Research Article

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Hydraulic model for flood inundation in Diyala River Basin using HEC-RAS, PMP, and neural network

https://doi.org/10.1515/eng-2022-0530
received June 13, 2023; accepted September 05, 2023

Abstract: The Diyala River Basin in Iraq is vital for water supply to residential, agricultural, and the Tigris River (with approximately 4.5 billion cubic meters annually), but it faces frequent floods and droughts due to reliance on rainfall. This study aims to address these issues by simulating flood inundation using the hydrological engineering centre-river analysis system model and predicting high-intensity rainfall with artificial neural networks. ArcGIS and remote sensing tools aid model development with data from official sources and organizations such as national aeronautics and space administration and food and agriculture organization. The hydraulic model is calibrated using satellite imagery to depict a 2019 flood, and artificial intelligence predicts the precipitation patterns for the next 50 years based on historical data from 1981 to 2021. One of the challenges and difficulties encountered in the study is the scarcity of available data, as well as the absence of scientific research pertaining to the region regarding hydraulic modeling. The study identifies flood risks in March and April every year, notably for the Hemrin Dam, which may exceed permissible water levels (reach a level over 110 m where the Hemrin Crest level is 109.5 m). To mitigate this, an artificial canal is proposed to divert water annually, protecting the dam and downstream areas without disrupting operations. The diverted water could also augment the Tigris River in Kut Governorate during summer. The study demonstrates the value of integrating multiple modeling techniques and data sources for accurate hydraulic predictions. It offers insights for decision-makers in flood management and planning. This study contributes to efficient flood management strategies by adopting a multidisciplinary approach.

Keywords: hydraulic model, HEC-RAS, ANN, Diyala River Basin, probable maximum precipitation

1 Introduction

The Diyala River Basin (DRB) holds great strategic importance due to its impact on various aspects of life, agriculture, and industry. It contributes around 4.6 billion cubic meters (BCM) of water annually to the Tigris River in southern Baghdad, accounting for approximately 17% of the total flow [1,2]. Thus, it is recognized as a significant basin in Iraq, with 70% of its area located within the country, while the remainder lies in Iran [1].

Droughts are a recurring issue in the DRB, particularly during the summer when rainfall is scarce. Addressing these droughts requires international agreements with Iran to increase water quotas and optimize dam operations, specifically the Derbendikhan and Hemrin dams [1,3]. On the other hand, the basin is susceptible to floods, particularly in the spring season, often resulting from heavy rainfall and overflow from Iran. The floods in 2019 posed a significant threat to the Hemrin Dam and adjacent residential areas along the Diyala River [1], as shown in Figure 1.

Developing an accurate and reliable hydraulic model is crucial to better understand and managing flood risks in the DRB. Such a model enables effective flood management strategies and provides valuable insights into the behavior of the basin's water systems. This study employed a two-dimensional hydraulic model utilizing the hydrological engineering centre-river analysis system (HEC-RAS) software to simulate the floodplain in 2019. Satellite photographs from the corresponding period were used to validate the extent of the flood.

Artificial intelligence methods, such as artificial neural networks (ANNs), can be utilized for future rainfall

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