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Irrigation water requirements of different crops in Limbasi branch canal command area of Gujarat

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ABSTRACT

In this paper, the net irrigation water requirement estimation is carried out for different crops in Limbasi branch canal command area of Mahi Right Bank Canal (MRBC) project located in Gujarat, India. The Hargreaves – Samani approach for reference crop evapotranspiration (ET_o) estimation is used for thirteen years of available data and the mean monthly ET_o values were computed which were analyzed statistically. The potential crop evapotranspiration (ET_c) and net irrigation requirement (NIR) of different crops in kharif, rabi and summer season were estimated. Results show that the NIR values (mm) for kharif crop paddy was 166.8; rabi crops jowar, tobacco & wheat were 404.3, 504.2 & 564.7 and summer crops paddy & bajri were 851.1 & 619mm respectively.

Key words : Limbasi branch canal, Hargreaves – Samani method, net irrigation requirement

Reference crop evapotranspiration (ET_o) plays an important role in estimating net irrigation requirement of crops for agricultural planning, irrigation scheduling, regional water balance studies and agro-climatic zoning (Samani, 2000) and hence, accurate estimate of ET_o is a key component in hydrological studies. ET_o depends on several climatological factors, such as temperature, humidity, wind speed, radiation, type and stage of growth of the crop etc. ET_o can be either directly measured using lysimeter or water balance approaches or estimated indirectly using climatological data. Measurement of ET_o using lysimeter is not always possible as it is a time-consuming method and needs precise and carefully planned experiments. The indirect methods of ET_o estimation based on climatological data vary from empirical relationships to complex methods such as the Penman Monteith method based on physical processes. The different methods of ET_o estimation can be grouped into temperature methods, radiation methods, combination theory types and pan evaporation methods. Monteith (1965) modified the Penman method by incorporating stomatal resistance term specific to the type of crop in addition to the existing aerodynamic term and formulated the Penman-Monteith evapotranspiration model. Dhiman (2012) estimated the potential evapotranspiration for kharif (paddy) by using the Blaney-Criddle method and quantified the uncertainties in estimation of potential evapotranspiration and net irrigation water requirement using fuzzy logic. Khandelwal and Dhiman (2014) carried out a comparative study of ET_o estimation in the Limbasi branch canal command area using Modified Penman's method and Hargreaves - Samani method. It was found that Modified Penman method requires detailed climatological data (which are not often available with required degree of preciseness), while Hargreaves-Samani method (Hargreaves-Samani, 1985) uses limited data like air temperature and extraterrestrial solar radiation data only to give reasonably good estimate of ET_o. Hence, Hargreaves-Samani method was adopted for ET_o estimation of the study area. This work of ET_o estimation is carried further in the present analysis for the estimation of NIR of different crops of the study area in different cropping seasons.

MATERIALS AND METHODS

Study area

The Limbasi branch canal command area is situated between latitudes of 22° 31' 33.19'' to 22 ° 36' 11.79''N and longitudes of 72 ° 32' 08.63'' to 72 ° 48' 18.69''E. It has a Gross Command Area (GCA) of 23405 ha and Culturable Command Area (CCA) of 15764 ha. The climate of the study area is semi – arid and it is located in the agro-climatic zone GJ-3 (middle Gujarat zone). The average annual rainfall is 850mm with most of the rainfall restricted to monsoon months of June to September. It is considered as hyperthermic

Table 1: Reference crop evapotranspiration (ET_o) values (mean of 2000 – 2013) of the study area

Months	Mean (mm)	Standard Deviation	Coeff. of Variation
January	109.8	3.3	3.0
February	128.3	5.1	4.0
March	191.8	8.8	4.6
April	219.6	9.1	4.1
May	234.0	12.1	5.2
June	188.4	9.0	4.8
July	142.3	12.3	8.7
August	123.9	12.3	10.0
September	127.5	11.1	8.7
October	154.8	10.5	6.8
November	128.5	8.0	6.2
December	111.1	4.9	4.4

regime and ustic moisture regime in general. The topography of the area is flat. There are no well defined natural existing drains in the command area. Hydrological perspectives and groundwater issues of the study area were investigated by Khandelwal and Dhiman (2013, a & b). The present study is focused on the estimation of NIR with respect to different cropping seasons (kharif, rabi & summer) and different crops of the study area.

Cropping pattern

Paddy is the major crop in kharif season and covers about 97% of the area in the kharif season. Wheat is the major crop in rabi season and covers about 93% of the area in the rabi season. Pearl millet (bajri), sorghum (jowar), tobacco, cotton, sugarcane, banana and other crops (vegetables) are also cultivated in the command area.

Climate Data

Climate data pertaining to rainfall, temperature, relative humidity, sun shine hours etc. of the Navagam station (Latitude 22°48' N and Longitude 72°34' E) located nearby the study area were collected from Department of Agricultural Meteorology, B. A. College of Agriculture, Anand Agricultural University, Anand. The data were collected for 13 years duration (2000 to 2013).

Estimation of net irrigation requirement (NIR)

NIR estimation was done from the values of reference crop evapotranspiration (ET_o), potential crop evapotranspiration (ET_c) and effective rainfall (R_{eff}). Hargreaves - Samani method (1985) is employed to determine ET_o. This method computes daily mean ET_o by using Eq. (1).

$$ET_O = 0.0023 * R_a * (T_{avg} + 17.8) * \sqrt{(T_{max} - T_{min})} \quad (1)$$

Where, ET_o = reference crop evapotranspiration (mm/day); R_a = extraterrestrial solar radiation (mm/day); T_{avg}, T_{max} and T_{min} are daily average, maximum and minimum air temperatures (°C).

The values of extraterrestrial solar radiation (R_a) depend on month of the year and location of place with reference to the latitude as given by Michael (2011). Following relationship was used to determine ET_c values of different crops:

$$ET_c = ET_o * K_C \quad (2)$$

Where, ET_c = potential crop evapotranspiration (mm); K_c = crop coefficient for a given crop.

Crop coefficient (K_c) values were collected from Water and Land Management Institute (WALMI), Anand. The value of K_c was taken as 1.1 for paddy, 0.8 for jowar and bajri, 1.0 for tobacco and 1.12 for wheat.

NIR values of different crops was determined by following relationship:

$$NIR = ET_c - R_{eff} \quad (3)$$

Where, NIR = net irrigation requirement (mm); R_{eff} = effective rainfall (mm).

Effective rainfall (R_{eff}) was determined by evaporation precipitation ratio method. (FAO - http://www.fao.org/docrep/x5560e/x5560e03.htm). This method gives the value of effective monthly rainfall (R_{eff}) by correlating mean monthly rainfall and mean monthly consumptive use (ET_c). Effective rainfall was considered for the monsoon months of June to October only, as in the remaining months, significant rainfall does not occur regularly in the command area and hence, effective rainfall is zero during this period. If the NIR values are negative (for $R_{eff} > ET_c$), then the NIR of the crop is considered as zero. The seasonal NIR of crops was computed by adding the monthly NIR of corresponding crops.

RESULTS AND DISCUSSION

Reference crop evapotranspiration (ET_o) values

The mean of monthly ET_o values for the 13 years (2000 – 2013) period along with standard deviation and coefficient of variation (CV%) are presented in Table-1. The monthly values during the year varied from 109.8 ± 3.3mm in January to 234.0 ± 12.1mm in May. During monsoon

Table 2 : Estimated ET_c and NIR values (mm) of different crops grown in different seasons.

Crop	Period	ET_o	K_c	ETc	R_{eff}	NIR
(a)	**Kharif**					
Paddy	June	188.4	1.1	207.2	91.9	115.3
	July	142.3		156.5	223.1	0.0 (*)
	August	123.9		136.3	213.7	0.0 (*)
	September	127.5		140.3	88.8	51.5
	Total	582.1		640.3	617.5	166.8
(b)	**Rabi**					
Jowar	October	154.8	0.8	123.8	0.0	123.8
	November	128.5		102.8	0.0	102.8
	December	111.1		88.9	0.0	88.9
	January	109.8		87.8	0.0	87.8
	Total	504.2		403.4	0.0	403.4
Tobacco	October	154.8	1	154.8	0.0	154.8
	November	128.5		128.5	0.0	128.5
	December	111.1		111.1	0.0	111.1
	January	109.8		109.8	0.0	109.8
	Total	504.2		504.2	0.0	504.2
Wheat	October	154.8	1.12	173.4	0.0	173.4
	November	128.5		143.9	0.0	143.9
	December	111.1		124.4	0.0	124.4
	January	109.8		123.0	0.0	123.0
	Total	504.2		564.7	0.0	564.7
(c)	**Summer**					
Paddy	February	128.3	1.1	141.1	0.0	141.1
	March	191.8		211.0	0.0	211.0
	April	219.6		241.6	0.0	241.6
	May	234.0		257.4	0.0	257.4
	Total	773.7		851.1	0.0	851.1
Bajri	February	128.3	0.8	102.6	0.0	102.6
	March	191.8		153.4	0.0	153.4
	April	219.6		175.7	0.0	175.7
	May	234.0		187.2	0.0	187.2
	Total	773.7		619.0	0.0	619.0

(*) indicates that R_{eff} is greater than ET_c and hence, NIR is zero.

Notations:

ET_c = potential crop evapotranspiration;
ET_o = reference crop evapotranspiration;
K_c = crop coefficient;
NIR = Net irrigation requirement;
R_a = extraterrestrial solar radiation;
R_{eff} = effective rainfall.
T_{avg}, T_{max} and T_{min} = daily average, maximum and minimum air temperatures (°C);

months, the coefficient of variation of ET_o was higher in comparison to other seasons / months (Table - 1)

ET_c and NIR values

ET_c and NIR values were estimated for the different crops of the study area. Monthly ET_c values were estimated from monthly ET_o values. The seasonal ET_c of crops was computed by adding the monthly ET_c of corresponding crops. The estimated ET_c values (mm) for kharif crop paddy was 640.3; rabi crops jowar, tobacco & wheat were 403.4, 504.2 & 564.7 and summer paddy & bajri were 851.1 & 619 respectively (Table2).

The estimated NIR values (mm) for *kharif* crop paddy was 166.8; *rabi* crops jowar, tobacco & wheat were 403.4, 504.2 & 564.7 and summer paddy & bajri were 851.1 & 619 respectively (Table2).

The estimated NIR values of paddy in *kharif* and summer season were 166.8mm and 851.1mm respectively showing a significant difference. The reason for this difference is that in kharif, major part of ET_c is satisfied by effective rainfall, which is not the case in summer season.

CONCLUSION

NIR values were estimated for different crops of the study area. The estimated NIR values (mm) for *kharif* crop paddy was 166.8; *rabi* crops jowar, tobacco & wheat were 403.4, 504.2 & 564.7 and summer paddy & bajri were 851.1 & 619 respectively. Significant difference of NIR values of paddy in kharif and summer season was observed, which may due to the reason that in kharif, major part of ET_c is satisfied by effective rainfall which is not the case in summer season.

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