

Comparison of Four Weighting Methods in Fuzzy-based Land Suitability to Predict Wheat Yield

F. Rahmati¹ - A. Kamali^{2*}

Received: 16-01-2016

Accepted: 01-08-2016

Introduction: Land suitability evaluation is a process to examine the degree of land fitness for specific utilization and also makes it possible to estimate land productivity potential. In 1976, FAO provided a general framework for land suitability classification. It has not been proposed a specific method to perform this classification in the framework. In later years, a collection of methods was presented based on the FAO framework. In parametric method, different land suitability aspects are defined as completely discrete groups and are separated from each other by distinguished and consistent ranges. Therefore, land units that have moderate suitability can only choose one of the characteristics of predefined classes of land suitability. Fuzzy logic is an extension of Boolean logic by LotfiZadeh in 1965 based on the mathematical theory of fuzzy sets, which is a generalization of the classical set theory. By introducing the notion of degree in the verification of a condition, fuzzy method enables a condition to be in a state other than true or false, as well as provides a very valuable flexibility for reasoning, which makes it possible to take into account inaccuracies and uncertainties. One advantage of fuzzy logic in order to formalize human reasoning is that the rules are set in natural language. In evaluation method based on fuzzy logic, the weights are used for land characteristics. The objective of this study was to compare four methods of weight calculation in the fuzzy logic to predict the yield of wheat in the study area covering 1500 ha in Kian town in Shahrekord (Chahrmahal and Bakhtiari province), Iran.

Materials and Methods: In such investigations, climatic factors, and soil physical and chemical characteristics are studied. This investigation involves several studies including a lab study, and qualitative and quantitative land suitability evaluation with fuzzy logic for wheat. Factors affecting the wheat production consist of climatic conditions like mean, maximum and minimum air temperatures during growing period as well as edaphologic properties like EC, pH, ESP, percent of clay, silt, sand, gravel, gypsum and CaCO₃ content. Climatic data collected from the Shahrekord synoptic station were used to assess climatic land suitability for wheat. Qualitative land suitability evaluation was carried out using the fuzzy approach. Potential yield was calculated using the method proposed by FAO. Using MATLAB software, qualitative and quantitative land evaluation were classified based on fuzzy logic approach. In fuzzy method, climatic factors are used to achieve climatic index. Clay and sand percent were applied to calculate soil texture. To determine the membership degrees, bell membership functions were used. Parameters of function shapes were transformed to equations with variable coefficients and the best coefficients were eventually chosen based on the model determination coefficient. In evaluation method based on fuzzy logic, the weights are used for land characteristics. In fuzzy logic method, weights were calculated by four methods. These methods consist of neural network using 1 neuron and 4 neurons, multivariate and Partial Least Squares (PLS) regressions. Comparison of the coefficient of determination results of multivariate regression and RMSE is carried out between observed and predicted yield. Weight calculations were conducted by using MINITAB software to PLS and multivariate regression. Also, Neurosolution 5 was used for weight calculation based on neural network.

Results and Discussion: The calculated weights were differed by using the four applied methods. In all methods, the maximum weight was related to gravel, and minimum weight was related to clay. The results of land index and predicted yield calculation were different in some points (3, 6, 7, 13, 14, 19, and 21) for four methods. The coefficient of determination of calculated weights were 0.595, 0.56, 0.6 and 0.56 for neural network, 1 neuron, 4 neurons, multivariate regression and PLS and RMSE values in these methods were 6.38, 6.4, 6.38 and 6.38 Ton/ha, respectively. The correlation coefficient between the observed and predicted yield indicated the partially appropriate selection of the factors and evaluation approach.

Conclusion: The results of weight calculation were not showed significant difference in three methods (neural network, PLS, regression). The predicted yield was somewhat closer to the observed yield when 1 neuron was introduced to the neural network than 4 neurons. The maximum coefficient of determination as well as the

1 and 2- M.Sc. Graduate and Assistant Professor of soil science, Department of soil science, Vali-e- Asr University of Rafsanjan, Rafsanjan

(* - Corresponding Author Email: a.kamali@vru.ac.ir)

minimum RMSE was achieved for weights calculated by multivariate regression. Because the method is almost accurate and easy to use, it is recommended in this study. The coefficient of determination generally became low because different traditional management practices were carried out in the study area. Finally, in regard to achieved results about the used methods, it is suggested to take into account the management factors in land suitability processes and compare the other weight calculated methods in land suitability evaluation based on fuzzy logic.

Keywords: Fuzzy logic, Land Suitability, Weighting methods

Archive of SID