Mapping of Climatic Suitability to Sugarcane Cultivation and Assessment of Irrigation Requirement in Pune District using Eco-Crop and CROPWAT Models of Geospatial Technology

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Abstract

Food shortage and malnutrition is major problem in India. Agriculture is a major sector of economy and contributes 18-19 % weightage of GDP. Agriculture provides employment opportunities to a large population i.e. 148 million employees for the financial year 2022-23 in India. Agriculture and is depend on environmental, socio-economic and cultural factors. Different crops cultivated in different climatic conditions. Sugarcane is a major cash crop cultivated in Pune district of Maharashtra. Temperature and Rainfall are major climatic factors determines the area of sugarcane cultivation and productivity. Eco-crop model is an approach used in DIVA-GIS software to assess the climatically suitable areas for sugarcane cultivation by using the data provided by WorldClim. Also, the investigation determines the change in sugarcane crop cultivation due to climate change. Irrigation is one of the important needs in unpredictable, erratic and uneven distribution of seasonal rainfall and temperature. It helps to increase the crop production and income. The present investigation identifies the temperature and rainfall suitable or unsuitable areas for deciding the crop cultivation seasons or additional efforts to increase the production. Designing the irrigation schemes, effective rainfall is needed to be estimated to know the amount of water supplied from irrigation. Cropwat is a decision support tool developed by the LWDD of FAO uses effective rainfall determination method where data taken from ClimWat. The present investigation calculates the crop water and irrigation requirements based on soil and climate. The model is used to evaluate farmers' irrigation practices to estimate crop performance. Additional study using soil–water balance is useful for effective rainfall determination in planning and designing of irrigation schemes. Geospatial technology tools and softwares are very helpful for data collection, analysis, mapping and representation cartographically in effective way. The present investigation is useful for effective planning of agricultural practices for smart and precision agriculture in Pune district which is the aim of planning and development of agricultural sector in India.

Keywords: Ecocrop, Climate suitability, Evapo-transpiration, Effective rainfall, Water Requirement, Irrigation

Introduction

Agriculture is an important economic activity in Pune district. In general, majority of population for employment is depend on agriculture and related activities. Agricultural productivity and cropping patterns are immensely affected by the climate and climate change along with other factors like soil, market, transport, capital, technology,

physiography etc. The present investigation focuses on an analysis of the potential effects of changing climate on the geographical distribution of suitable areas for the cultivation of sugarcane crop in Pune district along with the potential evapo-transpiration and requirement of water or rainfall for irrigation and irrigation schedules as well as schemes. To combat with the impact of climate change, FAO developed Ecocrop model to predict climatically-suitable areas of different crops for the current and future climate. It is a scientific model which uses gridded climate datasets of temperature and rainfall ranges along with elevation (DEM) as inputs to determine the main niche of a crop and then produces a suitability score as output predicts the crop distribution based on climatic and weather condition in an area. It is important to know the climatic suitability for different crops to decide the cropping pattern and productivity as well as barriers and problems of agricultural development and sustainability. The farmer should aware which areas are suitable for particular crop to promote agricultural development. This investigation is focusing on climate change and climatic suitability for sugarcane crop in Pune district. In addition, Geospatial technology helps in determination and mapping of climatic suitability for different crops. To overcome food shortage and malnutrition problems, there is a need to use technology for increase of production and sustainable farming. Farmers are also facing the problems of water shortage, minimum prizes, and uncertainty of climate. The investigation support to identify the problems and prospectus of irrigation facility for high productivity and development of agriculture. Cropwat is an effective tool developed by FAO uses effective rainfall determination method by using data from ClimWat. The present investigation estimates the ratio of evapotranspiration and triggers the effective rainfall. Also calculates the crop water and irrigation requirements based on soil and climatic conditions along with irrigation practices to estimate crop performance and productivity. The study using soil–water balance is useful for effective rainfall determination in planning and designing of irrigation schemes in agriculture to planners and administrators for allocation of funds and recognize the needy and beneficiaries of different agricultural schemes and policies. Indirectly the investigation also supportive in eradication of poverty, malnutrition and hunger problems in India.

Review of Literature:

CROPWAT - a computer program for irrigation planning and management article published by FAO (1992). Lal et al. (1995) studied the climate change phenomena for Indian subcontinental landmass and projected an increase in yearly mean maximum and minimum surface air temperatures by 0.7°C and 1.0°C respectively over land in the 2040s as compared to the 1980s. Oriental armyworm populations get raised when extensive period of drought is followed by heavy rainfall (Sharma et al. 2001). In the last 100 years the mean annual surface air temperature of India has increased by 0.4-0.6°C (Rupakumar 2002). Crop diversification increases resilience and brings higher spatial and temporal biodiversity on the farm (Holling 1973; Joshi 2005). Shakeel et al. (2009) reported increase in temperature up to 2°C in Kharif and 4.5°C during Rabi by 2070 over Indian subcontinent. IPCC in assessment report has predicted up to 4.3°C temperature rise over India by 2080s. Empirical approaches for assessing impacts of climate change on agriculture was studied by the Julian Ramirez-Villegas in the year 2011. According to Khan et al. (2009), the average rainfall of India is projected to increase by 10% during Kharif and Rabi seasons up to 2070 from the year 2010. Rupakumar

et al. (2003) revealed that marked increase in rainfall in the 21st century is likely to be evident severe after 2040s that the number of rainy days is likely to increase by 5-10 days in the foot hills of Himalaya and Northeast India. Annual precipitation increases by 1.2–2.4% by 2030s. Annamalai et al. (2010) reported decreasing rainfall tendency in both southwest and northeast monsoon seasons in most parts of central and northern India. According to Lin (2011), crop diversification improves soil fertility and brings about yield of crop stability. Similarly high intermittent rains resulted in outbreak of phytophthorablight in pigeonpea (Pande and Sharma 2009; Pande et al., 2011). Projected precipitation changes varying from 5 to 45% (Chaturvedi et al. 2012). Dry root rot in chickpea and charcoal rot in sorghum had raised in last 2-3 years due to rise in temperature and prolonged moisture stress (Sharma and Pande, 2013). Ecocrop model approach for agro-climatic sugarcane crop suitability in Bhogawati river basin of Kolhapur district assessed by Vikramsingh Pawar Patil in 2015. Agricultural Productivity calculated based on M.G. Kendall's method in Malshiras Tahsil was studied by Mr. Santosh P Mane in 2017. Monitoring and predicting agricultural drought study carried by Boken and et al. Crop combination region of Ausgram gram panchayat was studied by Badsha Pal in 2017. The TNAU worked on assessing impacts and developing adaptation strategies for agriculture in Tamil Nadu at river basin scale in Tamil Nadu. Vasant G and others studied isolation and molecular characterization of plant growth promoting rhizobacteria from Groundnut (2023). Agricultural Research Institute (IARI) recommended that Rabi crops will be affected seriously by increase in temperature would reduce wheat production by 4-5 million tons. Productivity of cereals would decrease due to increase in temperature and decrease in rainfall in northern India in future. All studies reveals that there is an urgent need to study the relation of climate on cropping patterns, productivity, combination, diversification and water requirements and irrigation of selected study area at grass root level for effective planning and development of agricultural sector which is a backbone of Indian economy. The Ministry of Agriculture through ICAR has undertaken extensive capacity building of farmers and scientists and researchers at various levels on the impact of climate on agriculture and promotion of locally appropriate adaptation strategies for welfare of community.

Aim and Objectives:

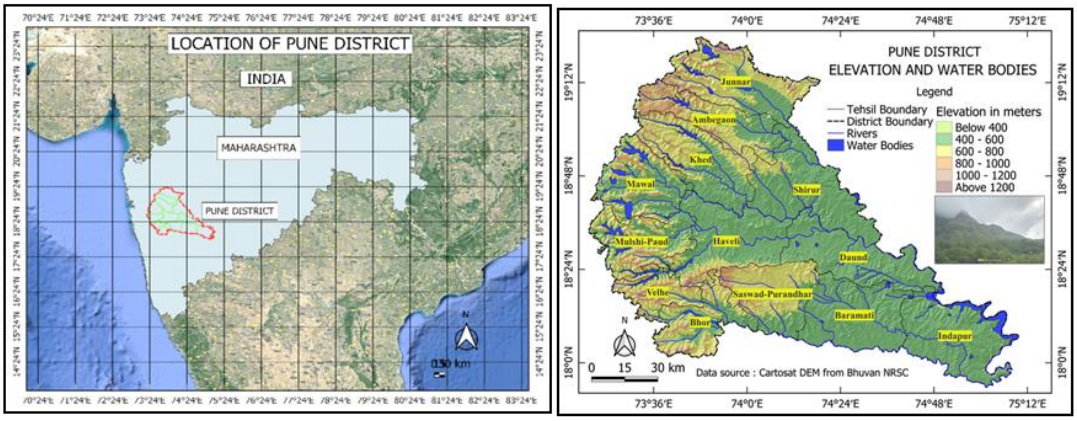
The investigation aims the mapping of climatic suitability to sugarcane cultivation and assessment of irrigation requirement in Pune district using eco-crop and cropwat models of geospatial technology.

1) Mapping of average temperature and rainfall distribution in Pune district.
2) Assessment of spatio-temporal climatic suitability for sugarcane crop in Pune district.
3) Measurement of evapotranspiration and effective rainfall in Pune district.
4) Calculation of pattern, water requirement and irrigation schedule for sugarcane in Pune district.
5) Evaluation of irrigation scheme for sugarcane cultivation in Pune district.

Study Area

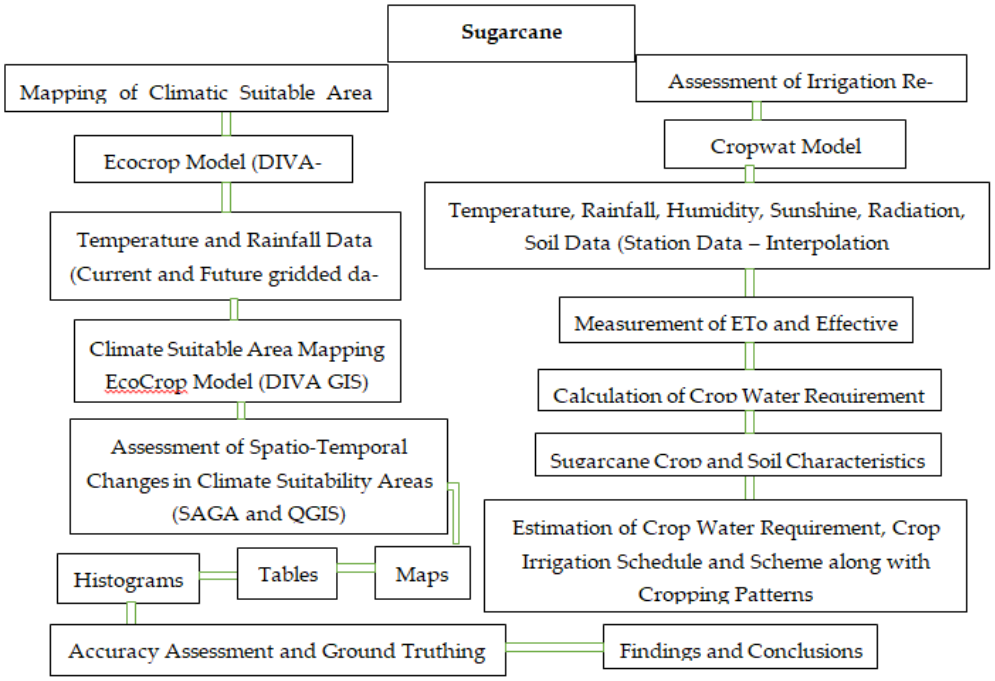
Pune district is located between 17^0 54′ and $19^0$24′ North latitude as well as $73^0$19′ and $75^0$10′ East longitude covers 15642 sq. km area i.e. 5.10% of Maharashtra and situated at

east of the Western Ghats surrounded by Thane, Ahmednagar, Satara and Raigad districts. Western part is hilly, eastern part plateau with interrupted hills and plains in river basin. Pune district experiences tropical monsoon climate shows a significant seasonal and distributional variations in temperature as well as rainfall conditions. Climate of the western region of Pune is cool whereas the eastern part is hot and dry. Mula, Mutha, Pawana, Bhīma, Ghod, Indrayani, Kukadi are major rivers originates at Western Ghats and source of water for irrigation from Panshet, Khadakwasla, Bhushi, Bhatghar, Dimbhe, Pimpalgaonjoga and other dams.



Map 1 Location map (left) and Physiography map (right) of Pune District.

Materials and Methods



Data:

The outline map of Pune district is downloaded from https://onlinemaps.surveyofindia.gov.in. Climate datasets for the current climate is used WorldClim version 1.4, available at http://www.worldclim.org. WorldClim is a set of global climate layers (grids) with a 30 arc-second spatial resolution (1 km sq.) depicting average

monthly climate as a maximum, minimum, mean temperatures and total monthly rainfall. ClimWat is a climatic database used in computer program Cropwat which is a joint publication of the Water Development and Management Unit and the Climate Change and Bioenergy Unit of FAO. CLIMWAT 2.0 offers observed agroclimatic data and provides long-term monthly mean values of seven climatic parameters i.e. 1) Mean daily maximum temperature in °C 2) Mean daily minimum temperature in °C 3) Mean relative humidity in % 4) Mean wind speed in km/day 5) Mean sunshine hours per day 6) Mean solar radiation in MJ/m2/day 7) Monthly rainfall in mm/month. ETo calculator is a software developed by the FAO to calculate reference evapotranspiration (ETo) according to FAO standards using climate data. The primary data about the suitability of different factors for the crops production as well as problems faced by farmers is collected by field visits. Secondary data of crops and agricultural conditions used from district gazetteers as well as socio economic reports of government of Maharashtra and other authentic sources. Outline map and other information referred from different magazines, research literature, topographical maps, and district planning series maps, census reports and other sources.

Methods:

Mapping of climatic parameters such as maximum and minimum temperature, average rainfall and current and future climatic suitable area for sugarcane crop is carried out by using Ecocrop Model in DIVA-GIS Software. All maps and data are processed and composed by using the QGIS and SAGA and Excel softwares. Evapotranspiration, effective rainfall, soil and sugarcane crop characteristics, crop water requirements, irrigation supply and irrigation scheduling are calculated using CROPWAT model for Pune district.

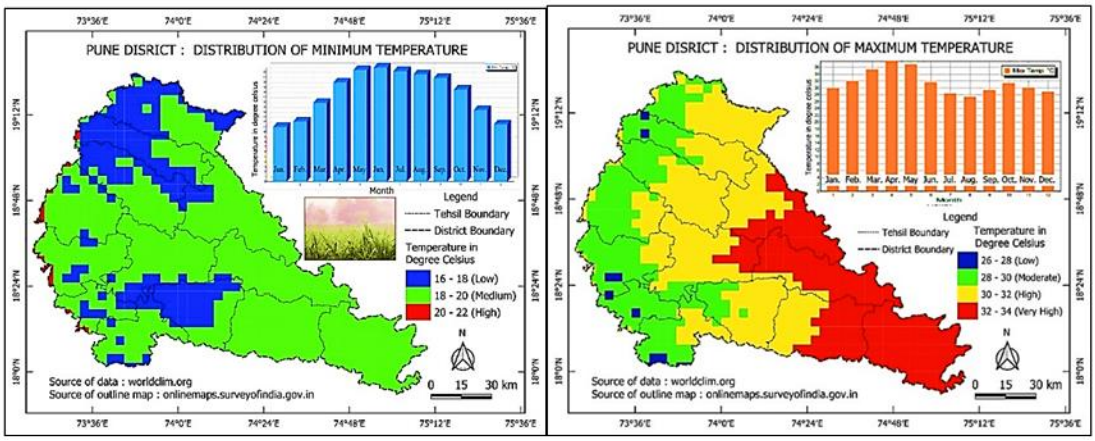
Findings / Discussion

Temperature and precipitation:

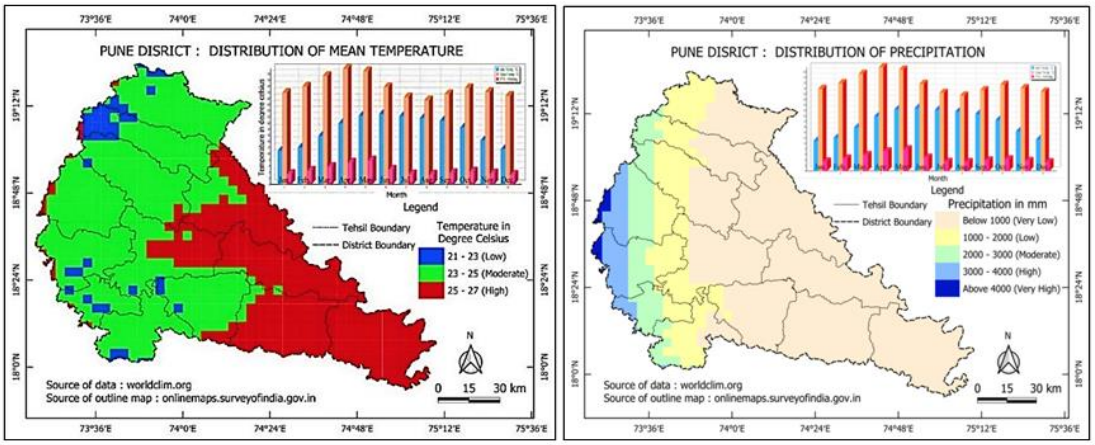
The temperature ranges from 16 ^{0} C to 34 ^{0} C depicted in Map 2. Maximum temperature during summer months frequently rises above 38°C. The western region of Pune district i.e. talukas Junnar, Ambegaon, Khed, Maval, Mulshi and Velha are cool whereas the eastern part i.e. talukas Shirur, Daund, Baramati and Indapur are hot. December and January are the coolest months, when average temperature falls as low as 11°C. Minimum temperature is recorded in western part, moderate in central and maximum temperature at eastern part of Pune district. The range and difference between maximum and minimum temperature is 10 to 12 ^{0} C. October heat wave is also severe in Pune district as well as cold waves. The fall of very low minimum temperature is common in irrigated area during winter season in comparison to non-irrigated area.

The average temperature is recorded from 21 ^{0} C to 27 ^{0} C in Map 3. Mapping of the climatic conditions within the Pune district, the rainfall is highly unevenly distributed. The Western part of the district which close to ocean and forested hilly area, the rainfall intensity is more compared to the eastern and south eastern part of the Pune district. Most of the moisture and rain is brought by the southwest monsoon winds during the late summer and about 87% of rainfalls during the rainy season months (June, July, August and September). April and May are the hottest and December and January are coldest months in the district.

Hilly area of Western Ghats receives highest rainfall such as place like Bhimashankar, Lonavala etc.



Map 2 Distribution of minimum and maximum temperature.



Map 3 Distribution of average temperature and precipitation.

Talukas falling in the highest rainfall intensity zone are Velhe, Mulshi and Maval. Talukas falling in the moderate rainfall intensity zone are Bhor, Ambegaon, Junnar, Khed, Haveli, Pune city and Purandar. Talukas with lowest rainfall intensity, the dry and semi-arid zone are Shirur, Daund, Indapur and Baramati. The talukas having low temperature but receives high rainfall due to orography. The talukas having high temperature but receives lowest rainfall due to rain shadow zone away from Western Ghats.

Evapotranspiration and effective rainfall:

Effective rainfall is measured as equal to the difference between total rainfall and actual evapotranspiration as well as waste from surface run off and deeper percolation beyond the root zone. Evapotranspiration includes water evaporation from the soil surface, groundwater table, water bodies on land and transpiration via plants and animals. In Table 1 ETo represents the evapotranspiration rate from a reference surface. Average evapotranspiration rate in Pune district is 4.56 mm per day. Highest evapotranspiration rate is observed in April and May months, moderate in February, March, June and October as well as low in January, July, August, September, November and December. Total effective

rainfall is 563.1 mm out of 717 mm yearly rainfall. Maximum effective rainfall is in June, July, August and September.

Table 1 Evapotranspiration and Effective Rainfall in Pune district.

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo	Rain	Eff rain
	°C	°C	%	km/day	Hours	MJ/m²/day	Mm/day	Mm	Mm
January	11.0	29.9	47	69	10.4	20.1	3.44	0.0	0.0
February	12.1	31.9	44	95	11.4	23.4	4.46	2.0	0.0
March	15.8	35.4	35	121	11.4	25.6	5.74	3.0	0.0
April	19.9	37.7	38	164	11.9	27.6	7.14	12.0	1.0
May	22.4	36.9	50	242	11.9	27.8	7.81	42.0	16.0
June	22.9	31.7	86	285	8.3	22.2	4.87	121.0	104.7
July	22.2	28.4	94	268	4.7	16.8	3.29	183.0	148.1
August	21.6	27.4	92	242	4.8	6.7	3.23	124.0	106.8
September	20.8	29.4	94	147	7.3	19.7	3.77	133.0	113.1
October	18.5	31.4	72	95	8.9	20.5	4.22	67.0	66.9
November	14.4	30.1	60	69	9.5	19.3	3.60	23.0	6.5
December	11.5	28.9	53	69	9.3	18.0	3.17	7.0	0.0
Average	17.8	31.6	64	156	9.2	21.5	4.56	717.0	563.1

*Eff. rain method: Empirical formula: Peff = 0.5 * Pmon + -5 (Pmon <= 50) Peff = 0.7 * Pmon + 20 (Pmon > 50)*

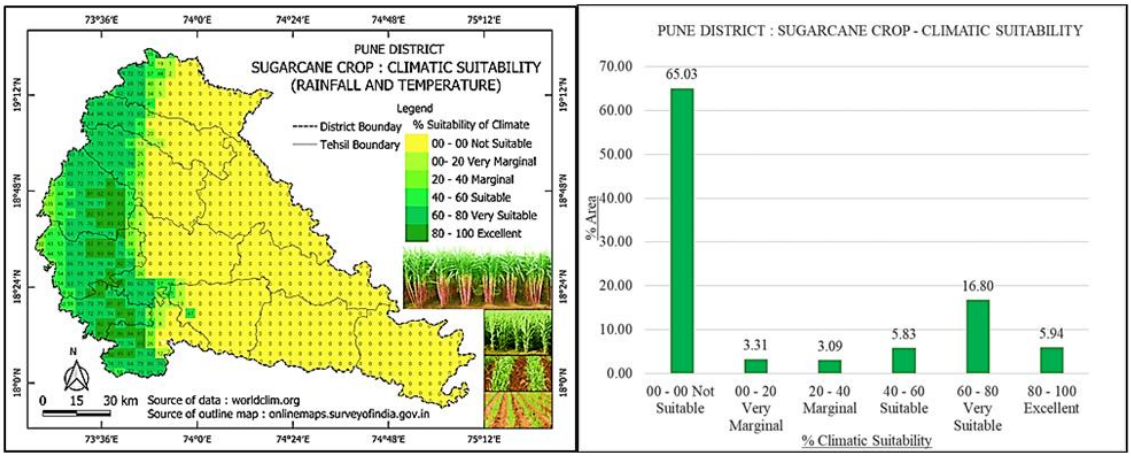
Climatic suitable area for sugarcane crop:

Ecocrop is database used to determine the suitability of a sugarcane crop for a specified environment in Pune district. Optimum temperature required for germination of stem cuttings is 32 to 38°C. Optimum growth is achieved with mean daily temperatures between 22 and 30°C positively. The duration of crop is approximately 9 months to 16 months. Thus, it needs enough water throughout the year. Pune district receives rainfall only from June to September. The climatic suitable area is identified based on suitable average, minimum and maximum temperature as well as precipitation rate in the particular area.

Table 2 Sugarcane Crop - Climatic Suitability in Pune district.

Sr. No.	% Suitability	No of pixels	Area in sq. km	% Area
1	00 - 00 (Not Suitable)	569	10171.77	65.03
2	00 - 20 (Very Marginal)	29	518.42	3.31
3	20 - 40 (Marginal)	27	482.67	3.09
4	40 - 60 (Suitable)	51	911.71	5.83
5	60 - 80 (Very Suitable)	147	2627.86	16.80
6	80 - 100 (Excellent)	52	929.58	5.94
Total		875	15642.00	100.00

Map 4 indicates that 65 % area (10171.77 sq. km) is not agronomical suitable that is central and eastern talukas of Pune district. 22 % area of Pune district is climatic best suitable i.e. part of Western Ghats and hilly area with red soil. Maximum cultivation of sugarcane is in the river's valleys or black soil areas of central and eastern part of district where the climate is not favorable especially rainfall. Insufficient rainfall throughout the year demands excessive assured irrigation in the sugarcane cultivation area for high productivity and survival of crop in rainshadow and low rainfall areas of Shirur, Baramati, Daund and Indapur.



Map 4 Climatic suitability (left) and climatic suitable area (right).

Soil: Deep black soil is existing in plain area of eastern rainfall scarcity zone of Purandar, Shirur, Indapur, Daund, Haveli talukas which accounts 45% of the Pune district. Red or brown soil is found in sub-mountain foothills and Western Ghats zone. In Pune district, red soil covers 5%, Alluvial soil 8%, Sandy soil 12% and Sandy loam soil 30% of the area. Total available soil moisture is 200.0 mm/meter in soil. Maximum rain infiltration rate found to be 30 mm/day in general of black soil. Maximum rooting depth can be 900 centimeters in black soil. Initial soil moisture depletion is around 50 % and initial available soil moisture 100.0 mm/meter. Black soil area of central and eastern part is suitable for cultivation of sugarcane in Pune district.

Sugarcane cultivation: Sugar cane is cultivated due to availability of water for irrigation in Pune district. The area under sugarcane crop was around 13000 hectares in 1961, 52000 hectares in 1991 and 164136 hectares in 2021. Around 15.19 percent area is under cultivation of sugarcane in Pune district. Winter season is best suitable for sugarcane plantation. Table 3 gives an idea about crop cultivation.

Table 3 Sugarcane crop (Ratoon) planting date: 01/11 Harvest: 30/10).

Stage	Initial	Develop	Mid	Late	Total
Length (days)	30	60	180	95	365
Kc Values	0.40	-->	1.25	0.75	
Rooting depth (m)	0.50	-->	1.00	1.50	Rooting depth (m)
Critical depletion	0.65	-->	0.65	0.65	
Yield response f.	0.50	0.75	1.20	0.10	1.20
Crop height (m)			3.00		

Sugarcane crop water requirement:

19 major, 8 medium and 4640 micro irrigation projects are located in Pune district. 1019 percolation tanks, 942 KT weirs, 1818 lakes and ponds, 19973 wells are the sources of irrigation in Pune district. 14 cooperative irrigation schemes are implemented for irrigation. Table 4 is representing the effective rainfall and irrigation requirement in each decade (10 days) from sugarcane plantation to harvesting

period. 1337.8 mm total irrigation water is required besides the 563.3 effective rainfall throughout the year in Pune district. Irrigation does not require in July, August and September months due to high effective rainfall. Approximately 90 mm / decade water for irrigation needed from March to May.

Table 4 Irrigation requirement.

Month	Decade	Stage	Kc Coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Oct	1	Init	0.40	1.65	16.5	27.9	0.0
Oct	2	Init	0.40	1.73	17.3	23.0	0.0
Oct	3	Deve	0.40	1.64	18.0	16.0	2.0
Nov	1	Deve	0.49	1.88	18.8	6.6	12.2
Nov	2	Deve	0.64	2.30	23.0	0.0	23.0
Nov	3	Deve	0.78	2.71	27.1	0.0	27.1
Dec	1	Deve	0.93	3.08	30.8	0.1	30.7
Dec	2	Deve	1.08	3.41	34.1	0.0	34.1
Dec	3	Mid	1.22	3.99	43.9	0.0	43.9
Jan	1	Mid	1.27	4.26	42.6	0.0	42.6
Jan	2	Mid	1.27	4.38	43.8	0.0	43.8
Jan	3	Mid	1.27	4.81	52.9	0.0	52.9
Feb	1	Mid	1.27	5.24	52.4	0.0	52.4
Feb	2	Mid	1.27	5.67	56.7	0.0	56.7
Feb	3	Mid	1.27	6.21	49.7	0.0	49.7
Mar	1	Mid	1.27	6.75	67.5	0.0	67.5
Mar	2	Mid	1.27	7.30	73.0	0.0	73.0
Mar	3	Mid	1.27	7.89	86.8	0.1	86.7
Apr	1	Mid	1.27	8.48	84.8	0.0	84.8
Apr	2	Mid	1.27	9.07	90.7	0.0	90.7
Apr	3	Mid	1.27	9.36	93.6	1.1	92.5
May	1	Mid	1.27	9.99	99.9	1.4	98.5
May	2	Mid	1.27	10.45	104.5	1.9	102.6
May	3	Mid	1.27	9.03	99.3	12.9	86.4
Jun	1	Mid	1.27	7.36	73.6	26.4	47.2
Jun	2	Mid	1.27	6.07	60.7	37.0	23.7
Jun	3	Late	1.27	5.43	54.3	41.1	13.2
Jul	1	Late	1.22	4.58	45.8	47.2	0.0
Jul	2	Late	1.16	3.70	37.0	53.4	0.0
Jul	3	Late	1.09	3.50	38.6	47.4	0.0
Aug	1	Late	1.03	3.34	33.4	38.7	0.0
Aug	2	Late	0.97	3.12	31.2	33.4	0.0
Aug	3	Late	0.90	3.08	33.8	34.8	0.0
Sep	1	Late	0.84	3.01	30.1	38.6	0.0
Sep	2	Late	0.78	2.93	29.3	40.1	0.0
Sep	3	Late	0.71	2.80	28.0	34.2	0.0
Total					1823.5	563.3	1337.8

Irrigation schedule:

When irrigation water is not scarce, Table 5 should be used to determine frequency and depth of irrigation required for a high yield. Total gross irrigation is 1978.1 mm although the total rainfall is 717.3 mm. Total net irrigation demand is 1384.7 mm and effective rainfall is 577.6 mm. Total irrigation losses 0 mm and total rain loss 139.6 mm. Actual water used by crop is 1820.7 mm approximately. Moisture deficit near to harvest period will be 8.4 mm. Potential water will be uses by crop is 1820.7 mm. Actual irrigation requirement is 1243 mm to fulfill the deficit of water required for the healthy growth of sugarcane crop. Efficiency irrigation schedule to be followed by farmer 100.0 % when efficiency of rainfall is 80.5 %. Farmers can fallow the irrigation schedule given in table 5. The irrigation schedule can be change according to prevailing local weather conditions. Table 5 reveals that in month of April, May and June the water requirement exceeds greater than 1 l/s/ha and December, January, March and September remain below 1 l/s/ha whereas gross irrigation remains beyond 200 mm.

Table 5 Irrigation schedule.

Date	Days	Stage	Rain	Ks	Eta	Depl	Net Irr.	Deficit	Loss	Gr. Irr.	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
6-Dec	67	Dev	0.0	1.00	100	66	197.1	0.0	0.0	281.6	0.49
25-Jan	117	Mid	0.0	1.00	100	66	197.4	0.0	0.0	282.0	0.65
2-Mar	153	Mid	0.0	1.00	100	66	199.3	0.0	0.0	284.7	0.92
29-Mar	180	Mid	0.0	1.00	100	65	195.3	0.0	0.0	278.9	1.20
21-Apr	203	Mid	0.0	1.00	100	65	195.3	0.0	0.0	279.0	1.40
14-May	226	Mid	0.0	1.00	100	68	204.2	0.0	0.0	291.8	1.47
20-Jun	263	Mid	0.0	1.00	100	65	196.1	0.0	0.0	280.1	0.88
30-Sep	End	End	0.0	1.00	0	3					

Irrigation scheme for water supply: Furrow irrigation is most commonly used and effective for healthy sugarcane growth in Pune district. Drip irrigation saves water which is deficient in the region. Table 6 is a scheme irrigation where maximum precipitation deficit recorded in summer months which exceeds 200 mm for a month and irrigation water demand is also required more than 1mm / day or 35 mm / month or 1.0 l/s/h.

Table 6 Irrigation scheme.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit	134.9	158.8	227.2	268.0	287.5	84.2	0.5	3.8	0.0	11.9	42.9	85.4
Net irr. (mm/day)	0.7	0.9	1.1	1.3	1.4	0.4	0.0	0.0	0.0	0.1	0.2	0.4
Net irr. (mm/month)	20.2	23.8	34.1	40.2	43.1	12.6	0.1	0.6	0.0	1.8	6.4	12.8
Net irr. (l/s/h)	0.08	0.10	0.13	0.16	0.16	0.05	0.0	0.0	0.0	0.01	0.02	0.05
Net irr. req. ((l/s/h))	0.50	0.66	0.85	1.03	1.07	0.32	0.0	0.01	0.0	0.04	0.17	0.32

Water for agricultural production act as a driver of food security and ending hunger considered as an engine for poverty alleviation of rural development.

Conclusions

The role of climate and water is pivotal in determining the food security and sustainable natural resource management in agriculture sector. The efficient, sustainable and equitable allocation and use of irrigation with the synoptic climatic conditions requires a sound

knowledge and understanding of the resource and environment. The present investigation detrimental to project the climatic suitability and irrigation requirement for sugarcane crop in Pune district of Maharashtra in India. The conclusions are:

1) Mapping of average temperature and rainfall distribution in Pune district is highly uneven. The western area of Pune district experiences the high rainfall but low temperature and eastern part receives low rainfall but high temperature. The range of maximum and minimum temperature is more than 10^{0} C. The central and eastern part of Pune district receives less the 1000 mm rainfall.
2) Assessment of spatio-temporal climatic suitability for sugarcane crop in Pune district projects that the western hilly area receives high rainfall and low temperature is most agroclimatically most suitable for sugarcane cultivation. But in reality the physiography, slope and type of soil is not suitable. The farmers does not cultivate the sugarcane in this area. The climate is not suitable in eastern plain black soil area which is under sugarcane cultivation demands water for irrigation to increase the production. 65 percent area is not suitable due to climatic barriers. Only 22.74 percent area is suitable from the perspective of temperature and rainfall for sugarcane.
3) Measurement of evapotranspiration and effective rainfall in Pune district based on climatic data reveals that the high evapotranspiration rate in summer months exceeds 7 mm/day and lowest in winter months falls below 4 mm/day. Highest effective rainfall recoded from June to September which is greater than 100 mm. The average evapotranspiration rate is 4.56 mm and effective rainfall is 563.1 mm.
4) Calculation of water requirement and irrigation schedule for sugarcane in Pune district depicts 1337.8 mm. The summer months needs an irrigation more than 80 mm/decade from March to May, moderate in winter and very less is rainy season. Net irrigation is required from 197 mm to 205 mm and gross irrigation from 278 mm to 292 mm in per cycle of watering the sugarcane crop in Pune district.
5) Evaluation of irrigation scheme for sugarcane cultivation in Pune district remarks 287.5 mm maximum precipitation deficit and needs 1.4 mm/day and 43.1 mm/month irrigation in the month of May whereas almost no deficit of precipitation and no need of irrigation from July to September. But the field observation recommends that such situation does prevails always due to erratic nature of monsoon spells either to heavy rainfall or long dry spells. Crop need irrigation for survival and high productivity during long dry spell. High and frequent demand irrigation is needed in the areas of low quality, course, sandy and high percolating soils. The area of fine alluvial soil demands less irrigation. The irrigation provision during winter needed less in comparison to summer.

The present investigation assessed the climatic suitable area for sugarcane cultivation and irrigation requirement in Pune district. There is demand of further research and investigation for all districts and all crops in the entire country. The application of research findings are helpful to all related to agricultural sector. Even grassroot level investigation will be very fruitful to the farmers in decision making of crop cultivation and high productivity. Water is very precious resource and available limited for irrigation. Planning of irrigation is needed can be supported by research and investigation.

To face the challenges of food security, climate change impact on agriculture and irrigation provision for cash crops like sugarcane, the country needs to reorient its land use and agriculture with the state-of-the-art technologies and policy initiatives. There is a need to develop policy framework for implementing the adaptation and mitigation options so that the farmers are saved from the adverse impacts of climate change and water shortage. Use of geospatial technology tools and techniques supports very positively to assess the

agricultural inputs, processes and drawbacks. It helps in decision making to farmers, planners and government of India.

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