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Climatological impact on groundnut crop over Junagadh district

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Abstract
The present study investigated the climatic vulnerability of the peanut cropping system in Gujarat's Junagadh district. The Junagadh district is situated in western Gujarat between the latitudes of 70.150 and 70.550 and the longitudes of 20.470 and 21.450. One of the significant oil seed crops in India is the groundnut crop. Gujarat is India's top groundnut producer. Gujarat's Junagadh district produces the majority of the state's ground net crops. Planning for climate change mitigation efforts requires an understanding of the past, present, and projected temperatures and precipitation in the Junagadh district. IMD provided historical daily temperature data with a resolution of 100 km for the years 1951 to 2019.Historical daily temperature data from 1951 to 2019 is downscaled to 1 km from IMD at a resolution of 100 km x 100 km. Data on historical precipitation was downscale from Cru's 25 km x 25 km resolution to 10 km. The temperature projections (RCP 4.5 and RCP 8.5) for five South Asian codex domain models at resolutions of 50 km x 50 km and scaled down to 1 km are displayed. 50 km x 50km and 10km downscale daily data from five South Asian codex domain models. The Taylor diagram demonstrated that, when tested against cru data, all models perform better in terms of rainfall and temperature. The cm5a model outperformed the other models in terms of performance. Maximum temperatures are seen to rise from 32.760 C to 35.50 C (RCP 4.5) and 37.20 C (RCP 8.5) and minimum temperatures are seen to rise from 23.920 C to 25.300 C (RCP 4.5) and 27.480 C between 1970 and 2100 (RCP 8.5). June, a crucial month for the germination stage of groundnut crops, sees an increase in both the maximum and minimum temperatures. From 1970 to 2100, June to November total precipitation increased from 853.2 mm to 1029 (RCP 4.5) and 1097 mm, respectively (RCP 8.5).

Keywords: Oil seed, production, mitigation, down scaled, codex, RCP

Introduction

The important grain legume crop known as groundnut is grown primarily for its use as a source of vegetable protein and edible oil. The production of peanuts takes place in the tropical and semi-arid tropical regions, which are characterized by high temperatures and little rainfall, to the tune of about 90% of the global total. In the majority of tropical regions, crops are getting close to the point where they can tolerate no more heat, which could result in lower crop yields. The ideal air temperature for groundnut terminative growth is between 260 and 300 °C, which is higher than the ideal air temperature for reproductive growth, which is between 220 and 250 °C (Cox, 1991) [11]. Meteorological factors, such as rising temperatures, shifting precipitation patterns, and rising atmospheric carbon dioxide levels, have a significant biophysical impact on crop production (H.R. Patel *et al*., 2013) [8]. The biophysical effects of climate change on agricultural production will vary over time and will be positive or negative depending on the type of agricultural system and region. Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, and Maharashtra account for 80 percent of India's land area and 84 percent of its production. Gujarat leads all of them in terms of both production and area (forest report, Directorate of agriculture, Gujarat state). In Gujarat, groundnut productivity averages 1603 kg/ha during the Kharif season and 1903 kg/ha during the summer (Anonymous, 2012b). The average global temperature had risen 1.80°C by 2100, reaching 40 °C (IPCC, 2014).In addition to the increase in temperature, the frequency of extreme weather events such as heat waves, floods, cyclones, and droughts is expected to rise. These parameters are bound to have an impact on agricultural production. Temperature increases of 10C to 30C may cause a reduction in groundnut production (24%), as has been reported with temperature increases of 2.80C to 7.70 C (Patel *et al*., 2008) [12]. When the maximum temperature was raised by 30 degrees Celsius, pod yield decreased by 39 to 48 percent in different cultivars, with the minimum temperature having less of an effect than the maximum temperature (B.M. Mote, 2016) [3]. In comparison to other food crops, the mean temperature varied with crop production.

Data

The India Meteorological Department, Government of India (Pai *et al*. 2014) [13] and the Climate Research Unit (CRU) of East Anglia, UK (Harris *et al*. 2014) [14] provide observed gridded climatology data for temperature and rainfall. Temperature data is further downscaled to 1 km resolution by adjusting temperatures in relation to a high-resolution digital elevation model (Gerlitz *et al*. 2014, Farr *et al*. 2007, and Reuter *et al*. 2007) [15-17]. IMD's gridded rainfall data has a much finer spatial resolution, i.e., 0.25° x 0.25°. (Pai *et al*., 2014) [13]. This high resolution observed rainfall dataset (1901–2015) is downscaled further using NASA's GPM precipitation data, which is available at a resolution of 10 km from 2003 to 2019. This downscaled data is used to analyse rainfall profiles and trends in the study area, as well as to correct for bias in future temperature and rainfall projections in the study area. Future projections for four Representative Concentration Pathways (RCP) scenarios are provided in global climate models. In this study, we used the RCP scenarios RCP4.5 and RCP8.5. RCP 2.6, RCP 4.5, RCP 6.0, and RCP 8.5 are the four RCP scenarios. These scenarios are written in such a way that they cover the entire spectrum of stabilization, mitigation, and baseline emission scenarios available in the literature. The naming convention reflects socioeconomic pathways that will reach a specific radiative forcing by 2100. RCP 8.5, for example, results in a radiative forcing of 8.5 Wm-2 by 2100. While there are four RCP scenarios available, we have used RCP4.5 and RCP8.5.Climate projections for the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report are based on these newly developed representative concentration pathways (RCPs) developed under the Coupled Model Inter-comparison Project 5 (CMIP5). More than 50 CMIP5 model outputs are now available from various climate modelling groups. Because the outputs of the CMIP5 models are available at coarse resolution, the Co-Ordinate Regional Downscaling Experiment (CORDEX) was carried out to facilitate local and regional adaptation planning. The Indian Institute of Tropical Meteorology, Pune, hosted these experiments and has since provided multiple dynamically downscaled high-resolution climate model projections for the South Asian domain, including India.

Methodology

The observed data for temperature (Tmax, Tmin) was of coarse resolution. We needed high-resolution data as the study area was small. For this purpose, we interpolated the existing observed data using the bilinear method and brought it down to 1 km x 1 km resolution. For precipitation data, we implemented CNN by taking the satellite data and IMD data and producing a merged dataset that was of 10km x 10km resolution. In the present study, we have taken five CORDEX models for the South Asian domain (WAS-44). As the resolutions of each model were different and the study area was small, we interpolated the model data to a 1km x 1km resolution for Tmax and Tmin using the bilinear method. For precipitation, we interpolated it to a 10km x 10 km resolution.

Tmax and Tmin datasets were further subjected to lapse rate correction to bring out the local features of the area. Tmean was computed using Tmax and Tmin. All the datasets were spatially averaged for the Junagadh, Vanthali, and Mendarda regions separately. Trend analysis has been done using the linear regression method. The standard deviation and variance were calculated spatially for each time step. Monthly, yearly, and decadal averages were computed for both observed and model datasets. An ensemble mean of all the model datasets has been computed. Bias correction has been done on model datasets. The bias computed in the historical data (observed, model) was added to the future projections.

The models were subjected to different skill tests to determine the best among them. Taylor's diagram has been plotted for Tmax, Tmin, Tmean, and precipitation. The Taylor scores, Root Mean Square Error (RMSE), and Interannual Variability skill score (IVS) have been computed.

Results and Discussions

In the present study, we studied the climatological impact of the meteorological parameters such as rainfall, maximum and minimum temperatures on the ground net crop in Junagadh district. We have conducted experiments using ensemble models of future projections of the two climate scenarios, RCP 4.5 and RCP 8.5. The results are presented here. The future projections are studied over a period of 100 years, i.e., up to 2100. Three major time periods have been studied for both the scenarios: time period one (2020-2030), time period two (2030-2070), and time period three (2070-2100). Monthly wise climate analysis was done for the parameters of rainfall, maximum, and minimum temperature of the months of June, July, August, September, October, and November, which are the most prominent months for the growth and yield of the ground net crop. A figure 2 depicts the comparison of the maximum, minimum, and means temperatures and yield over the Junagadh District from 1971 to 2017. As the temperature rises over time, the yield production declines in both the maximum and minimum temperatures. The mean or optimum temperature is critical for crop productivity. Figure 3 depicts total precipitation and yield across the Junagadh district from 1971 to 2021. The graph illustrates that rainfall is an important determinant for groundnut yield production; when rainfall is high, so is production; there is a direct relationship between yield and rainfall. Figure 4 shows the number of rainy days and Figure 5 depicts a comparison between the number of cloudy days, rainy days, and the maximum temperature of 35 degrees Celsius and the minimum temperature of 25 degrees Celsius. As the number of cloudy days and rainy days increase, so does the temperature, and the lower level moisture increases, creating a flood condition that may be favorable to ground nuts. As the number of cloudy days increases, so does the yield quality and output. And while to better understand microclimatological phenomena and their effects on crops, the district has been divided into three major blocks: Junagadh, Mendarda, and Vanthali. Figure 6 (a) shows the climate analysis of rainfall for the JJASON month using an ensemble of models for the three time series of the two scenarios and comparing it to the Junagadh district's climatologically mean rainfall (1971-2019). The average climatologically measured rainfall in Junagadh village for the JJASON month is 4.7 mm/day, with a maximum of 5.8 mm/day and a minimum of 3.6 mm/day, as shown in fig 6(a).The model forecasted average rainfall. The model ensembles in RCP 4.5, on the other hand, show a maximum of 7.1 mm per day, which is 0.9 percent higher than the mean rainfall.

Analysis of the maximum temperature for JJASON

Fig. 6 (b): Climate analysis for the JJASON month using an ensemble of models for the three time series of the two scenarios and compared to the Junagadh district's climatologically mean maximum temperature (1971–2019). The mean climatological maximum temperature for the JJASON month in Junagadh village is 32 °C/day, as shown in fig. 6 (b). The model indicates that the average maximum temperature will be in RCP 4.5, however, the model ensembles show a maximum of 38 °C each day. In the second time period (2031–2070), the average temperature rises to 34.2^0 degrees Celsius, with a maximum of 39.10^0 Celsius and a minimum of 29.3^0 Celsius every day. In the decade (2071–2099), 36.10^0 Celsius with a maximum of $31.2\text{-}41^0$ Celsius each day, in contrast to RCP 8.5. In both circumstances, the maximum temperature rises.

Analysis of the minimum temperature for JJASON

Fig. 6 (c): climatic analysis for the JJASON month using an ensemble of models for the three time series of the two scenarios and compared to the Junagadh district's climatologically mean minimum temperature (1971–2019). The mean climatological minimum temperature for the JJASON month in Junagadh village is 23.7 °Celsius each day, according to fig 6 (c). The model anticipated a mean low temperature of On the other hand, the model ensembles under RCP 4.5 show a maximum of 23.7 °C each day. The mean low temperature increased to 23.7^0C in the second time period (2031–2070), with a maximum of 27.7 °C and a minimum of 21.3 °C/day. 4.5 were similar when compared to the mean seen in the decade (2071–2099), 24.4 °C with a maximum of 23.2-29.5 °C day in contrast with RCP 8.5.

Analysis of the mean temperature for JJASON

Temperature is more significant than rainfall for crop development and productivity. Growth and development require optimal temperatures. In this study, we looked at the maximum and minimum temperature differences during the last three decades for both scenarios, from June to November. The climatological maximum temperature for June in the Junagadh district is 33^0 degrees Celsius.

Fig. 6 (d): Climate analysis for the JJASON month using an ensemble of models for the three time series of the two scenarios and compared to the Junagadh district's climatologically mean temperature (1971–2019). The mean climatological temperature for the JJASON month in Junagadh village is 27.8^0 C/day, as shown in fig. 6(d).The model anticipated the average temperature at In RCP 4.5, the model ensembles suggest a maximum of 26.50c each day. The average temperature rises to 28.9^0 Celsius in the second time period (2031-2070), with a maximum of 330 degrees Celsius and a minimum of 25.9^0 Celsius every day. In the decade (2071-2099), 29.5 °C with a maximum of 27.7–35.4 °C/day compared to RCP 8.5.

Regression Analysis (yield) (Table-7 (d))

The relationship between climate elements and the yield is analyzed through correlation with the null hypothesis (Ho) that there is a significant correlation in temperature (0.40) and precipitation (0.48). Regarding rainfall, temperature, and groundnut, the correlation coefficient of 0.48 and 0.40 is interpreted as a strong positive relationship between the two variables. The significance 2-tailed gives a P value of 0.06, which is greater than 0.05. Hence, the Ho is retained. The study does not provide enough evidence to conclude that there is a statistically significant correlation between temperature and ground nut yield. In terms of regression, HO is that there is no supported relationship between temperature and groundnut yield (b=0). The results give an R value of 0.4 and an R square of 0.16, meaning temperature explains only 16% of the ground nut yield. The significance 2-tailed gives a P value of 0.02, which is less than 0.05. Hence, H_0 is rejected and Ha is accepted, suggesting that a unit increase in rainfall results in a unit increase in the yield of groundnut. The regression analysis indicates an R value of 0.23 and an R square of 0.23 explains 23% of the ground nut yield.

Analysis of multiple regression (Table-7(e))

In this Multi-variant Analysis of Max- Temperature, Min-Temperature, Rainy Days, Cloudy Days, and Groundnut, yield is taken as the independent variable and pairs of (Temperature, Rainy Days), (Temperature, Precipitation, Rainy Days), (Temperature, Precipitation, Rainy Days), (Temperature, Precipitation, Rainy Days), (Temperature, Precipitation, Rainy Days), (Temperature, Precipitation, Rainy Days), (Temperature, Precipitation, Rainy Days), (Temperature, Precipitation, Rainy Days), (Temperature, Precipitation, Rainy Days),(Temperature, Precipitation, Rainy Days The significance level at 2-tailed is 0.03 and 0.03, which is less than 0.05. Hence, Ho is rejected. The regression analysis indicates R values of 0.63 and 0.55 and R squares of 0.39 and 0.3, suggesting that accounts for 39% and 30% of the variation in ground nut yield.

The correlation coefficients for (Temperature, precipitation); (Temperature, precipitation, rainy days); and (Temperature, cloudy, rainy days) are 0.59, 0.62, and 0.59, respectively. The significance 2-tailed is 0.06, 0.07, and 0.12, which is greater than 0.05. Hence, Ho is retained. The regression analysis indicates an R value of 0.59, 0.62, 0.59 and an R square of 0.35, 0.39, and 0.35, suggesting that accounts for 35%, 39%, and 35% of the variation in ground nut yield.

Summary and Conclusions

During the study period (1970–2017), we can see that the number of days with temperatures below 250 °C is bigger than the number of days with temperatures exceeding 350 °C. The number of cloudy days grows throughout time, but overall precipitation does not change significantly. From 1951 to 2019, Junagadh had the highest temperature of 39.040 degrees Celsius, followed by Mendarda at 39.10 degrees Celsius and Vanthali at 38.990 degrees Celsius. The lowest temperatures were recorded at 12.73^0 Celsius, 12.69^0 Celsius, and 12.78^0 Celsius, respectively. Precipitation and temperature are increasing in the RCP (4.5 and 8.5) future period compared to observed data. The association between the met parameters and groundnut crop yield can be identified here. We can see from this relationship that precipitation and yield have a correlation of 0.48 and a significance of 0.02. As a result, yield will increase with precipitation and vice versa. The correlation between maximum temperature and yield is 0.42, with a significance of 0.06. As a result, we can conclude that there is no linear relationship between these two variables. In my investigation, yielding was shown to be directly proportionate to precipitation, with no significant relationship found between temperatures and yielding. Based on the results above, we may predict that groundnut crop yields will grow in the future as precipitation increases.

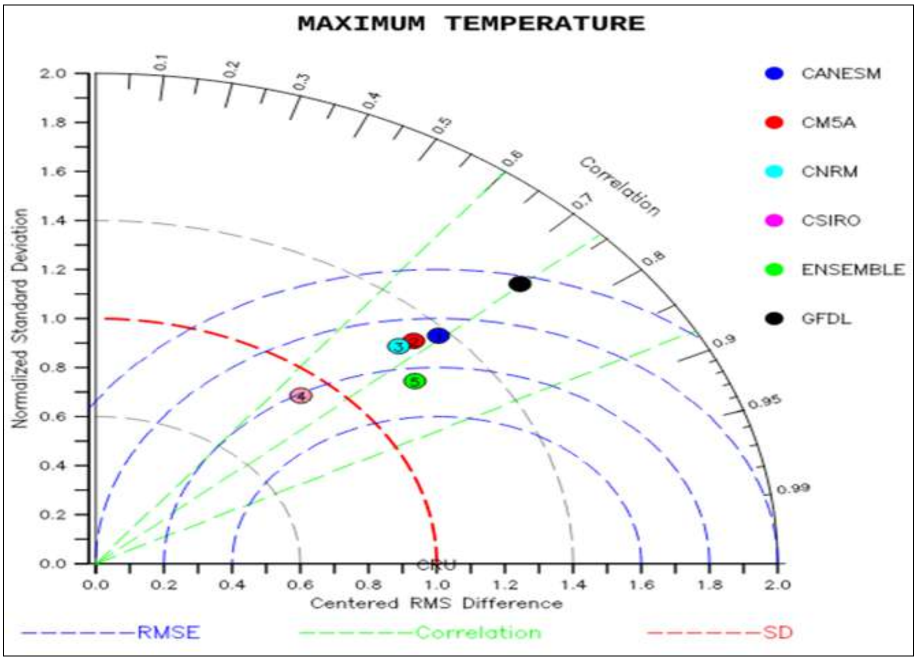

Fig 1: a) Taylor diagram representing the maximum temperature in different model historical datasets compared with the observed data from CRU for the period 1980-2014.

Table 1: a) Root mean square, Taylor score and IVS score have been calculated individually and represented in this table.

Models	N-RMSE	Taylor score	IVS
CANESM	0.9393	0.6828	0.4082
CM5A	0.9152	0.6881	0.285
CNRM	0.9085	0.6933	0.211
CSIRO	0.7987	0.6835	0.03397
ENSEMBLE	1.171	0.5807	1.201
GFDL	0.7538	0.7701	0.1299

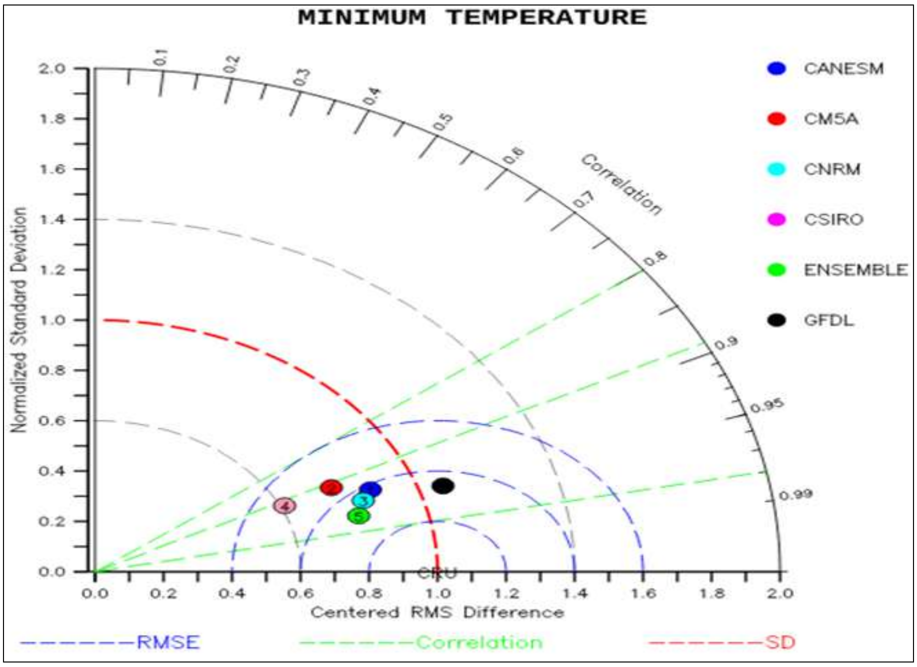

Fig 1: b) Taylor diagram representing the minimum temperature in different model historical datasets compared with the observed data from CRU for the period 1980-2014.

Table 1: b) Root mean square, Taylor score and IVS score have been calculated individually and represented in this table.

Models	N-RMSE	Taylor score	IVS
CANESM	0.3916	0.9106	0.08166
CM5A	0.4582	0.8425	0.2894
CNRM	0.3656	0.9116	0.1355
CSIRO	0.5173	0.7196	1.042
ENSEMBLE	0.3516	0.9451	0.01921
GFDL	0.3275	0.9164	0.1999

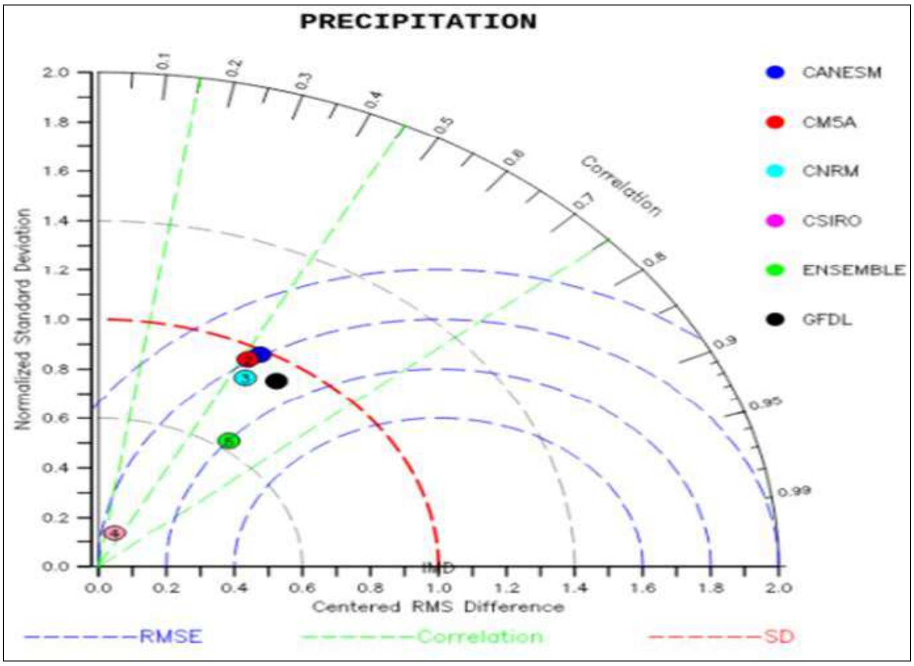

Fig 1: c) Taylor diagram representing the precipitation in different model historical datasets compared with the observed data from CRU for the period 1980-2014.

Table 1: c) Root mean square, Taylor score and IVS score have been calculated individually and represented in this table.

Models	N-RMSE	Taylor score	IVS
CANESM	0.9766	0.5512	0.001453
CMSA	0.9399	0.5475	0.06737
CNRM	0.8659	0.6133	0.0304
CSIRO	0.9706	0.03551	45.95
ENSEMBLE	1.01	0.5347	0.01156
GFDL	0.8101	0.5277	0.8728

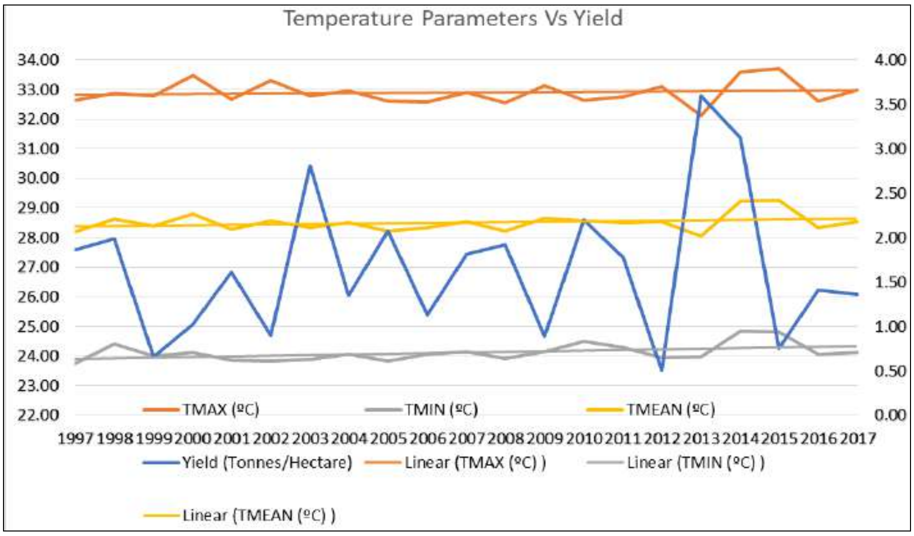

Fig 2: Time series graph comparing the changes of max, min and mean temperature with groundnut yield for Junagadh district.

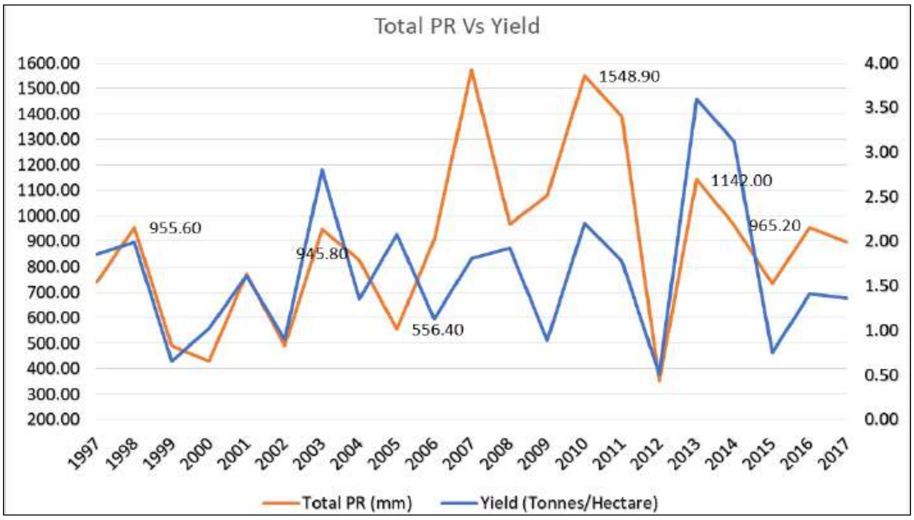

Fig 3: Time series graph comparing the changes of precipitation with groundnut yield for Junagadh district.

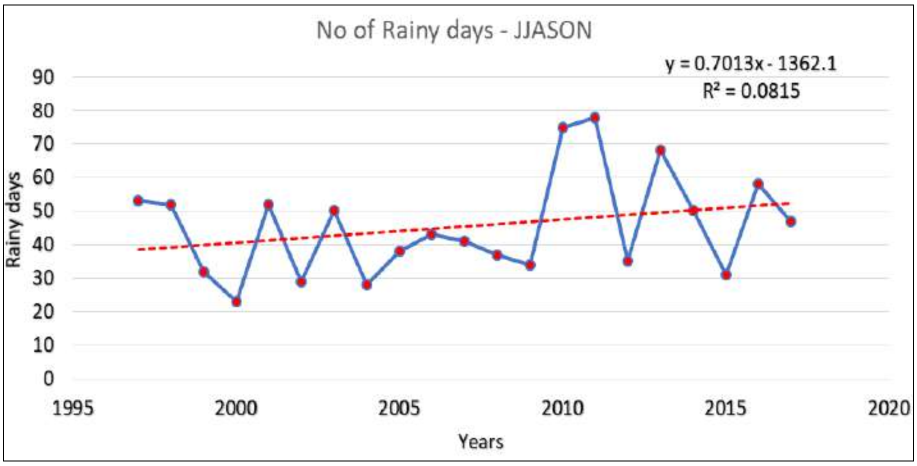

Fig 4: Time series graph with trend line calculated with linear regression for number of rainy days in the JJASON period for Junagadh district.

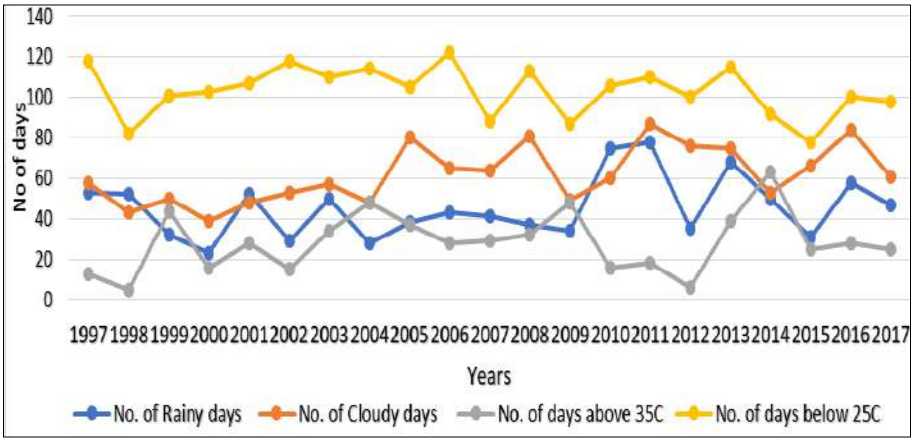

Fig 5: Comparison of Rainy, Cloudy days above 35 °C and below 25 °C

Table 6: a) RCP4.5 and RCP8.5 for different regions over various decades has been calculated in this table.

In project villages	1971-2019	2020-2030 (RCP4.5)	2020-2030 (RCP8.5)	2031-2070 (RCP4.5)	2031-2070 (RCP8.5)	2071-2099 (RCP4.5)	2071-2099 (RCP8.5)
Junagadh	3.6-5.8	2.6-6.6	2.8-7.1	2.9-7.2	2.9-7.4	3.-7.6	3.3-8.2
Mendarda	5.1-5.7	2.7-6.1	2.9-6.6	3.1-6.7	3-6.9	3.1-7.1	3.4-7.7
Vanthali	4.5-4.7	2.7-5.6	2.9-6	3.1-6.1	3-6.2	3.1-6.5	3.4-6.8

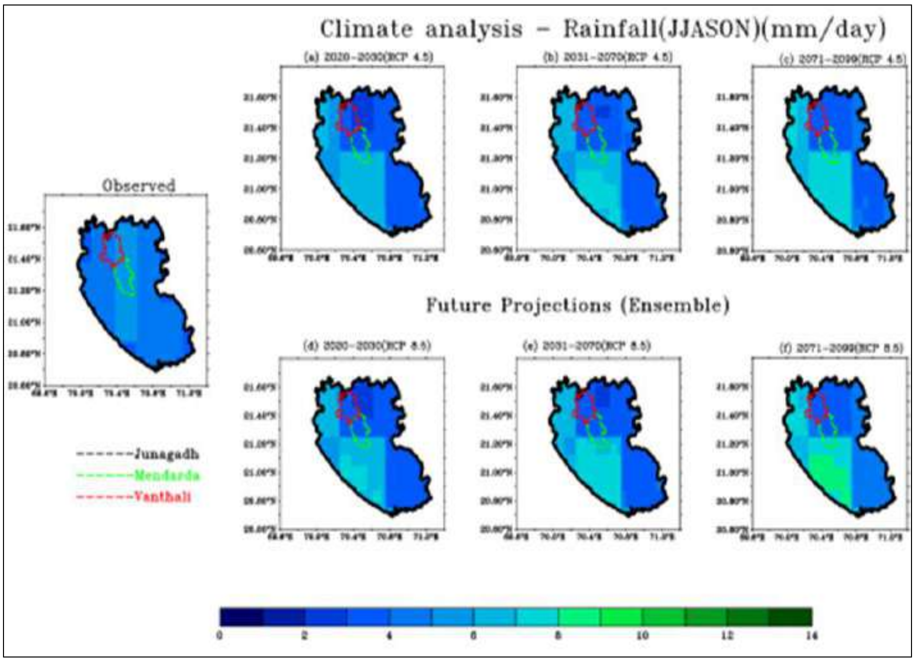

Fig 6: a) Spatial distribution of rainfall over Junagadh district during JJASON for observed and future projections from multi-model ensemble in RCP4.5 and RCP8.5 scenarios.

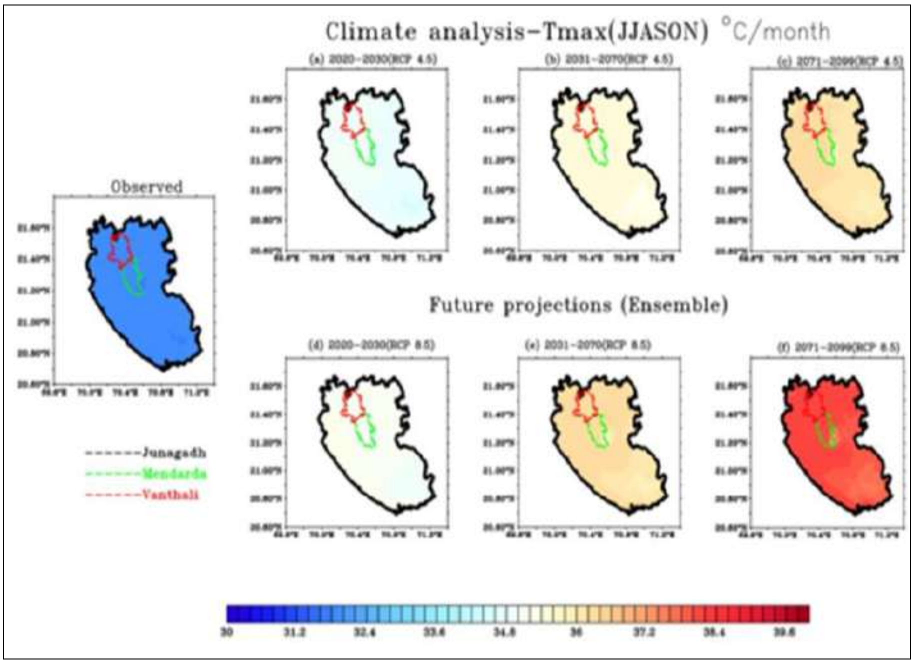

Fig 6: b) Spatial distribution of maximum temperature over Junagadh district during JJASON for observed and future projections from multi-model ensemble in RCP4.5 and RCP8.5 scenarios.

Table 6: a) RCP4.5 and RCP8.5 for different regions over various decades has been calculated in this table.

In project villages	1971-2019	2020-2030 (RCP4.5)	2020-2030 (RCP8.5)	2031-2070 (RCP4.5)	2031-2070 (RCP8.5)	2071-2099 (RCP4.5)	2071-2099 (RCP8.5)
Junagadh	32	38.33.4	28.3-38	28.7-38.4	29.4-39.1	29.3-39.1	31.2-41
Mendarda	31.8	30.9-37	31.3-37.3	31.6-37.1	32.4-37.5	32.2-37.7	34.3-40.1
Vanthali	32.0	32.8-37.2	32.1-37.3	33.8-38.4	34.1-39.1	33.1-38.6	36.3-41

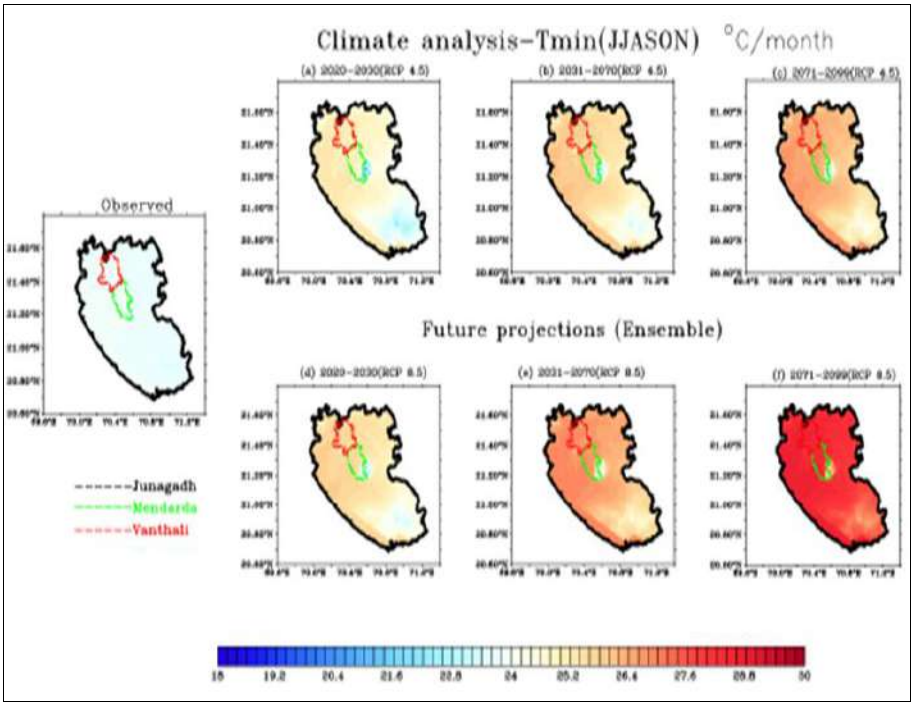

Fig 6: b) Spatial distribution of minimum temperature over Junagadh district during JJASON for observed and future projections from multi-model ensemble in RCP4.5 and RCP8.5 scenarios

Table 6: c) RCP4.5 and RCP8.5 for different regions over various decades has been calculated in this table.

In project villages	1971-2019	2020-2030 (RCP4.5)	2020-2030 (RCP8.5)	2031-2070 (RCP4.5)	2031-2070 (RCP8.5)	2071-2099 (RCP4.5)	2071-2099 (RCP8.5)
Junagadh	23.7	20-26.2	20.5-26.6	20.6-26.8	21.5-27.7	21.3-27.5	23.2-29.5
Mendarda	23.7	20-25.9	20.5-26.5	20.5-26	21.5-27.6	21.3-27.3	23.2-29.4
Vanthali	23.7	23.5-25.9	24.1-26.5	24.2-26.7	25.2-27.6	24.9-27.3	27-27

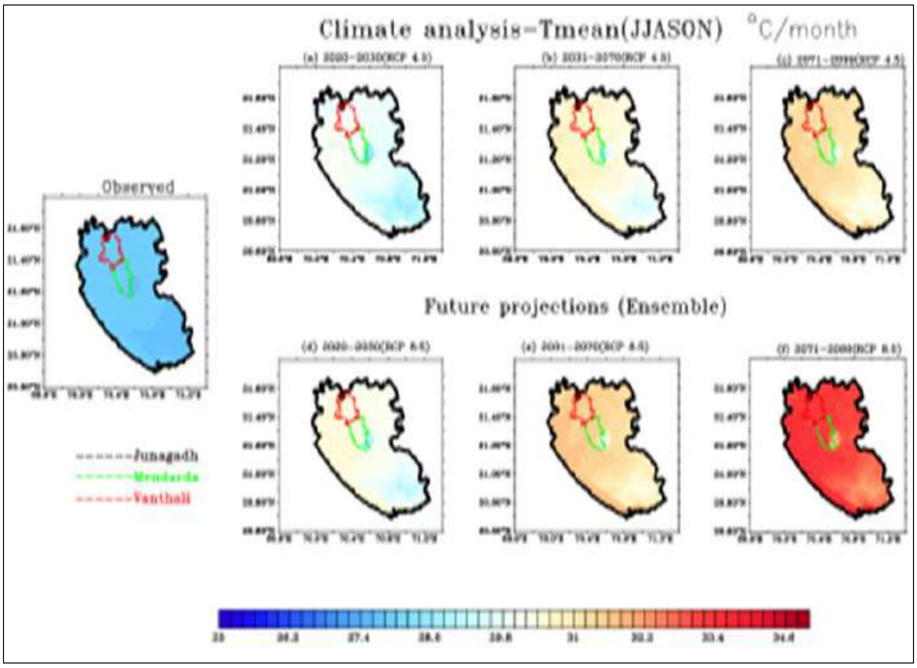

Fig 6: d) Spatial distribution of mean temperature over Junagadh district during JJASON for observed and future projections from multi-model ensemble in RCP4.5 and RCP8.5 scenarios

Table 6: e) RCP4.5 and RCP8.5 for different regions over various decades has been calculated in this table.

In project villages	1971-2019	2020-2030 (RCP4.5)	2020-2030 (RCP8.5)	2031-2070 (RCP4.5)	2031-2070 (RCP8.5)	2071-2099 (RCP4.5)	2071-2099 (RCP8.5)
Junagadh	27.8	24.3-32	23-30.1	25-32.8	25.9-33	25.6-33.4	27.7-35.4
Mendarda	27.8	25.4-30.6	25.9-31.1	26.1-31.4	27-32.3	26.8-32	28.8-34.1
Vanthali	27.8	29.4-30.7	25.9-31.1	30.1-31.4	31.-32.3	30.8-32.1	32.8-34.2

Table 7: The study area over a time period 1997-2017 considering yield and climate parameters.

Year	Season	Area (Hectare)	Production (Tonnes)	Yield (Tonnes /Hectare)	TMAX (ºC)	Total PR (mm)	TMIN (ºC)	No. of Cloudy days	No. of Rainy days	DTR (ºC)	No. of days above 35 C	No. of days below 25 C	T Mean (ºC)
1997	Kharif	422400	784700	1.857718	32.64787	742	23.74503	58	53	8.902842	13	118	28.1959
1998	Kharif	425800	847400	1.990136	32.86689	955.6	24.39475	43	52	8.472131	5	82	28.6306
1999	Kharif	433000	284300	0.656582	32.78224	489.5	24.01268	50	32	8.769563	44	101	28.39705
2000	Kharif	406300	414800	1.020921	33.46929	428.2	24.11044	39	23	9.358852	16	103	28.78989
2001	Kharif	444000	717100	1.61509	32.66344	770.6	23.86667	48	52	8.796776	28	107	28.26464
2002	Kharif	457800	412200	0.900393	33.28557	491.1	23.82765	53	29	9.457923	15	118	28.55639
2003	Kharif	415200	1163500	2.802264	32.77268	945.8	23.88257	57	50	8.890109	34	110	28.3277
2004	Kharif	415800	563200	1.354497	32.96388	826.5	24.06022	48	28	8.903661	48	114	28.5118
2005	Kharif	399900	830400	2.076519	32.60115	556.4	23.81962	80	38	8.78153	37	105	28.21077
2006	Kharif	374000	420700	1.124866	32.58306	905.9	24.06831	65	43	8.514754	28	122	28.32596
2007	Kharif	383400	693800	1.809598	32.89732	1574.7	24.14896	64	41	8.748361	29	88	28.52311
2008	Kharif	404300	776600	1.920851	32.53612	968.8	23.91902	81	37	8.617104	32	113	28.22749
2009	Kharif	397900	352300	0.885398	33.13803	1077.9	24.1518	49	34	8.98623	48	87	28.6447
2010	Kharif	402100	885300	2.201691	32.62727	1548.9	24.48661	60	75	8.140656	16	106	28.55689
2011	Kharif	392200	695600	1.773585	32.73716	1389	24.28169	87	78	8.455464	18	110	28.5094
2012	Kharif	306600	155800	0.508154	33.08847	351.3	23.9565	76	35	9.131967	6	100	28.52257
2013	Kharif	381800	1370777	3.590301	32.1223	1142	23.96852	75	68	8.15377	39	115	28.04475
2014	Kharif	224694	701809	3.123399	33.59989	965.2	24.84617	53	50	8.753716	63	92	29.22295
2015	Kharif	225024	169488	0.7532	33.70765	733	24.80563	66	31	8.902022	25	78	29.25628
2016	Kharif	253815	358209	1.4113	32.61869	953.9	24.06344	84	58	8.555246	28	100	28.34066
2017	Kharif	258272	352224	1.363772	32.97235	896.5	24.10262	61	47	8.869727	25	98	28.53743
1997-2017Average					32.75576		23.92387		46.08	8.831886			28.33975

Table 7: a) Relation between the mean DTR and average yield.

Growing season Mean DTR (deg C)	Average yield of groundnut (T/ha)
<8.50	2.39
8.50 - 8.75	1.88
8.76 - 9.00	1.49
>9.00	0.81

Table 7: b) Change in yield range.

	Min	Max	Change
Yield Range	0.51	3.59	3.08
TMAX Range	32.12	33.71	1.59
TMIN Range	23.75	24.85	1.1
TMEAN Range	28.04	29.26	1.22
DTR	8.14	9.46	1.32
Total PR	351.3	1574.7	1223.4

Table 7: c) Change in climate parameters over 1997-2017.

	1997	2017	changing (1997-2017)
Yield Range			
TMAX Range	32.65	32.97	0.32
TMIN Range	23.75	24.1	0.35
TMEAN Range	28.2	28.54	0.34
DTR	8.9	8.87	-0.03
Total PR	742	896.5	154.5

Table 7: d) Analysis of yield with respect to maximum temperature and precipitation.

Regression Analysis (Yield)					
Maximum	Multiple-R	Regression	Significance	T stat	p-value
Temperature	0.4	0.16	0.06	-1.93	0.06
Precipitation	0.48	0.23	0.02	2.43	0.02

Table 7: e) Analysis of yield by combining various climate parameters.

Multi- variant Analysis							
			T stat				
	Regression	Significance	T max	T min	Rainy days	Precipitation	Cloudy days
Temp VS Rainy Days	0.39	0.03	-0.81	0.67	1.35		
Temp VS pr	0.35	0.06	-1.64	1.03		0.48	
Temp VS pr VS Rainy days	0.39	0.07	-0.64	0.44	1.14	0.32	
Temp VS cloudy VS rainy days	0.35	0.12	-1.66	1.06		0.7	-0.45

References

1. Aggarwal PK. Global climate change and Indian agriculture: impacts, adaptation, and mitigation. Indian Journal of Agricultural Science. 2008;78:911-919.
2. Boote KJ, Jr Allen LH, Vara Prasad PV, Jones JW. Crop models are being tested for the effects of climate change. In: Handbook of Climate Change and Agro ecosystems (Eds. D. Hillel and C. Rosenzweig) (Imperial College Press, London, UK). p. 109-129.
3. Mote BM, Vyas Pandey. Temperature variation affects the phonology and heat units of summer groundnut cultivars; c2016.
4. Chhodavadia SK. Trends and variability in evapotranspiration at Junagadh, Gujarat. Journal of Agricultural Sciences Innovare; c2016.
5. Chinchorkar Sachin, Trivedi M, Patel G, Paradava D, Ram Bhavin. Evaluation of Temperature and Rainfall Trends using the Mann-Kendall Test in the Saurashtra Region (Junagadh) of Gujarat, India; c2020.
6. Cox FR. Temperature treatment effects on peanut vegetative and fruit growth, Peanut Sci. 1979;6:14-17.
7. Hansen James, Sato Makiko, Ruedy R, Lo K, Lea

David, Medina-Elizalde Martn. Global temperature change. Proceedings of the National Academy of Sciences of the United States of America. 2006;103:14288-93. 10.1073/pnas.0606291103.
8. Patel HR, Lunagari MM, Karande BI, Vyas Pandey, Yadav SB, Shah AV, *et al*. The impact of projected climate change on groundnuts in Gujarat; c2013.
9. Kumar K, Pant G, Parthasarathy B, Sotakke N. Spatial and sub-seasonal patterns of the long-term trends of Indian summer monsoon rainfall. 1992;12:257-268. 10.1002/joc.3370120303.
10. Kumar K, Prasanna Venkatraman, Kamala K, Deshpande Nayana, Patwardhan Savita, Pant GB. Report on task force recommendations to improve agricultural development in Gujarat; c2014.
11. Cox TH, Blake S. Managing cultural diversity: Implications for organizational competitiveness. Academy of Management Perspectives. 1991 Mar 1;5(3):45-56.
12. Patel JN, Kaminska B, Gray BL, Gates BD. PDMS as a sacrificial substrate for SU-8-based biomedical and microfluidic applications. Journal of Micromechanics and Microengineering. 2008 Aug 20;18(9):095028.
13. Pai DS, Rajeevan M, Sreejith OP, Mukhopadhyay B, Satbha NS. Development of a new high spatial resolution (0.25× 0.25) long period (1901-2010) daily gridded rainfall data set over India and its comparison with existing data sets over the region. Mausam. 2014 Jan 1;65(1):1-8.
14. Harris IP, Jones PD, Osborn TJ, Lister DH. Updated high- resolution grids of monthly climatic observations–the CRU TS3. 10 Dataset. International journal of climatology. 2014 Mar 15;34(3):623-42.
15. Gerlitz C, Lury C. Social media and self-evaluating assemblages: On numbers, orderings and values. Distinktion: Scandinavian Journal of Social Theory. 2014 May 4;15(2):174-88.
16. Farr TG, Rosen PA, Caro E, Crippen R, Duren R, Hensley S, *et al*. The shuttle radar topography mission. Reviews of geophysics. 2007 Jun, 45(2).
17. Reuter HI, Nelson A, Jarvis A. An evaluation of void- filling interpolation methods for SRTM data. International Journal of Geographical Information Science. 2007 Oct 1;21(9):983-1008.