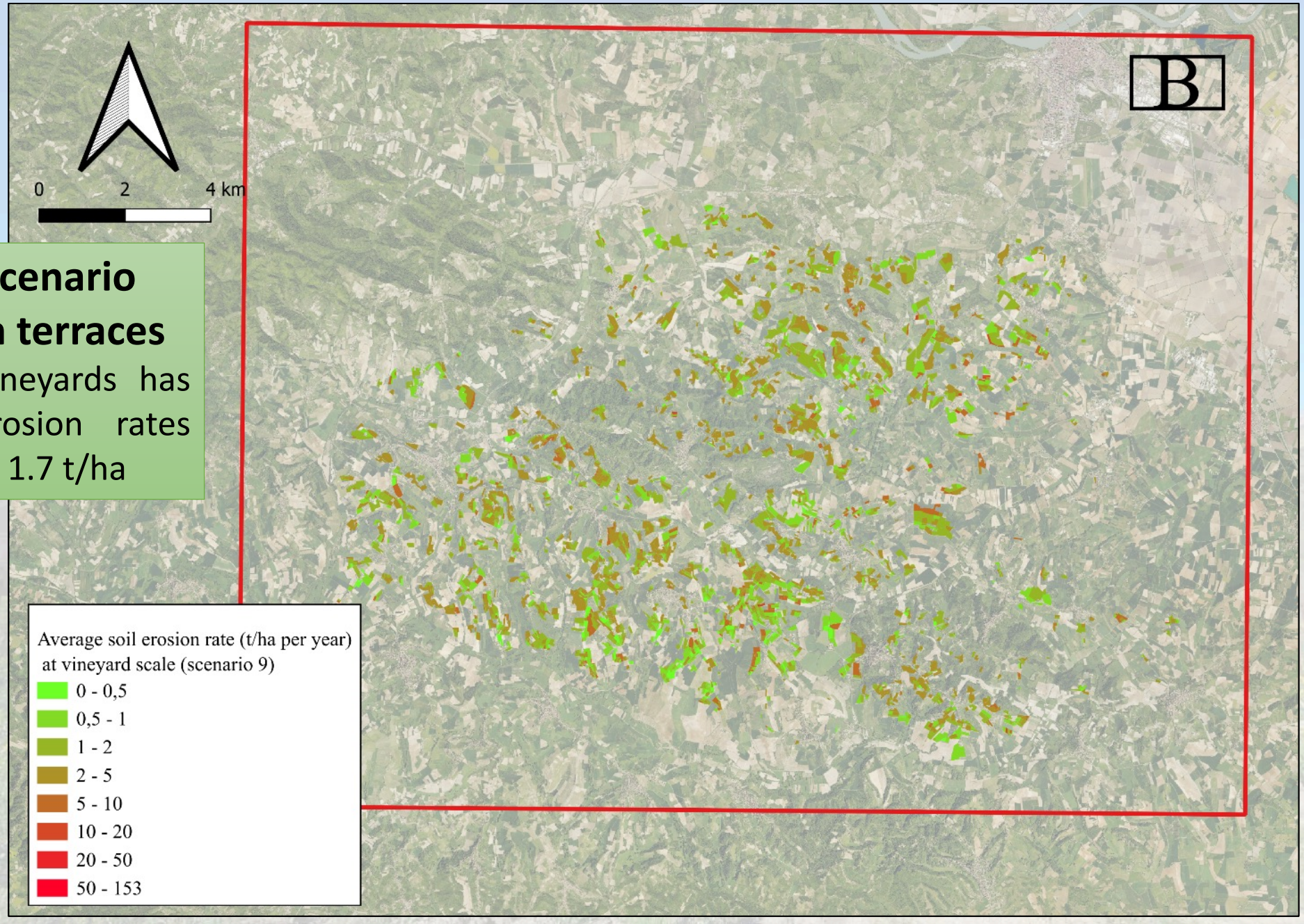
Worst scenario
CT without terraces

50% of vineyards has annual soil erosion rates higher than 35 t/ha



Best scenario
GC with terraces

50% of vineyards has annual erosion rates lower than 1.7 t/ha



Conclusions

- **It is complicated to achieve sustainable erosion rates with a cover crop based managements without additional support practices**
- Need of tailored inter-row soil and vineyard management to local seasonal conditions (extension of vegetation cover, timing of soil disturbance, contouring, terracing) to maintain erosion rates close to soil formation thresholds.
- **Soil and vineyard management practices**, that have a relevant role in **designing the landscape** of valuable vineyard region, have also a **dominant role in soil and landscape protection**
- The proposed methodology is promising in providing support to farmers in soil management decisions in vineyards, particularly in critical contexts and climate scenarios, and preserving the heroic vineyards and their ecosystemic role.

Next steps

- Use of more detailed DTM in order to improve terrace recognition and LS analysis.
- Extension of the study to other contexts sensitive to soil erosion
- User-friendly implementation of the methodology.

Thank you for your attention!

"Treat the earth well: it was not given to you by your parents, it was loaned to you by your children"

Ancient American Natives Proverb

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Lab Soil and Water Protection in Mechanized Agroforestry Systems

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