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# Theoretical Consideration for optimum irrigation scheduling for irrigation Scheme

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ABSTRACT

*With growing population the demand of water for various purposes is ever increasing Water is becoming a scarce resource as a result of the growing demand in various purposes. On the other hand, the availability of water of water resources is limited in space and time. A systematic and scientific planning for its optimal utilization is high imperative. Use of modern techniques in irrigation will go a long way in economizing consumption and saving of water which will bring greater areas under command and will result in more agricultural yield.*

Keywords : Penman-Monteith equation, Evaporation, Transpiration, Evapotranspiration, Irrigation

## I. INTRODUCTION

Water, like most natural resources is scarce at certain times and certain places. Irrigation Scheduling is the process of supplying the needed amount of water for crops at the most appropriate time so that soil water content never falls below the management allowable depletion (MAD) level at the crop stress is avoided, thus maximizing the yield. The scarcity of water, regarded as the most important factor in crop production, is usually a limiting factor in the development of irrigation scheme particularly in semi arid regions. Another important objective of Irrigation Scheduling is to maximize irrigation efficiency by minimizing runoff and percolation losses and in turn, saving water and energy Irrigation Scheduling on farm is commonly defined as determining when to irrigate and how much water to apply holding and socio-economic status.

## II. NEED TO STUDY

There are different systems of distribution prevailing in different part of the country.

The need to economy in use of water and proper application necessitates measures for limiting supply of water to individual field to that which is required for optimum growth of the crop. It further necessitates measures for enforcing discipline and minimizing the excessive water use. Assurance regarding supply has built up confidence of cultivators by virtue of which implementation of Irrigation Scheduling is made possible in all irrigated areas.

## III. SPECIFIC OBJECTIVES OF STUDY

1. To study the irrigation feature of Irrigation Scheme
2. To suggest suitable canal operation scheduling to match with the seasonal Irrigation Demand.
3. To study and evaluate the various irrigation options and suggests appropriate option for optimizing Net Irrigation Requirement and Irrigation Demand for the cropping pattern.
4. To explore the possibility of “CROPWAT” windows version 8.0 model as management tool in irrigation management.

## IV. STUDY AREA

Any Irrigation Scheme is for irrigation and drinking water. The total Culturable command area of the entire project is and gross command area in hectares is decided. The catchment area is decide for irrigation scheduling

## V. DATA COLLECTION AND ANALYSIS

Estimation of crop evapotranspiration, Irrigation scheduling, monthly crop water requirement for Irrigation Scheme command and ON/OFF schedule for canal operation, from climatologically data has been in practice for long. The regional climatologically a data are used to estimate crop evapotranspiration, Irrigation scheduling, monthly crop water requirement for Irrigation Scheme and ON/OFF schedule for canal operation.

### CLIMATOLOGICALLY DATA

The climatologically data of Weather Station representing Irrigation Scheme command it includes the daily values of temperature (maximum and minimum), humidity, wind speed, bright sunshine hours, and rainfall for 10 years The daily climatologically data are converted into mean value over the monthly and then averaged over the period of 10 years to arrive at the monthly

### Rainfall

Rainfall value based on 50% probability is included in monthly Cropping Pattern of Study Area

The existing cropping pattern is shown in below collected from Irrigation Sub Division.

The three distinct seasons are considered as:
Kharif - (1 July to 30 November)
Rabi - (10 November to 10 March)
Two Seasonal - (9 February to 10 June)

### Soil Types and Soil Moisture Variation
### Total Available Soil Moisture (TAM)

Indicative values for different texture class are:

| Soil: | Coarse | Sandy | Loamy | Clayey |
|---|---|---|---|---|
| TAM (mm/m): | 6 | 100 | 140 | 180 |

Initial Soil Moisture Depletion (% TAM)

For the analysis works, 40% initial soil moisture depletion is considered.

### Maximum Rooting Depth

Maximum rooting depth although in most cases the genetic characteristics of the crop will determine the rooting, in some cases the soil and certain disturbing soil depth

**Maximum Rain Infiltration Rate**
The maximum rain infiltration rate expressed in mm/day .For the analysis works; 80 mm/day maximum rain infiltration rates have been used.

**Irrigation Performance**
The following data on Irrigation performance are collected from the Irrigation Sub Division.

**Crop water requirement, irrigation requirement and irrigation schedules**
Calculations of crop water requirements and irrigation requirements from climatic and crop data are done by 'CROPWAT windows version 8.0, a computer programme for irrigation planning and management. The programme allows the development schedules for different management conditions and the calculations of scheme water supply for varying cropping patterns. It also helps in the development of recommendations for improved irrigation practices and planning of irrigation schedules under varying water supply conditions.

**Calculation of Reference Crop Evapotranspiration**
Using required climatic data for Penman-Monteith Method, the reference crop evapotranspiration were computed in mm/day for the monthly calculated.

**VI. METHODOLOGY**
**NET IRRIGATION UNDER DIFFERENT OPTIONS (for proposed cropping pattern)**
In order to optimize Irrigation Demand based Irrigation Scheduling options for efficient canal operations, the 'CRPOPWAT' model with required information pertaining to monthly value of climatological elements, soil factors, and crop factors and rainfall. The model was operated and result of this under different options areas under.

The model is operated for all given crops in Kharif, Rabi and Two seasonal

**Calculation of crop Evapotranspiration**
The evapotranspiration of an irrigated field is a function of meteorological factors, nature of crop and its canopy and crop growth stage and drought resistance of each crop. The actual crop evapotranspiration (ETa) depends on many parameters, which are difficult to measure and to define theoretically.

Evapotranspiration from the climatological data has been in practice for long. Owing to the difficulty obtaining accurate evapotranspiration data directly from field it is usually preferable to calculate evapotranspiration from more easily available regional climatic data. Extensive research on reference crop evapotranspiration methods and improved crop coefficients has been conducted because of their application in irrigation scheduling and other aspects of water resources allocation management and planning. Crop coefficient (Kc) is used with the values of reference crop evapotranspiration (ETo) to estimate the crop evapotranspiration (Ete). To account for the effect of the crop characteristics on crop water requirement, crop coefficient are presented to relate ETo to ETc. The Kc value related to evapotranspiration of disease free crop grown in large fields under optimum soil water and fertility conditions and achieving full production potential under the given growing environment. ETc. can be found by

**ETc. = Kc * ETo**
A good number of formulas are available to estimate reference crop evapotranspiration. However for present study, Penman-Monteith Method is adopted.

**v ETo by Penman-Monteith Method**
The Penman method was generalized to a significant extent by of a plant resistance parameter and a more general user of an aerodynamic

**Development of Crop Coefficient Curve**
The growing season of each of the crop is divided into four stages (1) Initial Stage, (2) Development Stage, (3) Mid Season Stage, (4) Late Season Stage.

Doorenbos and Pruitt (1977) present a set of crop coefficient using grass as reference crop as

Resistance parameter. Recent modifications by Allen et al. (1989) are now being implemented into practical methods of estimating ET. The original equation was intended for short term calculation such as for an hourly period. Special adaptations are required for daily periods (Allen et al., 1989).

**Crop Coefficient**
Crop coefficient (Kc) is generally empirical ratio of crop ETc. to some reference crop ETc. and is derived from experiments data. The timely distribution of a crop coefficient for a particular crop constitutes a "crop curve". A common form of crop coefficient is in which Kc is:

**Kc= ETc. /ETo**
Where, Kc= crop coefficient
ETc. = crop evapotranspiration in mm/day
ETo=reference crop evapotranspiration in mm/day

**The cop coefficient is dependent upon:**
1. soil water availability within root zone
2. Wetness of the exposed soil surface,
3. physiological characteristics of the crop
4. Its canopy and crop growth stage.

The crop coefficient is usually between 1.0 and 1.2 at full development stage. As the crop begins

As the crop begins to mature its physiological and crop coefficient rapidially decrease.

**Table: 01**
A characteristic curve is shown in a seven step procedure for development of crop curves.

- The planting date is first defined. This requires information on local practice.
- The length of the total growing season and of various development stages need to be defined. These are the stages for which crop coefficients are tabulated. Doorenbos and Pruitt (1977) divide the season into four development stages.
- The crop coefficient for the initial stage is plotted, and a horizontal line, extending from the plating date to the end of the initial stage, is drawn through this value.
- The crop coefficient for the mid season stage is plotted; a horizontal line extending from the beginning to the end of the season stage is drown through this value.
- The crop coefficient for the time of full maturity is plotted at the growing season, that is, at the time of full maturity.

A straight line is drawn from the end of the line passing through initial stage crop coefficient and the beginning of the line page through the mid season crop coefficient to the crop Coefficient plotted at the end of the growing season.

**Table: 01:Crop Coefficient (Kc) for Field and Vegetable Crops for Different Stages of Crop Growth and Prevailing Climatic Conditions**

| Crop | Humidity | Rhmin | >70% | Rhmin | <20% |
|---|---|---|---|---|---|
| | Wind m/sec | 0-5 | 5-6 | 0-5 | 5-8 |
| | A. Crop stage | | | | |

| | | | | | |
|---|---|---|---|---|---|
| All field crops | Initial 1<br>Crop dev. 2 | Use Fig.<br>By interpolation | | | |
| Artichokes (perennial clean cultivated) | mid-season 3<br>at harvest<br>or maturity 4 | .95 | .95 | 1.0 | 1.05 |
| Cotton | 3<br>4 | 1.05<br>.65 | 1.15<br>.65 | 1.2<br>.65 | 1.25<br>.7 |
| Millet | 3<br>4 | 1.0<br>.3 | 1.05<br>.3 | 1.1<br>.25 | 1.15<br>.25 |
| Peanuts (Groundnuts) | 3<br>4 | .95<br>.55 | 1.0<br>.55 | 1.05<br>.6 | 1.1<br>.6 |
| Potato | 3<br>4 | 1.05<br>.7 | 1.1<br>.7 | 1.15<br>.75 | 1.2<br>.75 |
| Radishes | 3<br>4 | .8<br>.75 | .8<br>.75 | .85<br>.8 | .9<br>.85 |
| Soybeans | 3<br>4 | 1.0<br>.45 | 1.05<br>.45 | 1.1<br>.45 | 1.1<br>.45 |
| Tomato | 3<br>4 | 1.05<br>.6 | 1.1<br>.6 | 1.2<br>.65 | 1.25<br>.65 |
| Wheat | 3<br>4 | 1.05<br>.25 | 1.1<br>.25 | 1.15<br>.2 | 1.2<br>.2 |

**Table: 02 Average Monthly Effective Rainfall as Related To Mean Monthly Rainfall and Mean Monthly Consumptive Use (U.S D.A. SCS, 1969)**

| Monthly Mean Rainfall mm | Mean monthly consumptive use, mm | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean monthly effective rainfall, mm | | | | | | | | | | | | | |
| | 25 | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | 275 | 300 | 325 | 350 |
| 12.5 | 7.5 | 8.0 | 8.7 | 9.0 | 9.2 | 10.0 | 10.5 | 11.2 | 11.7 | 12.5 | 12.5 | 12.5 | 12.5 | 12.5 |
| 25.0 | 15.0 | 16.2 | 17.5 | 18.0 | 18.5 | 19.7 | 20.5 | 22.0 | 24.5 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| 37.5 | 22.5 | 24.0 | 26.2 | 27.5 | 28.2 | 29.2 | 30.5 | 33.0 | 36.2 | 37.5 | 37.5 | 37.5 | 37.5 | 37.5 |
| 50.0 | 25.0<br>41.7 | 32.2 | 34.5 | 35.7 | 36.7 | 39.0 | 40.5 | 43.7 | 47.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 |
| 62.5 | | 39.7 | 42.5 | 44.5 | 46.0 | 48.5 | 50.5 | 53.7 | 57.5 | 62.5 | 62.5 | 62.5 | 62.5 | 62.5 |
| 75.0 | | 46.2 | 49.7 | 52.7 | 55.0 | 57.5 | 60.2 | 63.7 | 67.5 | 73.7 | 75.0 | 75.0 | 75.0 | 75.0 |
| 87.5 | | 50.0<br>80.7 | 56.7 | 60.2 | 63.7 | 66.0 | 69.7 | 73.7 | 77.7 | 84.5 | 87.5 | 87.5 | 87.5 | 87.5 |
| 100.0 | | | 63.7 | 67.7 | 72.0 | 74.2 | 78.7 | 83.0 | 87.7 | 95.0 | 100 | 100 | 100 | 100 |
| 112.5 | | | 70.5 | 75.0 | 80.2 | 82.5 | 87.2 | 92.7 | 98.0 | 105 | 111 | 112 | 112 | 112 |
| 125.0 | | | 75.0<br>122 | 81.5 | 87.7 | 90.5 | 95.7 | 102 | 108 | 115 | 121 | 125 | 125 | 125 |
| 137.5 | | | | 88.7 | 95.2 | 98.7 | 104 | 111 | 118 | 126 | 132 | 137 | 137 | 137 |
| 150.0 | | | | 95.2 | 102 | 106 | 112 | 120 | 127 | 136 | 143 | 150 | 150 | 150 |
| 162.5 | | | | 100<br>160 | 109 | 113 | 120 | 128 | 135 | 145 | 153 | 160 | 162 | 162 |
| 175.0 | | | | | 115 | 120 | 127 | 135 | 143 | 154 | 164 | 170 | 175 | 175 |
| 187.5 | | | | | 121 | 126 | 134 | 142 | 151 | 161 | 170 | 179 | 185 | 187 |
| 200.0 | | | | | 125<br>197 | 133 | 140 | 148 | 158 | 168 | 178 | 188 | 196 | 200 |
| 225 | | | | | | 144 | 151 | 160 | 171 | 182 | | | | |
| 250 | | | | | | 150<br>240 | 161 | 170 | 183 | 194 | | | | |
| 275 | | | | | | | 171 | 181 | 194 | 205 | | | | |
| 300 | | | | | | | 175<br>287 | 190 | 203 | 215 | | | | |
| 325 | | | | | | | | 198 | 213 | 224 | | | | |
| 350 | | | | | | | | 200<br>331 | 220 | 232 | | | | |
| 375 | | | | | | | | | 225<br>372 | 240 | | | | |
| 400 | | | | | | | | | | 247 | | | | |
| 425 | | | | | | | | | | 250<br>412 | | | | |
| | | | | | | | | | | | | | | |
| 450 | 25 | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | | | | |

❖ Although it looks better but generally does not affect the account very much, the straight lines can now be replaced by a smooth if desired, which is defined as crop curve.

❖ **Effective Rainfall**
Four different methodologies are given to determine the effective rainfall:

❖ **Fixed Percentage of Rainfall:**
Effective rainfall is calculated according to

Peff = a * Ptotal

Where, Peff = effective rainfall

Ptotal = total rainfall

Where a is fixed percentage to be given by the user to account losses from runoff and deep percolation. Normally are around 30%.
**a= 0.7 – 0.9**

❖ **Dependable Rain:** Dependable rain based on an analysis carried out for different arid and sub-humid climates an empirical formula was developed in FAO/AGLW to estimated dependable rainfall, the combined effect of dependable rainfall (80% prob. Exc.) and estimated losses due to runoff and percolation. This formula may be used for design purpose where 80% probability of accidence is required.

**Pef = 0.6*Ptotal – 10 for Ptotal < 70 mm**
**Pef = 0.8*Ptotal – 24 for** Ptotal > 70 mm

❖ **Empirical Formula:** The parameters may be determined from an analysis of local climatic records. An analysis of local climatic records may allow an estimation of effective rainfall. The relationship can, in most cases, be simplified by the following equations.
**Peff = a*Ptotal – b for** Ptotal < z mm
**Peff = c*Ptotal – d for** Ptotal > z mm
Where, a, b, c, d, z = correlation coefficient

❖ **USDA Soil Conservation Service Method:** Effective rainfall is can be calculated according to
**Peff= Ptotal (125 – 0.2 Ptotal)/125**
For Ptotal < 250 mm
**Peff= 125 + 0.1 * Ptotal** for Ptotal > 250 mm

**Table: 03 Multiplication Factors To Relate Monthly Effective Rainfall Value Obtained To Net Depth Of Irrigation Application (D) In Mm.**

| d mm | Factor | d mm | Factor | d mm | Factor |
|---|---|---|---|---|---|
| 10.00 | 0.620 | 31.25 | 0.818 | 70.00 | 0.990 |
| 12.50 | 0.650 | 32.50 | 0.826 | 75.00 | 1.000 |
| 15.00 | 0.676 | 35.00 | 0.842 | 80.00 | 1.004 |
| 17.50 | 0.703 | 37.50 | 0.860 | 85.00 | 1.008 |
| 18.75 | 0.720 | 40.00 | 0.876 | 90.00 | 1.012 |
| 20.00 | 0.728 | 45.00 | 0.905 | 95.00 | 1.016 |
| 22.50 | 0.749 | 50.00 | 0.930 | 100.00 | 1.020 |
| 25.00 | 0.770 | 55.00 | 0.947 | 125.00 | 1.040 |
| 27.50 | 0.790 | 60.00 | 0.963 | 150.00 | 1.060 |
| 30.00 | 0.808 | 65.00 | 0.977 | 175.00 | 1.070 |

**Table: 04**
**Calculation of ETo from climatologically data**

| Month | Min Temp | Max Temp | Humidity | Wind | Sun | Rad | ETo |
|---|---|---|---|---|---|---|---|
| | 0C | 0C | % | Km/day | Hours | mj/m2/day | mm/day |
| Jan | 20.8 | 31.5 | 57 | 3 | 8.9 | 16.7 | 2.52 |
| Feb | 20.8 | 31.6 | 57 | 3 | 9.1 | 19.0 | 3.10 |
| Marc | 21.0 | 31.7 | 57 | 3 | 9.1 | 21.4 | 3.74 |
| April | 21.1 | 31.8 | 57 | 3 | 9.2 | 23.2 | 4.24 |
| May | 21.1 | 31.7 | 57 | 3 | 9.3 | 23.9 | 4.45 |
| June | 21.1 | 31.9 | 57 | 3 | 9.4 | 24.1 | 4.51 |
| July | 21.1 | 31.9 | 57 | 2 | 9.2 | 23.7 | 4.43 |
| Augu | 21.1 | 31.9 | 57 | 2 | 9.2 | 23.3 | 4.28 |
| Septe | 21.1 | 31.8 | 57 | 2 | 9.2 | 22.0 | 3.90 |
| Octo | 21.1 | 31.9 | 57 | 2 | 9.4 | 20.0 | 3.34 |
| Nove | 21.1 | 31.9 | 57 | 2 | 9.4 | 17.7 | 2.71 |
| Dece | 21.1 | 31.8 | 58 | 2 | 9.5 | 16.6 | 2.44 |
| Aver | 21.0 | 31.8 | 57 | 3 | 9.2 | 21.0 | 3.64 |

**VII. ANALYSIS**
The steps of this method are as below:

Ø Compute monthly value of climatic elements of weather station as shown Table:04
Ø Decide soil factor of command required for irrigation scheduling.
Ø Compute crop factor used in irrigation scheduling for all given crops in Kharif, Rabi and Two seasonal
Ø Compute average monthly rainfall & effective rainfall
➢ Compute crop water requirement and corresponding values of field irrigation requirement and water supply at canal level
➢ Compute irrigation scheduling report for different crops as per planting date and decided irrigation efficiency and crop water requirement (ETm) for available soil moisture under different irrigation options.

**VIII. CONCLUSION**
1. CROPWAT is a strong tool for Irrigation Scheduling. It is a computer interactive and handling of database is very much smooth.

2. Canal system management for delivering required amount of irrigation water at right time is very much depending upon suitable Irrigation Scheduling matching with constraint and flexibility of the canal system.

3. The performances of this system depend on preparation of realistic canal operation plan and its implementation.

4. An effort has been made to study the important feature of Irrigation Scheme.

5. In order to judge suitability of Irrigation Scheduling options, options are selected and studied in respect of reference evapotranspiration of various crops in different seasons thereby working out crop water management,

6. Net Irrigation Requirement and Irrigation Demand with canal running time.

7. Crop yield and C.C.A will increase with optimum Irrigation Scheduling also saving water.

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