Climate Change And Its Impact On Wheat Grain Development Period And Yield In The United Kingdom From 1982-2011.

Abdulmalik Sada Maiwada

Abstract: A consensus among the global scientists essentially expanded as the changes in climate developed and these sharp changes are expected to happen when the earth's system is stretched across thresholds. Climate change is one of the global most imperative themes in our own time because of its consequences waiting for the upcoming generation. This paper aimed at assessing the impacts of climate change on the wheat production in the United Kingdom during the two development stages (Grain filling and Grain ripening) over the 30 years period from 1982-2011. A gridded meteorological data from UKCP09 was used to get the mean for the wheat development period that is most sensible to climate (June to September). This was correlated with the UK wheat yield data retrieved from the department for environment, food and rural affairs (DEFRA) using Microsoft excel and R statistical software. The results revealed a highest increase in temperature than rainfall during the wheat development period and that temperature is having more impact on wheat yield in the UK than rainfall. It is also found out that climate change is only but a factor among other factors that influenced the wheat yield in the UK for the past decades. Other factors such as genetic improvement, better changes in cultivating practice, better management of pests and diseases and high application of NPK fertilizers could have more effect on the UK's wheat yield for as far back as decades than only a change in climate.

Keywords: Climate change, Development, Impacts, United Kingdom, Wheat Grain, Yield.

1 Introduction

Climate change is one of the global most imperative themes in our own time because of its consequences and difficulties waiting for the upcoming generation. The IPCC report (2007a) uncovered that, it is detected that the density of the greenhouse gases (GHG) in the global atmosphere had an increase of about 70% in the period between 1970 and 2004. This affected the world's energy equilibrium in many diverse ways, which implications further prompted the greenhouse gases impacts in the local environment, regional and the global climate system as a whole (IPCC, 2013). A consensus among the global scientists essentially expanded as the climate change developed and sharp changes are expected to happen when the earth's system is stretched across thresholds (Alley, 2003). Numerous changes have happened in the global climate system throughout the most recent century as uncovered in the fifth Assessment report (AR5) of the IPCC, the cold days and night numbers diminished while the warm days and nights expanded comprehensively since 1950 and ocean level, ice volume and sea temperature changes are likewise observed globally (IPCC, 2013). Global environment changes mostly due to the increase in the density of the harmful greenhouse gasses in the atmosphere influences almost all parts of the earth's framework (Arnell and Reynard, 1996). Mendelsohn and Dinar (2009), according to their research stated that, there is sufficient scientific proof to propose that agricultural sector standout amongst other sectors as the most susceptible and vulnerable to climatic variability and changes. They proposed that there is an ideal climatic optimum base on Temperature and precipitation with which plants and animal achieve their highest growth and productivity.

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In the greater parts of the developed and developing nations, agricultural sector still remains solely reliant to environmental related assets particularly climate (Schmidhuber and Tubiello, 2007). Climate is an essential determinant of agricultural benefit and any unfavourable changes in it would likely have a drastic impacts in this facet, usually leading to failure in crop harvest and correspondingly influencing the livelihoods of most of the populace that rely on rain fed agricultural practices for their sustenance (Calzadilla et al., 2013). The past evaluations of the impacts of environmental change involve drastic changes in precipitation, temperature, humidity and other intense events (McMichael et al., 2007). In the 1990s, the first used models foretold that under environmental changes many people involved in agriculture would gain while some would lose (Rosenzweig and Parry, 1994) and later forms of these studies demonstrates that this disparity will most likely be intensified (Fischer et al., 2005). Even though, Garcia et al., (1998) and Malla, (2008) evaluated that increasing atmospheric temperature due to carbon dioxide emission can be productive to plants and crop production in light of the fact that it strengthens the procedure of photosynthesis. C3 plants like rice, wheat, pulses and oilseed react to raised level of CO_2 concentration since it lessen the oxygenase action of Ribulose-1, 5-bisphosphate corboxilase oxygenase compounds (Rubisco) in plants. However, with time this postures high likelihood of decrease in yield because of high temperature effects increasing the rate of transpiration, high evaporation from the soil which will lead to high concentration chemicals in the soil used as fertilizers, increment in pest events and desertification (Kimball et al., 2001). A change in precipitation pattern likewise has a noteworthy impact on crop production and productivity (IWMI, 2010). Changes in precipitation pattern due to the influence of the changes in climate could pose potential oblige for agricultural production and crop yield (Alam et al, 2011). In general, Lema and Majule, (2009) evaluated that in semi-arid regions higher precipitation favours increasing agricultural production and crop yield, whereas less precipitation limits production and yield. However, in high precipitation regions, more precipitation can likewise build soil water logging which influence seed germination and also lessened yield. In the United Kingdom, Wheat is a winter crop frequently planted to gather grains for human utilization and its expanded interest propose that wheat farmers' worldwide need to improve their mode of farming practices in order to achieve advance and expand yield (FOA, 2006). Atkinson et al (2005) described wheat to be more delicate to atmospheric conditions in two development stages (grain filling and grain ripening) with grain filling as the most influential to the wheat grain yield and weight. Wheat crop experiences three different stages as it develop from planting to harvest (foundation, construction and production) and the grain filling and the grain ripening happen at the last stage which is the production stages. Amid this period basic wheat yield and the grain weight are determined (Yara, 2015). In England, the wheat development begins at flowering (anthesis) then grain filling and this happens in June, essentially all yields and grain development stops in July emulated by a ripening period when the grain dries before harvest in August (Kettlewell et al., 2003). It is in view of this that this paper aimed at assessing the impacts of climate change on the wheat during the two development stages (Grain filling and Grain ripening) in the United Kingdom over the 30 years period from 1982-2011.

2 Materials and Method

In order to achieve the stated aim, meteorological data and the wheat yield data were retrieved from the UK meteorological office and the department for environment, food and rural affairs (DEFRA) respectively. The meteorological information used for this research was from the UKCP09 gridded data sets based on surface observation that have been produced for numerous climatic variables. This is principally purposed to motivate educational investigations in the field of environmental change effects, mitigation and adaptation. The grids were distributed across UK at 5 × 5 km^2 and this data set (UKCP09 gridded) was made with financial backing from the Department for Environment, Food and Rural Affairs by the meteorological office. The meteorological office has a long termed existent database that contained all the weather component observations from different meteorological stations. The observations originates from a diversely distributed meteorological stations spread all over the UK and in order to increase the value of the information from these stations, a reliable set of climatic applied mathematics was utilized to enable correlation between variables over space and time through some sort of quality control measures. The meteorological data was worked on in order to get the annual mean for the period when wheat is most sensitive to climatic variability (June to September) which is more influential to wheat grain filling and ripening that determine the grain yield for each year for the period of 30 under review (1982- 2011). The values for June to September every year was collected for all the 10359 grids across UK to calculate the mean that would allow comparison with the UK wheat yield data. Microsoft excel 2010 was chosen to analyse the meteorological data because of its ability to accommodate multiple pieces of data along with extensive statistical formulas making it more suitable and reliable than other programs available for statistical analysis. After getting the values, it was also used to plot the graphs in order to examine the rainfall and temperature changes over time and the relationship between these climatic variables and the wheat yield data. R statistical software was used to statistically determine the correlation between variables and a test of significance in which the Pearson product moment correlation coefficient (*r*) and the probabilities value (*P*) were used. Pearson correlation coefficient (*r*) has a limit of numerical value from +1 to -1. An estimation of 0 demonstrates that there is no relationship between the two variables. A value from 0 to +1 demonstrates a positive affiliation, that is as the estimation of one goes high so does the other variable while a value from -1 to 0 shows negative relationship in which as the estimation of one variable abates or go do down so does the other too.

3 Results and Discussion

In this section the annual mean rainfall (Figure 1) and temperature (Figure 2) for a period from June to September each year was plotted to describe the changes and fluctuations in the trend over the time 1982-2011 (30 years period). This is the time when wheat crop is most sensitive to climatic variation. The development from flowering (anthesis), grain filling and grain ripening takes place within this period which determines the crop yield.

Table 1: *The year/value of the Annual mean rainfall and annual mean temperature for the wheat most sensitive period to climate (June to September) data in the UK from 1982-2011.*

Year	Rainfall (mm)	Temperature (^{0}C)	Year	Rainfall (mm)	Temperature (^{0}C)
1982	89.8	14	1997	79	14.5
1983	61.3	14.5	1998	94.1	13.6
1984	67.5	14.1	1999	90.5	14.3
1985	110.5	13	2000	81.6	14
1986	66.1	12.6	2001	81.3	13.8
1987	89.9	13.1	2002	74.8	14.1
1988	96.6	13.2	2003	57.9	15.1
1989	65.3	14.3	2004	104.5	14.5
1990	73.4	13.9	2005	78	14.5
1991	74.7	13.9	2006	72.7	15.6
1992	99	13.7	2007	105.6	13.8
1993	79	12.9	2008	106	14
1994	74	13.6	2009	96.6	14.4
1995	58.9	14.8	2010	89.3	14.2
1996	54.3	13.8	2011	93.7	13.7

Source: *Met office, 2015.*

Table 2: *The year/value of the wheat yield data in the UK from 1982-2011*

Year	Wheat yield (tonnes per hectare)	Year	Wheat yield (tonnes per hectare)
1982	6.2	1997	7.4
1983	6.4	1998	7.6
1984	7.7	1999	8.1
1985	6.3	2000	8
1986	7	2001	7.1
1987	6	2002	8
1988	6.2	2003	7.8
1989	6.7	2004	7.8
1990	7	2005	8
1991	7.3	2006	8
1992	6.8	2007	7.2
1993	7.3	2008	8.3
1994	7.4	2009	7.9
1995	7.7	2010	7.7
1996	8.2	2011	7.7

Source: *DEFRA, 2015.*

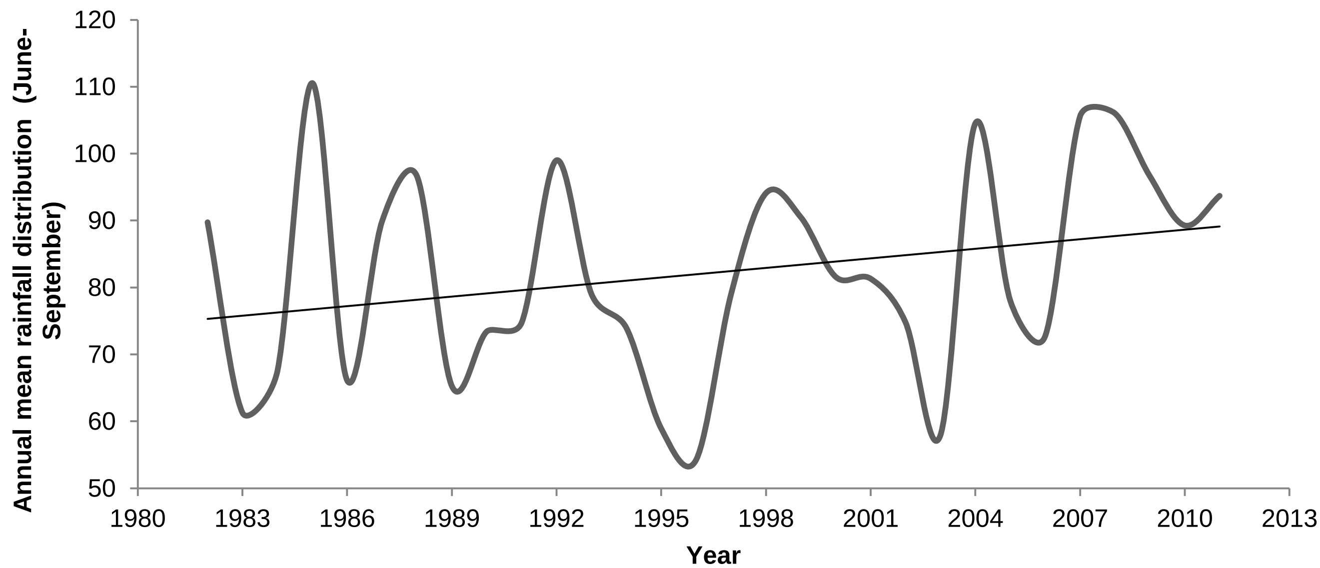

Fig 1: Annual mean rainfall distribution for the wheat most sensitive period (June-September) in the UK from 1982-2011 ($r = 0.267$, $P = 0.77$)

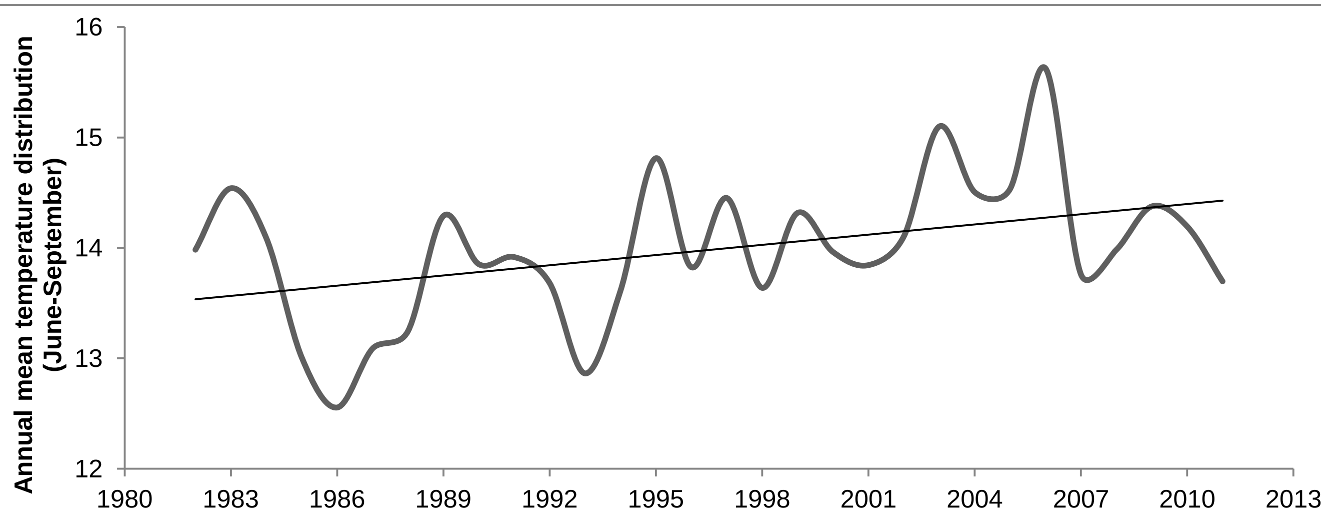

Fig 2: Annual mean temperature distribution for the wheat most sensitive period (June-September) in the UK from 1982-2011 ($r = 0.421$, $P = 0.010$)

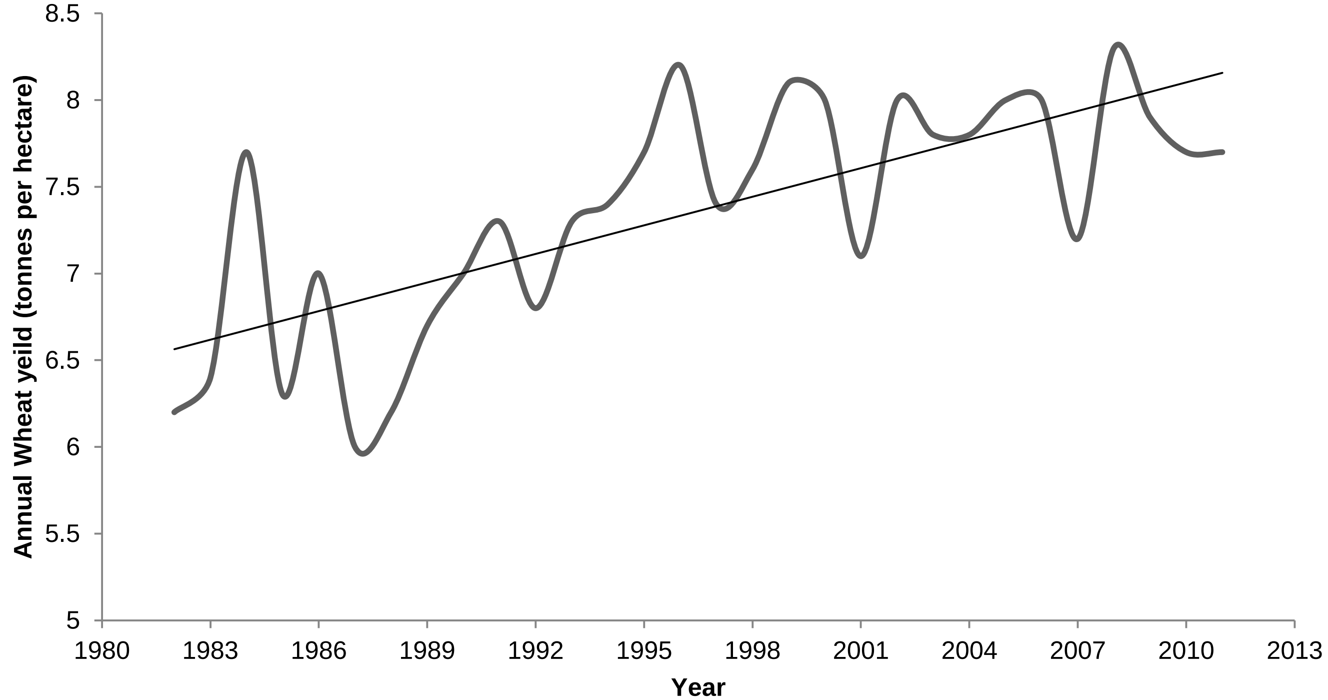

Fig 3: Annual wheat yield distribution (tonnes per hectare) from 1982-2011 (r = 0.732, P = 2.161e-06)

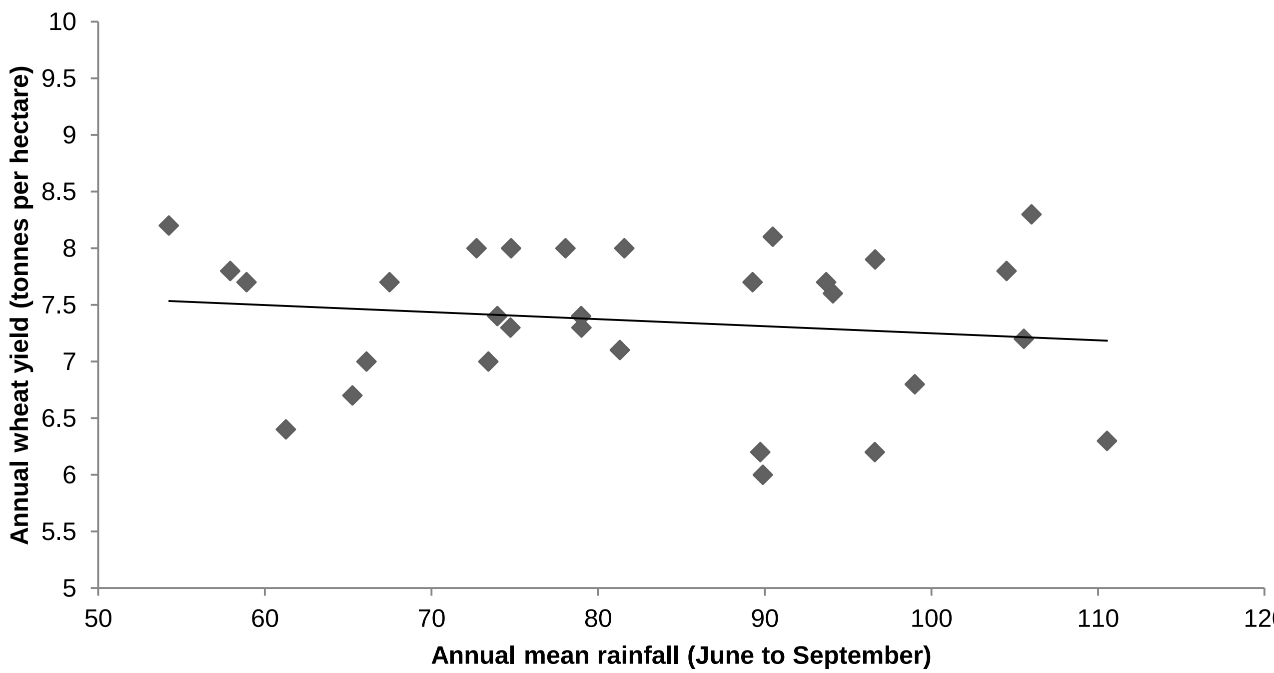

Fig 4: The association between the annual mean rainfall for the wheat most sensitive period to climate (June to September) and the annual wheat yield (tonnes per hectare) in the UK from 1982- 2011 (r = -0.147, P = 0.781)

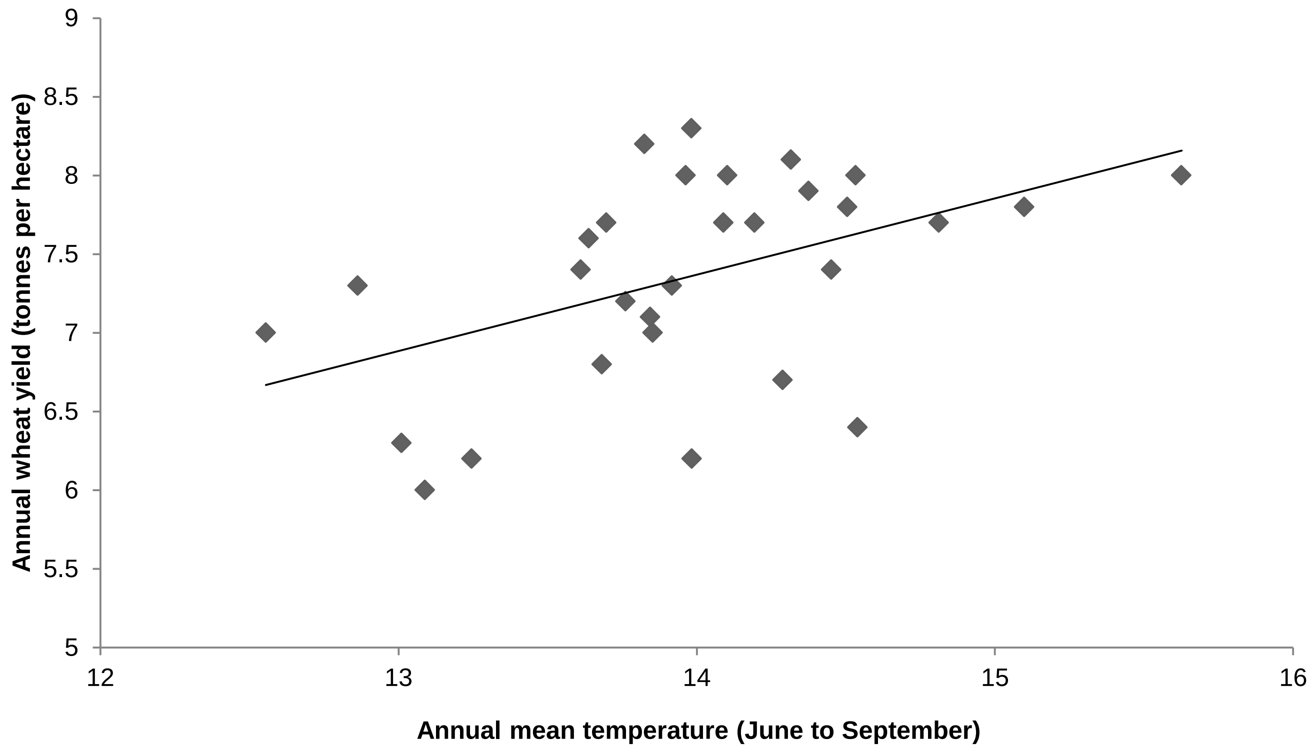

Fig 5: The association between the annual mean temperature for the wheat most sensitive period to climate (June to September) and the annual wheat yield (tonnes per hectare) in the UK from 1982- 2011 (r = 0.482, P = 0.004)

The IPCC report (2007b) revealed the anticipation of both positive and negative changes in the spatial and temporal distribution and seasonal pattern of rainfall and temperature all around the world. The rainfall and temperature in the UK experience has significant changes over time and between seasons. the data for the selected months during which wheat is most sensitive to climate and the time that wheat development take place (June to September) for both rainfall (Figure 5) and temperature (Figure 6), The trends shows an increase with rainfall (r = 0.267, P = 0.77). This corresponds to the findings of Osborn and Maraun (2008) which uncovered that for as far back as few decades, there were increase in the aggregate precipitation over the entire UK. Additionally, this is because of the way that an increase in the overall precipitation can happen on account of more wet days or on the grounds that it rains heavier on those days that it rains, or because of the accumulation of both. A thorough look at the daily observation data of some station over the period 1982-2011 demonstrates that there is an increase in the number of wet days in the numerous parts of the UK, but generally the increase was not high. The temperature also having (r = 0.421, P = 0.010). Perry, (2006) presented that there has been a substantial increase in the yearly mean temperature over the entire UK since 1914 and the strongest increase have happened in the midlands, south-east England and East Anglia. In these regions, the mean temperature has increase by about 0.9^0C since 1914, with a rate of expansion differed between months and seasons. The correlation test for the months that are more influential to wheat development (i.e. flowering, grain filling and grain ripening) each year (June to September) shown a negative correlation (r = -0.147, P = 0.781) between Annual wheat yield and annual mean rainfall (Figure 4) and a strong positive correlation (r = 0.482, P = 0.004) between Annual wheat yield and annual mean temperature (Figure 5). Numerous models predicted that the increase in temperature connected with environmental change is relied upon to have impact on product advancement and yield (Shewry, 2009). The results above shows that the wheat yield during the period that wheat is most sensitive to climate (June to August) in the UK is influenced more by temperature than rainfall. Ray et al., (2015) in their study used a detailed crop statistics time series and examined how climate variability led to variation in the yield some of the major world crops, for wheat approximately, 34-45% of its yield in the United Kingdom and some other countries located within the temperate region was explained by climate variability. In another research existing model results demonstrated that an increase in rainfall could expand some of the agricultural products yield in numerous parts of the world and that some crops yield is more sensitive to rainfall than temperature (Kang et al., 2009). However, Kettlewell et.al (2003) contended that rainfall reduces specific wheat grain weight through wetting and drying creating wrinkling of the grain surface during grain maturing and accordingly decreasing the grain packing efficiency.

4 Conclusion
In climate change effects especially in the agricultural setting, there is a need to understand the level of relationship that exists between the climatic variables and the crops. It is only through this way that yield can be determined and measures can be taken to improve it. As mentioned earlier, the research of Ray et al (2015) already mentioned that climate accounts for only approximately less than 50% of the wheat yield in many parts of the world's temperate regions in which UK is included. The wheat yield in the UK has increased to the extent that it had doubled over the last few decades. This means that climate change is only but a factor among other factors that influenced the wheat yield in the UK for the past decades. Other factors such as genetic improvement (particular the introduction of new 'green revolution' semi dwarf wheat cultivars), better changes in cultivating practice, better management of pests and diseases and high application of NPK fertilizers could have more effect on the UK's wheat yield for as far back as decades than only a change in climate.

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