Qualitative land suitability evaluation for maize (*Zea mays* L.) and wheat (*Triticum* spp. L.) crops using GIS: A case study in the Region of East-Macedonia and Thrace, Greece

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ABSTRACT

Land suitability evaluation is a prerequisite to achieve optimum utilization of available land resources for agricultural production. The principal purpose of land evaluation is to predict the potential and the limitations of land for a specific utilization type. Therefore, the objective of this study was to develop and implement a model for evaluating the suitability of land as a pilot project, in the Region of East-Macedonia and Thrace, Greece. The model was developed for maize and wheat crops and was built in ArcGIS Model Builder. The FAO Framework for land evaluation was selected to conduct the land suitability assessment. Nine land characteristics (soil attributes) were determined and brought together in order to determine the land suitability. The land characteristics selected were: 1) soil texture, 2) soil pH, 3) cation exchange capacity, 4) base saturation, 5) organic matter, 6) electrical conductivity, 7) exchangeable sodium percentage, 8) soil drainage class and 9) erosion risk. Land characteristics' values were integrated in GIS environment, and were rated based on threshold values for each crop and they finally overlaid to produce an overall land suitability. The results revealed that the study area has a very good ability to support the selected crops. It showed that more than 98% of the study area was suitable for maize production, while les than 2% was unsuitable. Similar results were obtained for wheat, almost 98% of the study area was suitable and about 2% was unsuitable for this crop. In this pilot project, results are confirmed by the current crops used of the area. Similar results could be obtained by applying the methodology in other areas.

INTRODUCTION

➢Estimation of physical land suitability is a crucial element of land use planning and development, since it provides guidelines for optimal utilization of land resources.

➢Land suitability method developed by FAO (1976) provides a widely used framework for assessing physical land suitability for a specific use, based on expert knowledge.

➢Since 1990s, GIS are effectively used, around the world, as a tool for supporting land suitability evaluation since they provide the capability to integrate and analyze spatial data (Obi Reddy *et al*., 2002) and allow for specialized and objective land suitability analysis (Van Diepen *et al*., 1991; Rossiter, 1996).

➢The objective of this study was to develop and implement a model for evaluating the suitability of land as a pilot project for maize and wheat production in the Region of East-Macedonia and Thrace, Greece.

STUDY AREA

➢It is located south of the capital city of Komotini in the Prefecture of Rodopi, Greece (40º.55'N – 25º.25'E) and includes 3,995 ha of agricultural land (Figure 1) .

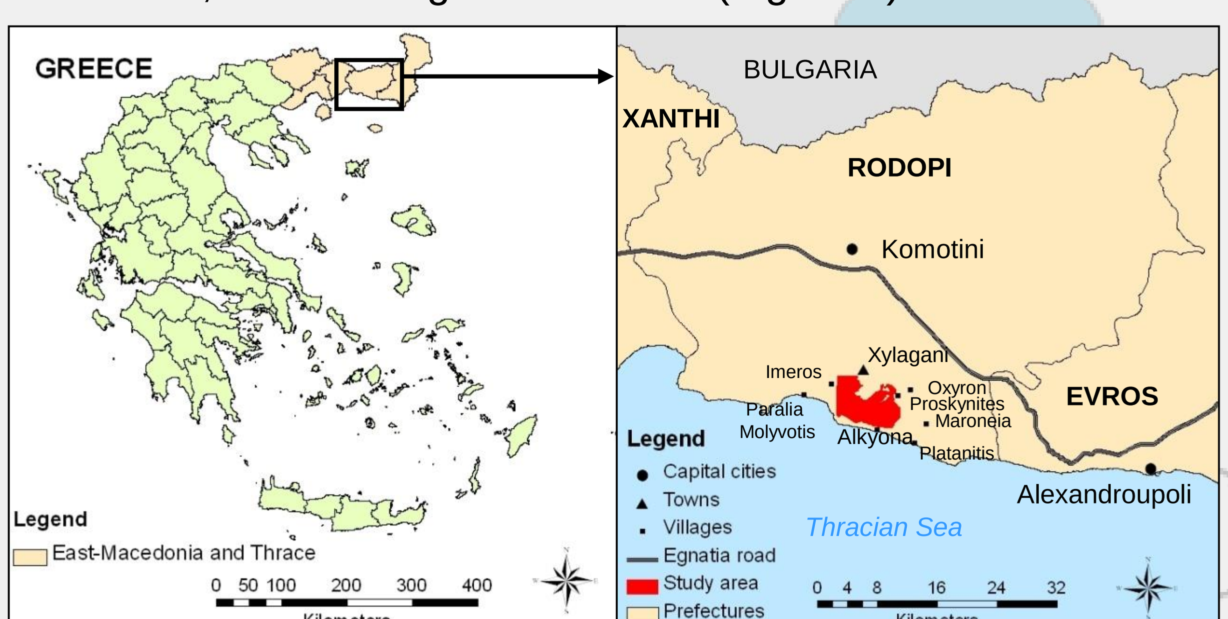

Figure 1: Location of the study area

MATERIALS AND METHODS

Materials used

➢Thematic maps of 9 land characteristics: 1) soil texture (TEX), 2) soil pH (pH), 3) cation exchange capacity (CEC), 4) base saturation (BS), 5) organic matter (OM), 6) electrical conductivity (EC), 7) exchangeable sodium percentage (ESP), 8) soil drainage (DR) (Misopolinos, 2010) and 9) erosion risk (ER) (Sotiropoulou, 2011).

➢ArcGIS ver.9.3 (ESRI)

Table 1. Land use requirements for maize and wheat

FAO CLASS	S1		S2		S3		N1		N2	
Sys *et al.* RATING	[100-98)		(98-85]		(85-60]		(60-45]		<45	
	MAIZE	WHEAT	MAIZE	WHEAT	MAIZE	WHEAT	MAIZE	WHEAT	MAIZE	WHEAT
EC (mS/cm)	<=2	<=4	(2-4]	(4-8]	(4-6]	(8-12]	(6-8]	(12-16]	>8	>16
ESP	<=8	<=15	(8-15]	(15-25]	(15-20]	(25-35]	(20-25]	(35-45]	>25	>45
CEC (meq/100g)	>24	>16	(16-24]	(8-16]	(8-16]	<=8	<=8	-	-	-
BS (%)	>80	>80	(50-80]	(50-80]	(45-50]	(35-50]	(40-45]	<=35	<=40	-
OM (%)	>2		(1-2]		(0.8-1]		(0.4-0.8]		<=0.4	
pH	(6-7.5]	(7-8.5]&	(5.5-6]& (7-5.3]	(6-7]& (8.5-8.7]	(5-5.5]& (8.3-8.6]	(5.5-6]	(4.5-5]& (8.6-8.9]	(4.5-5.5]& (8.7-8.9]	<=4.5 or >8.9	
Drainage	A (L, SL)		B (CL)		C (SCL)		D (SC)		E (C)	
Texture	SCL, CL	C, SC	SL, L, C	CL, SCL	SC, LS	L	-	SL	-	S, LS
Erosion risk (USLE) (tn/ha/year)	<=10		(10-20]		(20-30]		(30-40]		>40	

Method

➢FAO Framework

1)Compares of crop requirements with natural conditions of land

2)Defines 5 land suitability classes (Table 1).

➢Matching of land characteristics with maize and wheat requirements resulted in a numerical rating with a range from a maximum (100) to a minimum value (0), according to Sys *et al.* (1991) (Table 2)

Table 2. Land suitability classes (FAO, 1976)

FAO CLASS	DEFINITION
S1	Highly Suitable
S2	Moderately Suitable
S3	Marginally Suitable
N1	Currently not Suitable
N2	Permanently not Suitable

➢Suitability classes were related to a specific value of land index (LI), calculated from individual ratings of land characteristics according to Storie (1976):

$$LI = A * B/100 * C/100 * \ldots$$

where:

LI=Land Index (%) and A,B,C..= ratings of land characteristics.

➢By determining the specific LI, the land suitability classes for each crop were identified, according to Sys *et al.* (1991) (Table 3).

Table 3. Land suitability classes for different Land Indices

FAO CLASS	LI %
S1	[75-100]
S2	[50-75)
S3	[25-50)
N1	[12.5-25)
N2	<12.5

➢The model was built using GIS capabilities and modelling functions of Model Builder.

1) Creates, edits and manages mathematical models (ESRI, 2000).

2) Enables the user to create process-flow diagrams and scenarios to automate the modeling process.

RESULTS

The suitable land was distributed among classes as follows: a) 29.41% is highly suitable, b) 37.84% is moderately suitable and c) 31.53% is marginally suitable for maize and a) 17%, b) 45.68% and c) 35.31% respectively for wheat.

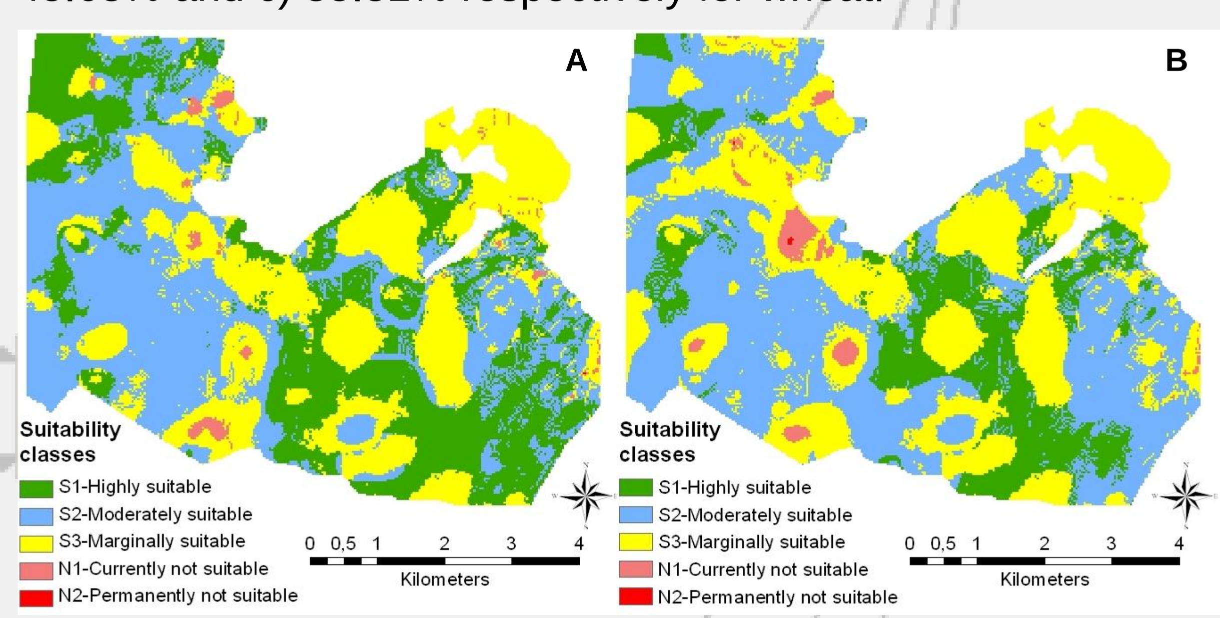

Figure 2. Land suitability of the study area for maize (A) and wheat (B)

Spatial distribution of land characteristics having the minimum rating per pixel is illustrated in figure 3.

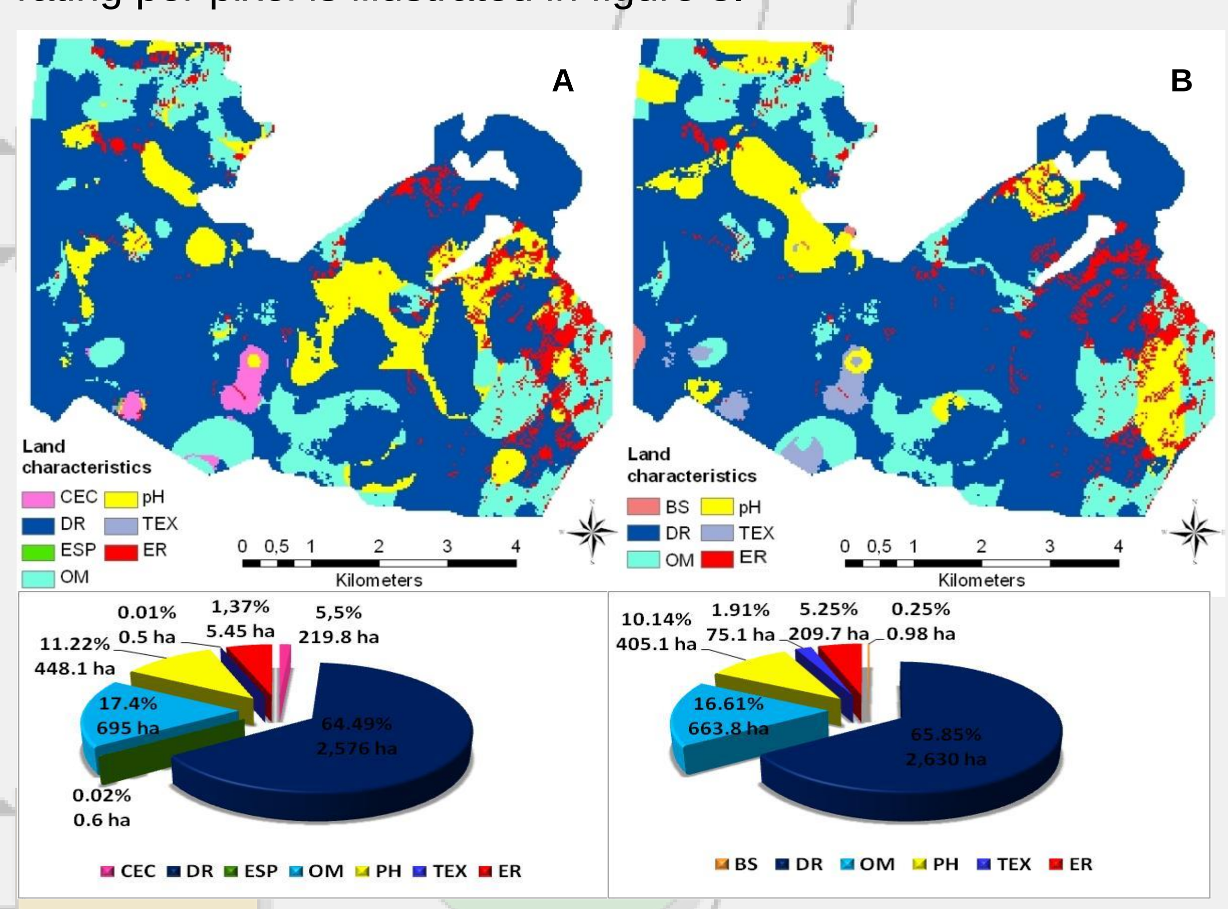

Figure 3. Spatial distribution of land characteristics with the minimum rating for maize (A) and wheat (B)

Spatial distribution of DR, OM, and pH is shown in figure 4, and 5.

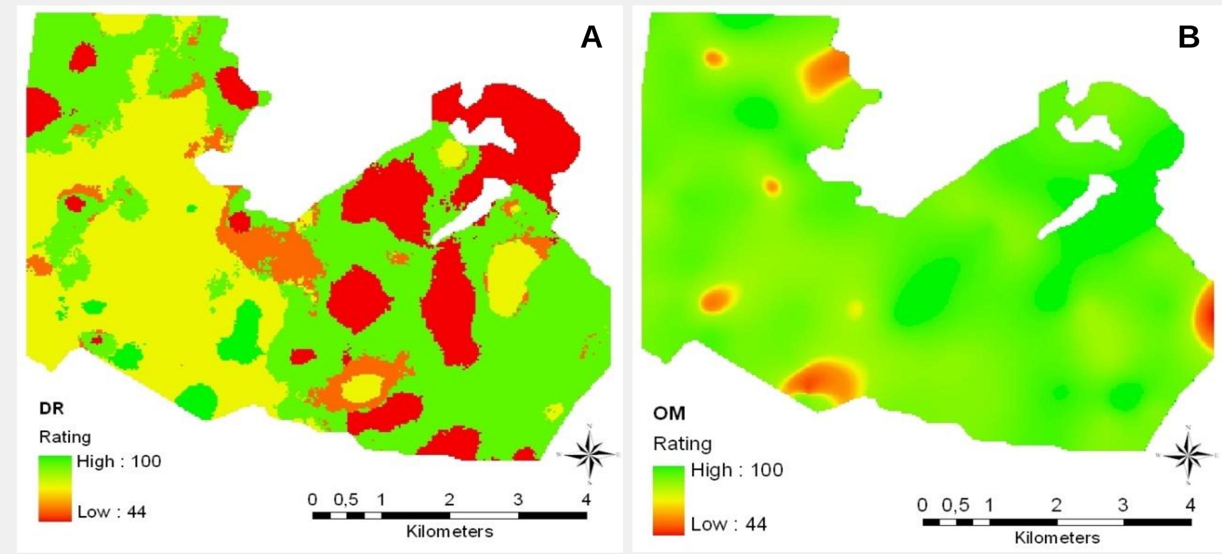

Figure 4. Rating of Drainage conditions (A), and Organic matter content (B) for both crops

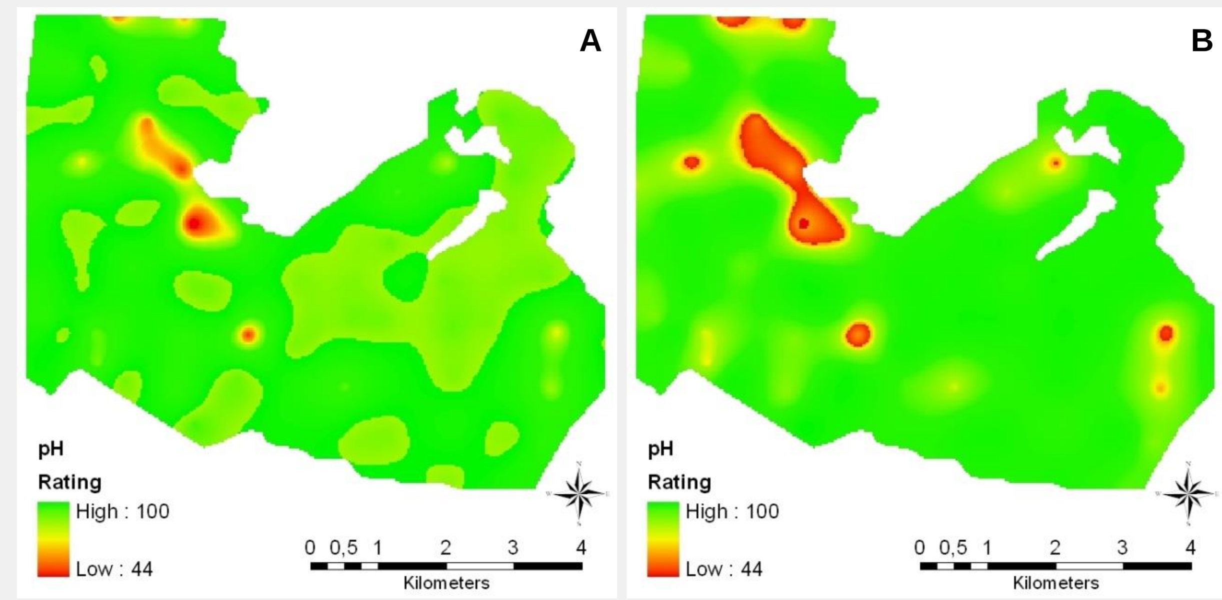

Figure 5. Suitability of pH values for maize (A) and wheat (B)

The above results indicated the limiting factors for each crop (Figures 6 and 7) per class. In S1 class there is no limiting factors since it is highly suitable.

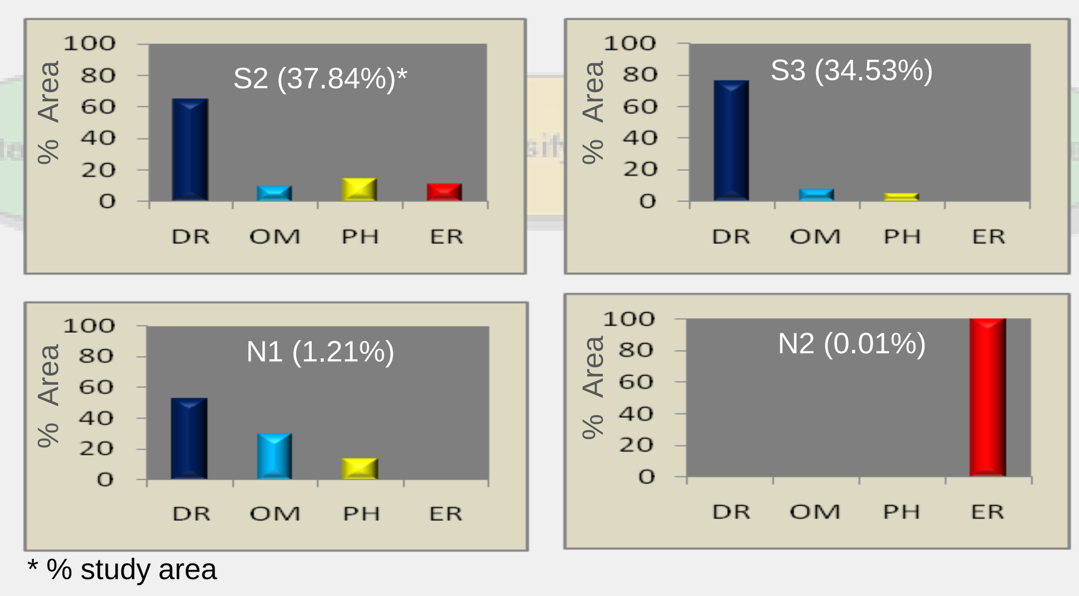

Figure 6. Limiting factors per class for maize in the study area

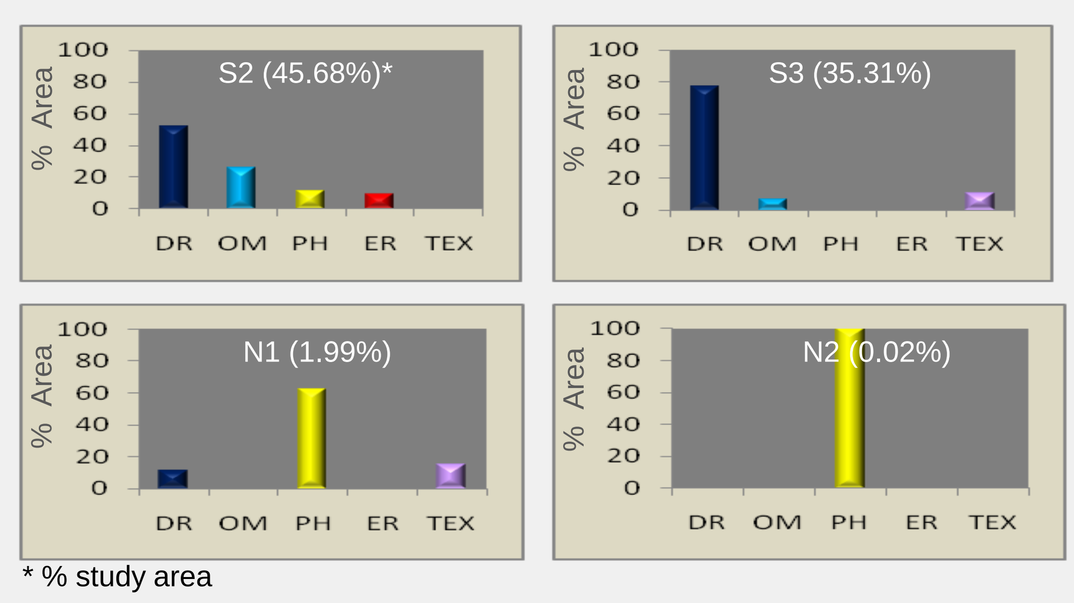

Figure 7. Limiting factors per class for wheat in the study area

Identification of limiting factors per class plays an important role in the different stages of decision making, since it gives information on the current land suitability conditions and guides land use planners to implement measures and select crop pattern towards sustainable land use.

CONCLUSIONS

➢Land suitability evaluation was carried out rapidly and effectively by developing an automated procedure in ArcGIS Model Builder.

➢The constructed model is a dynamic tool, since new land characteristics can be integrated into the model, its implementation can expand to larger areas or other geographic locations, and it can easily be modified encompassing more crops.

➢Updating of input data can produce a time series of land suitability results, tracking changes in time and identifying source of impacts.

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