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Measuring The Agricultural Stress Under Climate Change: A Case Study of Two Districts in Maharashtra

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Abstract
Agriculture is a culture of human interaction with the natural resources. Any change in the climatic conditions caused by temperature, rainfall and humidity has a direct hit to the agriculture sector. Agriculture is characterized by area under crop, crop production and productivity. The quality of the crops measured in terms of aroma, test, nutrient characteristics, fats, minerals, carbohydrates, proteins etc. Risk management under the agricultural stress on the part of the farmer practitioners is one of the attractions of the researchers. But the difficulty is adjudged by the measuring the risk under climatic change. Loss minimization and yield maximization tools are very useful for such research work. The regression model is fitted to measure the agricultural stress. Similarly, loss minimization and yield maximization with secured food system tool is used as an adaptive technique to manage the agriculture. Kolhapur and Solapur districts are extremes ends in various agrarian characteristics. Kolhapur belongs to moderate rainfall region, whereas the Solapur district belongs to drought region of the state.

Keywords: climate change, temperature, humidity, rainfall, precision agriculture.

Introduction:

Agriculture is almost dependent on the natural characters. The climate change directly hit the natural characters obviously agriculture sector is the first victim of climate change. The climatic change affects agriculture in several ways:

- Productivity, in terms of quantity and quality of the crops
- Agricultural practices and decisions,
- Environmental effects, in particular in relation of frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion, reduction of crop diversity
- Adaptation, organisms may become more or less competitive, as well as humans may develop urgency to develop more competitive organisms, such as flood resistant or salt resistant varieties of rice.

The Monsoon may disrupt in its regularity due to climate change. Climate plays an important role in shaping the agricultural production in India. Lack of irrigation makes agriculture a gamble with nature.

The effects of climatic variability are quite visible in case of majority of farmers who are marginal and small and lack resources required for adjustment for climatic variations. Excessive rains and extreme variation in temperature would affect the productivity of crops adversely thereby affecting the incomes of farming families in a negative manner. Thus, suitable strategies pertaining to resource use, planting flood and drought resistant varieties of crops, better irrigation networks and crop mix are to be adopted for mitigating the harmful effects of climatic changes.

During famine of 1972, 84 tehsils and 10 districts of Maharashtra state were severely affected. In the famine of 2003, Maharashtra had 114 tehsils and 14 districts falling under drought; which severely affected even in 2012. The famine affected tehsils has increased to 123 tehsils and 18 districts. There is an increment of 40 tehsils. On an average one tehsil every year is falling under the famine. The years of 2001, 2002, 2003, 2009, 2011 and 2012 have experienced scantiest rainfall. It had affected orchards. Even in areas of sugarcane, the diseases like wooly aphids were faced by the state. In 2002, 2003, 2004, there was a grand/bulk affected wooly aphid on sugarcane. In 2012, the orchards of orange were dried away because of wanting / failing water in Ambejogai in Marathwada.

The years 2005, 2006, and 2007 are known as the years of heavy rainfall. It had affected the paddy crop in Konkan, soybeans crops in Marathwada and Vidharbha. Despite thousands of tons of fertile soil had carried away with the rain on these years. The heavy rains have increased humidity in air on large scale, that arise bacterial blight (telya) on pomegranates

Hence, the researchers have intend to undertake a research on impact of CC on agriculture sector under the condition of with special reference to Kolhapur and Solapur districts as they are experiencing extremes of the geo-climatic conditions with the following objectives.

Objectives of the Study

The study is intended to study the problem with two objectives;

1. To study the impact of variability of temperature, rainfall and humidity (TRH) on the area, production and productivity (APP) of selected crops (paddy, wheat, jowar ragi, bajara, gram, sugarcane, all cereals, and all pluses) in the study area.
2. What adaptive technologies can be employed to provide relief to the affecting area?

Hypothesis

Climate change is a worst situation that the agricultural economy tending to be worsened or damaging the economic resources, which cannot be eliminated but relief to the agriculture sector can be managed properly through government interference.

The study creates awareness among people all over the country about the importance and impact of the climate change on agriculture. It would also help the researchers to undertake research in areas, which have not been covered in the present study. It will also provide valuable ideas regarding climate change to the Government and to the agriculturalists to take proper steps to overcome or limit the adverse impact of climate change.

Study area

The study area is located in the Maharashtra state in India. Two districts of the state are selected, they represents extremes of the geo-climatic conditions. The Kolhapur district belongs to medium rainfall and Solapur district belongs to imperfect rainfall or drought district of the state.

These districts are highly climate sensitive and vulnerable to climate change. The people experienced the impact of climate change through failure or irregular monsoon, high temperature and unseasonal rain and droughts. This has adversely caused area, production and productivity (APP) of the selected crops, income, production cost, cropping pattern and GDP. Hence it is necessary to assess the impact of climate change on agriculture.

Sample survey

The study is based on the secondary source of data. The secondary sources data include, temperature, rainfall, area, production and productivity of selected crops. The secondary source of data has been obtained from Indian Meteorological Department, District Social and Economic Review. Disaster Management Departments of Government of Maharashtra, IPCC Research Reports, Journals, Magazines and Website on climate change and agriculture, Published Reports of N.S.S.O. rounds, Census Reports, Reports of national, international conferences on climate change and agriculture, satellite data on climate change and agriculture. Use of 'EARTH EXPLORER' is used to get imagines of the study area. Use of 'ERDAS IMAGINE' software for analysing the effect of climate change on agriculture is used. The 'ARCGIS' software is used for the locating the maps.

Data Management:

Since the main purpose of the present study is to assess the impact of climate change on agriculture, following parameters are used to investigate the change due to CC. i) Production, ii) Productivity, iii) Cropping pattern, iv) Area under crop.

Statistical Tools:

Regression analysis for the environmental parameters is used to investigate the TRH impact on the APP of the crops. The constant value of combined TRH is derived along with un-standardized co-efficient B value. Besides, t value and level of significance is calculated for estimating TRH impact on APP of the selected crops. Similarly, for estimating the APP agricultural parameters we have used R square values and F value are derived from the data.

The ERDAS image software is used for mapping the cropping pattern, forest area, baron land, settlement and water bodies. Satellite images are decoded from the experts. Various features are identified and distinguished using interpretation key such as tone, texture, size, shape and association are used to interpret land use pattern. ArecGIS software is used to prepare land use land cover map and to calculate the area under various feature. Descriptive statistics is used in excel for preparing the tables and graphs.

Study period:

The study period is confined to fifteen years from 2000 to 2015. The climatic change occurred during the period are analyzed with some selected parameter and its economic impact.

Selection of crops:

The present study covers only important crops of Konkan region paddy Ragi peanut all cereals, all pluses. Pune region important crops i.e. paddy wheat jowar, bajara, sugarcane, all cereals and all pluses.

Regression Analysis between Temperature, Rainfall, Humidity and Area cover under cultivation of Crops in Kolhapur District

In view of the data explored in text, we tried to estimate the regression analysis between temperature, rainfall, humidity and the area covered under cultivation in all selected two district. For the purpose of the counting the impact on the crops, we have selected some important seven crops cultivated in the sampled districts. As stated earlier 15 years data has been pulled for the purpose. The analysis is

further classified in to three segments. The first part covers the area under various crops. Second part of the regression analysis covers the production of crops and the productivity of the same crops.

Constant value shows the aggregate regression value of the temperature, rainfall and the humidity. In some crops the impact of humidity and temperature remains significant.

The experience of Kolhapur district about TRH on the selected crops indicates variations on Jowar for humidity in the area under crops. The area under crops of jowar has experienced the impact of humidity. The calculated value of 'f' for jowar is estimated at 11.334 and 'p' value is 0.006 signifies the test is significant and model can further be interpretive. The calculated adjusted R^2 is 0.463, which is good and acceptable. For the dependent variable of jowar, the constant is significant; since its 't' value is - 2.620 and 'p' is 0.024 with another independent variable i.e. humidity, the 'p' value is 0.006; it's found significant. An independent variable i.e. temperature and rainfall is found to be not significant. It can be said that one independent variables i.e. humidity is significantly contributing the variations in the area under jowar.

The experience of maize indicates variations due to temperature and rainfall in the area under crops. The area under crops of maize has experienced the impact of T and R. The calculated value of 'f' for maize is estimated at 15.735 and 'p' value is 0.001 signifies the test is significant and model can further be interpretive. The calculated adjusted R^2 is 0.711, which is good and acceptable. For the dependent variable of maize, the constant is significant; since its 't' value is 0.000 and 'p' is 0.001for temperature and p value for rainfall is 0.008 with two independent variable is significant. An independent variable i.e. humidity is found to be not significant. It can be said that two independent variables i.e. T and R is significantly contributing the variations in the area under maize.

For all other crops the TRH impact on production remains not significant. (see Table 5.8)

In the case of productivity (Table 5.9) the temperature impact is observed with wheat and jowar. The productivity of wheat has experienced the impact of T. The calculated value of 'f' for wheat is estimated at 7.462 and 'p' value is 0.020 signifies the test is significant and model can further be interpretive. The calculated adjusted R^2 is 0.350, which is good and acceptable. For the dependent variable of wheat, the constant is significant; since its 't' value is 3.562 and 'p' is 0.004 and for temperature alone p value is 0.020 with two other independent variables i.e. R and H as insignificant. It can be said that only independent variables i.e. T is significantly contributing the variations in the productivity of maize

In the case of productivity of jowar the T impact is observed. The calculated value of 'f' for jowar is estimated at 20.176 and 'p' value is 0.001 signifies the test is significant and model can further be interpretive. The calculated adjusted R^2 is 0.615, which is good and acceptable. For the dependent variable of jowar, the constant is significant; since its 't' value is - 4.164 and 'p' is 0.002 and for temperature alone p value is 0.001 with two other independent variables i.e. R and H as insignificant. So it can be said that only independent variables i.e. T is significantly contributing the variations in the productivity of maize.

In rest other crops no significance is observed.

Table No. 1

Regression Analysis between Temperature, Rainfall, Humidity and Area cover under cultivation of Crop in Kolhapur District

Crop	Adjusted R^2	F	Sig.	Model	Un-standardized Coefficients		t	Sig.
					B	Std. Error		
Paddy	-.002	.994	.439[b]	(Constant)	138.786	123.602	1.123	.291
				Temperature Mean	-2.431	2.679	-.907	.388
				Rainfall	-.002	.004	-.575	.580
				Humidity Mean	.598	1.196	.500	.629
Wheat	.060	1.258	.346[b]	(Constant)	83.094	41.301	2.012	.075
				Temperature Mean	-1.649	.895	-1.842	.099
				Rainfall	.000	.001	-.266	.796
				Humidity Mean	-.598	.400	-1.496	.169
Jowar*	.463	11.334	.006[b]	(Constant)	-86.576	33.046	-2.620	.024
				Temperature Mean			-3.387	.707
				Rainfall			-604	.559
				Humidity Mean	2.013	.598	3.367	.006
Bajra	.348	3.138	.080[b]	(Constant)	-1.241	1.543	-.804	.442
				Temperature Mean	-.014	.033	-.404	.696
				Rainfall	-7.491	.000	-.152	.883
				Humidity Mean	.030	.015	2.028	.073
Maize*	0.711	15.735	.001[b]	(Constant)	31.987	6.081	5.260	.000
				Temperature Mean	-.504	.110	-4.591	.001
				Rainfall	.001	.000	3.310	.008
				Humidity Mean			.455	.660
Gram	.270	2.480	.127[b]	(Constant)	154.412	81.324	1.899	.090
				Temperature Mean	-3.108	1.763	-1.764	.112
				Rainfall	.003	.003	1.187	.266
				Humidity Mean	-1.188	.787	-1.509	.166

All cereals	.186	1.912	.198[b]	(Constant)	304.055	375.940	.809	.439
				Temperature Mean	-7.253	8.148	-.890	.397
				Rainfall	.017	.012	1.445	.182
				Humidity Mean	.722	3.638	.199	.847
All Pulses	-.021	.918	.471[b]	(Constant)	222.439	143.292	1.552	.155
				Temperature Mean	-2.689	3.106	-.866	.409
				Rainfall	-.001	.005	-.290	.779
				Humidity Mean	-2.268	1.387	-1.636	.136
All Oil Seed	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
All Fruits	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
All food grain	.251	1.003	.435[b]	(Constant)	163.739	75.721	2.162	.059
				Temperature Mean	-.256	1.641	-.156	.879
				Rainfall	-.001	.002	-.336	.745
				Humidity Mean	.868	.733	1.185	.266
Sugarcane	.124	1.566	.264[b]	(Constant)	-267.474	436.173	-.613	.555
				Temperature Mean	14.968	9.454	1.583	.148
				Rainfall	.007	.014	.496	.632
				Humidity Mean	-.296	4.221	-.070	.946

Source: Computed by Researchers

* Researcher has used forward method for regression analysis.

Table 2

Regression Analysis between Temperature, Rainfall, Humidity and Production of Crop in Kolhapur District

Crop	Adjusted R^2	F	Sig.	Model	Un-standardized Coefficients		t	Sig.
					B	Std. Error		
Paddy	-.261	.172	.912[b]	(Constant)	6281.439	11001.208	.571	.582
				Temperature Mean	-64.606	238.439	-.271	.793
				Rainfall	.166	.352	.472	.648
				Humidity Mean	-37.892	106.466	-.356	.730
Wheat	.004	1.018	.429[b]	(Constant)	1727.169	1740.629	.992	.347
				Temperature Mean	-39.080	37.726	-1.036	.327
				Rainfall	.050	.056	.890	.397
				Humidity Mean	-11.075	16.845	-.657	.527
Jowar	.292	2.647	.113[b]	(Constant)	16542.4	9910.863	1.669	.129
				Temperature Mean	-507.853	214.807	-2.364	.042
				Rainfall	-.052	.317	-.165	.873
				Humidity Mean	-56.485	95.914	-.589	.570
Bajra	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
Maize	-.096	.648	.604[b]	(Constant)	1868.408	2735.728	.683	.512
				Temperature Mean	-45.239	59.294	-.763	.465
				Rainfall	.068	.088	.772	.460
				Humidity Mean	-11.382	26.475	-.430	.677
Gram	-.212	.301	.824[b]	(Constant)	1.753	568.525	.003	.998
				Temperature Mean	-3.247	12.322	-.264	.798
				Rainfall	.000	.018	-.016	.987
				Humidity Mean	2.807	5.502	.510	.622
All cereals	-.276	.135	.937[b]	(Constant)	3987.192	17088.691	.233	.821

				Temperature Mean	-56.462	370.379	-.152	.882
				Rainfall	.247	.547	.451	.663
				Humidity Mean	16.001	165.379	.097	.925
All Pulses	.236	2.235	.153[b]	(Constant)	1080.338	798.868	1.352	.209
				Temperature Mean	-34.804	17.315	-2.010	.075
				Rainfall	-.019	.026	-.744	.476
				Humidity Mean	-.700	7.731	-.091	.930
All Oil Seed	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
All Fruits	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
All food grain	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
Sugarcane	.190	1.939	.194[b]	(Constant)	-697964.2	732500.97	-.953	.366
				Temperature Mean	29494.35	15876.162	1.858	.096
				Rainfall	11.165	23.460	.476	.645
				Humidity Mean	584.085	7088.901	.082	.936

Source: Computed by Researchers

Table No. 3

Regression Analysis between Temperature, Rainfall, Humidity and Productivity of Crop in Kolhapur District

Crop	Adjusted R^2	F	Sig.	Model	Un-standardized Coefficients		t	Sig.
					B	Std. Error		
Paddy	-.248	.205	.891[b]	(Constant)	958.915	9181.447	.104	.919
				Temperature Mean	89.940	198.998	.452	.662
				Rainfall	.107	.294	.364	.724
				Humidity Mean	-14.544	88.855	-.164	.874
Wheat*	.350	7.462	.020[b]	(Constant)	9184.395	2578.296	3.562	.004
				Temperature Mean	-127.431	46.651	-2.732	.020
				Rainfall			.959	.360
				Humidity Mean			1.334	.212
Jowar*	.615	20.176	.001[b]	(Constant)	-18865.59	4530.923	-4.164	.002
				Temperature Mean	800.175	178.140	4.492	.001
				Rainfall			-.432	.675
				Humidity Mean			.427	.678
Bajra	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
Maize	-.014	.946	.458[b]	(Constant)	432.752	14096.748	.031	.976
				Temperature Mean	224.486	305.532	.735	.481
				Rainfall	.361	.451	.800	.444
				Humidity Mean	-80.308	136.424	-.589	.571
Gram	.136	1.630	.250[b]	(Constant)	2293.286	5617.217	.408	.693
				Temperature Mean	78.649	121.747	.646	.534
				Rainfall	-.013	.180	-.071	.945
				Humidity Mean	-62.158	54.362	-1.143	.282
All cereals	.202	2.011	.183[b]	(Constant)	10741.36	5672.265	1.894	.091

				Temperature Mean	-79.443	122.940	-.646	.534
				Rainfall	.036	.182	.198	.847
				Humidity Mean	-119.658	54.894	-2.180	.057
All Pulses	-.089	.674	.589[b]	(Constant)	349.983	3773.990	.093	.928
				Temperature Mean	32.335	81.797	.395	.702
				Rainfall	.141	.121	1.170	.272
				Humidity Mean	-13.260	36.523	-.363	.725
All Oil Seed	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
All Fruits	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
All food grain	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
Sugarcane	.109	1.489	.282[b]	(Constant)	-389.130	255.684	-1.522	.162
				Temperature Mean	11.459	5.542	2.068	.069
				Rainfall	.003	.008	.407	.694
				Humidity Mean	3.268	2.474	1.321	.219

Source: Computed by Researcher

* Researcher has used forward method for regression analysis

Regression Analysis between Temperature, Rainfall, Humidity and Area cover under cultivation of Crops in Solapur District

Solapur district totally belongs to the imperfect rainfall or drought area. The TRH impacts on the area under crops, crop production and productivity of the crops is found significant in the case of few crops. Tables from 4 to 6 explore the facts. The temperature impact is significant in the case of the paddy

and wheat crops for area under crops. The humidity impact is seen for the maize in respect of area under maize.

Crop production has been affected significantly by humidity for paddy. While the T and R impacts are significant for all cereals in Solapur district.

The productivity of the jowar has been affected by T and R significantly. Sugarcane is largely cultivated in drought Solapur. Highest number of sugar factories and highest amount sugar production in the state takes place in the Solapur district. Humidity value of sugarcane shows at significant level.

In rest other crops the TRH values are insignificant (see Tables 4 to 6)

Table No 4

Regression Analysis between Temperature, Rainfall, Humidity and Area cover under cultivation of Crop in Solapur District

Crop	Adjusted R^2	F	Sig.	Model	Unstandardized Coefficients		T	Sig.
					B	Std. Error		
Paddy*	.609	16.567	.003[b]	(Constant)	11.047	2.259	4.897	.001
				Temperature Mean	-.222	.055	-4.070	.003
				Rainfall			.234	.821
				Humidity Mean			.268	.795
Wheat*	.306	5.415	.045[b]	(Constant)	159.740	42.785	3.734	.005
				Temperature Mean	-2.404	1.033	-2.327	.045
				Rainfall			-.082	.937
				Humidity Mean			2.074	.072
Jowar	.343	2.742	.123[b]	(Constant)	5345.671	2321.264	2.303	.055
				Temperature Mean	18.496	8.760	2.111	.073
				Rainfall	-.453	.312	-1.452	.190
				Humidity Mean	-185.869	81.652	-2.276	.057
Bajra	-.217	.405	.754[b]	(Constant)	27.777	382.246	.073	.944
				Temperature Mean	-1.013	1.443	-.702	.505
				Rainfall	-.012	.051	-.232	.823
				Humidity Mean	2.054	13.446	.153	.883
Maize*	.421	8.262	.018[b]	(Constant)	-244.982	94.286	-2.598	.029
				Temperature Mean			.074	.943
				Rainfall			.829	.431

				Humidity Mean	9.726	3.384	2.874	.018
Gram	.330	2.644	.131[b]	(Constant)	-283.495	205.323	-1.381	.210
				Temperature Mean	-1.826	.775	-2.357	.051
				Rainfall	.036	.028	1.302	.234
				Humidity Mean	13.408	7.222	1.856	.106
All cereals	.267	2.212	.174[b]	(Constant)	4589.371	1979.665	2.318	.054
				Temperature Mean	13.935	7.471	1.865	.104
				Rainfall	-.403	.266	-1.512	.174
				Humidity Mean	-148.726	69.636	-2.136	.070
All Pulses	.347	2.772	.120[b]	(Constant)	543.087	381.251	1.424	.197
				Temperature Mean	-3.191	1.439	-2.218	.062
				Rainfall	-.011	.051	-.217	.834
				Humidity Mean	-11.126	13.411	-.830	.434
All Oil Seed	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
All Fruits	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
All food grain	.344	2.397	.184[b]	(Constant)	6857.343	2849.631	2.406	.061
				Temperature Mean	15.365	7.293	2.107	.089
				Rainfall	-.596	.292	-2.042	.097
				Humidity Mean	-224.107	99.963	-2.242	.075
Sugarcane	-.392	.062	.978[b]	(Constant)	11.880	224.919	.053	.959
				Temperature Mean	-.318	.849	-.375	.719
				Rainfall	.009	.030	.290	.780

				Humidity Mean	2.343	7.912	.296	.776

Source: Computed by Researcher

* Researcher has used forward method for regression analysis.

Table No. 5

Regression Analysis between Temperature, Rainfall, Humidity and Production of Crop in Solapur District

Crop	Adjusted R^2	F	Sig.	Model	Unstandardized Coefficients		t	Sig.
					B	Std. Error		
Paddy*	.312	5.533	.043[b]	(Constant)	417.155	174.951	2.384	.041
				Temperature Mean			-.416	.688
				Rainfall			-1.487	.175
				Humidity Mean	-14.768	6.278	-2.352	.043
Wheat	.488	4.181	.054[b]	(Constant)	899.990	4868.247	.185	.859
				Temperature Mean	28.997	18.373	1.578	.159
				Rainfall	.919	.655	1.404	.203
				Humidity Mean	-71.921	171.244	-.420	.687
Jowar	.653	7.278	.015[b]	(Constant)	20634.679	15398.665	1.340	.222
				Temperature Mean	114.681	58.115	1.973	.089
				Rainfall	2.847	2.072	1.374	.212
				Humidity Mean	-872.213	541.660	-1.610	.151
Bajra	.198	1.824	.231[b]	(Constant)	2612.267	1326.640	1.969	.090
				Temperature Mean	-2.850	5.007	-.569	.587
				Rainfall	.030	.179	.167	.872
				Humidity Mean	-87.083	46.666	-1.866	.104
Maize	.193	1.799	.235[b]	(Constant)	2707.728	3465.472	.781	.460
				Temperature Mean	13.933	13.079	1.065	.322
				Rainfall	.258	.466	.552	.598
				Humidity Mean	-109.803	121.901	-.901	.398
Gram	.444	3.664	.071[b]	(Constant)	853.434	1685.654	.506	.628

				Temperature Mean	9.194	6.362	1.445	.192
				Rainfall	.269	.227	1.185	.275
				Humidity Mean	-42.643	59.294	-.719	.495
All cereals*	.806	19.703	.001[b]	(Constant)	-8524.442	2416.546	-3.528	.010
				Temperature Mean	184.349	63.462	2.905	.023
				Rainfall	7.851	1.935	4.057	.005
				Humidity Mean			-.554	.600
All Pulses	.367	2.739	.136[b]	(Constant)	4126.195	3989.144	1.034	.341
				Temperature Mean	12.507	12.837	.974	.368
				Rainfall	.347	.517	.671	.527
				Humidity Mean	-161.383	135.317	-1.193	.278
All Oil Seed	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
All Fruits	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
All food grain	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
Sugarcane	.324	2.595	.135[b]	(Constant)	6712.899	1002262.3	.007	.995
				Temperature Mean	8012.071	3782.551	2.118	.072
				Rainfall	30.139	134.858	.223	.830
				Humidity Mean	-10020.14	35255.365	-.284	.784

Source: Computed by Researcher

* Researcher has used forward method for regression analysis.

Table No. 6
Regression Analysis between Temperature, Rainfall, Humidity and Productivity of Crop in Solapur District

Crop	Adjusted R^2	F	Sig.	Model	Un-standardized Coefficients		T	Sig.
					B	Std. Error		
Paddy	-.201	.442	.730[b]	(Constant)	12916.248	11944.423	1.081	.315
				Temperature Mean	29.048	45.078	.644	.540
				Rainfall	-1.229	1.607	-.764	.470
				Humidity Mean	-453.210	420.154	-1.079	.316
Wheat	.703	8.900	.009[b]	(Constant)	-577.682	4239.160	-.136	.895
				Temperature Mean	25.702	15.999	1.607	.152
				Rainfall	1.590	.570	2.787	.027
				Humidity Mean	-12.847	149.116	-.086	.934
Jowar*	.840	20.223	.000[b]	(Constant)	-521.227	150.724	-3.458	.009
				Temperature Mean	16.642	4.264	3.903	.005
				Rainfall	.440	.133	3.312	.011
				Humidity Mean			-1.358	.217
Bajra	.082	1.296	.349[b]	(Constant)	-2196.500	2203.941	-.997	.352
				Temperature Mean	-4.130	8.318	-.497	.635
				Rainfall	.552	.297	1.861	.105
				Humidity Mean	86.573	77.525	1.117	.301
Maize	-.009	.973	.465[b]	(Constant)	-12103.05	15854.851	-.763	.474
				Temperature Mean	74.647	57.568	1.297	.242
				Rainfall	.114	2.073	.055	.958
				Humidity Mean	366.639	557.090	.658	.535
Gram	.616	5.823	.033[b]	(Constant)	3860.229	2962.465	1.303	.240
				Temperature Mean	19.190	10.757	1.784	.125
				Rainfall	.438	.387	1.131	.301
				Humidity Mean	-157.016	104.092	-1.508	.182
All cereals	.648	6.520	.026[b]	(Constant)	-1022.692	1787.010	-.572	.588
				Temperature Mean	19.207	5.751	3.340	.016
				Rainfall	.293	.232	1.265	.253
				Humidity Mean	21.705	60.618	.358	.733
All Pulses	.571	4.988	.045[b]	(Constant)	-1906.425	2287.764	-.833	.437

				Temperature Mean	21.671	7.362	2.944	.026
				Rainfall	.359	.297	1.212	.271
				Humidity Mean	46.433	77.604	.598	.571
All Oil Seed	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
All Fruits	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
All food grain	NA	NA	NA	(Constant)	NA	NA	NA	NA
				Temperature Mean	NA	NA	NA	NA
				Rainfall	NA	NA	NA	NA
				Humidity Mean	NA	NA	NA	NA
Sugarcane	.807	14.980	.002[b]	(Constant)	564.206	228.329	2.471	.043
				Temperature Mean	2.434	.862	2.825	.026
				Rainfall	.051	.031	1.662	.140
				Humidity Mean	-22.312	8.032	-2.778	.027

Source: Computed by Researcher

* Researcher has used forward method for regression analysis

Table No 7 Overall Impact of TRH on Crops

Region Pune	Agricultural Parameters	Environmental Parameters			Total
		Temperature	Rainfall	Humidity	
Kolhapur	Area under crop				05
	1. Jowar			✓	
	2.Maize		✓		
	Productivity				
	1. Wheat				
	2.Jowar				
Solapur	Area under crop				
	1.Paddy				
	2.Wheat				
	3.Maize			✓	
	Production				
	1.Paddy			✓	

	2.All cereals		✓		10
	Productivity				
	1.Jowar		✓		
	2.Sugarcane			✓	
Total		08	03	04	15

The regression values of the crops for TRH in the selected districts render significance for 2 crops frequently. They may be termed as sensitive crops for CC. All selected crops (9) have experienced the significant values in area under cops. Only three crops (paddy, wheat and all cereals) are CC sensitive to production of crops. Similarly, five crops (paddy, wheat, jowar, sugarcane and all cereals) are CC sensitive in respect of productivity of the crops. The more CC sensitive crop is paddy. Jowar, all cereals and all pulses experience less sensitive compared to paddy. The rest other crops are resistance to CC in the study area. The frequency of T and H impacts are highest at 12 and 10 in R only. Thus, we experience the diversified impact of CC on agriculture and environment in the study area. The impact of CC in Solapur district is higher (10). It means the CC impact is seen in drought zone of the study area. The R and H impact is much severe in high rainfall region (HRR). This region has no experience of T impact on agricultural parameters. The medium rainfall region (MRR) experiences high amount of T and H impacts. The R impact is meager in MRR. Similarly, drought or imperfect rainfall region (DRR) experiences high amount of T impact. Obviously, the R and H impact is less in drought zone.

Table 7

Environmental and Agricultural Profile of the Study the Study Area

Year 2016/17

Agricultural and environmental parameters	Kolhapur	Solapur
1.Area (sq km)	7,685	14,895
2.Forest (sq km)	1741.80	473.40
3. Area under crop (hectares)	4,87,800	9,25,700
4.land holders	6,38,000	6,68,000
5.major crops	Sugarcane, paddy, Ragi, jawar.	Jawar, tur, sugarcane, gram, bajara, wheat.
6.irrigated land (hectares)	1,64,300	2,59,500
7.Net district income rs (crores)	49,525	40,289
8. average rainfall (mm)	1,496	458.69

Source: Compiled from the DES Reports (Govt of Maharashtra).

Remote Sensing Data Analysis:

Agriculture is the backbone of our economy since the area under ariulture is large. Indian agriculture is depends on Monsoon rainfall. Rainfall affects the cropping pattern, crop productivity and general land use. Agriculture is important resource to meet increasing demands in India and source of raw material to agro-based industries. The cropping pattern is generally influenced by socio-economic, climatic and traditional factors. Climatic factors mainly, the rainfall changes the cropping pattern and the agricultural practices in the region. The decision of crop selection is based on the various factors such as soil, economic factors, market but rainfall is major factor in determining the crop. Earth is facing major

problem of climate change, due to which frequent occurrence of drought is common phenomena for every gap of two year in the drought prone area of the Solapur district.

The land use and land surface includes man- made and natural features. The land surface includes water body, forest, barren land, and land use includes the man made features like settlement, road, railway, and agriculture. Land use is dynamic in nature and provides a comprehensive understanding of the interaction and relationship of anthropogenic activities with the environment (Prakasam, 2010).

Land use and land tilling plays an important role in planning and management at different level. The land use and land cover for the present study was derived from the Landsat ETM satellite image which was downloaded from the GLCF website. The map was prepared by using ERDAS Imagine software and using supervised classification method. The study area is covered by different classes such as forest, barren land, settlement, water body, and agriculture. In the present study land use and cover of Barshi, Hatkangale and Mangaon mapped for the year of 2008 and 2016 is taken into consideration for analyzing the area under the agriculture and change detection in the land under agriculture. The satellite image of two different temporal resolutions is compared for the analysis of changing pattern of agriculture and cropping area.

Remote Sensing and GIS in Agriculture

The remote sensing and GIS techniques are applied by number of researchers for the land use and land cover mapping. The importance of GIS and remote sensing to agriculture is increasing because the advancement of technology for the acquisition, management, and analysis of spatial data of the farm is possible and feasible. The GIS and remote sensing techniques have been opened up with wide range of avenues for effective land use and land surface mapping.

The remote sensing and GIS technique plays a vital role in agricultural studies. They have a wide range of tools and techniques for effective planning of agricultural resources. The remote sensing data is combined with field survey data, which will provide unique and accurate results for optimal planning and management of cropping pattern, crop disease analysis and acreage yield estimation i. e. yield mapping. Space borne remote sensing technology is providing spatial, multi-spectral and repetitive information for planning. A GIS is a computer based decision support system for the integration of spatial data from different sources and for the analysis, manipulation and display of data. It is an excellent tool for the management of large spatial data with minimum computational error. The Remote Sensing and GIS is providing fast, cost effective and accurate results for application in various fields. Remote sensing and GIS data can be used in various applications such as soil moisture, water requirement for crop, crop inventory, cropping pattern analysis, problem identification, suitability for crop, and planning for crop.

Since the study area covers two district area, two local stations were selected from each climatic regions, medium rainfall area and dry area region (HRR, MRR and DRR). Barshi tehsil of Solapur district and Hatkangale tehsil of Kolhapur district were selected for remote sensing image data analysis. This selection of this region is based on the rainfall and climatic conditions of the area.

Satellite image of Landsat Satellite was used to analyze the land use and land cover. The satellite image was collected from following sources,

1. Landsat Satellite images, Earth Explorer (http://earthexplorer.usgs.gov)

Table No. 8 Details of Landsat Image

Satellite	Sensor	Path	Row	Year

Landsat 8	OLI and TIRS	146	47	2016
Landsat 8	OLI and TIRS	146	48	2016
Landsat 8	OLI and TIRS	147	47	2016
Landsat 5	MSS	146	47	2008
Landsat 5	MSS	146	48	2008
Landsat 5	MSS	147	47	2008

Following software were used to collect the data information.

1. ArcGIS 10.5
2. ERDAS Imagine 9.2

Methodology

The agriculture mapping is based on the satellite data. The satellite image processed using the ERDAS Image software and the land use and land cover feature was generated. Signature values are selected from the satellite image for the agriculture, water body, barren land, forest cover and settlement. The supervised, unsupervised classification techniques and ground truth verification method used for the preparation of land use/ land cover map. Various features are identified and distinguished using interpretation key such as tone, texture, size, shape, and association are used to interpret land use pattern. The ERDAS Imagine software is used for image processing such as image rectification, subset, supervised and unsupervised classification and ArcGIS software is used to prepare land use and land cover map and to calculate the area under various feature.

There are five steps to obtain the data. The fifth step is classified in to two parts, then the real data is obtained. The change detection is made later and cropping pattern and land use pattern can be obtained finally. Decoding the imagery views is technical hence required assistance from the experts. We obtained it officially from the websites as stated earlier.

Limitations

There are a few limitations in this research work. It was difficult for get accuracy assessment of the Landsat satellite images with ground truth data. The problem occurred while performing the land use and land cover classification. The spatial resolution of satellite image is low to differentiate the forest cover and agriculture land. However, there are some reviews, which indicates the reliability of the data.

Prakasam (2010) has analyzed the land use and land cover change detection of Kodaikanal using remote sensing and GIS for the forty years and experienced the change in agriculture and settlement area.

YANG Gui-juna et. al (2008) used automatic land use and land cover change detection based on remote sensing image method using multi-temporal data for the part of China. Bharathkumar L et. al (2014) worked on the study of cropping pattern mapping using remote sensing and GIS and concluded that farmers are facing different problems related agriculture, so he suggested crop suitability map to provide solutions to all these problems for Tumkur tehsil in Karnataka. Dong Qinghan et al (2008) have worked on application potential of remote sensing to estimate large crop areas on the North China Plain for Crop acreage assessment. So, we are confident in finding our objectives. Following exploration provides the results and the discussion is based on the same data images.

Result and Discussion

Mapping of land use and land cover is important to study the man-made and natural features on the surface. The mapping for the Barshi, Hatkangale and Mangaon tehsils is taken as the representative

cases in our research. The land is classified under the five different categories mainly to study the agriculture pattern in this region.

Hatkangale Tehsil

Agricultural land of Hatkanagle tehsil covers the area 154 sq km in 2008. It also increased upto 316.03 sq.km in 2016 (Table 6.3). The impact of climatic condition is not found in the Hatkangale tehsil. The rainy season is useful to maintain the cropping condition. The river Panchganga is the main source of irrigation. The over irrigation problem in noticed in Hatkangale tehsil. The soil salinity has increased due to mono-crop culture. Sugarcane is the main crop of the tehsil. Unscientific use of irrigation water and the chemical fertilizer has caused to deteriorate per acre yield. It has caused the land to become barren lands However since the measures are taken up like sub-surface drains the saline land area has been reduced to 85.37 sq.km. The forest cover is declined and settlement is increased.

Table No. 9 Land Use and Land Cover Hatkangale Tehsil

Land Use/ Land Cover	**Area in Km^2 (2008)**	**Area in Km^2 (2016)**
Agricultural Crop Land	**154**	**316.03**
Settlement	88.30	92.95
Forest	165	69.34
Barren Land	139.89	85.37
Water bodies	0.81	0.94
Total	**564.65**	**564.65**

Conclusions

in Crop Pattern mapping using land use and land cover. The Landsat 8 and Landsat 5 data is analyzed under land use and land cover mapping using supervised classification processes to carry out the agricultural area mapping. The land under agriculture in Barshi and Hatkangale tehsil has increased during the period from 2008 to 2016. Hoever, it has declined in Mangaon tehsil. The climatic factors mainly rainfall affect the cropping pattern because heavy rainfall is not suitable for sowing period and less rainfall affect on the growth of the plants.

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