Summary, Conclusions And Scope Of Further Research

CHAPTER – 10

SUMMARY, CONCLUSIONS AND SCOPE OF FURTHER RESEARCH

10.1 SUMMARY

10.1.1 The calculation of evapotranspiration estimates from wheather record is appealing due to relatively simple approach compared to on site evapotranspiration measurements. However no single existing method based on climatic data is universally adequate especially for tropical areas. To obtain correct value of evapotranspiration by more number of climatological data is a time consuming process. Studies were conducted to establish a simple relationship based on single or two climatic parameters which can be used without much loss of accuracy. An attempt is therefore made to develop equations with local climatic data for five different regions representing major part of the state.

10.1.2 Five stations covering different regions of Gujarat viz. Dantiwada (North Gujarat), Anand and Vadodara(Central Gujarat) and

Rajkot and Junagadh (Saurashtra) are selected. The selected stations coveres different agroclimatic zones of the state. Various meteorological parameters viz. Temperature, Sunshine hours, Wind velocity and Humidity which affects directly the evapotranspiration of a reference crop are selected and data of all such parameters for five stations are collected for 10 to 30 years.

10.1.3 Weekly average values for principal climatic variables are worked out for 10 to 30 years for five stations and finally average values of all years is calculated for the whole region under consideration.

10.1.4 Seven different prediction methods for calculating reference crop evapotranspiration are selected viz: Penman(FAO), Blaney Criddle (FAO), Radiation (FAO), Pan evaporation (FAO), Hargreaves, Jensen Haise and Thornthwaite. Evapotranspiration (ETo) is calculated using above methods for five stations.

10.1.5 A relationship between ETo and climatic variables is established using multiple regression model. The climate of Gujarat is such that two peaks are observed in the values of ETo. Therefore relationship is developed in two parts i.e. upto and beyond 33rd week. A regression model is developed in following form.

$$ETo = C + C_1 * T + C_2 * n + C_3 * RH + C_4 * U$$

Where

C, C_1, C_2, C_3, and C_4 are unknown regression constants.

ETo = Reference crop evapotranspiration

T, n, RH and U are meteorological parameters.

10.1.6 Since above equation involves four meteorological variables, attempt has been made to develop equation based on a single or two parameters. Looking to the dependability of temperature and bright sunshine hours parameters for tropical region, equation is derived in following form.

$$ETo = C + C_1 * T^2 * n$$

As evaporation is a direct measure of evapotranspiration and includes the effect of all other variables, another linear equation based on pan evaporation data is developed as under.

$$ETo = C + C_1 * Epan$$

10.1.7 Further analysis is carried out on week base and looking to uniform distribution of ETo along the year, equations are developed on week base as given below :

$$ETo = C_0 + \sum_{n=1}^{n} C_n * W^n$$

Where C_0 = additive constant and

C_n = multiplying constant where n varies from 1 to 5.

W = Standard weeks of the year starting from January.

10.1.8 Developed equations are used to calculate ETo values. Evapotranspiration of various crops (ETc) are worked out.Directly observed values of evapotranspiration (ETc) are available for seven crops from lysimetric observations at three stations. Lysimetric values are compared with predicted values for seven different crops grown under three different zones.Observed and predicted values of ETc are in good corelation.

10.2 CONCLUSIONS

This study provides an useful tool in planning,design and operation of irrigation and water resources systems.Basic aim of the study is to develop a simple relation for sub regions and for whole region which can be used satisfactorily without much loss of accuracy. Major findings of the study are summarised below.

10.2.1 Data of climatological factors collected and analysed for long records of 10 to 30 years reveals that for all five stations located in different part of the state, the pattern of variation and distribution throughout year is uniform.For all regions variation in bright sunshine hours and temperatures is uniform and having negligible deviation amongst each other. Likewise relative humidity also follows uniform variation for all the regions having inversely proportional pattern compared to bright sunshine hours and temperature.Though the pattern of wind velocity is same for all stations, due to effect of topography and other local conditions, wind velocity is not tallying perfectly for all stations. The non uniform distribution of wind velocity also affected the variation pattern of evaporation.

10.2.2 Evapotranspiration (ETo) is calculated by different seven methods. Results shows that the pattern of ETo variations throughout year is uniform for all the stations.Higher values are observed in mid of May and in early October.Whereas lower values of ETo are noticed during January,August and December. Close comparison between ETo of different regions is observed for Penman,Blaney-Criddle,Radiation, Hargreaves and

Jensen haise methods.Execpt Junagadh station close relation between ETo of different regions is also observed for Thornthwaite method. Whereas for pan evaporation method 3 to 5 mm/day variation is noticed amongst the values of different stations. It can be concluded that for five stations located under different agro-climatic zones of the state, a good agreement has been found amongst the estimated values by methods under study except Pan evaporation method.

10.2.3 For each station estimated ETo by different methods is compared.Variation amongst each method is negligible except Thornthwaite method.This method gives lower values in Rabi season and higher values in mid year compared to other methods. While comparing all methods excluding Thornthwaite,the variation in ETo between different methods is 1 to 2 mm/day.Thus execpt Thornthwaite method, all methods are having negligible variation for a region.Therefore to develop region based relationship six methods viz..Penman, Blaney-Criddle,Radiation,Panevaporation, Hargreaves and Jensen- Haise are considered for analysis.

10.2.4 Above discussions gives an answer to the need of an equation for the region under study.A relation between basic climatic parameters and ETo is developed as under

Met-Para Equations

$$ETo = 0.283\ T + 0.159\ n - 0.065RH + 0.094\ U \quad -----(1)$$

(1 to 33 weeks)

$$ETo = 0.218\ T + 0.106\ n - 0.003RH - 0.244\ U \quad ---(2)$$

(33 to 52 weeks)

The equations are simple which can be solved without using tables or charts. Observed data can directly be used. Correction factors are evaluated for various sub- regions as under.

Dantiwada and Vadaodara	0.97
Anand	0.95
Rajkot	1.09
Junagadh	1.00

A good agreement is found between the average ETo of six methods and estimated by these equations. Trials made to develop relationship using single parameter shows that except Pan evaporation, any other single climatic parameter have no good corelation with ETo.

10.2.5 Since the empiricism involved in any ET prediction method using a single weather factor is inevitably high, two variables used in combination. Relationship developed using temperature in combination with bright sunshine hours gives a good corelation with ETo. The recommended relationship is:

T-n Equations

$ETo = 2.63 + 0.00055\ T^2\ n$

(1 to 33 week)

$ETo = 2.63 + 0.00043\ T^2\ n$

(33 to 52 weeks)

To take care of over prediction of about 5 % in Rabi season a correction factor of 0.95 is suggested. For all sub-regions under study, correction factors are suggested as under.

Dantiwada	1.00
Anand and Vadodara	0.96
Rajkot and Junagadh	1.05

Computation of evapotranspiration by this equation is easier and realistic because of the involvement of simple mathematical calculations of climatic data which are recorded directly in the field.

10.2.6 Considering the fact that the panevaporation data gives integrated effect of radiation, wind, temperature and Humidity equation in following form is developed.

Pan-Ev Equations

$$ETo = 1 + 0.65\ E\ pan \quad .....(5)$$

(1 to 33 weeks)

$$ETo = -\ 0.45 + E\ pan \quad .....(6)$$

(33 to 52 weeks)

Recommended corrections factors for different sub-regions are as under.

Dantiwada	0.95
Anand	1.19
Vadodara	1.12
Rajkot	0.87
Junagadh	0.93

Analysis shows that these linear regression model gives good corelation with average of ETo estimated by other prediction methods.

10.2.7 A simple equation developed in following form is recommended when climatic data are not available.

$$ETo = Co + \sum_{n=1}^{n} Cn\ W^{n} \quad ..... \quad (7)$$

Values of constants for various regions are given in Table 8.1 This equation predicts good results. However calibration of such equations are necessary for each 10 years period.

10.2.8 Field corelation :

The predicted evapotranspiration (ETc) values using T - n equation closely reltes to the observed values of evapotranspiration by lysimeter. For all three stations viz. Dantiwada, Anand and Rajkot the values are in close conformity with directly observed ETc of various crops viz. Bajra,Tobacco, Groundnut, Maize and Cotton. These are the major crops grown in the area under consideration. Thus results of T - n equation gives good corelation with directly observed values of major crops of state and therefore can be used for getting accurate, handy and easy solution for evapotranspiration of reference crop (ETo).

10.3 SCOPE OF FURTHER RESEARCH

10.3.1 The state of Gujarat is geographically located in such a way that it experiences a wide range of climatology. With a longest coastal belt on western side, it has desert on north-west in Kachchha and a humid irrigated area in south. The districts covered under study includes semi-desert area like Banaskantha, Central Saurashtra and sub humid area of Central Gujarat. Thus in the area covered under study climatological data of coastal belt and arid zones (Kachchha District) are not covered. Further reserch for developing correction factors or new equations is required for such specific

areas.

10.3.2 Wind velocity and Relative humidity factors greatly influence ET particularly for humid climate. Therefore these factors needs to be consider for better estimation of ET for paddy in humid climate area of south Gujarat. It is necessary to attempt this aspect and to develop an equation to estimate consumptive use of paddy and other similar crops under upland conditions.

10.3.3 Irrigation Engineers and Researchers are now putting more stress on accurate measurements of crop water requirements. Data of lysimeter for more crops and period can be utilised to develop crop coefficients for all crops which can suit for the equation developed and the regions covered under study.

10.3.4 The equation is having limitations of range for humidity, wind and temperature. Correction factors are required to be evaluated for its calibration for the ranges other than give under this study.

10.3.5 An automatic weather station which can read and record temperature and sun shine hours can be connected to a small table computer with T - n equation software. This will directly give the values of estimated ETo for average daily/weekly values. With the input data of Kc values, it can even provide daily-weekly average values, for crop water requirements for different crops. Such arrangements made in large irrigated command can supply daily bulletins of on hand informations.