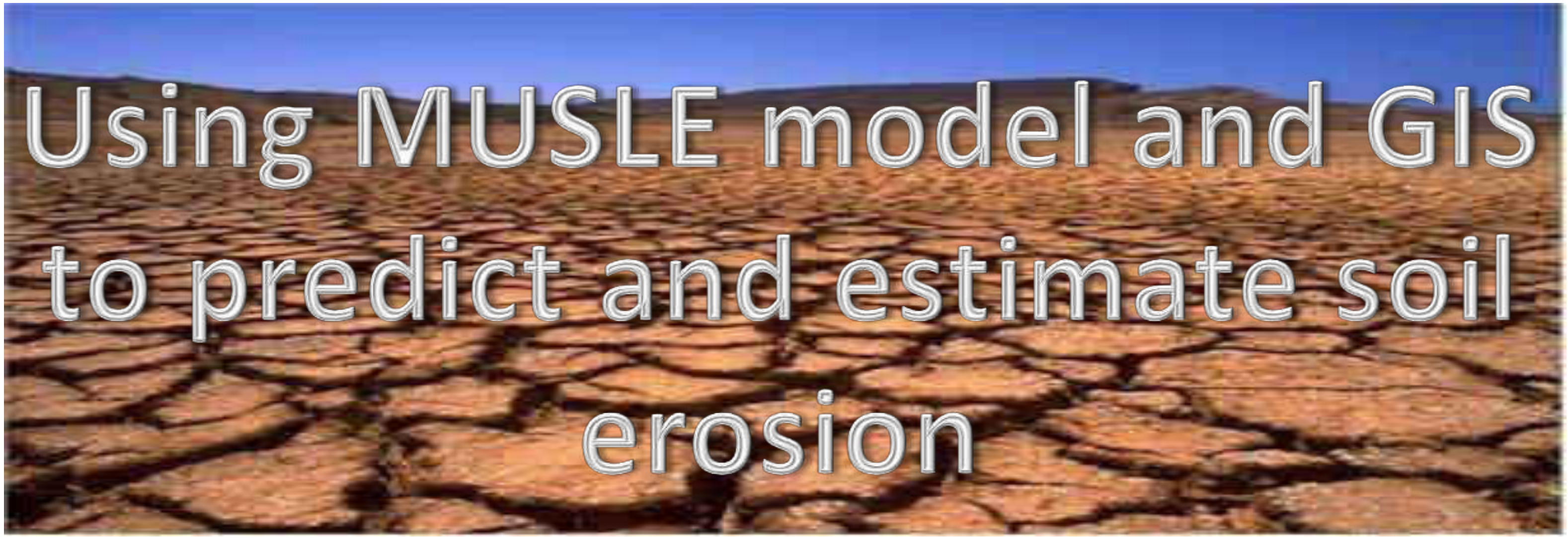
UNIVERSITÉ LAVAL

DÉPARTEMENT DES SCIENCES GÉOMATIQUES



Using MUSLE model and GIS to predict and estimate soil erosion

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Outline

- Statement of the Problem
- Methodology & Theoretical Orientation
- Findings
- Conclusion & Significance

Statement of the Problem

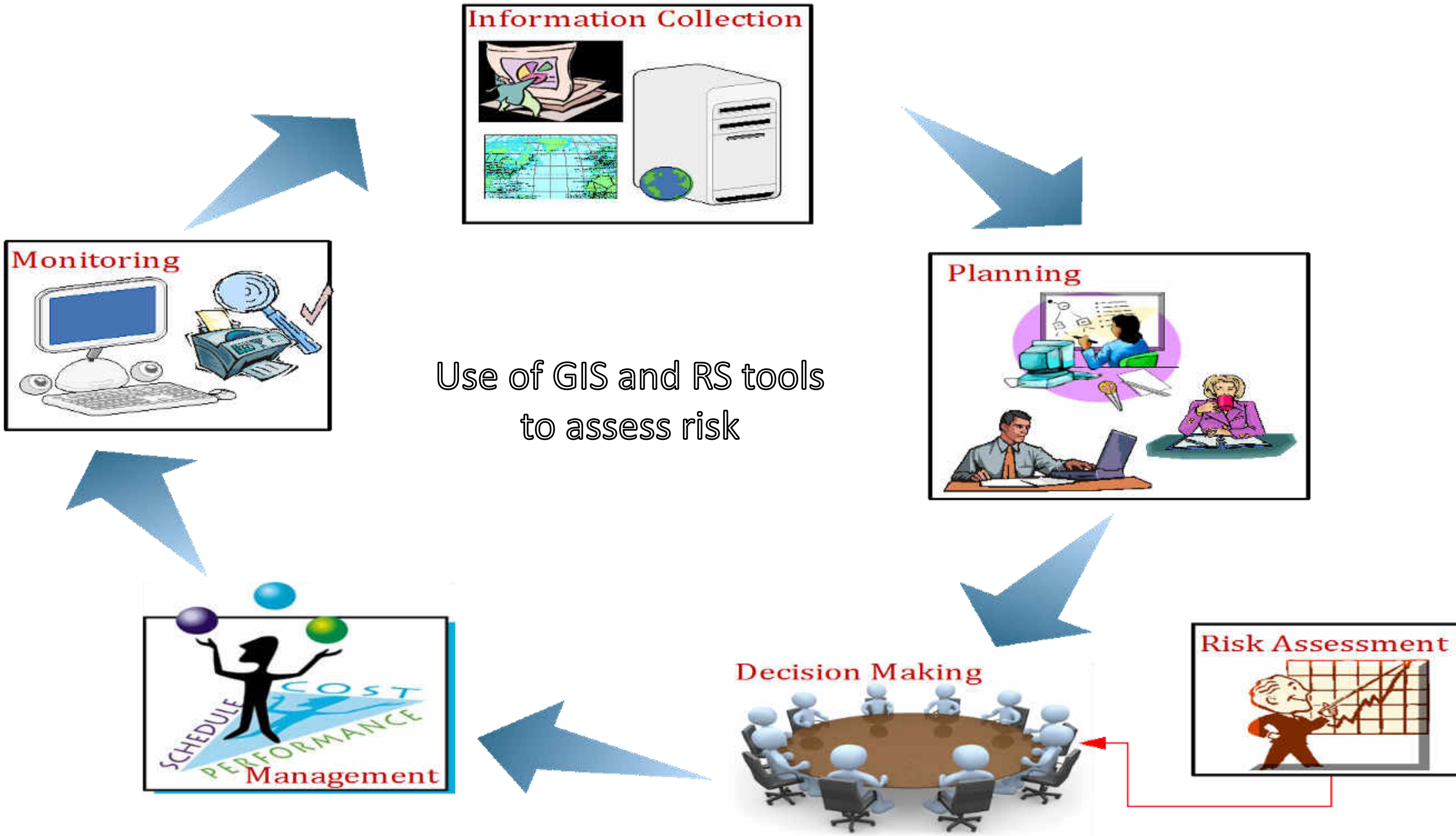
Soil erosion by water is:

- recognized as a major problem arising from agricultural intensification, land degradation and global climatic change
- a major threat to sustainable land and crop production and causes degradation of water resources
- leading to significant decrease of soil fertility in the Mediterranean region as well as in Europe

Statement of the Problem

https://www.google.ca/search?q=soil+erosion&source=lnms&tbm=isch&sa=X&sqi=2&ved=0ahUKEwjyur7818HTAhUIbxQKHbi6BNgQ_AUIBigB&biw=1280&bih=615#imgrc=8rDm20tfqFn2bM:

Statement of the Problem



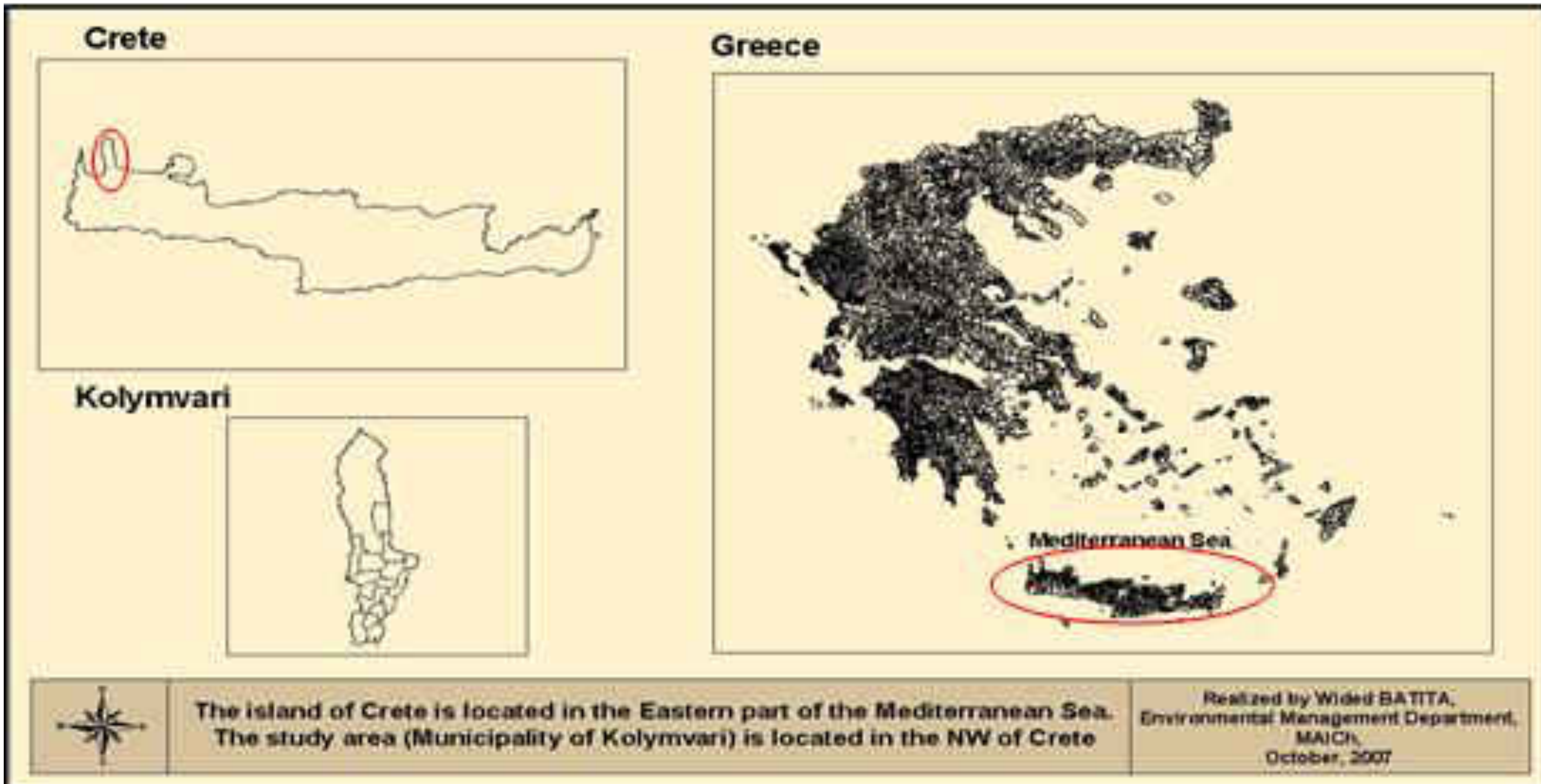
Methodology & Theoretical Orientation

Monitor potential land degradation in the Kolymvari municipality, which will be achieved through **Modified Universal Soil Loss Equation Model (MUSLE)** that could be utilized for predicting the scale and extent of land degradation in the study area

Methodology & Theoretical Orientation

Study area

The centre of geographic location of the Municipality of Kolymvari is approximately, E 23:46:18.00 longitude and N 35:28:54.00 latitude



Methodology & Theoretical Orientation

The characteristics of the study area:

- The area of Kolymvari, Crete, Greece is a typical Mediterranean landscape dominated by **olive cultivation**
- The island of Crete enjoys a **typical Mediterranean climate**, with **dry hot summers** and mild **rainy winters**
- Snow and frost are rare near the coast
- It is characterised by **Karstic limestone** of the White Mountains range
- Groundwater is discharged through the limestone mainly to the North and South of the island
- Two soil types that are predominant in the area: Rendzina soils & Terra Rosa soil
- Ecologically, the predominant flora in the area consists mainly of maquies, garrigues and phrygana with few varieties of coniferous, chestnut and plane forest

Methodology & Theoretical Orientation

The Dataset used:

- The Quickbird imagery (2.5m)
- A digital elevation model (DEM) is a digital representation of ground surface topography
- Corine Land Cover (CLC) is a map of the European environmental landscape
- Soil data
- Rainfall data by field work

Methodology & Theoretical Orientation

- The MUSLE: Modified version of the well known USLE
- The main difference compared to the USLE is the replacement of the rainfall factor with a direct estimate of surface runoff and peak runoff rate
- The equation : $\mathbf{S = 11.8\ (Q^{*}\ q_{p})^{0.56}\ K^{*}\ LS\ ^{*}\ C\ ^{*}P}$

where:
S is the single storm sediment yield,
Q is the runoff volume,
qpi is the peak discharge: $\mathbf{q_{p} = 0.278{*}A{*}d\ /\ T_{p}}$
where:
A is area (km^2)
d is runoff depth (mm)
Tp is the rise time of the hydrograph (h) (time from the beginning of runoff to the time of peak runoff)

Methodology & Theoretical Orientation

Slope length factor (LS)

- Soil loss increases more rapidly with slope steepness than it does with slope length
- Equation:

$$\mathbf{LS = L^{0.5} (0.0138 + 0.00974 * Y + 0.001138 * Y^2)}$$

where

Y is the gradient (Slope %) over the runoff length,

L is the length (m) of slope from the point of origin of the overland flow to the point where the slope decreases to the extent that sedimentation begins

Methodology & Theoretical Orientation

Soil erodibility factor (K)

- The K factor is the soil erodibility factor expressed in ton hectare hour/hectare megajoule millimetre (t ha h/ ha MJ mm) which represents both **susceptibility of soil to erosion** and **the rate of runoff**
- The K values are estimated by the soil erodibility nomograph tool
- It consists of interpolation among plotted curves
- The calculated 45-point K-factors were used to create a soil erodibility grid surface for the whole area, using Arc Map geostatistical analyst, radial basis functions interpolation

Methodology & Theoretical Orientation

Cover management factor (C)

- The C factor represents the effect of plants, soil cover, below-ground biomass, and soil-disturbing activities on soil erosion
- Soil erosion potential is increased if the soil has no or very little vegetative cover of plants and/or crop residues
- The C factor was derived from NDVI after reclassification using the fuzzy logic membership, monotonically increasing function (This method doesn't need a lot of field surveys and it can cover large areas without data)

Methodology & Theoretical Orientation

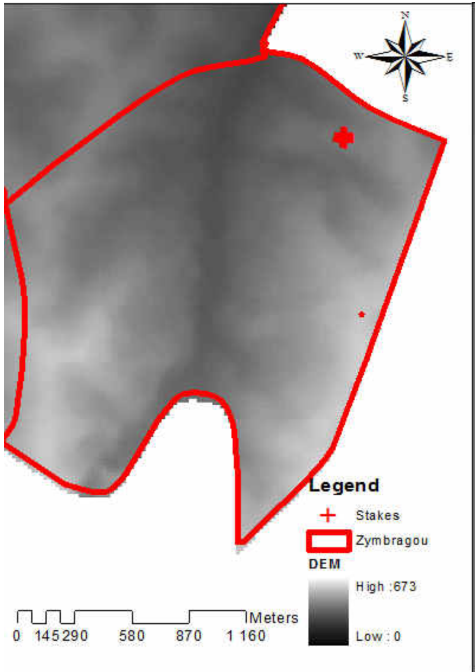
Support practice factor (P)

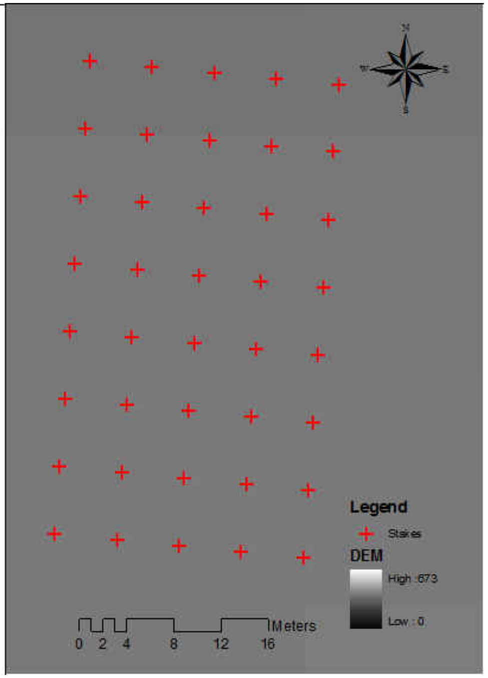
- P-factor reflects the impact of support practices on the average annual erosion rate
- For the Kolymvari municipality, the only support practice existing is terracing
- Terracing affects sheet and rill erosion by breaking the slope length into shorter distances and hence, decreasing runoff and the associated erosion
- After extraction of linear features, they were buffered by 30m and a value of 0.6 for the P factor was assigned

Methodology & Theoretical Orientation

Field work

- 30 pins were installed in Zympragou
- 10 more pins were added; they are statistically needed because erosion pins are frequently disturbed or lost due to farmers or animal traffic



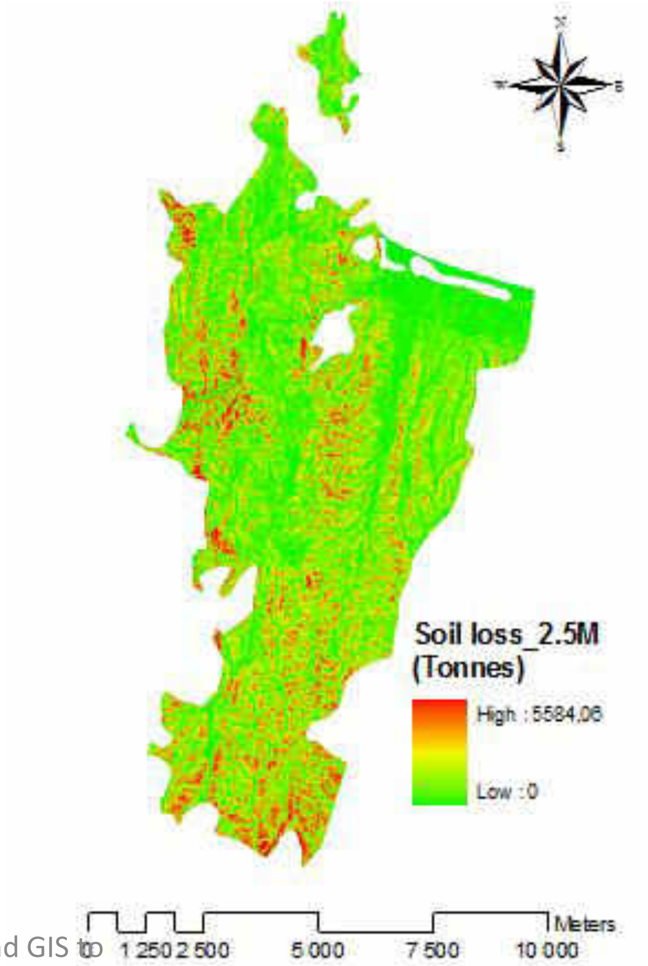


Findings

- The total precipitation for the winter period that corresponds to the study period was 750 mm.
- The estimation of the peak discharge and the runoff volume were estimated for the Zympragou area to 3.9 km^2
- They were extended for the whole olive cultivation area of Kolymvari
- The runoff volume (Q) was estimated to 525 m^3
- The average peak discharge (qp) was estimated to 0.085 $m^3 s^{-1}$
- The surface runoff was equal to 98.86.
- MUSLE equation becomes: **S = 98.86* <u>K* LS * C *P</u>**

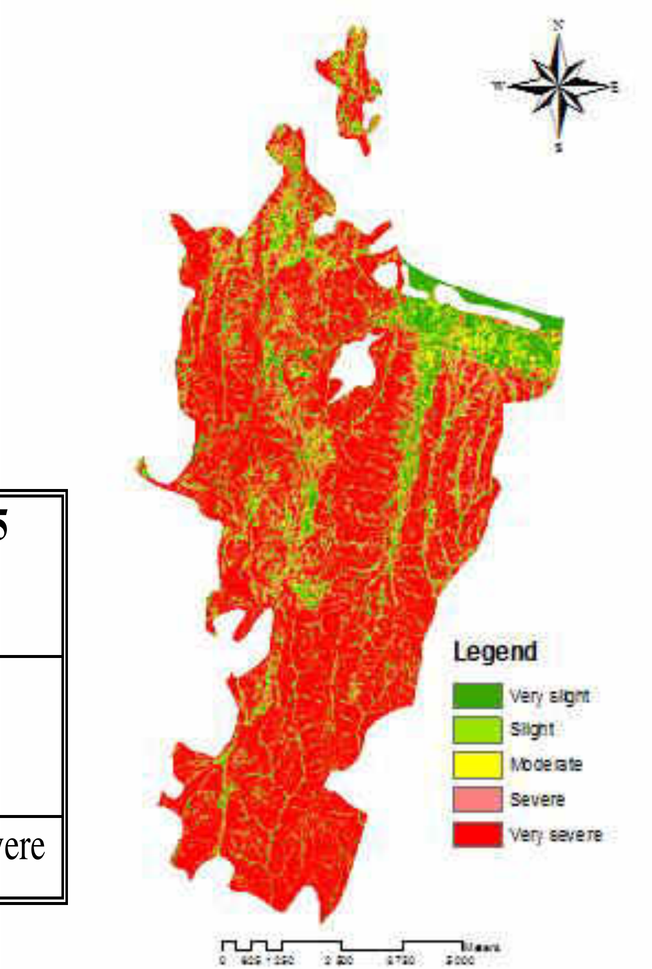
Findings

- The final thematic map of soil erosion risk over the olive cultivation area:



Findings

- The final thematic map of the soil erosion risk reclassified into the five ERC over the olive cultivation area



EROSION CLASS	ERC1	ERC2	ERC3	ERC4	ERC5
Loss t/ha/year	0-5	5-10	10-20	20-40	>40
Classification	Very slight	Slight	Moderate	Severe	Very severe

Findings

- The strength of MUSLE model includes its ability to directly estimate sediment delivery potential from soil erosion
- This is a valuable tool for environmental management and much needed for source-sink characterization of terrestrial source and aquatic sinks of particulate matters

Conclusion & Significance

I. The areas located in the northern part of the peninsula belong to ERC5, because soil erosion potential coincided with the steeper slope length (L) and steepness (S) factors

II. The areas in the southern part of the area belong to ERC5, because soil erosion potential coincides with relatively intense olive cultivation

III. There is no big difference between the thematic maps generated by the two models MUSLE and RUSLE, almost the same values were found for the 5 ERCs

IV. The assessment of soil erosion risk potential comprises a valuable tool for planning successful and sustainable management practices, especially for those areas with moderate to severe erosion potential

Conclusion & Significance

- The annual soil loss values generated by the MUSLE model was subject to errors included in different data and different GIS layers that are created by ArcMap software
- Some of these included errors in digitizing the roads, soil layer land cover as well as the support practices (terracing) from the Quickbird satellite imagery
- The processing of these different layers, by multiplication, into the Arc Map, will result in the magnification of the total error term

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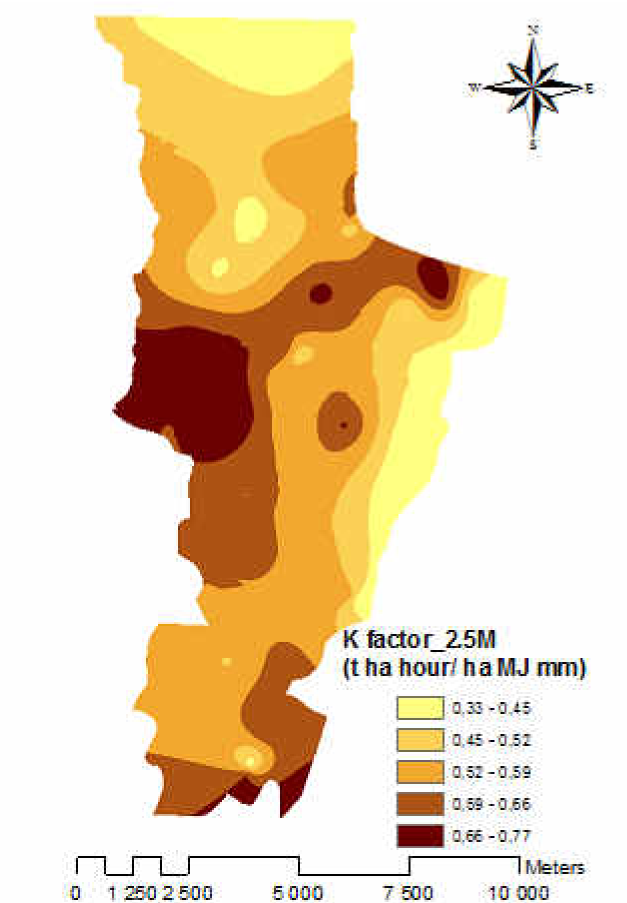
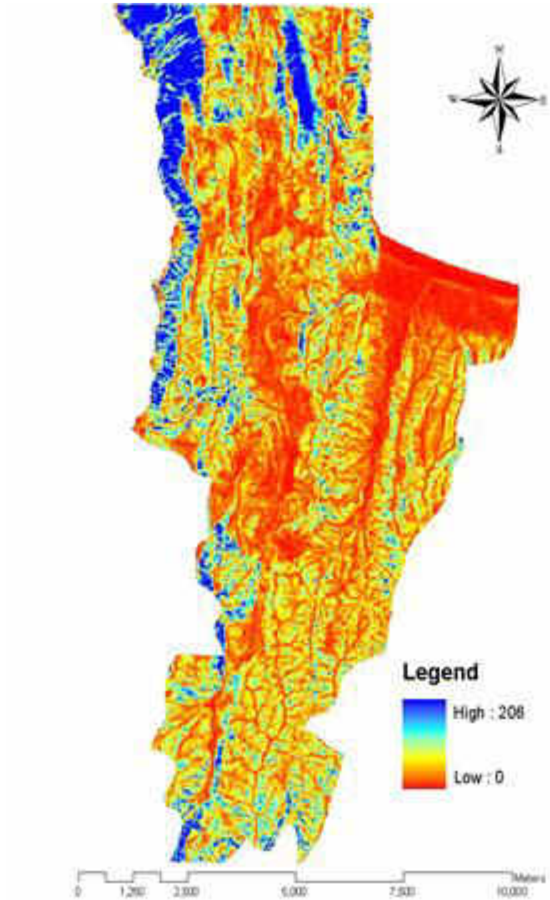
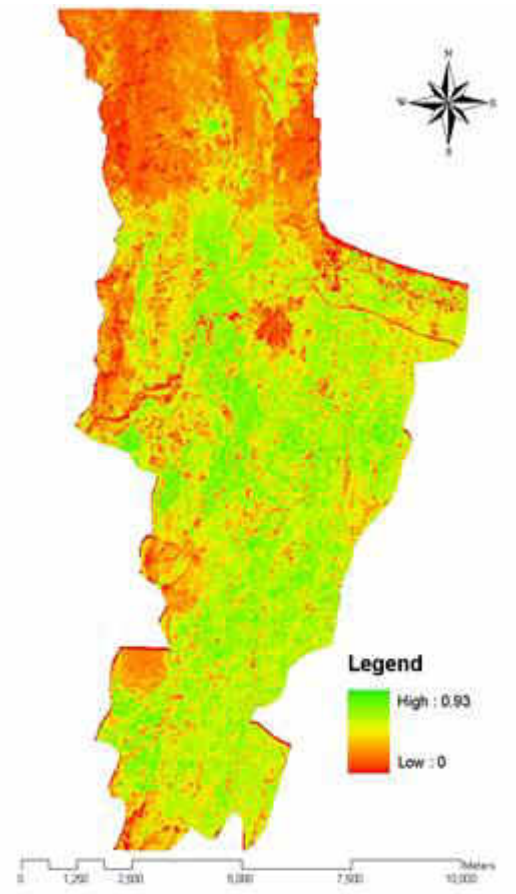
End

Thank you for your attention

Factors generation







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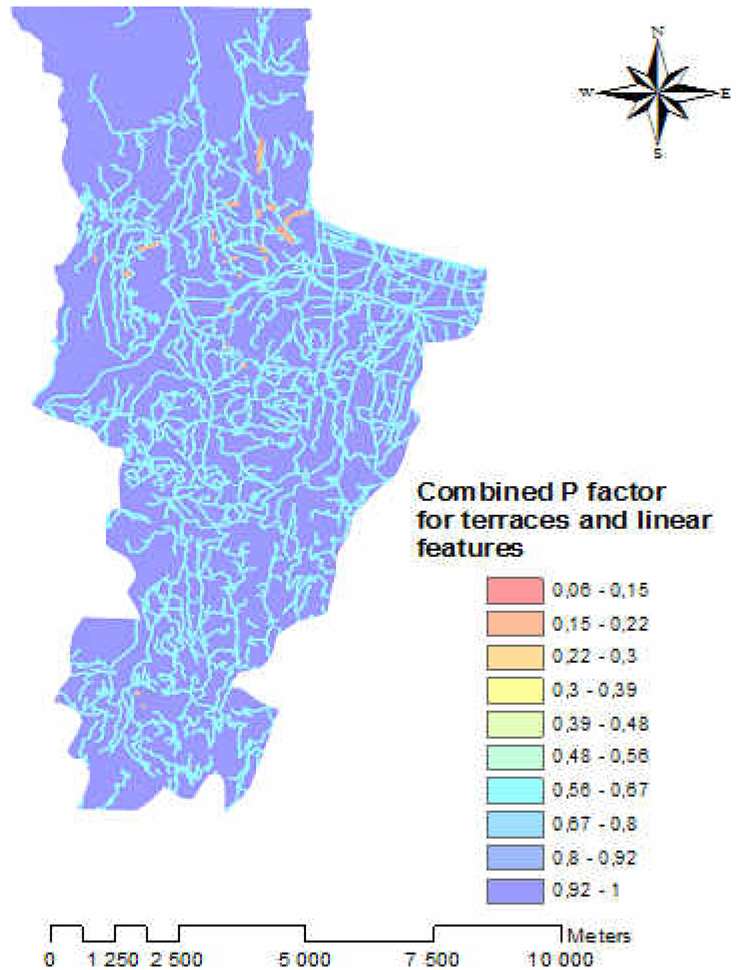

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