Rainfall Patterns and Food Crops Production to Evaluate Climate Change in Regidi-Amadalavalasa Mandal of Srikakulam District, A. P., India

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Abstract: Rapid changes in Land Use Land Cover (LULC) practices, burning of fossil fuels, change in food habits of man and a variety of man induced reasons are pushed the global climate in to an unsafe state. Climate is the expected weather conditions at a given location over time and can be measured at many geographic scales like cities, countries or the entire globe as a unit. Change in average temperatures and average number of rainy days in an area will influences the quantum of precipitation, frequency of droughts and food crops production. Increasing global surface temperatures are very likely to lead to changes in precipitation and atmospheric moisture because of changes in atmospheric circulation, a more active hydrological cycle, and increases in the water-holding capacity throughout the atmosphere. The study was made at Regidi-Amadalavalasa mandal of Srikakulam district, A. P. for 4 Years during 2014-15 to 2017-18. Results shows that changing patterns and variance in precipitation at regional level is significant, this change is influencing on the overall food production at the study site. This study revealing that wet areas become wetter, dry and arid areas become drier. This changing pattern calls for renewed efforts at adaptation to climate change, as the changing precipitation pattern will also affect the regional availability of food supply. To identify the gaps this study was conducted and recorded the data on changing patterns of precipitation at regional level, thus indicating that climate change is already a reality. Such a study is required not only for environmentalists but also for policy makers. The details were given in the results and discussions.

***Keywords* - Precipitation pattern, Climate change, Rainy days, Droughts, Crop production.**

I. INTRODUCTION

Kyoto Protocol came into force as a global treaty, binding its signatories to the reduction of greenhouse gases as set out in the Protocol, though the United States and Australia remain outside this fold. Nevertheless, the ratification shows that a global commitment to take some action to mitigate global climate change under the general framework the United Nations Framework Convention on Climate Change is finally underway, with further amendments and tightening of harmful emissions now a real possibility. Climate change is recognized as one of the most serious global challenges of the 21 century; this is because of its multiple effects on basic human support systems such as agricultural production, forests, water resources and the ecosystem (Aklilu & Alebachew, 2009). According to Bates et al (2008), precipitation over land has generally increased over the 20th century between 300 N and 850 N but the areas from 100 S to 300 N have rather shown a notable decrease in precipitation over the past 30 – 40 years. Their assessment also shows that temperatures will increase in the range of 1.50 C – 40 C by the end of this century. This warming will result in severe droughts, frequent episodes of floods and a decrease in yield potential of some arid areas. However, there is a direct influence of global warming on changes in precipitation and heavy rains. Increased heating leads to greater evaporation and thus surface drying, thereby increasing intensity and duration of drought. The water-holding capacity of air increases by about 6 to 7% per 1 ◦C warming, which leads to increased water vapor in the atmosphere, and this probably provides the biggest influence on precipitation (Kevin E Trenberth, 2005). There are uncertainties regarding the levels of damage that will result from this change in atmospheric conditions and impacts may also turn out to be locally specific (Morton, 2007). In recent years, the patterns of precipitation change have developed a distinctive pattern whereby higher latitudes have become wetter and the subtropics and much of the tropics have become drier.

However, a series of scientific studies and number of press reports show that climate change is well underway. While the subject of climate change is vast, there is at least one topic within climate change that deserves urgent and systematic attention, and that is the changing pattern of precipitation around the world. This calls for the development of approaches that are preferably more context specific in relation to the nature of risk associated with climate change, livelihoods and geographical location (IFAD, 2008). Earth's average surface temperature has increased by more than 0.8°C over the past 100 years, with much of this increase taking place over the past 35 years. As concentrations of heat trapping greenhouse gases increase in the atmosphere, Earth's natural greenhouse effect is enhanced like a thicker blanket, causing surface temperatures to rise. Interaction between atmosphere and terrestrial ecosystems will influence the heat exchange, trace gases, moisture etc. (Roger et al., 1998). Atmospheric CO_2 levels are increasing and will remain elevated for many centuries, about 45% of the CO_2 emitted by human activities remains in the atmosphere. Average CO_2 emissions from volcanoes are about 200 million tons per year, while humans are emitting an estimated 36 billion tons of CO_2 each year, 80-85% of which are from fossil fuels. Changes in Land Use and Land Cover (LULC) are another way that human activities are influencing Earth's climate. Deforestation is responsible for 10% to 20% of the excess CO_2 emitted to the atmosphere each year, and, as has already been discussed, agriculture contributes nitrous oxide and methane. Strong El Niño and La Niña events are associated with significant year-to-year changes in temperature and rainfall patterns across many parts of the planet. Overall, global land precipitation has increased by about 2% since the beginning of the 20th century (Jones and Hulme, 1996; Hulme et al., 1998). These events have been linked to a number of extreme weather events, such as flooding in mid western states and the severe droughts in southeastern states of the world.

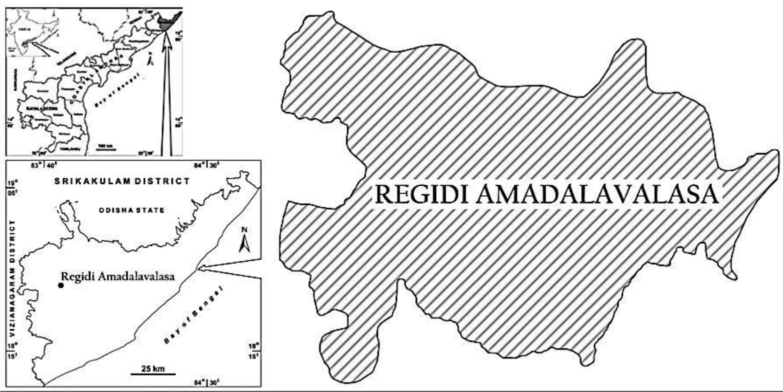
Globally, temperatures tend to be higher during El Niño periods and lower during La Niña years. The increase is statistically significant, though neither spatially nor temporally uniform (Karl and Knight, 1998; Doherty et al., 1999). It is estimated that the oceans have absorbed between one-quarter and one-third of the excess CO2 from human activities, becoming nearly 30% more acidic than during preindustrial times. Another example of a climate change observed during the past several decades has been changes in the frequency and distribution of precipitation. Total precipitation has not been geographically uniform conditions are generally wetter in the Northeast, drier in the Southeast, and much drier in the Southwest. As the climate has changed, many species have shifted their range as they try to stay in areas with the same ambient temperatures. Such changes can disrupt feeding patterns, pollination, and other vital interactions between species, and they also affect the timing and severity of insects, disease outbreaks, and other disturbances. Local temperatures vary widely from day to day, week to week, and season to season. Warming is greatest in the high latitudes of the Northern Hemisphere and is significantly larger over land than over ocean. Heat waves also are expected to last longer as the average global temperature increases. It follows that as global temperatures rise, the risk of heat-related illness and deaths also should rise. Global warming is expected to intensify regional contrasts in precipitation that already exist: dry areas are expected to get even drier and wet areas even wetter. Over the 20th century, the annual average precipitation increased by 7 to 12% in the northern hemisphere, on contrast recorded low precipitation has been observed at equatorial region since 1995 (Mohammed H.I. Dore, 2005). Regionally non-significant trends have occurred in the rainy season and precipitation is more erratic at tropics and sub-tropics. This is because warmer temperatures tend to increase evaporation from oceans, lakes, plants, and soil, which, according to both theory and observations, will boost the amount of water vapor in the atmosphere by about 7% per 1°C of warming. The results show that the subtropics, where most of the world's deserts are concentrated, are likely to see 5-10% reductions in precipitation for each degree of global warming. Observations in many parts of the world show a statistically significant increase in the intensity of heavy rainstorms. Computer models indicate that this trend will continue as Earth warms, even in subtropical regions where overall precipitation will decrease. In those regions, the projections show an increase in dry days between rainstorms with the average rainfall over seasons going down. In general, extreme rainstorms are likely to intensify by 5-10% for each 1°C of global warming, with the greatest intensification in the tropics, where rain is heaviest. Rising temperatures and increased evaporation and drought can also be expected to boost the risk of fire in some regions. While observing long-term rainfall tendency in India revealing that huge variations have occurred between different decades (Kumar et al., 1999). The strong spatial variability inherent in precipitation requires the use of estimates based on satellite observations for many regions. Thus, satellite data are essential to infer global changes in precipitation, as the oceans account for >70% of the global surface area. The distributional consequences are obviously very important for the poorest countries in the world and they are mostly at the equator. The stress of climate change on farming may threaten global food security especially in third world and poor nations.

Although an increase in the amount of CO2 in the atmosphere favors the growth of many plants, it does not necessarily translate into more food. Crops tend to grow more quickly in higher temperatures, leading to shorter growing periods and less time to produce grains. In addition, a changing climate will bring other hazards, including greater water stress and the risk of higher temperature peaks that can quickly damage crops. Agricultural impacts will vary across regions and by crop. For each degree of warming, yields of corn in the United States and Africa, and wheat in India, drop by 5-15%. Crop pests, weeds, and disease shift in geographic range and frequency. If 5°C of global warming were to be reached, most regions of the world would experience yield losses, and global grain prices would potentially double The recent UN-IPCC-18 report makes it clear that climate change is already happening and what comes next could be even worse, unless urgent international political action is taken (UN-IPCC, 2018). One of the key messages that come out very strongly from this report is that we are already seeing the consequences of 1o C of global warming through more extreme weather, rising sea levels and diminishing Arctic sea ice, among other changes. Even if warming is kept at or just below 1.5o C, the impacts will be widespread and significant. Countries in the southern hemisphere will be among the worse off, the report said, Projected to experience the largest impacts on economic growth due to climate change should global warming increase. The report underlines how even the smallest increase in the base target would worsen the impact of recent natural disasters. Every extra bit of warming matters, especially since warming of 1.5o C or higher increases the risk associated with long-lasting or irreversible changes, such as the loss of some ecosystems. The report cites specific examples of how impacts of global warming would be lessened with the 1.5o C increase, compared to the 2o C increase: Global sea levels would rise 10 cm lower by 2100; the likelihood of an Arctic Ocean free of sea ice in summer would be once per century, instead of at least once per decade. Coral reefs would decline by 70% to 90% instead of being almost completely wiped out. Thus, international cooperation is absolutely imperative to limit emissions and therefore global warming and its impacts, as well as coordinating effective and widespread adaptation and mitigation. The next few years will be critical in the evolution of these efforts. One key issue will be negative emissions, large scale carbon-scrubbing technologies that can reduce the amount in the atmosphere and act to counter continued pollution.

Study Area:

The present study area Regidi-Amadalavalasa Mandal is having 66 village hamlets along with 39 panchayats. The Mandal is situated with geographic co-ordinates of 18.58665o N Latitude and 83.7628o E Longitude. The present study area is bounded by Palakonda and Veeraghattam mandals on the north, Vangara mandal and Vizianagaram district on the west, Rajam and Santhakaviti mandals on the south and Burja mandal on the east is shown in Fig. 1. The average Elevation/Altitude is 67 mts Above Mean Sea Level (AMSL). The summer temperature at study site is ranging from 29o C to 35o C, whereas winter temperature is ranging from 18o C to 25o C. The normal precipitation in the experimental site is 1104 mm, however during study period the highest rainfall received is 1121.8 mm in the year 2015-16 and the lowest rainfall received is 880.5 mm in the year 2016-17. The mandal is located towards north and 37 km far from district headquarters of Srikakulam. The study area is occupied by mixed dry deciduous type of vegetation and majority of the land is under agriculture grown with major crops like paddy and sugarcane. Moreover, other commercial crops like cotton, ground nut, green gram, black gram, red gram etc. were also grown in the study site.

Fig. 1: Map showing the study area of Regidi Amadalavalasa Mandal



II. MATERIAL AND METHODS

Sampling Procedure:

The study used data from a field survey and experiments that involved continuous data collection during the entire study period. The unit of observation was the agricultural field and information was obtained for four years i.e. 2014-215, 2015-2016, 2016-2017 and 2017-2018. A two stage stratified sampling procedure was employed in selecting the sample. The first stage involved stratified selection of village hamlets from 39 panchayats of the experimental site. Selection was based on major variation in agro-ecological factors, access to agricultural fields, location of irrigation projects and local irrigation sources like ponds, tanks, lakes, canals, geddas etc. The second stage involved randomly selecting the stations for recording rainfall at agricultural fields from 39 panchayats. This study covered almost all 39 panchayats to collect and record the data from the field stations.

Data Collection Process:

The field work was conducted in all the months regularly throughout study period i.e. 2014-15 to 2017-18 for the collection of total cropped area and production of sugarcane and from June to December regularly in case of total cropped area and production of paddy. The process involved with two research students that were closely supervised by one research coordinator. One of the research students had experience with data collection in the region and he acted as the field supervisor. Data were collected through direct observation and estimation, individual face to face interviews with the farmers concerned and some data were collected from district and mandal agricultural departments.

A multipurpose data collection instrument was used and it consisted of five separate questionnaires; farmer type and characteristics questionnaire, plot characteristics questionnaire, land perception, irrigation source and finally the land administration committee questionnaire. It is the first two questionnaires that were of relevance to this study since they contained information regarding crop yields, inputs, plot characteristics and the household characteristics. The meteorological data was obtained from district meteorological station by the Research coordinator. Due to the inclusion of new issues worth investigation and challenges with previous responses, the interview tools underwent some adjustments over the years. The changes were nevertheless made in such a way as not to affect the validity of the tools for panel data analysis. Modification of the data entry sheets was concurrently done for any changes in the questionnaires; this kept the whole process consistent. The data collection process started off with pre-testing of the questionnaires. Pre-testing was done in one of the survey sites to check for the validity of the questionnaires and it involved all the research students and some employed enumerators including research coordinator. Pre-testing also had the advantage of giving enumerators exposure to the field conditions and a possibility to determine the interview time required for each questionnaire; this was later useful to the field supervisor in the development of a daily schedule for each enumerator. Adjustments in the questionnaire were accordingly made after the pretesting process and the data collection process continued thereafter. Interviews were performed in the local language by trained enumerators under close supervision by the research students. Since the survey area was large, research students and enumerators were divided into two groups that moved to different survey sites. Each of the groups had at least four enumerators to carry out the interviews.

Statistical Methods Used:

The crop growth simulation approach of measuring climate impacts can be divided into the crop suitability approach and the production function approach. The crop suitability approach assesses the suitability of various land types and biophysical attributes for crop production. By including climate as one determinant of agricultural land suitability, this model can be used to predict the impact of climate change on agricultural outputs and cropping systems (Du Toit et al., 2001). The more commonly used approach of the two is the production function approach. This method uses a crop model that has been calibrated from careful controlled agro economic experiments (Adams, 1989). It involves growing crops in the field or laboratories under different possible climates e.g. rainfall, humidity, temperature and CO_2 levels.

The same farming methods are employed across various climates and no adaptation is included. This ensures that all differences in yield are only a result of the climate variables. The changes in yields obtained are then entered into economic models that predict aggregate crop outputs and prices; experiments being done separately for each crop (Mendelsohn, 2000). The approach has been employed in a number of studies by Callaway et al (1982); Decker et al (1986); Adams et al (1989); Rosenzeweig & Parry (1994). The production function approach has the advantage that it gives dependable predictions of climate's effects on yields since the link between the two is generated through controlled experiments. The experiments carried out in the production function approach also do not account for adoption of new technologies in the future since they use climate change scenarios on current agricultural systems. SPSS version 16.0 is used for the analysis of data and to derive results.

Climate data

Precipitation data was recorded by establishing rainfall recording centers at random in the field and was validated with the data obtained from the district and mandal meteorological stations. This was compiled from monthly data that had been gathered from many field sites throughout region. This study chose to exclude the temperature variables from the analysis because most of the sites had gaps in the temperature measurements and minimal variation over the years. Precipitation data was collected for all months during the entire study period but emphasis was placed on precipitation received in the crop production season (May-December). The approach of deriving precipitation values has flaws since it overlooks the effect of site specific factors like location of the site which has an influence on the amount of precipitation received and retained. Employing interpolation methodologies like PRISM as done by Deschenes & Greenstone (2007) would have been suitable.

III. RESULTS AND DISCUSSIONS

Dynamic Patterns of Precipitation:

In recent past rainfall is more dynamic in nature due constant increase of temperatures occurring in the atmosphere. The results reveal that the maximum rainfall received is 1121.77 mm/Anum with an average precipitation of 93.48 mm during the year 2015-16 and the minimum rainfall is 880.5 mm/Anum with an average precipitation of 73.38 mm during 2016-17. Though, the normal rain is 1104 mm/Year with an average normal precipitation of 92 mm. It is indicating that the rainfall during experimental period is less than the normal rain in all the years except 2015-16 is shown in Fig. 2. The experiments shows that a shortage of rainfall is observed, in the year 2014-15 the shortage is 21 mm with -1.9% deviation is occurred as against normal rain. Whereas this was 223.5 mm with -20.25% deviation and 191 mm with -17.3% deviations is observed during 2016-17 and 2017-18 respectively. However in 2015-16 excess rainfall is recorded and this was 17.77 mm with 1.61% deviation is noticed against to normal precipitation was presented in Table. 1.

Fig. 2: Year Wise Rainfall Patterns (in mm)

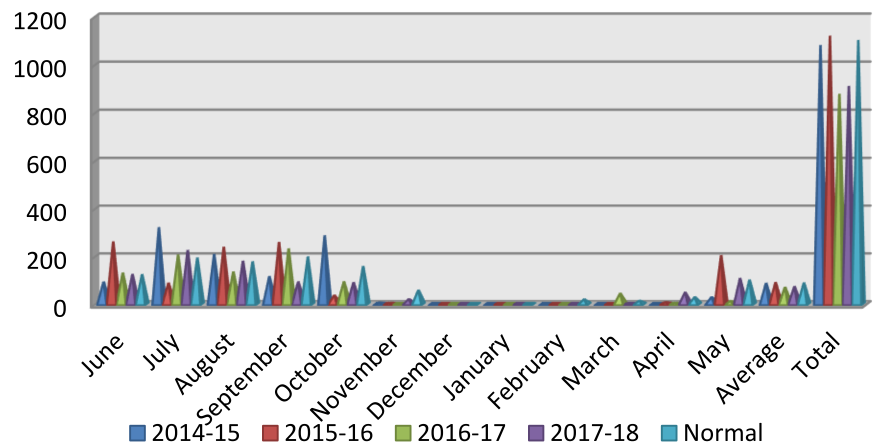


Table. 1: Year Wise Rain Fall at Regidi-Amadalavalsa Mandal During 2014-15 to 2017-18 (in mm)

Year/Month	2014-15	2015-16	2016-17	2017-18	Normal
June	95.4	264.2	133.4	127.6	126.9
July	324	91	209.1	228.2	196.7
August	211.4	241.8	138	183	180.7
September	118.8	261.8	235	96.4	201.1
October	289.6	38.8	97	93.2	161.1
November	7.2	6.2	0.4	22.4	60.8
December	0	0	0	0	1
January	3.4	0	0	0	3.4
February	0	0	0	0	21.5
March	0	2.6	47.2	0	15.4
April	2.2	8.8	5.9	51.4	31.4

May	31	206.57	14.5	110.8	104
Average	90.25	93.48083	73.375	76.08333	92
Total	1083	1121.77	880.5	913	1104

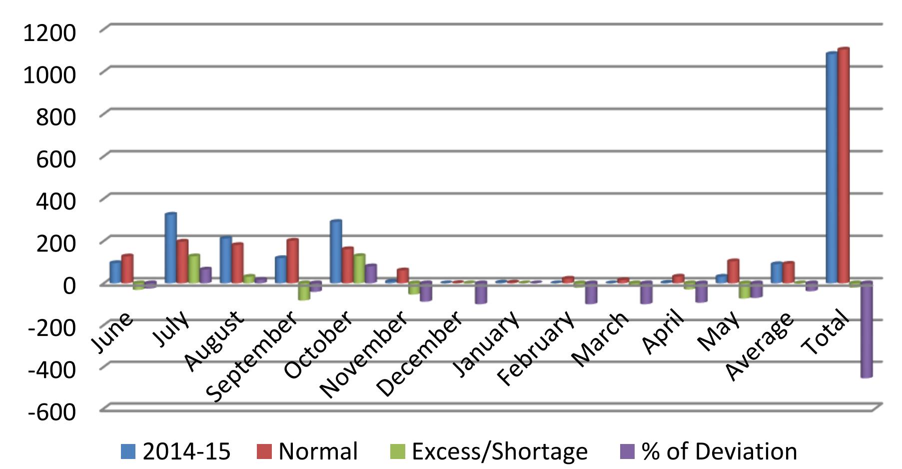
However it is in the year 2014-15 the total shortage of rainfall is 21 mm, in 2016-17 the shortage is 223.5 mm and in 2017-18 the total shortage is 191 mm. Nevertheless, the experiments revealed that an excess precipitation is recorded with 17.77 mm in the year 2015-16. The variations of average precipitation in the year 2014-15 and 2015-16 are very minute and ranged from -1.75 mm to 1.48 mm respectively when compared with normal average rain, i.e. 92 mm. Whereas, wide differences observed in average precipitation in the years 2016-17 and 2017-18 and this was -18.63 mm and -15.92 mm respectively is presented in Table. 2.

Table. 2: Deviations in Rainfall During 2014-15 to 2017-18 at Regidi-Amadalavalasa Mandal

Year/ Month	2014-15	Excess/ Shortage	% of Deviation	2015-16	Excess/ Shortage	% of Deviation	2016-17	Excess/ Shortage	% of Deviation	2017-18	Excess/ Shortage	% of Deviation	Normal
June	95.4	-31.5	-25	264.2	137.3	108	133.4	6.5	5	127.6	0.7	0.6	126.9
July	324	127.3	65	91	-105.7	-54	209.1	12.4	6.2	228.2	31.5	16	196.7
Aug.	211.4	30.7	17	241.8	61.1	34	138	-42.7	-23.7	183	2.3	-7	180.7
Sep.	118.8	-82.3	-41	261.8	60.7	30	235	33.9	16.8	96.4	-104.7	-52.1	201.1
Oct.	289.6	128.5	80	38.8	-122.3	-76	97	-64.1	-39.8	93.2	-67.9	-42.1	161.1
Nov.	7.2	-53.6	-88	6.2	-54.6	-90	0.4	-60.4	-99.4	22.4	-38.4	-63.2	60.8
Dec.	0	-1	-100	0	-1	-100	0	-1	-100	0	-1	-100	1
Jan.	3.4	0	0	0	-3.4	-100	0	-3.4	-100	0	-3.4	-100	3.4
Feb.	0	-21.5	-100	0	-21.5	-100	0	-21.5	-100	0	-21.5	-100	21.5
Mar.	0	-15.4	-100	2.6	-12.8	-83	47.2	31.8	205.7	0	-15.4	-100	15.4
April	2.2	-29.2	-93	8.8	-22.6	-72	5.9	-25.5	-81.3	51.4	20	63.7	31.4
May	31	-73	-70	206.6	102.57	98	14.5	-89.5	-86	110.8	6.8	6.5	104
Ave.	90.25	-1.75	-37.916667	93.48	1.48	-33.75	73.38	-18.625	-33.041667	76.08	-15.92	-39.8	92
Total	1083	-21	-455	1121.8	17.77	-405	880.5	-223.5	-396.5	913	-191	-477.6	1104

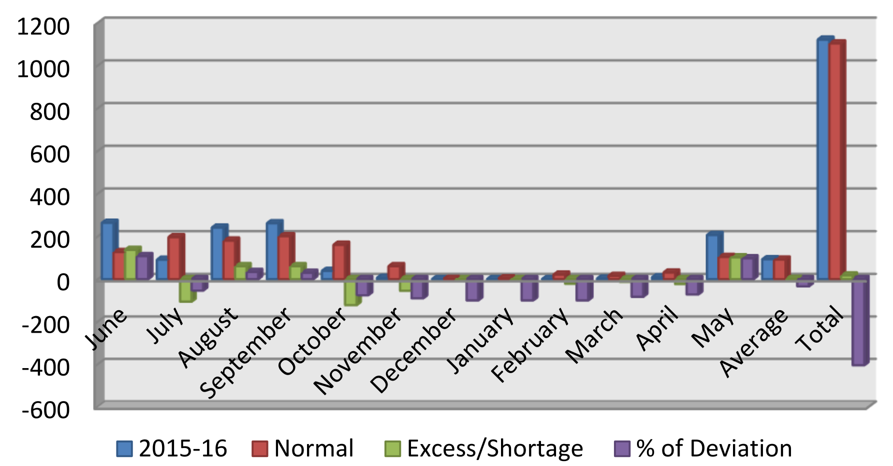
Though, the year wise precipitation is however wide differences observed between months. In the year 2014-15 the maximum precipitation is 289.6 mm occurred in the month of October against to normal rain of 161.1 mm and the minimum precipitation is ‘0’ mm occurred in the months of December, February and March as against to normal precipitation of 1 mm, 21.5 mm and 15.4 mm respectively is shown in Fig. 3.

Fig. 3: Precipitation in 2014-15



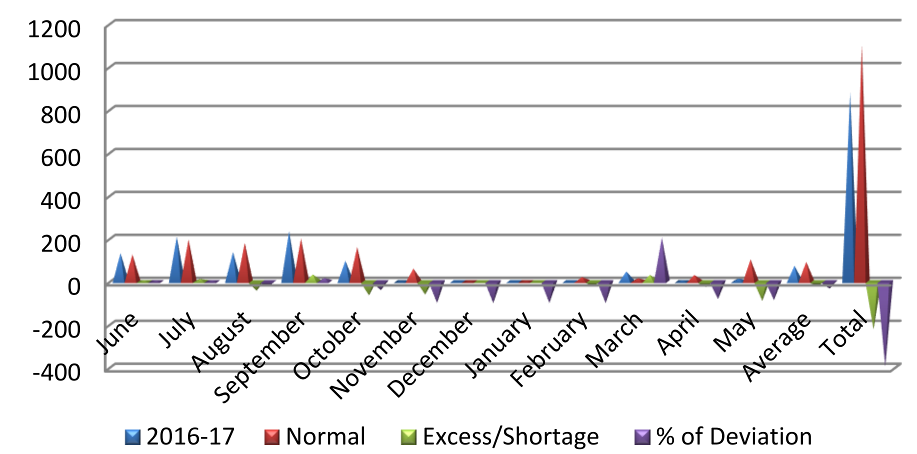
However, in the year 2015-16 the maximum precipitation is 264.2 mm occurred in the month of June against to normal rain of 126.9 mm and the minimum precipitation is ‘0’ mm occurred in the months of December, January and February as against to normal precipitation of 1 mm, 3.4 mm and 21.5 mm respectively is shown in Fig. 4.

Fig. 4: Precipitation in 2015-16



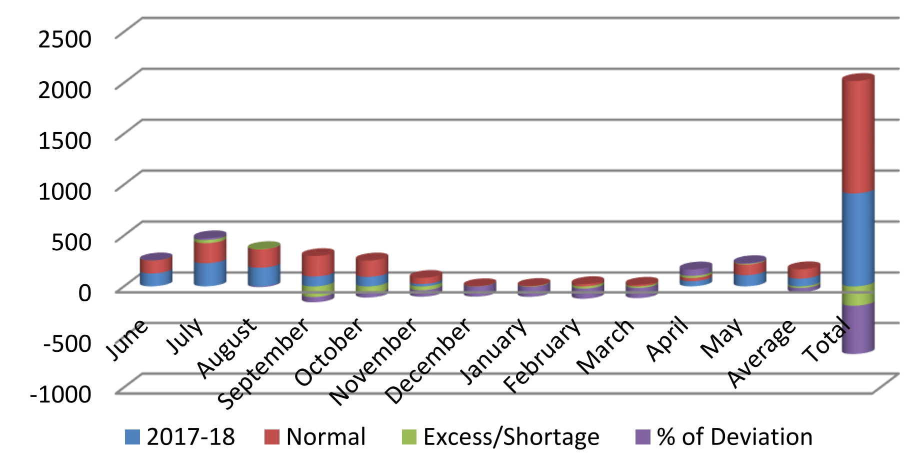
Whereas, in the year 2016-17 the maximum precipitation is 235 mm occurred in the month of September against to normal rain of 201.1 mm and the minimum precipitation is '0' mm occurred in the months of December, January and February as against to normal precipitation of 1 mm, 3.4 mm and 21.5 mm respectively is shown in Fig. 5. It is indicating that during 2015-16 and 2016-17 the rainfall is nil in the months of December, January and February.

Fig. 5: Precipitation in 2016-17



In the year 2017-18 the maximum precipitation is 228.2 mm occurred in the month of July against to normal rain of 196.7 mm and the minimum precipitation is '0' mm occurred in the months of December, January, February and March as against to normal precipitation of 1 mm, 3.4 mm, 21.5 mm and 15.4 mm respectively is shown in Fig. 6. It is observed that during 2017-18 the rainfall is nil for four months period.

Fig. 6: Precipitation in 2017-18



While observing the total number of rainy days during experimental period, in 2014-15 the numbers of rainy days are 67 with a precipitation of 1083 mm against to normal rainfall of 1104 mm. However, in 2015-16 the total rainy days are 61 with a rainfall of 1121.8 mm, in 2016-17 the numbers of rainy days are 94 with a precipitation of 880.5 mm and during 2017-18 the total rainy days are 57 with a rain of 913 mm against to normal precipitation of 1104 mm.

Crop Production

The results show that irrespective of precipitation the production of paddy and sugarcane per hectare is remains stationary from all the years. Though the rainfall is however yielding of paddy is 4.66 tons/ hectare were presented in Fig. 7, whereas, sugarcane is 79.07 tons/ hectare is recorded were shown in Fig. 8.

Fig. 7: Paddy Production

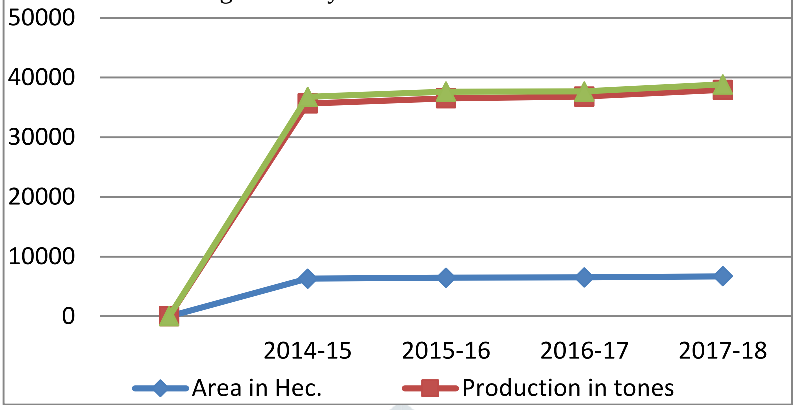
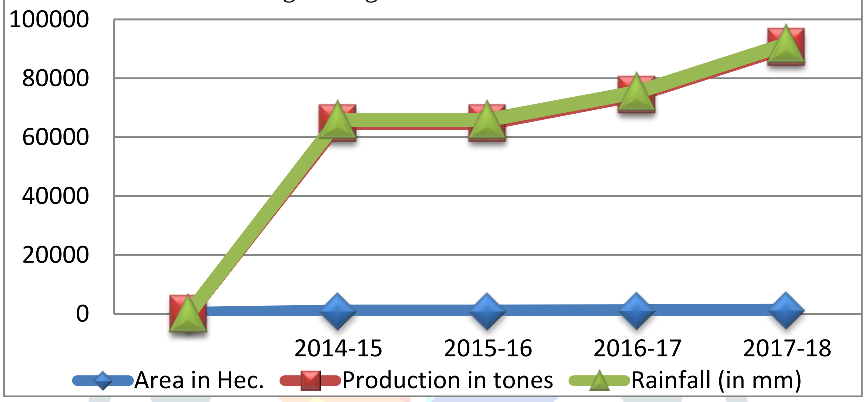


Fig. 8: Sugarcane Production



Paddy:

However, year wise yielding of paddy and sugarcane is showing dissimilarities. In the year 2014-15 paddy production is 29, 360 tons against to total area rose of 6, 300 hectares. This was 30, 059 tons/ 6, 450 hectares, 30, 292 tons/ 6, 500 hectares and 31, 224 tons/ 6, 700 hectares during 2015-16, 2016-17 and 2017-18 respectively with an average yielding of 30, 234 tons/ 6, 487.5 hectares of total area raised. The precipitation is 1083 mm, 1121.8 mm, 880.5 mm and 913 mm during 2014-15, 2015-16, 2016-17 and 2017-18 respectively with an average rainfall of 999.57 mm is presented in Table. 3.

Table. 3: Paddy Production at Experimental Site During 2014-15 to 2017-18

Year/ Production	Area (in hec.)	Production (in tons)	Rainfall (in mm)
2014-15	6300	29359.9	1083
2015-16	6450	30058.9	1121.77
2016-17	6500	30291.9	880.5
2017-18	6700	31224.1	913
Average	6487.5	30233.7	999.568

Sugar Cane:

In the year 2014-15 the sugarcane production is 64, 000 tones against to total area rose of 809.4 hectares. This was 64, 000 tons/ 809.4 hectares, 73, 600 tons/ 930.8 hectares and 89, 600 tons/ 1, 133.2 hectares during 2015-16, 2016-17 and 2017-18 respectively with an average yielding of 72, 800 tons/ 920.7 hectares of total area rised. The precipitation is 1083 mm, 1121.8 mm, 880.5 mm and 913 mm during 2014-15, 2015-16, 2016-17 and 2017-18 respectively with an average rainfall of 999.57 mm is presented in Table. 4.

Table. 4: Sugar Cane Production at Experimental Site During 2014-15 to 2017-18

Year/ Production	Area (in hec.)	Production (in tons)	Rainfall (in mm)
2014-15	809.4	64000	1083
2015-16	809.4	64000	1121.77
2016-17	930.8	73600	880.5
2017-18	1133.2	89600	913
Average	920.7	72800	999.568

Since industrialization to till date drastic changes have been occurred in the global atmosphere and these changes are escalating the regional and local level problems. Each of these scenarios is based on estimates of how different socioeconomic, technological, and policy factors will change over time, including population growth, economic activity, energy-conservation practices, energy technologies, land use land cover, dynamic patterns of agricultural activities and food production. Long-term global precipitation trends are however, during the last two to three decades, there have been some increases in the globally combined severe dry and wet areas, resulting from increases in either the dry area, e.g., over the Sahel, eastern Asia and southern Africa or the wet areas, e.g., over the United States and Europe (Mohammed H.I. Dore, 2005). The experimental study at Regidi-Amadalavalasa is revealing more dry spells against to normal precipitation during study period and the yielding per hectare of paddy and sugarcane remains constant from all the years. Though, the rainfall is more diversified in nature from different years the crop production is saturated against to population growth. This leads to regional imbalances of food supply purely because of changes in the climatic conditions and soil fertility is shown in Plate 1 and Plate 2.

PLATE. 1: PADDY CROP

PLATE. 2: SUGAR CANE CROP

There is a robust scientific agreement that human-induced climate change is occurring. The changes in climate are due to burning of fossil fuels and release of carbon emissions through different human induced sources. The Fourth Assessment Report (AR4) of the IPCC, the most comprehensive and up-to-date scientific assessment of this issue, states with “very high confidence” that human activities, such as fossil fuel burning and deforestation, have altered the global climate. During the 20th century, the global average surface temperature increased by about 0.6°C and global sea level increased by about 15 to 20 cm, global precipi¬tation over land increased about two percent dur¬ing the same period. Though the rainfall is however, the numbers of rainy days are either too high or too low is observed during our study period at Regidi-Amadalavalasa.

More over it is recorded that in less number of rainy days the maximum rain is receiving in some of the months and the remaining days are under dry spell, on the other hand though the rainy days are too large the areas are failed to get normal precipitation during some of the months. Looking ahead, human in¬fluences will continue to change Earth’s climate throughout the 21st century. The IPCC AR4 projects that the global average temperature will rise another 1.1 to 5.4°C by 2100, depending on how much the atmospheric concentrations of greenhouse gases increase during this time. This temperature rise will result in continued in¬creases in sea level and overall rainfall, changes in rainfall patterns and timing, and decline in snow cover, land ice, and sea ice extent. It is very likely that the Earth will experience a faster rate of climate change in the 21st century than seen in the last 10,000 years (CCSP, 2008).

Planet has only until 2030 to stem catastrophic climate change, experts warned in recent past. The report issued by the UN Intergovernmental Panel on Climate Change (UN-IPCC, 2018), says the planet will reach the crucial threshold of 1.5o C above pre-industrial levels by as early as 2030, precipitating the risk of extreme drought, wildfires, floods and food shortages for hundreds of millions of people. The planet is already two-thirds of the way there, with global temperatures having warmed about 1o C. Avoiding going even higher will require significant action in the next few years. This is concerning because we know there are so many more problems if we exceed 1.5o C global warming, including more heat waves and hot summers, greater sea level rise, and, for many parts of the world, worse droughts and rainfall extremes. Global net emissions of CO2 would need to fall by 45% from 2010 levels by 2030 and reach "net zero" around 2050 in order to keep the warming around 1.5o C. Lowering emissions to this degree, while technically possible, would require widespread changes in energy, industry, buildings, transportation and cities, the report says.

Annual mean rainfall is considerably low in most parts of the arid and semi-arid region of Asia. Moreover, temporal variability is quite high: occasionally, as much as 90% of the annual total is recorded in just 2 months of the year at a few places in the region. As projected by IPCC, climate change, rainfall variability and extreme climate events will adversely affect agricultural production (Christensen et al., 2007). Agriculture is most susceptible to these changes because of its high dependence on temperature and precipitation. In temperate Asia, the East Asian monsoon greatly influences temporal and spatial variations in rainfall.

In tropical Asia, hills and mountain ranges cause striking spatial variations in rainfall. Approximately 70% of the total annual rainfall over the Indian subcontinent is confined to the southwest monsoon season (June–September). In India, long-term time series of summer monsoon rainfall have no discernible trends, but decadal departures are found above and below the long time average alternatively for three consecutive decades (Kothyari and Singh, 1996). Recent decades have exhibited an increase in extreme rainfall events over northwest India during the summer monsoon (Singh and Sontakke, 2002). Moreover, the number of rainy days during the monsoon along east coastal stations has declined in the past decade.

Unlike the irrigated areas where yields depend on radiation and temperature, productivity in rain fed areas is mostly determined by rainfall and soil moisture storage (Aggarwal, 2008). The productivity decline is induced by direct changes in physiological crop growth and salinity problems resulting from a combination of increased temperature and reduced rainfall. Downing (1992); Rosenzweig & Parry (1994) and Benson & Clay (1998) noted that the effects of weather variability from climatic conditions on agricultural production will be pronounced in rural households of developing countries. To keep atmospheric concentrations of CO2 roughly steady for a few decades at any given level to avoid increasing climate change impacts, global emissions would have to be reduced by 80%.

Humans have emitted about 500 billion tons of carbon to date. Best estimates indicate that adding about 1, 150 billion tons of carbon to the air would lead to a global mean warming of 2° C. The United States is responsible for about half of the human-produced CO2 emissions already in the atmosphere and currently accounts for roughly 20% of global CO2 emissions, despite having only 5% of the world's population. The U.S. percentage of total global emissions is projected to decline over the coming decades as emissions from rapidly developing nations such as China and India will continue to grow. Thus, reductions in U.S. emissions alone will not be adequate to avert climate change risks. However, strong leadership demonstrated through strong domestic actions, may help influence other countries to pursue serious emission reduction efforts as well.

Overall, the decline in productivity appears small since we have only looked at climate change reducing precipitation amounts. If we, however, factor in the concern of precipitation frequency, the increased occurrence of droughts due to climate change as predicted for most semi arid areas will have more severe consequences on the livelihoods of subsistence farmers. To lessen the effect of the drought on livelihoods, which seems to be the potential climate change problem in such a semi arid area, there is need to support research which will enhance development of improved early warning systems. This will promote better planning by the government and households to avoid drastic falls in consumption levels during such a shock. Findings from this study are applicable to areas with semi-arid conditions and they provide ground for government action at a more regional specific level. This will enable efficient targeting of policies to be implemented. As an example, we have seen that average precipitation in the area is lower than what is required for maximum crop productivity, meaning that policies to increase non-rain fed agriculture could be appropriate.

V. CONCLUSION

Fortunately, scientists have made great strides in predicting the amount of temperature change that can be expected for different amounts of future greenhouse gas emissions and in understanding how increments of globally averaged temperatures increase of 1°C, 2°C, 3°C and so forth relate to a wide range of impacts. Many of these projected impacts pose serious risks to human societies and things people care about, including water resources, coastlines, infrastructure, human health, food security and land and ocean ecosystems. Depending on how much emissions are curtailed, the future could bring a relatively mild change in climate or it could deliver extreme changes that could last thousands of years. Capture and sequester CO2 directly from the atmosphere, for example, manage forests and soils to enhance carbon uptake; develop mechanical methods to "scrub" CO2 directly from ambient air etc. are will provide answers to our present problems. New analyses show that in regions where total precipitation has increased, it is very likely that there have been even more pronounced increases in heavy and extreme precipitation events.

Over the 20th century, there were relatively small increases in global land areas experiencing severe drought or severe wet conditions. In some regions, such as parts of Asia and Africa, the frequency and intensity of drought have been observed to increase in recent decades. According to the IPCC report, there are two main ways of removing carbon from the atmosphere: increasing natural processes and experimental carbon storage or removal technologies. However, all methods are at different stages of development and some are more conceptual than others, as they have not been tested at scale, the report warned. They will also require considerable political engagement globally, as will reducing the amount of carbon being emitted. Today the world's leading scientific experts collectively reinforced what Mother Nature has made clear that we need to undergo an urgent and rapid transformation to a global clean energy economy.

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