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"Study of rainfall pattern and its effects on agricultural crops in some localized areas of Srikakulam and Vizianagaram districts of Andhra Pradesh, India."

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ABSTRACT : *Climate change affects the environment and natural resources immensely. Rainfall, temperature and evapotranspitration are major parameters of climate affecting changes in the environment evapotranspitration plays a key role in crop production and water balance of a region, one of the major parameters affected by climate change. The present study deals with the change in rainfall pattern and temperature levels at industrial localized and coastal belt regions of Srikakulam and Vizianagaram districts and its impact on crops during the period of 1st February, 2016 to 31st January, 2017.Here we use a statistical downscaling technique for projections of all India monsoon rainfall at a resolution of 0.50 in latitude/longitude. This technique develops a statistical relationship between large scale climate variables from reanalysis data and fine resolution observed rainfall, and then applied the relationship to coarse resolution GCM output. GCM, developed by the Canadian Centre for Climate Modeling and Analysis was employed for this study with its fine ensemble runs for capturing intromodel uncertainity. The downscaling model seems to capture the orographic effect on rainfall in mountainery areas of the Western Ghats and North East India. Pydibheemavaram, which has been emerging as an large in Arial hub in Andhra Pradesh yields to the maximum temperature of 30.40C in the month of May and minimum temperature of 24.10C in the month of February. As well as Pydibheemavaram begins with 2.8 mm rainfall in February 2016 and ends with 2.5 mm rainfall in January 2017. Across the districts of Srikakulam and Vizianagaram, the water becomes very oppressive particularly in the industrial costal region where humidity dwells constantly high. It raises the pest and diseases in the crops. In addition to that being polluted and they get very less rainfall which severely affected on fields of agriculture.*

Key words: *Climate change, Rainfall, Evapotranspiration, Agricultural productivity, coastline, hydrologic study*

INTRODUCTION

Climate change generally occurs in the statistical distribution of weather patterns. Certain human activities have been identified as primary causes of present climate change which is mainly observed in industrial localized and Coastal region of Vizianagaram and Srikakulam districts. In 1966 the World Metrological Organization (WMO) proposed the term 'Climate Change' to encompass all forms of climate variability on different scales in order to reflect the atmospheric causes.

Indian economy is highly dependent on agriculture. Accurate rainfall pattern is essential for agricultural purpose. Indian

Meteorological Department (IMD) uses rain gauss based gridded rainfall. Product developed by Rajeevan et al to monitor rainfall across the country. Dense network of uniformly distributed rain gauge stations are used tom estimate rainfall for a particular area (Mishra et. al 2011). Insufficient gauge density leads to error in representing the areal rainfall of a region. It's also found that rainfall is also affected by the distance of rain gauge stations from the grid point (Bhownik and Das, 2007).

Agriculture plays a vital role in India's economy. Over 58% of the rural households depend on agriculture as their principal means of livelihood. Agriculture production is directly depends on climate change and weather. Possible changes in participation, temperature and CO2 concentration and expected to impact significantly on crop growth. The overall impact of climate change on worldwide food production is considered to be low to moderate with successful adaptation and adequate irrigation. The agricultural operation in North Coastal Andhra Pradesh (NCAP) of Indi is mainly fed with minimal irrigation facility. The inter-annual variation of rainfall affects the agricultural operations and associated crop production over this region.

The study by Burney and Ramanathan (2014) projected that one degree centigrade rise in temperature could lead to a crop decline of 4 percent for wheat and 5 percent for rice. But losses from pollution could be greater most pollutants impact temperature by absorbing incoming radiation from the sun and reflected heat from the earth. Black Carbon across and ozone are of special concern as they affect crops directly black carbon changes the amount of radiation reading the surface while ozone is toxic to plants. 15 percent of yield decrease in rice was observed during 2010 over Gangetic plains could be attributed to pollutants. There are no such extensive studies were conducted to estimate the impact of industrialization related air pollution over Coastal Andhra Pradesh. In our study we try to find out the changes in precipitation patterns and pollution accumulation on crop production over North Coastal regions of Srikakulam and Vizianagaram districts in Andhra Pradesh.

Agriculture in Andhra Pradesh is mostly depends on rainfall. Agricultural production mainly depends upon the seasonal distribution of rainfall. In the state, South West and North East monsoons are the two important periodic winds, which are the important sources of the rain. South West monsoon (66 percent) is spread over the period from June to September and North East monsoon (24 percent) (October to December). The influence of South West monsoon is predominant in Telangana region (716 mm) followed by Coastal Andhra and Rayalaseema (407 mm).

STUDY AREA:

During my study period, Srikakulam and Vizianagaram districts have a reasonably good annual rainfall with a fairly long growing season. However the rainfall patterns of Coastal areas (such as Chintapalli, Pusapatirega, Pydibheemavaram etc.,) are mainly affected by proximity to the growing industrial hubs. Here in this area no more irrigation sources can be found. As many industries emit a lot of polluted gases into the air then the weather becomes humidify. The high humidity conditions cause to occurrence pests and

diseases. Due to this reason the productivity levels of important crops like paddy, sugarcane and pulses are low and stagnant.

The force of industrialization may knock off a significant chunk of land from agriculture with opportunities for earning better wages. Consequently the labour migrates out of the agriculture sector. The agriculture activity in this area entirely depends upon monsoon rains. These areas experience drought conditions too often due to less rainfall.

MATERIALS AND METHODOLOGY:

1) **Collection of literature:** Literature regarding the rainfall collected from Indian Meteorological department (IMD), Visakhapatnam, Kalingapatnam, Srikakulam, Thasildar Offices of Vizianagaram, Bhogapuram, Pusapatirega Mandals, V. S. Krishna Librry, Undhra University, Visakhapatnam and Department of Meteorology and Oceanography, Andhra University, and also from e-sources.

Agriculture crops data collection from season and crop coverage report 2015m Andhra Pradesh, Department of Agriculture, Vizianagaram and Srikakulam districts and also Agriculture centre, Amadalavalasa, Srikakulam.

2) **Observations of Temperature Levels, Rainfall, details and rain fed crops:** The temperature levels could be observed in some localized industrial areas such as Pusapatirega, Kandivalasa, Pydibheemavaram and rural Varisam and Ranasthalam. Measurement of rainfall have been noticed at the Coastal areas of Chintapalli, Tippalavalasa, Chepala Konderu, Munjeru, Konada, Tudam Kosta, Bhogapuram, Varisam etc., with the help of rain gauzes. Temperature and pollution levels could be measured by using Spectrophotometers, Infrared spectrometers and thermometers. Agricultural crops like Paddy, Maize, Sugarcane, Sunflower, Red grains Black grains and other Pulses Ragi, Sown during Kharif season have been observed in the areas of Srikakulam and Vizianagaram districts.

3) **Identifying pollutants emitted in Industrialized area**: Agricultural crops can be injured when exposed to high concentration of various air pollutants. Injury ranges from visible making on foliage to reduce growth and yield to premature death of the plant. The development and severity of the injury depends on the concentration of the particular pollutant. Dust samples have been collected at the industrial areas of Dr. Reddy's Lab, Matrix Lab, Vera Lab, Andhra Organics, Aurobindo Industries at Pusapatirega, Kandivalasa, and Pydibheemavaram. And identified the pollutants Carbon monoxide (C0), Sulphur dioxide (SO2) Chlorofloro Cabons (CFC's) and Nitrozen Oxidse.

4) **Identifying inter link among pollutants, temperature, rainfall and agriculture crops:** In these industrial areas temperature is getting high other than remaining areas of Srikakulam and Vizianagaram districts. In my study, the rainfall pattern emerges low at industrial localized areas when compared with other areas. Due to this, some rain fed crops like Paddy, Sugarcane, Groundnut, Ragi, Maize etc., are being disappeared. So the farmers prefer to cultivate the industrial plants like Teku, Devadaru, Eucalyptus, Survey plants, which don't need the abundant water sources. Besides, how the pollutants make the atmosphere humidify and their ill effect

on the rain fed crops yet to be identified in the studying region of Srikakulam and Vizianagaram districts.

5) **Data Collection :** Collected data on temperatures observed, areas of agricultural crops sown during the study period, rainfall details measured, have been represented in Tables drawn below. Kurtosis formula has to be used to draw the rainfall distribution and pollutants' effect.

Table : 1

Month wise Temperature levels, observed at various villages in Vizianagaram and Srikakulam districts during the study year [in 0C]

S. No	Name of the Village	From 03-02-2015 to 31-01-2016											
		Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan
1	Tudem	24.2	25.0	28.9	31.0	29.5	29.0	28.7	28.3	28.0	25.2	23.1	23.1
2	Polipalli	25.2	27.9	29.9	31.4	30.9	29.2	29.1	28.7	28.0	25.4	23.3	23.3
3	Bhogapuram	25.0	27.8	29.8	31.4	30.2	29.2	29.0	28.6	28.0	25.4	23.3	23.1
4	Vizianagaram	32.0	32.3	34.0	34.2	33.8	31.8	31.0	29.8	29.0	29.0	28.9	27.0
5	Denkara	25.2	27.9	30.0	31.3	30.7	29.1	28.9	28.7	28.0	25.2	23.1	23.1
6	Chintada	24.4	26.8	29.4	31.0	29.5	29.0	28.0	27.0	26.4	25.0	22.8	22.0
7	Konada	24.7	26.4	29.0	30.6	29.4	29.7	27.4	26.6	26.0	24.8	22.7	22.9
8	Pusapati Rega	25.1	27.8	29.8	31.1	30.7	29.0	28.9	29.7	27.9	25.2	23.0	23.0
9	Kandivalasa	29.0	31.5	32.9	33.6	33.0	31.0	31.2	31.0	30.5	30.9	28.8	26.9
10	Pydibhimavaram	29.5	32.0	33.7	34.6	33.9	31.8	31.8	31.6	31.1	31.1	29.1	27.7
11	Naruva	29.0	32.0	33.0	34.4	33.7	31.6	31.9	31.6	31.0	31.2	28.4	27.2
12	Ranastalam	24.8	27.6	29.6	33.0	30.4	28.8	28.7	28.4	27.6	24.7	22.5	22.8
13	Munjeru	24.0	26.2	29.0	30.4	28.9	28.0	28.0	28.0	27.8	25.1	23.0	22.9
14	Kosta	24.8	29.5	29.6	30.8	30.3	28.7	28.6	28.4	27.5	24.7	22.4	22.7
15	Chilakalapalem	24.7	27.0	29.4	31.0	30.0	28.5	28.0	27.6	27.0	24.0	21.9	21.8
16	Varisam	24.8	25.6	29.7	31.0	30.5	28.9	29.0	28.8	27.6	24.8	22.5	22.7

Across the districts of Srikakulam and Vizianagara, about the middle of February, the temperatures rise rapidly till the month of May which is the hottest month with the means daily maximum temperature at about 350C and the mean minimum at about 270C. When we study the table, the weather is very oppressive particularly in the industrial coastal region where humidity dwells constantly

high. It raises the pests and diseases in the crops. The factors have to be identified beyond the occurrence of low temperature levels at the presence of industrial hubs.

Table : 2

Month wise Rainfall Pattern, observed at various villages in Vizianagaram and Srikakulam districts during the study year (in mm)

S. No	Name of the Village	From 03-02-2015 to 31-01-2016											
		Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan
1	Tudem	4	12	17	65	118	139	155	188	250	65	5	2
2	Polipalli	4	12	17	64	116	133	153	185	258	65	5	2
3	Bhogapuram	6	12	19	50	130	159	190	196	220	57	5	4
4	Vizianagaram	5	11	19	77	132	157	172	204	245	57	5	2
5	Denkara	6	12	17	67	131	140	175	190	250	61	6	8
6	Chintapalli	6	12	18	66	145	162	190	196	255	63	5	2
7	Konada	6	12	19	66	148	163	190	195	248	62	5	2
8	Pusapati Rega	4.5	13	18	65	133	138	172	180	234	60	6	2.5
9	Kandivalasa	3	11	18	64	133	140	172	180	231	58	6	2
10	Pydibhimavaram	3	13	18	62	135	144	170	173	220	57	4	2
11	Naruva	4	12	17	59	135	149	172	180	227	58	4	3
12	Ranastalam	5	12	18	59	133	151	174	187	235	59	6	4
13	Munjeru	5	12	18	52	136	161	192	199	223	59	5	4
14	Kosta	5	12	19	53	131	159	171	186	225	59	6	5.2
15	Chilakalapalem	4	11	18	53	131	160	170	182	220	60	4	2
16	Varisam	5	11	17	46	125	155	161	179	222	61	5	4

These industrial localized areas, situated across the coastal belt have been getting very less rainfall since many industries had been established in an abrupt manner, when we compare with other villages of Srikakulam and Vizianagaram districts. The rainfall pattern of 15 villages merely measured. The rainfall pattern of some more villages, have yet to be measured.

Across the districts of Srikakulam and Vizianagaram, about the middle of February, the temperatures rise rapidly till the month of May which is the hottest month with the means daily maximum temperature at about 370C and the minimum temperature at about 30.20C. When we study the table, the weather condition is too hot when we compare with previous years as 2016 has been named the hottest year ever since annual temperatures were measured. In however the weather is very oppressive particularly in the industrial coastal region where humidity dwells constantly high. It raises the pests and diseases in the crops. The factors have to be identified beyond the occurrence of low temperature levels at the presence of industrial hubs.

Table : 3

Crop wise area sown during study period (Area in Hectares)

S. No	Crop	Irrigated / Rainfed	Normal	Current	Percentage of sown
1	Paddy	Irrigated	16.76	13.2	78.76%
2	Sugar cane	Rainfed	1.52	1.3	85.50%
3	Maize	Rainfed	0.86	0.64	80.2%
4	Raagi	Rainfed	0.34	0.269	79.1%
5	Red Gram	Rainfed	2.02	1.95	96.53%
6	Black Gram	Rainfed	0.19	0.094	52.1%
7	Ground nut	Rainfed	10.56	7.235	68.5%
8	Sun Flower	Rainfed	0.2	0.04	20%
9	Cotton	Rainfed	5.84	5.99	102.5%
10	Turmeric	Rainfed	0.19	0.143	75.2%
11	Chilies	Rainfed	1.11	0.64	57.65%
12	Onions	Rainfed	0.26	0.278	106.9%
13	Minor Millets	Rainfed	0.27	0.389	144%
14	Green Gram	Rainfed	0.26	0.29	111.5%
15	Soya bean	Rainfed	0.02	0.011	55%

Table : 4

Month wise Temperature levels, observed at various villages in Vizianagaram and Srikakulam districts during the study year [in 0C]

S. No	Name of the Village	From 01-02-2016 to 01-01-2017											
		Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan
1	Tudem	24.8	24.2	28.6	30.5	30.4	29.8	28.6	28.7	28.4	26.8	24.5	24.8
2	Polipalli	24.3	24.9	27.4	31.2	31.0	30.8	29.3	29.4	29.8	28.4	26.8	26.9
3	Bhogapuram	29.4	31.5	32.1	34.3	32.3	31.4	30.4	31.0	28.4	29.0	24.3	23.4
4	Vizianagaram	29.9	32.3	32.8	34.6	32.3	30.8	29.8	31.2	29.7	28.4	28.9	28.6
5	Denkara	23.5	26.8	29.8	32.3	31.8	30.2	29.4	29.8	29.5	28.6	28.7	28.5
6	Chintada	23.3	24.3	28.9	30.0	29.8	28.9	26.8	27.2	27.0	26.8	26.9	26.8
7	Konada	23.2	24.6	26.7	31.2	30.0	29.3	29.1	28.8	28.7	26.4	26.8	26.9
8	Pusapati Rega	24.5	26.2	26.8	37.1	30.8	30.2	28.4	28.8	28.2	27.8	27.2	24.0
9	Kandivalasa	26.0	26.8	27.9	30.2	29.8	30.0	29.4	29.5	29.8	25.9	24.0	23.2
10	Pydibhimavaram	24.1	28.3	29.4	30.4	29.9	29.8	29.4	28.6	29.0	28.2	27.3	27.0
11	Naruva	27.2	29.3	30.0	37.4	30.3	30.1	29.8	29.6	29.0	24.4	24.3	23.3
12	Ranastalam	28.1	29.0	30.2	32.3	31.8	30.2	30.0	29.8	28.7	24.8	25.2	24.3
13	Munjeru	26.9	27.8	28.7	29.8	29.7	30.0	29.4	29.0	28.4	24.8	23.7	23.8
14	Kosta	27.8	27.9	27.8	32.4	30.2	30.1	26.8	28.4	28.8	26.4	24.2	24.0
15	Chilakalapalem	27.5	29.8	31.2	32.4	31.5	30.3	29.4	29.2	29.8	28.9	26.5	25.3
16	Varisam	26.4	30.2	30.8	31.0	30.4	30.0	30.1	29.8	29.5	29.0	27.8	27.6

Table : 5

Month wise Rainfall Pattern, observed at various villages in Vizianagaram and Srikakulam districts during the study year (in mm)

S. No	Name of the Village	From 01-02-2016 to 01-01-2017											
		Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan
1	Tudem	5	11	18	61	130	154	184	178	142	63	6	4
2	Polipalli	4	10	17	54	124	142	167	166	134	55	5	3.5
3	Bhogapuram	6	12	21	60	135	164	208	184	130	59	5	3
4	Vizianagaram	4	9	26	53	120	128	148	132	128	62	8	4
5	Denkara	5	11	19	59	122	156	189	179	116	54	4	2
6	Chintapalli	5	10	18	62	137	149	193	184	128	65	5	3.5
7	Konada	6	13	21	63	133	168	204	198	129	64	8	5
8	Pusapati Rega	4	8	18	55	128	138	158	162	120	54	6	4
9	Kandivalasa	3	8	16	51	112	120	138	134	124	52	5	4.2
10	Pydibhimavaram	2.8	7	18	50	116	118	143	146	118	42	4	2.5
11	Naruva	4	5	16	56	123	134	147	152	134	50	6	3.2
12	Ranastalam	5	9	19	61	140	154	195	185	139	65	7	4.6
13	Munjeru	5	8	18	63	138	157	198	192	142	65	7	4.3
14	Kosta	4	6	17	56	131	133	148	152	129	57	5	54
15	Chilakalapalem	5	9	19	58	124	156	190	182	129	53	6	5
16	Varisam	4	8	15	55	125	128	140	144	128	54	6	3.7

Here the above data reveals how the industrial localized areas and coastal belt areas have been getting very less rainfall rather than other areas, since many industries extend their area on buying the field meant for cultivation, pollution levels seriously affect rainfall pattern in these areas. Pydibhimavaram begins with 2.8 mm rainfall in February 2016 and ends with 2.5 mm rainfall in February 2017. Pydibhimavaram while emerged as a main industrial hub in Andhra Pradesh is gradually losing its weather conditions as a full pack of pollutants and a high rain lost area.

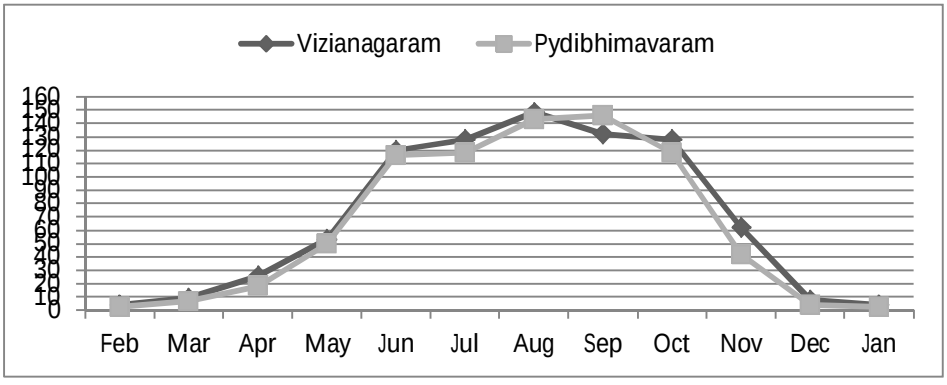
Table : 6

Crop wise area sown during study period (Area in Hectares)

S. No	Crop	Irrigated / Rainfed	Normal	Current	Percentage of sown
1	Paddy	Irrigated	16.76	12.8	76.37%
2	Sugar cane	Rainfed	1.52	1.41	92.76%
3	Maize	Rainfed	0.86	0.79	91.8%
4	Raagi	Rainfed	0.34	0.28	82.35%
5	Red Gram	Rainfed	2.02	1.90	94%
6	Black Gram	Rainfed	0.19	0.089	46.8%
7	Ground nut	Rainfed	10.56	7.39	6998%
8	Sun Flower	Rainfed	0.2	0.08	40%
9	Cotton	Rainfed	5.84	5.76	98.6%
10	Turmeric	Rainfed	0.19	0.12	63.1%
11	Chilies	Rainfed	1.11	0.78	70.2%
12	Onions	Rainfed	0.26	0.16	61.5%
13	Minor Millets	Rainfed	0.27	0.28	103.7%
14	Green Gram	Rainfed	0.26	0.29	111.5%
15	Soya bean	Rainfed	0.02	0.011	55%

Graph : 1

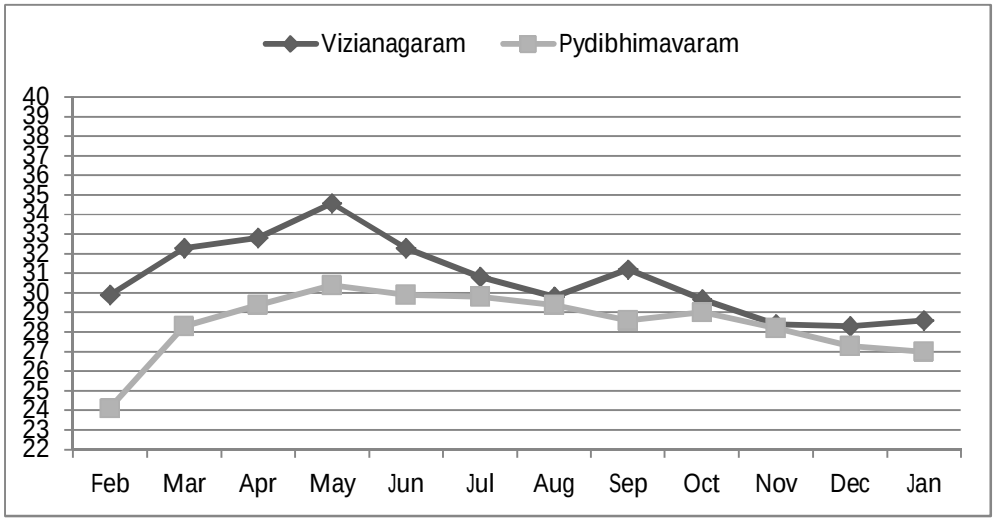
Comparing rainfall pattern of Pydibhimavaram (Industrial area) and Vizianagaram (Non-industrial area)



Months	Vizianagaram	Pydibhimavaram
Feb	4	2.8
Mar	9	7.0
Apr	26	18.0
May	53	50.0
Jun	120	116
Jul	128	118
Aug	148	143
Sep	132	146
Oct	128	118
Nov	62	42.0
Dec	8	4.0
Jan	4	2.5

Graph : 2

Comparing temperature levels of Pydibhimavaram (Industrial hub) and Vizianagaram (Non-industrial area)



Months	Vizianagaram	Pydibhimavaram
Feb	29.9	24.1
Mar	32.3	28.3
Apr	32.8	29.4
May	34.6	30.4
Jun	32.3	29.9

Jul	30.8	29.8
Aug	29.8	29.4
Sep	31.2	28.6
Oct	29.7	29.0
Nov	28.4	28.2
Dec	28.3	27.3
Jan	28.6	27.0

RESULTS AND DISCUSSION:

The people in the research area overwhelmingly perceive climatic changes happening today in the form of rainfall variability. The most common changes reported relate to the timing, quality, quantity and overall predictability of rainfall, including delayed onset and shorter rainy seasons; reduced number of rainy days per year; increased frequency of heavy rainfall events and more frequent prolonged dry spells during rainy seasons. The largely agriculture based households in the research sites overwhelmingly report rainfall variability negatively affects production and contributes to food and livelihood insecurity. Levels of food insecurity varied significantly.

In order to understand the potential for rainfall to become a significant driver of human mobility in the future, it's important to identify the range of impacts that likely climatic change in the Costal belt areas of Srikakulam and Vizianagaram districts.

The above study mainly focused on three objectives.

a) To understand how large amounts of the pollutants emitted by industries at the Coastal belt region of Srikakulam and Vizianagaram districts.
b) To understand how these pollutants affect the temperature levels in sustaining humidity is high quantity leads to the increase of pests diseases in the crops.
c) To understand how these pollutants affect the rainfall pattern in the industrial localized areas and how they affect the yield of cultivation at the immense level.

SUMMARY AND CONCLUSIONS:

In the present study we have taken the observations of temperature and rainfall pattern at some industrial localized areas in the Coastal belt region of Srikakulam and Vizianagaram districts. Obviously the data gives the huge insight into the human activities and how they affect the behavior of natural resources.

Humidity found in weather and changing precipitation pattern will severely affected the production pattern of different crops. Across the belt of Industrial areas, humidity occupies vey high in quantity. Due to this, the required temperature needed to the growth of crops can be deteriorated. It largely affects on the livelihood of the farmers, living at industrial localized areas who are going end their lives with pathetic suicides.

CONFLICT OF INTEREST:

The authors declare that they have no conflict of interest related to the work.

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