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# Evaluation of Crop Water Requirement and Effective Rainfall Using CROPWAT 8.0.

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***Abstract:*** In any nation, the development of agriculture and the economy depends on land and water. Without water, it would be impossible for people to irrigate their crops; thus, farmers would need to increase the amount of food they produced from already-cultivated land, especially in India, in order to feed the world's rapidly growing population. To properly manage irrigation, crop water requirements for different crops and different management levels must be estimated in order to achieve maximum use of groundwater resources. The aim of the current study is to evaluate the effective rainfall and crop water requirements using CROPWAT 8.0. The Vansda taluka of Gujarat's Navsari district is the research area that is being taken into consideration here. The crops used for Vansda taluka calculations of crop water requirements include Rice, Sugarcane, Brinjal, Ladyfinger, and Pigeon pea. In this work, reference evapotranspiration (ETo) was computed using the FAO Penman Monteith method and effective rainfall was calculated using the USDA SCS method. The data gathered from farmers and small amounts of data from the STATE WATER DATA CENTER in Gandhinagar were used to establish the water requirements of each crop. In this study, ETo ranged from 4.77 to 11.34 mm/day. Maximum effective rainfall occurred in year 2012 (87.4mm). Crop water requirements were determined for this study from 2012 to 2016. Rice irrigation requirements range from 491.5 to 1032.6 mm/Dec, with June typically requiring the most water. The middle of May required 1039.3 to 2591.4 mm/Dec of irrigation for Sugarcane. Brinjal required irrigation from 303.8 to 1030.8 mm/Dec, with a high water demand in the final stages of March. For Ladyfinger Irrigation requirements Range from 288.1 to 988.5 mm/Dec. for Pigeon pea Irrigation Requirements range from 181.5 to 408.2 mm/Dec in the last stages, with the month of September requiring the most water.

***Index Term* - Effective Rainfall, Crop Water Requirement, Irrigation Scheduling, CROPWAT 8.0.**

## I. INTRODUCTION:

Water scarcity has become a problem as a result of population growth and rising standards, and it is now critical to improve integrated technology and multidisciplinary water resource management capabilities. Proper water management techniques are now important than ever in order to increase food production while saving as much water as possible, or, to put it another way, to increase the water use effectiveness of field crops. In addition to the rising demand for water for other uses (industrial and home usage), declining water quality will also reduce the amount of water available for the agricultural sector in the future. Water can be saved by careful planning and timely delivery of the necessary amount. In order to increase water use efficiency, methods and practices that give a more precise supply of water to crops will be a key challenge in the near future.

The second-largest producer of goods like fruits, vegetables, sugarcane, rice, and wheat in the world is India. India is the most well-known country and one that is most associated with agriculture sector. Population growth, urbanisation, and climate changes will all have a substantial impact on the agricultural sector. Agriculture now consumes 80% of the water in India. In 2021, 52% of agricultural land will be irrigated, and the remaining 49% will depend on rainfall. In order to get the highest crop production possible, the ideal amount of water must be supplied and the watering schedule must be maintained.

There are various ways for calculating the crop water requirement and scheduling, but the traditional approaches are difficult and time-consuming. The FAO (food and agriculture Organization) discovered the best, most straightforward, and easiest-to-use software, CROPWAT 8.0, to estimate crop water requirements simply and more accurately, as well as to establish scheduling. The CWR, irrigation schedule, evapotranspiration, effective rainfall, and cropping pattern are all calculated using this program. In the present study, we used the CROPWAT 8.0 tool for calculating the effective rainfall, CWR and irrigation scheduling in Vansda taluka. CROPWAT is being developed as a practical tool. It enables the creation of suggestions for better irrigation techniques and the scheduling of irrigation system under various water supply situations.

## II. STUDY AREA:

The Vansda taluka in the Navsari district is the research area for the current study. Vansda taluka is located at latitude 20.7655° N and longitude 73.3607° E. There are 76 meters of elevation. Vansda taluka is located on the Ambika River. There are 94 villages in Vansda taluka. This taluka's geographic area is 557km2. Vansda taluka is in the southern Navsari district. In general, the soil in Vansda taluka is composed primarily of sandy soil, deep black soil, and a trace quantity of clay. Rice, sugarcane, pigeon pea, brinjal, banana, onions, and other crops are the most widely farmed in the Vansda taluka and irrigated by the Keliya dam.

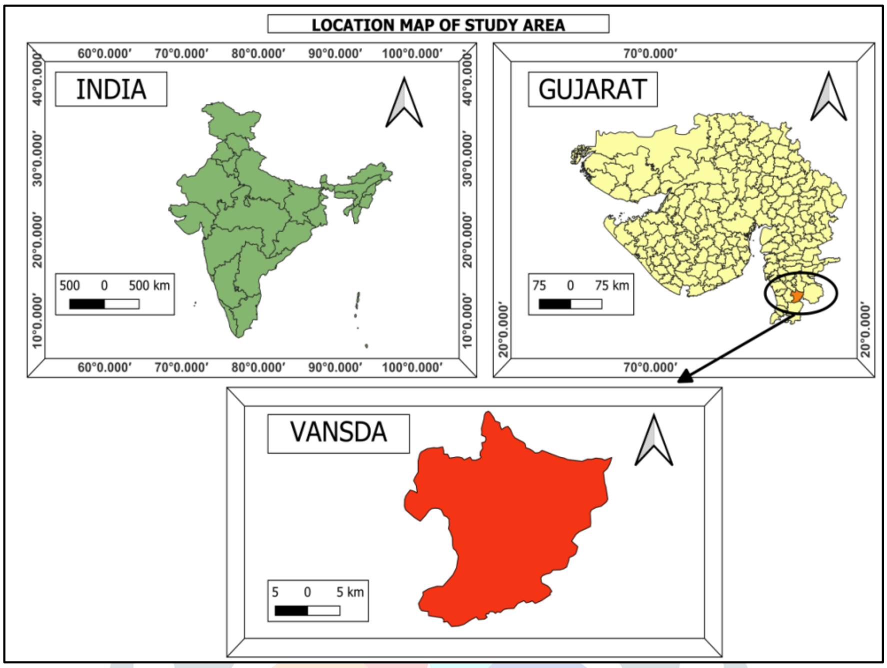



**Figure 1.1** Study Area Map

## III. DATA COLLECTION:

Climate data such as maximum and minimum temperature, humidity, wind speed, and sunshine hours were used in this study. In this study, we calculating crop water requirement and effective rainfall using CROPWAT 8.0. For this calculation, the required data are climate data, rain data, crop data and soil data. Climate data was obtained from the Gandhinagar STATE WATER DATA CENTER for the years 2012 to 2016. Using climate data, CROPWAT determines radiation and ETo.

Rain data was collected from the SWDC. Crop information has been obtained from the FAO manual, like the crop coefficient, critical depletion, and yield response factors. Through the survey, farmers provide crop information such as growth stages and height. Soil data such as maximum infiltration rate, rooting depth, and soil moisture depletion are obtained from the FAO manual. The total available soil moisture is carried out by soil testing. The CROPWAT programme is used to calculate this data in order to access the CWR, effective rainfall and scheduling.

## IV. METHODOLOGY:

### A. CROPWAT

Developed by the FAO (food and agriculture organization), CROPWAT is a decision- support tool with the following primary purposes: to calculate reference evapotranspiration, crop water requirement, and irrigation needs; to construct irrigation schedules for different management scenarios; and to scheme water supply. The penman-Monteith method is used to calculate reference evapotranspiration. Crop water requirements and irrigation schedule calculations use this reference evapotranspiration estimate. Cropwater determines the amount of irrigation water needed at various phases of crop development throughout the growing season, either on a monthly, weekly, or cropping pattern basis in an irrigated area. Meteorological data, crop growth data, and soil data are main input parameters in this programme. This software saves time and is simple to use. It also produces better results.

**B. Penman Monteith equation**

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34 u_2)}$$

Where,
ETo= Reference evapotranspiration, mm day$^{-1}$
Rn= Net radiation at the crop surface, MJ m2 day$^{-1}$
G= Soil heat flux density, MJ m2 day$^{-1}$
T= Mean daily temperature at 2m height, °C
u2= Wind speed at 2 m height, ms$^{-1}$
es= Saturation vapoure pressure kPa
ea= Actual vapour pressure, kPa
es – ea = Saturation vapour pressure deficit, kPa
Δ = Slope vapour pressure curve, kPa °C$^{-1}$
γ = Psychometric constant kPa °C$^{-1}$

**C. Effective Rainfall**

Using CROPWAT software, the effective rainfall is calculated. Effective rainfall, fixed percentage, dependable rainfall, empirical formula, and USDA soil conservation service are the four methods to calculate rainfall. Here I compare this four method. To determine the percentage losses of rainfall in the research area, I evaluated four approaches. These are the results:

Fixed percentage of rainfall (80%) = 29.9%
Dependable rainfall = 69.4%
Empirical formula = 67.8 %
USDA soil conservation services = 15.3%

The USDA soil conservation service method was selected to determine the effective rainfall in the research area because it estimates the lowest loss at 15.3%. Crop water requirements are calculated using input from soil and crop data. Calculating the amount of water a crop needs requires multiplying the reference evapotranspiration by the crop coefficients. The FAO manual determines the Kc value for various stages. Using below equation determine effective rainfall.

Peff = P*(125-0.2*P)/ 125 For P < = 250 mm
Peff = 125 +0.1 *P For P > = 250 mm

**D. Crop coefficient**

The crop coefficient (Kc) includes the impact of factors that differentiate a particular crop from the reference crop. According to the crop coefficient approach, the reference evapotranspiration (ETo) is a multiplied by the appropriate Kc to determine the crop evapotranspiration under standard conditions (Etc). Crop type has a biggest impact on Kc, with the climate and soil evaporation having less of an impact. Also the Kc for a certain crop changes as the crop grows, as crop development effects ground cover, crop height and leaf area.

**E. Crop coefficient curve**

The total growing period for seasonal crops can be divided into four different growth stages:

- The first stage: it extends from planting to about 10 % ground cover.
- Stage of development: this stage 10% ground cover to effectively complete cover, which typically happens at the start of flowering.
- Mid-season stage: this time extends from effective full cover to the start of maturity, which is frequently characterized by beginning of ageing, yellowing and senescence of leaves, leaf drop, or browning of fruit.
- Late season stage: this duration includes the stage leading up to harvest or complete senescence.

**f. Crop Evapotranspiration (Etc)**

The difference in evapotranspiration between the reference grass surface and the cropped grass surface is expressed by the coefficient Kc, which is multiplied by ETo to compute crop evapotranspiration.

$$ETc = Kc \times ETo$$

### G. Irrigation scheduling

In cases where rainfall is inadequate to compensate for water lost through evapotranspiration, irrigation is necessary. The main goal of irrigation is to apply the appropriate amount and timing of water. The following circumstances are used to carry out irrigation scheduling: critical depletion, fixed depletion irrigation, user defined interval irrigation, fixed interval irrigation for each stage.
Below fig show crop data input and soil data Input in CROPWAT.

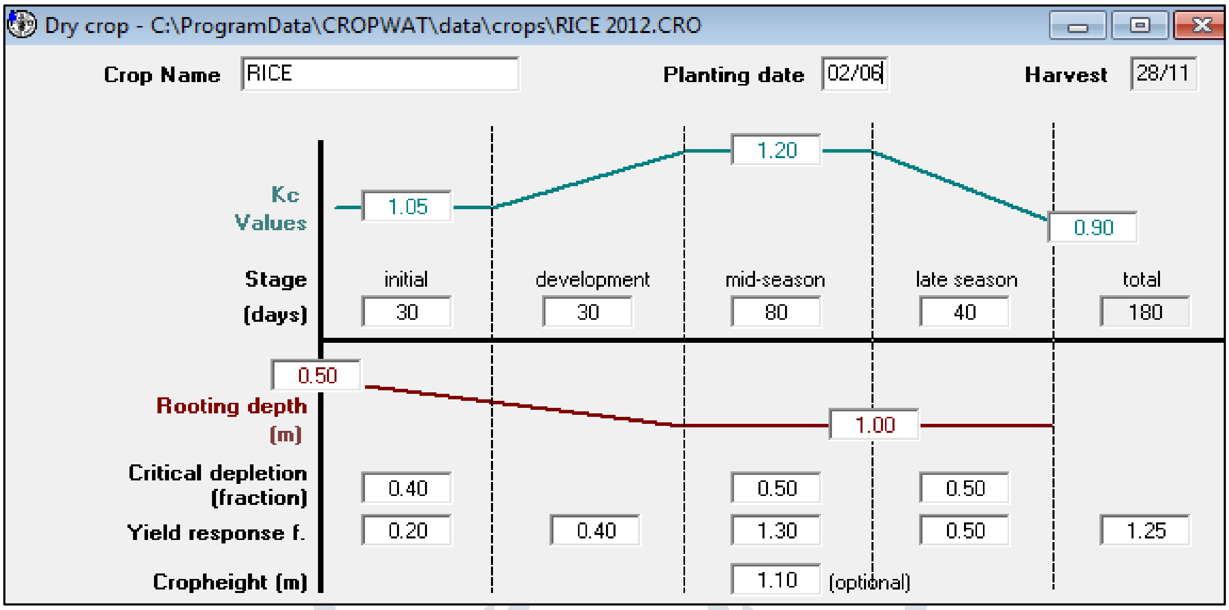



**Figure 1.2** Crop Data Input

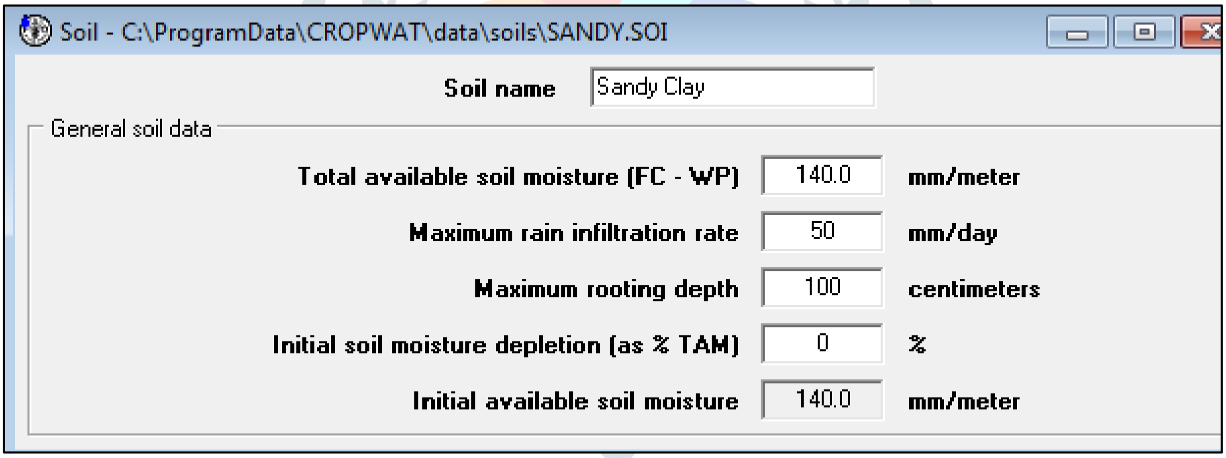


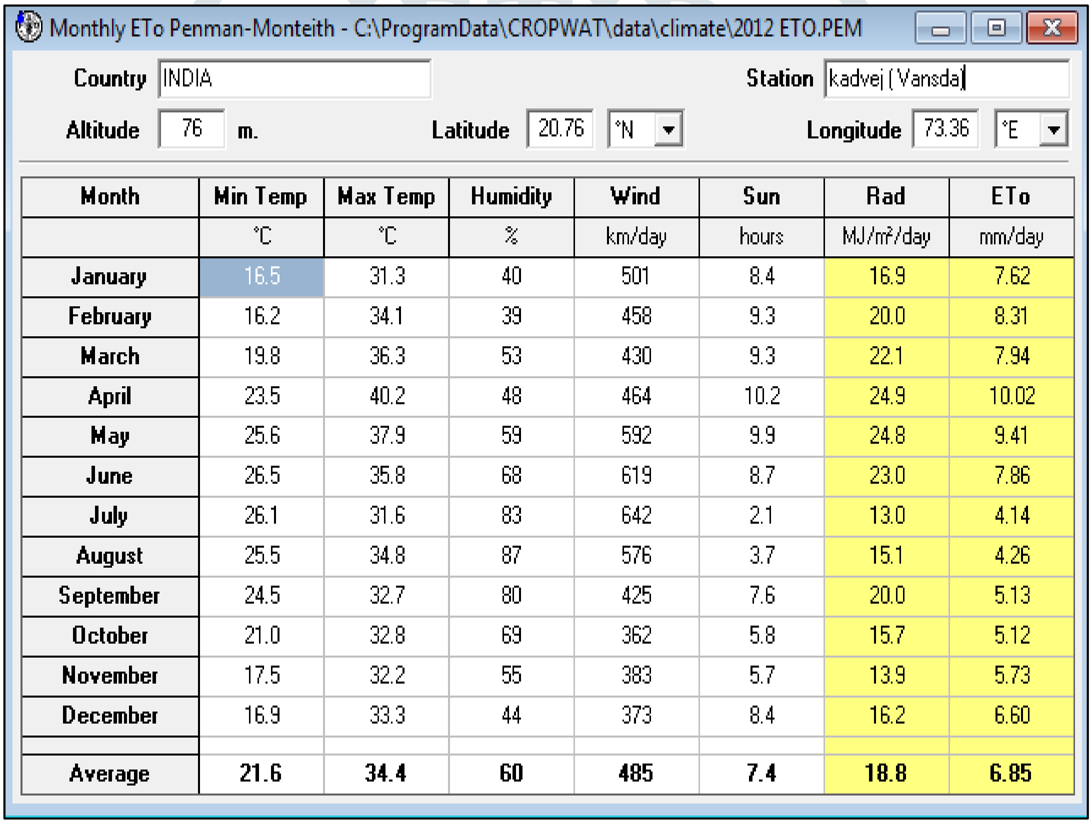

**Figure 1.3** Soil Data Input

## V. RESULT AND DISCUSSION:

Using data from 2012 to 2016, I am calculating the crop water requirements for five different crops in my current research. Here, I'm providing a tabular representation of the reference evapotranspiration and effective rainfall calculations. As I m collecting daily data and all value in the table are in monthly format, I first converted the daily data to monthly format in MS-EXCEL before entering the data. The USDA SCS method is used to compute effective precipitation, and penman equation is used to determine reference evapotranspiration. As an example of how to inputs and receive values for effective rainfall and ET0, I'm only using climate and precipitation data from one year. Other year's procedures are the same.

**Table 1.1** Calculation of effective rainfall in CROPWAT

| Station: Ghodmal | | effective rainfall method:USDA SCS |
|---|---|---|
| (Vansda) | Rain (mm) | Effective rain (mm) |
| January | 0 | 0 |
| February | 0 | 0 |
| March | 0 | 0 |
| April | 0 | 0 |
| May | 0 | 0 |
| June | 0 | 0 |
| July | 36.1 | 34 |
| August | 48.2 | 44.5 |
| September | 5.6 | 5.5 |
| October | 0.7 | 0.7 |
| November | 0 | 0 |
| December | 0 | 0 |
| Total | 90.6 | 84.7 |




| Month | Min Temp | Max Temp | Humidity | Wind | Sun | Rad | ETo |
|---|---|---|---|---|---|---|---|
| | °C | °C | % | km/day | hours | MJ/m²/day | mm/day |
| January | 16.5 | 31.3 | 40 | 501 | 8.4 | 16.9 | 7.62 |
| February | 16.2 | 34.1 | 39 | 458 | 9.3 | 20.0 | 8.31 |
| March | 19.8 | 36.3 | 53 | 430 | 9.3 | 22.1 | 7.94 |
| April | 23.5 | 40.2 | 48 | 464 | 10.2 | 24.9 | 10.02 |
| May | 25.6 | 37.9 | 59 | 592 | 9.9 | 24.8 | 9.41 |
| June | 26.5 | 35.8 | 68 | 619 | 8.7 | 23.0 | 7.86 |
| July | 26.1 | 31.6 | 83 | 642 | 2.1 | 13.0 | 4.14 |
| August | 25.5 | 34.8 | 87 | 576 | 3.7 | 15.1 | 4.26 |
| September | 24.5 | 32.7 | 80 | 425 | 7.6 | 20.0 | 5.13 |
| October | 21.0 | 32.8 | 69 | 362 | 5.8 | 15.7 | 5.12 |
| November | 17.5 | 32.2 | 55 | 383 | 5.7 | 13.9 | 5.73 |
| December | 16.9 | 33.3 | 44 | 373 | 8.4 | 16.2 | 6.60 |
| | | | | | | | |
| Average | 21.6 | 34.4 | 60 | 485 | 7.4 | 18.8 | 6.85 |

**Figure 1.4** Climate data input and ETo result in CROPWAT

The estimations for each crop only show the decreasing and increasing water consumption from 2012 to 2016. The term "CWR" refers to the amount of water used at depth by each crop to compensate for water loss due to evapotranspiration. Here I show only more and less water requirements for each crop in the study area.

**Rice:** The CWR for rice had a range of 491.5 to 1032.6 mm/Dec. the date of planting rice is March 13. The need of water is high in June. In 2012, 1032.6 mm/Dec of irrigation water needed; however, in 2016 less water needed. Effective rainfall for the years 2016 and 2012 is 69.5mm/Dec and 84.9mm/Dec, respectively. The CWR represented in various stages. Below table also shows the relation between the need of irrigation and actual rainfall.

**Table 1.2** Low water requirements for rice

| Month | Decade | Stage | Kc | ETc | ETc | Eff rain | Irri. Req. |
|---|---|---|---|---|---|---|---|
| | | | Coeff | mm/day | mm/Dec | mm/Dec | mm/Dec |
| Jun | 1 | Init | 1.05 | 4.7 | 42.3 | 0 | 42.3 |
| Jun | 2 | Init | 1.05 | 4.3 | 43 | 0 | 43 |
| Jun | 3 | Init | 1.05 | 3.84 | 38.4 | 0.5 | 37.9 |
| Jul | 1 | Deve | 1.05 | 3.32 | 33.2 | 6.4 | 26.9 |
| Jul | 2 | Deve | 1.06 | 2.85 | 28.5 | 9.5 | 19 |
| Jul | 3 | Deve | 1.07 | 2.81 | 30.9 | 9.9 | 21 |
| Aug | 1 | Mid | 1.07 | 2.72 | 27.2 | 10.8 | 16.4 |
| Aug | 2 | Mid | 1.07 | 2.59 | 25.9 | 11.9 | 14 |
| Aug | 3 | Mid | 1.07 | 2.91 | 32 | 9 | 22.9 |
| Sep | 1 | Mid | 1.07 | 3.33 | 33.3 | 5.3 | 28 |
| Sep | 2 | Mid | 1.07 | 3.65 | 36.5 | 2.6 | 33.8 |
| Sep | 3 | Mid | 1.07 | 3.4 | 34 | 1.9 | 32 |
| Oct | 1 | Mid | 1.07 | 3.11 | 31.1 | 1.2 | 29.9 |
| Oct | 2 | Late | 1.07 | 2.89 | 28.9 | 0.2 | 28.7 |
| Oct | 3 | Late | 1.04 | 2.74 | 30.1 | 0.1 | 30 |
| Nov | 1 | Late | 0.98 | 2.54 | 25.4 | 0.1 | 25.3 |
| Nov | 2 | Late | 0.92 | 2.36 | 23.6 | 0 | 23.6 |
| Nov | 3 | Late | 0.88 | 2.09 | 16.7 | 0 | 16.7 |
| | | | | | 561 | 69.5 | 491.5 |

**Table 1.3** High water requirements for rice

| Month | Decade | Stage | Kc | ETc | ETc | Eff rain | Irri. Req. |
|---|---|---|---|---|---|---|---|
| | | | Coeff | mm/day | mm/Dec | mm/Dec | mm/Dec |
| Jun | 1 | Init | 1.05 | 8.94 | 80.4 | 0 | 80.4 |
| Jun | 2 | Init | 1.05 | 8.47 | 84.7 | 0 | 84.7 |
| Jun | 3 | Init | 1.05 | 7.09 | 70.9 | 0.1 | 70.8 |
| Jul | 1 | Deve | 1.08 | 5.46 | 54.6 | 8.3 | 46.3 |
| Jul | 2 | Deve | 1.15 | 4.2 | 42 | 12.4 | 29.6 |
| Jul | 3 | Deve | 1.23 | 4.72 | 52 | 13.2 | 38.7 |
| Aug | 1 | Mid | 1.26 | 5.33 | 53.3 | 15.2 | 38.1 |
| Aug | 2 | Mid | 1.26 | 5.38 | 53.8 | 17.1 | 36.6 |
| Aug | 3 | Mid | 1.26 | 5.74 | 63.2 | 12 | 51.1 |
| Sep | 1 | Mid | 1.26 | 6.11 | 61.1 | 5.1 | 56 |
| Sep | 2 | Mid | 1.26 | 6.48 | 64.8 | 0.2 | 64.5 |
| Sep | 3 | Mid | 1.26 | 6.47 | 64.7 | 0.2 | 64.5 |
| Oct | 1 | Mid | 1.26 | 6.47 | 64.7 | 0.7 | 64 |
| Oct | 2 | Late | 1.26 | 6.46 | 64.6 | 0.1 | 64.5 |
| Oct | 3 | Late | 1.21 | 6.45 | 71 | 0.1 | 70.9 |
| Nov | 1 | Late | 1.14 | 6.28 | 62.8 | 0.1 | 62.7 |
| Nov | 2 | Late | 1.06 | 6.1 | 61 | 0 | 61 |
| Nov | 3 | Late | 1 | 6.01 | 48.1 | 0 | 48.1 |
| | | | | | 1117.5 | 84.9 | 1032.6 |

**Sugarcane:** the range of crop water requirement for sugarcane is 1039.3 to 2591.4 mm/Dec, with high crop water requirement in 2012 and low crop water needed in 2016. Typically, the crop water requirement is in the month of May at mid- stage of development. Effective rainfall for the years 2012 and 2016 is 84.9mm/Dec and 69.5 mm/Dec, respectively. The next table also shows the connection between the need of irrigation and actual rainfall. The crop water requirement is represented in various stages.

**Table 1.4.**Low water requirements for sugarcane

| Month | Decade | Stage | Kc | Etc | ETc | Eff rain | Irri. Req. |
|---|---|---|---|---|---|---|---|
| | | | Coeff | mm/day | mm/Dec | mm/Dec | mm/Dec |
| Jan | 1 | Init | 0.73 | 1.57 | 9.4 | 0 | 6.3 |
| Jan | 2 | Init | 0.4 | 0.88 | 8.8 | 0 | 8.8 |
| Jan | 3 | Init | 0.4 | 0.98 | 10.8 | 0 | 10.8 |
| Feb | 1 | Deve | 0.4 | 1.09 | 10.9 | 0 | 10.9 |
| Feb | 2 | Deve | 0.46 | 1.36 | 13.6 | 0 | 13.6 |
| Feb | 3 | Deve | 0.53 | 1.74 | 13.9 | 0 | 13.9 |
| Mar | 1 | Deve | 0.6 | 2.17 | 21.7 | 0 | 21.7 |
| Mar | 2 | Deve | 0.68 | 2.67 | 26.7 | 0 | 26.7 |
| Mar | 3 | Deve | 0.76 | 3.18 | 35 | 0 | 35 |
| Apr | 1 | Deve | 0.84 | 3.73 | 37.3 | 0 | 37.3 |
| Apr | 2 | Deve | 0.92 | 4.3 | 43 | 0 | 43 |
| Apr | 3 | Deve | 0.99 | 4.85 | 48.5 | 0 | 48.5 |
| May | 1 | Mid | 1.07 | 5.57 | 55.7 | 0 | 55.7 |
| May | 2 | Mid | 1.1 | 5.99 | 59.9 | 0 | 59.9 |
| May | 3 | Mid | 1.1 | 5.49 | 60.4 | 0 | 60.4 |
| Jun | 1 | Mid | 1.1 | 4.92 | 49.2 | 0 | 49.2 |
| Jun | 2 | Mid | 1.1 | 4.5 | 45 | 0 | 45 |
| Jun | 3 | Mid | 1.1 | 4.02 | 40.2 | 0.5 | 39.7 |
| Jul | 1 | Mid | 1.1 | 3.47 | 34.7 | 6.4 | 28.3 |
| Jul | 2 | Mid | 1.1 | 2.95 | 29.5 | 9.5 | 20 |
| Jul | 3 | Mid | 1.1 | 2.89 | 31.7 | 9.9 | 21.9 |
| Aug | 1 | Mid | 1.1 | 2.79 | 27.9 | 10.8 | 17.1 |
| Aug | 2 | Mid | 1.1 | 2.65 | 26.5 | 11.9 | 14.6 |
| Aug | 3 | Mid | 1.1 | 2.98 | 32.7 | 9 | 23.7 |
| Sep | 1 | Mid | 1.1 | 3.41 | 34.1 | 5.3 | 28.8 |
| Sep | 2 | Mid | 1.1 | 3.73 | 37.3 | 2.6 | 34.7 |
| Sep | 3 | Mid | 1.1 | 3.48 | 34.8 | 1.9 | 32.8 |
| Oct | 1 | Mid | 1.1 | 3.18 | 31.8 | 1.2 | 30.6 |
| Oct | 2 | Mid | 1.1 | 2.96 | 29.6 | 0.2 | 29.4 |
| Oct | 3 | Mid | 1.1 | 2.91 | 32 | 0.1 | 31.9 |
| Nov | 1 | Late | 1.09 | 2.83 | 28.3 | 0.1 | 28.2 |
| Nov | 2 | Late | 1.03 | 2.63 | 26.3 | 0 | 26.3 |
| Nov | 3 | Late | 0.97 | 2.31 | 23.1 | 0 | 23.1 |
| Dec | 1 | Late | 0.91 | 2.01 | 20.1 | 0 | 20.1 |
| Dec | 2 | Late | 0.84 | 1.73 | 17.3 | 0 | 17.3 |
| Dec | 3 | Late | 0.78 | 1.63 | 18 | 0 | 18 |
| Jan | 1 | Late | 0.73 | 1.57 | 6.3 | 0 | 6.3 |
| | | | | | 1112 | 69.6 | 1039.3 |

**Table 1.5** High water requirements for sugarcane

| Month | Decade | Stage | Kc | ETc | ETc | Eff rain | Irri. Req. |
|---|---|---|---|---|---|---|---|
| | | | Coeff | mm/day | mm/Dec | mm/Dec | mm/Dec |
| Jan | 1 | Init | 0.88 | 6.43 | 38.6 | 0 | 25.7 |
| Jan | 2 | Init | 0.4 | 3.05 | 30.5 | 0 | 30.5 |
| Jan | 3 | Init | 0.4 | 3.14 | 34.5 | 0 | 34.5 |
| Feb | 1 | Deve | 0.4 | 3.28 | 32.8 | 0 | 32.8 |
| Feb | 2 | Deve | 0.48 | 4.04 | 40.4 | 0 | 40.4 |
| Feb | 3 | Deve | 0.58 | 4.75 | 38 | 0 | 38 |
| Mar | 1 | Deve | 0.67 | 5.28 | 52.8 | 0 | 52.8 |
| Mar | 2 | Deve | 0.78 | 5.95 | 59.5 | 0 | 59.5 |
| Mar | 3 | Deve | 0.89 | 7.51 | 82.6 | 0 | 82.6 |
| Apr | 1 | Deve | 1 | 9.56 | 95.6 | 0 | 95.6 |
| Apr | 2 | Deve | 1.11 | 11.45 | 114.5 | 0 | 114.5 |
| Apr | 3 | Deve | 1.22 | 12.19 | 121.9 | 0 | 121.9 |
| May | 1 | Mid | 1.32 | 12.8 | 128 | 0 | 128 |
| May | 2 | Mid | 1.36 | 12.94 | 129.4 | 0 | 129.4 |
| May | 3 | Mid | 1.36 | 12.19 | 134.1 | 0 | 134.1 |
| Jun | 1 | Mid | 1.36 | 11.58 | 115.8 | 0 | 115.8 |
| Jun | 2 | Mid | 1.36 | 10.97 | 109.7 | 0 | 109.7 |
| Jun | 3 | Mid | 1.36 | 9.19 | 91.9 | 0.1 | 91.8 |
| Jul | 1 | Mid | 1.36 | 6.87 | 68.7 | 8.3 | 60.4 |
| Jul | 2 | Mid | 1.36 | 4.96 | 49.6 | 12.4 | 37.1 |
| Jul | 3 | Mid | 1.36 | 5.23 | 57.6 | 13.2 | 44.3 |
| Aug | 1 | Mid | 1.36 | 5.74 | 57.4 | 15.2 | 42.2 |
| Aug | 2 | Mid | 1.36 | 5.79 | 57.9 | 17.1 | 40.8 |
| Aug | 3 | Mid | 1.36 | 6.18 | 68 | 12 | 56 |
| Sep | 1 | Mid | 1.36 | 6.58 | 65.8 | 5.1 | 60.7 |
| Sep | 2 | Mid | 1.36 | 6.98 | 69.8 | 0.2 | 69.5 |
| Sep | 3 | Mid | 1.36 | 6.97 | 69.7 | 0.2 | 69.5 |
| Oct | 1 | Mid | 1.36 | 6.97 | 69.7 | 0.7 | 69 |
| Oct | 2 | Mid | 1.36 | 6.96 | 69.6 | 0.1 | 69.5 |
| Oct | 3 | Mid | 1.36 | 7.24 | 79.6 | 0.1 | 79.6 |
| Nov | 1 | Late | 1.35 | 7.45 | 74.5 | 0.1 | 74.4 |
| Nov | 2 | Late | 1.27 | 7.31 | 73.1 | 0 | 73.1 |
| Nov | 3 | Late | 1.19 | 7.19 | 71.9 | 0 | 71.9 |
| Dec | 1 | Late | 1.11 | 7.02 | 70.2 | 0 | 70.2 |
| Dec | 2 | Late | 1.03 | 6.8 | 68 | 0 | 68 |
| Dec | 3 | Late | 0.94 | 6.55 | 72.1 | 0 | 72.1 |
| Jan | 1 | Late | 0.88 | 6.43 | 25.7 | 0 | 25.7 |
| | | | | | 2689.2 | 84.9 | 2591.4 |

**Brinjal:** The CWR for brinjal varied from 303.8 to 1030.8 mm/Dec, with high crop water requirement in the year 2013 and low needed in 2015. Typically, the crop water requirement is in month of March at late-stages. Effective precipitation is 0.0mm/decade in both years. Thus, greater amount of water are needed for crop growth. The CWR is represented in various stages. The next table also shows the connection between the need of irrigation and actual rainfall.

**Table 1.6** Low water requirements for brinjal

| Month | Decade | Stage | Kc | Etc | ETc | Eff rain | Irri. Req. |
|---|---|---|---|---|---|---|---|
| | | | Coeff | mm/day | mm/Dec | mm/Dec | mm/Dec |
| Dec | 1 | Init | 0.6 | 1.43 | 1.4 | 0 | 1.4 |
| Dec | 2 | Init | 0.6 | 1.32 | 13.2 | 0 | 13.2 |
| Dec | 3 | Init | 0.6 | 1.31 | 14.4 | 0 | 14.4 |
| Jan | 1 | Deve | 0.6 | 1.3 | 13 | 0 | 13 |
| Jan | 2 | Deve | 0.68 | 1.46 | 14.6 | 0 | 14.6 |
| Jan | 3 | Deve | 0.8 | 1.83 | 20.1 | 0 | 20.1 |
| Feb | 1 | Deve | 0.92 | 2.24 | 22.4 | 0 | 22.4 |
| Feb | 2 | Mid | 0.99 | 2.56 | 25.6 | 0 | 25.6 |
| Feb | 3 | Mid | 0.99 | 2.81 | 22.4 | 0 | 22.4 |
| Mar | 1 | Mid | 0.99 | 3.04 | 30.4 | 0 | 30.4 |
| Mar | 2 | Mid | 0.99 | 3.28 | 32.8 | 0 | 32.8 |
| Mar | 3 | Late | 0.97 | 3.7 | 40.7 | 0 | 40.7 |
| Apr | 1 | Late | 0.9 | 3.99 | 39.9 | 0 | 39.9 |
| Apr | 2 | Late | 0.86 | 4.26 | 12.8 | 0 | 12.8 |
| | | | | | 303.8 | 0 | 303.8 |

**Table 1.7** High water requirements for brinjal

| Month | Decade | Stage | Kc | Etc | ETc | Eff rain | Irri. Req. |
|---|---|---|---|---|---|---|---|
| | | | Coeff | mm/day | mm/Dec | mm/Dec | mm/\Dec |
| Dec | 1 | Init | 0.6 | 3.38 | 3.4 | 0 | 3.4 |
| Dec | 2 | Init | 0.6 | 3.52 | 35.2 | 0 | 35.2 |
| Dec | 3 | Init | 0.6 | 3.55 | 39 | 0 | 39 |
| Jan | 1 | Deve | 0.6 | 3.52 | 35.2 | 0 | 35.2 |
| Jan | 2 | Deve | 0.72 | 4.21 | 42.1 | 0 | 42.1 |
| Jan | 3 | Deve | 0.9 | 5.89 | 64.8 | 0 | 64.8 |
| Feb | 1 | Deve | 1.07 | 7.84 | 78.4 | 0 | 78.4 |
| Feb | 2 | Mid | 1.18 | 9.38 | 93.8 | 0 | 93.8 |
| Feb | 3 | Mid | 1.18 | 10.73 | 85.9 | 0 | 85.9 |
| Mar | 1 | Mid | 1.18 | 12.59 | 125.9 | 0 | 125.9 |
| Mar | 2 | Mid | 1.18 | 14.13 | 141.3 | 0 | 141.3 |
| Mar | 3 | Late | 1.16 | 13.14 | 144.6 | 0 | 144.6 |
| Apr | 1 | Late | 1.08 | 11.12 | 111.2 | 0 | 111.2 |
| Apr | 2 | Late | 1.03 | 10.04 | 30.1 | 0 | 30.1 |
| | | | | | 1030.8 | 0 | 1030.8 |

**Ladyfinger:** The crop water requirement for ladyfinger had a range of 288.1 to 988.5 mm/Dec, with high crop water requirement in 2013 and low crop water needed in 2015. Typically, The CWR id in the month of March at late-stage of development. The date of planting ladyfinger is 23/11. The crop water requirement is represented in various stages. The next table also shows the relation between the need of irrigation and actual rainfall. Effective precipitation is 0.0 mm/Decade in both years.

**Table 1.8** High water requirements for ladyfinger

| Month | Decade | Stage | Kc | ETc | ETc | Eff rain | Irri. Req. |
|---|---|---|---|---|---|---|---|
| | | | Coeff | mm/day | mm/Dec | mm/Dec | mm/Dec |
| Nov | 3 | Init | 0.6 | 1.55 | 12.4 | 0 | 12.4 |
| Dec | 1 | Init | 0.6 | 1.43 | 14.3 | 0 | 14.3 |
| Dec | 2 | Init | 0.6 | 1.32 | 13.2 | 0 | 13.2 |
| Dec | 3 | Deve | 0.64 | 1.4 | 15.4 | 0 | 15.4 |
| Jan | 1 | Deve | 0.75 | 1.61 | 16.1 | 0 | 16.1 |
| Jan | 2 | Deve | 0.85 | 1.8 | 18 | 0 | 18 |
| Jan | 3 | Deve | 0.95 | 2.17 | 23.9 | 0 | 23.9 |
| Feb | 1 | Mid | 1 | 2.44 | 24.4 | 0 | 24.4 |
| Feb | 2 | Mid | 1 | 2.59 | 25.9 | 0 | 25.9 |
| Feb | 3 | Mid | 1 | 2.83 | 22.6 | 0 | 22.6 |
| Mar | 1 | Late | 1 | 3.06 | 30.6 | 0 | 30.6 |
| Mar | 2 | Late | 0.94 | 3.12 | 31.2 | 0 | 31.2 |
| Mar | 3 | Late | 0.87 | 3.31 | 36.4 | 0 | 36.4 |
| Apr | 1 | Late | 0.83 | 3.67 | 3.7 | 0 | 3.7 |
| | | | | | 288.1 | 0 | 288.1 |

**Table 1.9** High water requirements for ladyfinger

| Month | Decade | Stage | Kc | ETc | ETc | Eff rain | Irri. Req. |
|---|---|---|---|---|---|---|---|
| | | | Coeff | mm/day | mm/Dec | mm/Dec | mm/Dec |
| Nov | 3 | Init | 0.6 | 3.24 | 25.9 | 0 | 25.9 |
| Dec | 1 | Init | 0.6 | 3.38 | 33.8 | 0 | 33.8 |
| Dec | 2 | Init | 0.6 | 3.52 | 35.2 | 0 | 35.2 |
| Dec | 3 | Deve | 0.66 | 3.9 | 42.9 | 0 | 42.9 |
| Jan | 1 | Deve | 0.81 | 4.71 | 47.1 | 0 | 47.1 |
| Jan | 2 | Deve | 0.95 | 5.53 | 55.3 | 0 | 55.3 |
| Jan | 3 | Deve | 1.1 | 7.23 | 79.5 | 0 | 79.5 |
| Feb | 1 | Mid | 1.18 | 8.57 | 85.7 | 0 | 85.7 |
| Feb | 2 | Mid | 1.18 | 9.33 | 93.3 | 0 | 93.3 |
| Feb | 3 | Mid | 1.18 | 10.66 | 85.3 | 0 | 85.3 |
| Mar | 1 | Late | 1.17 | 12.47 | 124.7 | 0 | 124.7 |
| Mar | 2 | Late | 1.13 | 13.51 | 135.1 | 0 | 135.1 |
| Mar | 3 | Late | 1.08 | 12.17 | 133.9 | 0 | 133.9 |
| Apr | 1 | Late | 1.05 | 10.73 | 10.7 | 0 | 10.7 |
| | | | | | 988.5 | 0 | 988.5 |

**Pigeon pea:** The crop water requirement for pigeon pea is varied from 181.5 to 408.2 mm/ Decade, with high CWR in 2012 and low water needed in 2016. Typically crop water requirement is in month of September in late-stage of development. The date of planting pigeon pea is 10 June. The crop water requirement is represented in various stages. Effective rainfall for the years 2012 and 2016 is 84mm and 67.3mm, respectively. The next table is also shows the relation between the need of irrigation and actual rainfall.

**Table 1.10** Low water requirements for pigeon pea

| Month | Decade | Stage | Kc | Etc | ETc | Eff rain | Irri. Req. |
|---|---|---|---|---|---|---|---|
| | | | Coeff | mm/day | mm/Dec | mm/Dec | mm/Dec |
| Jun | 1 | Init | 0.5 | 2.24 | 2.2 | 0 | 2.2 |
| Jun | 2 | Init | 0.5 | 2.05 | 20.5 | 0 | 20.5 |
| Jun | 3 | Init | 0.5 | 1.83 | 18.3 | 0.5 | 17.8 |
| Jul | 1 | Init | 0.5 | 1.58 | 15.8 | 6.4 | 9.4 |
| Jul | 2 | Deve | 0.54 | 1.44 | 14.4 | 9.5 | 5 |
| Jul | 3 | Deve | 0.72 | 1.89 | 20.8 | 9.9 | 11 |
| Aug | 1 | Mid | 0.91 | 2.3 | 23 | 10.8 | 12.2 |
| Aug | 2 | Mid | 0.96 | 2.32 | 23.2 | 11.9 | 11.2 |
| Aug | 3 | Mid | 0.96 | 2.6 | 28.6 | 9 | 19.6 |
| Sep | 1 | Late | 0.96 | 2.97 | 29.7 | 5.3 | 24.4 |
| Sep | 2 | Late | 0.95 | 3.21 | 32.1 | 2.6 | 29.5 |
| Sep | 3 | Late | 0.93 | 2.95 | 20.6 | 1.4 | 18.7 |
| | | | | | 249.3 | 67.3 | 181.5 |

**Table 1.11** High water requirements for pigeon pea

| Month | Decade | Stage | Kc | Etc | ETc | Eff rain | Irri. Req. |
|---|---|---|---|---|---|---|---|
| | | | Coeff | mm/day | mm/Dec | mm/Dec | mm/Dec |
| Jun | 1 | Init | 0.5 | 4.26 | 4.3 | 0 | 4.3 |
| Jun | 2 | Init | 0.5 | 4.03 | 40.3 | 0 | 40.3 |
| Jun | 3 | Init | 0.5 | 3.38 | 33.8 | 0.1 | 33.7 |
| Jul | 1 | Init | 0.5 | 2.52 | 25.2 | 8.3 | 17 |
| Jul | 2 | Deve | 0.56 | 2.05 | 20.5 | 12.4 | 8.1 |
| Jul | 3 | Deve | 0.87 | 3.33 | 36.6 | 13.2 | 23.4 |
| Aug | 1 | Mid | 1.18 | 4.96 | 49.6 | 15.2 | 34.5 |
| Aug | 2 | Mid | 1.26 | 5.37 | 53.7 | 17.1 | 36.6 |
| Aug | 3 | Mid | 1.26 | 5.74 | 63.1 | 12 | 51.1 |
| Sep | 1 | Late | 1.26 | 6.09 | 60.9 | 5.1 | 55.8 |
| Sep | 2 | Late | 1.21 | 6.22 | 62.2 | 0.2 | 62 |
| Sep | 3 | Late | 1.17 | 5.97 | 41.8 | 0.2 | 41.6 |
| | | | | | 492.3 | 84 | 408.2 |

**Net Irrigation Requirement and irrigation schedule:** Understanding irrigation water demand and arranging irrigation times is crucial for improving irrigation water management in the field. With the use of the CROPWAT model, agriculturalists can create suggestive irrigation schedule and determine how they would affect crop yields .I'll present the net irrigation requirement (NIR) and gross irrigation requirement (GIR) Table here in the form of a higher crop water need. This section only includes the most likely year's water requirement.

**Table 1.12** The high NIR and GIR requirement for all crops

| Sr. no | Crops name | Duration | NIR | GIR |
|---|---|---|---|---|
| 1 | Rice | 180 | 1012.9 | 1447 |
| 2 | Sugarcane | 365 | 2542.1 | 3631.5 |
| 3 | Brinjal | 125 | 967.4 | 1381.5 |
| 4 | Ladyfinger | 130 | 941.3 | 1344.6 |
| 5 | Pigeon pea | 110 | 304.8 | 435.5 |

## VI. CONCLUSION:

As a result of the current study, it is concluded that reference evapotranspiration, effective rainfall, crop water requirement, and irrigation water requirement can all be calculated using CROPWAT 8.0 software with the input of climate data like maximum and minimum temperature, relative humidity, wind speed, sunshine hours, and rainfall.

High crop water requirements are estimated by the simulation results analysis for rice, sugarcane, brinjal, ladyfinger and pigeon pea at 1032.6mm/Dec, 2591.4mm/dec,1030.8mm/dec,988.5mm/Dec and 408mm/Dec, respectively. Effective rainfall average high in the year 2012 is 84.7mm. The crop water requirement was determine highest for sugarcane and lowest for pigeon pea.

Modern scientific methods, such as CROPWAT, can be used to accurately determine how much water crops needs, as well as advice crop rotation and crop patterns that farmers will find acceptable. The results of this study can be used as a guide for farmers to choose the amount and frequency of irrigation for the crops under consideration, and they can also be used by water resource planners for future planning and water conservation. The irrigation department of the Keliya dam can utilise this study to plan how much water will be applied to the Vansda taluka canal for upcoming projects. The study will be helpful in predicting the amount of rainfall that will be most effective and the amount of irrigation water that will be consumed at the lowest rate, allowing farmers to plan their crops well and optimise crop yields.

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