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The study of land use and slope role in flow coefficient determination

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Abstract

Floods, one of the most destructive risks on the planet's surface, are difficult to forecast using an accurate model. In Turkey, floods are the second most costly natural disaster after earthquakes. By determining the flow coefficient, which is the most effective factor in flood flow, the existing problems will be greatly reduced. There are numerous techniques for modeling flow coefficients available in the existing literature. However, the majority of them are based on black-box methodologies that cannot be generalized. In this study, a new approach called Fuzzy SMRGT Method, which takes into account the physics of the event, was chosen. The data containing the land use and slope details of the Aksu river basin were used. The model's output was compared to actual data.

Introduction

Flooding is among the most destructive natural hazards, endangering people and property on a large scale. It is critical to identify flood risk areas to manage this area optimally. The number of such disasters registered in the last few decades has increased as a result of global climate change [1]. The number of impervious surfaces incorporated into development patterns is a major factor when considering the relationship between land conditions and flooding. Natural landscape transformation to urban or suburban development can minimize the functionality of hydrological processes. Large sections of the impermeable area can lessen precipitation infiltration into the soil and increases the surface discharge into nearby streams and rivers [2]. Several studies used machine learning and deep learning models to examine the predictive outcomes of multiple models in fields such as hydrology and hydraulics [3]. In this study, the flow coefficient under the influence of land use and the slope are determined and modeled by using the fuzzy SMRGT method.

Material and Method

Aksu river basin located between 36◦ -38◦ north latitudes, and 30◦ -31◦ east longitude in a Mediterranean Sea region, was chosen as a study area. It is one of the 10 sub-basins of the Antalya basin and has an area of about 7505 km^2 according to the measurements in the GIS environment. The data of land use and slope were taken into account in the modeling. The flow coefficient calculation should be as accurate as possible, therefore, in this research the flow coefficient of the basin was determined using Simple Membership functions and fuzzy Rules Generation Technique (SMRGT), which is first introduced by Toprak [4]. To establish the model MATLAB'2019b package program and the Fuzzy Logic are used. It is possible to explain the procedure in eight steps: (1) the independent and dependent variables that influence the current event was chosen. (2) For each independent variable, five membership functions were defined (Very low, Low, Medium, High, and Very high) (Fig.1) & (Fig.2). (3). The shape of the membership functions (MFs) was chosen to be triangular. The first and last membership functions should be right-angled triangles, while the MFs in the middle should be an isosceles triangle. (4) The number of key values was determined to be equal to the number of MFs for each independent variable. (5) Package programs, such as MATLAB, were configured to include the fuzzy set. (6) The Excel program makes it easier to complete all of the procedures mentioned in the first five articles. It is important to note that the above operations are only for the model's installation (calibration). The input and output data files using calibration data in the relevant package program were prepared. (7) The fuzzy system was created with the help of the relevant package programs. A simple subprogram was used to run the program and evaluate the results. (8) If the output membership functions are overly intertwined, they must be reduced by combining two or more membership functions into one [4-5].

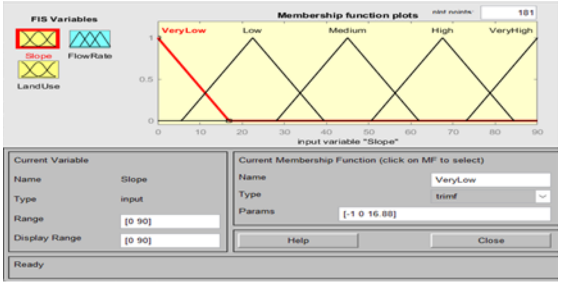

Figure 1. Membership functions for the slope (input1)

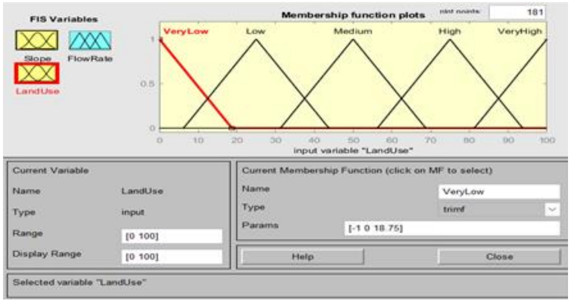

Figure 2. Membership functions for the land use (input2)-

Results

The scatter diagram of the model and the data are presented in (Fig.3). the values are scattered rather impartially (with an angle of 45) and linearly. As can be seen in (Fig.3), & Table 1. The determination coefficient (R^2) was calculated as 0.997. The mean absolute relative error (MARE) was calculated as 13.44%. Table 1 shows that the model results and key values are generally good predictions of the model, with a low mean absolute relative error (MARE).

Table 1. Fuzzy rules generation

Rules No	Slope Numerical Verbal	Land use Numerical Verbal	Flow Coefficient (data)	Flow Coefficient (model)	MARE (Mean absolute relative error)	Rules No	Slope Numerical Verbal
1	5.625	Very low	6.25	Very low	0	1	5.625
2	5.625	Very low	25	Low	2	2	5.625
3	5.625	Very low	50	Medium	5.3	3	5.625
4	5.625	Very low	75	High	10.2	4	5.625
5	5.625	Very low	93.75	Very high	12.75	5	5.625
6	22.5	Low	6.25	Very low	20	6	22.5
7	22.5	Low	25	Low	22.5	7	22.5
8	22.5	Low	50	Medium	26.2	8	22.5
9	22.5	Low	75	High	32.65	9	22.5
10	22.5	Low	93.75	Very high	34	10	22.5
11	45	Medium	6.25	Very low	35.2	11	45
12	45	Medium	25	Low	42.1	12	45
13	45	Medium	50	Medium	47.3	13	45
14	45	Medium	75	High	51.25	14	45
15	45	Medium	93.75	Very high	54.7	15	45
16	67.5	High	6.25	Very low	59.4	16	67.5
17	67.5	High	25	Low	66	17	67.5
18	67.5	High	50	Medium	66.25	18	67.5
19	67.5	High	75	High	69.2	19	67.5
20	67.5	High	93.75	Very high	75.2	20	67.5
21	84.375	Very high	6.25	Very low	81.95	21	84.375
22	84.375	Very high	25	Low	84.3	22	84.375
23	84.375	Very high	50	Medium	88.6	23	84.375
24	84.375	Very high	75	High	91.7	24	84.375

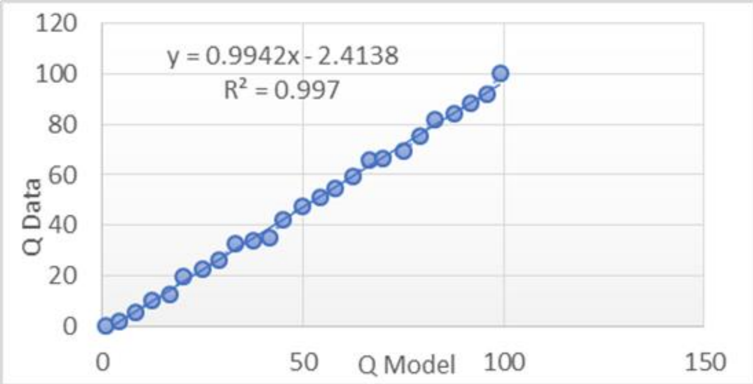

Figure 3. Scatter diagram of the data and the model

Discussion

From the results, we can clearly notice that when the slope and the land use are low the flow coefficient is (0.869%), also when the slope and the land use are very high, the flow coefficient is (99.1%), this confirms a physical result that land use and slope have an effect on permeability, and high permeability reduces flow. This is also a good indication that the model gives realistic results. The three-dimensional relationship between dependent and independent variables is shown in (Fig.4).

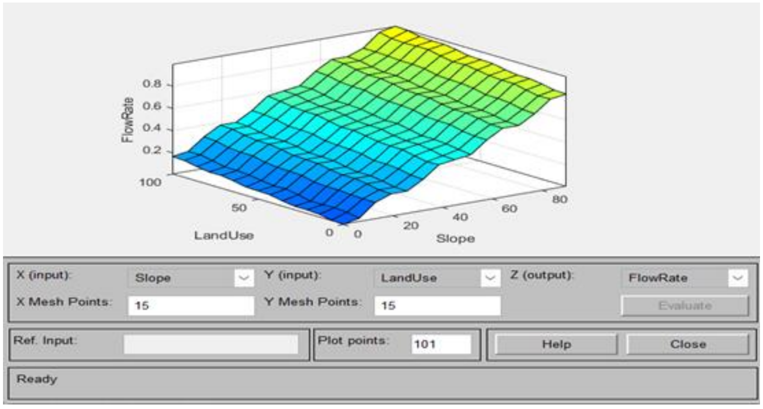

Figure 4. The changing of the output as a function of inputs

Conclusion

It is concluded that when determining flow coefficients, it is critical to consider all aspects of the study area, such as meteorological features, land use, and soil properties. Rather than relying on values from pre-made tables. It is important to study the precipitation-flow relationship, which is a hydrological event, using fuzzy logic because it contains uncertainties. The fuzzy SMRGT method is a very practical and effective method of determining the flow coefficient. The number of variables and fuzzy sets and the shape of membership functions can be easily determined. On the other hand, the SMRGT method considers the physical cause-and-effect relationship, therefore, it can be generalized to any basin or region.

References

1. Alfieri, L., Dottori, F., Betts, R., Salamon, P., & Feyen, L. (2018). Multi-model projections of river flood risk in Europe under global warming. Climate, 6, 6.
2. Gill, S.E., Handley, J.F., Ennos, A.R. & Pauleit, S. (2007). 'Adapting cities for climate change: the role of the green infrastructure', Built Environment 33, pp. 115-33.
3. Ali, A. S. A., Ebrahimi, S., Ashiq, M. M., Alasta, M. S., & Azari, B. (2022). CNN-Bi LSTM Neural Network for Simulating Groundwater Level. Environmental Engineering, 8, 1-7.
4. Toprak, Z. F. (2009). Flow Discharge Modeling in Open Canals Using a New Fuzzy Modeling Technique (SMART). CLEAN – Soil, Air, Water, 37(9): 742–752.
5. Toprak, Z. F, Toprak A, & Aykac, Z. (2017). Practical applications of fuzzy SMRGT method, Journal of DU Engineering Faculty, 8(1), 123-132.