

## Title (in 16pt Bold)

# An Analysis of Morphometric Features for Flood Management in the Dinavar Watershed

NAYERALZAMAN AZIMI– *Planning and budget manager – master of planning.*

## Introduction

Flooding is one of the most significant natural phenomena threatening human societies, causing irreparable damage to both human infrastructure and natural ecosystems (Kumar et al., 2021; Jha and Dev, 2024). Over recent decades, the impacts of flooding have intensified due to population growth, rapid urbanization, and the effects of climate change. The expansion of urban development, particularly construction along riverbanks, has significantly increased flood risks in many areas.

While it is not currently feasible to control atmospheric factors and elements to prevent such destructive phenomena, implementing effective flood management strategies on the ground, particularly in flood-prone areas, is essential (Mansour et al., 2022; Sutradhar and Mondal, 2023). Watersheds and their sub-basins play a critical role in flood occurrence and management. Each sub-basin uniquely influences the main channel depending on its distinct drainage morphometry. Furthermore, changes in river channel morphology—whether natural or anthropogenic—can alter river flow dynamics and exacerbate flood risks (Dutal, 2023; Víg et al., 2022). This analysis focuses on the morphometric features of the Dinavar Watershed to better understand their influence on flood potential and to inform more effective flood management strategies.

To effectively manage floods, it is crucial to identify areas with high flood potential within watersheds. However, the vast size and complexity of watersheds make large-scale implementation and remedial operations impractical. Flooding does not simply refer to how frequently it occurs but rather to the capacity of sub-watersheds to contribute to the overall flood discharge. This contribution is determined by the interaction of multiple factors rather than any single element (Alatas et al., 2022; Koralay and Kara, 2023).

The physical characteristics of a watershed, along with human activities, are key factors influencing flood risks. Recognizing and classifying these factors is fundamental for effective flood control and risk mitigation. Identifying flood-prone areas and understanding the factors driving floods are essential steps toward reducing the impact of natural disasters. Determining the flood potential of sub-watersheds provides a foundation for targeted interventions (Taib et al., 2024). Watershed characteristics play a major role in flood occurrence, with many meteorological, hydrological, and soil conservation issues directly or indirectly tied to them. Morphometric analysis, a key tool in hydrological studies, involves evaluating the shape, size, and structure of watersheds. This analysis allows researchers to understand the behavior of hydrological systems and assess how physical features contribute to flood risks (Singh et al., 2023).

Using geomorphological principles to assess flood risk potential provides valuable insights into the relationships between morphometric parameters and flooding. These parameters play a crucial role in identifying and understanding the physical characteristics of a watershed and their influence on flood dynamics. Incorporating morphometric parameters in flood hazard studies, along with the preparation of zoning maps, is a highly effective, practical, and cost-efficient method for watershed management.

Flood hazard zoning maps, which are easy to interpret and apply, significantly contribute to reducing the adverse impacts of floods. Morphometry, encompassing the measurement and numerical analysis of landforms, including their surface, shape, dimensions, and structure, serves as a key tool in assessing and managing flood risks. This approach facilitates the development of targeted strategies for sustainable flood management.

## Materials and methods

### Study area

The study area is located in the northeast of Kermanshah Province and is centered around the Dinavar River. This river joins the Gamasyab River in Bisotun, forming the main branch of the Upper Karkheh River Basin. Covering an area of 40,000 hectares, the basin features a mix of mountainous, hilly, and plain landscapes, supporting activities such as agriculture, livestock farming, gardening, and urban and industrial development. The Jamishan reservoir dam is also part of this river system. The average precipitation, temperature, and evaporation in the basin are 450 mm, 12°C, and 110 mm, respectively. However, significant variations in these climatic factors are observed between the plain areas and the surrounding highlands, with the plains receiving less water.

The Dinavar River has three hydrometric stations on its various branches, and the river's average flow rate is 2.38 cubic meters per second. Below is a summary of the hydrological unit and basin characteristics for the Gamasyab Basin:

**Table 1. Study area**

Area (km <sup>2</sup> )	Perimeter (km)	Basin Length (km)	Basin Shape Coefficients			
			Miller Method	Horton-Shiom Method	Gravilius Method:	Gravilius Method
2190	307	85.5	0.29	0.29	1.93	1.8

## Research Method

The VIKOR method is a multi-objective, process-oriented model developed by Tsang (1998), based on the LP metric method. It is derived from the adaptive planning approach and is particularly useful when decision-makers cannot clearly identify or prioritize a problem during its

initial stages. This method serves as an effective decision-making tool in various fields, especially development planning.

One of the key advantages of the VIKOR method is its ability to incorporate both objective and subjective criteria simultaneously. It is especially helpful in cases where decision-makers are unable to define their priorities clearly at the start of designing a system.

The steps for applying this model are outlined as follows:

#### Step 1: Construct the Decision Matrix

The decision matrix is formed based on the number of criteria, alternatives, and evaluations of all alternatives with respect to various criteria. It is structured as follows:

where  $f_{ij}$  represents the performance of alternative  $i$  concerning criterion  $j$

#### Step 2: Normalize the Decision Matrix

In this step, the criteria with different dimensions are converted into dimensionless criteria. Normalization is done using the following formula:

The VIKOR method uses linear or standard normalization, making the normalized value independent of the criterion's unit of measurement (Chou et al., 2007).

#### Step 3: Determine the Weight Vector of Criteria

Since criteria often have varying levels of importance, their weights must be determined. This is usually done using methods such as AHP, ANP, or entropy weighting. Based on the relative importance of the criteria, a weight vector is defined as:

#### Step 4: Determine the Best and Worst Values for Each Criterion

For each criterion, the best and worst values are calculated as follows:

$$f_j^+ = \max (f_{ij})$$

$$f_j^- = \min (f_{ij})$$

For each criterion, the best and worst values are calculated as follows:

$$\min (f_{ij})$$

$$f_j^- = \max (f_{ij})$$

Here, represent the best and worst values of criterion j among all alternatives.

Step 5: Calculate S and R Values

The (closeness to ideal) and (regret measure) values are calculated as:

Here,  $S_i$  represents the overall closeness to the ideal solution, and  $R_i$  indicates the maximum regret.

Step 6: Compute the Q Value

The Q value is calculated using the following formula:

Where:

The  $Q_i$  value indicates the VIKOR score of alternative i

V is the weight of group utility, typically set to 0.5.

Step 7: Rank the Alternatives

Alternatives are ranked in ascending order based on their S, R, and Q values.

Step 8: Select the Best Alternative

The best alternative is the one with the smallest  $Q_i$ , provided the following conditions are met:

Acceptance Condition:

$$\frac{Q_i - Q^*}{Q^*} \leq D$$

Stability in Decision-Making:

must also have the best rank in S or R.

If either condition is not satisfied, a compromise solution is proposed:

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- If only the second condition is unmet, select , .
- If the first condition is unmet, consider ,

where  $m$  is the alternative position satisfying:

In this study, 14 morphometric factors and the VIKOR decision-making method were used to prioritize watershed sub-basins. Morphometric factors significantly influence hydrological processes and the loss of water and soil resources within the watershed, whether in linear or surface forms. Numerous morphometric indices are available for watersheds, and the most critical ones are chosen for sub-basin prioritization based on their relative importance and the availability of data. Generally, morphometric indices are categorized into two groups of topographic characteristics, including the Hypsometric Integral Index, Mountain Front Sinuosity, Drainage Basin Elongation Ratio, Form factor, Basin relief, Sinuosity index of river, Asymmetry factor, Valley floor to valley height Ratio, Drainage density, Bifurcation ratio, Texture ratio, Constant of channel maintenance, and Transverse topography symmetry.

## Conclusions

Morphometric factor analysis of the Dinavar watershed has proven to be both accessible and reliable due to the stability of its physiographic and morphometric conditions, making it a valuable tool for prioritizing significant watersheds. Morphometric factors play a key role in identifying and assessing flood-prone areas, as their impact on flood risk varies. It is essential to evaluate the importance of each parameter individually.

The results of the VIKOR model indicate that the Valley floor to valley height Ratio (VF), with a significance of 0.59, had the greatest influence on flood risk and prioritization. Additionally, regions differ in terms of flood risk, influenced by morphometric factors, watershed characteristics, and land cover. Conversely, the Sinuosity index of river index had the least impact on flood risk.

In prioritizing flood risk across watersheds, not all factors have equal effects, with both positive and negative influences observed. In this study, the texture ratio index and the Constant of channel maintenance index showed negative effects, while all other indices demonstrated positive impacts.

## References

1. Alatas, H., Pawitan, H., & Syafiuddin, A. (2022). Morphometric analysis of Ciliwung river and identification of suitable locations to build artificial dams for flood mitigation. *Environmental Quality Management*, 32(1), 45-52.

2. Dotal, H. (2023). Using morphometric analysis for assessment of flash flood susceptibility in the Mediterranean region of Turkey. *Environmental monitoring and assessment*, 195(5), 582.
3. Jha, M. K., & Dev, M. (2024). Impacts of Climate Change. In *Smart Internet of Things for Environment and Healthcare* (pp. 139-159). Cham: Springer Nature Switzerland.
4. Koralay, N., & Kara, Ö. (2023). Effects of morphometric characteristics on flood in Degirmendere sub-watersheds, Northeastern Turkey. *International Journal of River Basin Management*, 21(2), 327-337.
5. Kumar, A., Nagar, S., & Anand, S. (2021). Climate change and existential threats. In *Global climate change* (pp. 1-31). Elsevier.
6. Mansour, M. M., Ibrahim, M. G., Fujii, M., & Nasr, M. (2022). Sustainable development goals (SDGs) associated with flash flood hazard mapping and management measures through morphometric evaluation. *Geocarto International*, 37(26), 11116-11133.
7. Singh, D., Karan, K., Singh, S. K., Chauhan, P., & Berndtsson, R. (2023). Fusing morphometric characteristics with extreme precipitation indices for identifying the most vulnerable sub-basin at risk of flooding. *Journal of Hydro-environment Research*, 50, 44-56.
8. Sutradhar, S., & Mondal, P. (2023). Prioritization of watersheds based on morphometric assessment in relation to flood management: A case study of Ajay river basin, Eastern India. *Watershed Ecology and the Environment*, 5, 1-11.
9. Taib, H., Hadji, R., Bedri, K., Defaflia, N., Hamed, Y., Gentilucci, M., ... & Pambianchi, G. (2024). Morphometric analysis and risk assessment of flash floods in the Atlas chain of eastern Algeria and the Algerian–Tunisian borders. *Euro-Mediterranean Journal for Environmental Integration*, 1-15.
10. Víg, B., Fábian, S. Á., Czigány, S., Pirkhoffer, E., Halmaj, Á., Kovács, I. P., ... & Lóczy, D. (2022). Morphometric analysis of low mountains for mapping flash flood susceptibility in headwaters. *Natural Hazards*, 114(3), 3235-3254.