Climate change and its impacton crop water requirement of Mulberry (*Morus* spp., Moraceae) **crop in Yadgir District, Karnataka, India**

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Abstract

This study was carried out toexamine trends in crop water requirement under several climate change scenarios to provide projections of changes in crop water requirement of mulberry. According to Indian Network for Climate Change Assessment (INCCA) and Inter-Governmental Panel for Climate Change (IPCC), scenarios which may be included for assessment were developed from their reports. A CROPWAT-8.0 model was utilized to determine the required water requirements for crops in a variety of climate change scenarios. The estimated and demonstrated growing and reducing trend in crop water requirements of Mulberry over the last 35 years was seen in the Yadgir districtin overall displayed. As regards Mulberry, there has been a rising ETc tendency in all study area even if different climate change scenarios are used. It was found that climate variability has an impact on the Mulberry crop's water needs. To help address this, it was suggested that to reduce the risk of yield loss due to changing water availability, water conservation efforts such as rainwater harvesting, soil and water conservation, and increased ground water recharge should be implemented in the study area.

There should some key values of results included in the abstract

Keywords: Climate Change, Mulberry,Trend Analysis, IPCC Scenarios, CROPWAT-8.0

Introduction

Global warming is a shift in the seasonal and longer-term variations of meteorological conditions, or an overall change in weather patterns (IPCC, 2007). The Inter-Governmental Panel for Climate Change(IPCC) forecasts that global surface temperature would rise by 1.4 to 5.8 Degrees Celsius by the year 2100 under various greenhouse gas emission scenarios (IPCC, 2007). Climate change has been researched by several non-profit groups as well as government agencies in India. The Indian Network for Climate Change Assessment (INCCA) is made up of the Ministry of Environment and Forests (MoEF) of the Indian government and a variety of Indian institutions. It is an independent, self-funded entity dedicated to conducting scientific research and providing impact assessments on the effects of climate change. In the INCCA report, the projection is for an increase of 1.7 °C and 2.0 °C in the 2030s.

As the temperature rises, the supply of water may be impacted (Kambale et al, 2017). A substantial portion of agriculture's water usage is located in nations across the world, including India. Since the effects of climate change on crop evapotranspiration (ETc) are crucial for water management and agricultural sustainability, the influence of climate change on crop ETc will become critical for future food production. While other elements, such as sunlight exposure, relative humidity, wind speed, and rainfall also affect the ET0, these are not the only factors. When other parameters vary, so will the ETc. Despite these complications, it's very possible to project the effects of these changes on a regional or local scale (Chattopadhyay and Hulme, 1997).

India had the most yearly Mulberry production, according to World across time. (Morus spp., Moraceae). With a production of 30,263 MT of raw silk (in 2016–17), India is the second-largest producer of silk in the world. It is also unique in that it produces all four varieties of natural silk that are now recognized, namely mulberry, tasar, eri, and muga. In the country's total production of 21,203 MT of mulberry silk, Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu, and Jammu & Kashmir account for 70.1% of the entire production. (Rajaram et al, 2017). In India, 2.21 lakh acres are used for mulberry farming, and 8.51 million people work in sericulture. It is clear from the fact that 80% of mulberry gardens are irrigated how crucial irrigation is to the crop. Sericulture is a labour-intensive, agro-based cottage industrial activity, which makes the problem worse. Lack of irrigation water, massive increases in the cost of inputs, and high labour wages all contribute to increased cost of production, endangering agriculture.Research on climate change impacts on agriculture, crop production, irrigation water, crop water and on meteorological parameters throughout the world has been carried out by numerous people over the years (Wang et al, 2016, Surendran et al, 2015, Rotich, 2017, Ojeda, 2014, Mohan and Ramsundram, 2014 and many others). While conducting experiments using different climatic models, the researchers are also studying the impact of climate change on agricultural water requirements. Investigating climate impacts under various situations, otherwise time-consuming and costly, may be achieved using these methods. In view of this, the present investigation is intended to gather information on the long-term temporal variability, followed by an assessment of its current trend in crop water requirements for Mulberry (Morus spp., Moraceae).

MATERIALS AND METHODS

Description of Study Area

The location chosen for this study is located in the north-eastern zone of Karnataka state, India (Fig. 1). Figure 2 depicts a flowchart of the work process. The study area is situated on the Deccan plateau, with elevations ranging from 300 to 750 metres above Mmean Ssea Llevel (MSL). The majority of the land is covered with black dirt, with some red soil thrown in for good measure. It is located between 17^{0} 12” and 17^{0} 46” N latitude and 76^{0} 04” and 77^{0} 54” E longitude.

The district's climate is usually dry, with temperatures ranging from 8 ^{o}C to 45 ^{o}C with an average rainfall of around 750 mm. May is the warmest month, with an average maximum temperature of 40 °C, while December is the coldest, with an average minimum temperature of 15.9 °C. During the peak summer season, temperatures may reach 45 °C, the average wind speed is 5.5 metres per second, the average day duration is from 10 to 12 hours, and relative humidity ranges from 26% during the summer to 62% during the rainy and winter seasons.

Figure 1. should come immediately after you read about it. The sequence of things will be better.

Data collection

Weather data

Long-term weather data of average temperature (°C), maximum and minimum temperature (°C), rainfall (mm), wind speed (ms-1), relative humidity (percent), and solar radiation (MJm-2day-1) obtained from the National Aeronautics and Space Administration prediction of worldwide energy resource full name (NASA POWER) project (Hassan et al, 2019, Siddharam et al, 2020). For the years 1981 to 2018, historical data for all weather parameters were gathered for three weather stations*viz.*Shahpur, Yadgir and Surpur of Yadgiri district.

Soil properties

Table 1 presents data on soil characteristics such as soil type, field capacity, wilting point maximum penetration rate, initial soil moisture depletion, and initial available soil moisture obtained from FAO, 56, and CROPWAT 8 standard datasets.

Table 1 show be seen here

Crop data

Crop data related to growth, such as crop coefficient (kc), crop growth phases, crop growth yield response factor, and crop height, were gathered and utilised as input parameters to the CROPWAT 8 model for crop water requirement estimation. Mulberry is a kind of fibre that is the crop development stage, yield response factor, and crop height data were acquired from the research region by in situ sampling. Crop coefficient (Kc), crop coefficient, and canopy factor were all gathered (Nagraj, 2019). Kc Table 2 shows Mulberry values with different development stages.

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Crop water requirement

Due to the difficulties of accurately measuring field data, prediction methods are always applied in the calculation of crop water requirements. The accuracy of techniques under novel conditions is tedious, time-consuming and time-consuming, yet crop water requirement data are sometimes needed shortly for project planning. The CROPWAT Model 8.0 is a model of irrigation management designed by the Food and Agriculture Organization (FAO) to assess crop water and irrigation need (Clarke et al., 1998).

CROPWAT 8

A decision support system called CROPWAT 8.0, created by the Land and Water Development Division of FAO, is now in use. CROPWAT 8.0 can estimate the evapotranspiration reference, crop water requirements and irrigation needs. A data *viz.* maximum and lowest temperature, wind speed, solar radiation, relative humidity, and rainfall used in modified Penman–Monteith explicit equation to calculate the reference evapotranspiration (ETo). Most meteorological data and equations for CROPWAT measurements are located in the database, making CROPWAT an extremely accurate system.

The ETo was estimated using CROPWAT. An estimate of the required water for Mulberry, utilising ETo, crop coefficients, and the number of growing days is provided starting in 1981 to 2018. Table 2 provided crop growth phases and their associated crop coefficients before. (In these scenarios,) values of different meteorological parameters from 1981 to 2018 are used as reference values. In order to analyse the influence of climate on the various water requirements, several situations were compared.

Penman-Monteith equation

The FAO Penman-Monteith method used to estimate ETo (FAO, 1998 and Siddharam et al, 2022) is given by following equation (1).

$$ETo= \frac{0.408\Delta\left(R_n\text{-}G\right)+\gamma(\frac{900}{T+273})u_2(e_s\text{-}e_a)}{\Delta+\gamma(1+0.34u2)} \tag{1}$$

Where,

ETo-reference evapotranspiration (mm day^{-1})

R_n - net radiation at the crop surface (MJ m^{-2} day^{-1})

G - Soil heat flux density (MJ m^{-2} day^{-1})

T - Mean daily air temperature at 2 m height (°C)

u_2 - wind speed at 2 m height (m s^{-1})

e_s - Saturation vapour pressure (kPa)

e_a - actual vapour pressure (kPa)

e_s-e_a - saturation vapour pressure deficit (kPa)

Δ - Slope vapour pressure curve (kPa °C^{-1})

γ - Psychometric constant (kPa °C^{-1})

In the crop coefficient approach the crop evapotranspiration (ETc) is calculated by multiplying the reference crop evapotranspiration (ETo) with crop coefficient (Kc):

$$ET_c= K_c\times ET_o \tag{2}$$

Where,

ETc -Crop evapotranspiration (mm d^{-1})

K_c -Crop coefficient (dimensionless)

ETo- Reference crop evapotranspiration (mm d^{-1})

Statistical analysis

An study of long-term water demand data from agriculture was done in Microsoft Excel, and that analysis used the MS Office Excel programme. Mann-Kendall test for assessing the presence of monotonic rising or decreasing trend revealed that a monotonic increasing or decreasing trend was present. Sen's slope method used for gauging the linear trend in the region. That item's computation specs may be found on that item in the specs box (Siddaram et al. 2020). The detailed estimation procedure and formulae used for its calculations given in (Siddaram et al. 2020).

RESULTS AND DISCUSSION

Crop Water Requirement (ET_c)

To determine the crop water requirement (Siddharam et al, 2022) for Mulberry crop, the Shahapur, Shorapur and Yadgir taluka's area was analysed for last 35 yearsand the findings are depicted in Figure 4. (a to g). Table 4 displays Mann-Kendall trend (Z), Sen's slope value (Q) over a long period of time, with yearly average ETc in mm, along with average high and low values for the locations Shahapur, Yadgir and Surpur. The anticipated amount of water this crop would require was calculated based on meteorological characteristics that affect crop water requirements. In the Shorapur, Mulberry observed the highest amount of ETc (1879.2 mm) in 2000 and the least (1504.9 mm) in 1998, and the average of that quantity (1550 mm) was calculated (as seen in Fig. 4 (a)). With the investigation conducted for ETc in Shorapur, it was found that the series of Mann-Kendall (Z) had a negative trend, with a value of -0.957 and a Sen's slope of -0.937. The fig. 4 (b) showed the ETc of Mulberry, recorded at Shahapur, with the highest value of 1783.9 mm in 1988, and the lowest value of 1537 mm in 2007 with 1534 mm average values. Also, it was found that the series of Mann-Kendall (Z) had a negative trend, with a value of -0.072 and a Sen's slope of -0.181. In the figure on the right, 1687.8 mm of highest Mulberry ETc was measured in Yadgir in 2013, with lowest 1282.6 mm in 1984, an average of 1551.0 mm with Mann-Kendall (Z) series had a positive trend, with a value of 0.793 and a Sen's slope of 0.849. According to the findings, there has been a decline in ETc's Shahapur and Shorapur, and an increase in ETc of Yadgir during the last 35 years. In addition, the wind speed, relative humidity, and solar radiation changes had an impact on the increase of crop water requirement (Kambale et al. 2017). The study region is comprised of black dirt and some measure of red soil. Trivedhi et al. (2018) found similar results and came to the conclusion that evapotranspiration occurred in the Shipra river basin. CROPWAT 8.0 model was applied to the data set from 1990 to 2010 to calculate the estimated and measured potential evapotranspiration. Overall, the 35-year crop water requirement data for Yadgir indicated a favourable trend. These data show a negative trend in the series: ETc found a decline in numbers in Shahapur and Shorapur (Table. 4).

Table 4 and Figure 4 show be seen here

Predicted Crop Water Requirement (ETc)

ETc is given in Table 4, with reference average values of 35 years meteorological records. Scenarios 1, 3, 4, 5, 6, and 2, respectively, are based on the IPCC and INCCA findings. For Scenario 1, 2, and 3, Shorapur had the lowest measured ETc of 1705.6 mm, 1709.4 mm, and 1715.2 mm. The ETc for scenario 4 was highest in Yadgir, where the ETc was found to be 1734.5 mm, and lowest in Shorapur, where the ETc was determined to be 1726 mm. In case of Scenario 5, Shahapur found the greatest ETc at 1767.5 mm and the lowest at 1753.8 mm on the Shorapur. The ETc recorded its peak of 1795.4 mm in Shorapur and the lowest of 1781.1 mm in Shahapur. Similarly, as was reported bySiddharam et al (2022), similar findings were found in their performed investigations. The total ETc of across all locations was shown to be variations as the climate changes under all scenarios. In addition to these,similar kind of results also observed in Kambale et al (2017). Manasa and Anand (2016) anticipate a rise in global ETc (Manasa and Anand, 2016) in all places, as predicted by the INCCA and IPCC. Keep in mind that the anticipated ETc for IPCC and INCCA scenarios follows the long-term trend of ETc for Shahpur, Shorapur and Yadgir which is calculated using meteorological data over an extended period of time.

CONCLUSION AND SUMMERY

The crop water requirement of Mulberry showed a negative trend in Shahapur and Shorapur and a rising trend in Yadgir. Despite temperature rising to a certain extent, the ETo concentration did not increase as predicted in all the sites. It may be that the other climate parameters are being controlled. This study evaluated several climate change scenarios to help determine the various coping mechanisms farmers and ranchers in the study region will adopt in the face of climatic unpredictability. The key results from the study are; All locations under various climate change scenarios showed a rising ETc. The highest and minimum ETc observed in scenarios 6 and 2 respectively, in the future scenarios of INCCA and IPCC.Keep in mind that the anticipated ETc for IPCC and INCCA scenarios follows the long-term trend of ETc for Shahpur, Shorapur and Yadgir, which is calculated using meteorological data over an extended period of time.In order to decrease the danger of production reduction due to climatic variability, we must encourage water conservation techniques such as rainwater collection, soil and water conservation, and improve ground water recharge in the research region.

REFERENCES

1. Chattopadhyay, N. and Hulme, M., 1997, Evaporation and potential evapotranspiration in India under conditions of recent and future climate change. *Agric. For. Meteorol.*, 434(1):55-73.
2. Clarke, D., Smith, M. and Askari, K., 1998, New software for crop water requirements and irrigation scheduling. *J. Irrign. and Drain.*, 47(2): 45–58.
3. FAO 56, 1998, Crop evapotranspiration- guidelines for computing crop water requirements- FAO Irrigation and drainage paper 56 Italy, Rome. p:1- 9.
4. Hassan, A., Mostafa, M. and Gamal, A., 2019, Assessment of agroclimatology NASA POWER reanalysis datasets for temperature types and relative humidity at 2 meters against ground observations over Egypt. *Advan. in Space Res.*, 5(2):1-20.
5. INCCA, 2010, Indian Network for Climate Change Assessment, Climate Change and India: A 4x4 Assessment, Ministry of Environment and forests, Government of India.
6. IPCC, Climate Change, 2007, Climate change impacts, adaptation and vulnerability. Working Group II contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report. Summary for policymakers, pp:23.
7. Kambale JB, DK Singh, A Sarangi, 2017. Impact of climate change on groundwater recharge in a semi-arid region of northern India. *Applied Ecology and Environmental Research* 15 (1), 335-362

8. Kambale, J. B., Singh, D. K. and Sarangi, A., 2017, Modelling climate change impact on crop evapotranspiration. *Nat. Environ. and Pol. Tech.*, 16(3): 953-958.
9. Manasa H. G. and Anand V. S., 2016. Implications of climate change on crop water requirements in hukkeri taluk of Belagavi district, Karnataka, India. *Int. J. Res. in Engg. and Tech.*, 5(6): 1-6.
10. Mohan, S. and Ramsundram, N., 2014, Climate change and its impact on irrigation water requirements on temporal scale. *Irri. Drainage Sys. Eng.* 3(1): 1-8.
11. Nagraj, D. M., 2019, Performance evaluation of Piegion pea under drip irrigation and plastic mulch under Raichur agroclimatic condition. Unpublished thesis, University of agricultural sciences Raichur.
12. Ojeda, B. W., Sifuentes, I. E., Iniguez, C. M. and Montero, M. M. J., 2014, Climate change impact on crop development and water requirements. *Agrociencia*, 4(1): 1-11.
13. Rajaram, S., Qadri, S. M. H. and Sivaprasad, V.2017.Irrigation Water Savings in Mulberry Cultivation without Affecting the Quality Linked Productivity of Raw Silk and Income to Sericulture Farmers. *Int J of Tropical Agric.*35(4):1073-1081.
14. Rotich, S. C., and Mulungu, D. M. M., 2017, Adaptation to climate change impacts on crop water requirements in kikafu catchment, Tanzania. *J. Water and Climate Change.*, 8(2): 274-292.
15. Siddaram, JB Kambale, D Basavraja, Nemichandrappa M and Anilkumar Dandekar. 2020, Assessment of long term spatio-temporal variability and Standardized anomaly index of rainfall of northeastern region, Karnataka, India, *climate change,* 6 (21), 1-11.
16. Siddharam, Kambale J.B., Nemichandrappa M., Dandekar A.T., Basavaraja D. 2022. Spatio-temporal Variability and Climate Change Impact on the Crop Water Requirement of Pigeonpea (Cajanus cajan) - A Case Study, North-Eastern Karnataka, India. *Legume Research.* 45(6): 780-789.
17. Surendran, U., Sushanth, C. M., George, M. and Joseph, E. J., 2015, Modelling the crop water requirement using FAO-CROPWAT and assessment of water resources for sustainable water resource management: A case study in Palakkad district of humid tropical Kerala, India, *Aquatic Procedia.*, 4: 1211-1219.
18. Trivedi, A., Pyasi, S. K. and Galkate, R. V., 2018, Estimation of evapotranspiration using CROPWAT 8.0 model for shipra river basin in Madhya Pradesh, India. *Int. J. Curr. Microbiol. App*. Sci., 7(5): 1248-1259.
19. Wang, X., Zhang, J. Y., Ali, M., Shahid, S., He, R. M., Xia, X. and Jiang, Z., 2016, Impact of climate change on regional irrigation water demand in Baojixia irrigation district of China. *Mitig. Adapt. Strat. Gl.,* 21(2): 233-247.
20. https://power.larc.nasa.gov. Accessed on 01/12/2022

Table 1. Properties of Soil

Sl. No.	**Properties**	**Values**	
1	Soil type	Red soil	Black soil

2	Total available soil moisture, mm^{-1}m	25-100	200
3	Initial available soil moisture, mm^{-1}m	25 -100	175 - 250
4	Field capacity, %	45-55	25-35
5	Wilting point, %	15-20	10-15
6	Maximum infiltration rate, mm h^{-1}	20 - 30	5 - 10

Source: (FAO, 56, 1998)

Table 3. Climate change scenarios considered for prediction of crop water requirement under Mulberry.

Climate Scenarios	Descriptions
Reference (baseline)	Average values of 1981 to 2018 weather parameters
1	**IPCC Scenario for 2050s** Increase in temperature 1.5 ºC
2	**INCCA scenario for 2030s** Increase in temperature 1.7 ºC
	IPCC Scenario for 2080 to 2100s
3	Increase in temperature 2 ºC
4	Increase in temperature 2.3 ºC
5	Increase in temperature 4 ºC
6	Increase in temperature 5.4 ºC

Table 4. Yearly highest, lowest values, Long term average, Mann-Kendall trend (Z) and Sen's slope value (Q of crop water requirement.

Places/ Indices	Crop water requirement, mm			Test Statistics	
	Highest	Lowest	Average	Z	Q
Yadgir	1687.8 (2013)	1282.6 (1984)	1551.0	0.793	0.849
Shahapur	1783.9 (1988)	1537.0 (2007)	1534.0	-0.072	-0.181
Shorapur	1879.2 (2000)	1504.9 (1998)	1603.1	-0.957	-0.937

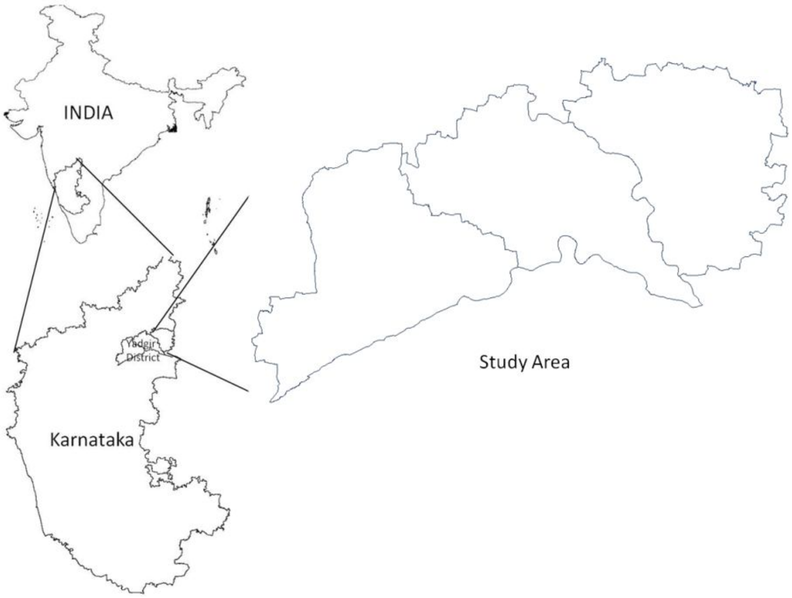

Fig. 1. Location of study area.

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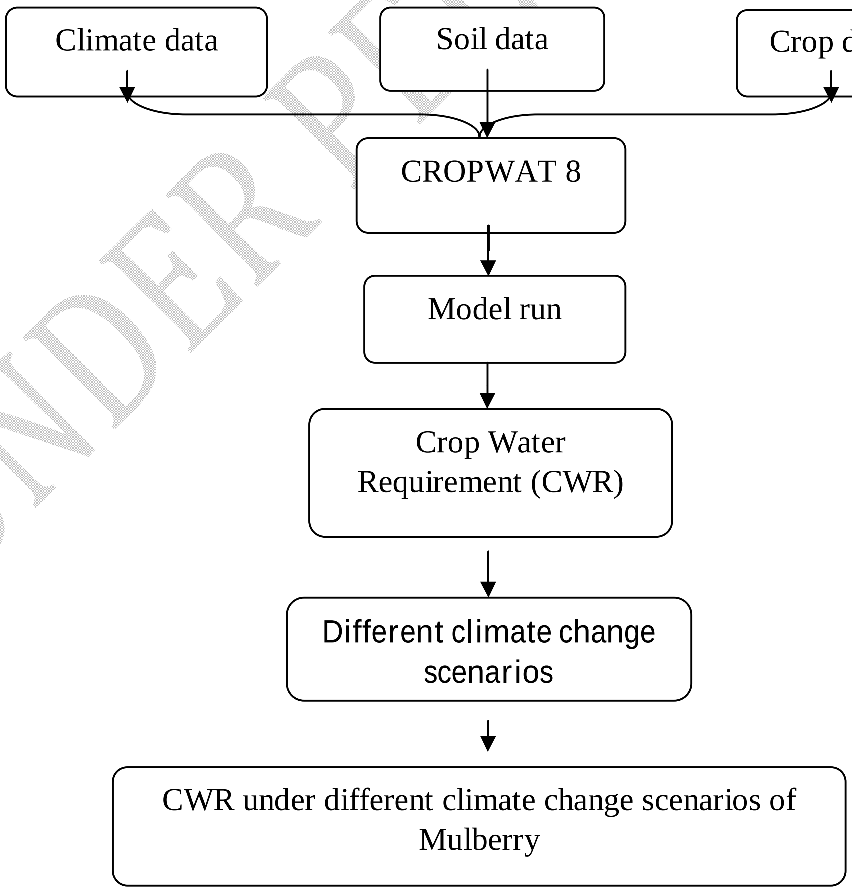
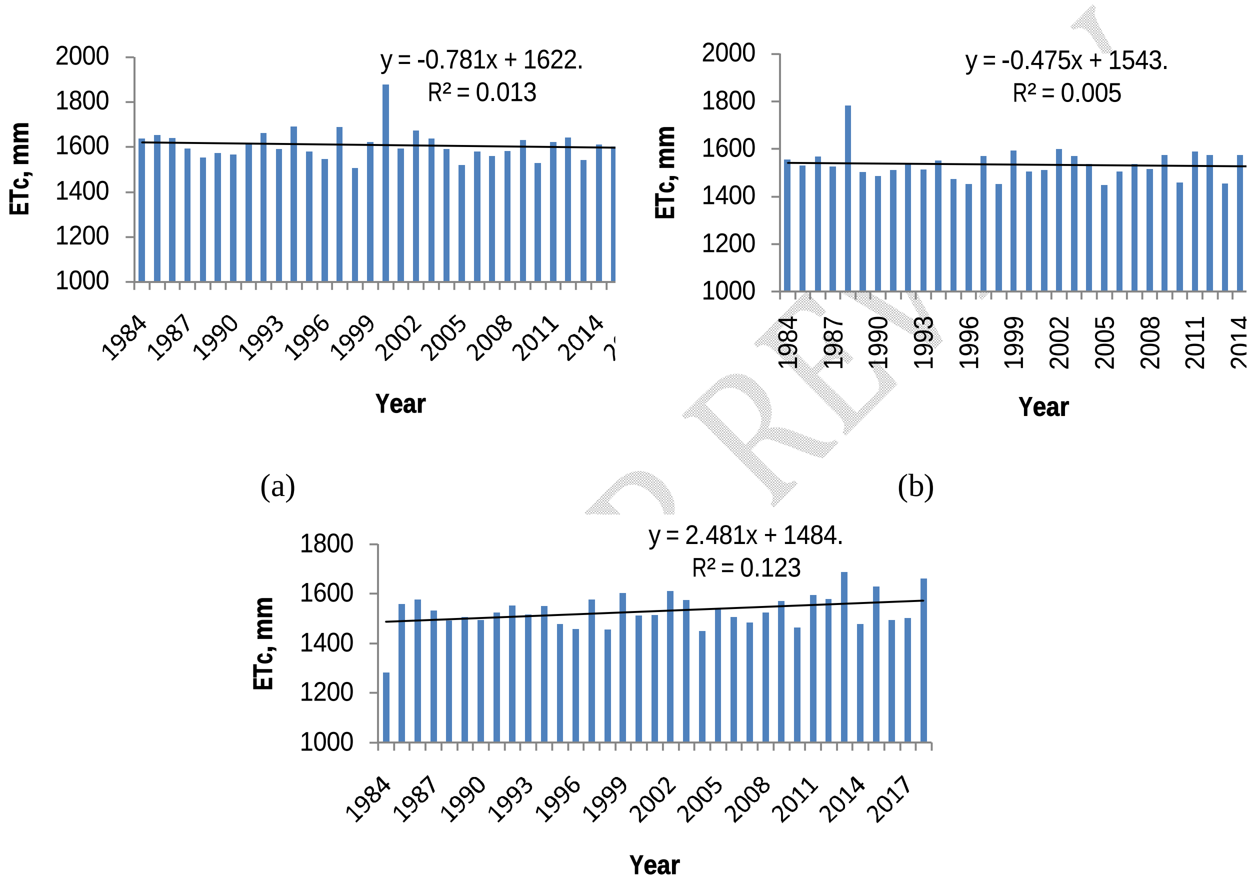


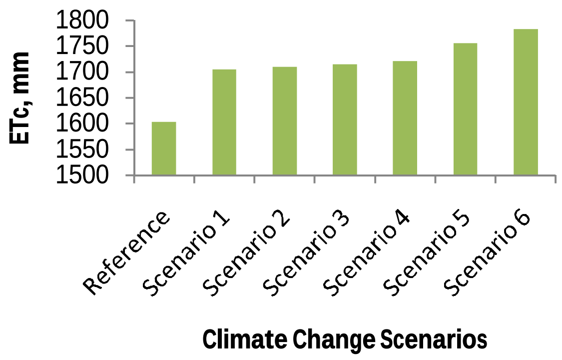
Fig. 2 Study process flow chart

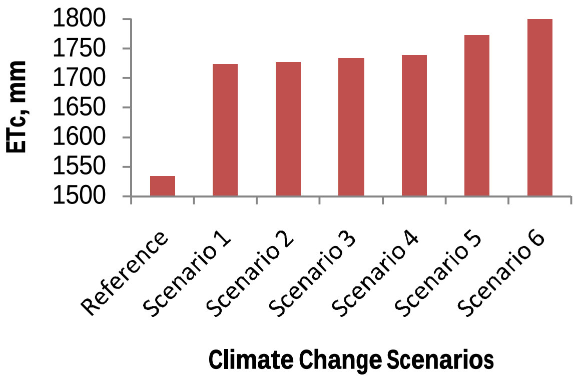


(a) (b)

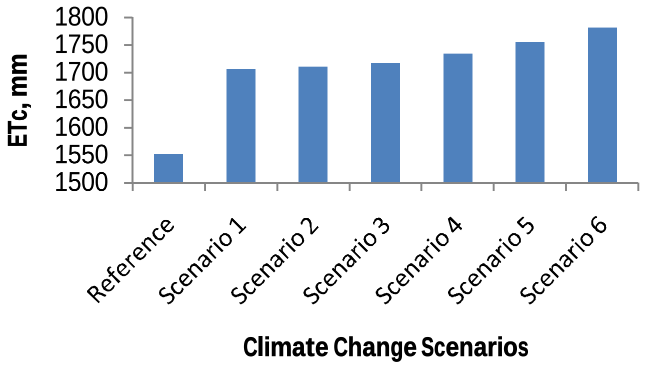
(c)

Fig. 3. Crop water requirement of Mulberryat (a)Shorapur, (b) Shahapur, and (c) Yadgir





(a) (b)



(c)

Fig. 4. Crop water requirement of Mulberry under different climate change scenarios for locations (a)Shorapur, (b) Shahapur, (c) Yadgir