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Water Balance Assessment using Q-SWAT

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Abstract***: The factors influencing decrease in water level are related to one another, such as scanty rainfall, excess evaporation, landuse changes, deforestation and smaller amount of groundwater recharge which fallout into inadequate supplies in most parts of Maharashtra. To meet the demands of the area; proper planning for judicious use of limited resources is essential. The study has been carried out to determine the availability of resources in small watershed which lies in Gangapur District, Maharashtra. The analysis has been carried out by using QSWAT 1.2 for time period of 33 years from 1979 to 2012. Daily data of precipitation, temperature, radiation, wind velocity and solar radiation has been processed on monthly time scale. After proper watershed delineation; the graphical and numerical summary of the simulated results for hydrological parameters such as Actual Evapotranspiration, Groundwater Contribution, Potential Evapotranspiration and Surface runoff are represented.***

Keywords: PET; QGIS; QSWAT; Watershed Delineation

I. INTRODUCTION

Water is very essential resource for mankind. The availability of pure water is less in the region and one of the factors dependent is rainfall which is unevenly distributed. In the semi-arid region rainfall is less and unpredictable; hence demands of water for drinking and irrigation becomes critical. For the planning and managing of available resources at watershed scale water regime of area need to be studied by using water balance approach. Water balance is an application law of conservation of mass which can be applied to a particular spatial unit. Balancing the availability and the demand of resources will be the best way to deal with drought conditions. To achieve this change in storage should be equal to difference between inflow as precipitation and outflow as surface runoff, groundwater flow, and evapotranspiration. For any watershed development work it is necessary to understand relationship between physical parameters of watershed and hydrological components and hence water balance approach is widely used for watershed management practices. By using water balance approach the components of hydrological cycle can be evaluated there are many applications of this study such as Agricultural water management, climate change impact assessment, flow forecasting, water quality assessment etc. Available resources can be determined by knowing precipitation, runoff, groundwater, evaporation and transpiration. There are various computer based models developed to calculate water balance also many theoretical and experimental studies has been carried out in the past years.

Water balance models have been developed at various time scales such as hourly, daily, monthly and yearly. Monthly water balance models were first developed in the 1940s by Thornthwaite (1948) and later revised by Thornthwaite and Mather (1955, 1957). Xu and Singh [1] reviewed assumption and limitation of monthly water balance by using model used worldwide. Melesse et al. [2] evaluated spatial evapotranspiration from remotely sensed data using surface energy flux model. The grid GIS-based spatial surface water balance predicted the observed values with an average error of prediction of 0.12m. Changes in Evapotranspiration are detected using SEBAL approach Components of water balance were estimated at the pixel level. Myronidis and Emmanouloudis [3] estimated the water balance of protected area on a monthly time step and integrated Geographical Information Systems and computational hydrology techniques of Thornthwaite and Mather.

Jasorita et al. [4] used water balance assessment approach to estimate the moisture deficit and moisture surplus for an entire watershed using Thornthwaite-Mather (TM) model along with remote sensing and GIS for the study. Jenifa et al [5] developed spatially semi distributed water balance model was developed to simulate mean monthly hydrological processes. The model was developed using SCS-CN (Soil Conservation Service Curve Number) model to derive the runoff component and Food and Agriculture Organization-Penman Monteith model to derive the evapotranspiration component spatially with the help of remote sensing and GIS techniques. Jain et al [6] applied SCS approach to each cell in a gridded rainfall map yielded a grid of expected runoff. Evapotranspiration has been estimated using an energy balance model. Advanced very high resolution radiometer, have been used for preparation of various maps required for runoff and ET analysis. Sathian [7] used, SWAT model, to analyse and quantify the water balance of a river basin. Predicted water balance components were also been compared with their measured or alternately computed counterparts. Fadil et al. [8] used Arc SWAT model to simulate the stream flow, establish the water balance and estimate the monthly volume inflow to SMBA dam.

SWAT is physical based which requires specific information about meteorological parameters, soil type, topography, vegetation, and land use for a watershed. Physical processes associated with water movement can be studied. It is a hybrid model spatially based on HRU (hydrological response units) includes both, conceptual and physical approaches. A central part of SWAT is the general water balance equation. Surface runoff is determined by the SCS Curve Number approach. Potential evapotranspiration is determined by Penmen- Moneith method. The Simulated results are visualized statically, graphically and numerically in QSWAT output.

Objective:

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The main objective of the study is to carry out SWAT analysis for 33 years of data small watershed lies in Gangapur, Maharashtra to compute all the water balance components such as average amount of Precipitation, Potential evapotranspiration, Actual precipitation, Groundwater Contribution, Surface runoff, Soil water content, Water yield for the day, month or year for each sub basin with help of QSWAT.

II. STUDY AREA

The study area consists of watershed which is located in Gangapur, Aurangabad, Maharashtra between the latitudes 19^{0}38'13.2" - 19^{0}44'9.6" North and longitudes 74^{0}57'7.2" - 75^{0}5'24"East as shown in figure 1. The Watershed of area is delineated from a toposheet 47M/2 and 47I/14 includes Gangapur, Ambewadi, Ganeshwadi, Lakhmapur, Antapur, Saidapur and Navin Kaigaon. Total area contributing for calculation of the study is about 54 Sq.km with average elevation of 486m MSL with gently sloping rolling lands. In summer highest temperature recorded is in between 34°C to 42°C. The area is having average annual rainfall i.e. less than 625 mm.

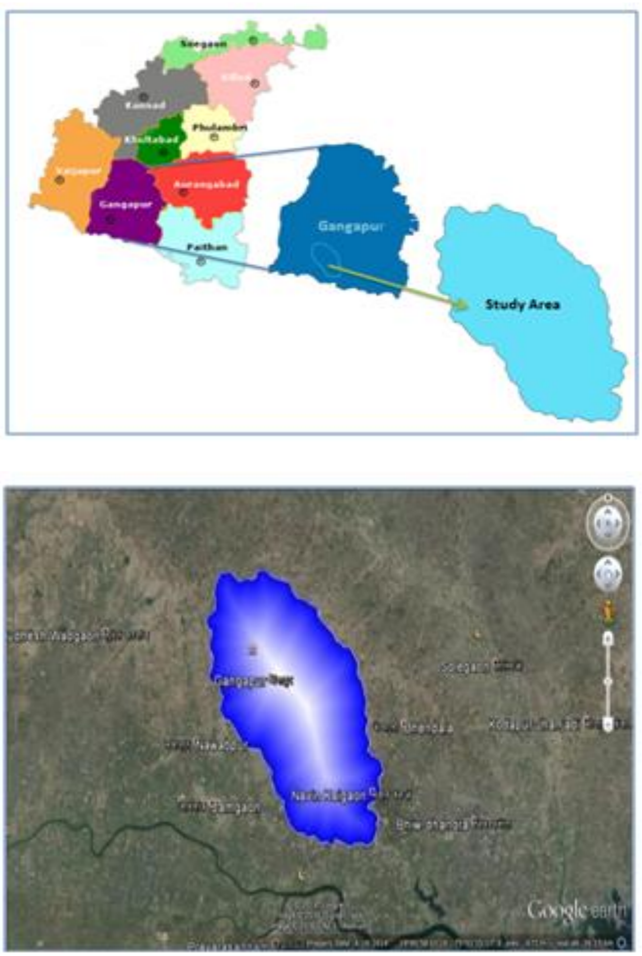

Fig.1 Location of study area

III. METHODOLOGY

The Methodology used for entire SWAT analysis is described in figure 2

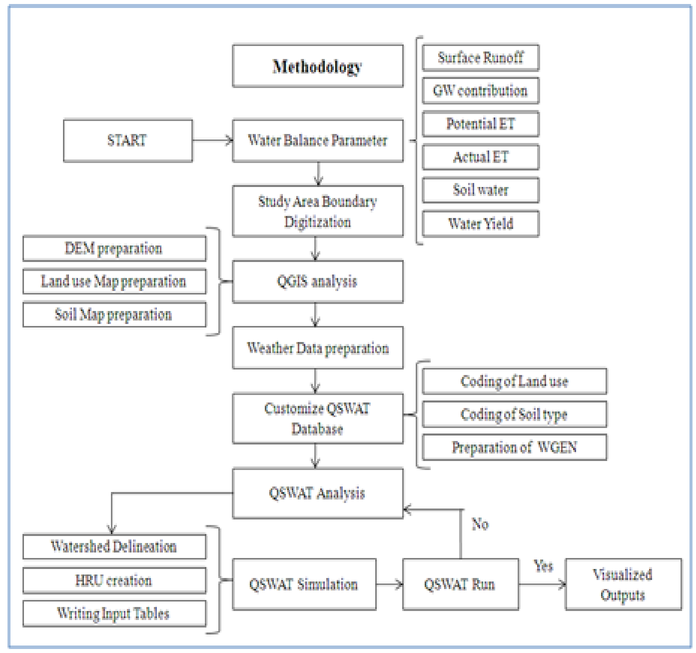

Fig.2 Flow chart of Methodology for QSWAT Analysis

The Input data required for SWAT model is boundary of study area, landuse map, soil map, and weather data for the study area. To develop the boundary map of study area toposheets of scale 1:50,000 were collected from survey of India department and georeferenced in QGIS environment.Then digitization of boundary map. 30m × 30 m Digital Elevation Modelfor Aurangabad and Ahmadnagar was downloaded from http://earthexplorer.usgs.gov.in. Then two tiles of DEM were merged In QGIS. After that by using boundary, DEM of area was extracted. DEM of the study area is as shown in figure 3.

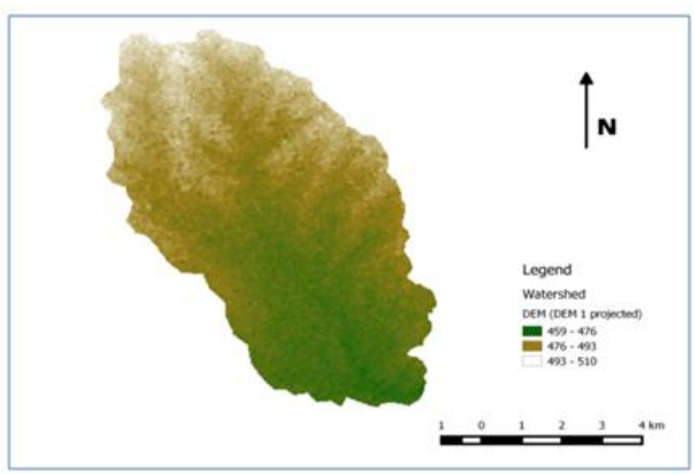

Fig. 3 DEM of study area

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After this DEM of the study area was processed to develop slope map, flow direction which is necessary for watershed delineation. The Land use map of area was digitized and rasterized in QGIS by adding web map service layer provided by http://bhuvan.nrsc.gov.in then by using QSWAT Ref 2012.mdb file SWAT Code was assigned to each land-use and copied to excel file Watershed_soils.xls file. Land use map is shown in figure 4. Soil map of Maharashtra developed by NBSS, Nagpur was geo-referenced and used for digitized and rasterize soil map. The soil map for the area is as shown in figure 5. It was observed that 75.72 % Agricultural land, 19.265% Fallow, 4.392% Built up area and only 0.027% Barren land is there. Then by using QSWAT Ref 2012.mdb file SWAT Code was assigned to each land-use and copied to excel file Watershed_soils.xls file. Then Soil map of Maharashtra developed by NBSS, Nagpur was Geo-referenced and used for digitizing and rasterizing soil map using this Watershed_soils.xls file was created. The B and C type of Hydrologic Soil Groups are identified. B type Soils having moderate infiltration rates, well drained soils and C type soils having slow infiltration rates.

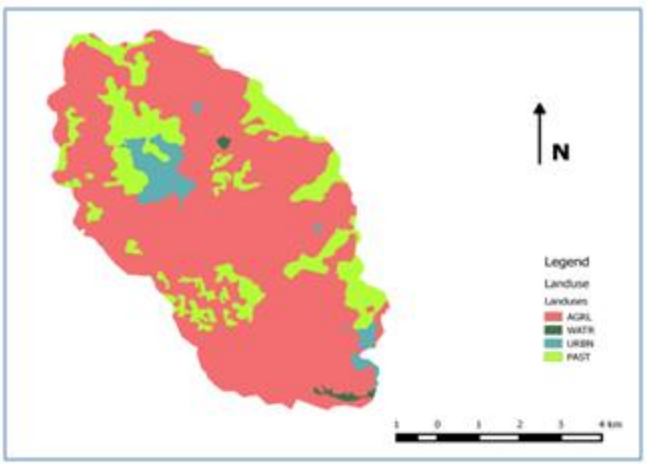

Fig.4 Land use Map of the Study Area

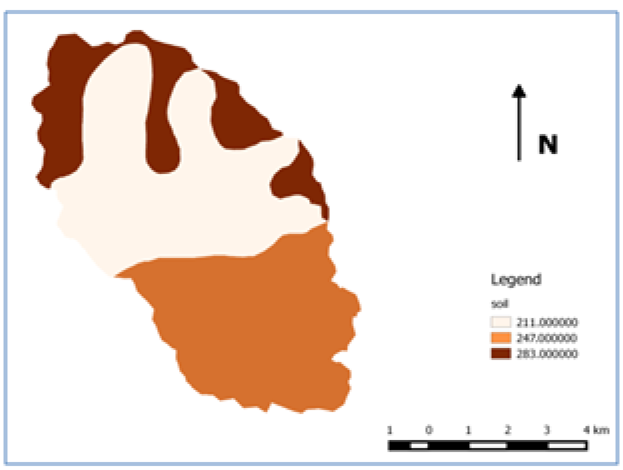

Fig.5 Soil Map of study area

The weather data for station nearby study area was downloaded from http://globalweather.tamu.edu site. The daily data such as precipitation (mm), Temperature (^{0}C), Wind velocity (m/s) and solar radiation (MJ/ m^2) available for station has been used. To generate weather database for QSWAT input, various parameters related temperature, precipitation and dew point temperatures were calculated. Calculation of TMPMX, TMPMN, TMPSTDMX, SOLARAV, WNDAV has been carried out with the help of Microsoft excel. Precipitation related parameters and dew point were computed using customized software called pcpSTAT.exe and dewpoint.exe. Then all the results are copied to the WGEN_WatershedGan.xls file.

The central part of the SWAT model is water balance the basic equation is

$$PREC - SURQ - GW - PET - ET - SW = WYLD$$

Where,

PREC- Amount of Precipitation in mm
SURQ- Amount of Surface runoff in mm
GW- Groundwater Contribution in mm
PET- Potential Evapotranspiration in mm
ET- Actual Evapotranspiration in mm
WYLD- Water yield (mm of H_2O)
SW- Soil water content (mm)

In SWAT model surface runoff computed with the help of SCS-Curve number method and Potential evapotranspiration is calculated by using Penman-Moneith method. In watershed delineation watershed get divided into multiple sub-basins, then for each sub-basin the water balance components were calculated.

IV. RESULTS

The Simulated results are obtained after successful running SWAT. The results can be visualized totally, annually daily, monthly and yearly basis. It gives all hydrological components average amount of Precipitation, Potential evapotranspiration, Actual precipitation, Groundwater Contribution, Surface runoff, Soil water content, Water yield for each sub basin. The output can be visualized statically, numerically and graphically in SWAT as shown in figure 6 and figure 7. Figure 8 shows the results of QSWAT simulation run in visualized format.

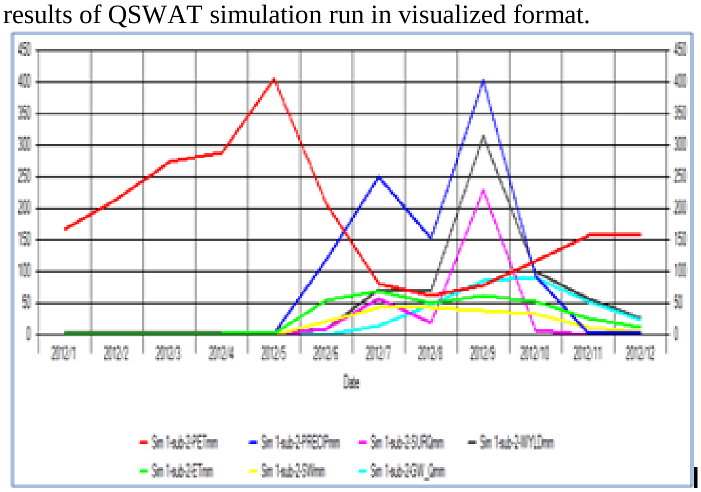

Fig.6 Graph showing variation of all the parameters for 2012 for subbasin-2

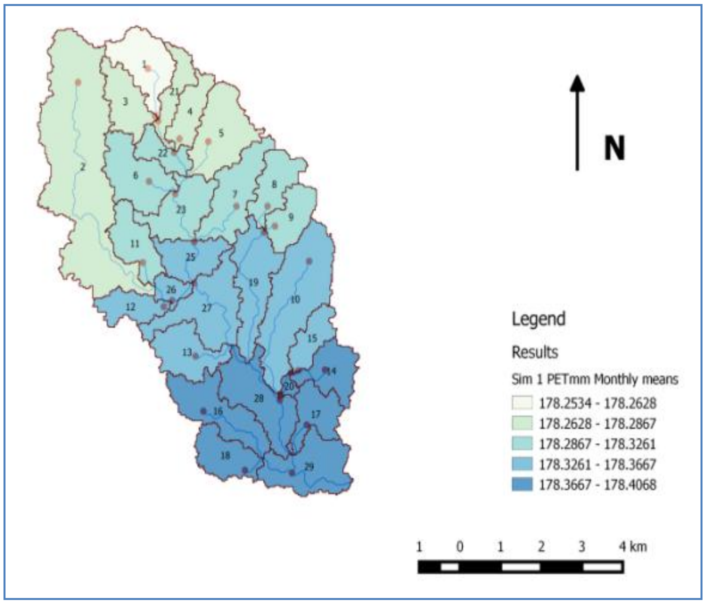

Fig.7 Monthly Potential evapotranspiration in mm

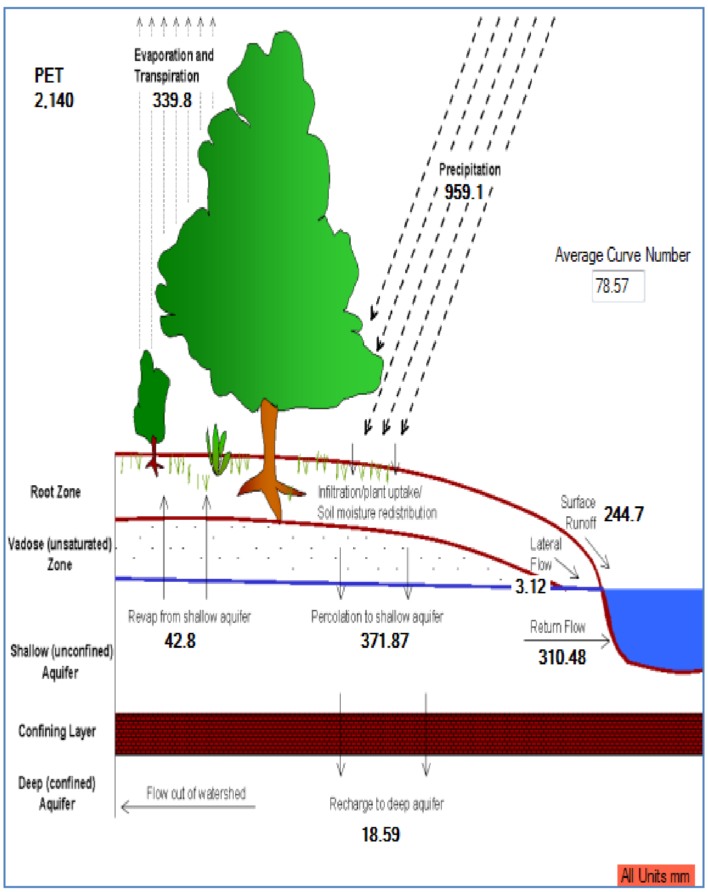

Fig.8 The hydrology of study area can be visualized after running SWAT check

V. CONCLUSION

Water regime of the specific area is well understood by assessment of resources. Water balance is best way of determining availability of water in different components of hydrological cycle and changes in between these components. The Open-source geospatial techniques were used to prepare various thematic maps of study area influence land use, soil, drainage, and slope used as input for SWAT model. SWAT model proves as an effective tool in simulating the hydrology of large basins at watershed scale. This gives simulated results of each parameter. The estimated parameters can be used for many other purposes of study such as agricultural water management, climate change impact assessment, flow forecasting, water quality assessment etc. This water balance study minimizes risk of drought and mismanagement, and hence will lead to a proper utilization of water resource available.

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