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Study of Evapotranspiration in Context of Changing Climate

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Abstract: *It seems imperative to study evapotranspiration (ET) more broadly as a need of hour because in context of climate change as the average temperature is rising; certainly the evaporative demand is shooting up. The present study provides idea about likely change in evapotranspiration due to change in climatic parameters in context of changing climate. As different methods of estimating ET responses differently in specific meteorological parameters on ET demand. The change in temperature causes change in other parameters such as humidity, wind speed, and vapour pressure which ultimately changes ET. In the present study ten years (2002-2011) weather data taken from Ozone unit, Indian Meteorological Department, Banaras Hindu University (BHU), Varanasi, has been analysed for the change in temperature, wind speed and net radiation. It is found that an increase in 14.87% of total ETo demand with increase in temperature by 20 % for FAO 56 PM model, which is followed by net radiation (13.6%) and wind speed (4.16%) in comparison with temperature. While among the other ten temperature and radiation based methods taken up for same study Hargreaves & Samani temperature based method shows the highest change (21.87%) to temperature & solar radiation (Rs) based Irmak model evaluates least change (5.5%) for 20 % increase in temperature. Moreover, the details of the various combinations of changes in different parameters have been analysed. Further, it is found that approximately1oc increase in temperature could increase ETo by 30 m.m per year. It means it would require a huge amount of extra water to cater the need of several thousands of hectares of crops per year.*

Keywords: *FAO 56 PM, Evapotranspiration, climatic parameters, temperature, net radiation, wind speed.*

I. Introduction

In today's world, the water is becoming more & more scare, not only affecting the per capita water demand, also the water for the agricultural and other purposes are approaching to the stress level. So, it is the utmost important to know each and every controlling factor of water losses qualitatively as well as quantitatively. In this regard, in the water cycle, the least understood and most complicated phenomenon, evapotranspiration (ET) needs to be understood. Also, the factors which controls the ET and how much or till what extent they affect the phenomenon of ET. Therefore, it seems imperative to study ET more broadly as a need of hour because in context of climate change as the average temperature is rising; certainly the evaporative demand is shooting up.

The present study provides idea about likely change in evapotranspiration due to change in climatic parameters in context of changing climate. As different methods of estimating ET responses differently in specific meteorological parameters on ET demand. The change in temperature causes change in other parameters such as humidity, wind speed, and vapour pressure which ultimately changes ET. As, the FAO56 PM method is the standard sole method for the determination of ET, it is used as the main method to compare the results as well as the dependency of meteorological parameters.

II. Methodology

The relative sensitivity has been examined to compare the importance of different meteorological parameter. Also, we have climatic data (2002-2011); with all those data the sensitivity of ETo has been checked & evaluated. This analysis shows the relative importance of climactic parameters that affect the evapotranspiration. As FAO56 PM is currently used and is considered to be a standard method. First, FAO56 PM method is used to evaluate the importance of independent parameters such as temperature, wind speed, net radiation. Again, the different temperature and radiation-based models were taken into consideration towards checking & evaluating the sensitivity of meteorological parameters for every year.

All these analysis have been arranged in the tabular form. The average of the entire ten years analysis is presented in the form of graph to visualise it clearly.

III. Study Area & Data Collection

This study has been carried out in the Banaras Hindu university campus, Varanasi, Uttar Pradesh, India. The daily average data of last ten years (2002-2011) collected from the Ozone unit, Indian Meteorological Department, Banaras Hindu University Campus, Varanasi. Figure 1 shows the location of study area, situated at $25^{o}18'0"$ N latitude and 83^{o} $01'0"$E longitude at an altitude of 76.0 m above the mean sea level. The main river

system in the study area is Ganga River system. The study area comes under humid subtropical region with an average annual rainfall of 1,047.96 mm. The rainfall pattern in the region is very erratic as evidenced from the high amount of rainfall 963.71 mm during rainy season June to October. While the weekly average data collected from department of agronomy, Institute of Agricultural Sciences, BHU observatory for the period of five years (2007-2011). The mean maximum temperature 32.8^{o}C, mean minimum temperature 26.3^{o}C, mean maximum relative humidity 87%, mean minimum relative humidity 64%, average daily actual sunshine duration 7.02 hr, average net radiation 13.3 MJ m^{-2} day^{-1}, and average wind velocity 0.68 m s^{-1}.

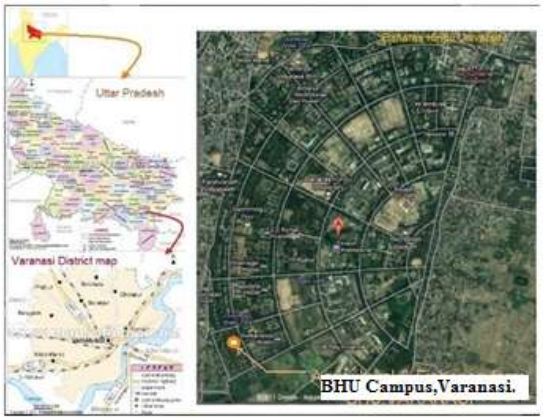

Figure: 1 Location of study area

IV. Results

Ten years daily average meteorological data has been used to evaluate the interdependency of the climatic parameters to ETo. These data has been shown in the table form (see Appendix A).

The change in different parameters such as temperature, wind speed, net radiation changes different equation in different manners. Sometimes a direct linear relationship can be obtained, but most of the time it varies with certain variation in percentage change. The average of all the ten year (2002-2011) values of percent change has been plotted in the form of graph as below. The figure 2 clearly depicts that due to the change in temperature all the eleven data series shows change in ETo. Series II shows maximum change in ETo due to change in temperature, which is approximately 11.02% for change in 10% in temperature while series IV shows minimum sensitivity to temperature which is 2.75% change in ETo due to 10% change in temperature.

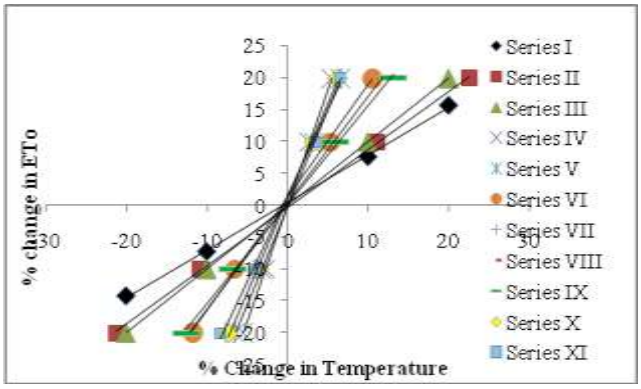

Figure2. Percent change in ETO due to percent change in temperature

Where, I = FAO 56 PM equation, II = Hargreaves & Samani equation, III = Schendle equation, IV = Solar Radiation based (Rs) Irmak, V = Solar Radiation based (Rn) Irmak, VI = Mass transfer based Romanenko equation, VII = FAO 24 Radiation method, VIII = Hargreaves Radiation method, IX = Priestley -Taylor Radiation method, X = Makkink model, XI = Turc method.

The figure 3 clearly depicts that due to the change in wind speed only series I, FAO 56 PM method which shows 2.11% change in ETo for 10 percent change in wind speed and series VII, FAO 24 Radiation method, which shows only 0.50% change in ETo for 10% change in wind speed.

The figure 4 clearly depicts that due to the change in wind speed only series I, FAO56 PM, which shows 6.81% change in ETo values dur to 10% change in net radiation and series IX, Makkink model show linear changes in ETo i.e 10 % change in ETo due to 10% change in net radiation.

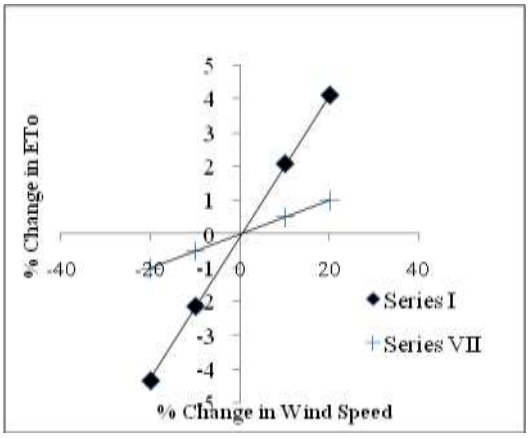

Figure3. Percent change in ETo due to percent change in wind speed

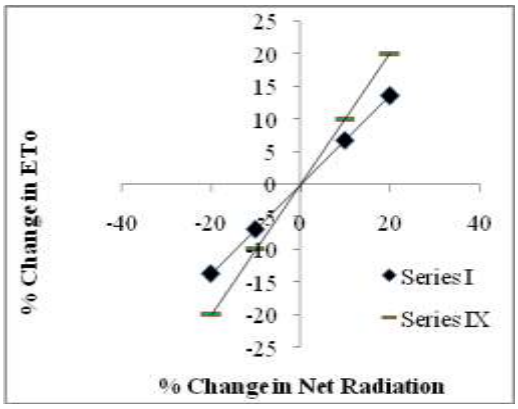

Figure4. Percent change in ETO due to percent change in net radiation

V. Conclusion & Suggestions

The study has revealed a widely varying performance of different equations and, acknowledging that PM and all other methods require local calibration, has reached the following conclusions:

I. On examining the relative sensitivity of ETo to different input variables, it is found that an increase of 14.87 % of total ETo demand with increase in temperature by 20% for the FAO 56 PM model. ETo is less sensitive (13.60 %) to increase in net solar radiation, followed by wind speed (4.16%) in comparison to temperature.

II. While among other ten models, Hargreaves & Samani temperature model showed the highest sensitivity (21.87%) to temperature, & solar radiation (R_s) based Irmak model evaluates least sensitivity (5.50%) for 20% increase in temperature values.

III. While only FAO 24 radiation model show sensitivity of ETo towards wind speed (4.23%) and Priestely Taylor radiation method show sensitivity of ETo towards the net radiation (R_n) by 20.00% for 20 % increase in the wind speed and net radiation values.

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