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# Effect of Climate Change on the Production and Productivity on Rice (*Oryza sativa* L.) and Maize (*Zea mays* L.) in Arunachal Pradesh

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**ABSTRACT**

A study was conducted in the state of Arunachal Pradesh in order to study on the climate change pattern in Arunachal Pradesh for the time period 1987 to 2018 and its impact on the production and productivity on rice (*Oryza sativa* L.) and maize (*Zea mays* L.) in the state. The study was carried out in two districts of Arunachal Pradesh, viz. East Siang and Lohit; each being the highest producing district of rice and maize in the state respectively. The study showed a declining annual rainfall pattern in the study area. The monthly rainfall pattern and seasonal rainfall pattern exhibited erratic rainfall pattern with a non-uniform linear trend for different months and different seasons. The districts of East Siang as well as Lohit received a minimum monthly rainfall of 0.00 mm while the highest monthly rainfall was recorded to be 2363 mm in the month of August for East Siang and 786.70 mm in the month of April for Lohit district. Both the districts received maximum seasonal rainfall during the monsoon months of April to September with 5992.90 mm and 2831.1mm of rainfall received in East Siang and Lohit districts respectively. The study did not show a significant change in the annual rainfall pattern. However, the monthly and seasonal rainfall exhibited a high inter year variation and irregular trends proving that the study area observed erratic monthly and seasonal rainfall during the study period. The productivity of rice and maize crops were found to have decreased by the end of the study period. It was also found that total annual rainfall had a significant effect on the yield of paddy but not in maize.

***Keywords:*** *Climate change, climate change pattern, rice, paddy, maize, rainfall trend, yield, temperature.*

## 1. INTRODUCTION

Climate change is a change in the long-term weather patterns that characterize the regions of the world. It is usually a slow and gradual process, and unlike year-to-year variability, is quite difficult to perceive without scientific records. Scientists detect climate change by looking for long-term continuous changes (trends) in climatological averages and normals and the variety around these averages. Climate change is about the non-normal variations to the climate, and the effects of these variations on other parts of the earth. These changes may take tens, hundreds or even millions of years (Mahato, 2014). It is important to understand that climate change in itself is natural and not inherently wrong. It is a fact that it has happened in the past and will happen again. However, what concerns us most about climate change is the rate at which the changes are happening. The rapid increased in anthropogenic activities such as industrialization, urbanization, deforestation, agriculture, change in land use pattern etc. have led to a rapid increase in the rate of climate change and is fuelling it to accelerate at an alarming rate.

Climate isn't defined by any particular timeframe, however scientists typically use average weather conditions over 30 year time intervalscalled climatological normal to track climate. These 30-year averages are used to determine, monitor or represent the climate - or a specific slice of climate - at a particular location. Thirty years of data is long enough to calculate an average that is not influenced by year-to-year variability. Normal can be calculated for a variety of weather variables, such as temperature or precipitation based on data from weather stations in the region of interest. There is significant year-to-year variability around these 30-year averages. This year-to-year fluctuation around the normal is climate variability (Arndt *et al.* 2012).

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### 1.1 Climate Change and its Impact on Agriculture*:*

Climate change causes alterations in weather conditions and thus has direct, biophysical effects on agricultural production. Agriculture can easily be considered as the most weather dependent human activity (Hansen, 2002). Climate change is expected to influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems (Adams *et.al.* 1998). However, the nature of these biophysical effects and the human responses to them are complex and uncertain. For example, crop and livestock yields are directly affected by changes in climatic factors such as temperature and precipitation and the frequency and severity of extreme events like droughts, floods, and wind storms. In addition, carbon dioxide is fundamental for plant production; rising concentrations have the potential to enhance the productivity of agroecosystems. One of the most direct impact of global climate change may have on human societies is the potential consequences on global crop production (Berg et al., 2013). Climate change can disturb food availability, decrease access to food, and affect food quality as reported by USDA (2015). Agricultural systems are managed ecosystems which are also dynamic wherein the producers and consumers are continuously responding to changes in crop and livestock yields, food prices, input prices, resource availability, and technological change. Thus, the human response is critical to understanding and estimating the effects of climate change on production and food supply (Adams *et.al.* 1998).

Climate change is expected to cause changes in the climatic scenarios of the world and manifest primarily in terms of higher temperatures, changes in precipitation, and higher atmospheric $CO_2$ concentrations. The plausible changes can have both positive and negative impact on agriculture. For example, an increased temperature has been found to reduce yields and quality of many crops, most importantly cereal and food grains due to higher respiration rates and shorter seed formation and grain filling period. On the other hand, an increase in precipitation may benefit semi-arid and other areas with shortage of water by increasing soil moisture. The same can however aggravate problems in regions with excess water, while a reduction in rainfall in some places can cause drought like scenario.

Many studies propose higher impact of climate change on agriculture in developing countries as compared to developed countries (Stern, 2006).

## 2. RESEARCH METHODOLOGY

A study was conducted in the East Siang and Lohit districts of Arunachal Pradesh in order to study the climate change pattern in the state through the years 1987 to 2018 and its effect in the production and productivity of rice (Oryza sativa L.) and maize (Zea mays L.). The study was conducted in the state of Arunachal Pradesh wherein the districts East Siang and Lohit were selected purposefully due to them being the districts with highest productivity in terms of rice and maize crops respectively. Two blocks each from each district were then purposefully selected following which two villages from each block were then randomly selected. In order to make sure that the sample drawn for the study is a proper representation of the population from which the sample is drawn, it is required that the sampling method followed be efficient and as unbiased as possible. For that, the total numbers of households in the selected villages were obtained by contacting the village elders out of which, three percent of the total village households were selected from each village by following the simple random sampling technique. The research work was based on the primary and secondary data wherein the primary data was collected from the farmers with the help of structured and pre-tested questionnaires through personal interview method and the secondary data was collected from the meteorological department and other concerned organizations and institutions functioning in the state. Collected data was scrutinized, tabulated and processed systematically according to the objectives laid down for the study. Tabular and functional analysis was used to meet the objectives of the study as and where needed. The collected data was then made to undergo statistical analysis in order to identify the trends in monthly, seasonal as well as annual patterns of rainfall along with the trend in crop yield during the study period. Regression analysis to study the effect of climatic parameters on crop production was conducted to examine the effect of climate on crop production, we regressed crop yield on weather variables using the following models:

Model 1: Yield = f (rainfall)

Model 2: Yield = f (temperature (max, min), rainfall)

## 3. RESULTS AND FINDINGS

The farmers if Arunachal Pradesh mostly practices organic method of cultivation of crops with minimum usage of chemical input in the farms. Rice and maize are some of the major crops grown in terms of area under cultivation. It was observed that 68.88 per cent of the area under cultivation was utilised for paddy cultivation in East Siang followed by 12.18 per cent area under maize. Lohit district had 48.13 per cent of its area under cultivation growing maize followed by 31.12 per cent of agricultural area under rice cultivation. However, a great portion of the farm family income is obtained by horticultural and plantation crops with these sectors having low volume - high income characteristics.

Rice is mostly cultivated in the kharif season with the sowing period spanning from the month of April-May to June-July depending on the variety of rice sown and harvested in the months of September to November. A variety of rice is grown in the region both local and introduced. The local varieties of rice include Itanagar, Deku, Amka, Neori, Yagrung, Katum, Kayong, Mosina, Raling, Kolom dhani etc. the farmers have also started to grow introduced varieties like CAU R1, IR8 and Ranjit in their farms. Maize is grown in both kharif and rabi seasons. Farmers prefer to grow local varieties of maize during the winter season wherein the sowing is done during the months of September to October and harvested during December-January. During the summers, farmers usually plant introduced varieties of maize like DKC 9165, DHH77, DHH107 and DURGA. These are sown during the months of February to March and harvested in June-July.

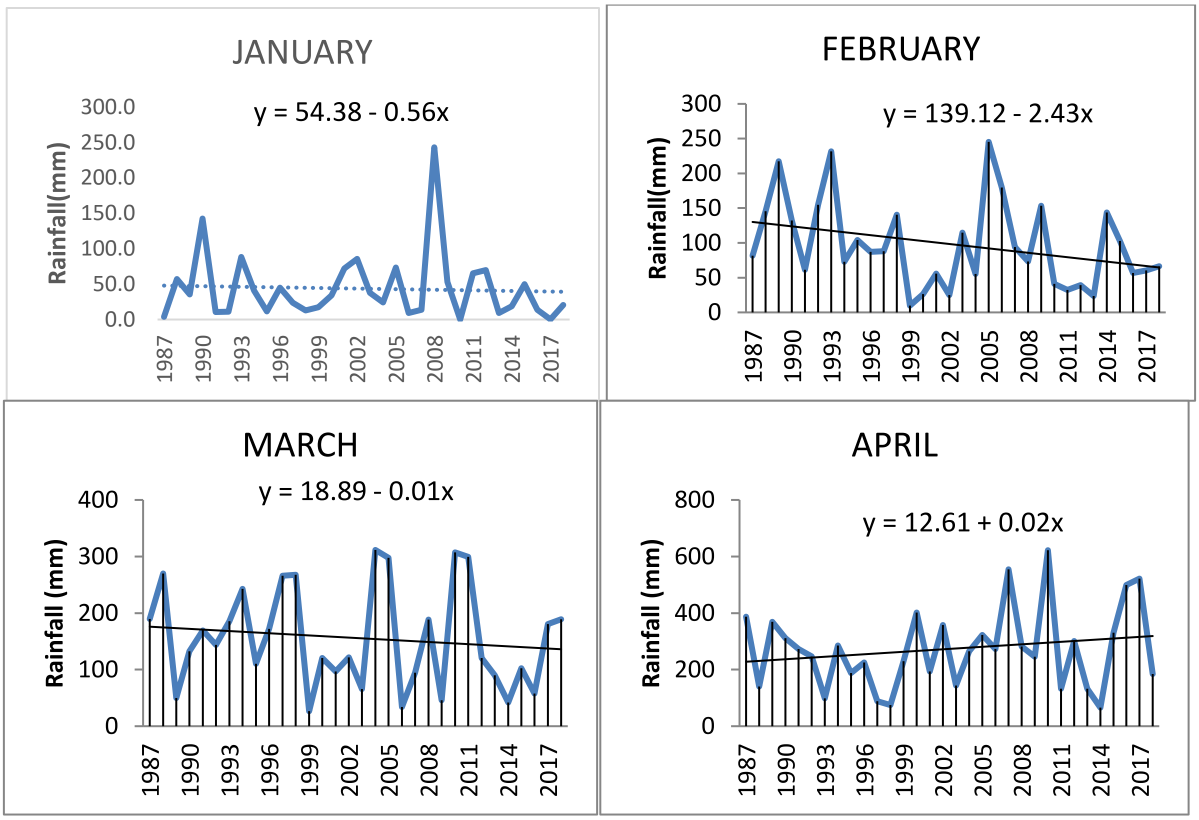
### 3.1 RAINFALL PATTERN IN EAST SIANG DISTRICT DURING 1987 -2018

**Table 1. Monthly rainfall in East Siang during 1987- 2018**

| S. No. | Months | Normal rainfall (mm) | Percentage Contribution | Extreme value (total monthly) (mm) | | CV (%) | Trend coefficient |
|---|---|---|---|---|---|---|---|
| | | | | Minimum | Maximum | | |
| 1. | January | 43.51 | 1.00 | 0.0 | 243.0 | 111.46 | -0.56 |
| 2. | February | 97.36 | 2.23 | 9.7 | 245.3 | 63.97 | -2.43 |
| 3. | March | 155.99 | 3.58 | 26.5 | 311.6 | 56.99 | -0.01 |
| 4. | April | 273.33 | 6.27 | 65.5 | 622.2 | 51.57 | 0.02 |
| 5. | May | 406.07 | 9.32 | 77.4 | 1128.1 | 57.65 | -0.01 |
| 6. | June | 748.53 | 17.17 | 301.2 | 1559.2 | 38.28 | -3.31 |
| 7. | July | 1068.29 | 24.51 | 301.1 | 2261.3 | 43.44 | -10.95 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8. | August | 703.20 | 16.13 | 152.0 | 2363.0 | 67.47 | -8.41 |
| 9. | September | 599.46 | 13.75 | 232.9 | 1549.6 | 45.33 | 0.00 |
| 10. | October | 211.41 | 4.85 | 11.7 | 1166.5 | 101.61 | -0.01 |
| 11. | November | 34.09 | 0.78 | 0.0 | 158.1 | 133.25 | 0.05 |
| 12. | December | 17.49 | 0.40 | 0.0 | 72.8 | 108.12 | -0.02 |

The months of January, November and December received a minimum rainfall of zero during the study period while there was a maximum rainfall of 2363 mm in the month of August followed by July with 2261.30 mm rainfall during the study period. The inter year variation was very high for all the months ranging from 38.00 per cent to 133.00 per cent. The maximum variation was observed during the month of November (133.25 per cent) (Table 1).



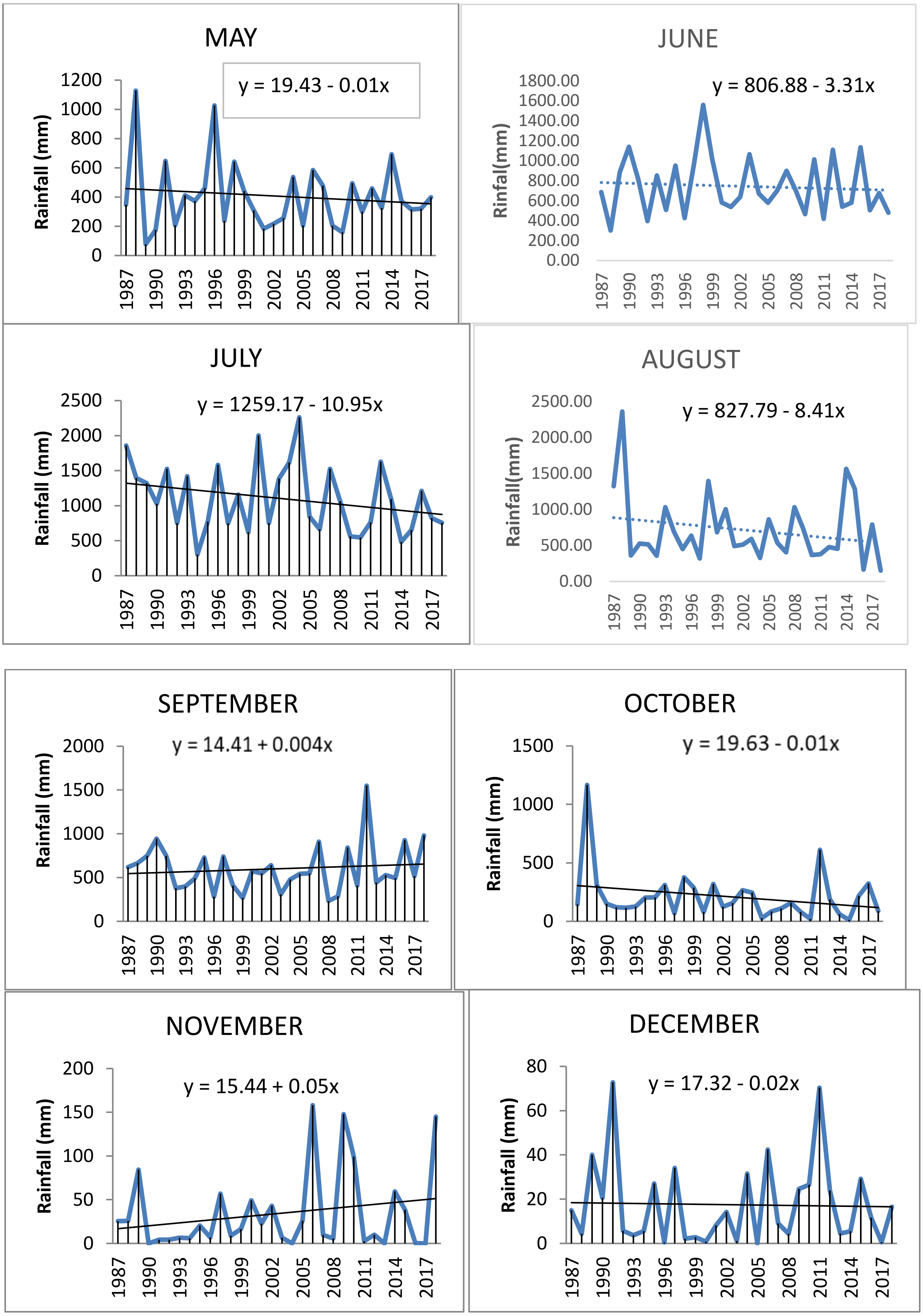



**Figure 1. The monthly rainfall trends in East Siang during 1987 to 2018**

The study showed that the monthly rainfall in the district of East Siang exhibited a decreasing trend for all the months except April and November wherein the rainfall showed an increasing trend through the study period.

**Table 2. Seasonal and annual rainfall pattern in East Siang during 1987-2018**

| Month | Normal rainfall (mm) | Percentage contribution | Extreme values (mm) | | CV (%) |
|---|---|---|---|---|---|
| | | | Minimum | Maximum | |
| Pre monsoon | 296.86 | 6.78 | 53.40 | 616.60 | 40.83 |
| Monsoon | 3817.28 | 87.21 | 2335.90 | 5992.90 | 23.69 |
| Post monsoon | 262.99 | 6.01 | 79.40 | 1196.70 | 77.37 |
| Annual | 4377.13 | - | 2771.90 | 7662.00 | 23.78 |

The district if East Siang received a normal annual rainfall of 4377.13 mm during the study period. Normal rainfall of 296.90 mm was received during the pre-monsoon period, 3817.28 mm during the monsoon and 262.99 mm during the post monsoon periods. Minimum rainfall of 53.40 mm was received during the pre-monsoon months and maximum rainfall of 5992.90 mm was received during the monsoon months. The rainfall pattern of East Siang exhibited a high annual as well as seasonal variation wherein the maximum variation was observed in the monsoon period.

**Table 3. Seasonal and annual rainfall pattern in East Siang during 1987-2002 and 2002-2018**

| TIME PERIOD | Month | Normal rainfall (mm) | Percentage contribution | Extreme values (mm) | | CV (%) |
|---|---|---|---|---|---|---|
| | | | | Minimum | Maximum | |
| 1987-2002 | Pre monsoon (1987-2002) | 305.61 | 6.73 | 53.40 | 505.70 | 36.76 |
| | Monsoon (1987-2002) | 3938.01 | 86.73 | 2335.90 | 5992.90 | 24.91 |
| | Post monsoon (1987-2002) | 296.92 | 6.54 | 126.00 | 1196.70 | 84.30 |
| | Annual rainfall (1987-2002) | 4540.54 | - | 2771.90 | 7662.00 | 25.96 |
| 2003-2018 | Pre monsoon (2003-2018) | 288.11 | 6.84 | 122.60 | 616.60 | 44.72 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Monsoon (2003-2018) | 3696.55 | 87.73 | 2403.80 | 5529.20 | 21.71 |
| | Post monsoon (2003-2018) | 229.06 | 5.44 | 79.40 | 645.50 | 58.35 |
| | Annual rainfall (2003-2018) | 4213.73 | - | 2893.50 | 6404.30 | 20.19 |

In order to better understand the variation as well as trends, the study period was further divided into two time periods of sixteen years each. The district received a minimum rainfall of 53.40 mm in the pre monsoon months and a maximum rainfall of 5992.90 mm during the monsoon season for the time period of 1987 to 2002. In the time period 2002 to 2018, however, the minimum rain was received in the post monsoon season with 79.40 mm and a maximum amount was received during the monsoon months. The annual variation in both the time periods range from 20.00 to 26.00 per cent. Although the variation is quiet high for all the seasons in both the time periods, maximum variation of 84.30 per cent and 58.35 per cent was observed in the post monsoon months in both the time periods.

It can here be observed that the variability in the rainfall pattern happened more exponentially during the early half of the study period.

**Table 4. Linear trends for pre monsoon, monsoon, post monsoon and annual rainfall in East Siang during 1987-2018**

| Particulars | Trend value | p-value |
|---|---|---|
| Time period 1987-2018 | | |
| Pre monsoon | -11.06 | 0.078 |
| Monsoon | -24.61 | 0.165 |
| Post monsoon | -5.01 | 0.211 |
| Annual | -33.30 | 0.101 |

It was observed that the annual seasonal rainfall shows significant decreasing linear trend for all the three seasons.

**Table 5. Linear trends for pre monsoon, monsoon, post monsoon and annual rainfall in East Siang during 1987-2018**

| Particulars | Trend value |
|---|---|
| Time period 1987-2002 | |
| Pre monsoon | -11.06 |
| Monsoon | -82.19 |

| | |
|---|---|
| Post monsoon | -16.39 |
| Annual | -109.64 |
| Time period 2003-2018 | |
| Pre monsoon | -11.87 |
| Monsoon | -24.36 |
| Post monsoon | 1.74 |
| Annual | -34.49 |

When distributed into two time periods viz., 1987-2002 and 2002-2018, in an attempt to better understand the changes, the seasonal rainfall exhibited erratic trend with significantly decreasing trend for all the seasons during the years 1987 to 2002, along with pre monsoon and monsoon seasons of the time period 2002 to 2018. However, rainfall in the post monsoon months of 2002 to 2018 showed a significant increasing linear trend hence, the overall observation proved to be erratic.The overall study of the rainfall pattern of East Siang shows that although there was no significant change in the overall amount of annual and seasonal rainfall throughout the study period, the monthly and seasonal trends exhibited erratic behaviour. It can thus be said the study area observed a change in the timing and distribution of rainfall throughout the study period with rather insignificant change in the volume of rainfall received throughout the years.

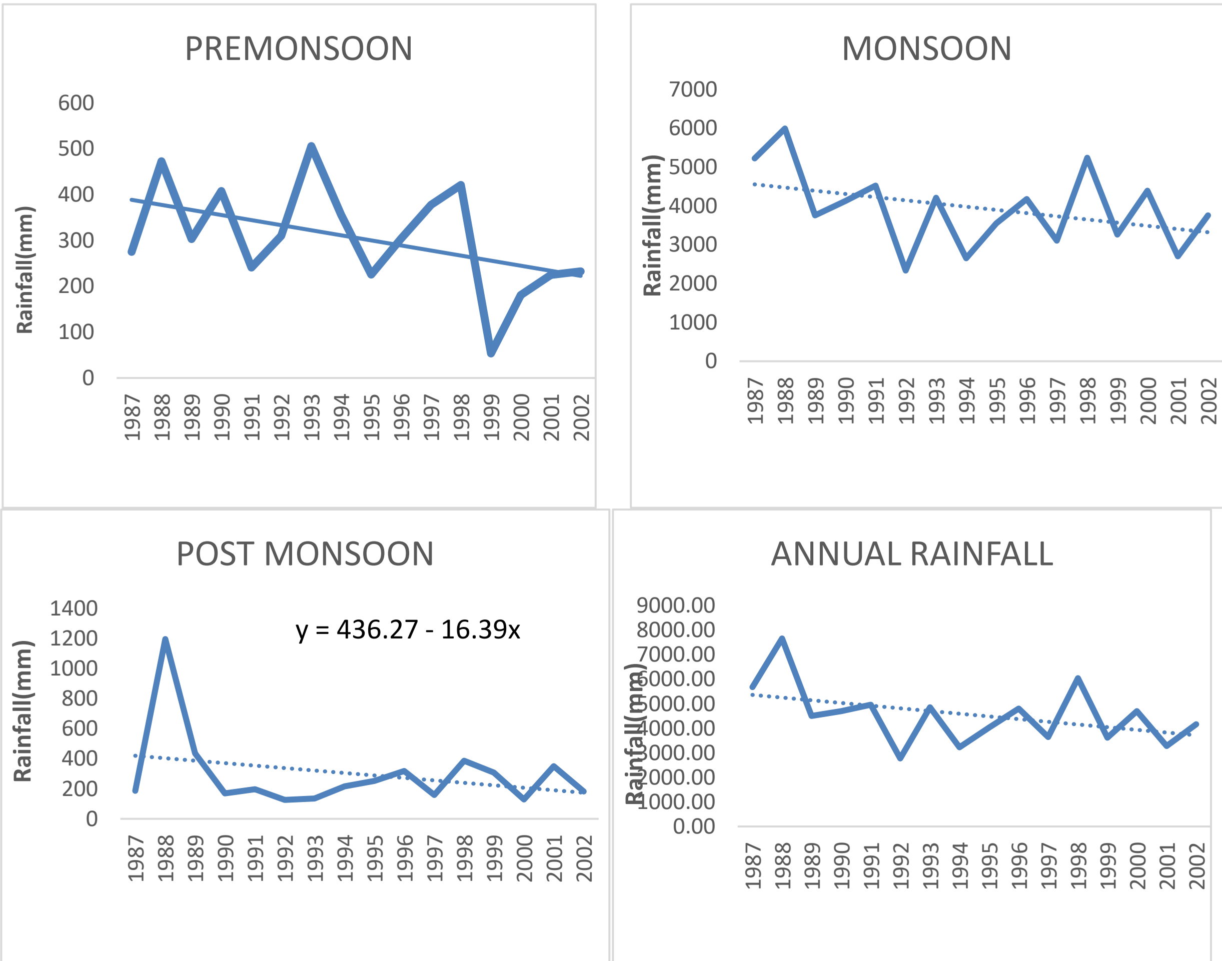



**Figure 2. Linear trend graph for seasonal and annual rainfall pattern for East Siang from 1987 to 2002**

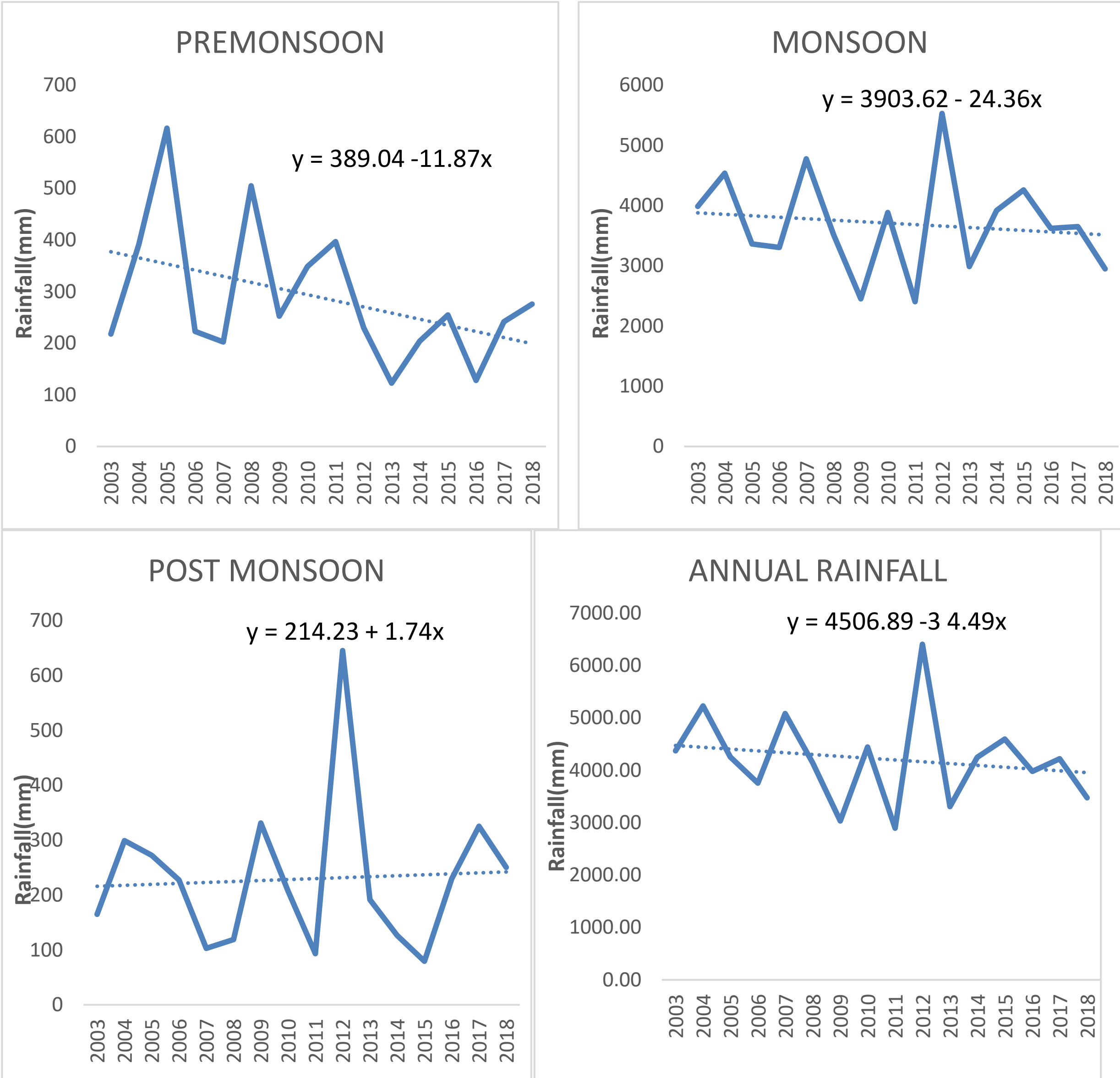



**Figure 3. Linear trend graph for seasonal and annual rainfall pattern for East Siang from 2003-2018**

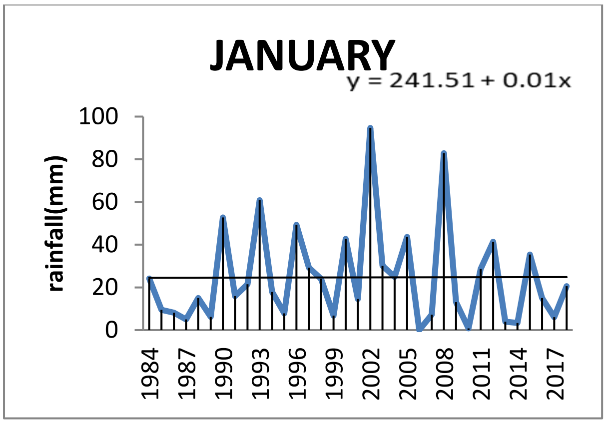
## 3.2.RAINFALL PATTERN IN LOHIT DISTRICT DURING 1987 -2018

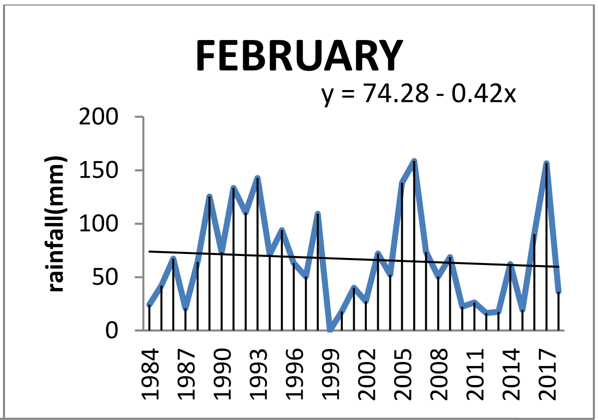
**Table 6. Monthly rainfall pattern in Lohit district during 1987-2018**

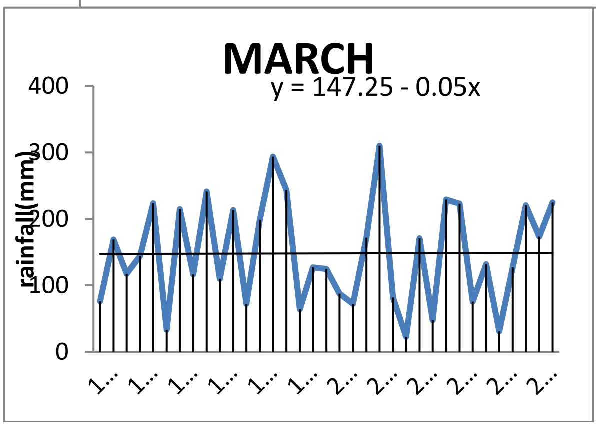
| Month | Normal rainfall (mm) | Percentage Contribution | Extreme value (total monthly) (mm) | | CV (%) | Trend coefficient |
|---|---|---|---|---|---|---|
| | | | Minimum | Maximum | | |
| January | 24.67 | 1.05 | 0.00 | 94.70 | 91.33 | 0.01 |
| February | 66.75 | 2.84 | 0.00 | 158.60 | 66.26 | -0.42 |
| March | 148.09 | 6.30 | 22.60 | 310.10 | 52.10 | 0.05 |
| April | 269.41 | 11.45 | 52.70 | 786.70 | 58.69 | 1.46 |
| May | 267.49 | 11.37 | 73.20 | 689.40 | 56.31 | 1.44 |
| June | 349.76 | 14.87 | 145.10 | 673.70 | 33.12 | 0.40 |
| July | 451.81 | 19.21 | 221.60 | 785.10 | 28.44 | -4.28 |
| August | 327.25 | 13.91 | 122.30 | 692.30 | 38.36 | -2.02 |
| September | 285.29 | 12.13 | 109.20 | 601.20 | 41.99 | 0.23 |
| October | 126.43 | 5.37 | 19.90 | 303.90 | 54.67 | -0.09 |
| November | 18.67 | 0.79 | 0.00 | 56.30 | 93.21 | -0.28 |

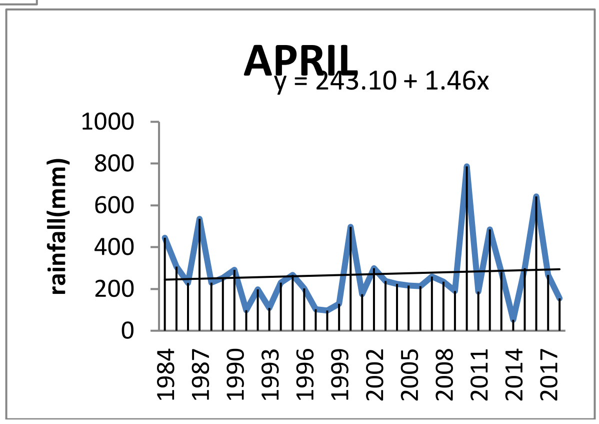
| | | | | | | |
|---|---|---|---|---|---|---|
| December | 16.89 | 0.72 | 0.00 | 61.70 | 108.49 | -0.47 |

During the study of the monthly rainfall pattern in Lohit district, the study area showed to have received a minimum rainfall of 0 mm during the months of January, February, November and December. Maximum rainfall was received in the month of April i.e. 786.70 mm followed by July with 785.10 mm rainfall. The rainfall exhibits high inter year variation for all the months. The variation during the period of paddy cultivation, i.e. monsoon and post monsoon months range from 28.00 per cent to 108.5 percent (Table 6)



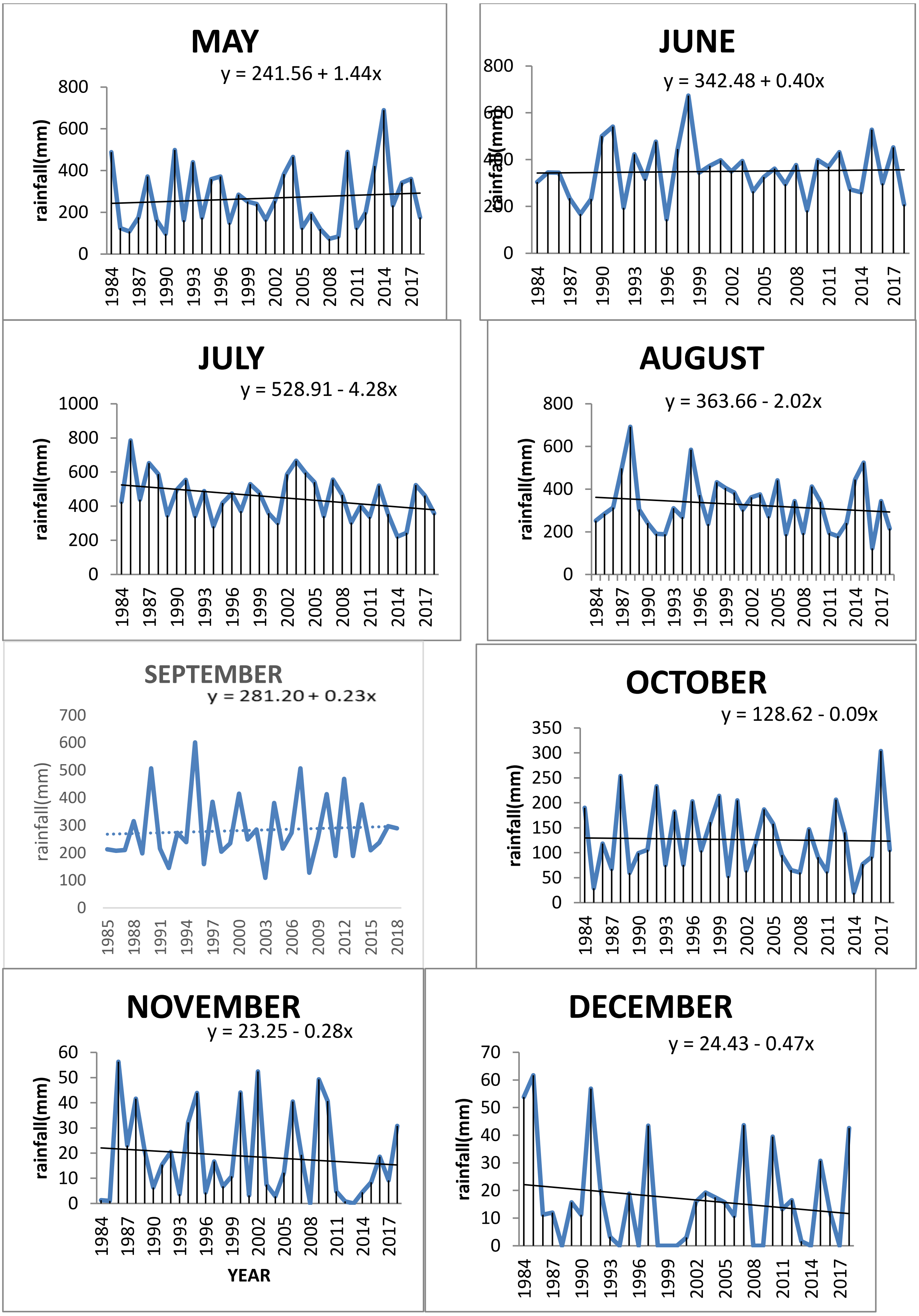



**Figure 4. Monthly rainfall pattern in Lohit district during 1984-2018**

**Table 7. Seasonal rainfall pattern in Lohit district from 1987 to 2018**

| Season | Normal rainfall (mm) | Percentage contribution | Extreme values (mm) | | CV (%) |
|---|---|---|---|---|---|
| | | | Minimum | Maximum | |
| Pre monsoon | 232.48 | 9.92 | 70.80 | 491.90 | 41.34 |
| Monsoon | 1954.34 | 83.41 | 1229.80 | 2831.10 | 19.36 |
| Post monsoon | 157.97 | 6.74 | 24.30 | 295.20 | 39.33 |
| Annual | 2343.07 | - | 1573.40 | 3254.70 | 17.36 |

Lohit district received an annual rainfall of 2343.07 mm during 1987 to 2018. The region received the minimum seasonal rainfall of 24.30 mm during the post monsoon season of the study period and the highest seasonal rainfall of 2831.10 mm during the monsoon season. The the area showed high variability in the seasonal rainfall ranging from 19.36 per cent in the monsoon period to 41.34 per cent in the pre monsoon season. The district received an average minimum seasonal rainfall of 157.97 mm during the post monsoon months and the highest average rainfall of 1954 mm during the monsoon months (Table 7).

**Table 8. Seasonal and annual rainfall pattern in Lohit during 1987-2018**

| TIME PERIOD | Season | Normal rainfall (mm) | Percentage contribution | Extreme values (mm) | | CV (%) |
|---|---|---|---|---|---|---|
| | | | | Minimum | Maximum | |
| 1987-2002 | Pre monsoon (1987-2002) | 254.73 | 10.67 | 70.80 | 376.60 | 36.63 |
| | Monsoon (1987-2002) | 1961.80 | 82.20 | 1229.80 | 2706.00 | 19.30 |
| | Post monsoon (1987-2002) | 174.13 | 7.30 | 82.50 | 295.20 | 37.00 |
| | Annual rainfall (1987-2002) | 2386.76 | - | 1757.40 | 3018.60 | 15.08 |
| 2003-2018 | Pre monsoon (2003-2018) | 210.24 | 9.14 | 96.40 | 491.90 | 44.55 |
| | Monsoon (2003-2018) | 1946.88 | 84.67 | 1403.20 | 2831.10 | 19.42 |
| | Post monsoon (2003-2018) | 141.80 | 6.17 | 24.30 | 223.80 | 38.92 |
| | Annual rainfall (2003-2018) | 2299.37 | - | 1573.40 | 3254.70 | 19.33 |

To better understand the variation as well as seasonal trends, the study period was further divided into two time periods of sixteen years each. It was thus observed that the district received a minimum rainfall of 70.80 mm in the pre monsoon months and a maximum rainfall of 2706.00 mm during the monsoon season for the time period of 1987 to 2002. In the time period 2003 to 2018, however, the minimum rain of 6.17 mm was received in the post monsoon season with maximum amount of 2831.10 mm received during the monsoon months. The annual variation in both the time periods range from 15.00 to 20.00 per cent. The variability was found higher in the post monsoon season for the time period 1987-2002 and pre-monsoon period for the time period 2003-2018 (Table 8).

**Table 9. Linear trends for pre monsoon, monsoon, post monsoon and annual rainfall in Lohit district during 1987-2018**

| Particulars | Trend value | p-value |
|---|---|---|
| 1987-2018 | | |
| Pre monsoon | -1.90 | 0.317 |
| Monsoon | -2.68 | 0.722 |
| Post monsoon | -1.75 | 0.150 |
| Annual | -6.29 | 0.435 |

The study showed that the annual seasonal rainfall exhibited a significant decreasing linear trend for all the three seasons during the study period (Table 9).

**Table 10. Linear trends for pre monsoon, monsoon, post monsoon seasons and annual rainfall in Lohit during 1987-2018**

| Particulars | Trend value | p-value |
|---|---|---|
| 1987-2002 | | |
| Pre monsoon | 6.32 | 0.239 |
| Monsoon | -12.29 | 0.580 |
| Post monsoon | 1.32 | 0.727 |
| Annual | -8.69 | 0.682 |
| 2003-2018 | | |
| Pre monsoon | -4.83 | 0.376 |
| Monsoon | -3.59 | 0.872 |
| Post monsoon | -3.22 | 0.313 |
| Annual | -8.91 | 0.733 |

Further distribution of the study period into two time periods viz., 1987-2002 and 2002-2018, showed that the seasonal rainfall exhibited erratic trend with significantly decreasing trend for all the seasons during the time period 2003-2018, and monsoon seasons during the time period 1987-2002. The study however, showed that the rainfall in the pre and post monsoon months of 1987 to 2002 showed a significant increasing linear trend. This observation thus brings us to the understanding that the seasonal rainfall during the study period exhibited an erratic behaviour. The study on the rainfall pattern in the Lohit district during 1987-2018 shows no significant change in the volume of annual rainfall throughout the study period. However the change observed is in the distribution pattern as well as the timing of the rainfall received by the place.

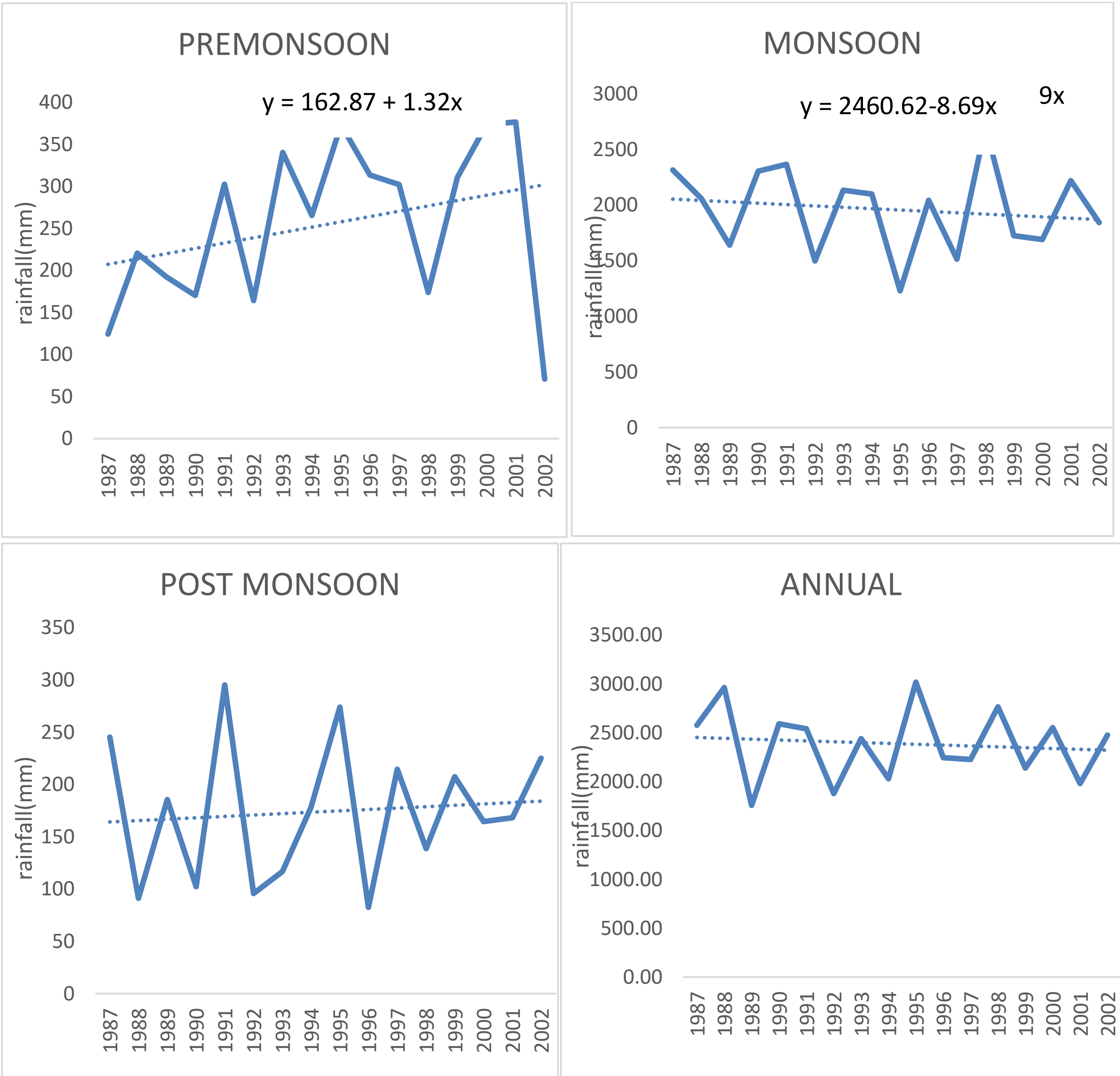



**Figure 5. Linear trend graph for seasonal and annual rainfall pattern for Lohit district from 1987-2002**

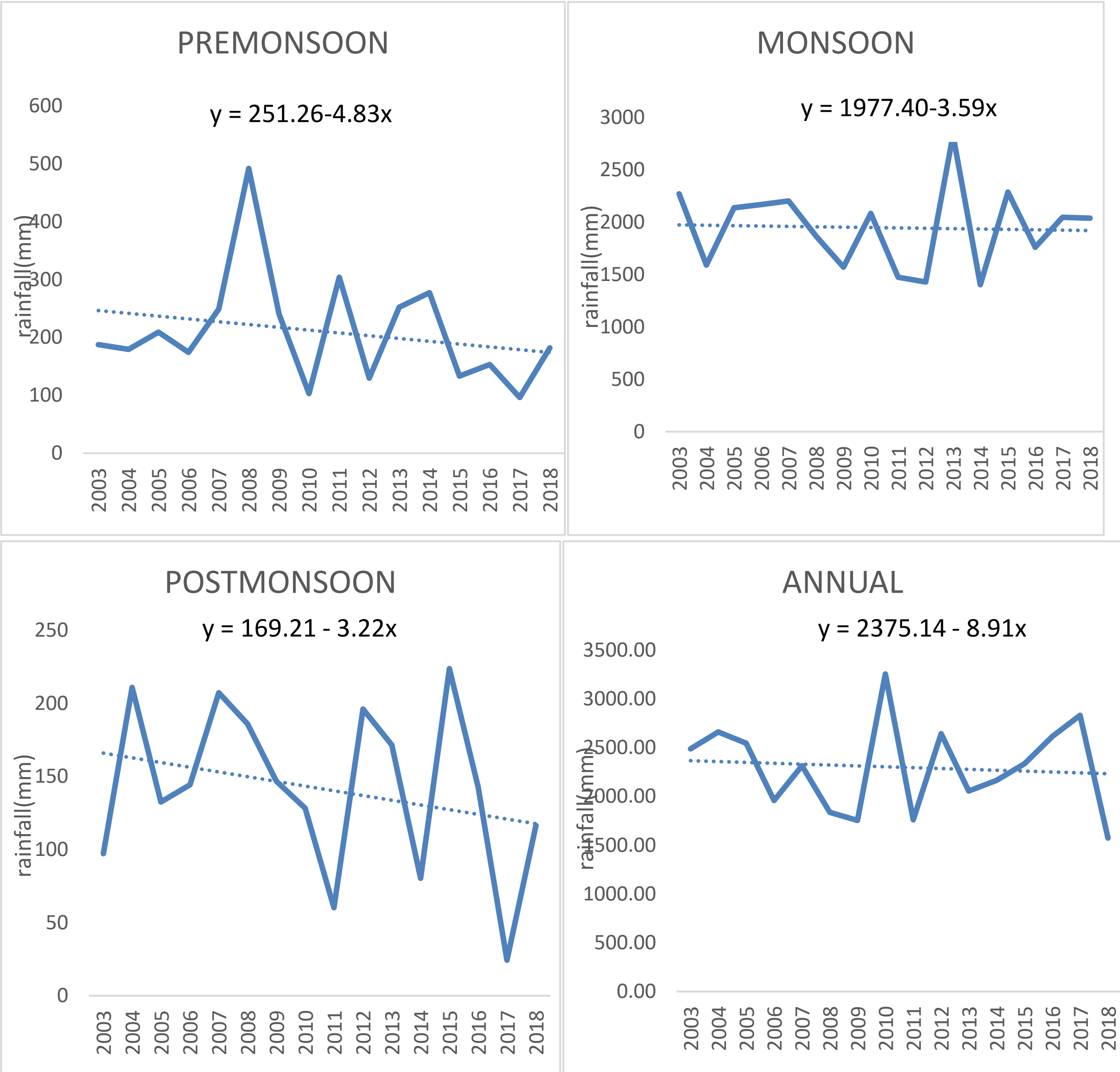



**Figure 6. Linear trend graph for seasonal and annual rainfall pattern for Lohit district from 2003-2018**

### 3.3. Effect of climate change in the production and productivity of rice.

**Table 11. Productivity of rice and total annual rainfall in East Siang during 1987-2018**

| YEAR | YIELD (Kg/Ha) | TOTAL ANNUAL RAINFALL (mm) |
|---|---|---|
| 1987 | 1475.5 | 5684 |
| 1988 | 1200.5 | 7662.8 |
| 1989 | 1462.5 | 4498.8 |
| 1990 | 1469.75 | 4700.8 |
| 1991 | 1470 | 4961.2 |

| | | |
|---|---|---|
| 1992 | 1350.5 | 2771.9 |
| 1993 | 1472.25 | 4853.2 |
| 1994 | 1400.25 | 3220.6 |
| 1995 | 1445.23 | 4008.8 |
| 1996 | 1470.5 | 4798.1 |
| 1997 | 1427.25 | 3615 |
| 1998 | 1289.75 | 6049.1 |
| 1999 | 1428.25 | 3619.2 |
| 2000 | 1099.5 | 1596.1 |
| 2001 | 1444.75 | 3280.5 |
| 2002 | 1451.3 | 4168.5 |
| 2003 | 1453.42 | 4369.6 |
| 2004 | 1399.23 | 5229.3 |
| 2005 | 1452 | 4251.9 |
| 2006 | 1431.32 | 3756 |
| 2007 | 1472 | 5079.7 |
| 2008 | 1449.27 | 4140.9 |
| 2009 | 1100.53 | 1753.9 |
| 2010 | 1454.34 | 4441.3 |
| 2011 | 1256.25 | 2893.5 |
| 2012 | 1290.56 | 6404.3 |
| 2013 | 1421.67 | 3303.4 |
| 2014 | 1450.65 | 4248.3 |
| 2015 | 1468.54 | 4596.3 |
| 2016 | 1242.5 | 2613.8 |
| 2017 | 1254.76 | 2832 |
| 2018 | 1099.74 | 1573.4 |

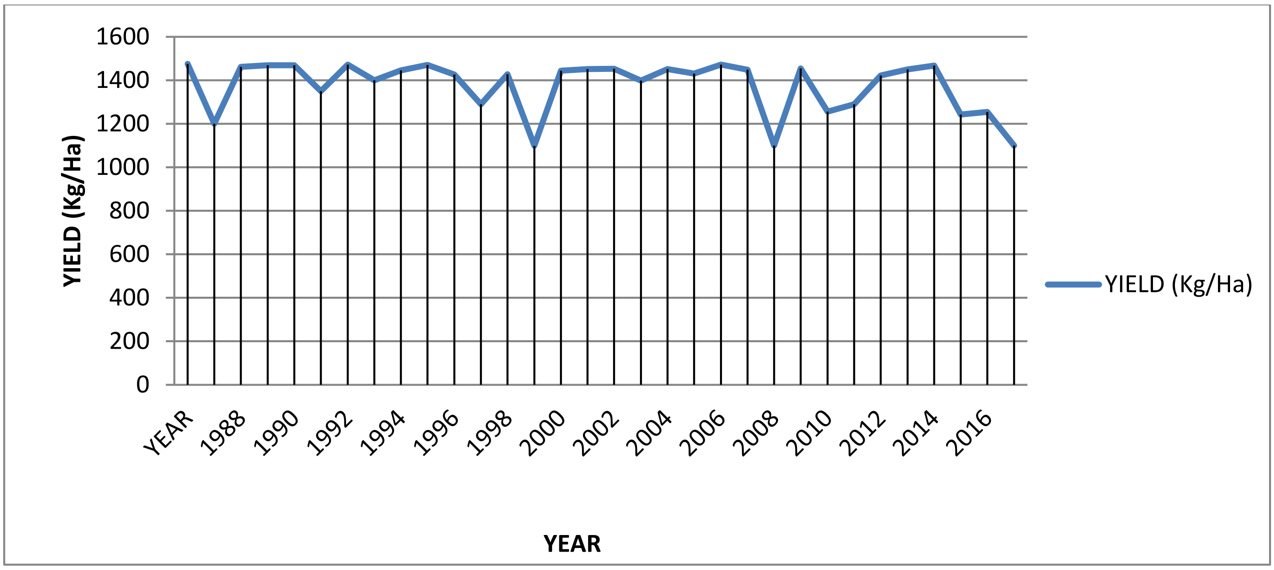



**Figure 7. Productivity of rice in East Siang during 1987-2018**

The study showed that the productivity of rice faced fluctuations of varying degrees during the study period. It was also observed that the productivity exhibited a slight decrease through by the end if the study period.

**Table 12. Regression analysis for yield of rice as a function of temperature and amount of rainfall**

**Yield=*f (temperature (max, min), rainfall)***

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.733418 |
| R Square | 0.537902 |
| Adjusted R Square | 0.445482 |
| Standard Error | 101.5565 |
| Observations | 19 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 3 | 180084.1 | 60028.03 | 5.820208 | 0.007624 |
| Residual | 15 | 154705.9 | 10313.73 | | |

| | | |
|---|---|---|
| Total | 18 | 334790 |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 1703.747 | 931.2324 | 1.829562 | 0.087261 | -281.127 | 3688.622 | -281.127 | 3688.622 |
| RAINFALL | 0.073507 | 0.019023 | 3.864158 | **0.001529** | 0.032961 | 0.114053 | 0.032961 | 0.114053 |
| TEMP (MAX) | -16.7252 | 24.51894 | -0.68213 | 0.505553 | -68.9861 | 35.53572 | -68.9861 | 35.53572 |
| TEMP (MIN) | -1.23937 | 11.61175 | -0.10673 | 0.916415 | -25.9892 | 23.51048 | -25.9892 | 23.51048 |

A regression analysis of yield of rice as a function of total annual rainfall and maximum and minimum temperature showed that rainfall does have an impact on the crop yield. i.e. the relationship between yield of rice and total annual rainfall is significant whereas the relationship between yield and maximum and minimum temperature is not significant.

### 3.4. Effect of climate change in the production and productivity of maize

**Table 13. Productivity of maize and total annual rainfall in Lohit district during 1987-2018**

| YEAR | YIELD (Kg/Ha) | TOTAL ANNUAL RAINFALL (mm) |
|---|---|---|
| 1987 | 1613 | 2578.6 |
| 1988 | 1605.34 | 2964.1 |
| 1989 | 1548.32 | 1757.4 |
| 1990 | 1594.07 | 2592.4 |
| 1991 | 1591.76 | 2541.9 |
| 1992 | 1549.89 | 1877.1 |
| 1993 | 1592.76 | 2439.9 |
| 1994 | 1556.78 | 2030.3 |
| 1995 | 1420.25 | 3018.6 |
| 1996 | 1568.45 | 2244.5 |
| 1997 | 1564.43 | 2228.3 |
| 1998 | 1595.99 | 2765.2 |

| | | |
|---|---|---|
| 1999 | 1560 | 2137.8 |
| 2000 | 1592.65 | 2554.2 |
| 2001 | 1554.87 | 1979.7 |
| 2002 | 1595.76 | 2478.2 |
| 2003 | 1595.99 | 2486.3 |
| 2004 | 1596.37 | 2659.4 |
| 2005 | 1590.65 | 2544.1 |
| 2006 | 1489.76 | 1958.7 |
| 2007 | 1496.43 | 2314.2 |
| 2008 | 1476.84 | 1837.6 |
| 2009 | 1468.34 | 1753.9 |
| 2010 | 1360.85 | 3254.7 |
| 2011 | 1470.65 | 1761.1 |
| 2012 | 1546.56 | 2643.4 |
| 2013 | 1503.67 | 2055.2 |
| 2014 | 1509.87 | 2166.2 |
| 2015 | 1511.23 | 2335.9 |
| 2016 | 1476.56 | 2613.8 |
| 2017 | 1452.99 | 2832 |
| 2018 | 1433.5 | 1530.8 |

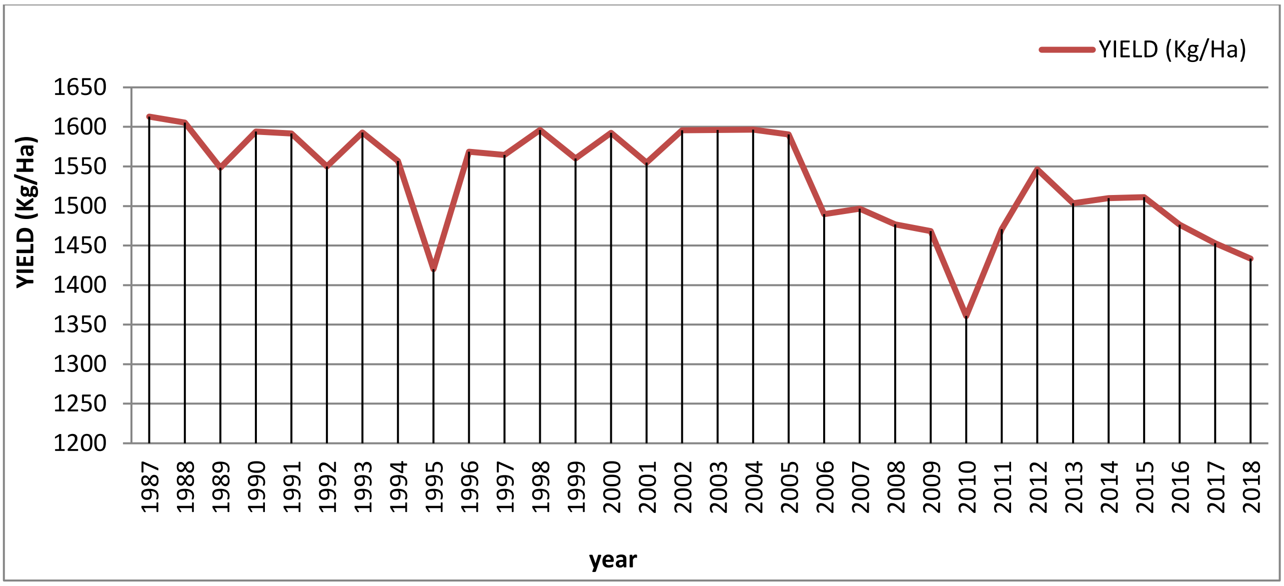



**Figure 8. Productivity of maize in Lohit district during 1987-2018**

The study showed that the annual productivity of maize exhibited a steep decline throughout the study period.

**Table 14. Regression analysis for yield of maize as a function of total annual rainfall**

**Yield=*f (rainfall)***

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.085069 |
| R Square | 0.007237 |
| Adjusted R Square | -0.02586 |
| Standard Error | 65.07992 |
| Observations | 32 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 926.2084 | 926.2084 | 0.218683 | 0.643425 |
| Residual | 30 | 127061.9 | 4235.397 | | |
| Total | 31 | 127988.1 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 1503.119 | 66.80611 | 22.49972 | 2.44E-20 | 1366.683 | 1639.555 | 1366.683 | 1639.555 |
| X Variable 1 | 0.013142 | 0.028102 | 0.467635 | 0.643425 | -0.04425 | 0.070534 | -0.04425 | 0.070534 |

A regression analysis for yield of maize as a function of total annual rainfall showed no significant relationship between the parameters.

## 4. CONCLUSION

It was observed through the study that the total annual rainfall for both East Siang and Lohit districts decreases throughout the study period.The monthly rainfall for East Siang exhibited a decreasing linear trend for all months except for the months of April which showed an increasing trend and the month of September which showed a trend coefficient of zero. The monthly variability was also found to be very high. East Siang received a minimum monthly rainfall of 0mm during the months of January, November and December. It received maximum rainfall during the months of July and August**.** Annual seasonal rainfall of East Siang exhibited erratic rainfall pattern with both increasing as well as decreasing seasonal trends. The maximum annual seasonal rainfall was received during the monsoon months of April to September. Lohit district received a minimum monthly rainfall of 0 mm in the months of January, February, November and December. The highest rainfall was obtained in the months of April and July. The monthly variation was observed to be very high and the monthly rainfall was observed to be erratic with both increasing and decreasing linear trends. The study area received the minimum seasonal rainfall during the post monsoon months and the highest in the monsoon months. It could thus be concluded that although the change in the total annual rainfall in the study area was rather insignificant, the distribution of rainwater exhibited an erratic monthly and seasonal trend throughout the observation period. It thus brings us to an understanding that the study area is witnessing climate change in the form of unpredictable and untimely distribution of the rainfall throughout the seasons rather than an increase or decrease in the volume of total annual rainfall. The productivity of bothrice and maize crops were observed to have fluctuations throughout the study period and exhibited a decreasing trend. It was found that total annual rainfall had an effect on the productivity of rice but not on that of maize in the study area. The relationship between temperature and productivity of rice was also found to be insignificant.

## REFERENCES

Arndt, Channing., Farmer, William., Strzepek ,Kenneth. and Thurlow, James. 2012. Climate Change, Agriculture and Food Security in Tanzania. Policy research working paper:no.6188. World Bank, Washington DC. https://doi.org/10.1596/1813-9450-6188

Mahato, Anupama., 2014. International Journal of Scientific and Research Publicationswww.ijsrp.org Climate Change and its Impact on Agriculture Junior Research Fellow, Guru GhasidasVishwavidyalaya, Koni, C.G , India, , Volume 4, Issue 4, 1 ISSN 2250-3153.

Adams, Richard, M., Hurd, Brian H., Lenhart, Stephanie., and Leary, Neil. 1998. Effects of global climate change on agriculture: an interpretative review. Leary31Department of Agricultural and Resource Economics, Oregon State University, Corvallis, Oregon 97331 Vol. 11: 19–30.

Hansen.J.W., 2002. Realizing the potential benefits of climate prediction to agriculture: issues,approaches, challenges. Agric. Syst. 74, 309– 330.

Berg. A., Noblet-Ducoudré. N. de., Sultan.B., Lengaigne. M., Guimberteau. M. 2013. Projections of climate change impacts on potential C4 crop productivity over tropical regions, Agricultural and Forest Meteorology 170, 89–102

USDA United States Department of Agriculture, 2015. Brown. M.E., Antle. J.M., Backlund. P., Carr. E.R., Easterling. W.E., Walsh. M.K., Ammann. C., Attavanich. W., Barrett. C.B., Bellemare. M.F., Dancheck. V., Funk. C., Grace. K., Ingram. J.S.I., Jiang. H., Maletta. H., Mata. T., Murray. A., Ngugi. M., Ojima. D., O'Neill. B., and Tebaldi. C. 2015. Climate Change, Global Food Security, and the U.S. Food System. 146.

Stern. N., 2006. The Economics of Climate Change: The Stern Review. Cambridge, UK Cambridge University Press.