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Climate Change Impact on Irrigation Requirement of Major Crops of Sangareddy District

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ABSTRACT: Water for agriculture is becoming scarce due to increasing demand in the allied sectors. The knowledge of irrigation requirement for crops and the available water supplies under changing climate is necessary for efficient management of water resources. This aids in efficient application of irrigation based on crop water requirement. In this study, the irrigation water requirement for major crops of Sangareddy was estimated based on changing climate scenarios. The variability in rainfall, temperature, crop water and irrigation requirements of major crops under present and future scenario was assessed using ENSEMBLE data, Hargreaves and Samani (1985) equation and ten-day effective rainfall. During the period from 1951-2013, it was observed that the average rainfall and average effective rainfall of Sangareddy district were 875 and 527 mm respectively. The irrigation requirement estimated for major crops of Sangareddy such as cotton, rice, maize, groundnut, green gram, sesame, sorghum and sugarcane varied from 471.5 to 497.2 mm, 679.6 to 724.7 mm, 343.2 to 347.6 mm, 414.2 to 422.2 mm, 125.6 to 153.7 mm, 99.6 to 113.0 mm and 1329 to 1362 mm respectively. In case of future scenarios, the irrigation water requirement is expected to increase for almost all the *kharif* and *rabi* crops.

Key Words: Crop coefficients, crop water requirement, effective rainfall, gross irrigation requirement

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Introduction

The demand for water in agriculture has increased to meet the food production need of growing population. It has become a major challenge for all countries to increase food production, as water become a scarce commodity. It has been argued that irrigation in India has lived up both to its productive and protective role in terms of its impact on agricultural productivity, farm income and protection against drought. Irrigation practice therefore becomes a most reasonable option as it is able to assist agriculture in areas with minimum rainfall and erratic rainfall distribution pattern. For better management of available resources and agricultural production, it is necessary to understand the irrigation water requirement and the present level of water supplies (Aiyelaagbe and Ogbonnaya, 1996).

Irrigation practice or schedule depends on the frequency and quantity of irrigation water required based on the type of crop and the rainfall precipitated over the time period. Earlier studies by several R&D institutes viz. Kerala Agricultural University (KAU), ICAR-CPCRI (Central Plantation Crops Research Institute), and CWRDM (Centre for Water Resources Development and Management) revealed that sufficient soil moisture by way of irrigation/rainfall can augment crop production and increased yield by 15% to 40% compared with the unirrigated (rainfed) crops for most of the crops in Kerala, based on the secondary data (Surendran *et al.,* 2019).

Climate parameters like precipitation, temperature and carbon dioxide levels changes can affect the demand for water as well as supply. Increased water use efficiency attributable to higher carbon dioxide levels may lead to increased frequency of water application as temperature rises (Frederick 1997). Irrigation systems require modernization and good management by evaluating water system prerequisites precisely. It is important to know the crop water requirements and irrigation scheduling to take care of the irrigation demand (Ewaid *et al.,* 2018). Software modeling by programs like AQUACROP and CROPWAT 8.0 is used by scientists for the assessment of crop evapotranspiration. CWR and irrigation scheduling software programs were developed by the Food and Agriculture Organization (FAO) as tools to assist irrigation engineers and agronomists in performing the usual calculations for water irrigation studies and mainly in the management and design of irrigation schemes (Clarke *et al.,* 2001). Therefore, quantifying and analyzing the spatial and temporal characteristics of the regional demand for irrigation water for agriculture is important in developing strategies for water management under the future impacts of climate change and the associated demographic, socioeconomic and technological changes.

Materials and Methods

Study area

The research was carried out in Sangareddy district of Telangana (Fig.1). Sangareddy is located between 17°21`43" to 18°13`58" N Latitude and 74°29`19" to 78°27`34" E Longitude with a total geographic area of 4403 km^2 with an elevation ranging

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from 391 to 695 m above MSL (Fig. 2a). Out of which, gross cropped area and net cropped area were 265290 ha and 234478 ha respectively. With respect to irrigation, the total irrigated area is 61051 ha, out of which net irrigated area accounts to be 45797 ha. Average annual rainfall of Sangareddy is 930 mm and average annual temperature is 26.6 °C (Telangana Planning Dept, 2016). According to Central Groundwater Board, 15% of administrative blocks are over exploited and is growing at a rate of 5% every year. Blocks of Sangareddy are in over exploited to semi critical category and bore well irrigated area is increasing at an alarming rate whereas canal irrigated and tank irrigated area are decreasing. The major crops of Sangareddy are cotton, green gram, groundnut, rice, maize, sesame, sorghum, sugarcane and predominant soil is of clayey texture and crop land is the major LULC (Fig. 2b and 2c).

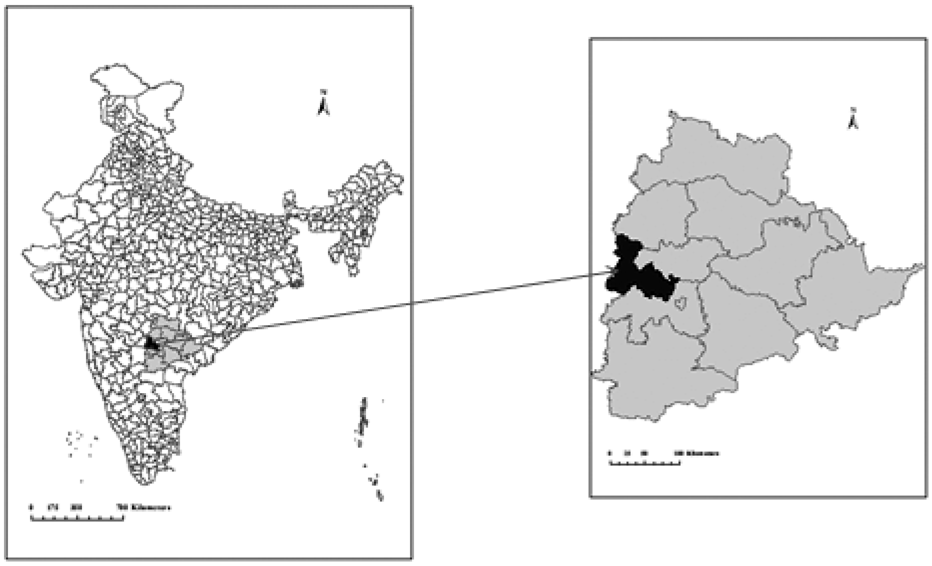

Fig. 1. Location map of the study area

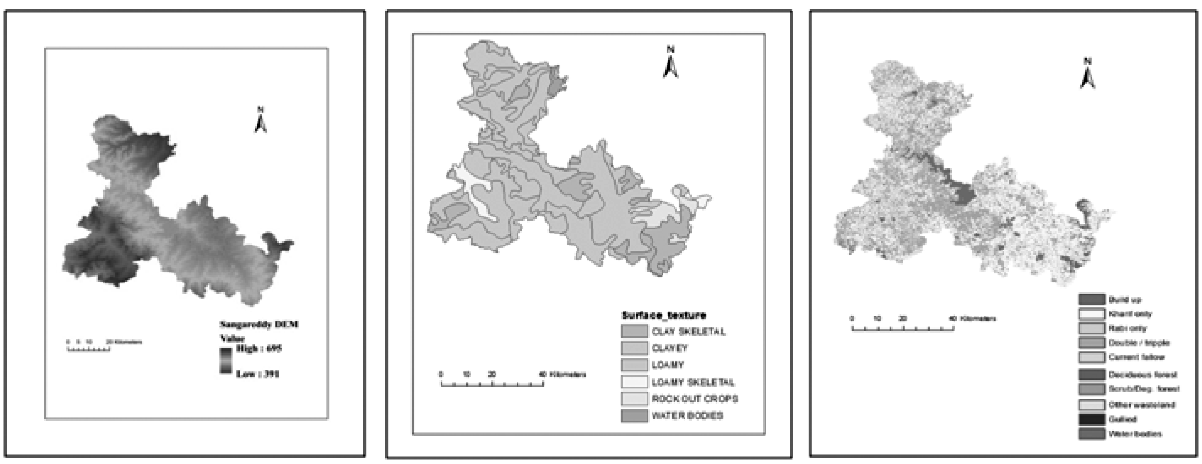

Fig. 2 (a, b & c): Topography, soil & LULC map of Sangareddy

Data sources

Data was obtained from ICAR-CRIDA Hyderabad which includes the rainfall and temperature data from 1951 to 2013 of IMD (Indian Meteorological Department) and ENSEMBLE data of CMIP 5 from ICAR. The effective rainfall and irrigation requirement of crops under future climate scenarios was estimated using ENSEMBLE data. The daily rainfall ENSEMBLE data pertaining to base line (1976 to 2005) and 2020's (2010 to 2039), 2050's (2040 to 2069) and 2080's (2070 to 2099) for four emission scenarios namely, RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 was used.

Determination of irrigation requirement

The crop water requirement was estimated during current scenario (using IMD data), baseline period and under changing climatic scenarios for crops such as cotton, green gram, groundnut, rice, maize, sesame, sorghum, sugar cane. Although many methods are available to determine reference evapotranspiration based on availability of meteorological data, suitable method could be selected. FAO Penman-Monteith method has been recommended as a standard method for ET_o calculation. Due to lack of availability of solar radiation data, Hargreaves and Samani (1985) method was used for estimating ETo (Rejani *et al.,* 2016). This method requires extra-terrestrial radiation, minimum & maximum temperature along with latitude of the area.

Hargreaves and Samani (1985) equation is given as below:

$$\lambda ET_0 = 0.0023 R_a T_d^{0.5}(T+17.8) \quad (1)$$

Where, R_a = Extra-terrestrial solar radiation (MJ $m^{-2}d^{-1}$); T_d = Difference between the daily maximum and daily minimum temperature (°C); T = Mean temperature (°C); λ = Latent heat of vaporization (MJ/kg)and ETo= Reference crop evapotranspiration (mm/day).

The extraterrestrial radiation R_a, for each day of the year and for different latitudes can be estimated from the solar constant, the solar declination and the time of the year by *Eqn (2)*

$$Ra = \frac{24 \times 60}{\pi} Gscdr[\omega s \sin(\varphi)\sin(\delta) + \cos(\varphi)\cos(\delta)\sin(\omega s)] \quad (2)$$

Where, G_{sc} = Solar constant (0.0820 MJm^{-2} min^{-1}); ωs = Sunset hour angle [rad] in *Eqn (3)*; dr = Inverse relative distance Earth-Sun in *Eqn (4)*; δ = Solar declination [rad] in *Eqn (5)*; φ = Latitude [rad];

$$\omega_s = \arccos(\tan\varphi \tan\delta) \quad (3)$$

$$d_r = 1 + 0.033 \cos \frac{2\pi}{365} J \quad (4)$$

$$\delta = 0.409 \sin \frac{2\pi}{365} J - 1.39 \quad (5)$$

where, J is the number of days in a year between 1st January to 31st December

The crop evapotranspiration, ET_c was calculated using *Eqn* 6

$$ET_c = K_c ET_o \quad (6)$$

where, K_c is the crop coefficient depends on the crop growth stages

Effective rainfall

Effective rainfall was estimated from daily rainfall using empirical formula developed at ICAR-CRIDA (Rejani *et al.*, 2020).

$$R_e = \frac{P(41.7-0.2P)}{41.7} \text{ for } P<83 \quad (7)$$

$$R_e = 41.7 + 0.1P \text{ for } P>83 \quad (8)$$

Where, R_e = 10 days effective rainfall (mm) and P = 10 days rainfall (mm).

The gross irrigation requirement is determined by the formula shown in *Eqn* (9)

$$RIR = \frac{ETc - Re}{np} \quad (9)$$

where, GIR = Gross irrigation requirement (mm); R_e = Effective rainfall (mm); n_p = Project efficiency (application efficiency × conveyance efficiency × field canal efficiency)

Results and Discussion

During current scenario (1951-2013), the average rainfall of Sangareddy was 875 mm. The highest and lowest temperatures were 44.29 °C and 26.49 °C. The average evapotranspiration rate (ET_o) was 1380 mm and average effective rainfall of the area was 527 mm respectively. The irrigation requirement of major crops such as cotton varied from 471.5 to 497.2, green gram from 142.0 to 181.8 mm, groundnut from 414.2 to 422.2mm, maize from 343.2 to 347.6 mm, rice from 679.64 to 724.7 mm, sesame from 125.6 to 153.7 mm, sorghum from 99.6 to 113.0 mm and sugarcane from 1329 to 1362 mm respectively.

The percentage increase of irrigation requirement during 2020's, 2050's and 2080's under RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 was determined (Table 1). Compared to baseline period, there is an increase in the irrigation requirement of all *kharif* and *rabi* crops such as cotton, green gram, rice, sesame, sorghum, sugarcane, groundnut & maize during 2050s and 2080s. Similarly, a decrease in the irrigation requirement was noted during 2020s in groundnut, maize (under RCP 4.5) and sugarcane (all RCPS). For cotton, it expected to increase to 5.65, 7.6, 8.29 & 11.55%, rice may increase to 3.2, 5.01, 5.73 & 5.57% by 2080s. Similarly, in case green gram, sesame & sorghum, a slight increase in the irrigation requirement is noted under RCP 2.6, 4.5, 6.0 & 8.5 respectively. Similarly, in case of *rabi* crops. The changes in the water requirement of the cultivated crops depend on atmospheric characteristics *ie.,* increase of temperature and change of CO_2 percentage (Zhang *et al.,* 2019).

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Table 1: Percentage increase of irrigation requirement during 2020's, 2050's and 2080's (w.r.t baseline) under RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 at Sangareddy

Crops	Irrigation requirement, BL (mm)	Per cent increase in irrigation requirement			RCP
		2020 (%)	2050 (%)	2080 (%)	
Cotton	369.93	1.29	5.04	5.65	2.6
		1.23	4.93	7.6	4.5
		0.42	4.54	8.29	6.0
		2.47	7.91	11.55	8.5
Greengram	79.75	0.11	0.23	0.24	2.6
		0.16	0.24	0.27	4.5
		0.16	0.23	0.33	6.0
		0.2	0.25	0.29	8.5
Groundnut	459.7	1.01	1.41	2.09	2.6
		-0.17	1.01	1.9	4.5
		0.15	1.1	1.99	6.0
		1.32	1.53	2.07	8.5
Maize	312.5	0.19	2.1	2.77	2.6
		-0.38	1.6	2.54	4.5
		1.05	1.94	2.59	6.0
		1.78	2.17	2.69	8.5
Rice	414.6	2.56	6.39	3.22	2.6
		1.16	2.82	5.01	4.5
		0.96	2.28	5.73	6.0
		2.66	5.57	1.26	8.5
Sesame	68.15	0.16	0.2	0.3	2.6
		0.21	0.302	0.33	4.5
		0.22	0.29	0.33	6.0
		0.25	0.21	0.36	8.5
Sorghum	58.75	0.083	0.17	0.18	2.6
		0.21	0.18	0.21	4.5
		0.1	0.18	0.21	6.0
		0.13	0.21	0.26	8.5
Sugarcane	902.15	-0.48	0.63	0.84	2.6
		-0.94	0.52	1.3	4.5
		-1.06	0.04	0.47	6.0
		-0.32	0.56	1.68	8.5

Conclusion

The irrigation requirement of cotton and rice is expected to increase during 2020's, 2050's and 2080's under RCP 2.6, 4.5, 6.0 & 8.5. There is a very slight increase of irrigation requirement in case of green gram, sesame & sorghum under all scenarios. In case of groundnut & maize, there is very slight decrease of irrigation requirement is expected during 2020's and is predicted to increase during 2050's & 2080's under all RCP scenarios. The irrigation requirement of sugarcane is expected to decrease during 2020's and may increase during 2050's & 2080's under all 4 RCPs with respect to its baseline period. Hence, there is an increase of irrigation requirement is expected for almost all *kharif* and *rabi* crops i.e, cotton, green gram, rice, sesame, sorghum, sugarcane, groundnut & maize at Sangareddy.

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