International Journal of Agricultural Engineering, Vol. 2 No. 2 (October 2009 to March 2010) : 310-314

Research Paper :

Prediction of runoff for small watershed using GIUH_CAL model and GIS approach in Chhattisgarh

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Accepted : *September, 2009*

ABSTRACT

A Geomorphological Instantaneous Unit Hydrograph Calculator (GIUH_CAL) model was applied for estimating the direct runoff from a small watershed (Arang) in Chhattisgarh (India). Various maps including Digital Elevation Model (DEM), watershed and sub-watershed boundaries, drainage network and soil texture were generated using topographic and soil resource data in the environment of a Geographical Information System (GIS). Several geomorphological parameters of the watershed were determined using various maps generated through GIS and given as input to the model. The GIUH_CAL model was tested for the monsoon season of years 2003 and 2004 using daily rainfall data of selected events. Performance of model was evaluated by comparing runoff values predicted by the model with the observed values using graphical, statistical and mathematical criteria. The results revealed that the observed runoff values were having good agreement with the runoff values predicted by the GIUH_CAL model. Student's t-test resulted that the means of observed and predicted runoff were found to be similar at 95 per cent confidence level. Value of coefficient of determination (r^2) was found to be 0.88 and it was indicated that the predicted runoff values for each selected rainfall events were close to the observed values. Overall deviation indicated that the model over predicted the daily runoff by 18 per cent. On the basis of the study it can be concluded that the GIUH_CAL model is capable of predicting direct runoff from the Arang watershed for various storm events satisfactorily.

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Key words : GIUH_CAL model, GIS, Runoff, Validation and watershed

In India most of the watersheds are still ungauged or having very limited data due to economic and social constraints. Several hydrological models including physically based models and models incorporating geomorphological parameters are available to study the rainfall-runoff transformation process. The physically based models, though technically sound are too expensive, probably beyond the economic reach of the developing countries like India, whereas geomorphological parameters based models are comparatively less expensive and uses a simplistic approach (Tiwari *et al*., 1997).

The compilation of input data, which are required by the geomorphological parameter based models are often cumbersome. The time-consuming nature of extraction of watershed parameters can be eliminated by means of Geographical Information System (GIS) in addition to obtaining high accuracy. Jain *et al*. (2001) found that the input data for the hydrological models can be extracted with the use of GIS mainly from the map layers including DEM, soil, slope, drainage and watershed and sub-watershed boundaries.

Among the several hydrological simulation models which are in use to study the rainfall-runoff transformation process, the Geomorphological Instantaneous Unit Hydrograph Calculator (GIUH_CAL) model is the most recent one and used successfully for generating Instantaneous Unit Hydrograph (IUH) and Direct Runoff Hydrograph (DRH) of various watersheds. A physically based model GIUIH_CAL was developed by Panigrahy (2002) at Indian Institute of Technology (IIT), Kharagpur, West Bengal, India to estimate the surface runoff from ungauged watersheds. Looking to the importance of hydrological models and GIS technique the current study was under taken with the use of a physically based model (GIUH_CAL) and GIS technique to estimate the surface runoff from a small watershed in Chhattisgarh state of India.

The Geomorphological Instantaneous Unit Hydrograph (GIUH) model is based on the theory proposed by Valdes *et al*. (1979). According to the theory, the unit input (unit depth of rainfall) is considered to be composed of an infinite number of small, non-interacting drops of uniform size, falling instantaneously over the entire region. The travel time of a randomly chosen drop of water, from its starting point to the outlet, represents the Instantaneous Unit Hydrograph (IUH) of the basin. Several research workers (Rodriguez-Iturbe *et al*., 1982a;