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Research Paper Engineering

Optimization of the Irrigation water Efficiency

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ABSTRACT

In the present world scenario, the issue of water resource management has assumed paramount importance and occupied the centre stage of politico-economic debates. The crucial role of water can be gauged from the MIT prediction that "if at all there is going to be third world war, it would be for the sake of water" (Conflict Analysis Wing, MIT, USA).
The world is passing through a critical phase with regard to water. And looking to the future trends, the picture regarding water is very gloomy. The importance of agriculture sector for initiating and sustaining economic growth in developing countries is alone a recognized fact. In developing countries with limited cultivable land, growing population pressure and diminishing returns in agriculture, exploring the possibilities for achieving significant land-augmenting technical progress offered by the "Green Revolution" technology is of utmost importance.

I. Introduction

To increase crop yield, proper development and management of irrigation is of paramount importance since the success and efficiency of other inputs are dependent on the quantity, quality and timing of water supply and the control over it. The role of irrigation has been significant in increasing the crop yields. Further, under Indian conditions also the role of water, which is a scarce economic resource as an instrument of socio-economic development hardly, needs any emphasis. This is especially so in view of the monsoon pattern of rainfall in India, which is capricious in its incidence and variable in its amount. There is a marked seasonality in many regions, even total precipitation is grossly inadequate for crop growth and is often undependable due to it's wide departure from the normal.

OBJECTIVES OF THE STUDY

Objectives

- To determine the irrigation water supply for a given crop in terms of frequency and irrigation depth, assuring optimal crop growth and efficient water use.
- To assess adequacy of existing irrigation practices in terms of efficient water use and production level as a base to develop and promote better irrigation practices.
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Study Area - Dharoi Command Area

The Sabarmati originates in the Aravaili hills of Rajasthan state at an elevation of 762 meters above the mean sea level.

After traveling approximately 48 km in the state of Rajasthan, it enters the Gujarat state.

The River Joins the Gulf of Cambay after traveling 323 km in Gujarat. The Sabarmati basin is bordered by Ravioli hills on the North and North East and on the east by a ridge separating it from the basin of Mahi. (GOG. 1996). The total drainage area of the basin is about 21,674 sq km, of which 17,550 (80 per cent) is in Gujarat, and the remaining (20 per cent) in Rajasthan.

The area covering upper sub-basin and the catchment of the main river up to Dharoi dam is designated as Dharoi sub-basin. Constructed in 1978, the Dharoi dam is located about 165 km upstream form Ahmedabad, in village Dharoi of Mehsana district.

The location of Sabarmati Reservoir Project is at latitude 24 -N & longitude 72-52' E,near village Dharoi, Taluka- Satlasana, Dist.-Mehsana in Gujarat State.

Aim : To study and analyze the cropping pattern and to develop an analytical solution to help the farmers for achieving them their economic goals by integrating the different controlled and uncontrolled parameters with the efficient use of irrigation water.

METHODOLOGY:

THE CROPWAT 8.0

CROPWAT 8.0 for Windows is a computer programme for the calculation of crop water requirements and irrigation requirements from existing or new climatic and crop data. Furthermore, the program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns.

Programme structure

The CROPWAT programme is organised in 8 different modules, of which 5 are data input modules and 3 are calculation modules. These modules can be accessed through the CROPWAT main menu but more conveniently through the Modules bar that is permanently visible at the left hand side of the main window. This allows the user to easily combine different climatic, crop and soil data for calculation of crop water requirements, irrigation schedules and scheme supplies.

The data input modules of CROPWAT are:

1. Climate/ETo: for the input of measured ETo data or of climatic data that allow calculation of ETo Penman-Monteith;
2. Rain: for the input of rainfall data and calculation of effective rainfall;
3. Crop (dry crop or rice): for the input of crop data and planting date;
4. Soil: for the input of soil data for (only needed for irrigation scheduling);
5. Crop pattern: for the input of a cropping pattern for scheme supply calculations

The calculation modules of CROPWAT are:

6. CWR - for calculation of Crop Water Requirements
7. Schedules (dry crop or rice) - for the calculation of irrigation schedules
8. Scheme - for the calculation of scheme supply based on a specific cropping pattern

How to calculate ETo Penman-Monteith
Select the Climate/ETo module on the Module bar. A data window will open on the right for the current default data type for climate/ETo. If the data type is not the one you want to work with, click on the small arrow of the New button on the Toolbar, and select the correct data type from the drop down menu.

You can then either load data from an existing file, or enter new data. As soon as data for i.e.. a specific month are complete, CROPWAT automatically calculates the Radiation and ETo Penman-Monteith and displays the results in the last two columns of the table.

See the technical reference for more information on the Penman-Monteith algorithms.

Note: when loading files from the CLIMWAT database, CROPWAT re-calculates Radiation and ETo values. Because of some minor differences in algorithms rounding procedures, the results from CROPWAT may differ slightly from those included in the CLIMWAT database.

Climate / ETo module
This module can be selected by clicking on the Climate/ETo icon in the module bar located on the left of the main CROPWAT window. The data window will open with the default data type for that data; it is possible to quickly change to another data type by using the drop down menu from the New button on the toolbar. In alternative, use the New button in the File drop down menu; sub menus allow selection of the kind of new data and data type to be entered.

Data types available within this module are:
- Monthly ETo Penman-Monteith
- Decade ETo Penman-Monteith
- Daily ETo Penman-Monteith
- Monthly measured ETo
- Decade measured ETo
- Daily measured ETo

Monthly/Decade/Daily ETo Penman-Monteith
The Climate/ETo module is primary for data input, requiring information on the meteorological station (country, name, altitude, latitude and longitude) together with climatic data, that can be inputted on a monthly, decade or daily basis. Concerning climatic parameters, CROPWAT requires Temperature, but Humidity, Wind speed and Sunshine should be entered, where available.

This module also include calculations, producing:
- Radiation
- Reference evapotranspiration (ETo) data using the FAO Penman-Monteith approach.

Climate / ETo options
The Climate/ETo options are accessed by choosing Options from the Settings menu or by choosing the Options button on the toolbar while the Climate/ETo module is the active window.

UNITS OPTIONS:
The following unit options are available:

Humidity: expressed as relative humidity (%) or actual vapour pressure (kPa)

Wind speed: expressed as kilometres per day (km/day) or meters per second (m/s)

Sunshine: expressed as hours of sunshine (hours), percentage of daylight (%) or fraction of daylight (fraction)

Reference evapotranspiration (ETo) expressed as mm per day or mm per period. Period corresponds to the data type: monthly, decade or daily data.

Humidity
In CROPWAT 8.0, air humidity can be expressed as relative humidity or actual vapour pressure.

Relative humidity expresses the degree of saturation of the air, as the ratio between the amount of water the ambient air actually holds and the maximum amount it could hold at the same temperature. Relative humidity fluctuates between a maximum near the sunrise and a minimum around early afternoon, in accordance with temperature variations. Relative humidity is expressed as a percentage (%). The figure below shows the variation of the relative humidity over 24 hours for a constant actual vapour pressure.

Actual vapour pressure represents the vapour pressure exerted by the water in the air. It is expressed in kPa.

Radiation
On the base of climatic data available, CROPWAT estimates the solar radiation reaching soil surface.

The extraterrestrial radiation (Ra) represents the radiation received at the top of the earth's atmosphere on a horizontal surface, depending on latitude, date and time of the day. Solar radiation (Rs), computed in CROPWAT calculations, represents the amount of extraterrestrial radiation reaching a horizontal plane on soil surface, that is computing the fraction of extraterrestrial radiation scattered, reflected or absorbed by the atmospheric gases, clouds and dust. Part of the solar radiation is reflected from the soil surface, part is absorbed (Rns).

Radiation is expressed in MJ /m2 /day.

Reference Evapotranspiration (ETo)
The evapotranspiration rate from a Reference crop not short of water is called the Reference evapotranspiration (ETo).

The concept of ETo was introduced to study the evaporative demand of the atmosphere independently of crop type, crop development and management practices. As water is abundantly available at the reference evapotranspiring surface, soil factors do not affect ETo. Relating the evapotranspiration process to a specific surface provides a reference to which evapotranspiration from other surfaces can be related. It obviates the need to define a separate evapotranspiration level for each crop and stage of growth. ETo values measured or calculated at different locations or in different seasons are comparable as they refer to the evapotranspiration from the same reference surface.

The only factors affecting ETo are climatic parameters. Consequently, ETo is a climatic parameter and can be computed from weather data. ETo expresses the evaporating power of the atmosphere at a specific location and time of the year and does not consider the crop characteristics and soil factors. The FAO Penman-Monteith method is recommended as the sole method for determining ETo. This method has been selected because it provides values that are very consistent with actual crop water use data worldwide, as it has been demonstrated through many years of evaluations reported in the scientific literature. This method overcomes the shortcoming of previously recommended methods, and explicitly incorporates both physiological and aerodynamic parameters. Moreover, procedures have been developed for using the this method even with limited climatic data.

Sunshine
Sunshine represents the duration of the daylight without clouds. Apart from the cloudiness, it depends on the position of the sun and is hence a function of latitude and day of the year. It is expressed as hours of sunshine (hours), as a percentage of daylight (%) or as fraction of daylight (fraction). To set sunshine units, choose Options from the Settings menu or by choosing the Options button on the toolbar while the Climate/ETo module is the active window.

In case only Temperature data are available, CROPWAT 8.0 will estimate the values for the other climatic data (Humidity, Wind speed and radiation).

Temperature
In line with agrometeorological standards, CROPWAT 8.0 refers to air temperature measured at 2 meters above the ground. Temperature is given in degree Celsius (°C).

CROPWAT 8.0 can work with minimum and maximum temperatures (default), or with average temperatures if minimum / maximum temperatures are not available. Daily maximum air temperature and daily minimum air temperature are, respectively, the maximum and minimum air temperature observed during the 24-hours period, beginning at midnight. For longer periods, such as decades or months, maximum and minimum temperatures are obtained by dividing the sum of the respective daily values by the number of days in the period.

Wind speed
In line with agrometeorological standards, CROPWAT 8.0 refers to wind speed as measured at 2 meters above the ground.

Wind speed is slowest at the surface and increases with height. To adjust wind speed data obtained from instruments at elevations other than the standard height of 2 m, a logarithmic wind speed profile may be used:

In CROPWAT 8.0, wind speed is given in kilometres/day (km/day) or in meters per second (m/s).

Estimate (F6)
The Estimate button is located on the right-hand side of the Toolbar. This button is only enabled for the data entry screens for ETo Penman-Monteith calculations, to allow estimates of values for humidity, wind speed and/or sunshine, based on the minimum and maximum temperatures (plus altitude/latitude in the case of sunshine).

FAO Penman-Monteith Approach A consultation of experts and researchers was organised by FAO in 1990, in collaboration with the International Commission for Irrigation and Drainage and with the World Meteorological Organization, to review the FAO methodologies on crop water requirements and to advise on the revision and update of procedures.

The panel of experts recommended the adoption of the Penman-Monteith combination method as a new standard for reference evapotranspiration and advised on procedures for calculation of the various parameters. By defining the reference crop as a hypothetical crop with an assumed height of 0.12 m having a surface resistance of 70 s m-1 and an albedo of 0.23, closely resembling the evaporation of an extension surface of green grass of uniform height, actively growing and adequately watered, the FAO Penman-Monteith method was developed. The method overcomes shortcomings of the previous FAO Penman method and provides values more consistent with actual crop water use data worldwide.

From the original Penman-Monteith equation and the equations of the aerodynamic and surface resistance

The FAO Penman-Monteith equation is a close, simple representation of the physical and physiological factors governing the evapotranspiration process. By using the FAO Penman-Monteith definition for ETo, one may calculate crop coefficients at research sites by relating the measured crop evapotranspiration (ETc) with the calculated ETo, i.e., Kc = ETc/ETo. In the crop coefficient approach, differences in the crop canopy and aerodynamic resistance relative to the hypothetical reference crop are accounted for within the crop coefficient. The Kc factor serves as an aggregation of the physical and physiological differences between crops and the reference definition.

Effective Rainfall
For agricultural production, effective rainfall refers to that portion of rainfall that can effectively be used by plants. This is to say that not all rain is available to the crops as some is lost through Runoff (RO) and Deep Percolation (DP).

As input of monthly rainfall, the average, dependable or actual rainfall data can be given of long-term rainfall records.

Through the Rain Options, CROPWAT 8.0 offers the possibility to use several methods to calculate the effective rainfall:

1. Fixed percentage of rainfall
2. Dependable Rain
3. Empirical formula
4. USDA Soil Conservation Service Method

Moreover, it offers the possibility to carry out irrigation calculations without considering rainfall.

Note that in the CWR calculations, the decade effective rainfall is used, estimated through one of the methods proposed in the Rain Options.

On the contrary, in the Scheduling calculations, the intake of rain into the soil is determined on a daily basis and rainfall losses due to deep percolation and surface runoff are estimated according to actual soil moisture content in the root zone. Total rainfall and not effective rainfall is therefore used for the water balance calculations.

Calculation of Crop Water Requirements
To calculate Crop Water Requirements, you first have to make sure that data are available on climate/ETo, rainfall and crop (dry crop or rice). If you have previously saved a combination of these data files as a session you can quickly reload those data through the File>Open Session menu item. If not, you have to go to each of these modules through the Modules bar, and either load existing data or enter new data.

Conclusion
By using this software we can have The Scientific approach towrads the use of water efficiency and we able to create conjuctive use of water. In this software the calculation of the water requirement is done based on Evapotranspiration, crop water requirement, cropping pattern, available water, replenishment of the water by rainfall so by doing this we can have the optimum use of water instead of the traditional approach of available water and warabandi adopted by the irrigation department.

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