J. Agric. Res. Technol., 49 (1) : 223-227 (2024)

Review Paper on Watershed Modeling System (WMS) Software

S. A. Lad[1] and B. K. Gavit[2]

Department of Soil and Water Conservation Engineering, Dr. Annasaheb Shinde College of Agricultural Engineering and Technology, Rahuri - 413 722 (India)

(Received : 19.11.2024 Accepted : 15.12.2024)

Abstract

Watershed Modeling System (WMS) is the software used for the watershed modeling using computer simulation. It supports the software like HEC-1, HEC-HMS, TR-20, TR-55 and MODRAT. Web-based data collecting, topographical data import and editing, automated hydrologic modelling and watershed delineation, support for standard hydrologic models, hydraulic modelling and floodplain mapping, and storm drain modelling are just a few of the many uses for it. WMS applications can be used to visually represent the outcomes of developing strategies for managing watersheds. It also help for planning of various conservations measures.WMS is effectively tool to compute geometric and hydrologic watershed data for a watershed. Snyder, NRCS and Clark methods with WMS software tested statically using Nash efficiency test shows that the Snyder method with WMS software is effective methods for estimating synthetic DRH for the available recorded rainfall storms

Key words : Watershed Modeling System (WMS); Hydrologic Engineering Center (HEC); Hydrologic Modeling System (HMS); Digital Elevation Model (DEM); Geological Information System (GIS).

Watershed is ridge line which separates the drainage areas from the catchment having one outlet. Watershed modeling is a tool for understanding hydrological processes and their simulations. It plays a vital role in water resource assessment and management. It is useful for groundwater quality, quantity and their development. When watershed modeling is depends on various hydrologic processes, it is also called as hydrologic modeling. Hydrologic modeling is generally used with integration of Geographical Information System (GIS) for water resource assessment and management. GIS software is plays a vital role in defining the drainage basin boundaries, developing stream network and computing area of the basin (Erturk *et al.*, 2006).

Watershed Modeling System (WMS) is used for watershed modeling using computer simulation. This software is applicable for hydraulic and hydrologic models. This software supports the others software's like HEC-1, HEC-HMS, TR-20, TR-55 and MODRAT software's. It is utilized for various purposes, including web-based data collection, the import and editing of topographical data, automated hydrologic modelling and watershed delineation, support for standard hydrologic models, hydraulic modelling and floodplain mapping, and storm drain modelling.

1. Student and 2. Associate Professor.

History of WMS

Watershed Modeling System (WMS) was developed in 1900 century at Brigham Young University. The United States Army Corps of Engineers (COE) funded the WMS for the development of Software. COE used the WMS software firstly for Sava river basin in Bosnia in 1997. Environmental Modeling Systems sold the WMS software commercially.

Needs of Watershed Modeling System (WMS):

1. Data acquisition based on web
2. Terrain data import and editing tools
3. Watershed delineation & hydrologic modeling
4. Support for the standard hydrologic models
5. Hydraulic modeling & floodplain mapping
6. Storm drain modeling

Applications of Watershed Modeling System (WMS):

1. Computing slope, area, mean elevation, maximum flow distance (Geometric basin data) etc.
2. Computing time of concentration, curve number and infiltration parameters (Hydrologic basin data)
3. Delineation of watershed and sub-basins
4. Formation of flood extents and flood depth maps
5. Computing elevations, lengths, and slopes of pipes

Review on Watershed Modeling System (WMS) : Erturk *et al.* (2006) used the Watershed Modeling System (WMS) 7.1 for the delineation of boundaries of Koycegiz Lake-Dalyan Lagoon watershed situated in the southwest of Turkey at the Mediterranean Sea coast. Using WMS, an IA Digital Elevation Model (DEM) was constructed for Kargicak Creek, one of the watershed's principal streams. The watershed's borders were then drawn and stream networks were extracted using DEM data. They identified the typical characteristics that would be utilised as model inputs in hydrological and diffuse pollution modelling, such as drainage areas, characteristic lengths, and slopes of sub-drainage regions. Run-off hydrographs for the sub-drainages were computed using the rational method, which yields useful data for estimating the time-varying inflow and input pollution loads that will be further used in the Creek's future water quality models. WMS was used in the study to show how well it could visualise the results and create plans for maintaining watersheds.

Majed and Sharkh (2009) used the Watershed Modelling System (WMS) and GIS to estimate runoff for a small watershed. In this study, the surface runoff from the Wadi Hasca Watershed, which is located in the Hebron district south of the West Bank, was estimated using the Watershed Modelling System (WMS) in conjunction with GIS. The result showed that average annual runoff depth for the study area was 95 mm and the average volume of surface runoff from the same watershed was 6,93,500 cubic meter per year. The amount of runoff was found to be 19% of the total rainfall. This study's methodology could be used to create other conservation strategies in other Palestinian watersheds.

Moghaddasi *et al*. (2016) evaluated the effects of mechanical watershed management measures implemented across the Boostan dam Watershed on reduction of flood peak. For comparing peak flow before and after of implementation of the measures, Watershed Modeling System (WMS) was used. The mechanical measures have been implemented during 2000-2007. The primary methods of conserving soil and water in the Boostan dam Watershed were limited-area mechanical and biological approaches. The watershed has been modeled in WMS environment for determining the effect of these measures. Calibration and validation of the model were used for five flood events occurred before implementation of the measures. Three other flood events occurred after completions of the measures were then used for the evaluation. The findings showed that the mechanical measures reduce average peak flow by 1.79 percent compared to the lack of these precautions, even though their reservoirs are full of silt. If certain structures were left intact, the reduction would even reach 5.95 percent. It should be mentioned that the average peak flow rate would drop by 7.24% compared to the absence of structures and by 3.5% compared to the existing scenario if the structures were devoid of silt.

Khalid and Mohanad (2017) used the Watershed Modeling System (WMS) 8.1 and The HEC-1 v (4.1) hydrological models to estimate the Synthetic runoff hydrograph resulting from two storm events over Solag Basin (located in Sinjar district north of Iraq), using Synthetic unit hydrograph technique and available recorded storms rainfall. Natural Resources Conservation Service (NRCS), Snyder Synthetic Unit Hydrograph and Clark methods were used for determined direct runoff hydrographs. For comparing the efficiency of the Synthetic runoff Hydrograph using both Synthetic and recorded discharge data for Solag basin, which were available for two storms within water years 1991- 1992, was carried out by Nash model. Snyder, NRCS and Clark methods with WMS software were tested statically using Nash efficiency test. The results revealed that the synder method was best method as compare to other methods for Solag basin in Sinjar district in north of Iraq. Hence snyder method used for estimating synthetic DRH for the available recorded rainfall storms.

Kamal *et al.* (2018) studied valuation of hydrological analysis using WMS versus ARC-GIS. Digital Elevation Model (DEM) of 30 m resolution for the study area was extracted from Shuttle Topographic Rader Mission (STRM). The hydrological model (HEC l) was applied to simulate surface runoff in watersheds. The research tested the techniques by using two commonly software, WMS and ARC-GIS. The research investigated the comparative between using Watershed Modelling System (WMS), (Arc-GIS) to extract watershed, water basin of the study area. The difference between results of the two techniques showed that the calculations by ARC-GIS were more accurate than calculations by WMS.

Zollweg (2018) studied the Object-Oriented Watershed Modeling System (O2WMS), which demonstrated the potential of object-oriented approach for development of watershed models. The objects in O2WMS were sub-watersheds sufficiently small as to be functionally homogeneous and drained by an identifiable flow path. The core of O2WMS is a Python-based user interface that allowed rules to be added to each object to represent the hydrologic physical processes the hydrologist proposes. Finally, a highly-efficient Python-based computation phase calculates and outputs both clumped and distributed results. The result showed that the O2WMS model development 'playground' which drastically lowers the barriers to new model development for both expert and novice hydrologists. It allows rapid development and deployment of new models and is especially valuable for creating new models to address emerging needs.

Imani *et al*. (2021) evaluated the Watershed Modeling System (WMS11.0) to simulate peak discharge and volume of floods of Babolrood catchment. Two and three rainfall events were used for WMS model calibrated and validated. Afterwards, they were determined design precipitation (DP) for 2, 5, 10, 25, 50, 100 and 500-year return periods and flood resulting from DPs simulated. The results indicated that the WMS model could accurately estimate the peak discharge (the error was about 5%) and flood volume (the error was less than 26%). But the model was not able to simulate properly the shape of the hydrograph. It also revealed that peak discharge and flood volume arising from 2 to 500-year return periods of rainfall vary between 50 to 300 m^3 s^{-1} and 6.6 to 32.4 Mm^3, respectively.

Mohmmed and Hassan (2022) aimed to use GIS technology to study the best dam construction sites in the study area, and the basin is located in Samarra, Salah al-Din Governorate. The area of the basin was (5379.8) square kilometers at an altitude ranging between 23 to 144 meters above sea level, and the study used the natural criteria as a better suggestion was to use the integrated GIS programs in (ArcGIS10), WMS and (AHP). There were 7 sites for constructing dams with varying storage capacities. One of the dams in the felt basin was chosen to have the largest water storage capacity. The water capacity of the reservoir was 7.3 m 3 with an area of 144.2 km^2. The study recommended the establishment of water catchments to store rainwater for purposes that serve the region during the drought period, and good planning is to invest in water in various areas of water resource management and employ other skills for environmental planning.

Results and Discussions

In Majed and Sharkh research, result showed that average annual runoff depth for the study area was 95 mm and the average volume of surface runoff from the same watershed was 6,93,500 cubic meter per year. The amount of runoff was found to be 19% of the total rainfall. In Moghaddasi et al. research, results revealed that the mechanical measures, despite the fact that their reservoirs are full of sediment, decrease the average peak flow 1.79 % compared to the absence of these measures and if some structures would not be destructed, the reduction would reach 5.95 per cent. It should be noted that if the structures were out of sediment, the average peak flow rate would decrease 3.25% in comparison with current situation and 7.64% when compared to absence of structures .

Snyder, NRCS and Clark methods with WMS software were tested statically using Nash efficiency test in Khalid and Mohanad research. The results showed that the synder method was best method as compare to other methods for Solag basin in Sinjar district in north of Iraq. Kamal et al., 2018 investigated the comparative between using Watershed Modelling System (WMS), (Arc-GIS) to extract watershed, water basin of the study area. The difference between results of the two techniques revealed that the calculations by ARC-GIS were more accurate than calculations by WMS. In Zollweg research, result revealed that the O2WMS model development 'playground' which drastically lowers the barriers to new model development for both expert and novice hydrologists. It allows rapid development and deployment of new models and is especially valuable for creating new models to address emerging needs. In Imani et al. research, result revealed that peak discharge and flood volume arising from 2 to 500-year return periods of rainfall vary between 50 to 300 m^3 s^{-1} and 6.6 to 32.4 Mm^3, respectively.

Conclusions

For comparing peak flow before and after of implementation of the measures, Watershed Modeling System (WMS) can be used. WMS model can accurately estimate the peak discharge (the error was about 5%) and flood volume (the error was less than 26%). But the model cannot simulate properly the shape of the hydrograph.

WMS applications can be used to visually represent the outcomes of developing strategies for managing watersheds. It also help for planning of various conservations measures.

WMS is effectively tool to compute geometric and hydrologic watershed data for a watershed. Snyder, NRCS and Clark methods with WMS software tested statically using Nash efficiency test shows that the Snyder method with WMS software is effective methods for estimating synthetic DRH for the available recorded rainfall storms.

References

Erturk, A., Gurel, M., Baloch, M. A., Dikerler, T., Varol, E. and Akbulut N. 2006. Application of Watershed Modeling System (WMS) for Integrated Management of a Watershed in Turkey. Journal of Environmental Science and Health, 41: 2045-2056.

Imani. T., Mahdi. D., Samad. E. and Zahra. G. N., 2021. Estimating Floods of Various Return Periods for Babolrood Catchment Using WMS Model. Journal of Range and Watershed Management. 74(3): 469-481.

Kamal, M. M., Elhifnawy, H. E., Elsharkawy A. S. and Mousa O. M., 2018. Assessment of hydrological analysis using WMS versus ARC-GIS. 12th International Conference on Civil and Architecture Engineering. Military Technical College Kobry El-Kobbah, Cairo, Egypt.

Khalid, M. K. and Mohanad T. A. 2017. Estimating Storm Direct Runoff Using Synthetic Unit Hydrograph Methods By (WMS) Model (Solag Basin As A Case Study), Journal of University of Duhok. 20 (1): 727-735.

Majed, S. and Sharkh A. F. 2009. "Estimation of runoff for small watershed using Watershed Modelling System (WMS) and GIS."

Moghaddasi, N., Sheikh, V., Najafinejad, A. and Karimirad I. 2016. Technical note: Effect of mechanical measures on peak flow of Boostan Dam Watershed using Watershed Modeling System. Journal of Watershed Engineering and Management, 8(3): 332-338.

Mohmmed, S. J. and Hassan, M. A. 2022. Assessment of the possibility of water harvesting for the Al Labad Basin - west of Samarra, using artificial intelligence technology, watershed modeling (WMS). International Journal of Health Sciences, 6(5): 1035-1054.

Zollweg, J. A. 2018. A Python-Based Object-Oriented Watershed Modeling Strategy to Address New and Emerging Water Resource Issues. In AGU Fall Meeting Abstracts.