Soil erosion assessment and monitoring by using ImpelERO model in east Azerbaijan province, Iran.

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Abstract
Soil erosion continues to be a major concern for the development of sustainable agricultural management systems. Neural networks, as an artificial intelligence technology, have grown rapidly over the past few years and have an ability to deal with nonlinear multivariate systems. An integrated Model to Predict European Land use named ImpelERO is a decision trees/neural network hybrid model. This paper focuses on the possibility of model application in an area of west Asia by recalibration and generalization. The overall approach of ImpelERO model was applied in 14 natural regions from the east Azerbaijan province, Iran. Results showed that vulnerability indexes vary from 0.03 to 1.32 while risk classes will be very small (V1), small (V2), moderate (V3), large (V4), and very large (V5) in an area extension of 1080, 1860, 1184, 2981, and 1772 hectares, respectively. Lands belong to Zargar and Dizanlou natural regions because of topographical limitation factors are established with a very large risk class. Long term productivity reduction for time horizons 2020, 2050 and 2100 indicates that management planning is necessary to minimize soil loss rate.

Key Words
Decision trees, ImpelERO model, neural network, soil erosion, West Asia

Introduction
In the last years, scientists working with a new approach in agricultural production: farming by soil, precision agriculture, plot specific management or soil tillage research, have provided new research information on pertinent processes related to soil tillage in order to prevent and reduce soil erosion (Robert *et al.* 1993; Horn *et al.* 1998). Recently, connections have emerged between the neural network technique and its application in engineering, agriculture, and environmental science. Hybrid systems are the combination of dynamic simulation models and empirically based land evaluation techniques. Within the new MicroLEIS DSS framework, the Agricultural Soil Erosion Evaluation Model (ImpelERO) is a decision trees/neural network hybrid model developed to predict the water erosion vulnerability, productivity reduction and optimal management strategies for an agricultural parcel. For evaluating the soil erosion process, formulation, calibration, sensitivity and validation analysis of model were carried out in a total of 237 field-units, which represent 34 major land resource areas for five traditional crops in the Andalusia region, Spain (De la Rosa *et al.* 1999). According to previous reports, soil erosion is an increasing phenomenon not only in Europe (Blum 1990) but also in west Asia (Shahbazi *et al.* 2009a). Therefore, it is necessary to separate the current status from the future risk or soil vulnerability. This paper illustrates assessment of soil erosion vulnerability using the recently proposed approach for predicting agricultural soil erosion to investigate the effects of soil loss on crop yield in semi-arid region which is located in Iran (Shahbazi 2008).

Methods
Western European sites
Mediterranean, Atlantic and Continental regions corresponding to 20 selected benchmark sites in Europe were selected to apply ImpelERO model with Luvisols and Vertisols in the Mediterranean, Cambisols in Atlantic and all soil groups in Continental regions. Dataset files on climate data for meteorological station closer to the selected benchmark sites were compiled from the world weather datdbase (WDA 1994).On the basis of the expert system/neural network structure of ImpelERO model within the new MicroLEIS DSS framework, a computerized procedure was followed to find an appropriate combination of management practices to minimize soil loss for a particular site (De la Rosa *et al.* 2000). According to model generalization option, it can be specifically generalized for each study area while the main goal of this research is to show the possibility of model application outside of the calibrated area such as a semi-arid region.

West Asia studied site

The study area covers 14 natural regions and includes 23 soil families within three soil orders: Entisols, Inceptisols and Alfisols in the north-west of Iran, east Azerbaijan province, in an area extension about 9000ha. Typic Calcixerepts are the most dominant subgroups (Figure 1). However, 44 soil mapping units were distinguished according to geo-pedology soil surveying (Shahbazi *et al.* 2009b). Altitude varies from 1300 to 1600m with a mean of about 1450m, and slope gradients vary from flat to more than 10%. The dominant farming system on the studied area is direct seeding on permanent soil cover in wheat- alfalfa-barley rotation. For this case study, the selected benchmark soil physical, chemical and morphological data were stored in SDBm plus which is a geo-referenced soil attribute database and engine of MicroLEIS DSS. On the other hand, the climate database CDBm and farming database MDBm are used as important software to warehouse the basic information.

Figure 1. Site and soil profile described in the studied area (e.g. Clayey, mixed, mesic, semiactive Typic Calcixerepts with soil horizons A, B1, Bk2, C of a dark greyish brown colour on topsoil); Location: 38° 24′31″N and 47° 00′ 58″ E.

Model application and calibration

Basic elements for running the model are region, field unit, soil, climate, management and perturbation. The evaluation region is a complete set of field-units identify the spatial unit of analysis to be evaluated by application of the ImpelERO model. land characteristics is a simple attribute of the land that can be directly measured or estimated in routine natural resource survey referred to the soil which define a field-unit. Land quality will be described following the land characteristics related not only to soil but also to climate characteristics. A set of management characteristics which consider basically crop properties and cultivation practices. It is a simple attribute of the agricultural management that can be estimated and can be employed as a means of describing management qualities. Climate changes referred to temperature and precipitation from the existing meteorological data, and generally based on predictions for future scenario (Christensen *et al*. 2007) were perturbation procedure. There are three main options: i) to enter or edit input data; ii) To create the model generalization calibration is possible. Runoff erosivity, relief hazard, soil erodibility, crop production, tillage translocation and production influence are principal revised parameters according to the nature of tested area and local environmental conditions, only the ratio Fournier/humidity index was revised (Figure 2); iii) to run the model. Testing analysis is under instruction compared to same investigations using USLE and PSIAC methods.

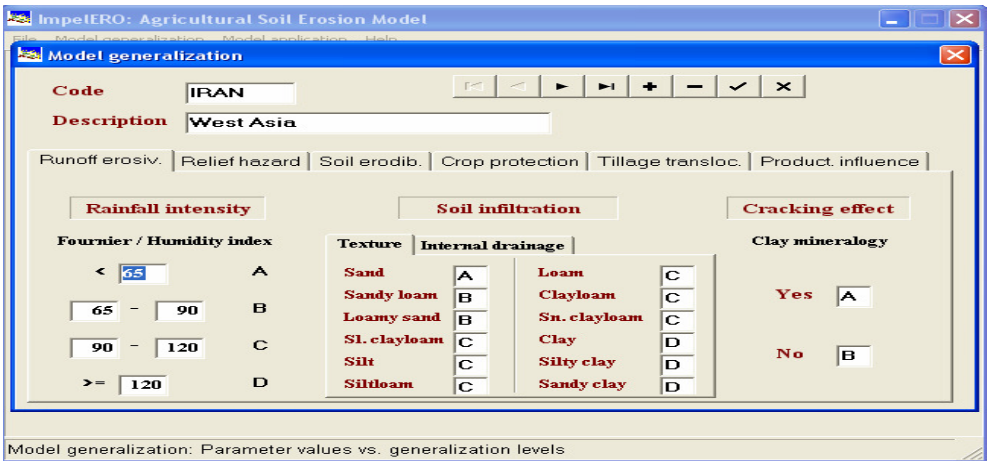

Figure 2. Generalization levels of each land/management characteristic considered for the studied area.

Spatialization analysis

The spatialization analysis includes the utilization of spatial techniques to expand land evaluation results from local scale to geographic areas using soil survey and other related maps. The use of geographical information system leads to the rapid generation of thematic maps and areas estimates, and enables the use of many analytical and visualization procedures to produce interpreted maps.

Results

The agro-ecological land evaluation decision support system such as MicroLEIS reflects the many advances in these technologies and their possibilities for the development and application to soil quality assessment. Vulnerability index, risk class, soil loss rate (Mg/ha/y) and soil depth reduction (cm/y) are the main outputs from the ImpelERO model which are summarized in Table 1. Areas with a high risk vulnerability (classes V4 and V5 a total of 4753ha) were considered as marginal lands management plan is needed to decrease soil loss rate

Table 1. Summary of model application results in the studied area.

Soil unit	Natural region	Area Ext. (ha)	Risk class	Soil loss rate (Mg/ha/y)	Soil depth reduction (cm/y)	Productivity reduction (%)		
						2020	2050	2100
1	Kord Ahmad	165	V2	7.3	0.06	0	1	4
2	Kord Ahmad	354	V2	8.5	0.07	0	1	5
3	Central Ahar	82	V3	45.2	0.29	2	11	25
4	Central Ahar	93	V1	3.3	0.02	0	0	0
5	Dizaj Chalou	277.3	V4	69.2	0.53	1	5	10
6	Dizaj Chalou	141.7	V5	101.8	0.76	8	29	64
7	Kord Ahmad	64.5	V2	6.2	0.05	0	0	1
8	Central Ahar	84	V3	46	0.41	1	3	8
9	Central Ahar	214	V2	8.7	0.06	0	0	1
10	Central Ahar	89	V2	9.9	0.09	1	3	7
11	Central Ahar	198.1	V2	7.1	0.05	0	1	4
12	Kord Ahmad	55.1	V3	10.7	0.08	0	3	6
13	Dizbin	340	V4	56.9	0.39	4	15	33
14	Dizbin	200	V4	87.3	0.68	7	26	57
15	Mardehkatan	310.5	V5	101.8	0.8	8	31	68
16	Garangah	176	V4	56.9	0.41	1	3	8
17	Garangah	262	V1	4.8	0.03	0	1	3
18	Dizbin	276.1	V5	101.8	0.8	8	31	68
19	Dehestan	220	V4	72.1	0.54	5	21	47
20	Dizaj Talkhaj	264	V5	118.9	0.89	9	36	78
21	Garangah	324.4	V5	117.6	0.97	10	37	82
22	Garangah	180	V4	84.5	0.66	6	25	55
23	Khonyagh	283.3	V2	9.8	0.08	0	0	1
24	Dizbin	130.3	V2	6	0.04	0	1	3
25	Dehestan	282	V4	70.6	0.53	1	5	10
26	Mardehkatan	165	V2	9.9	0.07	0	3	6
27	Garangah	246	V3	45.2	0.28	3	10	23
28	Garangah	22.4	V4	74.4	0.55	6	21	46
29	Khonyagh	167	V1	3.1	0.03	0	0	0
30	kalhor	298	V1	4.9	0.03	0	1	3
31	Dizaj Talkhaj	128.7	V3	12.6	0.08	0	3	6
32	Mardehkatan	183.3	V4	88.8	0.79	2	7	15
33	Garangah	328	V3	45.2	0.28	0	2	5
34	Cheshmevazan	180	V2	9.9	0.07	0	0	1
35	kalhor	30	V4	4.8	0.57	1	5	11
36	Dehestan	490	V4	70.6	0.54	1	5	10
37	Kordlar	140	V2	9.9	0.08	0	3	6
38	Kordlar	261	V1	4.8	0.03	0	1	3
39	Garangah	367	V4	70.6	0.51	6	19	43
40	Gorchi	213	V4	88.8	0.74	1	6	15
41	Kalhor	134.1	V3	46	0.34	1	3	6
42	Kordlar	237.3	V5	101.8	0.83	8	31	70
43	Dehestan	110	V3	23.2	0.17	2	6	15
44	Zargar	218	V5	145.2	1.32	14	51	100

Conclusion

According to the obtained results, productivity reduction due to soil loss rate and soil depth reduction in 20 examined soil mapping units is appreciable. Decreased soil erosion is the basic principal of sustainable agricultural practice focusing on the positive effects on the soil quality. A vulnerability classification map can be provided by integrating the model results with GIS (Figure 3).

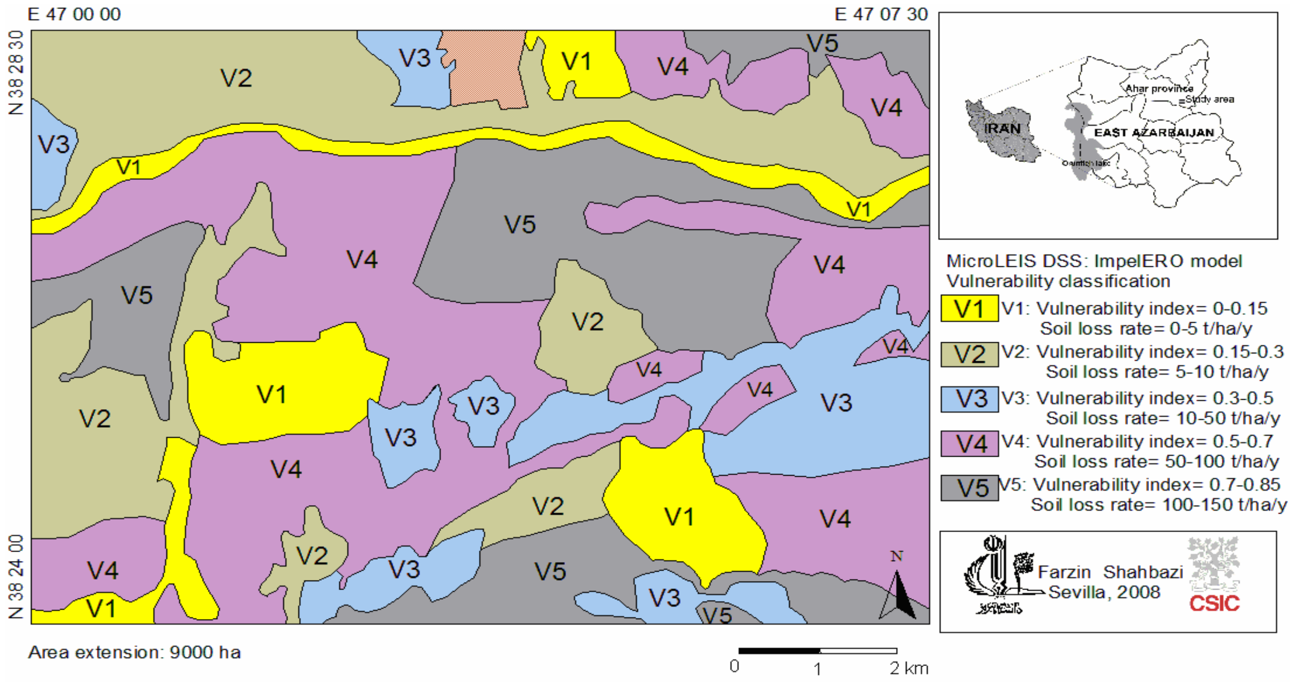

Figure 3. Vulnerability classification map of studied area.

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