IMPACT OF CLIMATE VARIABILITY ON STREAMFLOW AND CROP YIELD IN PARAVANAR BASIN

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ABSTRACT - *Gradual increases in air temperature and precipitation resulted in mean annual increases in potential and actual evapotranspiration, Streamflow and decrease in soil moisture and groundwater recharge. Thus, we are in situation to analysis the impacts climate change on stream flow and rainfall over past few decades. Paravanar basin is located in Cuddalore district a semi- arid region of Tamilnadu. Cuddalore is facing water scarcity problem due to semi-arid condition, but it may also facing flood due to storm activity every year and aggravated by the global climatic changes. So it is necessary to adopt climate change impact assessment on Paravanar Basin. Rainfall-runoff computation by distributed hydrological models and using GIS techniques has become increasingly possible, practical and popular. The models are becoming more capable for predicting flood and decision making in watershed management. Grid-based GIS appears to be a very suitable tool for spatially distributed hydrologic modeling. Starting from a digital elevation model, hydrologic features of the terrain can be determined using standard GIS functions that operate on raster terrain data. Also, estimation of surface and soil related parameters become feasible by combining soil type and land use data in raster format. Flow routing can be achieved by tracking the water throughout the cell network along topographic flow paths. In this, long term past trends of stream flow in relation to climatic data would be studied in sub-basin of the Paravanar basin in Cuddalore district. A hydrologic simulation was performed on the basin using the HEC-HMS models. From 2008-2009 precipitation and stream flow data are taken for calibration and 2009-2015 years data are taken for validation. Result shows that land use gets changed in past decades which lead to occurrence of peak flood during Northeast monsoon. Due to this Evapotranspiration gets increased which leads to water scarcity during summer and results in decrease in crop yield and its production. Thomas –Fiering model predicts climate data for two decades from 2011-2030 which shows that there is significant increase in maximum and minimum temperature and also indicates high rainfall during this period.*

KEYWORDS: *HYDROLOGICAL MODELING,HEC-HMS MODEL,EVAPORATION,TEMPERATURE,STREAMFLOW*

I.INTRODUCTION

Hydrology is the study of the occurrence, movement, distribution and quality of water throughout the Earth and Earth's atmosphere. Today, the competition for the fixed amount of water resources is much more intense giving rise to the concept of peak water. In future, even more water will be needed to produce food because the Earth's population has been forecasted to be 9 billion by 2050. Water runoff often collects over catchment flowing into rivers. Some of water is diverted to irrigation for agriculture. Flood occurs when an area of land, usually low-lying is covered with water. A drought is an extended period of months or years when a region undergone a deficiency in its water supply. Hydrological modeling has been carried out for more than three decades. The traditional deterministic hydrological models are of lumped conceptual (lumped parameter) type. Due to the nature of lumped models, all homogenous parameters and variables represent average values over the entire watershed. From the review of various models, HEC-HMS is a continuous simulation model useful for analyzing mainly long-term impacts of hydrological changes and watershed management practices. Hydrological models are simplified representation of a real-world system and consist of a set of equations that may be empirically founded or based on physical laws or a set of conceptual operations. In surface water modeling, models use an empirical method to convert rainfall volume into runoff volume.

1.1 OBJECTIVES

- To estimate the water yield and Streamflow extremes using HEC-HMS.
- To analyse and generate change in climate variability using Thomas - Fiering model.
- To study the impact of climate variability on Streamflow and crop yield.

1.2 STUDY AREA

The study area is the Paravanar sub-basin which lies in the Cuddalore district between the longitude 11º18’N to11º45’N and latitude 79º15’E to 79º45’E. It is bounded on the north by the main Gadilam river basin, on the south by the Vellar basin, on the east by Bay of Bengal. Most part of the study area is a flat plain, sloping very gently towards the sea on the east. The River Paravanar originates from the Cuddalore sandstone of Tertiary age. Cuddalore sandstone occurs at capper plateau south of Cuddalore town and is made up of sandstone, clay and silt. The lower Cuddalore sandstone is unconsolidated at few places.

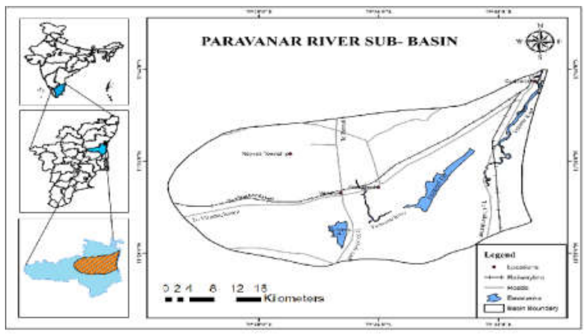


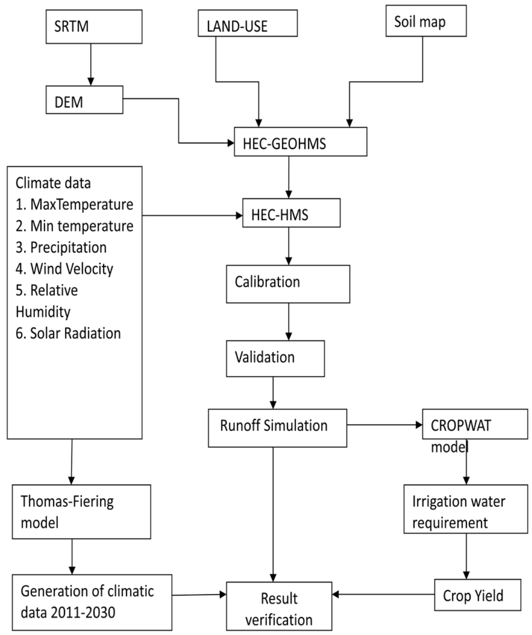
Figure 1.Index map showing Paravanar Basin

1.3 NEED FOR THE STUDY

In Paravanar sub-basin frequent flooding occur due to Storm, heavy rainfall and runoff events. Due to climate change, the precipitation and temperature vary irregularly. In order to predict these climatic parameters, Regional Climatic Model (RCM) is used. Due to this climate change streamflow may vary and frequency of flooding occurrence increases. Frequent flooding is the most damaging and widely spread form of land degradation. Hence it is important to quantify the streamflow and identify areas that are vulnerable to flood. Flooding not only reduces the storage capacity of the hydraulic structures downstream but also deteriorates the crop productivity. So better understanding of runoff generation in this region is needed.

II. METHODOLGY

The literatures reviewed in this chapter are related to prediction of Climatic parameter such as Rainfall, Temperature and Evaporation using Thomas Fiering model and simulation of Streamflow using HEC-HMS model. The following methodology is proposed depending on the input data used and the basin characteristics and the schematic representation of the methodology is shown in Figure below.



2.1 RUNOFF ESTIMATION USING HEC-HMS

The HEC-HMS model requires inputs on weather, topography, soil, land use, Daily precipitation, maximum, minimum temperatures, solar radiation and humidity. DEM is used as the input to delineate sub-watersheds based on the elevation in the pre-processor of HEC-HMS, viz., HEC-GeoHMS**.** Using DEM terrain data, HEC-GeoHMS produces HMS input files, a stream network, sub-basin boundaries and connectivity of various hydrologic elements in an ArcView GIS environment via a series of steps called terrain pre-processing and basin processing.The drainage pattern, initial stream network are also derived from it. The DEM used for the delineation of drainage line and basin boundary must have a resolution of 90mx90m. Problems often arise when the drainage area has a coarse resolution. These problems can be overcome by taking proper care in the terrain pre-processing stage to produce a fine resolution of the drainage area. The basin, sub-basin boundaries, drainage line and other parameters derived from HEC-GeoHMS serves as inputs for HEC-HMS. Routing is done using Muskingum method and runoff evaluation is done using SCS curve number method.

2.1.1 MODELLING OUTPUT USING HEC-HMS

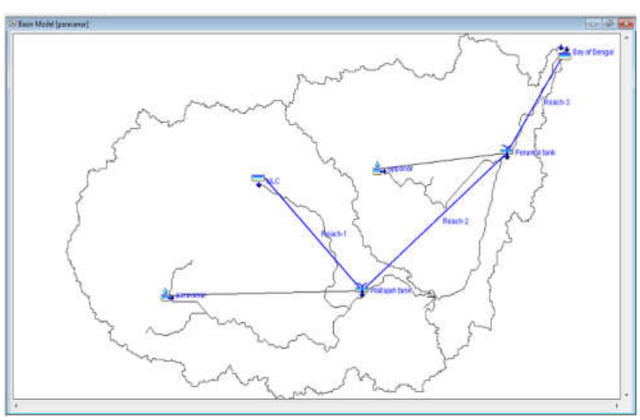


Fig 2. Basin model in HEC-HMS

2.1.2 CALIBIRATION AND VALIDATION RUN

Calibration of the model with appropriate data is a crucial step in the creation of a reliable basin representation. Parameter is defined as the variable, whose value is adjusted to make the model specific to a given situation. Calibration is the process of adjusting these variables. Parameters such as CN lag time, Muskingum k & x and base flow may need modification to produce a best fit between model and observations. Discharge output from a rainfall–runoff model is calibrated with observed Streamflow. Validation is the process of determining the degree to which a model or simulation is an accurate representation of the real world from the perspective of the intended uses of the model or simulation. Validation should always be focused on the intended use. If a simulation is valid, then it can be used to make decisions about the system and similar systems. The calibration graph for Paravanar sub basin and Uppanar Sub basin shows there is significant matching between observed and estimated peak discharge r^2 values are 0.831 and 0.779. The calibration and validation graphs, along with their efficiency coefficients for two sub basins are shown in Figure3and 4.

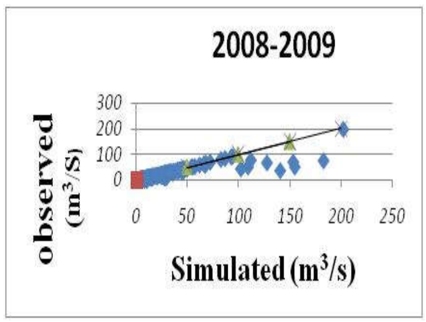


Fig3. Comparison between estimated and observed discharge– calibration

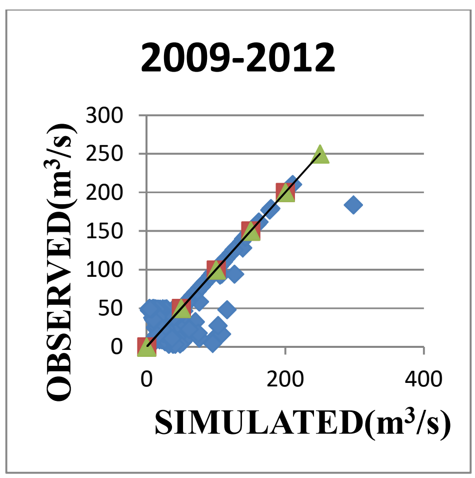


Fig4. Comparison between estimated and observed discharge –validation

2.2 THOMAS-FIERING MODEL

Thomas Fiering's method is widely used for the generation of synthetic Streamflow. It is a Markov Chain model which describes that there is a definite dependence between the flow of present time step and that of previous time step. For applying Thomas Firings method input data is generally transformed by using different methods like log transformation, power transformation to have the input data in a normal distribution. In this study log transformation method is adopted to transfer the historical data. The recursive equation of Thomas Fiering model used for the study is give below:

$Q_{t+1} = Q_{av\ t+1} + b_t (Q_t - Q_{av\ t}) + S_{t+1} \times I_{t+1} (1-r_t^2)^{1/2}$.... (1)

Q_{t+1} and Q_t are synthetic mean monthly flows for month's t+1 and t.

$Q_{av\ t+1}$ and $Q_{av\ t}$ are average monthly flows for month's t+1 and t.

b_t is the observed regression coefficient of q_t on q_{t+1}.

S_{t+1} are the observed standard deviation for the month t+1.

I_{t+1} are the value of random deviate at t+1(I_{t+1} have zero mean and unit variance).

r_t is the observed correlation coefficient between q_t and q_{t+1}.

This model is used for generation of climatic data such as maximum temperature, minimum temperature, precipitation, wind velocity and relative humidity.

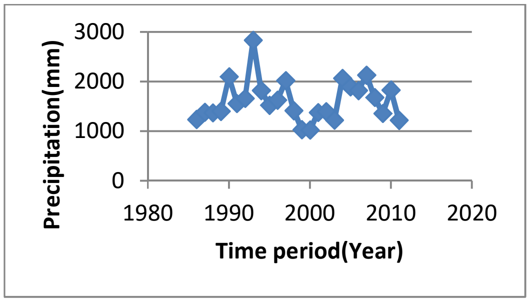
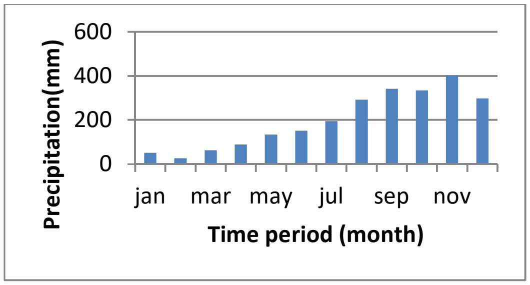


Fig5. Comparison between Precipitation and Time period



2.3 WATER DEMAND ESTIMATON USING CROPWAT

CROPWAT model is used to calculate the irrigation water requirement for particular type of crop. In Paravanar basin paddy crop is mainly cultivated .In this model the climatic data such as precipitation, minimum and maximum air temperature, relative humidity and wind speed is used for calculation of evapotranspiration. By knowing the soil type and duration of crop cultivation irrigation water requirement for paddy is evaluated. From the demand and availability of water from HEC-HMS model crop yield is calculated. In this model Penman Monteith method is used for calculation of evapotranspiration.

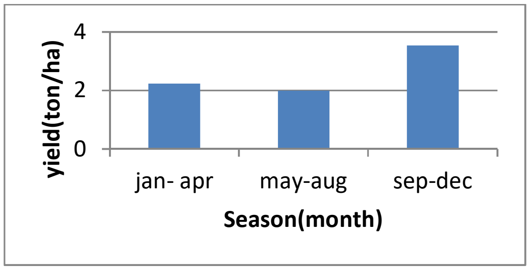


Fig6. Comparison between Paddy Yield and Season for 2020

III LANDUSE AND SOIL MAP

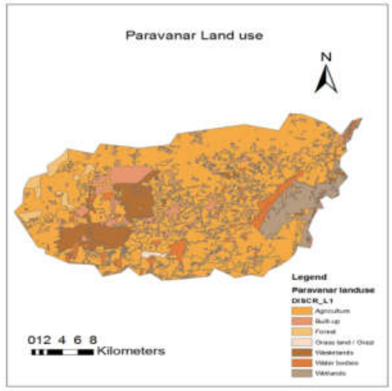
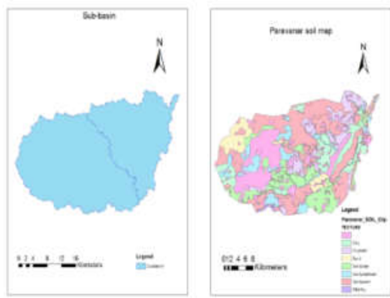


Figure 8. Paravanar Basin land use

Figure9.Paravanar basin and Soilmap



IV RESULTS AND DICUSSION

The process includes creation of new shape file in Arc Catalog tools and this was denoted as boundary. The boundary is created using Editor Tool and the corresponding DEM extracted which is input file for the process. Then, by using Terrain Pre-processing tool Fill sinks for the basin were obtained, the extracted DEM was used as input for fill sinks. And the Flow direction was obtained by using processed Fill sinks and Flow Accumulation which were processed using this. Stream Grid for the extracted basin was processed by giving Flow Accumulation as input and Streamlink was processed by stream grid as input. Catchment Grid processing were done by using Streamlink as input and Catchment Polygon processing done giving this grid as input. And add outlet point and generate the project. After, this basin characteristic and Hydrological parameters are given for particular catchment and HMS project was done by giving these data as input.

The outputs obtained from HEC-GeoHMS are presented in this chapter. The parameters for computing losses, direct runoff, base flow and runoff routing are estimated and given below. The development of model using the HEC-GeoHMS outputs and estimated parameters is discussed. The calibration and validation of the model are done using the observed discharge data.

V CONCLUSION

Based on the calibration and validation of model shows the following

i) From above result it is clear that HEC-HMS model is an useful tool for simulation of Streamflow in which matching between observed and simulated values doesn't differ too much. Simulated results will help to manage and utilize the runoff water for useful purpose and to protect, conserve and improve the basin for more efficient and sustained production.

ii) Over past decades indicates that there is an increase in climate parameters such as maximum and minimum temperature which leads to increase in evapotranspiration. Crop yield per hectare gets reduced due to scarcity of water and high evapotranspiration and ultimately leads to decline in production. Due to this crop cultivation during summer is not possible in Paravanar basin ayacut area which force them keep the land as fallow.

iii) From analysis over the climatic data, it shows that there is increase in temperature over last 5 years which leads decrease in crop yield.

VI SCOPE FOR FURTHER STUDIES

Global simulations of precipitation from climate models lack sufficient resolution and contain large biases that make them unsuitable for regional studies, such as forcing hydrologic simulations .Hydrologic models are an important tool in studying the effect of climate variability and change on water resources by simulating the Streamflow associated with climate scenarios.This may be due to the variations in precipitation, temperature and land use/land cover. This can be overcome by updating the model, so that it represents the real time conditions of the study area. A number of recent studies have attempted to link hydrologic models with climate scenarios. The rainfall-runoff relationship obtained can be used for the estimation of total runoff from the catchment.

REFERENCE

[1] *Ahmet Kurunc., Huseyin Simsek and Kadri Yurekli 'Prediction of daily maximum Streamflow based on Stochastic approaches'. Journal of spatial Hydrology, Vol 4, pp.1-12 (2004).*

[2] *Bouabid R and Chafai Elalaoui A 'Impact of Climate Change on Water Resources in Morocco: The case of Sebou Basin', Journal of Economics of Drought and Drought preparedness in Climate Change, pp. 57-62 (2010).*

[3] *Bruce M. McEnroe 'Continuous Simulation of streamflow in Johnson County, Kansas', Journal of Hydrology, pp. 1-42 (2010).*

[4] *Cheleng .A. Arselen 'Streamflow simulation and synthetic flow calculation by Modified Thomas-Fiering model. Journal of Hydrology', Vol 20, pp 1-10 (2011).*

[5] *Duane C.Boes, Jose D. Salas and Mohamed Chebaane 'Product Periodic autoregressive processes of modeling intermittent monthly streamflows'. Water resources research, Vol 31, pp.1513-1518 (1995).*

[6] *Isiguzo. E. Ahaneku., Otache. Y. Martins and Sadeeq .A.Mohammed 'Parametric linear stochastic modelling of Benue river flow process'. Open Journal of marine science , Vol 3, pp.73-81 (2011).*

[7] *Majidi .A, Shahedi .K 'Simulation of rainfall-runoff process using Green-Ampt method and HEC-HMS model'. International Journal of Hydraulic Engineering', Vol 1, pp. 5-9 (2012).*

[8] *Samuel Jonson Sultanto and Segel Ginting 'Use of proposed reservoirs to reduce flood in Semarang city'.Journal of Hydrology , Vol 1, pp.1-10 (2009).*

[9] *Sorman A.U. Yener., Sensoy A and Gezgin T 'Modeling studies with HEC-HMS and runoff Ssenarios in Yuvacik Basin, Turkey', Journal of River Basin Flood Management, pp. 622-634 (2006).*