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SWAT-based assessment of natural resources in the Kunthipuzha basin

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Abstract
The wise and well planned conservation of natural resources such water and land is the most practical solution to address various water-related challenges, including droughts, floods, and water quality issues. In this study, SWAT model was used for modeling a watershed named Kunthipuzha. The model was calibrated and the calibrated model was used for watershed modeling. The basin elevation extent from 0 to 2330 m, out of which 0-50 m elevation band encompasses nearly 18.95% area. Most of the portion i.e., 31.53% were covered by plantains followed by rubber trees (19.98%) and evergreen forests (12.37%) as observed from land use map, while the soil map indicates that the Mannursree series (21.10%) is the most prevalent, followed by Karinganthodu (19.23%) and Mannamkulam (11.01%). SWAT model was successfully applied to the watershed to extract the information related to the natural resource management in Kunthipuzha basin. This information was very crucial and makes the water managers to make water management decisions effectively.

Keywords: SWAT, calibration, modelling, conservation, water management

1. Introduction

As fundamental natural resources, water and land are crucial for sustainable agriculture and the survival of all life forms. However, both are increasingly becoming scarce due to overuse and mismanagement. Of particular concern is water, as it exhibits significant spatial and temporal variability, making its availability highly unpredictable and challenging to manage effectively. Understanding watershed systems is crucial for sustainable watershed planning and effective management decisions. As a result, watershed modeling has emerged as a powerful tool for the design, planning, and decision-making of water resource systems offering cost-effective solutions within a reasonable time frame (Mirchi *et al.*., 2009) [10]. Around the late 1960's, the development of physically based hydrologic modeling was started (Islam, 2011) [5]. The use of distributed models has been increased in hydrological applications due to easy availability of spatial data sets at finer resolutions, information about physical catchment properties at relatively small catchment scales and increased availability of computer resources (Pechlivanidis *et al.*., 2011) [13]. But most of the physically based distributed watershed models have some limitations such as inability to perform continuous-time simulations, inability to characterize the area in the needed spatial detail and failure of simulating at appropriate temporal and spatial scale. SWAT is the most efficient physically based distributed hydrologic model that is being used by many scientists to predict hydrology, sediment flow and water quality (Golmohammadi *et al.*., 2014) [4]. Calibrated SWAT model can be useful for assessing the runoff potential in future and thus helps in implementing soil and water conservation measures to avoid water loss and to reduce sediment loads that enter through runoff water (Santra *et al.*., 2013) [17]. SWAT model efficiently analyzes water balance and river flow at various reaches which can be helpful in addressing water scarcity issues (Tejaswini and Sathian, 2025) [19]. Remote sensing technologies play a vital role in the management and monitoring of agricultural resources, supporting informed policy-making and sustainable land management (Kumar *et al.*., 2024) [7]. The integration of Remote Sensing (RS) and Geographic Information System (GIS) data offers a valuable tool for resource managers, policymakers, and planners to promote the sustainable utilization of natural resources (Lakshmi *et al.*., 2022) [8]. Existing spatial database systems can be customized to suit specific needs and are adaptable for application in various other regions (Rao *et al*.., 2016) [16]. Now-a days, smart agricultural techniques plays a major role in determining the status of commodities and crops (Krishna *et al*.., 2024) [6]. Statistical tools serve as powerful instruments for drawing reliable conclusions and enabling quantitative comparisons between datasets (Sridevi *et al*.., 2024) [18].

2. Methodology
2.1 Study area
The Kunthipuzha River, located in the state of Kerala, India, was chosen for this study which flows through the Silent Valley National Park. Locally known as Thuthapuzha, it is one of the major tributaries of the Bharathapuzha River, which is the second-longest river in Kerala. The river primarily serves the people of Mannarkkad and Pattambi taluks in the Palakkad district, as well as the Perinthalmanna taluk in the Malappuram district.

2.2 SWAT Tool
The Soil and Water Assessment Tool (SWAT) is a physically based, distributed watershed model developed by the USDA Agricultural Research Service (Arnold *et al*.., 1998) [1]. Over the years, the model has been significantly enhanced with various capabilities. SWAT is recognized as a reliable tool for continuous simulation in predominantly agricultural watersheds (Bora and Bera, 2003) [2]. It has proven to be computationally efficient in modeling both hydrology and water quality over extended time periods (Neitsch *et al*.., 2005) [12]. SWAT operates through a GIS interface and divides a watershed into number of sub-watersheds which again broken down into Hydrological Response Units, the smallest computational elements within the model. The foundation of SWAT's simulation process is based on the water balance concept (Neitsch *et al*.., 2011) [11]. SWAT has demonstrated its effectiveness in simulating hydrological processes across a range of scales-from large river basins (Devkota and Gyawali, 2015) [3] to smaller watershed areas (Malunjkar *et al*.., 2015) [9].

2.3 Methodology for SWAT set up
To run the SWAT model, specific spatial datasets are essential, including a Digital Elevation Model (DEM), land use map, and soil map. Choosing an appropriate Digital Elevation Model (DEM) is crucial for effective decision-making and water resource management (Tejaswini and Sathian, 2025) [20]. The DEM must be provided in ESRI GRID format, while the land use and soil maps can be in any of the following formats: ESRI GRID, shapefile, or feature class. In addition to spatial data, SWAT also requires meteorological data such as precipitation, temperature, solar radiation, relative humidity, and wind speed, all in the specified formats compatible with the model.
SWAT model set up includes the following steps
1. Create a new ArcSWAT project
2. Delineation of watershed
3. Analysis of hydrologic response units
4. Write input tables
5. Edit SWAT input
6. SWAT simulation

2.4 Manual calibration
In SWAT simulation command, the "Manual calibration helper" dialogue box allows the user to adjust the parameters across a user defined group of HRU'S and sub basins during the manual calibration process. Manual calibration was done to obtain more accurate values of parameters and to get best match between simulated values and calibrated values with best NSE and R^2 values. The final parameters obtained from the automatic calibration are used for manual calibration and evaluated using NSE and R^2 factors.

2.5 Validation of the model
Validation involves comparing the model's results with an independent set of observed data that was not used during the calibration process. This step helps assess the model's accuracy and reliability without making any further adjustments to its parameters.

3. Results and Discussion
This study was aimed at assessing the natural resources of Kunthipuzha basin using SWAT model. The results of the study and their inferences are presented in this section.

3.1 SWAT Model Set up for Kunthipuzha Basin
The spatial data set for running the SWAT model viz. DEM, land use and soil maps are presented in Figure 1 to Figure 3. The basin elevation extent from 0 to 2330 m, out of which 0-50 m elevation band encompasses nearly 18.95% area. Most of the portion i.e., 31.53% were covered by plantains followed by rubber trees (19.98%) and evergreen forests (12.37%) as observed from land use map. Soil map indicates that major geographical representation was for Mannursree series (21.10%) followed by Karinganthodu (19.23%) and Mannamkulam (11.01%).
Before calibration, the Nash Sutcliffe Efficiency and Coefficient of determination were found to be 0.75 and 0.76, respectively, indicating that tool possessed a moderate predictive capability even in its uncalibrated state. After calibration, the NSE and R^2 values improved to 0.80 and 0.81, respectively, indicating an enhanced predictive performance of the model. The variation between simulated and observed peak flows reduced following calibration as shown in Figures 4 and 5. However, despite these improvements, the SWAT model still under-simulated some peak flows.
Varughese (2016) [21] suggested that such discrepancies could result from inaccuracies in meteorological data, errors in input spatial datasets/errors in data handling and also variations in rainfall and topography. SWAT model's dependence on the empirical SCS-CN method for estimation of runoff also contributes to model inaccuracy in simulating peak flows as curve number method does not account intensity of precipitation and duration (Qui *et al*.., 2012) [15]. Similar underestimation patterns were reported by Pereira *et al*.. (2016) [14] in their study. During the validation period, the model evaluation statistics showed NSE and R^2 values of 0.73 and 0.88, respectively, indicating that the calibrated model performs well in predicting outcomes beyond the calibration period.

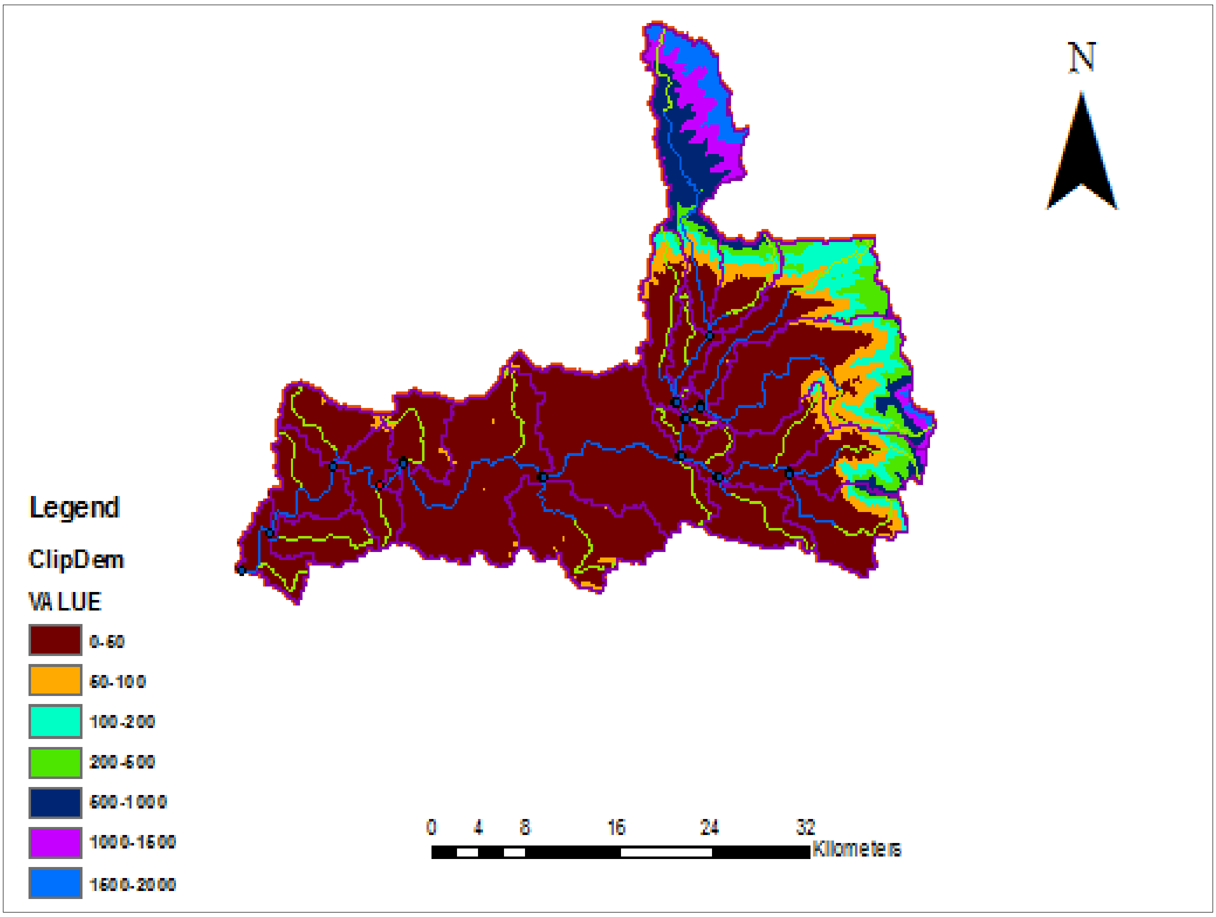

Fig 1: Digital elevation model of Kunthipuzha basin

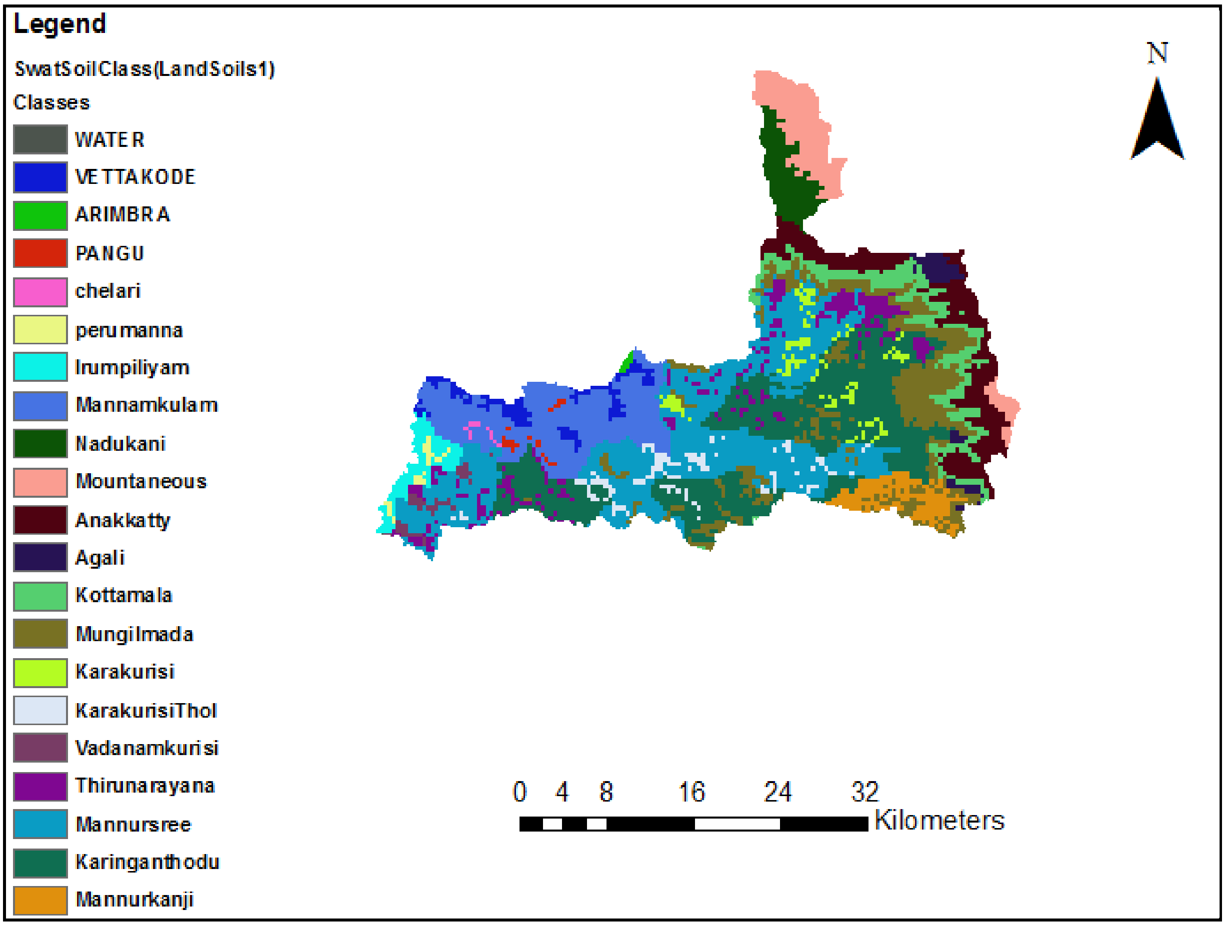

Fig 2: SWAT soil classification for Kunthipuzha river basin

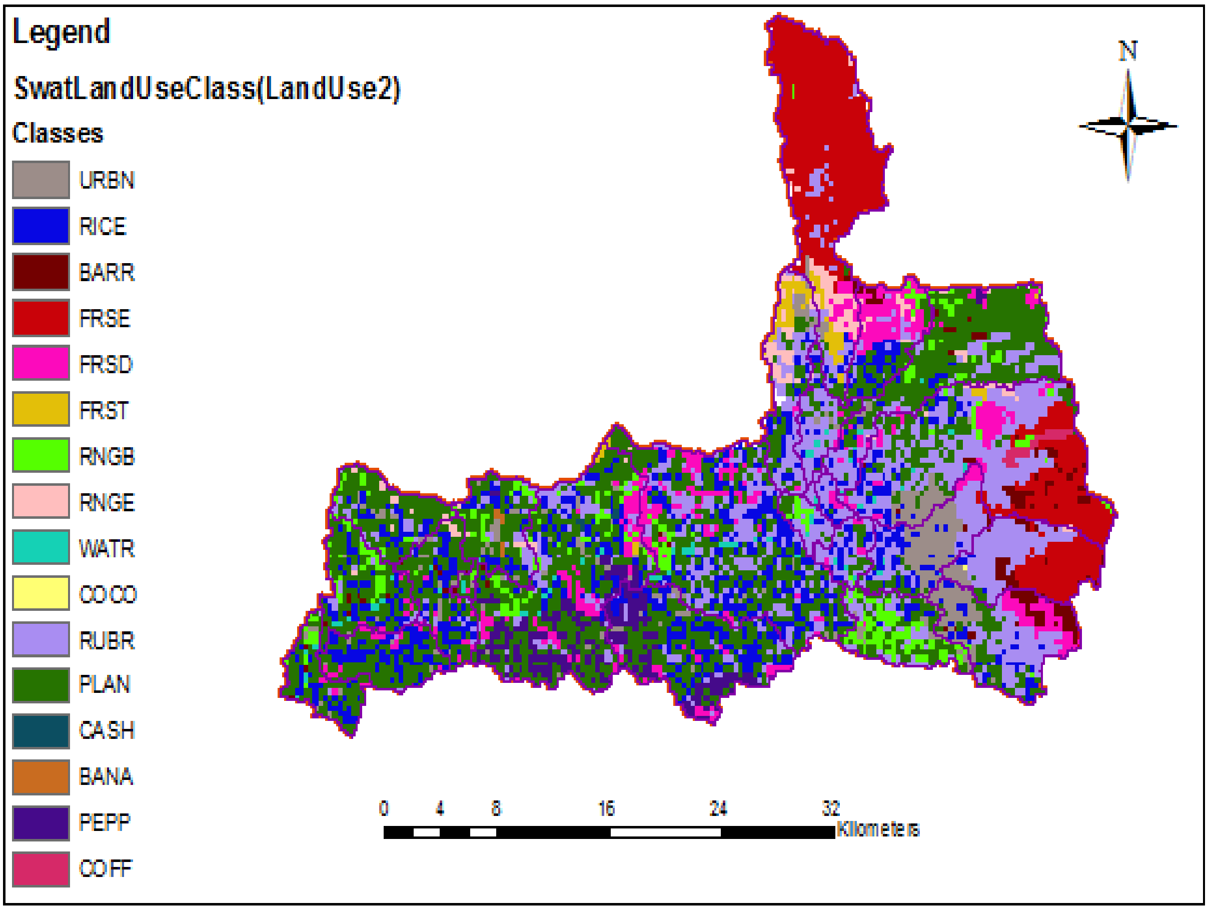

Fig 3: SWAT land use classification for Kunthipuzha river basin

3.2 Model Calibration and Validation

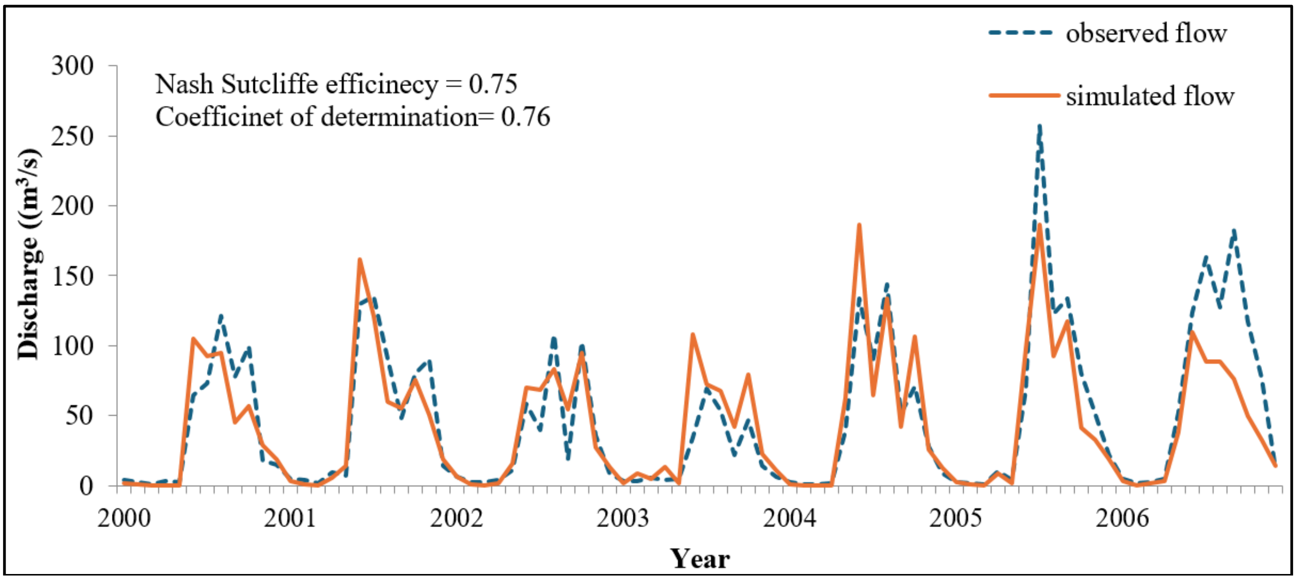

Fig 4: Observed and simulated monthly stream flows at Pulamanthole before calibration

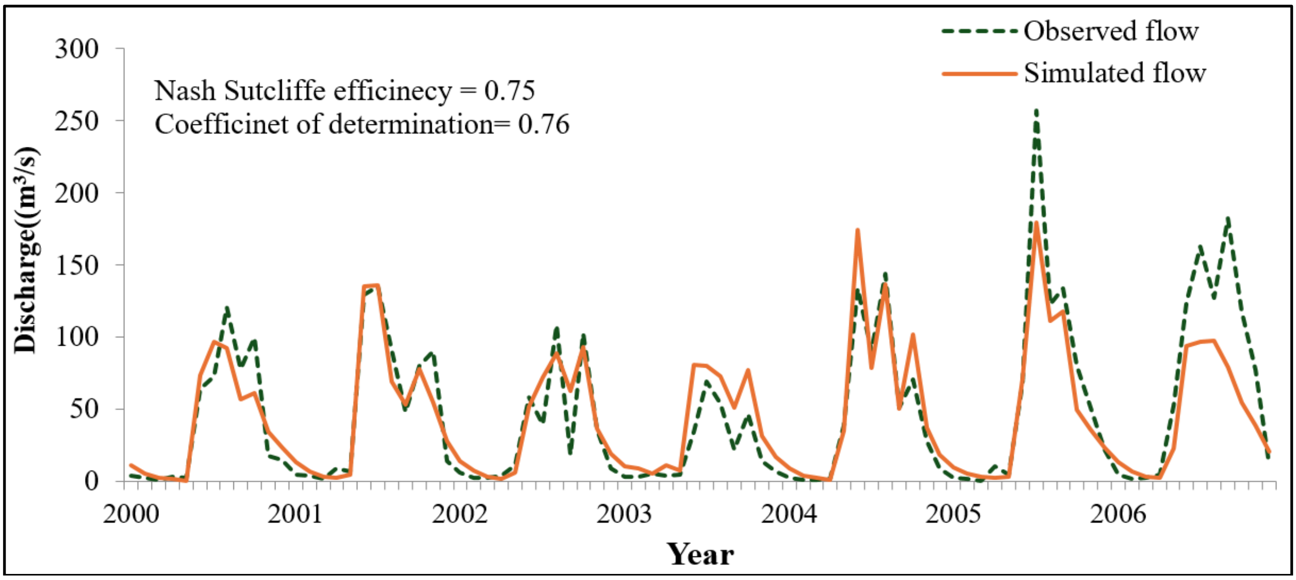

Fig 5: Observed and simulated monthly stream flows at Pulamanthole after calibration

4. Conclusion
The wise and well planned conservation of natural resources such as water and land is the most practical solution to address various water-related challenges, including droughts, floods, and water quality issues. The successful application of the SWAT model in the Kunthipuzha basin provided valuable insights into land use, soil distribution, and elevation patterns, supporting effective natural resource management and enabling informed water management decisions.

5. References

1. Arnold JG, Srinivasan R, Muttiah RS, Williams JR. Large-area hydrologic modeling and assessment: Part I. Model development. Journal of the American Water Resources Association. 1998;34(1):73-89.
2. Borah DK, Bera M. Watershed-scale hydrologic and non point-source pollution models: Review of mathematical bases. Transactions of the ASAE. 2003;40:1553-1566.
3. Devkota LP, Gyawali DR. Impacts of climate change on hydrological regime and water resources management of the Koshi river basin, Nepal. Journal of Hydrology: Regional Studies. 2015;4:502-515.
4. Golmohammadi G, Prasher S, Madani A, Rudra R. Evaluating three hydrological distributed watershed models: MIKE-SHE, APEX, SWAT. Hydrology. 2014;1:20-39.
5. Islam Z. Literature review on physically based hydrologic modeling. ResearchGate. 2011. doi:10.13140/2.14544.5924.
6. Krishna SV, Jain SK, Panwar NL, Sunil J, Wadhawan N, Kumar A. Emergence of internet of things technology in food and agricultural sector: A review. Journal of Food Process Engineering. 2024;47(8):e14494. (*Add page numbers if available*.)
7. Kumar J, Rajesh GM, Singh G, Sambasiva Rao P, Kumar P. Monitoring land use dynamics and agricultural land suitability in Samastipur district, Bihar using Landsat imagery and GIS. Journal of Climate Change. 2024;10(4):43-53.
8. Lakshmi YN, Paul E, Deekshitulu NVG. Land use and land cover change detection in East Godavari district, India (2002-2020). Asian Journal of Agricultural Extension, Economics & Sociology. 2022;40(9):254-262.
9. Malunjkar VS, Shinde MG, Ghotekar SS, Atre AA. Estimation of surface runoff using SWAT model. International Journal of Inventive Engineering and Sciences. 2015;3(4):12-15.
10. Mirchi A, Watkins D, Madani K. Modeling for watershed planning, management and decision making. In: Watersheds: Management, Restoration and Environmental. New York: Nova Science Publishers; 2009. p. 1-25.
11. Neitsch SL, Arnold JG, Kiniry JR, Williams JR. Soil and water assessment tool theoretical documentation version 2009. Technical Report No. 406. Texas Water Resources Institute; 2011.
12. Neitsch SL, Arnold JG, Kiniry JR, Williams JR, King KW. SWAT theoretical documentation version 2005. Temple, TX: Soil and Water Research Laboratory, ARS; 2005.
13. Pechlivanidis IG, Jackson BM, McIntyre NR, Wheater HS. Catchment scale hydrological modeling: A review of model types, calibration approaches and uncertainty analysis methods in the context of recent developments in technology and applications. Global NEST Journal. 2011;13(3):193-214.
14. Pereira DDR, Martinez MA, Pruski FF, DaSilva DD. Hydrological simulation in a basin of typical tropical climate and soil using the SWAT model. Part 1: Calibration and validation tests. Journal of Hydrology: Regional Studies. 2016;7:14-37.
15. Qiu LJ, Zheng LF, Yin RS. SWAT-based runoff and sediment simulation in a small watershed, the loessial hilly-gullied region of China: capabilities and challenges. International Journal of Sediment Research. 2012;27:226-234.
16. Rao BK, Chakravarthy ASN, Rao MJ. A study on developing groundwater information system for sustainable management of groundwater resources-A case study from Visakhapatnam urban region.

International Journal of Science & Research. 2016;5(5):2185-2190.
17. Santra P, Das BS. Modeling runoff from an agricultural watershed of western catchment of Chilika Lake through ArcSWAT. Journal of Hydro-Environment Research. 2013:1-9.
18. Sridevi B, Rama Sree S, Prasad MHMK. Statistical comparative analysis of semantic similarities and model transferability across datasets for short answer grading. International Journal of Intelligent Systems and Applications in Engineering. 2024;12(15):530-538.
19. Tejaswini V, Sathian KK. Comparison of digital elevation models for hydrological modelling. International Journal of Agriculture and Food Science. 2025;7(4):104-106.
20. Tejaswini V, Sathian KK. Spatial and temporal distribution of water availability in a small watershed to combat agricultural drought. International Journal of Agriculture and Food Science. 2025;7(4):26-33.
21. Varughese A. Impact of climate change and watershed development on river basin hydrology using SWAT-A case study [Ph.D. thesis]. Thrissur: Kerala Agricultural University; 2016. p. 1-120.