IMPLICATIONS OF CLIMATE CHANGE ON CROP WATER REQUIREMENTS IN THE KALKALAMMA CHERUVU TANK IRRIGATION COMMAND AREA, TELENGANA

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Abstract: Understanding crop water requirements (CWR) in semi-arid region is essential for better irrigation practices, scheduling and efficient use of water since the water supply through rainfall is limited. This study estimated the crop water requirements of cotton crop in “kukunoorpally kondapak mandal kalkalamma cheruvu”, tank irrigation command area using CROPWAT model. The recorded climatic data, crop and soil data from 2001 to 2010 were given as input to CROPWAT. The results showed that the annual reference evapotranspiration (ETo) was estimated as 5.55 mm/day. The lowest monthly value of ETo was observed in December, while the highest value 8.42 mm/day was observed in April. The crop evapotranspiration ETc and irrigation water requirements (IR) was estimated as 1.7 mm/day and 20.7 mm/day respectively in monsoon season. ETc and IR for dry season was calculated as 12.7mm/day and 36.5 mm/day respectively. Hypothetical climate change scenarios can then be scheduled for water use efficiency based on these findings.

Keywords: CROPWAT 8.0, Crop Water Requirement (CWR), Hypothetical Climate Change Scenarios.

Introduction: The continuing growth of world population places new demands on water resources every day. Improved management and planning of water resources are needed to ensure proper use and distribution of water among competing users. Fortunately, there are opportunities for conservation and significantly more effective use of water use by the world’s largest user, agriculture (Aghdasi, 2010). Climate change is referred as variation in statistical distribution of weather patterns (i.e rate, range and magnitude). Changes in climate are influenced by various factors such as incoming and outgoing solar radiations, biotic and abiotic processes and movement of tectonic plates. Some manmade action such as burning of fossil fuels, vehicular emission etc. aggravates the effects and they are recognized as anthropogenic climate change. Climate change may effect on different agricultural dimensions like loss in profitability, migration of farmers to urban areas, conversion of agricultural lands to residential plots etc. The term crop water requirement means the total amount of water required by the crop from planting date to harvesting date. To achieve effective irrigation scheduling under climate change scenario accurate information about crop water requirements, soil type, weather conditions are needed. Penman-Monteith method is used in the present study to determine the crop evapotranspiration since the results are consistent worldwide. Climate change has possible implication on hydrological cycle and it has effect on irrigation water requirements. Under these circumstances, a controlled water supply at regular interval according to the changing climate is needed.

Irrigation in India includes a network of major and minor canals from Indian rivers; groundwater well based systems, tanks, and other rainwater harvesting projects for agricultural activities. Of this groundwater system is the largest. In 2010, only about 35% of total agricultural land in India was reliably irrigated. About $2/3^{rd}$ cultivated land in India is dependent on monsoons. Irrigation in India helps improve food security, reduce dependence on monsoons, improve agricultural productivity and create rural job opportunities. Construction of irrigation projects has been taken up on a massive scale in Telangana, India. In the history of irrigation development, there is no precedence in the state and this activity is going to boost the irrigation sector in a significant manner, benefiting irrigated agriculture throughout the state. Twenty six major and medium irrigation projects are taken up for execution. The command area of Kukunoorpally, Kondapak mandal of Siddipet district of Andhra Pradesh, India are constantly subjected to drought and are in urgent need for sustainable water resources planning and management. Hess (2005) defined crop water requirements as the total water needed for evapotranspiration, from planting to harvest for a given crop in a specific climate regime, when adequate soil water is maintained by rainfall and/or irrigation so that it does not limit plant growth and crop yield. K.Saravanan (2014) determined crop water requirements of (1) rice crop varies from 0.74mm/day, (2) Groundnut crop varies from 2.4mm/day to 5.03mm/day, (3) Sugarcane crop varies from

2.07mm/day to 6.57mm/day. Banavath Ranga Naik (2015) determined crop water requirement of (1) rice crop requires 836.3mm/year (2) chilly crop requires 339.6mm/year (3) Brinjal crop requires 290.8mm/year. The objective of this study was to determine crop water of cotton crop in the Kalkalamma Cheruvu tank irrigation command area.

CROPWAT Model: CROPWAT is an irrigation planning and management decision support system developed by land and water development division of FAO, Italy with the assistance of Institute of Irrigation and Development Studies of Southampton, UK and National Water Research Centre, Egypt. The model carries out calculations for reference evapotranspiration, crop water requirements and irrigation requirements in order to develop irrigation schedules under various management conditions and schemes of water supply. It allows the development of recommendations for improved irrigation practices and for the planning of irrigation schedules and the assessment of production under rain fed conditions or deficit irrigation (Adriana and Cuculeanu (1999). It allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules under varying water supply conditions, and the assessment of production under rain fed conditions or deficit irrigation (FAO, 1992). Water use requirement for same crop varies under different weather conditions. The program uses climate data for the calculation of reference evapotranspiration. From the input of crop data such as growth stages, Kc factors, root zone depth and allowable soil moisture depletion factor it calculates crop water requirements on a decade (10-days) basis. The calculated reference evapotranspiration crop water requirements are used to develop irrigation schedules under various management conditions and schemes of water supply. The scheme of water supply is based on the cropping pattern provided in the model. The main inputs of CROPWAT 8.0 are climate data, crop data and soil data which include (i) Temperature, relative humidity, wind speed, sunshine hours and rainfall (ii) crop growing days, root zone depth and crop factor (iii)soil moisture depletion, available water content, infiltration rate and extreme rooting depth.

Study Area and Data Collection: The area selected for the study is Kalkalamma Cheruvu, Kukunoorpally, Kondapak mandal tank command area located in Siddipet district of Telangana. Kalkalamma Cheruvu tank is located at a latitude of 17°58’ N and longitude of 78°51’ E. The average altitude of this region is 515m. The annual rainfall of Siddipet district varies from 600mm to 1185mm. The agro climatic zone of the study area comes under agroclimatic zone. The major crops grown in this region are rice, cotton, corn and soyabean. Black cotton soil is the predominant soil type in this region covering 77% of the study area. It is poorly drained and deep suitable for cotton crop. The command area of the tank is 56.8 ha and around 167 farmers are making use of the tank water for irrigation purposes. The tank gets filled upto 30% each year and the average size of holding is 0.244ha. The data required for the model are collected from the Chief Planning Office (CPO) of Siddipet district of Telangana. The climatic data collected for 10 years (2001-2010) and use for the baseline scenario. The maximum and minimum temperatures of the study area vary between 20°C to 30°C and 17°C to 28°C respectively. Mean monthly relative humidity ranging between 43% and 65%. The highest rainfall is recorded in the September and lowest rainfall is recorded in April month. The months January, November and December are remains as dry months without any rainfall readings. More than 60% of rainfall is obtained from southwest monsoon only. The google image of the study area are shown in the figure 1.1.

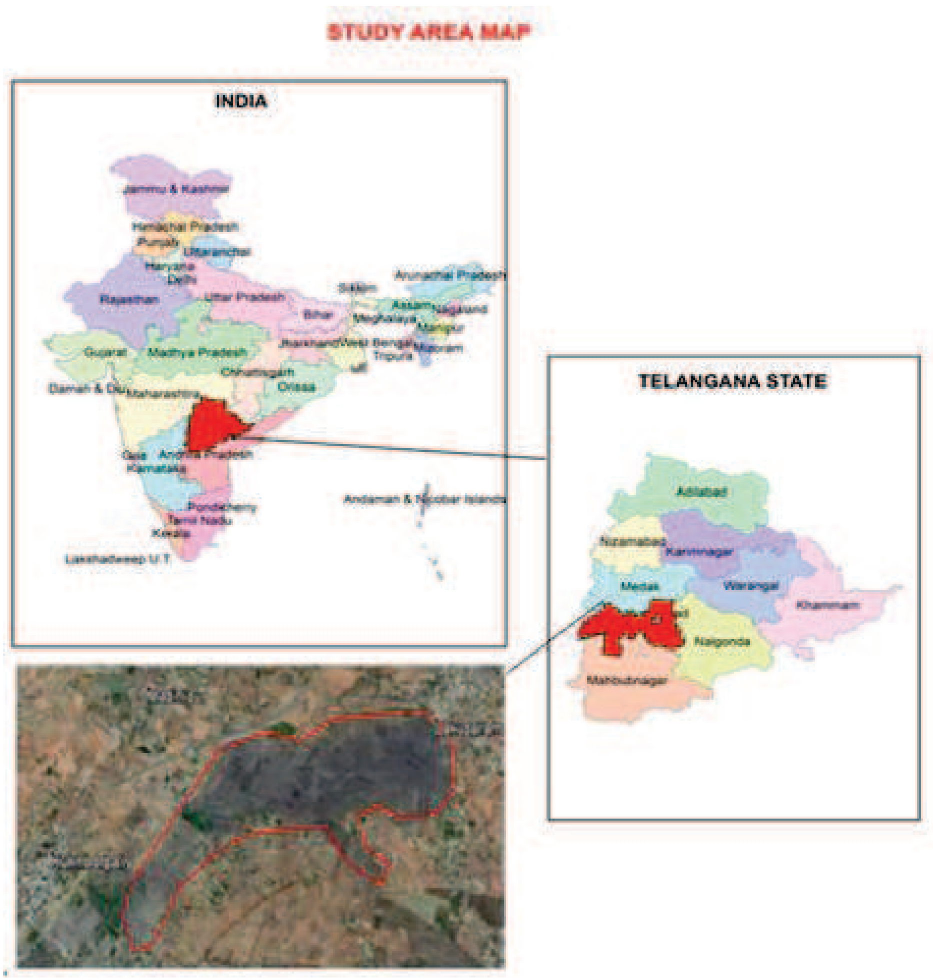

Figure 1.1 Google Image of the Study Area

Methodology: In this study the daily 10 years climate data is used for the baseline scenario. Hypothetical climate change scenario has been applied using four cases. (i)1°C increase in temperature (ii) 1°C decrease in temperature (iii) 10% increase in rainfall (iv) 10% decrease in rainfall. CROPWAT model is used for the evaluation of reference evapotranspiration, crop water requirements for the cotton crop. Reference crop evaportranspiration (ET_O) represents the rate of evaporation of vegetation with adequate water status in the soil. The type of vegetation and crop management practices determine evaporative requirement. Penman-Monteith method was used to estimate ETo. Crop coefficients (Kc) from the phenomenological stages of cotton were applied to adjust and estimate the actual evapotranspiration ETc. Reference crop evapotranspiration can be calculated by the following formula,

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

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; (*ea–ed*): vapor pressure deficit, kPa;
Δ: slope of the vapor pressure curve, kPa/ C;
γ: psychrometric constant, kPa/ C;
900: conversion factor.

Here the Crop Evapotranspiration (ETc) is calculated by using the formula
ETc =Kc·ETo

where, ETc is a crop evapotranspiration;
Kc a crop coefficient;
ETo a reference crop evapotranspiration.

Results and Discussions: The average climate data of 10 years is used for the determination of crop evapotranspiration (ETc) for baseline scenario. These values range from 1.64 mm/day in July to 5.81mm/day in August. The crop growing stage is divided into initial stage (June), Development stage (July- Aug), Mid stage (Sep-Oct), Late stage (Nov-Dec). During the southwest monsoon the rainfall obtained in July, August months are very high as compared to the other season and hence effective rainfall is also more. For the baseline scenario, the results showed that the annual reference evapotranspiration (ETo) was estimated as 5.55 mm/day. The lowest monthly value of ETo was observed in December, while the highest value 8.42 mm/day was observed in April. The crop evapotranspiration ETc and irrigation water requirements (IR) was estimated as 1.7 mm/day and 20.7 mm/day respectively in monsoon season. ETc and IR for dry season was calculated as 12.7mm/day and 36.5 mm/day respectively. For the baseline scenario, ET_C is calculated as 673.1mm/decade, effective rainfall is calculated as 530.4mm/decade and the irrigation water requirement is calculated as 284. 8mm/decade. The CWR value are calculated for every 10 days in CROPWAT. The crop evapotranspiration (ET_C) is calculated for future climate by using hypothetical scenario. The scenario analysed in this study are 1°C increase, 1°C decrease in temperature, 10% increase, 10% decrease in rainfall. Table 1 shows the Crop water requirement for cotton crop under baseline and climate change scenario. Table 2 shows the ET_C comparison between baseline and climate change scenario.

Table 1: Crop Water Requirement for Cotton Crop under Baseline and Climate Change Scenario

	Baseline (mm/dec)	1°C increase (mm/dec)	1°C decrease (mm/dec)	10% increase in rainfall (mm/dec)	10% decrease in rainfall (mm/dec)
ET_C	673.1	690	612.4	554.1	686.4
ER	530.4	689.1	650.9	690.2	560.8
IR	284.8	268.8	231.6	211.8	305.8

For the baseline condition from the beginning of the later stage of the crop the basin receives only limited rainfall. Therefore, in that duration effective rainfall is less than the CWR and so require large amount of water for irrigation, whereas for all the three decades the ER is sufficient to compensate ET losses. Hence there is only small amount of water requirement for irrigation.

Table 2: ET_C Comparison between Baseline and Climate Change Scenario

Months	ET_C (mm/day)				
	Baseline	1°C increase	1°C decrease	10% increase	10% decrease
June	20.3	21.4	20.1	19.2	21.6
July	21.7	21.9	21.8	20.4	22.9
August	54	55.7	53.4	52.5	55.6
September	52.6	56.2	53.2	51.4	54.8
October	47.2	46.9	46.1	46.8	48.3
November	32.9	33.6	31.5	31.5	34.6
December	11.5	10.4	10.9	10.4	12.9

The crop water requirements is more for the late developments and mid stage as compared to other stages particularly in 10% decrease in rainfall. The total ER will be less for these stages. Unlike other stages, the Irrigation water requirement also needed is more to compensate ET losses. During the harvesting stage, the CWR for the crop is less comparing to other stages for all the scenarios.

Conclusion: CROPWAT can be used to compute the crop water requirement in all season and it is verified by the experimental field (CARDI) results of Cotton crop. Moreover, this model has capabilities to calculate and estimate irrigation water requirement. The results of the study shows that there is sharp increase in CWR particularly for 10% decrease in rainfall as compared to the baseline conditions. The study reveals that there is a sporadic variation in CWR for climate change scenario compared with baseline scenario. Water can be saved due to reduced crop water requirements during harvesting stages and can be used to some other purposes. Water conservation practices like drip and sprinkler irrigation has to be well adapted in this command area.

The outcome of this study is useful for policy makers and water resources planners for better allocation of water resources.

References:

1. Aghdasi. Crop water Requirement assessment and Annual Planning of Water Allocation. [Masters].The Netherlands: International Institute for geo-information science and earth observation; 2001.
2. Banavath Ranga Naik, T Hema Latha, C Mahesh Babu (2015) Command area development by using FAO Cropwat 8.0 model and impact of climate change on crop water requirement-a case study on Araniar reservoir basin, International Journal of Applied Research; 1(13): 142-155
3. Food and Agriculture Organization (FAO) (1992) CROPWAT: A Computer Program for Irrigation Planning and Management, by M. Smith. FAO Irrigation and Drainage Paper No. 46. Rome.
4. Hess T (2005) Crop Water Requirements, Water and Agriculture, Water for Agriculture, WCA infoNET.
5. Saravanan K, Saravanan R. Determination of Water Requirements of Main crops in the Tank Irrigation Command area using CROPWAT 8.0. International Journal of Interdisciplinary and Multidisciplinary Studies. 2014 May; 1(5): 266-272.

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