

Effects of climate change on wool production and crop yield by the Livestock Experiment Station (LES) in Jaba district Mansehra, Khyber Pakhtunkhwa, Pakistan

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ABSTRACT

Climate changes are the long-term changes in weather conditions and/or patterns of unusual extreme weather events. Climate changes by natural factors include volcanic eruptions, variations in solar output, natural aerosol emissions, variations in the earth's orbital characteristics and some anthropogenic factors including burning of fossil fuels, industrial activities, cement production, land use changes, deforestation and mismanaged agriculture. All these activities result in higher emissions of greenhouse gases (GHGs) i.e., carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). The study suggested that LES, Jaba is particularly vulnerable to climatic change because it is rainfed – Barani area. As per results of the present research, the crop production from LES, Jaba, during 2008 – 2017, has decreased. The adverse effects of climate change on the crop production (Maize and wheat), were pronounced during the last three years i.e., 2015 - 2017. The study expressed that the average maize and wheat production was 1763 and 321 (kg/acre) throughout the study respectively. In the present research extreme weather, increase in temperature, drought and water availability directly affected wool production by livestock and it indirectly affected them via diseases spread. The study revealed that climate change has been found to have significant environmental and economic impacts on wool production and crop yield.

Keywords: Climate change · Adverse effects · Wool production · Maize · Wheat · Crop yield

1. Introduction

Natural and anthropogenic activities directly or indirectly, over comparable time periods, are implicated as causes for climate change [1]. Climate changes have negative impacts on agriculture (crop and livestock). The yield of many crops is severely being threatened due to the continuous increase in global temperature [2]. Industrialization and concurrent pollution are the fruits of the 21st century. Pakistan being under developing nation, don't fully observe all the rules and regulations about tree cuttings, forest destructions and roads and building construction. A long term continuous fluctuation in weather pattern with its extreme conditions is causatively known as climate change [3]. Climate change is a global issue and there is misconception that weather and climate is a same thing. Weather is the day to day change in climate whereas climate is the composite structure of weather condition of some area. Pakistan is one of the heavily populated countries in the world with less than 5% of area covered by trees and forests. Due to having agro-based economy the effects of climate change over Pakistan is very severe [4] which ultimately affects the crop yield [5].

The negative impact of climate change on crops yield and livestock production poses a severe threat to food security. Universal change in climatic condition may have major impacts on agriculture and other factors [6-9]. Increase of temperature in a particular area also results in increasing diseases and pests and attacks which ultimately results in low crop production. Livestock production is significantly influenced by the change in the climatic

condition by reducing the availability of feed and fodder. Climate change may also influence the variability of monsoon and winter rainfall patterns, the depression of glaciers in the Himalayas, increase in average temperatures, may also warmer winters, which ultimately deteriorates the ecosystems. Recent changes in temperature and heavy rainfalls could severely affect the livelihoods of small farmers because their livelihoods mainly depend on the natural resources and availability of these natural resources depend on appropriate climatic conditions [10]. Agricultural and livestock productions are highly sensitive to climate changes.

The extreme weather condition like droughts and floods and the increasing frequency of pest attack and diseases associated with climate change can be significantly responsible for the failure/destruction of crop production [11, 12]. There are several examples of climate issues towards livestock management and agricultural fields including fluctuations in temperature and precipitation, availability of water, distribution of humidity, air parcel dispersion etc. [13]. In the study area, the most valuable and profitable commodity for human consumption is permanent field crop. There was an age old practice of field crop cultivation for the period of about 25 years that made the cultivated crops susceptible to climate change pattern. Keeping in view the above-mentioned data/information, this research was designed to observe the impacts of climate change on the livestock and crop production of LES, Jaba sheep farm, District Mansehra, during the last 10 years (2008 – 2017). The objective of the study is to examine/evaluate the effects of climate change on the crop

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production (wheat and maize) and wool production by sheep of LES, Jaba sheep farm (300 acres) over period of 10 years (2008 – 2017).

2. Materials and methods

The present research was conducted in livestock experiment station (LES), Jaba sheep farm (300 acres), District Maneshra, located in the province Khyber Pakhtunkhawa (KPK), Pakistan. It is situated at the coordinates of 34°09' N latitude and 73°13' E longitude, at an altitude of 4,120 feet (1456 m). It is located about 125 km from Islamabad, and about 235 km from Peshawar. The study was based on experimental field data to study the impact of climate change on crop yield and wool production. There are two types of crops have been harvesting i.e maize and wheat in LES, Jaba. The data were collected on the crop production (wheat and maize) and wool production by sheep of LES, Jaba sheep farm (300 acres) over the period of 10 years (2008 – 2017). There are three breeds of sheep were studied in livestock experiment station (LES) Jaba i.e. 1) Rambouillet, 2) Ramghani, 3) Kaghani. To accomplish the requirements of the local population, various vegetables and food crops are cultivated in this area.

3. Results and Discussion

3.1 Environmental condition in the study area

Climate change is the most dynamic environmental issue of any time. Through serious and far reaching damaging

impacts, warming of the planet weakens biotic structures, people groups' employment, and species survival. Various studies related to effects of climate change suggested that climate change had significant impacts on crop production [14-18] and wool production [19, 20].

The average temperature of Livestock experiment station (LES) Jaba District Maneshra was not that high during 2008-2012 i.e., 16°C-17°C (Fig. 1). There was no fluctuation in the temperature of LES Jaba during these years. During 2013 there was an abrupt increase in the average temperature and it reached to 21°C. During 2014-2017 the average annual temperature remained between 18°C -20°C. Thus, from 2008 till 2012 the average annual temperature was in the moderate range and remained constant, it abruptly rose during 2012 and in the next five years till 2017 annual temperatures is with fluctuation/ variations (Fig. 1). In the country like Africa, the domestic animals are affected very much with the issues of climate change such as, temperature fluctuation and rate of rain fall. Production of food grains becomes lower by changes in climatic factors and may have influence over the grazers. Extensive heat is one of the climatic features that may results in dispersal of infectious and endemic diseases to the domestic grazers. The extensive destruction and decline of crop lands and destruction of habitat of animals may be occurred. Wool production with its quality and quantity may have direct influence of change in climatic factors like temperature, precipitation, humidity etc. A persistent decrease may arise in animal food stock and food security with the adverse effect of environment and climate change over agriculture and crop production.

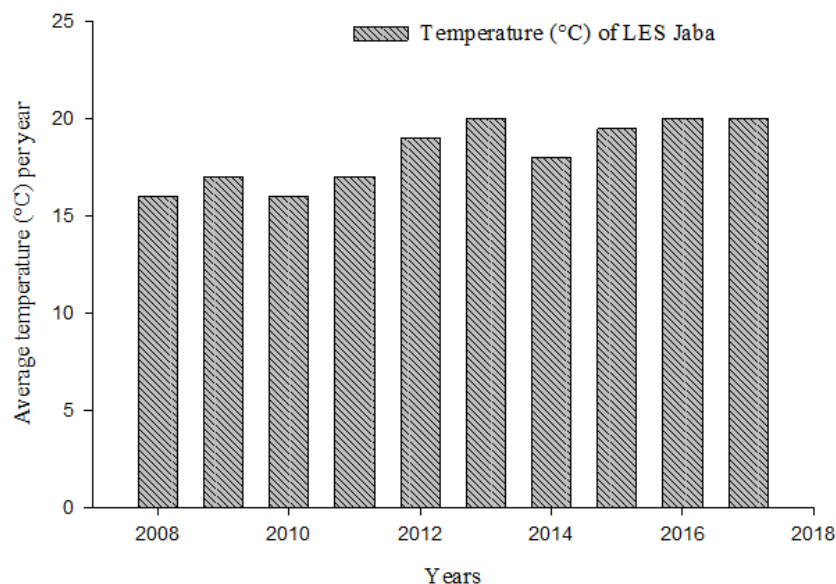


Fig. 1. Average Temperature (°C) per year

The average annual temperature of the last decade in the study area (2008-2017) was 18.24°C. During earlier years i.e., 2008-2010 the humidity was higher (60-70%), and with the decreased temperature LES Jaba, Maneshra was with

higher humidity (Fig. 2). During 2011 and 2012 when average annual temperature was high (21°C), the humidity was dropped as compare to previous years. During 2013-2016 the average humidity reached to 47.5-61.58%.

During 2013-2016, the average annual temperature was higher and the average annual humidity was decreased (Fig. 2). During 2017 the average annual humidity was on decline, it reached to 59% but the temperature was

increased ($> 18^{\circ}\text{C}$) (Fig. 2). As we know that when the temperature rise then the humidity decreased this is because colder air does not require as much moisture to become saturated as warmer air. The average humidity in

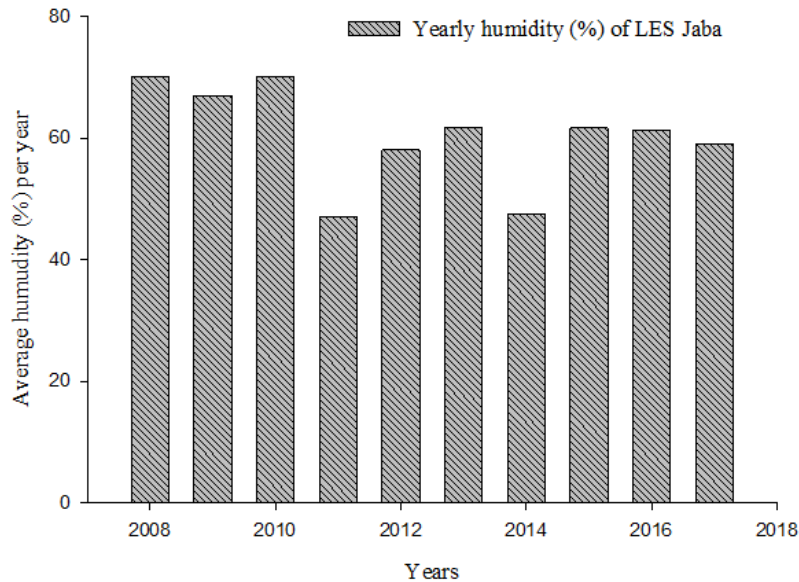


Fig. 2. Average humidity (%) per year

the decade was 60.3%. During the years 2008 and 2009 the average annual precipitations were 95 and 92 mm, respectively (Fig. 3). During 2010 the average precipitation was much bit increased and reached to 100 mm. During 2011 relative to 2010, the average precipitation dropped to

93mm. During 2012, 2013 and 2014 the annual precipitation remained similar as 2008 and 2009. Except 2014, during the last decade the decline in the annual precipitation is observed (Fig. 3). The average precipitation in the last decade (2008-2017) was 83.2mm.

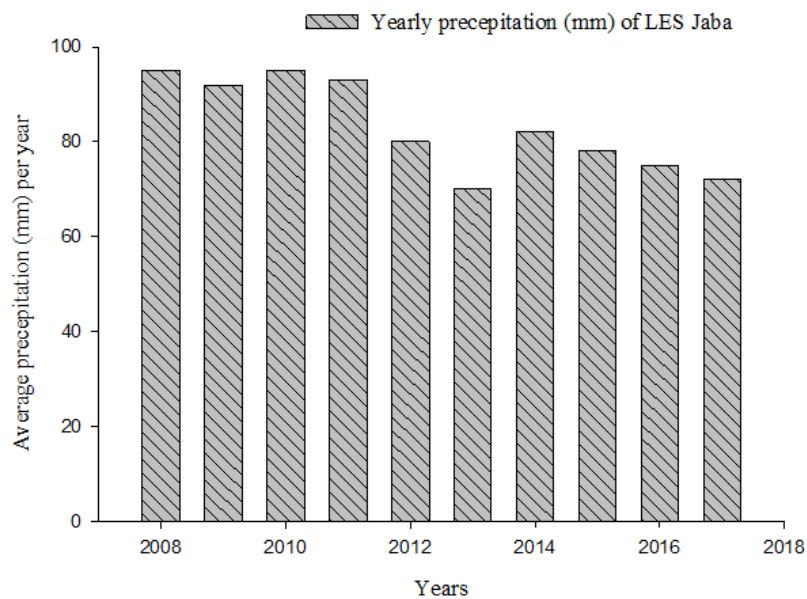


Fig. 3. Average precipitation (mm) per year

3.2 Effects of climate change on Wool production

Change in climatic condition may have the potential impact on wool production in respect to its quality and measurable quantity. In a geographical area, wool production per head / hectare may be affected by the changing variables of climate and pasture. Regional climate change may pose negative impact on health, nutrition and growth of sheep production due to thermal stress and other specific factors. Quality and quantity of wool production may be reduced in marginal area and may increase slightly in areas with high rainfall. In the natural sphere of environment, wool is the indicator of exposure of stress or wealth of sheep irrespective of species variety. Climate change may impart effects on animal growth and wool production in active environmental stress factors [21]. The production potential of lambs and ewes may be drastically affected by low precipitation and high temperature during summer season. The stress may have effects on survival rate, reproduction, growth, health status, lactation and wool production of lambs and ewes

[22]. In the growing season, the changing climate may affect sheep production and growth [23].

3.2.1 Yearly wool production by Rambouillet (RB) in LES, Jaba (2008-2017)

Rambouillet(RB) sheep's wool production during 2008 and 2009 were 840 and 800 kg yr⁻¹ respectively, which were the highest productions. During these years the temperature remained moderate with relative high precipitations which are most suited environmental conditions for the livelihood of RB stock (Fig. 4). During 2010 the wool production was 770 kg, it was decreased from previous years. During 2011, 2012 and 2013 the wool production by RB sheep got reduced and was 391.5 kg - 520 kg. As compare to 2008-2010, a decline in wool production by RB was monitored, the reason behind which is the high temperature to which RB is sensitive. As compare to 2011-2013, during 2014-2017, increasing trend of wool from 440 kg-727 kg was observed as compared to 2011 – 2013. Wool production by RB during 2014 – 2017 was reduced as compared to 2008-2010 (Fig. 4).

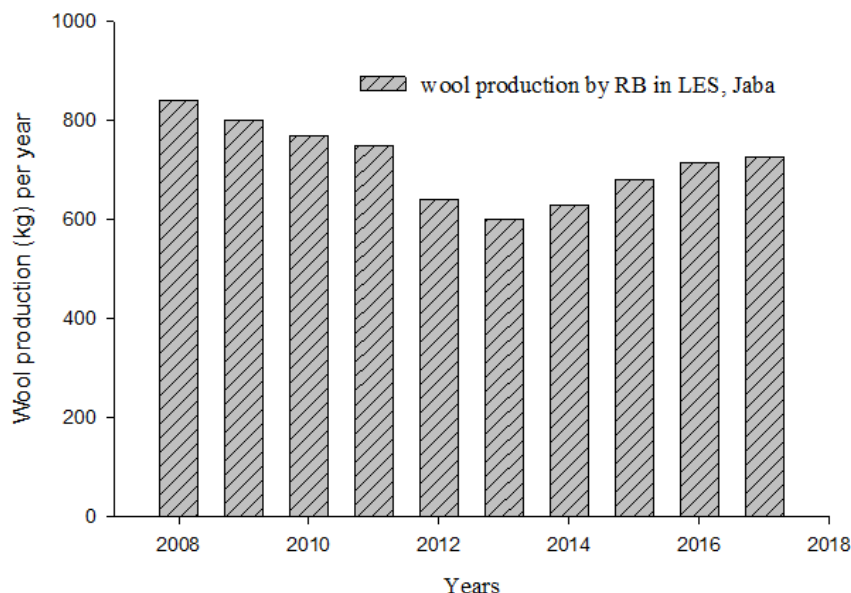


Fig. 4. Effect of climate change on wool production by Rambouillet (RB)

3.2.2 Yearly wool production by Ramghani (RM) in LES, Jaba, (2008-2017)

Figure 5 shows the wool production by Ramghani sheep (RM), during 2008 – 2017. Wool production by RM, during 2008 was 392.5 kg, due to moderate temperature and high precipitation. From 2009 onward till 2014, decreasing trend in the wool production by RM was observed perhaps due to continuous rise in temperature. During 2015, the wool production by RM was improved to 422.5 kg. During 2016 and 2017 the wool production was reduced to almost half of the previous year production i.e., 286 kg and 284 kg, respectively (Fig. 5). The reason behind this decrease may be were less rainfall and related low

quality food. Several factors affecting wool production may vary with the variation of climatic condition. The factors of qualitative and quantitative pattern of wool production are animal health, animal reproduction, water demand and available water. There may be an adverse effect of increased temperature with the enhancement of pest and disease cycle towards health and reproduction of animals. In the variable climate pattern, landscape becomes stressful mainly due to lack of sufficient rainfall. As a result of agriculture dependent other activities like production of meat and crop may increase a competition within land resources and water system. So the climate change has a significant role in wool production.

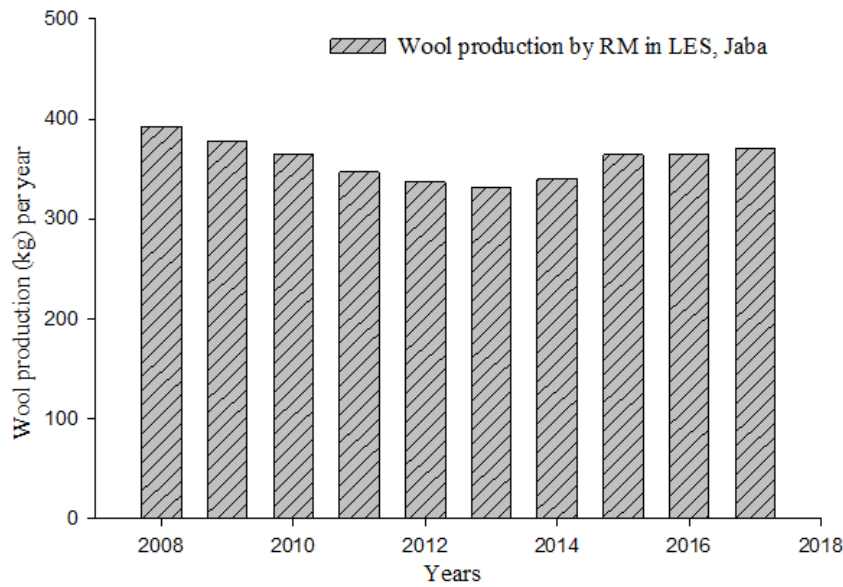


Fig . 5. Effects of climate change on wool production by Ramghani (RM)

3.2.3 Yearly wool production by Kaghani (KG) in LES, Jaba (2008-2017)

The wool production by Kaghani sheep (KG) during 2008 was 310 kg (Fig. 6). From 2009 onwards, decreasing trend in the wool production by KG was observed (Fig. 6).

This perhaps was due to high temperature and related high mortality. KG belongs to colder areas and cannot survive in warmer areas. Although KG is local breed of Pakistan, but the overall wool production by KG is less than the other two breeds.

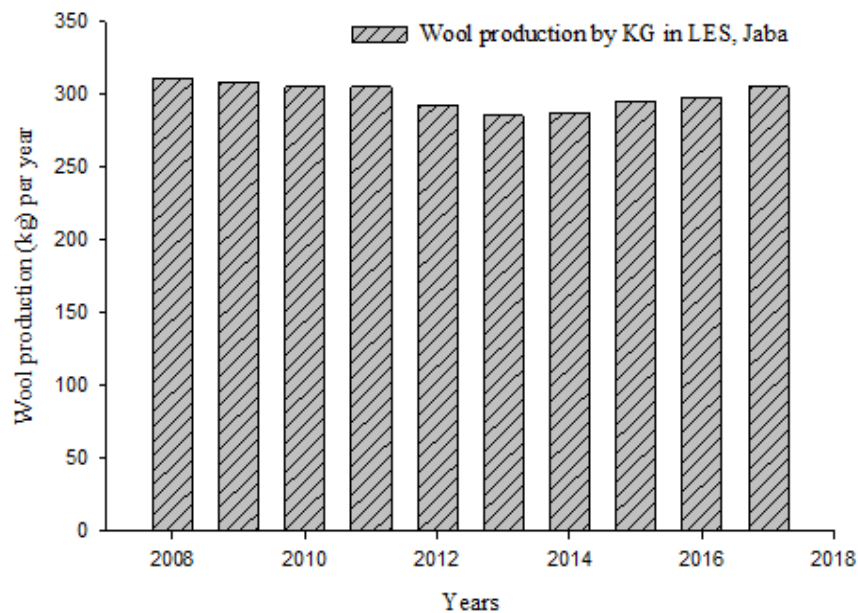


Fig. 6. Effects of climate change on wool production by Kaghani (KG)

3.3 Effects of climate change on maize and wheat production

There may be a neutral to positive effect of climate change lies on crop production associated with acclimatization of farmers to be adapted in the changing climatic environment. In the temperature range of average 30 degree centigrade the production ratio of harvested crop is increased slightly instead of decreasing trend in higher temperature areas. Change in weather declined universal

production of wheat and maize upto 5.5%. Average crop production is sensitive to change in weather components like temperature, rain falls etc. Both of the parameters show potential effects over production of crops like potato, wheat, sugar, beets etc. Diverse climatic factors decline yield variability of wheat and other plants [24-27]. The average annual rice production is positively correlated with temperature and negatively correlated with rainfall of an area. Both the variable factors are high risk factors. [28].

Table 1 Maize and wheat productions (kg/acr/yr) in LES, Jaba (2008-2017)

Maize and wheat production (kg/acr/yr), during 2008 - 2017				
year	Total acre	Total maize production (kg/acre/yr)	Total acre	Total wheat production (kg/acre/yr)
2008	33	1893	6	186
2009	28	1607	6.5	190
2010	33	1600	10	310
2011	40	2000	15	483
2012	35	1752	12	387
2013	35	1730	12	374
2014	36	1800	15	448
2015	40	1840	10	290
2016	35	1800	15	360
2017	40	1615	7	190

The maize and wheat production during the last years 2008-2017 is presented in Table 1. In 2008 the maximum maize production was 1898 (kg/acre/year) and minimum production of maize was 1607 (kg/acre/year) and the average production of maize was 1763 (kg/acre) in the whole years (2008-2017). The maximum wheat production was 483 in 2011 and minimum production is 186 in 2008 and average production of wheat was 321 (kg/acre) in the last 10 years (2008-2017).

According to IPCC (2014), over the late 20th century, worldwide there is ~ 4°C rise in temperature. In current survey, approximately 1-2°C increase in the temperature of the study area i.e., LES, Jaba District Manshera in the last 10 years (2008-2017), was observed. The climate change has direct effects on temperature, humidity, wind, precipitation distribution, milk formation, fertility rate and wool generation by the livestock of LES. Rabi and Kharif are the two cropping seasons of Pakistan. Normally, Rabi crops are grown during November to April while Kharif crops are grown from May to October. Climate change generally affects agriculture with the changes in temperature, humidity and precipitation.

The LES, Jaba is particularly vulnerable to climatic change because it is rainfed – Barani area. As per results of the present research, the crop production from LES, Jaba, during 2008 – 2017, has decreased. There was an inverse relation between efficiency and growth of the harvested

plants with rise in temperature which ultimately affects the crop production and livestock of a geographical area. As per IPCC Fourth assessment report - Climate Change (2007), by 2035, wheat productivity will be reduced by 4.5 - 9 %. Climate change catalyzes competition between crops and weeds for light, humidity and nutrients. Increase or decrease in temperature and rainfall patterns accelerates shortage of food and water. Thus, under high temperature, crops die due to increased evapotranspiration and moisture loss. Similarly, a decline in rainfall results in water scarcity for farming.

4. Conclusion

Climate change has direct as well as indirect effect on wool production by the livestock of LES. In the present study extreme weather, increase in temperature, drought and water availability directly affected wool production by livestock and it indirectly affected them via diseases spread. During the last decade, 1-2 % increase in the atmospheric temperature of LES Jaba is observed. Humidity and precipitation are also reduced in the study area. Wool production by RB, RM and KG, during 2008 – 2017, almost remained the same except the decrease during 2012 – 2014. The adverse effects of climate change on the crop production (Maize and wheat), were pronounced during the last three years i.e., 2015 -2017. The study revealed

That the average maize and wheat production was 1763 and 321 (kg/acre) throughout the study respectively. Climate change has been found to have significant environmental economic impacts in the study area.

Conflict of interest

The authors declare that there is no conflict of interest in this manuscript.

Data availability

The authors confirm that all data collected or analyzed during this study are included in this published article.

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