Assessing and monitoring soil erosion and environmental sensitivity in Malta

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MAIN AIM: To assess and monitor soil erosion and land degradation in Malta between 1991-2002 using the RUSLE and the Environmental Sensitivity Area Index (ESAI)

AREA OF STUDY

Maltese Islands

Three main islands: **Malta, Gozo & Comino**

- Located in the **Mediterranean Sea**, 80km south of Sicily
- Area of 316km^2

Climate: Subtropical-Mediterranean

- Average yearly **temperature** = 22.5°C
- Average yearly **rainfall** = 524mm (November, December = wettest)
- **Rainfall** is characterised by storms of high intensity and relatively short duration.


Figure 1


Figure 2

METHODS:

The Environmental sensitivity area index (ESAI)

Criteria of Basso et al. (2000) used for selecting the different **indicators** for identifying **sensitive areas** according to the **MEDALUS ESAI** (Kosmas et al., 1999a).

These criteria are:

(i) the relationship with the degradation phenomena
(ii) the availability of data
(iii) the ability of updating the datasets
(iv) the ability to refine, further develop or even remove existing layers of information in the future, if this is deemed important.

Figure 3 shows the **11 indicators** that were estimated belonging to **4 Environmental Quality Indices,** namely:

1. Climate Quality Index (CQI)
2. Vegetation Quality Index (VQI)
3. Soil Quality Index (SQI)
4. Socio-economic Quality Index (SosQI)

Indicators were standardized from 1 (=least sensitive) to 2 (=most sensitive; Tables 1-4) and the ESAI was estimated as follows:

$$ESAI = (CQI * VQI * SQI * SEQI)^{1/4}$$

Acknowledgements
Elias Symeonakis is supported by an EU FP7 Marie Curie Career Integration Grant (PCIG12-GA-2012-3374327)

METHODS

Revised universal soil loss equation (RUSLE)

We adapted the ESAI considering our data availability and used the RUSLE to assess soil erosion as follows (Renard et al. 1991; Table 5):

A= RKLSCP

where A = estimated average soil loss in tons per acre per year
R = rainfall-runoff erosivity factor
K = soil erodibility factor
L = slope length factor
S = slope steepness factor
C = cover-management factor
P = support practice factor

P factor values were obtained from Shin (1999) & Sheikh et al. (2011) who provide values according to the type of cultivation on a slope.

- As Malta's cultivated land is mostly terraced (Figure 2), we applied the following classification scheme:

Slope (%)	Terracing
0.0-7.0	0.1
7.0-11.3	0.12
11.3-17.6	0.16
17.6-26.8	0.18
26.8>	0.2

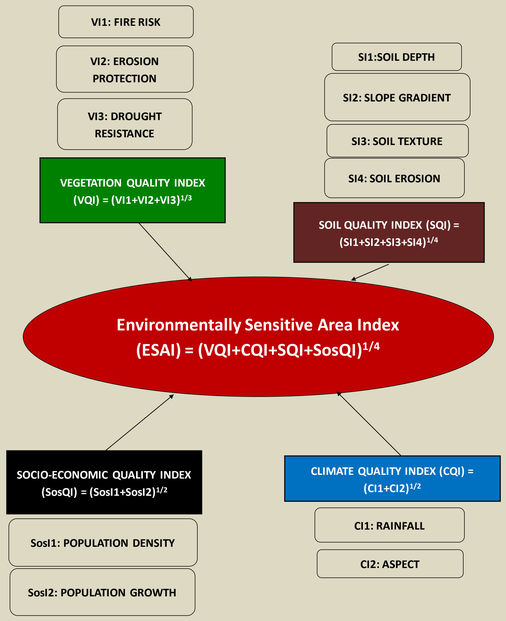


Figure 3. Flowchart of the methodological framework for the estimation of the modified Environmentally Sensitive Area Index (ESAI) (modified from Symeonakis et al., 2014)

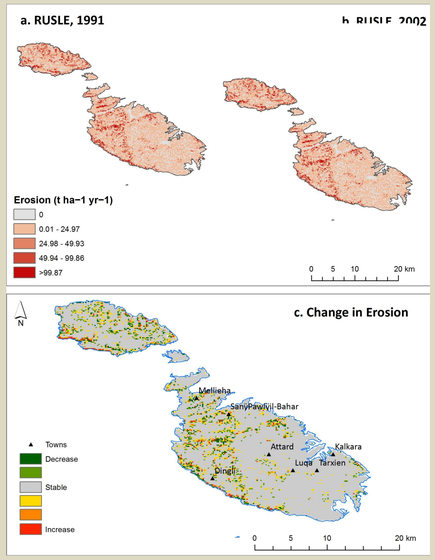
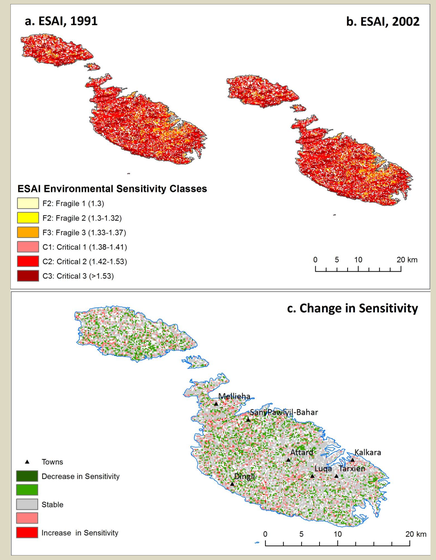


Figure 4. Average annual soil loss estimated using the RUSLE for (a) 1991 & (b) 2002 . (c) Change in average annual soil loss.



Figures 5. Environmental sensitivity according to the ESAI for (a) 1991 and (b) 2002. (c) Change in Sensitivity between 1991 & 2002

RUSLE factor	Data used Source
K	Soil depth & textures- Sultana Data (2014)
L	45m DEM ASTER
S	45m DEM ASTER
C	Land Cover Classification of Landsat imagery (Maximum likelihood)
P	45m DEM ASTER & Land Cover classification

Tables 5. Data used and their sources for estimating the different RUSLE factors

	Parameter	Classes	Score	Data/Source/Date
Climate Quality	Rainfall	280-650	1.5	BIOCLIM data for 1950-2000 yearly average rainfalls.
	Aspect	N, NE, NW S, SE, SW	1 2	45 DEM from Aster.

	Parameter	Classes	Score	Data/Source/Date
Vegetation Quality	Drought Resistance	Maquis, Shrub land, bedrock and bare soil Conifer woodlands Agricultural land	1 1.2 2	Landsat Classification of land cover classes for: 1986 & 2002
	Erosion Protection	Mediterranean Macquis, conifer forests Agricultural land & Bare rock	1.3 2	
	Fire Risk	Bare rock Agricultural land Mediterranean maquis Conifer Woodlands	1 1.3 1.6 2	

	Parameter	Classes	Score	Data/Source/Date
Soil Quality	Texture	LSCL, SL, LS and CL SC, SiL and SiCL Si, C and SiC S	1 1.2 1.6 2	Soil Texture Survey by MALIS (Source MEPA)
	Soil Depth	>75 30-75 15-30 <15	1 1.2 1.6 2	Soil Depth Survey produced by Sultana (2014) (Source MEPA)
	Soil Erosion	0-2 2-5 5-10 10-25 25-45 45-75 >75	1 1.2 1.3 1.5 1.6 1.8 2	Soil Erosion Model created by our research modelled for 1986 & 2002.
	Slope Gradient	<6 6-18 18-35 >35	1 1.2 1.5 2	Slope gradient produced by Aster DEM (45m)

	Parameter	Classes	Score	Data/Source/Date
Socio-Economic quality	Population Density (people per km^2)	>400	2	Census Surveys
	Population Growth	2 2-4 4-6 6-8 8-10 >10	1 1.2 1.4 1.6 1.8 2	Census Surveys

Tables 1-4. Main indicators & adopted scores used in the GIS to assess environmental sensitivity to degradation & desertification

RESULTS & DISCUSSION

Erosion results

Figure 4 is the RUSLE soil erosion results for 1991 and 2002 and the respective change between the two dates.

- Erosion rates are higher in Northern Areas of Malta (e.g. Mellieha and Maghtab) and the Island of Gozo
- One of the main reasons for increased erosion rates is the condition of the terraces (Sultana, 2014; Figure 2).
- Soil loss decreases are potentially due to agricultural land abandonment in the North West of Malta near Mellieha (Alkharabsheh et al., 2013). Commonly, Maquis or pines re-establish and are able to control erosion more efficiently

Environmental Sensitivity results

- Malta has become less sensitive in the areas around the largely built up areas of Luqa and Tarxien in the East.
- In the East and the West near the towns of Dingli and Attard it has become more critical and fragile.
- The San Pawl il-Bahar and Il-Mizieb areas require attention, as these areas have increased in sensitivity. This is most likely due to the increases in soil erosion.

CONCLUSIONS

- This is the first attempt to map soil erosion and environmental sensitivity at the national-scale in Malta.
- RUSLE and the ESAI can be combined to assess these two important problems in Mediterranean areas concurrently.
- The most sensitive areas of San Pawl il-Bahar and Il-Mizieb in the North of Malta in the Mellieha area have been identified as critically sensitive and could be prioritised for erosion control and land degradation mitigation.

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