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Predicting Pan Evaporation from Meteorological Parameters at *Tarai* region of Uttarakhand (India)

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Abstract- In this study, impact of different meteorological parameters and their inter-relationship with observed values of pan evaporation at Udham Singh Nagar district situated in the *Tarai* region of Uttarakhand were analyzed on the basis of 22 years (1991-2012) of daily meteorological data recorded at G.B. Pant University of Agriculture & Technology, Pantnagar. For conducting the analysis, daily observed values of different meteorological parameters like maximum air temperature (Tmax), minimum air temperature (Tmin), maximum relative humidity (RHmax), minimum relative humidity (RHmin), rainfall amount (RA), sunshine duration (SH), and wind velocity (WV) were considered as independent variables, whereas, pan evaporation (Epan) was taken as dependent variable. Daily values of observed meteorological parameters and Epan were grouped together to get their respective values for all 52 SMWs and 12 months in accordance with CWS-1 format suggested by IMD, Pune with aim to identify climatic variables which can predict Epan fairly accurately on both weekly and monthly basis and it was found that best performance indicators for predicting Epan both on weekly and monthly basis are maximum relative humidity followed by wind velocity, maximum air temperature and sunshine hours. It was also found that Epan values on both weekly and monthly basis can be predicted fairly accurately at *Tarai* region of Uttarakhand.

Index Terms- Pan evaporation prediction; meteorological parameters.

1. INTRODUCTION

Knowledge about variation and magnitude of evaporative losses is needed in assessment of irrigation efficiency of existing projects, crop yield forecasting model, ecosystem modeling, irrigation management, planning and management of water resources, preparation of river forecasts, quantification of deep percolation losses under existing water management practices, reservoir design, river flow forecasting, water balance computation, water supply requirements of proposed irrigation projects etc. Irrigation can substantially increase crop yields, but its scheduling is based on evaporation estimates. Knowledge of evaporation from soil is also essential for analyzing water balances at the land surface that is important to calculate drainage requirements for preventing water logging and removing enough water from the root zone to enhance crop production [3].

The term, "Evaporation" is simply defined as the process of transfer of water vapour from liquid or solid state into the gaseous state through the transfer of heat energy and from water surface due to concentration gradient of water vapour in the water surfaces and air stream. Being evapotranspiration is difficult to measure directly, atmospheric evaporative demand is often estimated by observing evaporation rate in "Evaporimeters" or "open pans". Among many types of available evaporation pans and tanks, U.S. Weather Bureau Class "A" pan evaporimeter is most widely used throughout the world which is a circular pan made of galvanized iron, 21 cm in diameter and 25.5 cm deep, mounted on an open wooden platform 15 cm above the soil surface [1, 2] is the standard instrument used for such observations in India. The pan evaporation data is very useful in estimating evapotranspiration (from agricultural crops) and losses (from reservoirs and lakes) as it combines accumulated effect of all meteorological parameters and, thereby, it can be used as a climate index for a particular region.

2. MATERIALS AND METHODS

The meteorological data on daily basis for air temperature (maximum and minimum), relative humidity (maximum and minimum), wind velocity, sunshine duration, pan evaporation and rainfall were acquired for a period of twenty-two years (1991-2012) from meteorological observatory stationed at Crop Research Centre of G.B. Pant University of Agriculture & Technology, Pantnagar situated in *Tarai* region of Uttarakhand. The study area is lies in *Tarai* belt of the Himalayas and has a sub-humid subtropical climate with three distinct seasons. It has summer (March to June), a very wet rainy season (July to October), and a cold winter (November to

February). The annual total rainfall in the study area is about 1400 mm and eighty percent of this occurs during period from June to September. July and August are wettest months while November and April are driest months of the year.

The daily observed values of all observed meteorological parameters were converted to form SMWs and months by following CWS-1 format suggested by Indian Meteorological Department, Pune and by considering Epan values as dependent variable and other meteorological parameters (individually and collectively) as independent variables, inter-relationship between them on weekly and monthly basis were deduced by doing simple linear regression and multiple regression analysis.

3. RESULTS AND DISCUSSIONS

From regression models developed for predicting pan evaporation values and correlation coefficients for average weekly and monthly values (Table 1), it is evident that weekly and monthly values of Epan can be fairly accurately predicted with maximum relative humidity followed by wind velocity and maximum air temperature as they are very highly correlated with observed Epan values which signifies that these meteorological parameters plays very important role in predicting Epan values, whereas, meteorological parameters namely, maximum air temperature, sunshine duration and wind velocity are found highly correlated for predicting Epan values. It is also clear from analysis that with an increase of one unit of maximum air temperature, minimum air temperature, rainfall amount, sunshine duration and wind velocity on weekly basis, Epan values will get increased by 0.4230 mm/day, 0.2427 mm/day, 0.1439 mm/day, 0.9910 mm/day and 5.1890 mm/day respectively, whereas, on monthly basis, there will be an increment of 0.4301 mm/day, 0.2449 mm/day, 0.0547 mm/day, 1.0843 mm/day and 5.2683 mm/day respectively with increment of above-mentioned parameters by one unit.

Table 1. Regression models for predicting pan evaporation

Regression model(s)	r
Weekly basis	
Epan = - 7.8845 + 0.4230Tmax	0.8790
Epan = 0.5855 + 0.2427Tmin	0.6481
Epan = 26.5967 - 0.2589RHmax	0.9411
Epan = 9.0612 - 0.0861RHmin	0.4632
Epan = 4.4984 + 0.0439RA	0.0941
Epan = - 2.4698 + 0.9910SH	0.8775
Epan = - 1.8159 + 5.1890WV	0.8976
Epan = 16.7512 - 0.1588Tmax + 0.2501Tmin - 0.1237RHmax - 0.0651RHmin + 0.00029RA + 0.0075SH + 1.6975WV	0.9973
Monthly basis	
Epan = - 8.0913 + 0.4301Tmax	0.8839
Epan = 0.5519 + 0.2449Tmin	0.6585
Epan = 27.2632 - 0.2669RHmax	0.9485
Epan = 9.0453 - 0.0856RHmin	0.4473
Epan = 4.4549 + 0.0547RA	0.1126
Epan = - 3.1419 + 1.0843SH	0.8835
Epan = - 1.9416 + 5.2683WV	0.9129
Epan = 19.9688 - 0.2316Tmax + 0.3138Tmin - 0.1284RHmax - 0.0864RHmin + 0.0009RA - 0.0590SH + 1.5594WV	0.9989

Epan = pan evaporation (mm/day), Tmax = maximum air temperature (°C), Tmin = minimum air temperature (°C), RHmax = maximum relative humidity (%), RHmin = minimum relative humidity (%), RA = rainfall amount (mm), SH = sunshine duration (hours), WV = wind velocity (m/sec), r = correlation coefficient.

From Table 1, it is also evident that average Epan values are inversely related with relative humidity (maximum and minimum) on both weekly and monthly basis. On weekly basis, an increase in one unit of these parameters will result in decrease in Epan value to the tune of 0.2589 mm/day and 0.0861 mm/day respectively, whereas, on monthly basis, Epan values will get decreased by 0.2669 mm/day and 0.0856 mm/day respectively. From analysis, it can be concluded that best index for predicting pan evaporation on both weekly and monthly basis are observed values of maximum relative humidity followed by wind velocity, maximum air temperature and sunshine hours at Udham Singh Nagar district.

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