Hydrogeomorphology, Vol.6, No.23, Summer 2020, pp (44-51)

Received: 2020.08.13
Accepted: 2020.09.14

Analysis and Ranking of Soil Erosion Prevention Methods Using Multi-Criteria Decision-Making Methods in Rural Areas of Darmian County, South Khorasan

Mohammadjavad Vahidi*[1], Rasoul Mirabbasi[2], Mohsen Ahmadi[3]

1- Assistant Professor, Department of Agriculture, Plant Breeding and Soil Sciences, Faculty of Agriculture, University of Birjand
2- Associate Professor, Department of Water Engineering, Faculty of Agriculture, Shahrekord University
3- BSc, Student, Department of Agriculture, Plant Breeding and Soil Sciences, Faculty of Agriculture, University of Birjand

Abstract

1- Introduction

Soil erosion has significant environmental impacts and economic losses on crops and reservoir capacity, and affects water quality both directly and indirectly (Issaka and Ashraf, 2017: 3). Therefore, identifying factors affecting soil erosion and ranking the prevention methods in rural areas provide valuable information for managers and planners for soil conservation (Asadi et al., 2016: 99). Soil erosion, on the one hand, is affected by natural features and, on the other hand, by human activities. The type of precipitation regime and water erosion, erosion-sensitive formations, low natural vegetation cover, topographic conditions of natural factors, incorrect use or overuse of lands, poor pasture grazing, plowing of low-yield rainfed fields, and implementation of construction projects, such as road construction, building construction, and mining, without considering the principles of soil protection are the factors caused by human intervention in the country (Darabi et al., 2018: 201). The most appropriate scientific methods can be selected to prevent soil erosion in accordance with the opinion of relevant experts and scientists. Another important issue is the use of appropriate criteria and sub-criteria

* (Corresponding Author), **E-mail:** m.jvdi@birjand.ac.ir

to obtain final responses. In fact, if the study method is selected properly, but the criteria and sub-criteria used are not of the desired quality, the results are not reliable and the final output will cause deviations in the final decision. Therefore, it is necessary to extract all required criteria and sub-criteria from the research literature and validate them by experts. Among the methods used to control soil erosion are contour plowing, mulching, mixed cultivation, adding organic fertilizers and manure, grass cultivation, terracing, and cultivation on contour lines (Begum Nasir Ahmad et al., 2020: 104). Darmian County is one of the important agricultural centers of South Khorasan province. As reported previously, 93.3% of the total area is in the severe desertification class (Parvaneh, 2009: 150). According to most studies on multi-criteria decision making techniques (MCDM), the VIKOR technique results in a lower percentage and intensity of changes and yields more valid results (Nazmfar and Padarvandy, 2015: 36; Kim and Ahn, 2019: 126). Therefore, this technique was used in the present study. Keshtkar et al. (2017: 133) conducted a study with the aim of prioritizing the biological management options of Delichay watershed using MCDM. They identified four biological management activities and developed 16 management scenarios in the region. Also, the social, ecological, economic, and physical criteria were assigned the first to fourth priorities, respectively, and scenario number 10 (grazing management and pit-seeding) was determined as the top scenario in the first priority. Vulević et al. (2015: 317) prioritized soil erosion vulnerable areas in the Topčiderska River Watershed, northern Serbia, using multi-criteria analysis methods, and identified the most vulnerable sub-basins due to a significant presence of arable and very steep arable lands, which, therefore, had priority for protection. Also, Zhang et al. (2020: 1331) identified priority areas for soil and water conservation planning using multi-criteria decision analysis in the Xinshui River watershed, China. They selected six assessment indicators, including slope gradient, precipitation, NDVI, land use, soil texture, and slope aspect. They concluded that more attention should be paid to the slope of farmland

and grassland during the planning and management of soil and water conservation projects.

Darmian County is an important region in terms of agricultural and horticultural products and severe erosion that threatens the products and natural resources in rural areas. In this research, therefore, an integrated approach based on the multi-criteria decision making methods, including Best-Worst (BWM) and the VIKOR methods, is presented according to expert's opinions to analyze the factors affecting soil erosion and ranking the prevention methods in the rural region of Darmian, South Khorasan Province.

2- Methodology

In this study, the weights of the identified criteria and sub-criteria from the research literature and experts' opinion were first determined using the BWM and then the VIKOR method was used for ranking the erosion prevention methods. According to the review of the literature, many methods have been proposed to rank the methods of preventing soil erosion. However, these methods usually have a relative level of uncertainty due to a high level of decision maker involvement in the production of final answers. However, the best-worst method has a very strong approach in determining the weight of criteria compared to other decision-making methods (Rezaei, 2016: 126).

Best-worst method: This is one of the powerful methods in solving the multi-criteria decision making problems used to obtain the weights of options and criteria (Rezaei, 2016:126). This method compensates for the weaknesses of methods based on pairwise comparisons (e.g., AHP and ANP) such as incompatibility. In addition, it reduces the number of pairwise comparisons significantly by only performing reference comparisons. In recent years, the best-worst method has been used by many researchers to determine the weights and rankings of options in various fields.

VIKOR method: This method is an adaptive ranking technique that is often used in situations with different conflicting criteria (Opricovic, 1998: 5). This method creates a compromise solution based on "proximity to the ideal solution and mutual agreement through concessions". This method has been widely used by many researchers to rank options (Arab Ameri et al., 2018: 1400; Gupta, 2018: 47; Opricovic and Tzeng, 2004: 445). It uses linear normalization that specifies a summation function indicating the distance from the ideal solution.

3- Results and Discussion

The criteria and sub-criteria used in this research (based on a review of the research literature) are presented in Table 1.

Table (1): The criteria and sub-criteria affecting soil erosion

Sub-criteria	Criteria	Sub-criteria	Criteria
Aggregate stability	Technical	Destruction of vegetation	Environmental
Water penetration capacity		Surface water flows	
Depth of soil		Runoff volume	
Clay particles	Chemical	Destruction of ecosystems	
Soil organic carbon content		Drought	Climatic
Non-use of livestock manures	Social	Fire	
Overgrazing		Rainfall	
		Land slope	

A consensus method was used to achieve valid results, as for gathering information, a committee of experts was asked to evaluate the performance of the options against the criteria (Table 1) using the scales listed in Table 2.

Table (2): Verbal scale for pairwise comparisons of best-worst methods and Victor techniques

Scale for the best- worst approach								
Extremely Imp.	**Very strongly to extremely Imp.**	**Very strongly Imp.**	**Strongly to very strongly Imp.**	**Strongly Imp.**	**Moderately to strongly Imp.**	**Moderately Imp.**	**Equal to moderately Imp.**	**Equally Imp.**
9	8	7	6	5	4	3	2	1
Scale for Victor technique								
Degree of Imp. for positive effect criterion	Degree of Imp. for negative effect criterion						**Verbal expressions**	
1	5						Least Imp.	
2	4						Moderately Imp.	
3	3						Strongly Imp.	
4	2						Very Strongly Imp.	
5	1						Extremely Imp.	

P.S. Imp. = Important

Calculating the weights of the criteria using the best-worst method

Out of all the criteria, the best and worst criteria were selected by experts through mutual agreement. The priority of other criteria was also determined by the worst criteria. After collecting the best-worst method questionnaires, the weights related to the criteria and sub-criteria were obtained using the GAMS optimization software version 24.3 by the BARON solver. The degrees of priority for all the criteria were achieved to calculate the optimized local weights. The results showed that the "technical" and the "chemical" criteria had the highest (0.293) and the lowest (0.085) local weights, respectively, among all the examined criteria.

Prioritization of erosion prevention methods using the VIKOR method

After achieving the weights of the criteria, the methods of erosion prevention were prioritized in the next step based on the weights of these

factors using the VIKOR method. According to the computational results, the technical and the chemical criteria (with scores of 0.293 and 0.085) had the highest and the lowest ranks, respectively. In the final prioritization of the erosion prevention methods, Biochar and injection of organic maters were in the first and second ranks, respectively, and artificial rain was at the lowest rank.

4- Conclusion

In this research, a new combined approach is presented based on the best-worst method and VIKOR technique to identify the factors affecting soil erosion and to rank the prevention methods based on the opinions of experts and scientists in the field of agricultural development. According to the obtained results, "technical", "climatic", and "environmental" sub-criteria are the three important factors in evaluating erosion prevention methods. In the next step, the options were finally ranked using the VIKOR method, indicating that the top three options are "Biochar", "Arch planting", and "injection of fertilizers and organic matter", respectively. Considering that the development of infrastructure to select scientific methods to prevent soil erosion in rural areas is one of the effective factors in the development of agricultural science in the country, studies in this area should be given more attention. It is expected that the results of this research can provide a suitable tool for managers to make correct decisions.

Keywords: Ranking, VIKOR method, Soil erosion, Darmian County, South Khorasan Province.

5- References

Anonymous, (2013). *Detailed executive studies of Darmian city*, Ministry of Jihad Agriculture, Forests and Watershed Management Organization, General Department of Natural Resources of South Khorasan, 5 P.

Arab Ameri, A., Pourghasemi, H.R., & Cerda, A. (2018). Erodibility prioritization of sub-watersheds using morphometric parameters analysis and its mapping: A comparison among TOPSIS, VIKOR, SAW, and CF multi-criteria decision making models, *Science of the Total Environment*, 613-614, 1385-1400.

Asadi, O., Rostamikhalaj, M., Mohseni Saravi, M., & Sour A., (2016). Prioritizing of watershed management planning using TOPSIS method in the watershed (Case study: Zydasht-Taleghan), *Journal of Water and Soil Science*, 6(12), 98-107.

Begum Nasir Ahmad, N., Syabeera Nasir Ahmad, N., Syabeera Begum Mustafa, F., Begham Muhammad Yusoff, S.Y., & Didams, G. (2020). A systematic review of soil erosion control practices on the agricultural land in Asia. *International Soil and Water Conservation Research*, 8, 103-115.

Darabi, M., Gharehdaghy, H., & Nejabat, M. (2018). Evaluation of watershed projects performance on erosion and sediment transport in Sivand Dam Watershed, Fars Province, Iran, *Journal of Hydrogeomorphology*, 14, 199-218.

Gupta, H. (2018). Evaluating service quality of airline industry using hybrid best worst method and VIKOR, *Journal of Air Transport Management*, 68, 35-47.

Issaka, S., & Ashraf, M.A. (2017). Impact of soil erosion and degradation on water quality: a review, *Geology, Ecology, and Landscapes*, 1(1), 1-11.

Keshtkar, A., Mohammadkhan, S., Houshmandi, R., & Dalfardi, S. (2017). Prioritizing determination of watershed biological management options using multi-criteria decision making techniques (Case study: Delichay Catchment), *Journal of Water and Soil Science*, 21(3), 133-147.

Kim, H.H., & Ahn, B.S. (2019). Extended VIKOR method using incomplete criteria weights. *Applied Mathematical Modelling*, 126, 124-132.

Nazmfar, H., & Padarvandy, B. (2015). Comparative analysis of the application of multi-criteria analysis (MCDM) (Case study: Lorestan Province), *Journal of Regional Planning*, 17, 31-44.

Opricovic, S. (1998). *Multicriteria Optimization of Civil Engineering Systems*, PhD Thesis in Civil Engineering, Faculty of Civil Engineering, University of Belgrade, 302 p.

Opricovic, S., & Tzeng, G.H. (2004). Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS, *European Journal of Operational Research*, 156(2), 445-455.

Parvaneh, H. (2009). *Evaluation of the Current Situation of Desertification in South Khorasan Using Madalus Method-Tabas Messina Region-Darmian city*, Master Thesis in Natural Resources Engineering, Faculty of Natural Resources, Isfahan University of Technology, 150 p.

Rezaei, J. (2016). Best-worst multi-criteria decision-making method: Some properties and a linear model, *Omega*, 64, 126-130.

Vulević, T., Dragović, N., Kostadinov, S., Simić, S.B., & Milovanović, I. (2015). Prioritization of soil erosion vulnerable areas using multi-criteria analysis methods, *Polish Journal of Environmental Studies*, 24(1), 317–323.

Zhang, H., Zhang, J., Zhang, S., Yu, C., Sun, R., Wang, D., Zhu, C., & Zhang, J. (2020). Identification of priority areas for soil and water conservation planning based on multi-criteria decision analysis using Choquet Integral, *International Journal of Environmental Research and Public Health,* 17(4), 1331.