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Modeling of Evapotranspiration using SWAT Model for Tungabhadra Sub-basin

Chitralekha Nagoli, Dr. Nagraj S. Patil

Abstract— Evaporation and Transpiration are the prime process of water vapor which transferred to the atmosphere. Evapotranspiration is an important key term of hydrologic cycle and energy balance at various spatial scales. It is necessity to evaluate evapotranspiration value for the ecosystem modeling and hydrological studies. In order to attain excellent water yield, it is essential to estimate irrigation water requirements while planning, designing, and development of irrigation systems.ET is estimated manually and experimentally, which are not feasible, since these methods are costly and time consuming. In this study ET is estimated for Tungabhadra sub basin using semi distributed hydrological model Soil and Water Assessment Tool(SWAT). The output derived from the SWAT model includes ET values which are calibrated and then validated using IMD observed data.

Keywords: Hydrological model, SWAT model, Tungabhadra Sub-basin.

I. INTRODUCTION

The combine effect of transpiration and evaporation with respect to spatial variation is known as ET. Actual ET is necessary for optimal irrigation planning and management [1] Water availability during summer season is insufficient and causes water deficiency in the root zone of the crop which effects crop growth and ET, since the crop yield is closely related to actual ET, therefore it is necessary to estimate ET for such conditions [2]

Changes in hydrological events are expected with the changing climates ET may be varies depends on crop type, transpiration, crop height, type of soil, and weather [3] different displaying devices have been produced in water assets. Since their development, surface water demonstrating and groundwater displaying has been accumulate separately.

Different models have been produced to demonstrate the watershed, SWAT (Arnold et al., 1991) being the most generally utilized model .However, common procedures are complex. degrading administration of water value leads to the water scarcity which harm the human survival. In this study, to model surface hydrology Arc-SWAT has been used. SWAT uses individual modules to calculate various hydrologic parameters. Environmental applications such as optimizing irrigation water system, irrigation system framework execution, crop water deficiency, mitigation strategies of drought and accurate initialisation of atmosphere prediction models particularly in arid and semiarid catchments where scarcity of water is a basic issue.

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Chitralekha Nagoli, Final year M. Tech, Dept. of Water & Land Management, Visvesvaraya Technological University, Belagavi, India

Dr. Nagraj S. Patil, Associate Professor, Dept. of Water & Land Management, Visvesvaraya Technological University, Belagavi, India

II. STUDY AREA

Tungabhadra subbasin was selected as the study area, which comes under Krishna basin, India, is one of the most important agricultural areas in the north Karnataka. The Tungabhadra River is a holy river in southern part of India which flows through the Karnataka state to Andhra Pradesh state.(Figure1) It is formed by the convergence of two rivers, the River Tunga and the River Bhadra, which flows down the eastern gradient of the Western Ghats in the Karnataka state at an altitude of about 1,196 m. (Annual report of 2011-2012, Tungabhadra board) Sub-Basin catchment is predominantly semi-arid. The catchment of the Tungabhadra basin lies approximately between the northern latitudes 13° 00[1] and 16° 00[1] and eastern longitudes 75° 00[1] and 79°30[1].

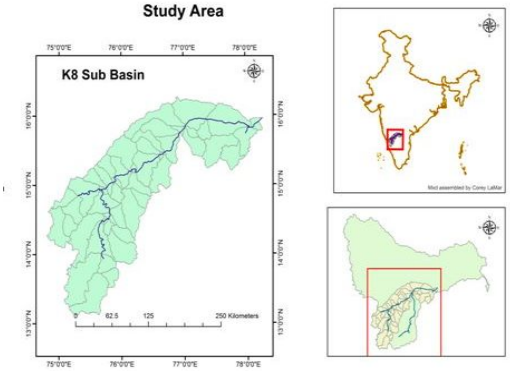

Fig. 1: Location of Study area

III. METHODOLOGY

Methodology is a sequence of activities that starts with the decision making, problem recognition and ends with recommendation.

SWAT Model

Soil and Water Assessment Tool (SWAT) is a consistent, physically based, long term, semi-distributed model created with the joint commission of USDA Agricultural Research

Service and Texas University. SWAT model runs on a daily time step and is reasonable for both short and long term forecasts. Spatial enumerating is usefully keep up as handling is done in light of extensive number of watersheds and hydrological reaction units in view of different information. Swat

The model operates on daily, monthly or yearly time step. The ArcSWAT 2012 interface runs within the ArcGIS 10.1. The hydrologic cycle as simulated by SWAT is based on the water balance equation.

$$S_{wt} = S_{wo} + \sum_{i-1}^{t} (R_{day} - Q_{surf} - E_a - W_{seep} - Q_{gw}) \ldots\ldots(1)$$

Where S_{wt} is the final soil water content (mm), S_{wo} is the initial soil water content on day (mm), t is the time (days), R_{day} is the amount of precipitation on day (mm), Q_{surf} is the amount of surface runoff on day (mm), E_a is the amount of evapotranspiration on day (mm), W_{seep} is the amount of water entering vadose zone from the soil profile on day (mm), Q_{gw} is the amount of return flow on day (mm). SWAT model setup and execution is followed by using flowchart (Figure 2)as shown below.

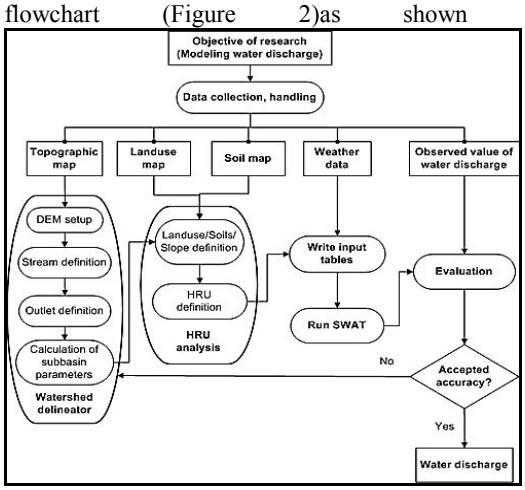

Fig.2:Flowchart of the Methodology for SWAT (Source: Loi, 2012)

The data are used to run the model namely DEM, soil map, LULC map. (Figure 3 and 4)

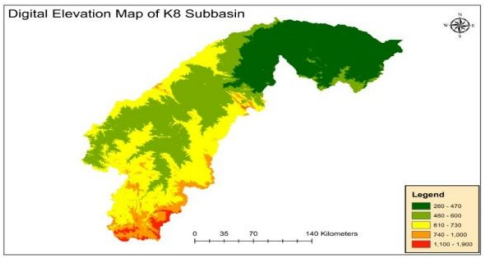

Fig.3:Digital elevation map of Tungabhadra subbasin

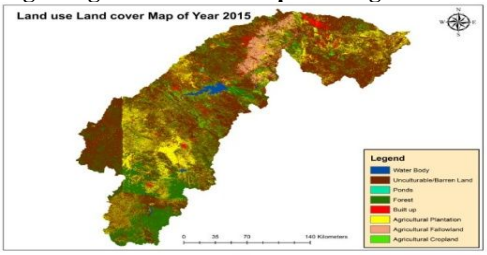

Fig.4: LULC Map of Tungabhadra subbasin of the year 2015

The data used for SWAT are DEM, Land use land cover maps, Soil maps, Slope maps and meteorological data and flow data for calibration and validation of model.

ET Mapping

Mapping is the graphic symbolic representation of the significant features of the real world. Mapping is done by several methods. In this study, the model SWAT is run to obtain results which include Evapotranspiration values. These evapotranspiration values are used to develop ET maps. The mapping is done using Arc-GIS interface to understand the spatial distribution of ET values over the study area. ET values are used for the analysis of water requirement and usage, operation of ground water models, and determination of crop water requirement.

IV. RESULTS AND DISCUSSIONS

Model application are follows three steps: The calibration, process used to adjust the input data and model parameters to meet the observed output value. The validation of the model is to check the output of calibrated model with the next time series of observed output data, and finally results of the study.

Analysis of SWAT output

The SWAT model was run for the period 1971-2011 and the results were obtained. The calibration and validation was done manually with respect to the observed discharge obtained from IMD. Figure 5 and represent the comparison between simulated and observed discharge during calibration. During calibration NSE value obtained are 0.611 and R^2 is0.604.

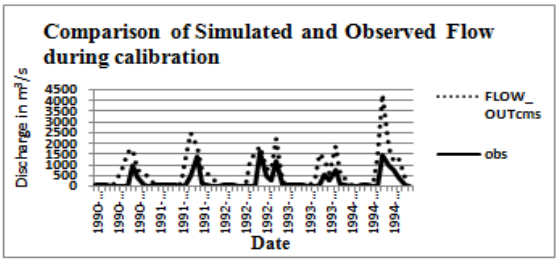

Fig.5:Comparison of simulated and observed flow during calibration

Validation is carried out for the period 1997-2000. It is done to check the accuracy of the model after calibration. R^2 and NSE are the performance indices used for validation of the model.

Figure 6 represent the comparison between simulated and observed discharge during validation period. During validation obtained NSE value is 0.66623 and R^2 value is 0.607.

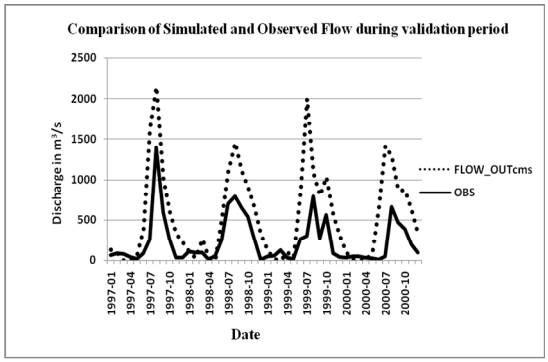

Fig.6: Comparison of simulated and observed flow during validation period

ET Mapping

Mapping is the graphic symbolic representation of the significant features of the real world. Mapping is done by several methods. In this study, the model SWAT is run to obtain results which includes Evapotranspiration values. These evapotranspiration values are used to develop ET maps. ET maps gives an idea to supply required quantity of water to the irrigated fields. (Figure 7)Therefore the ET maps were prepared for the Tungabhadra subbasin using calibrated SWAT model results. Different types of method are used for ET mapping. In this study the mapping was done by using Inverse Distance Weighting (IDW) using ArcGIS 10.1 interface.

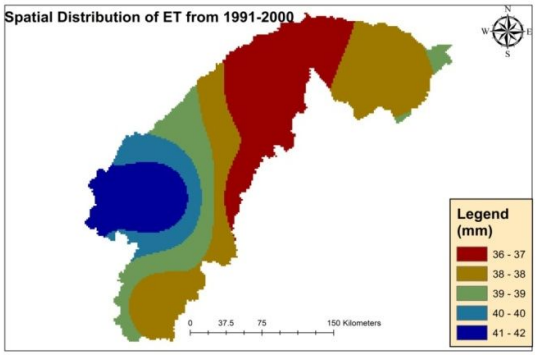

Fig.7: Spatial Distribution of ET for Tungabhadra sub-basin for the period 1991-2000

V. CONCLUSION

An estimation of ET is very important for analyst, because it allows them to better estimate the amount of water that is being removed from the soil. With this they can better estimate how much water they must use in irrigation. In this study ET mapping is done for Tungabhadra sub basin using semi distributed hydrological model SWAT. The data used are land use/ land cover, soil and meteorological data. The output from SWAT contains ET values which is calibrated using observed data. After the calibration ET mapping is done by using ARCGIS 10.1. The obtained results which helps to watershed management and future development of irrigation system.

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Chitralekha Nagoli
Final year M. Tech. Dept. of Water and Land Management. Center for PG Studies, VTU, Belagavi, Karnataka, India
Email:chitralekha.h.nagoli@gmail.com

Dr. Nagraj S. Patil
Associate Professor, Dept. of Water and land Management. Center for PG Studies, VTU, Belagavi, Karnataka, India
Email: *nagrajspatil@yahoo.com*