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ESTIMATION OF EVAPOTRANSPIRATION IN THE IRRIGATED AREA OF PUNJAB, PAKISTAN

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Evapotranspiration is a major and basic component of the hydrologic cycle and is involved to some degree in nearly all the hydrologic studies. It affects the soil water balance from the time water falls on the land as precipitation until the residual reaches the ocean. This paper presents the estimation of evapotranspiration of an irrigated area of Punjab which is severely affected by waterlogging and salinity. Evapotranspiration of the waterlogged area was estimated for the water table depth simulation and then operated for the planning and design of a sub-surface drainage system. It was found that with an ample amount of precipitation, the evapotranspiration was directly related to the atmospheric temperature.

Key words: estimation of evapotranspiration, irrigated area, Pakistan, Punjab

INTRODUCTION

Evapotranspiration forms a foundation for planning and design of most of the irrigation and drainage projects. It is usually the starting point in determining surface and *sub-surface* water storage requirements, capacity of *the delivery* system and general operation practices. *The* evapotranspiration depends upon the climate, time of year, cropping pattern and cropping intensity of the area. The effects of climate and time at *the* year are included for estimating the reference crop evapotranspiration.

Prior to actual evapotranspiration, it is important to discuss the reference crop evapotranspiration (ETo) and crop coefficient (Kc) as these will be used to estimate the actual evapotranspiration. Doorenbos and Pruitt (1977) defined reference crop evapotranspiration (ETa) as "the rate of evapotranspiration from an extensive surface of 8-15 cm tall green grass cover of uniform height, actively growing, completely shading the ground surface and not short of water". In developing a guideline for determining the crop water requirements Doorenbos and Pruitt estimated the reference crop evapotranspiration (ETo), using Blanney-criddle, Radiation, Penman combination methods and pan evaporation method.

Gill and Early (1979) recommended the use of pan evaporation method because of its provision for measuring the integrated effects of temperature, radiation, wind and humidity. Moreover, this method gives precisely reliable results. Reference crop evapotranspiration (ETa) from pan evaporation (Epan) can be obtained from the following equation:

$$ETo = Kp \times Epan$$

Where Kp is pan coefficient and depends mainly on the pan environment and climatic conditions i.e. wind and relative humidity for a given pan.

Study Area: The study area is situated in the South-West of Bechna Doab, Punjab, Pakistan. It covers an area of 28,500 square kilometers between the two rivers, Ravi and Chenab. The study was done under the ongoing Fourth Drainage Programme of the Salinity Control and Reclamation Project (SCARP) called as the Lower Rechna Remaining SUb-Project. The area is sub-tropical, continental lowland and characterized by large seasonal fluctuations of both temperature and precipitation. Summers are hot and last from April through September with temperature variation from 21°C to 49°C during the day. Winters last from October through April with an average day time temperature of 32°C. Average annual precipitation ranges from 200 to 350 mm. The maximum pan evaporation rate over a span of 10 days is 80 mm. Climatic features of the area are given in Table 1.

Collection of Data

i) Evaporation data were collected from the Monitoring and Evaluation Division of the Water and Power Development Authority (WAPDA). The evaporation pans were installed in the study area.

Table 1. Climatic features of the study ana.

Month	Temperature QC			Precipitation 2~.hours (mm)	Pan evaporation (mm)	
	Min.	Max.	Mea~?	Max.	Avg.	Max.
Jan	4.8	19.4	16.3	36.8	68.6	101.6
Feb	7.6	22.4	18.0	43.7	76.2	104.1
Mar	12.6	27.4	23.1	::i4t,~1	137.2	190.5
Apr	18.3	34.2	13.7	30:'>	198.1	236.2
May	24.1	39.7	8.6	44.7	:~;j,trj 312.4	528.3
Jun	27.6	41.0	28.7	87.6	c;;~68.3	556.3
Jul	27.9	37.7	96.5	100. 12&.il.	2	495.3
Aug	27.2	36.5	97.5	155.7	~48,.9	330.2
Sep	24.5	36.6	28.5	149.4	147.~	271.3
Oct	17.7	33.9	5.1	39; 1	165.'1	228.6
Nov	10.4	28.2	23	22.6	101.6	139.7
Dec	6.1	22.1	7.8	38.1	17.1	111.8

Table 2. Cropping pattern and cropping intensity

Season	Crop	Cropping intensity (%)
Kharif	Cotton	8.0
	Rice	4.0
	Maize	13.0
	Fodder	10.0
	Sugarcane	20.0
Rabi	Wheat	41.0
	Oilseed	6.0
	Fodder	12.0
	Sugarcane	20.0

ii) The data relateo to crop grown in the area and their respective cropping intensities were collected from the Agriculture Section of WAPDA.

Estimation of E.vapotranspiration: The effect of crop for estimating of potential evapotranspiration (ETcp) is taken into account by a factor known as crop coefficient (Kc) (Israelsen and Hansen, 1962). The crop coefficient and the reference crop evapotranspiration are related by the following relationship.

$$ETcp = Kc \times ETo$$

Actual evapotranspiration is the actual amount of vapours transferred to the atmosphere which depends not only on the existing meteorological conditions, but also on theavailabilitv of soil moisture to meet the atmospheric demand and ability of crop to extract moisture from the soil.

Actual evapotranspiration takes place from the rainfall/irrigation on the same day and then from the available soil moisture when there is insufficient rain/irrigation in the area. The actual evapotranspiration takes place at different rates from different zones but the greatest concentration being near the soil surface. When the upper portion of the root zone is kept moist, most water used consumptively by the plant is removed from the soil near the surface. However, when soil moisture in the upper soil zone is insufficient, less water may be used from the soil surface than from the succeeding depth (Israelsen and Hansen, 1962). The actual evapotranspiration from the soil zones is expressed by the following formula:

$ETAZ_{IK,I}$ = FACT(kJ x ETAm
Where,
$ETAZ_{IK\cdot II}$ = Actual evapotr anspiratton, Of zone K at time I,
$FACT_{Ikl}$ = Fraction factor for *zone,* and
ETA_{IIII} = Total evapotranspiraf.ion at time I.

Reference crop evapotranspirationwBs calculated by pan evaporation method whichrsthe product of pan evaporation (Epan) and pan~efficient (Kp). Pan coefficient was estimated 'by'the pan environment and climatic conditions. Reference crop evapotranspiration was calculated from the pan evaporation and pan c6efficient.

Ctopping Pattern. and Intensity: Cropping pattern is tHe result.m fiJnctidn of irrigation water availability, soil contf"ioO·,.~cllrrrate and economic status of an area.. There are two cropping seasons in Pakistan namel.y,Kharif (April to September) or summer seasoo and Rabi(October to March) or winter season. T~cropping *intensity* was calculated by the ttmbwing formula:

CI = (CAS/TCA) x 100

Where
CI = Cropping intensity in percentage,
CAS = Cropped area in any season, and
TCA = Total cultivated area.

The cropping intensity was found 134% which revealed that inspite of waterlogging and salinity, the cropping intensity was relatively high. The cropping pattern and cropping intensity for Kharif and Rabi seasons are given in Table 2.

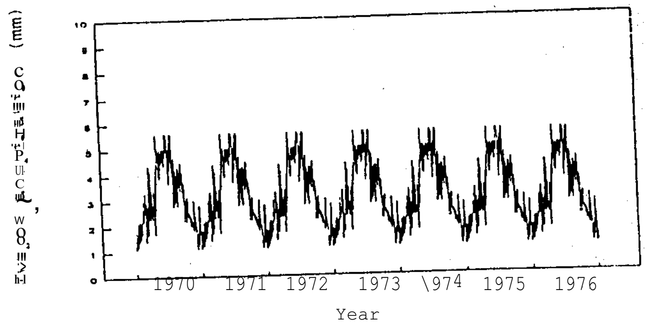
Crop Coefficient: The monthly crop coefficient .tor different crops are given in Table 3. Sorghum is a Kharif fodder for the period from June to September and Rabi fodder is alfalfa (berseem) for the period from September to February. Rabi oilseeds are mustard and rapeseed. The crop growth stage coefficients of selected crops have been developed in the province of Punjab, Pakistan, through a coordinated research project between Pakistan Agricultural Research Council (PARC) and Colorado State University (CSU). The crop coefficients for the crops in Table 2 were obtained from the final technical report of the above mentioned project (PARC, 1982)

Table 3. Crop coefficients of the cr,ops grown in study area

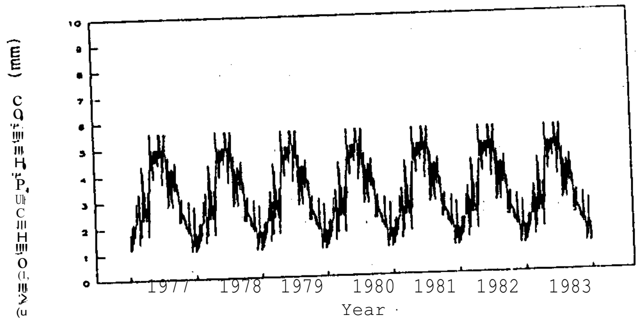
Month	Cotton	Rice	Maize	Kharif todder	Sugar-cane	Wheat	Oil- seed	Rabi fodder
Jan	-	-	-	-	-	1.11	0.37	0.95
Feb	-	-	0.40	-	-	1.08	0.95	0.95
Mar	-	-	0.63	-	0.61	0.71	-	-
APT	-	-	0.69	-	0.83	0.43	0.36	-
May	0.36	-	0.71	-	1.26	-	0.88	-
Jun	0.72	-	-	0.44	1.19	-	1.14	-
Jul	1.11	1.10	-	0.81	1.01	-	0.90	-
Aug	0.98	1.10	-	1.07	1.26	-	-	-
Sep	0.68	1.05	-	0.91	1.32	-	-	0.95
Oct	0.51	1.05	-	-	0.94	0.75	-	0.95
Nov	0,40	0.95	-	-	0.79	1,00	-	0.95
Dec	0.28	-	-	-	0.68	1.05	-	0.95

Table 4. Weighted average coefficients

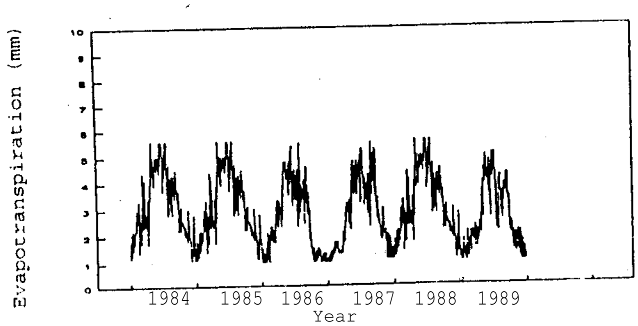
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coef.ficient	0.61	0.64	0.51	0.31	0,45	0.44	0.48	0.51	0.59	0,42	0.68	0.72



The reference crop evapotranspiration was trarrstorrned into' actual evapotranspir,ation. using weighted average coefficient for t'he respectiV~ 'month for the crops -grown and the evaporation from the bare soil. The calculated weighted average coefficients are given in Table 4. Factors affecting the value of the crop coefficient are mainly the crop characteristics, crop planting or sowing date, rate of craplopment, length of growing season and clirnatic conditions. Particularly, following sowing and during the early growth stage, the frequency of rain or irrigati on is important.



After de'termining all the factors needed, the actual evapotranspiL ation -._was calculated. Estiniat'ed evapotranspirati on and its variation over a long period are shown in._ F-~.J. Fig,1 depicts' that evapotranspiratian w'aj;;$:lf~ater than that at the two ends of each year. Ho~¥~r, the greatest value of evapotranspiration was offerSled during the month of June, This agrees with the data given in Table 1, since the area is sub-tropical," <it>ntinental lowland, designated as semiarid. The climati4 conditior:s have marked variation in temperature'anctr:ecipitation, The monsoon, or rainy season occursfsern June to September and accounts for about 75 % (i)f the total annual rainfall. Although the heaviest pre:cipitation occurred during the month of August -Yl;lt the maximum temperature during the month of June caused more pan evaporation. This leads to the conclusion that having enough precipitation, higher the temperature, more will be the evapotranspiration. Moreover, the variation in evapotranspirati()nis dependent on the meteorological factors. The major soil and crop factors when soil water is not limiting plant growth, are: (a) wetness of the surface soil with a little or no crop cover, (b) transpiration as influenced by leaf area and characteristics of the leaves as crop cover develops, and (c) transpiration as the crop matures.



Fig, 1, Variation of daily evapotranspiration

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