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Estimation and Future Prediction of Evapotranspiration Using Hydrological Model (SWAT)

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Abstract*: Water being most essential need for maintainability of the life on earth because of heightening in the population, the conveyance and sharing of water assets have becoming problematical issue. With the escalation of water request because of industrialization, agricultural practices and local need. It is critical to deal with the water assets in an ideal way. With this perspective, hydrological models demonstrate crucial part which would perform as a critical tool for the evaluation of water at the watershed scale. In the present study, the Soil and Water Assessment tool (SWAT) have been adopted in evaluating the hydrological change on Malaprabha Sub-Basin. The model has been setup and calibration is done from the year 1988-1998 and validation is done from the year 1999-2002. SWAT-CUP (SUFI-2) which is a semi-automatic program has been utilized in calibration and validation process. This investigation gives idea of degree of change in Evapo-transpiration that might be observed in the forthcoming period in study area and this information can be utilized in water structure design, watershed administration, and crop pattern adaptability.

***Keywords*: Climate Change, Hydrological model, Runoff, SWAT model, SWAT-CUP, Malaprabha Sub-Basin.**

I. INTRODUCTION

Water has noteworthy influence in forming the ecosystem and is a prime prerequisite for the maintainability of the human on the earth. Water is an exceptionally essential and its management has become the crucial challenge facing today (Nagraj et al. 2016). As Global warming created by human activities has built up an expanding stress all around the world and fore mostly affects overall mean temperature and ocean level (Chen et al., 2014) Kusangaya et al., (2014). Along these lines, it is exceptionally critical to look at the impact of climate variations on hydrology, fundamentally on a basin scale (Thompson et al., 2013, Zhang et al. 2014). The effect of climate change is extremely experienced in the Asia-Pacific region which is the greatest disaster exposed region on earth. It is termed that sea level upsurge is an extreme worry, with 8 of the 10 countries with the highest population habiting in low-lying coastal sectors (Loo et al., 2014). Several countries in Asia are now experiencing more frequent floods and droughts in recent decades as an effect of climate change and human exploitation (Hansson et al. 2008).The evapotranspiration (ET) plays a vital role in the procedure of water cycle, it is examined to be the main determinant variable in water cycle (Z. X. Xu et al., 2003).The main factors that affects ET are solar radiation, percentage of soil cover, wind, humidity and temperature. Aim of the examination is to assess the effect of change in Evapo-transpiration in the forthcoming years.

II. STUDY AREA AND DESCRIPTION

Malaprabha Sub basin (Fig 1) emerges at the Western Ghats of Belagavi District, Karnataka at an attitude of 792.4m at Kanakumbi town which of 16 kms far from the Jamboti town, Khanpur taluk, Belagavi region of Karnataka and the Sub basin altogether lies in Karnataka. It is a tributary of the Krishna Basin and records 5% of Krishna Basin. Study Region lies between 15° 45' N and 16°25' N and 74°00'E and 75°55' E and rainfall varies from 2000mm to 500mm in the region (Reshmidevi etc. 2012). Malaprabha Sub basin has total of 11,549km2 catchment territory and situated in semi-dry area in India. Precipitation of this range is seasonal (Monsoon) resulting reservoir need for the supply to meet the agricultural and drinking requests of the zone Malaprabha Sub basin.

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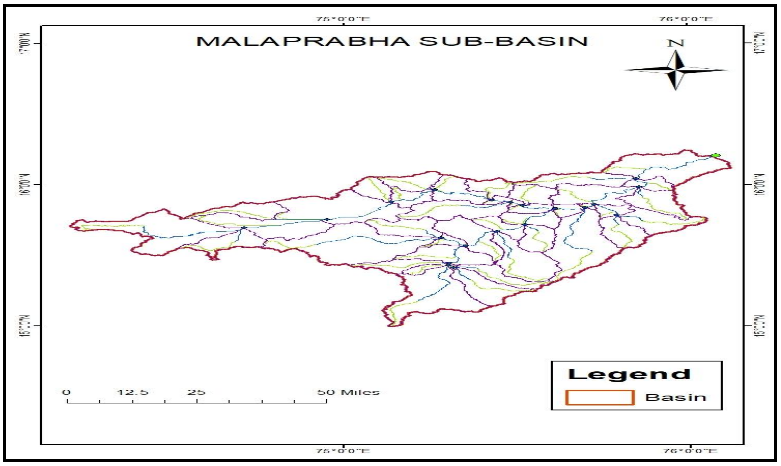

Fig. 1: Map of Malaprabha Sub basin

III.METHODOLOGY

Hydrological models can be marked as abbreviated numerical demos of hydrological structure mostly waterway or a part of it. These models are leading attire for hydrologist appropriate for different purposes for instance, water assessment, and watershed administration and so on. Hydrological models have been sorted distinctively indicating the models positively justifiable and can be worked easily. SWAT is a semi-distributed watershed model programed by the Agricultural Research Service of the United States Department of Agriculture (USDA) has been employed for the analysis. SWAT requires a significant measure of data and parameters for execution and calibration. The foremost utilization of SWAT is the identification of runoff (Williams and Arnold 1993; Arnold et al. 1998). Due to very documentation, it is simple in comprehension and application. Normally SWAT keeps running by picking a solitary watershed, and the confining it into different Sub basins. These Sub basins are then broken into unique land use, soil and slope combinations which are known as Hydrological Response unit (HRUs). Fig 2 demonstrates the work stream of the SWAT model.

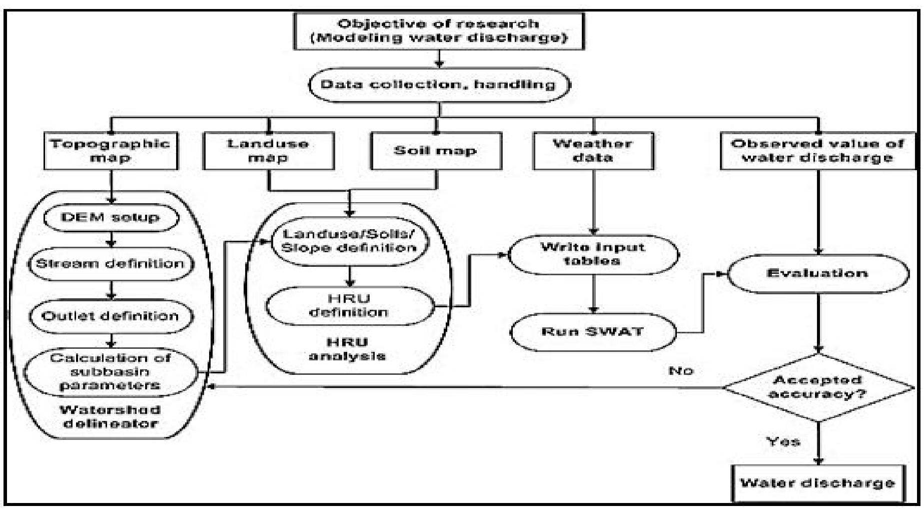

Fig. 2: Flowchart of the methodology for SWAT (Source: Loi, 2012).

A. Data Required

For the setup of the model various data are required namely DEM (Fig.3), LULC (Fig.4), soil data, Weather data (temperature and rainfall) and RCM data (Fig 5).

B. Weather data

The World Climate Research Program (WCRP) created Coordinated Regional Climate Downscaling Experiment (CORDEX) for the locations of south Asia is conveyed to improve anticipates concerning climate change impacts at regional scale. The dataset involves progressively downscaled projections of 10 scenarios and models for which everyday scenario were framed and spread under

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CMIP5.The CORDEX informational index contains downscaled climate scenario which are been gotten from the Atmosphere-Ocean coupled General Circulation Model (AOGCM).Future projection information are been taken from the IITM site from the year 2041 to 2060. AOGCM Regional Climate Model Grid has been laid over the study area. The precipitation and temperature data have been extracted from datasets using ArcMap 10.1. Fig 5 shows the RCM grid, the grid points inside the Sub-basin are opted for the extraction purpose.

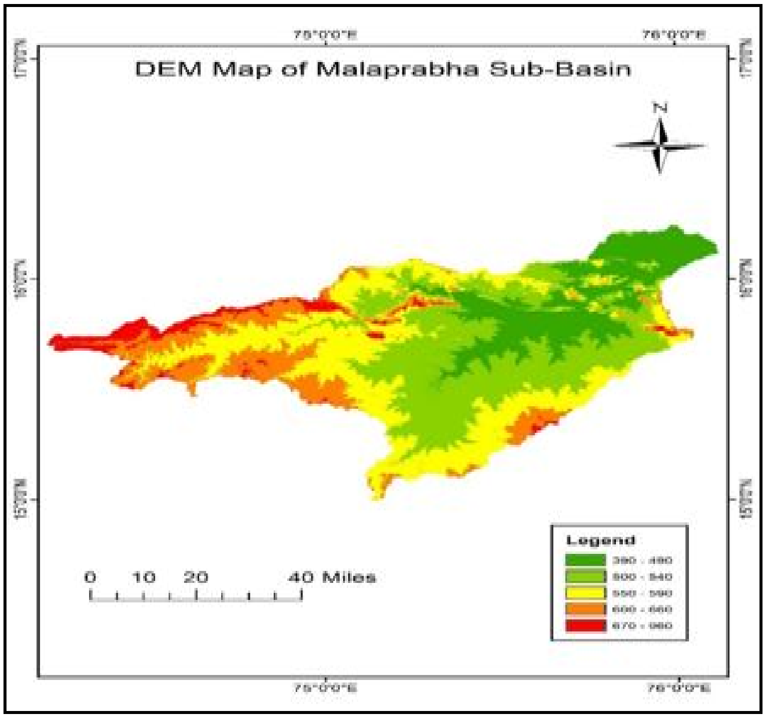

Fig. 3: DEM map of Malaprabha sub basin

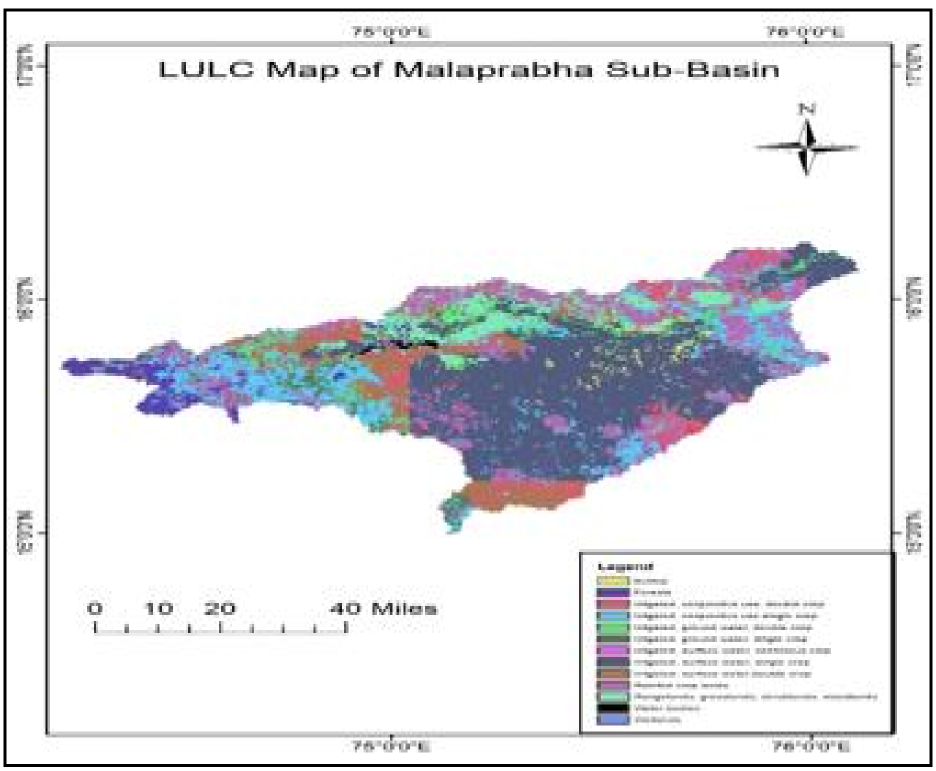

Fig. 4: LULC map of Malaprabha sub basin

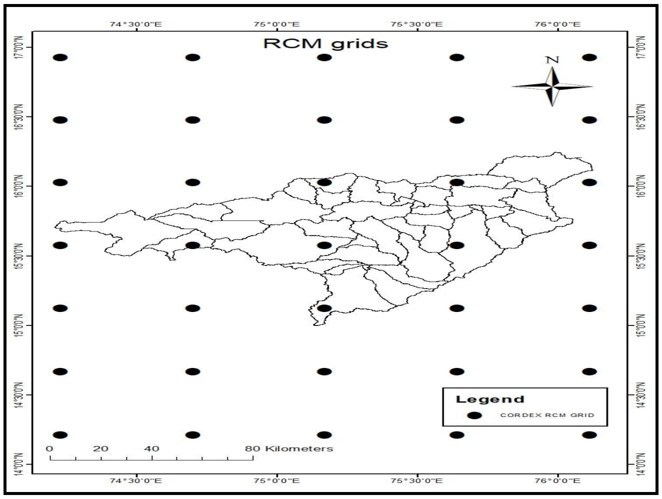

Fig. 5: RCM Grids for the Study Area

IV. RESULTS AND DISCUSSIONS

A. SWAT Calibration and Validation

At the first instance monthly discharge output from the model (Simulated) have been compared with the monthly observed discharge of study area and found to be not satisfactory. Consequently the calibration is required. The difference among the simulation and observed discharge can be seen in the fig 6.According to model evaluation guidelines the desirable limits of R^2 (>0.6 &<1.0) & NSE (>0.5 &<1.0) (Moriasi etc, 2007). Before calibration relationship coefficient (R^2) and Nash Sutcliffe Coefficient (NSE) esteem are observed to be 0.53 and 0.73 separately. As R^2 value doesn't fit into desirable limit hence calibration and validation is carried out.

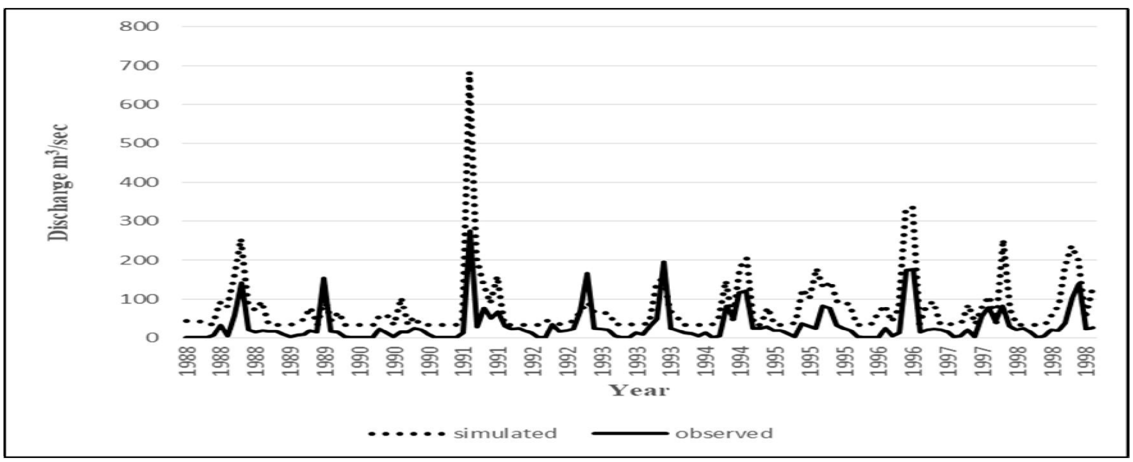

Fig. 6: Comparison of simulated and observed discharge before calibration

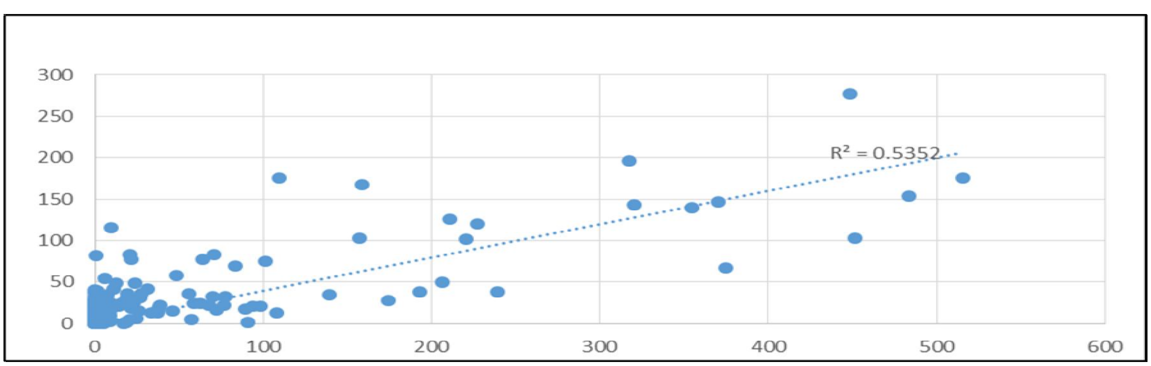

Fig. 7: Scattered graph of simulated and observed discharge before calibration

B. Calibration

For the Calibration and Validation motive SWAT-CUP (SUFI-2) has been utilized. Calibration is an art of matching up simulated and observed discharge data, calibration has been done from the year 1988 to 1998(11 years). At first 4 essential parameters are preloaded in the SWAT-CUP. In light of writing and understandings of literatures, parameters are included. The Parameters utilized for the calibration and its extents are given in the table 1. With the parameters included, programming is kept running for different number of iteration with 300 simulations for every iteration. The parameter values will be fitted and further these parameter ranges are imported for the next iteration until the desired limits of R2 and NSE is obtained. Fig 8 and Fig 9 gives the variation of simulated and observed discharge before and after calibration. The desirable values of R^2 and NSE are achieved and model is initiate to be satisfactory. During calibration period the R^2 values is found to be 0.67 and NSE values is found to be 0.86.

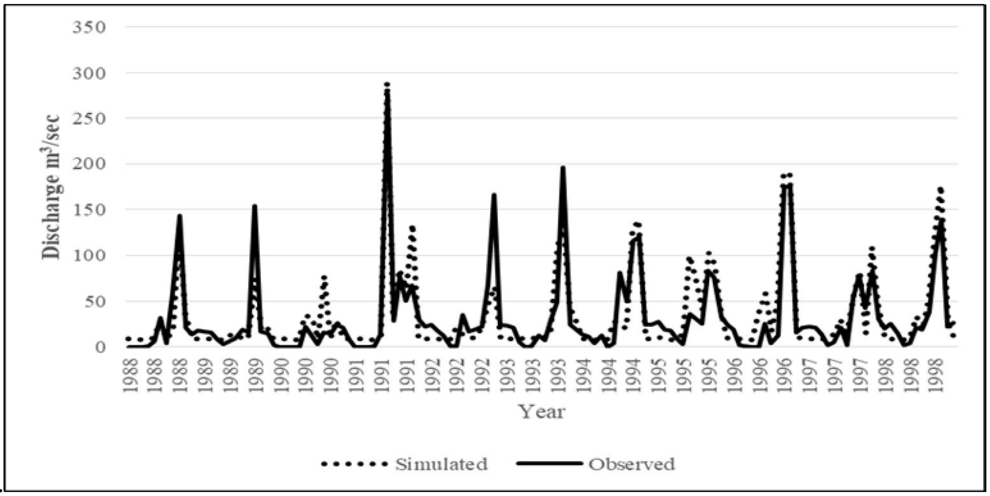

Fig. 8: Comparison of simulated and observed discharge after calibration

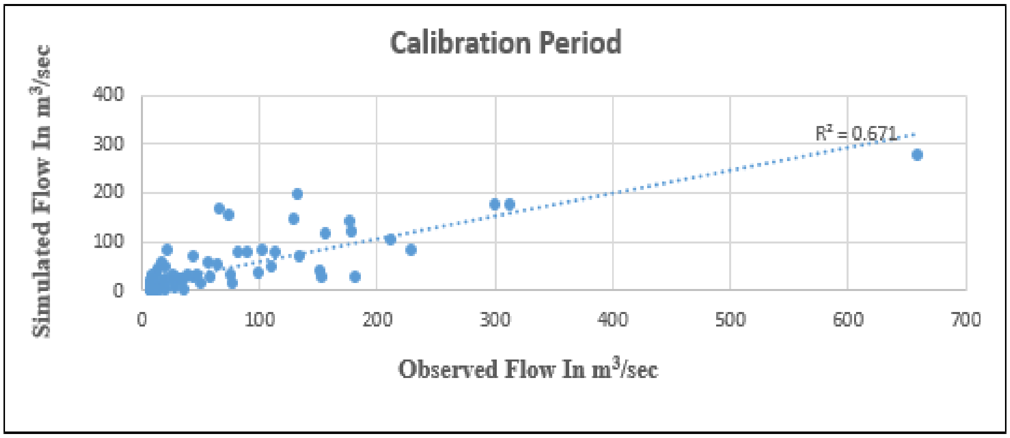

Fig. 9: Scattered graph of simulated and observed discharge after calibration

Table 1: Parameters and their ranges used during calibration

Sl.No	Parameter	Fitted value	Min value	Max value
1	R_CN2.mgt	-0.25	-0.32	0.08
2	V_ALPHA-BF.gw	1.0	0.80	1.27
3	V_GW_DELAY.gw	28.01	12.63	33.70
4	V_GWQMN.gw	1759	1300	3000
5	R_CH_K2.rte	3.79	2.60	3.80
6	R_CH_N2.rte	0.0021	-0.00	0.0062
7	R_EPCO.bsn	0.94	0.87	1.12

8	R_ESCO.bsn	0.25	0.12	0.32
9	R_GW_REVAP.gw	1.12	0.86	1.24
10	R_RCHRG_DP.gw	0.13	0.07	0.38
11	R_REVAPMN.gw	43	40	100
12	R_SOL_AWC.sol	-0.34	-0.55	-0.14
13	R_SOL_K.sol	0.25	0.15	0.35
14	R_SURLAG.bsn	6.39	5.41	7.68

C. Validation

Validation is the method of checking whether the calibration has been fitted appropriately for the following arrangement of years. SWAT-CUP does not have other system for the calibration reason, it is done by contributing a similar arrangement of parameters and their ranges which are utilized during the Calibration. The estimations of R^2 and NSE are observed to be 0.70 and 0.93 respectively and as the values fit into the desirable limit the model is satisfactory and the further analysis has be carried out.

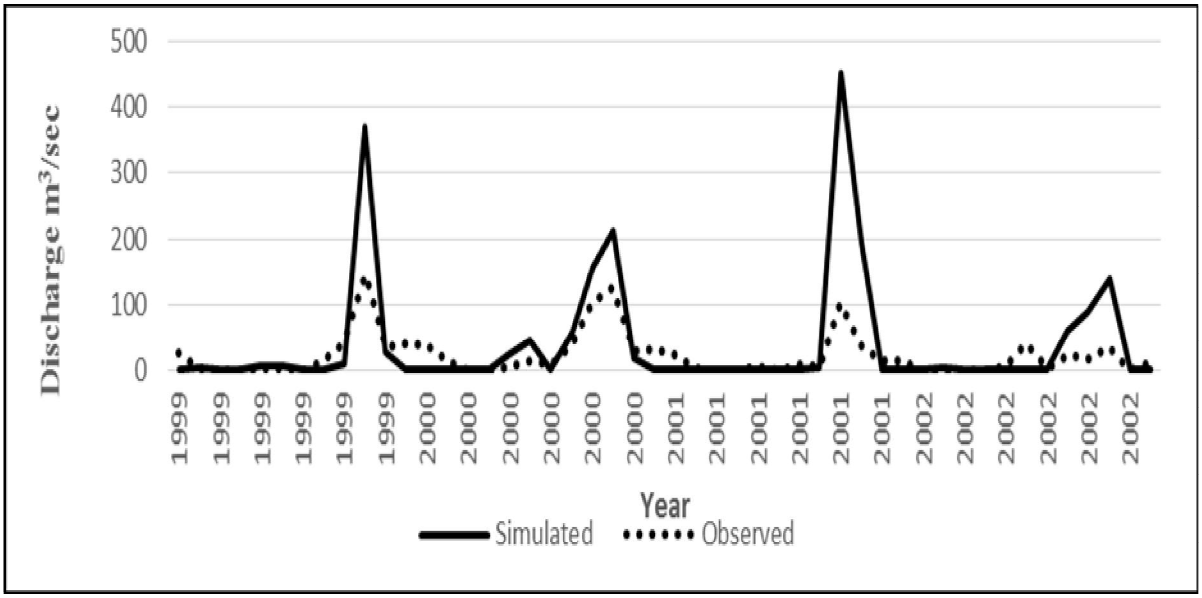

Fig 10: Comparison of simulated and observed discharge before validation

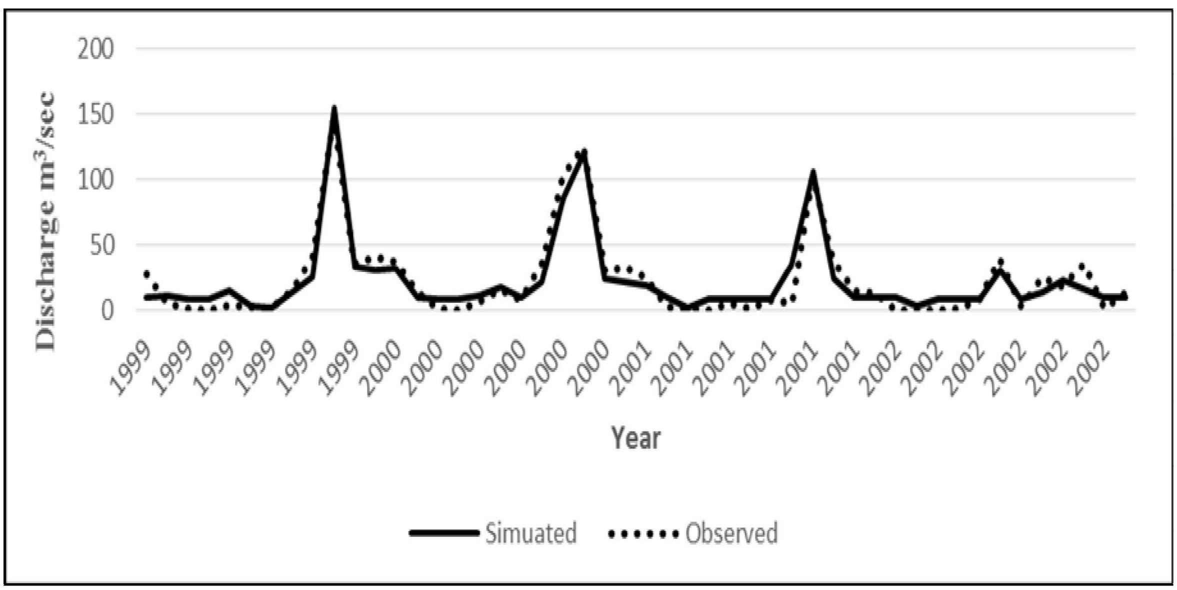

Fig 11: Comparison of simulated and observed discharge after Validation

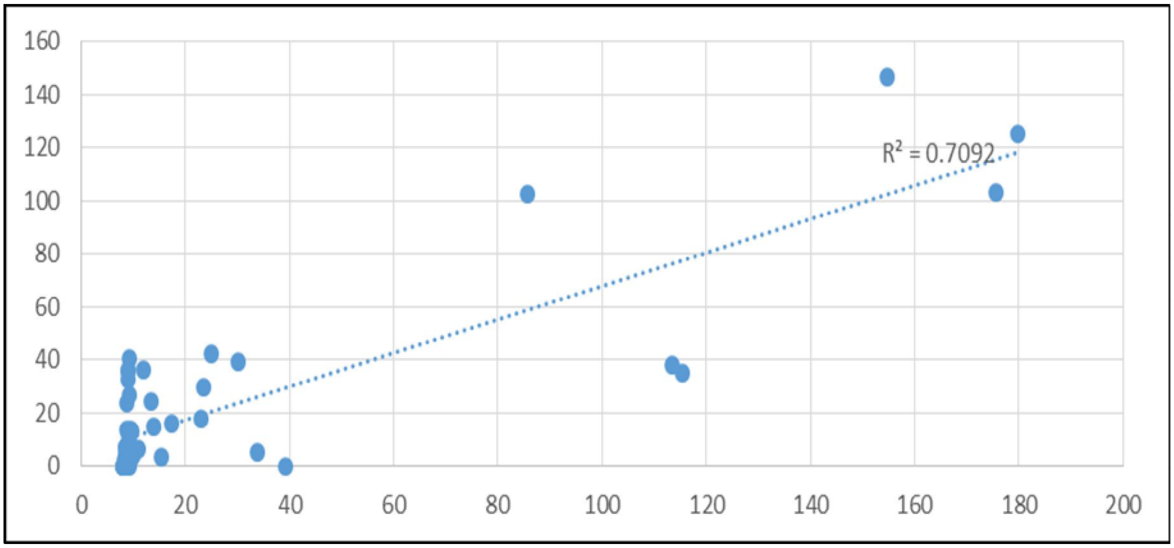

Fig 12: Scattered graph of simulated and observed discharge after validation

The model was executed from the year 1985 to 2005.From the year 1988 to 2002 (15 years) results are considered as baseline scenario for the assessment of future Evapotranspiration. For the future forecast as described before AOGCM Regional Climate Model data been extracted from the year 2041 to 2060 (20 years) as the each dataset are of 10 years. For the analysis of change in Evapo-transpiration, future predicted data from year 2046 to 2060(15 years) have been employed as future scenario.

D. Evapotranspiration (ET)

Transpiration is the water vaporized from the plants and evaporation is the process of vaporization of water from the earth surface. The combination or sum of transpiration and evaporation are stated as Evapotranspiration. Usually the evapotranspiration is considered as the losses but it plays a vital role in the water balance. Table 2 shows the comparison of the baseline and future scenario for Evapotranspiration, it is observed that Avg. change in ET compared to both scenario is about 4.49 mm. The highest ET in the Baseline scenario is observed in the year 1995 with 40.2265 mm and lowest in the year 2001 with 28.8877.In the future scenario the highest ET is observed in the year 2048 with 51.1602mm and lowest in the year 2055 with 35.2003. When future scenario is compared with the baseline scenario almost in every year there is rise in ET but in the year 2052 and 2055 the baseline scenario ET is more with 0.7234 mm and 3.3302mm respectively. Fig 13 shows the variation in the ET among the baseline and future scenario.

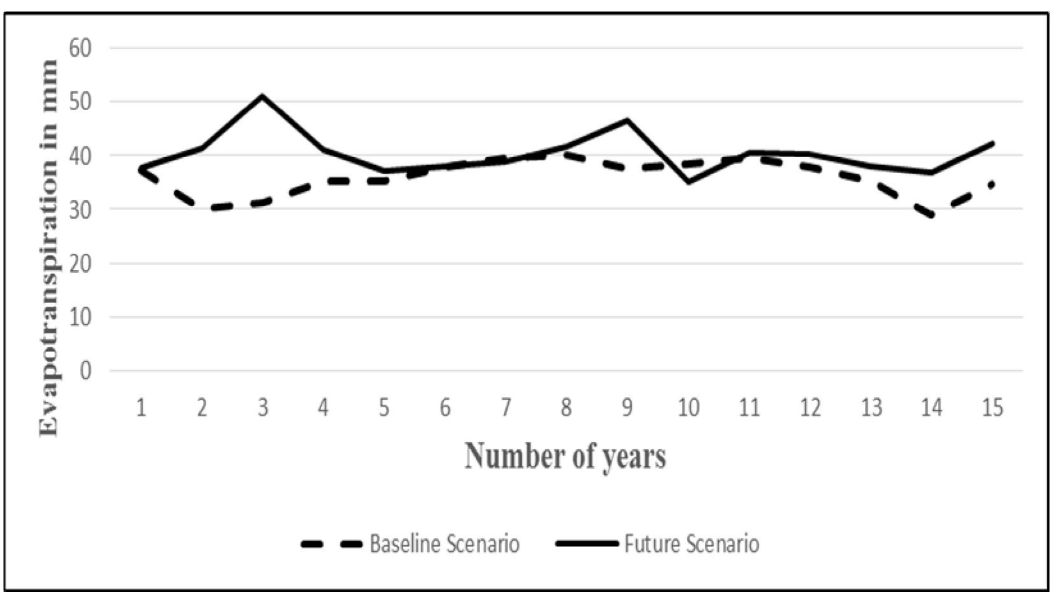

Fig 13: Comparison of baseline and future scenario of evapotranspiration

Table 2: Comparison of Baseline scenario and future scenario for Evapotranspiration

Baseline scenario		Future scenario		Change In mm
Year	Evapotranspiration (mm)	Year	Evapotranspiration (mm)	
1988	37.3206	2046	37.761	0.44
1989	30.1944	2047	41.5235	11.329
1990	31.406	2048	51.1602	19.7542
1991	35.3970	2049	41.2294	5.8323
1992	35.1999	2050	37.2002	2.0003
1993	37.8245	2051	37.8905	0.0659
1994	39.6388	2052	38.9154	-0.7234
1995	40.2265	2053	41.7905	1.5639
1996	37.4515	2054	46.5225	9.071
1997	38.5305	2055	35.2003	-3.3302
1998	39.692	2056	40.6185	0.9265
1999	37.9782	2057	40.4074	2.4291
2000	35.3588	2058	37.9226	2.5638
2001	28.8877	2059	36.7787	7.891
2002	34.6132	2060	42.1995	7.58633
Avg	35.9813	Avg	40.47471111	4.4933

V. CONCLUSION

Global warming and climate change is a basic issue everywhere throughout the world as it involve a negative effect on the environment and human life. This examination was directed to comprehend the change that may occur on Evapotranspiration (ET) in the future years at Malaprabha Sub-Basin. The model was setup for the year 1985 to 2005 and output from the year 1988 to 2002 have utilised for the analysis and is considered as Baseline Scenario. CORDEX Dataset have been adopted for the future forecast data from the 2046 to 2060 as Future scenario. The results found from the Model states that there an average increase of 4.49 mm of ET for the future period of time. The highest ET in the Baseline scenario is observed in the year 1995 with 40.2265mm and lowest in the year 2001 with 28.88 .In the future scenario the highest ET is observed in the year 2048 with 51.16mm and lowest in the year 2055 with 35.20.As the increase in ET is predicted but rise in ET fits in an acceptable limit even though an appropriate measures should be taken to avoid the ET in the future years. The analysis done can be utilized in the designing and construction of the water structures in the Sub-basin, watershed management programs, adoption of alternate crop patterns.

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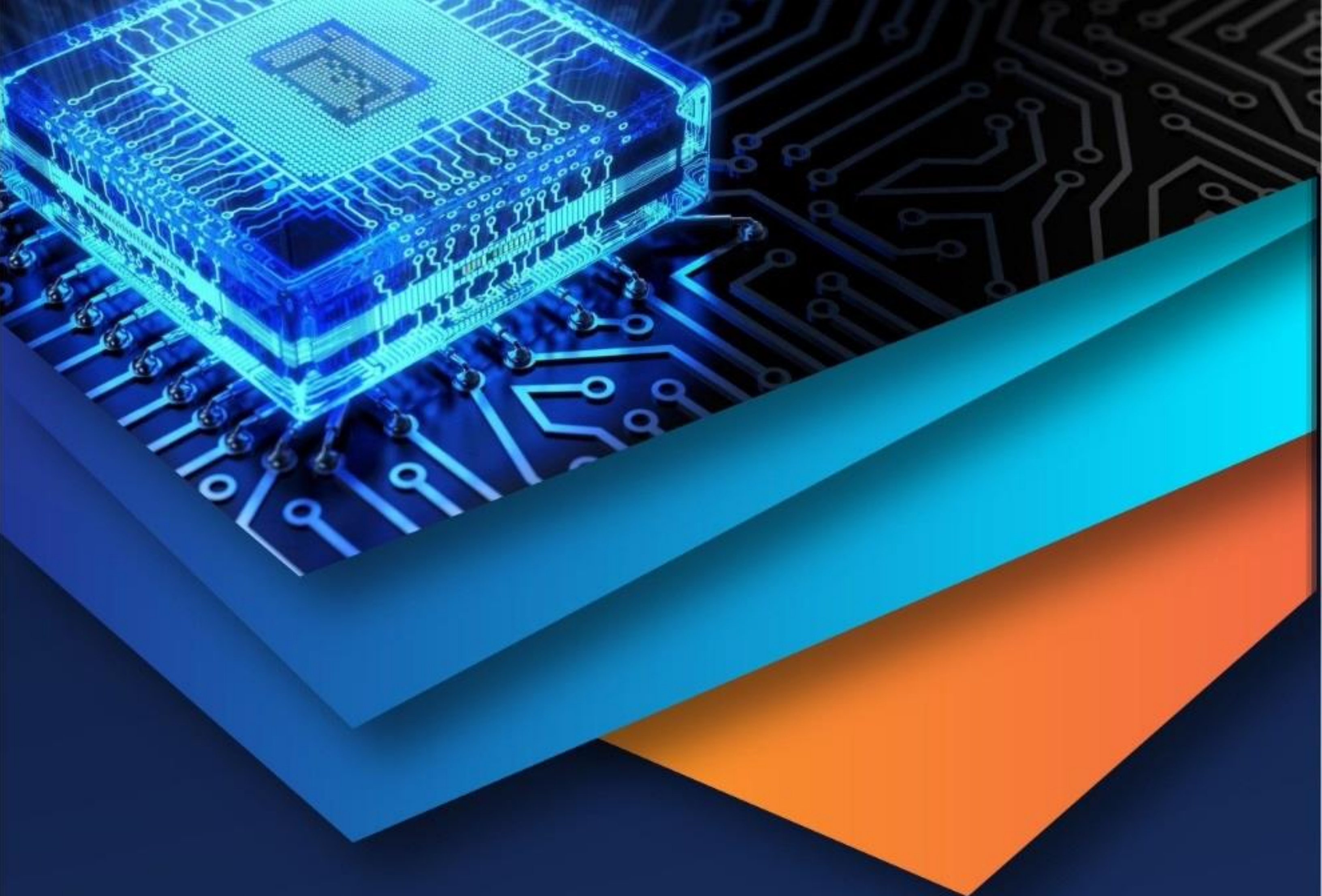

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