# Irrigation Water Requirements of Different Crops by Using Cropwat 8 Software in Taungdwingyi Township

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***Abstract-*** ***This paper aims to estimate different crop water requirement and irrigation water requirement By using Cropwat 8 software in Taungdwingyi Township at Magway Division. Irrigation is an essential part of different crops because rainfall is not enough for irrigated farmland. To develop this model, the required data, such as crop types and crop patterns are collected from Ministry of Agriculture and Irrigation. The meteorological data from Taungdwingyi Station for 2014-2018 are collected from the Department of Meteorology. The crop stage data, including the crop coefficient*** $k_c$***, stage days, rooting depth, critical depletion and crop height of different crops are taken from FAO Irrigation and Drainage Paper 56. The yield response factor is also obtained from FAO Irrigation and Drainage Paper 33. The Penman-Monteith Method was used to estimate*** $ET_o$ ***and*** $ET_c$ ***respectively. Estimate the actual evapotranspiration*** $ET_c$ ***through a water balance of the irrigation water requirements (IR). The results of different crops describe by using tables.***

***Indexed Terms- different crop water requirement, irrigation water requirement, cropwat 8 software, Taungdwingyi Township.***

## I. INTRODUCTION

Agricultural is a key sector of Myanmar's economy and the back-bone of its economy. Agricultural in Myanmar is the main industry in the country, accounting for 60% of GDP and employing some 65% of the labour force. In Myanmar, the process of population growth and urbanization are occurring at an ever increasing phase at every year. The government focused on the development of the irrigation sector to improve the food security and aimed to develop the irrigation area can boost the food production and rural development but sufficient available water resources are needed. In the middle part of Myanmar so called Dry zone, agricultural production mainly depends on irrigation. Myanmar has a hot wet climate and an agricultural country. It can grow different kinds of crops on her wealth, land in both tropical and temperate climates in every part of the country. It grows such as a cereal crop, industrial crops, vegetables, fruits and flowers in different cropping systems. In Myanmar, annual rainfall varies from 20-50inchees in the central dry zone 80-140inchees in the delta areas, 50-150inchees in the hilly regions and100-200inchees in the coastal area. Even though the rainfall is sufficient for the cultivation of paddy in the monsoon season, irrigation is required in the hot dry season. In the central dry zone where rainfall is inadequate, irrigation is essential for crop cultivation even in the wet season.

## II. MATERIAL AND METHODS

### A. Study area

The site lies at East Longitude 95º 23' and North Latitude 20º 04' and 135m above sea level. Taungdwingyi Township is situated in the Eastern part of Magway Region. Geographically it lies within the Central Basin of the Dry Zone or at the Western Foothill of Bago Yoma.Taungdwingyi Township has a total area of 760square miles or 486,403 acres. The highest rainfall amount mostly occurred in June, July, August, September and October. For 28 years, the average annual rainfall was 39.8 inches. Therefore, water is needed for agriculture, especially during the dry season. (ie. from November to May).

### B. Methology

The data we use in this study are mainly meteorological data, including monthly sunshine hours, rainfall maximum temperature and minimum temperature, relative humidity, wind speed from 2014-2018 in Taungdwingyi Station for calculation of reference evapotranspiration $ET_o$

C. Calculate reference evapotranspiration

The reference evapotranspiration $ET_o$ was calculated by FAO Penman-Monteith method, using decision support software – CROPWAT 8.0 developed by FAO, based on FAO Irrigation and Drainage Paper 56 named FAO56. FAO56 adopted the P - M (Penman - Montieth) method as a global standard to estimate $ET_o$ from meteorological data. The Penman – Monteith equation integrated in the CROPWAT program is expressed by Equation (1).

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} U_2 (e_a - e_d)}{\Delta + \gamma(1 + 0.34U_2)} \quad (1)$$

where,

$ET_o$: reference crop evapotranspiration, mm/d;

$R_n$: net radiation at the crop surface, MJ/ ($m^2$.d);

G: soil heat flux, MJ/($m^2$.d);

T: average air temperature, ° C;

$U_2$ : wind speed measured at 2 m height, m/s; ($e_a - e_d$):vapor pressure deficit, kPa;

$\Delta$: slope of the vapor pressure curve, kPa/ ° C;

$\gamma$: psychrometric constant, kPa/ °C;

900: conversion factor.

The FAO CROPWAT program incorporates procedures for reference crop evapotranspiration and crop water requirements and allow the simulation of crop water use under various climates, crop and soil conditions. $ET_o$ was calculated for every ten days (defined as "decade" by FAO) and then cumulated to monthly data. Soil characteristics considered for estimation of crop water requirement are available water content (mm/m) and depth of soil (cm).

D. Crop data

The major cultivated crops in the study area are summer paddy, monsoon paddy, monsoon groundnut, winter groundnut, summer sesame, monsoon sesame, pigeon pea, chick pea, green gram, black gram, pulse sunflower, sugarcane, maize, onion, potato, cotton etc. Crop coefficient values ($K_c$) are taken from available published data. $K_c$ values for initial, mid and late growth stages of different crops are used for the rainy, dry and winter season's months.

E. Crop evapotranspiration ($ET_c$)

$ET_o$ is multiplied by an empirical crop coefficient ($K_c$) to produce an estimate of crop evapotranspiration ($ET_c$), as in Equation (2).

$$ET_c = K_c \cdot ET_o \quad (2)$$

where,

$ET_c$ ; a crop evapotranspiration;

$K_c$ ; acrop coefficient;

$ET_o$ ;a reference crop evapotranspiration.

## II. RESULTS AND DISCUSSION

A. Calculation of reference evapotranspiration

The average reference evapotranspiration $ET_o$ in Taungdwingyi Township is estimated at 5.42mm. Table show $ET_o$ by Month. The months February to June have a relatively high values, more than 5mm per month and the months July to January showed lowest $ET_o$. In the dry season, the resulting low relative humidity combined with high temperatures led to increased evapotranspiration over this period of a year. Inversely the low values of $ET_o$ in rainy season may be due to the high frequencies of rainfall combined with high relative humidity and relatively low temperatures.

In Taungdwingyi Township found low $ET_o$ due to high humidity in thestudy area. As the trend of $ET_o$ affecting by climatic factors such as temperatures, solar radiation, and rain fall as well as wind, relative humidity of the air consequently $ET_o$ is a climatic parameter. With the variations of these parameters $ET_o$ will vary greatly within and between seasons.

Table1- Climate Data / Calculated $ET_o$ of Taungdwingyi Township

| Month | Min Temp | Max Temp | Humidity | Wind | Sun | Rad | $ET_o$ |
|---|---|---|---|---|---|---|---|
| | º C | º C | % | km/day | hours | MJ/$m^2$/d | mm/day |
| Jan | 10.8 | 34.2 | 65 | 137 | 8 | 16.6 | 3.88 |
| Feb | 12.1 | 38 | 54 | 259 | 9.1 | 19.9 | 6.36 |
| Mar | 17.1 | 41.1 | 43 | 284 | 8.5 | 21.1 | 7.93 |
| April | 22.1 | 43.5 | 53 | 389 | 8.3 | 22.1 | 9.28 |
| May | 23.1 | 41.9 | 58 | 277 | 8 | 21.9 | 7.75 |
| June | 22.2 | 37.7 | 77 | 230 | 4.9 | 17.2 | 5.11 |
| July | 21.6 | 34.6 | 83 | 187 | 4.3 | 16.3 | 4.15 |
| Aug | 22 | 34.3 | 84 | 184 | 5 | 17.1 | 4.14 |
| Sept | 21 | 35.9 | 84 | 166 | 6.4 | 18.3 | 4.41 |
| Oct | 19.8 | 35.2 | 84 | 94 | 7 | 17.5 | 3.94 |
| Nov | 12.2 | 35 | 77 | 169 | 7.9 | 16.8 | 4.14 |
| Dec | 10.4 | 33.9 | 70 | 169 | 8 | 15.9 | 3.94 |
| Avg | 17.9 | 37.1 | 69 | 212 | 7.1 | 18.4 | 5.42 |

B. Actual evapotranspiration $ET_c$

The crop evapotranspiration ($ET_c$) of rice was found to be around 1236 mm in the dry season cropping where as in the rainy season cropping it was estimated to be a round 677.4mm. $ET_c$ was more during rainy season than the dry season. The groundnut evapotranspiration $ET_c$ is equal to 489.2mm during the rainy season, but in the winter season groundnut $ET_c$ is 474.1mm .The ETc values of sesame was 768.3mm and 395.3mm for dry and rainy season. The water needs of crops are 697.4mm in pigeon pea, 353. 6mm in chick pea, 427.1mm in black gram, 325.4mm in pulse, 318.5mm in green gram, 778.4mm in sunflower, 467.3mm in maize, 753.2mm in potato, 344.7mm in onion and 957.4mm in cotton. In that crops grown in the dry season needs more water than those grown during the rainy season. This phenomenon is partly due to the meteorological factor.

For example, more rainy days and shorter sunshine duration are experienced in rainy season. The $ET_c$ is a function of the amount of rainfall and varies greatly within and between seasons considering the crop development cycle, growth stages.

Table 2 Values of $K_c$ for Different Crop

| Crop Type | Initial | Mid | Late |
|---|---|---|---|
| Summer paddy (150days) | 1.05 | 1.20 | 0.90 |
| Monsoon paddy(150days) | 1.05 | 1.20 | 0.90 |
| Winter Groundnut(130days) | 0.40 | 1.15 | 0.60 |
| Monsoon Groundnut(130days) | 0.40 | 1.15 | 0.60 |
| Pigeon pea(150days) | 0.5 | 1.05 | 0.9 |
| Chickpea(150days) | 0.4 | 1.00 | 0.35 |
| Monsoon Sesame (100days) | 0.35 | 1.10 | 0.25 |
| Summer Sesame(100days) | 0.35 | 1.10 | 0.25 |
| Black gram(150days) | 0.40 | 1.05 | 0.6 |
| Pulse(100days) | 0.4 | 1.15 | 0.35 |
| Tomato (135days) | 0.60 | 1.05 | 0.75 |
| Green gram(110days) | 0.40 | 1.05 | 0.6 |
| Sunflower(130days) | 0.35 | 1.15 | 0.35 |
| Maize(125days) | 0.30 | 1.2 | 0.60 |
| potato(115days) | 0.4 | 1.15 | 0. 75 |
| Cotton(180days) | 0.35 | 1.2 | 0.7 |
| Onion(95days) | 0.7 | 1 | 1 |

Table 3 Rooting Depth for DifferentCrop

| Crop Type | Initial | Mid | Late |
|---|---|---|---|
| Summer paddy | 0.50 | 1.00 | 1.00 |
| Monsoon paddy | 0.50 | 1.00 | 1.00 |
| Winter Groundnut | 0.50 | 1.00 | 1.00 |
| Monsoon Groundnut | 0.50 | 1.00 | 1.00 |
| Pigeon pea | 0.50 | 0.7 | 0.7 |
| Chickpea | 0.60 | 1.00 | 1.00 |
| Monsoon Sesame | 1.00 | 1.50 | 1.50 |
| Summer Sesame | 1.00 | 1.50 | 1.50 |
| Black gram | 0.60 | 1.00 | 1.00 |
| Pulse | 0.60 | 0.9 | 0.9 |
| Tomato | 0.7 | 1.50 | 1.50 |
| Green gram | 0.60 | 1.00 | 1.00 |
| Sunflower | 0.80 | 1.50 | 1.50 |
| Maize | 1 | 1.7 | 1.7 |
| potato | 0.5 | 0.6 | 0.6 |
| Cotton | 0.7 | 1 | 1 |
| Onion | 0.3 | 0.6 | 0.6 |

Table 4 Critical Depletion Fraction Values for Different Crop

| Crop Type | Initial | Mid | Late |
|---|---|---|---|
| Monsoon paddy | 0.20 | 0.20 | 0.20 |
| Summer paddy | 0.20 | 0.20 | 0.20 |
| Winter Groundnut | 0.50 | 0.50 | 0.50 |
| Pigeon pea | 0.45 | 0.45 | 0.45 |
| Chick pea | 0.50 | 0.50 | 0.50 |
| Sesame | 0.60 | 0.60 | 0.60 |
| Black gram | 0.45 | 0.45 | 0.45 |
| Pulse | 0.45 | 0.45 | 0.45 |
| Tomato | 0.40 | 0.40 | 0.40 |
| Green gram | 0.45 | 0.45 | 0.45 |
| Sunflower | 0.45 | 0.45 | 0.45 |
| Maize | 0.55 | 0.55 | 0.55 |
| potato | 0.35 | 0.35 | 0.35 |
| Cotton | 0.65 | 0.65 | 0.65 |
| Onion | 0.3 | 0.3 | 0.3 |

Table 5. Values of Crop Height and Yield Response Factor for Different Crop

| Crop Type | Crop height (m) | Initial | Develop | Mid | Late | Total |
|---|---|---|---|---|---|---|
| Summer paddy | 1.0 | 1.00 | 1.09 | 1.32 | 0.50 | 1.10 |
| Monsoon paddy | 1.0 | 1.00 | 1.09 | 1.32 | 0.50 | 1.10 |
| Winter Groundnut | 0.4 | 0.20 | 0.80 | 0.60 | 0.20 | 0.70 |
| Monsoon Groundnut | 0.4 | 0.20 | 0.80 | 0.60 | 0.20 | 0.70 |
| Pigeon pea | 0.4 | 0.2 | 0.9 | 0.7 | 0.3 | 1.10 |
| Chickpea | 0.4 | 0.2 | 1.10 | 0.75 | 0.2 | 1.15 |
| Monsoon Sesame | 1.0 | 0.90 | 0.6 | 0.8 | 0.8 | 0.95 |
| Summer Sesame | 1.0 | 0.90 | 0.6 | 0.8 | 0.8 | 0.95 |
| Black gram | 0.4 | 0.2 | 0.9 | 0.7 | 0.2 | 1.15 |
| Pulse | 0.4 | 0.2 | 1.10 | 0.75 | 0.2 | 1.15 |
| Tomato | 0.6 | 0.4 | 1.1 | 0.8 | 0.4 | 1.05 |
| Green gram | 0.40 | 0.29 | 1.10 | 0.75 | 0.20 | 1.15 |
| Sunflower | 1.0 | 0.25 | 0.5 | 1.00 | 0.80 | 0.95 |
| Maize | 2 | 0.4 | 1.5 | 0.5 | 0.2 | 1.25 |
| potato | 0.6 | 0.45 | 0.8 | 0.7 | 0.2 | 1.1 |
| Cotton | 1.5 | 0.2 | 0.5 | 0.85 | 0.25 | 0.85 |
| Onion | 0.3 | 0.45 | 0.1 | 0.8 | 0.3 | 1.1 |

C. Irrigation Requirement (IR)

It is important to mention here that the 10-day (decade) mean IR was run to have an idea of how much water to irrigate. The total IR of paddy was estimated at 1184.4 mm for the dry season and 244.6

mm for the rainy season. The high irrigation requirements during the months of dry season may be explained by the severe drought conditions and the resulting low relative humidity due to the lack of rain combined with high temperatures which led to increased evapotranspiration. In the sesame field, the irrigation water requirements at 626.4mm and 10.6 mm for dry and rainy season respectively, while groundnut has been estimated by 1.8mm in rainy season and 395.5mm in winter. The total IR of pigeon pea is 609.8mm, chick pea is330.4 mm, black gram is 402.8 mm, pulse is 247.2mm, tomato is 626.9 mm. The total effective rainfall of green gram is 474.4 mm for total IR 5.7 mm. In the case of sunflower, the total IR is 698 mm but in maize field, it can be seen that irrigation requirements of 3.9mm for effective rainfall is 611mm. Besides, potato of IR is 673.4 mm and cotton of IR is shown as 408.9 mm from Table 7. Table 7 shows the value of the irrigation requirements for onion is 306.1mm. The difference in irrigation requirements for different crop might be due to the combined effect of the changes in temperature, sunshine hour percentage and wind and the decrease in effective rainfall.

Table.6 Crop Water Requirements obtained from CROPWAT model (Onion)

| Month | Decade | Stage | $K_c$ coeff | $ET_c$ (mm/day) | $ET_c$ (mm/dec) | Eff: rain (mm/dec) | Irr:Req (mm/dec) |
|---|---|---|---|---|---|---|---|
| Nov | 1 | Initial | 0.7 | 2.85 | 22.8 | 9.9 | 10.5 |
| Nov | 2 | Initial | 0.7 | 2.9 | 29.0 | 4.1 | 24.9 |
| Nov | 3 | Develop | 0.73 | 2.96 | 29.6 | 2.9 | 26.8 |
| Dec | 1 | Develop | 0.80 | 3.21 | 32.1 | 0.6 | 31.5 |
| Dec | 2 | Develop | 0.87 | 3.45 | 34.5 | 0.0 | 34.5 |
| Dec | 3 | Develop | 0.95 | 3.74 | 41.1 | 0.5 | 40.6 |
| Jan | 1 | Mid | 1.02 | 3.79 | 37.9 | 5.3 | 32.6 |
| Jan | 2 | Mid | 1.03 | 3.71 | 37.1 | 7.7 | 29.3 |
| Jan | 3 | Late | 1.04 | 4.7 | 51.7 | 5.2 | 46.5 |
| Feb | 1 | Late | 1.05 | 5.81 | 29.1 | 0.0 | 29.0 |
| Total | | | | | 344.7 | 36.1 | 306.1 |

Table 7 Crop Water Requirements for Taungdwingyi Township

| Crop name | Planting date | Harvest date | $ET_c$ mm/dec | Eff rain mm/dec | Irrigation Req. mm/dec |
|---|---|---|---|---|---|
| Summer Paddy | 01/03 | 28/06 | 1236.0 | 284.5 | 1184.4 |
| Monsoon Paddy | 10/07 | 06/11 | 677.4 | 660.3 | 244.6 |
| Monsoon Groundnut | 22/05 | 28/09 | 489.2 | 627.2 | 1.8 |
| Winter Groundnut | 07/10 | 13/02 | 474.1 | 104.8 | 395.5 |
| Pigeon pea | 10/02 | 10/05 | 697.4 | 87.6 | 609.8 |
| Chick Pea | 24/11 | 03/03 | 353.6 | 22.8 | 330.4 |
| Summer Sesame | 15/02 | 04/06 | 768.3 | 152.7 | 626.4 |
| Monsoon Sesame | 14/05 | 31/08 | 395.3 | 527.2 | 10.6 |
| Black Gram | 03/12 | 12/03 | 427.1 | 25.6 | 402.8 |
| Pulse | 01/10 | 08/01 | 325.4 | 111.1 | 247.2 |
| Tomato | 16/11 | 30/03 | 373.6 | 45.8 | 626.9 |
| Green Gram | 01/07 | 08/10 | 318.5 | 474.4 | 5.7 |
| Sunflower | 15/12 | 23/04 | 778.4 | 76.7 | 698 |
| Maize | 24/05 | 25/09 | 467.3 | 611.0 | 3.9 |
| Potato | 01/01 | 25/04 | 753.2 | 79.8 | 673.4 |
| Cotton | 03/03 | 29/08 | 957.4 | 609.4 | 408.9 |
| Onion | 03/11 | 05/02 | 344.7 | 36.1 | 306.1 |

## III. CONCLUSION

In order to calculate the crop water requirement, the reference crop evapotranspiration is firstly determined and then the crop evapotranspiration is calculated by using crop coefficient.Reference crop evapotranspiration ($ET_0$) is calculated by using FAO Penmen-Monteith on the basis ofthe meteorological data from Taungdwingyi Township in Magway Division. The required data to use this method are air temperature, relative humidity, sunshine hours, wind speed, latitude andlongitude of the proposed location. Where, rainfall is inadequate for the amount of water lost. by evapotranspiration, irrigation water need is required to calculate based on rainfall and how much water is maximum irrigated for the study area. Thus, effective rainfall is determined by a fixed percentage of rainfall formula with 80% of total annual rainfall. Crop coefficient values ($K_c$); rooting depth; length of plant growth stages; planting date and allowable depletion are taken from FAO Paper 56. From the model results, reference evapotranspirationthe highest ($ET_0$) is 9.2 8mm in April and the lowest ($ET_0$) is 3.88 mm in January. Yield response factor for crops are taken from paper 33.

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