International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 02 | Feb 2024 www.irjet.net p-ISSN: 2395-0072

Review on: Rainfall Runoff Modelling.

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Abstract - *One of the most significant natural resources and a vital component of a state's and nation's socioeconomic growth is water. Water has an impact on every aspect of the ecosystem that sustains life on Earth. Since fresh water is a finite resource, humanity is concerned about its fluctuating availability in space and time. A rainfall-runoff model is a mathematical representation of the relationships between rainfall and runoff in a watershed, drainage basin, or catchment area. Calculating discharge from a basin can be greatly aided by the use of a rainy runoff model.*

Hydrological modelling is a popular technique for assessing a basin's hydrological response to precipitation. There are many disadvantages of using hydrological measurement. It is true that we have a restricted range of measurements in both space and time, as well as a limited breadth of measurement techniques. We consequently require a method to extrapolate from those available observations in space and time to assess the potential impact of future hydrological change, particularly to ungauged catchments (where measurements are unavailable) and into the future (where measurements are unfeasible). When making judgments, it should be helpful to be able to predict or extrapolate statistically using various types of models.

Despite the fact that water covers 70% of the earth's surface, there is a severe water issue. This is due to the fact that 97.5 percent of all water on Earth is saltwater. 99 percent of the water that is left is trapped in subterranean aquifers and glaciers. Therefore, in actuality, less than 1% of freshwater is accessible to humans as rivers, lakes, streams, etc. Please be aware that even the last man on Earth may have his needs met by the less than 1% water availability. But if appropriate precautions are not taken for the best possible management of water resources, human existence would soon be in jeopardy due to human invasion at all levels. For example, the "day zero" scenario is already affecting 12% of the Indian population.

In recent decades, India has experienced an increase in the frequency of flood disasters. A flood is a stream's natural flow that overwhelms a riverbank or hydraulic structure, causing harm to nearby property or human lives. The primary cause of this is the changing climate and massive development, which have changed the features of the basin. The development projects near riverbanks have the worst effects on a reach's ability to drain, which increases the likelihood of flood-like conditions. Numerous scholars are concentrating their investigations on these problems and attempting to identify a remedy. Here is a quick summary of some of these scientists' research projects that suggested using rainfall runoff models.

Key Words: Flood Modelling, River, DEM, GIS, HEC-HMS.

1. LITERATURE REVIEW

M. P. Rajurkar, U. C. Kothyari & U. C. Chaube (2017)[1]

This study presents the use of artificial neural networks to model daily flows during monsoon flood events in a sizable watershed of the Narmada River in Madhya Pradesh, India. The Jamtara gauge and discharge station, situated in the central Indian state of Madhya Pradesh, is the source of daily rainfall and runoff data for the Narmada watershed. In comparison to linear and nonlinear MISO models, it is demonstrated that a linear multiple-input single-output (MISO) model combined with the artificial neural network (ANN) offers a superior representation of the rainfall-runoff relationship in such large size catchments. Compared to the previous models examined here, the current model improves prediction accuracy and offers a methodical approach to runoff estimates.

AnilKumar Lohani, N.K. Goel & K.K.S.Bhatia (2011)[2]

In order to estimate daily rainfall-runoff, this article analyzes techniques based on artificial neural networks (ANN), fuzzy logic (FL), and linear transfer functions (LTF). The Takagi-Sugeno (TS) fuzzy model's potential and the effect of antecedent soil moisture conditions on the daily rainfall-runoff models' performance are also examined in this work. To examine the effects of input data vector on rainfall-runoff modeling, eleven distinct input vectors are investigated under four classes: (i) rainfall, (ii) rainfall and antecedent moisture content, (iii) rainfall and runoff, and (iv) rainfall, runoff, and antecedent moisture content. Based on a variety of model performance metrics, a viable modelling technique with an adequate model input structure is proposed using the rainfall-runoff data of the upper Narmada basin, Central India. The outcomes demonstrate that the fuzzy modeling strategy.

Geoffrey O'Loughlin, Wayne Huber & Bernard Chocat (2007)[3]

Almost all urban stormwater management studies, whether they focus on reducing stormwater pollution or mitigating flooding, are based on rainfall-runoff models. Stormwater flow estimates are necessary for each of these goals. This study describes the fundamental theory of the rainfall-runoff process, the evolution of modeling techniques, and the application of computer models in practice today. It also draws attention to the shortcomings and problems with rainfall runoff modeling.

Keh-Han Wang and Abdusselam Altunkaynak (2012)[4]

This research presents a comparative case study of a fuzzy logic model and SWMM for the purpose of predicting the total runoff within the Cascina Scala watershed in Pavia, Italy. To train fuzzy logic parameters, a data set of 23 events spanning from 2000 to 2003 is utilized, which includes the total amount of rainfall and runoff. For the purpose of setting up and calibrating SWMM for runoff modeling, additional data (1990–1995) with precise time changes of rainfall and runoff are provided. By comparing the anticipated total runoffs with observed data, 35 different rainfall events are chosen from the 1990–1995 data set to evaluate the forecast accuracy of the SWMM and fuzzy logic models. Root-mean-squared error was used to evaluate the fuzzy logic model's and the SWMM's performance.

M. Kh. Askar (2014)[5]

This article uses Geographic Information System (GIS) to calculate runoff depth using the SCS CN approach. In runoff calculations, remote sensing is typically used as a source of input data or as a tool to help estimate model parameters and equation coefficients. The investigation was conducted in the 540 km2 catchment areas of the Gomal River watershed in Iraq. The territory inside the Kurdistan region's borders stretches from north of Shahia to Dohuk City's southwest. The average yearly rainfall depth from 1947 to 2005 is taken into account in this study in order to calculate runoff. Using the WMS 7.1 tool, the impact of slope on CN values and runoff depth was ascertained.

A. R. Senthil Kumar, K.P. Sudheer, S.K.Jain and P. K. Agarwal (2005)[6]

This study provides a thorough assessment of the effectiveness of neural network models of the MLP (multi-layer perceptron) and RBF (radial basis function) types that were created for the rainfall-runoff modeling of the Malaprabha watershed in India. A comparison between two ANN configurations—an MLP and an RBF—in terms of their ability to simulate rainfall and runoff is provided. The findings imply that the model prediction accuracy is undoubtedly impacted by the type of network selected. The study's findings, however, suggest that when it comes to rainfall-runoff modeling, RBF networks' generalization qualities pale in comparison to MLPs'. But it is evident from this study that a determination of which is superior cannot be made.

Kishor Choudhari, Balram Panigrahi, Jagadish Chandra Pau (2014)[7]

In this article, the rainfall-runoff process in the Balijore Nala Watershed in Odisha, India, is simulated using the HEC-HMS model. The SCS curve number, SCS unit hydrograph, exponential recession, and Muskingum routing methods are selected, respectively, to calculate runoff volume, peak runoff rate, base flow, and flow routing methods. Using data from 24 randomly selected rainstorm occurrences over four years (2010–2013), a rainfall–runoff simulation is carried out. Twelve of these are chosen for model calibration, and the other twelve are chosen for model validation. The statistical tests of error functions between the observed and simulated data, such as mean absolute relative error (MARE) and root mean square error (RMSE), are carried out for model calibration. The validated model's produced square functions, according to the results, indicate that HEC-HMS is performing satisfactorily.

Vinithra R, Yeshodha L. Rainfall- runoff modelling using SCS-CN method: a case study of Krishnagiri district, Tamilnadu. International Journal of Science and Research. 2013; 6:35-39.[8]

Vinithra (2013) attempted to use the SCS-CN approach to estimate the surface runoff for the Krishnagiri district in Tamil Nadu. Data from multispectral remote sensing, soil, land use/cover maps, and hydrological soil group (HSG) are employed in the analysis. Runoff is calculated for various land uses, including agriculture, forestry, industry, and barren land. Group C is the classification for soil based on these calculated data. The Krishnagiri district's average annual surface runoff is projected to be 76.53 mm, or 54% of the district's normal annual rainfall.

Nayak PC, Venkatesh B, Krishna B, Jain SK. Rainfall – runoff modelling using conceptual, data based and wavelet based computing approach. Journal of Hydrology. 2013; 493:57-67.[9]

Nayak (2013) created a rainfall-runoff model for the Malaprabha basin in India to show how wavelet neural networks (WNNs) can be used to model river flow. For 21 years (from 1980 to 2000), daily data on precipitation, discharge, and evaporation have been employed in the modeling process. Wavelets were used in the initial modeling model to break down inputs, and the resulting sub-series were then fed into an artificial neural network (ANN). 17 years' worth of data are used to calibrate the model's parameters, and the remaining data are utilized to validate the model. The model input has been determined using a statistical method. Based on the evaluation criteria obtained, which include the Nash-Sutcliffe efficiency coefficient and root mean squared error, the best designs for the WNN models are chosen. By creating both the NAM model and the traditional neural network model, the study's findings have been compared. The study's findings show that the WNN model outperforms the ANN and NAM models in accurately estimating the hydrograph's properties, such as the flow duration curve.

Kumar R. Research Methodology: A Step-by-Step Guide for Beginners. (3). Sage, New Delhi, 2011.[10]

A distributed method to model the rainwater runoff process in a watershed was created by Kumar (2011). The number of divisions within the catchment region corresponded to the number of rain gauge stations. Every sub-catchment in a given rain gauge is thought to get the same amount of rainfall. SRTM digital elevation data with a precision of 90 meters has allowed for the extraction of spatially dispersed watershed features. Additionally, a lump model was created using the catchment's average rainfall. The land use and soil properties affect the basin's infiltration capability. The two equations that are most frequently used to estimate infiltration of a basin are Horton's and Green-Ampt. Another popular technique for determining the infiltration characteristics of a watershed based on soil and land use properties is the Curve Number (CN) method. As a result, the basin's curve number or infiltration parameters are first estimated. In order to estimate the curve numbers for the lump and scattered models, an inverse model is developed and solved.

Gobena S. daily rainfall runoff modelling of upper awash sub basin using conceptual rainfall runoff models. Ph.D. Thesis, Addis Ababa University, 2010. [11]

A study by Gobena (2010) used two models—AWBM and SMAR—among five lumped conceptual models nested in the Rainfall-Runoff library to conduct a daily rainfall-runoff modeling for three selected catchments of the Upper Awash Sub Basin. This modeling is very helpful in strengthening the assessment, planning, and management of water resource in the basin. The models were automatically calibrated and verified using the Genetic Algorithm optimization approach, with the runoff difference and Nash Sutcliffe criteria serving as the primary and secondary objectives, respectively. A performance comparison between the two models and an analysis of the simulated and observed flow were carried out. With overall Nash Sutcliffe criteria of 0.6 to 0.85 for both the calibration and verification periods, the AWBM and SMAR models both predict the flows pretty well.

Tramblay Y, Bouvier C, Ayral PA, Marchandise A. Impact of rainfall spatial distribution on rainfall-runoff modelling efficiency and initial soil moisture conditions estimation. Natural Hazards Earth Syst. Sci. 2011; 11:157-170 [12]

In comparison to mean areal rainfall over the watershed, Tramblay et al. (2011) examined how rainfall-runoff modeling utilizing an event-based model can be sensitive to the usage of spatial rainfall. This comparison was based on the model's ability to accurately replicate flood events as well as its ability to estimate the beginning conditions using various inputs of rainfall. The model's efficacy is enhanced by spatial rainfall, according to the results. Using spatial rainfall has a noticeable benefit for some of the biggest floods. Additionally, when spatial rainfall is used, especially when spatial radar data is included, the relationship between the model's initial state and the external predictor of soil moisture provided by the SIM model is improved, with R2 values rising from 0.61 to 0.72.

Kumar PS, Praveen TV, Prasad MA. Artificial Neural Network model for rainfall-runoff -a case study. International Journal of Hybrid Information Technology. 2016; 9(3):263-272. [13]

In a study done by Kumar (2016), the raster data was georeferenced, processed in ERDAS, and then converted into GIS as LU/LC, drainage, contour, and DEM (digital elevation model) maps. For the years 2008, 2009, 2010, 2011, and 2012, runoff, simulated, and real rainfall data are used to calculate the estimated runoff using SCS-CN & RRL. The overall correlation between the estimated runoff and observed runoff is good (r2 = 0.76).

2. CONCLUSIONS

Several techniques, including artificial neural networks, fuzzy modeling, and storm water management models, are included here for simulating rainfall and runoff.

The foundation of practically all studies on urban stormwater management is provided by rainfall-runoff models.

The accuracy of the model's predictions is undoubtedly impacted by the sort of network selected.

The computer models, like HEC-HMS, can also be used to simulate rainfall and runoff. By using this model instead of measuring runoff in the watershed, time and money can be saved when acquiring runoff data. Additionally, in ungauged watersheds without gauging stations to measure runoff, simulating runoff may be helpful.

An alternative approach to rainfall runoff modeling is the SCS CN method, which is an accurate and straightforward way for calculating runoff.

The outcome demonstrates that fuzzy logic modeling produces results that are generally excellent. The models that are created using ANN are also useful and produce decent outcomes.

As a result, the type of data determines the model selection or choice.

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