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Research Article

ASSESSMENT OF SOIL EROSION BY NEURAL NETWORK-BASED IMPEL EROMODEL USING GIS IN NEYSHABOUR PLAIN, NORTHEAST OF IRAN

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ABSTRACT
Soil erosion has proven one of the main obstacles in developing systems of sustainable agriculture management. In recent years, neural networks as an artificial intelligence technology have increased rapidly in their ability to deal with multivariate non-linear systems. The integrated model that has been used in European agriculture is called ImpelERO, which functions as a hybrid model of neural networks and decision trees. This article aims to extend the use of this model to the reduction of soil erosion in the climatic and soil conditions of the Neishabour Plain. In this plain, 41 units of the of the targeted soil profile have been analyzed. Also, three agricultural products were chosen: wheat, potatoes, and sunflowers. The results demonstrate that the V1 to V5 selections are risk classes, where V1 represents the lowest risk class and V5 represents the highest risk class. Topographical constraints will increase the prevalence of risk classes and reduce long-term efficiency. Using these results, it is possible to manage soil conditions to minimize the rate of soil loss.

Keywords: *ImpelERO Model, Erosion Vulnerability, Wheat, Sun Flower, Potato, Neyshabour Plain*

INTRODUCTION
Nowadays, soil erosion issues are considered one of the most important topics in the management of agriculture, natural resources, the environment and water resources; which is the comprehensive management of water catchment areas. Disputes over water resources have proven one of the most controversial concerns in recent years, especially in developing countries. In the field of soil water erosion, especially in the discipline of soil research, extensive studies have been undertaken. Through scientific progress, humans have uncovered more critical details (Shahbazi *et al.,* 2010). New approaches emerging from agricultural science have kept soil issues in frequent mainstream coverage, which has played a very important role. Consequently, those immersed in modern methods of agricultural soil conservation have been emphasized as the main experts for determining the potential growth of major agricultural ecosystems. Climate, vegetation, soil and topography are the major factors influencing soil erosion in regional meadows. Water and soil form the basis of life and erosion constantly acts to destroy it. For this reason, the fight against erosion across the world has attracted serious consideration (Refahi, 2006). Climate change, the destruction of vegetation, and human destructive activities increase soil erosion and degradation throughout different regions of the Earth (Ravi *et al.,* 2010). Soil erosion is one of the most important problems of the 21st century, especially in arid regions, where it results in food insecurity and different environmental implications (Field *et al.,* 2009). In this regard, knowing the effects on soil that lead to soil destruction, in order to understand the process of erosion and soil degradation in different climatic zones, is necessary to prevent and reduce degradation (Turenbull *et al.,* 2008; Okin, 2009; García-Ruiz, 2010). Neural networks are one of the most dynamic areas of contemporary research, and they have attracted a great deal of attention in ways that have permeated different sciences and created an overwhelming number of applications (Kim and Gilley, 2008). Despite significant advances in structure-based computational intelligence in various disciplines, the applications of this tool in the field of agriculture remain minimal and in their infancy. However; the abilities of these tools to simulate very complex and uncertain processes in the agricultural sciences are found in abundance, and a number of modern research applications have been found (Jalalian and Ayoubi, 2006). Additionally, soil erosion

remains a major concern for the development of sustainable agricultural management systems. The ImpelERO model focuses on the effects of soil erosion, the utilization of applicable products, and new methods of agricultural management for soil conservation (Delaroza *et al.*, 2000). Soil erosion by water is one of the biggest problems in agro-ecology and the management of soil loss. The ImpelERO model forecasts water erosion over time, depending on the type of soil and its management. This model is a useful tool to predict soil erosion and choose new management methods. Weather data received from meteorological stations of the studied areas, as well as data on pedology and soil maps are also required for this model.

With the use of till age and cover crop cultivation areas and types of equipment, it seems that it is possible to make accurate predictions on soil erosion in the region (Delaroza *et al.*, 2002). Our goal, therefore, is to predict a method of application for agricultural lands and, due to that, we should identify the factors that cause soil erosion and collect them in a complete database and through designed models. These would include neural network models such as ImpelERO, as well as the use of geographic information systems (GIS). We should combine these tools to provide management solutions for land use. The aim of the present study was to assess and provide the most suitable crop pattern for selected crops based on ImpelERO model to minimize the risk of soil erosion in the study area.

To identify constraints associated with each territorial unit, and to estimate the vulnerability index of the soil against erosion; this also includes the depth of soil erosion annually, as well as a comparison of maps of vulnerability and soil loss based on the proposed modeling system produced by geographic information systems (GIS).

MATERIALS AND METHODS

Geographic Position of the Study Area

The study area covers part of the hydrological plain of Neyshabour, northeast of Iran (Consulting Engineers Tom\Vysan 2001). The study area includes Neyshabour flat plain with the elevation of 1100 to 1700 meters asl. The study area is located between 35^o 41' to 36^o 39' N and 58^o 13' to 59^o 30' E with total surface area of 5068.57Km^2 (Figure 1). The region has a semi-arid climate with an average annual precipitation of 238.2 mm and an average annual temperature of 14.4 °C.

ImpelEro Model

The data of the soil samples have been extracted from the studies of soil monitoring of Khorasan Razavi, Neyshabour Plain. In this context, regional climate features include maximum, minimum and mean annual temperatures, precipitation and annual average monthly precipitation in the period from 1991 to 2010 to determine the Fournier index and the moisture index during the growing season of the plants independently, and also the land quality; such as the land topographic situation, shelves, slopes and drainage; soil physical properties such as soil texture, soil bulk density, soil depth and soil of gravel; chemical properties and soil fertility, including soil organic matter, exchangeable sodium percentage, clay mineralogy; crop management systems including farming systems, interactions with crop residue after harvesting, plowing systems, the product type (summer or winter); during the growing season, the use of soil stabilizers, row spacing, basic functionality, performance prediction and plant height. Lastly, one considers the frequency of use and type of equipment used for plowing from planting to harvesting. Its features are presented in the framework of the ImpelEro model based on artificial neural network algorithms from the MicroLEIS software.

In this regard, the risk of erosion, the loss of soil, yearly soil erosion, the index of soil sensitivity (vulnerability) against erosion, the class of erosion-caused surface runoff; along with the class of soil erosion and soil erosion management classes such as the product protection class, class displacement of soil by plowing, the class of soil fertility and finally, recommending soil erosion control methods regarding the reduction of the sensitivity of the soil in the studied area are estimated and evaluated (Figure 2).

In this model, the qualities of soil and land management as a model input parameters in the input layer, after spending a hidden layer with three knots. This leads to an output as an indicator of vulnerability to soil erosion (Vi) (vulnerability index). The entered land quality in the neural network includes: runoff erosivity land quality (LQr), relief hazard land quality, soil erodibility land quality; management qualities including crop protection (MQc), till age translocation management quality, and productivity influence management quality (MQy) (Figure 3).

RESULTS AND DISCUSSION

Using the ImpelEro model based on neural networks, the amount of soil loss (Mg/ha/yr) and the depth of soil eroded in (cm/yr), as well as the risk of soil erosion between classes V1 to V6, as shown in Table 1 for wheat, potatoes and sunflowers, have been calculated. Note that all three erosional classes are high in the region, and wheat displays a lower erosional class compared to potatoes and sunflowers. One of the main factors involved in soil erosion is the inherent characteristics of soil; through recognition and evaluation of these factors and through systematic solutions, the loss of soil erosion can be brought to a minimal level.

According to the results of studying large areas of land under cultivation, the region now faces a severe erosion risk. In this respect, necessary measures should be undertaken to reduce vulnerability and increase soil productivity. The results demonstrated that soil texture, topography, and soil slope are the most important factors affecting the level of risk and soil vulnerability. This means that soil which is sandier and contains more silt exhibits lower attrition rates and a lower risk class. As well as increasing silt in the soil increases the risk of soil erosion will be.

As well as the plowing depth, type and frequency of use of agricultural equipment are important factors affecting the rate of soil erosion and the losses. Using the decision-making system ImpelERo model is an opportunity to optimize the use of soil and prevent the increase in soil erosion and loss, with respect to which we can identify vulnerable segments of soil suitable for cultivation. Using Geographic Information System (GIS) technology, the map of the classes of soil erosion in the study areas for wheat, potatoes and sunflowers are presented (Figure 4).

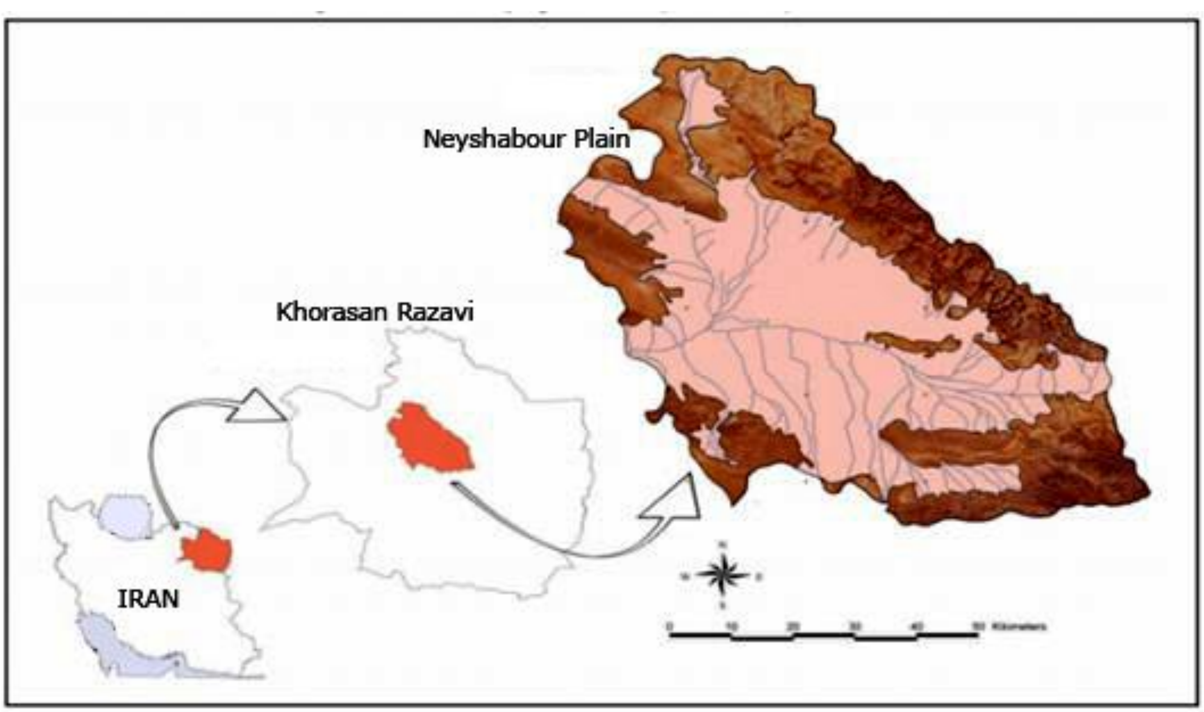

Figure 1: The Geographic Position of the Studied Area

Table 1: Summary of Model Application Results in the Studied Area

	Wheat			*Potatoes*			*Sunflowers*		
Land Unit	**Risk Class**	**Soil Loss Rate (mg/ha/yr)**	**Soil Depth Redaction (cm/yr)**	**Risk Class**	**Soil Loss Rate (mg/ha/yr)**	**Soil Depth Redaction (cm/yr)**	**Risk Class**	**Soil Loss Rate (mg/ha/yr)**	**Soil Depth Redaction (cm/yr)**
1	v2	5.2	0.03	v2	5.4	0.03	v2	5.8	0.03
2	v4	74.2	0.46	v5	112.3	0.7	v5	112.3	0.7
3	v3	17.6	0.12	v3	36.5	0.26	v3	36.5	0.26
4	v2	9.3	0.07	v3	40.8	0.29	v3	48.5	0.34
5	v4	59.5	0.42	v4	96.6	0.69	v4	96.6	0.69
6	v3	28.3	0.21	v3	48.5	0.36	v3	48.5	0.36
7	v4	51	0.36	v5	106.4	0.75	v5	106.4	0.75
8	v4	59.5	0.41	v4	96.6	0.67	v4	96.6	0.67
9	v3	17.6	0.12	v3	36.5	0.26	v3	36.5	0.26
10	v4	65.2	0.42	v5	112.3	0.72	v5	122.4	0.78
11	v4	59.5	0.4	v4	96.6	0.65	v4	96.6	0.65
12	v4	65.2	0.49	v5	112.3	0.84	v5	122.4	0.92
13	v2	7.9	0.05	v3	36.5	0.24	v3	29.3	0.19
14	v1	4.5	0.03	v3	32.1	0.25	v3	32.1	0.25
15	v4	62.8	0.38	v4	91.7	0.51	v4	91.7	0.51
16	v3	25	0.17	v4	65.1	0.43	v4	74.4	0.49
17	v4	59.5	0.41	v4	96.6	0.67	v4	96.6	0.67
18	v4	51	0.39	v4	96.6	0.74	v5	106.4	0.82

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19	v2	6.1	0.04	v2	8.1	0.05	v3	36.8	0.24
20	v3	38.1	0.26	v4	50.6	0.35	v4	50.6	0.35
21	v1	3.7	0.02	v2	6.8	0.04	v3	38.1	0.24
22	v3	15.4	0.1	v4	50.6	0.31	v4	59.7	0.37
23	v3	20.6	0.13	v4	59.7	0.37	v4	50.6	0.31
24	v2	7.7	0.06	v2	9.3	0.07	v3	11.9	0.09
25	v4	65.2	0.5	v5	122.4	0.93	v5	122.4	0.93
26	v3	20.6	0.14	v4	50.6	0.33	v4	50.6	0.33
27	v4	68.2	0.45	v4	91.7	0.6	v4	91.7	0.6
28	v4	65.2	0.47	v5	112.3	0.8	v5	122.4	0.87
29	v3	46	0.37	v4	91.7	0.75	v4	83.3	0.68
30	v4	68.2	0.49	v4	83.3	0.6	v4	91.7	0.66
31	v2	7.9	0.05	v3	36.5	0.25	v3	29.3	0.2
32	v3	11.2	0.08	v3	39.5	0.27	v3	46	0.31
33	v2	5.2	0.04	v2	6.8	0.05	v3	36.6	0.28
34	v4	51	0.37	v4	96.6	0.71	v5	106.4	0.78
35	v4	56.5	0.39	v5	106.4	0.7	v5	106.4	0.7
36	v3	27.8	0.18	v3	39.5	0.26	v3	39.5	0.26
37	v2	9.6	0.06	v3	46	0.28	v3	46	0.28
38	v4	59.5	0.36	v4	96.6	0.59	v5	106.4	0.65
39	v4	51	0.38	v4	96.6	0.73	v4	96.6	0.73
40	v4	65.2	0.33	v5	112.3	0.57	v5	122.4	0.62
41	v1	5.2	0.04	v2	6.8	0.05	v3	36.2	0.21

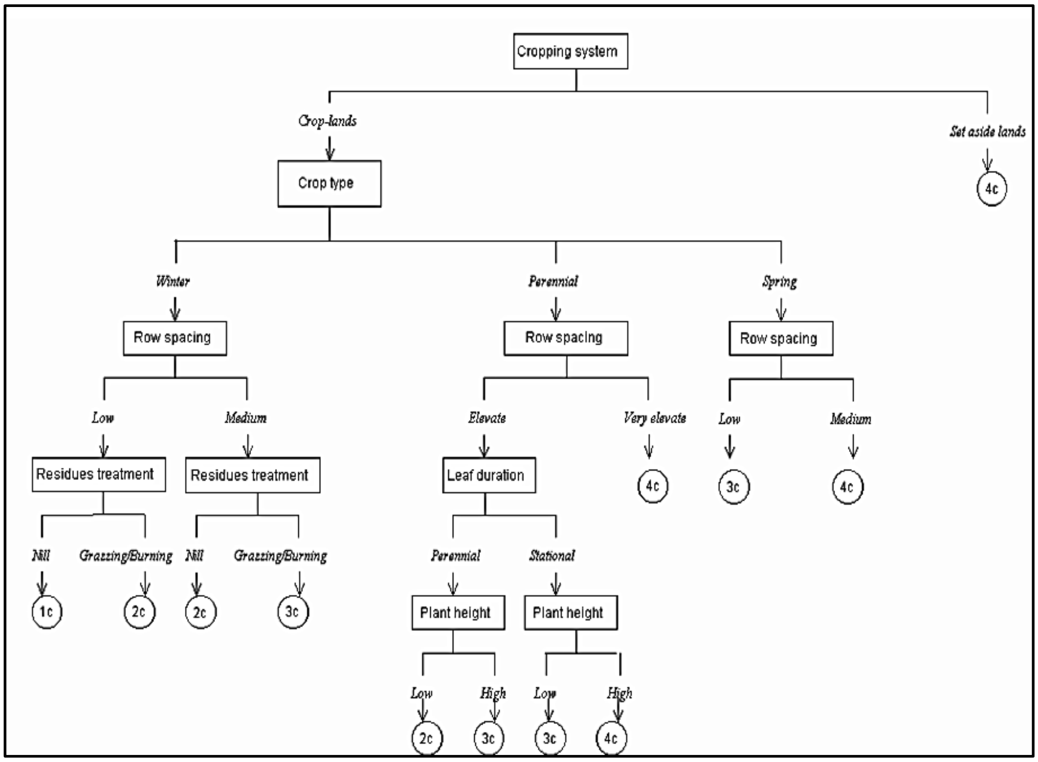

Figure 2: Classification of Quantitative and Qualitative Variables

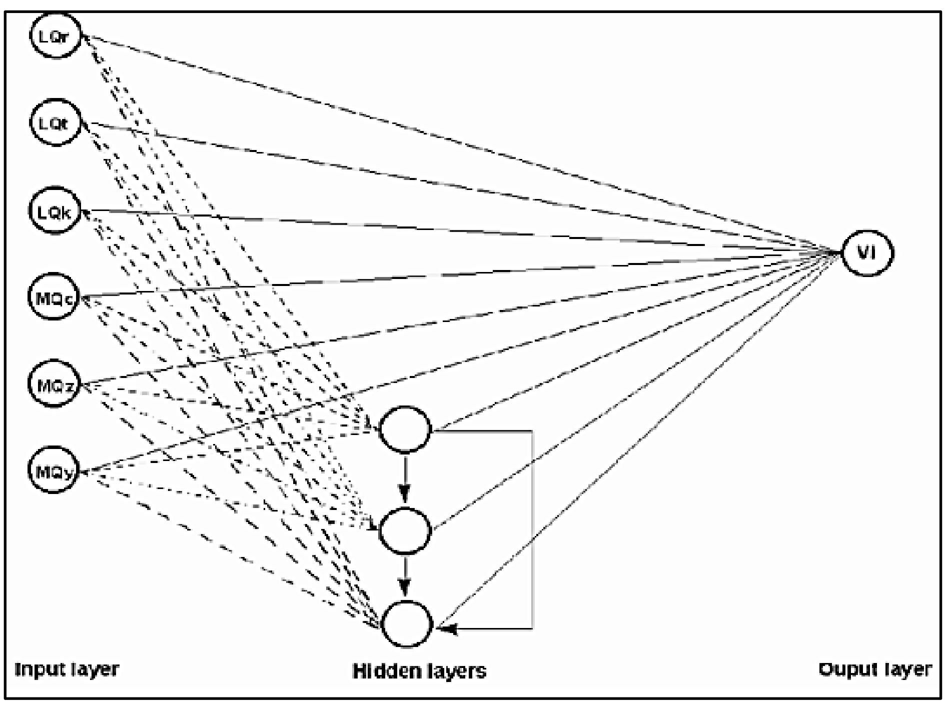

Figure 3: Showing the Different Layers of Soil Property Qualities Used to Estimate Soil Vulnerability to Erosion in the ImpelERO Model

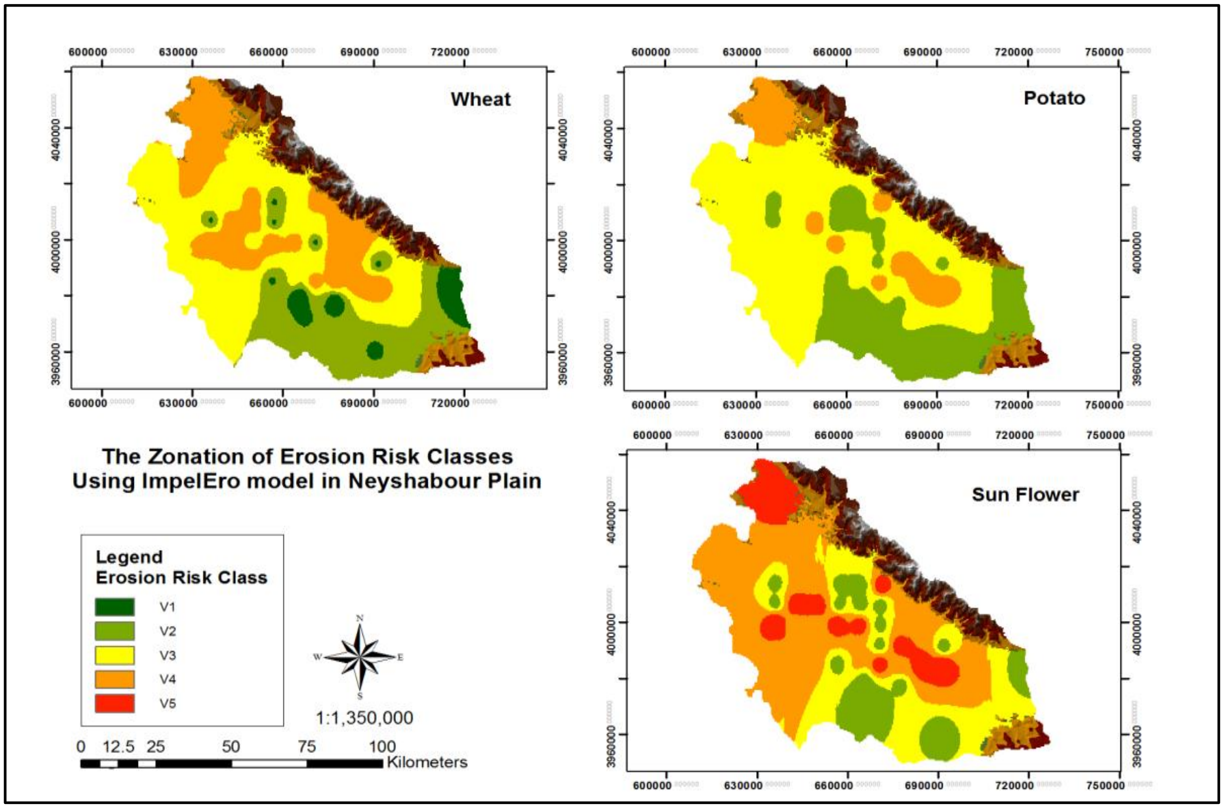

Figure 4: The Zonation of Soil Erosion Risk Classes in the Study Area for Wheat, Sunflower and Potato Crops

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