Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

EFFECTS OF TEMPERATURE AND PRECIPITATION FLUCTUATIONS ON CROP YEILD IN MINGORA, PAKISTAN

SANAULLAH
Department of Environmental Sciences, University of Peshawar, Khyber Pakhtunkhwa, Pakistan.

SAEEDA YOUSAF
Department of Environmental Sciences, University of Peshawar, Khyber Pakhtunkhwa, Pakistan.

JAVAID IQBAL*
Department of Environmental Sciences, University of Peshawar, Khyber Pakhtunkhwa, Pakistan.
Department of Environmental Sciences, University of Lakki Marwat, Khyber Pakhtunkhwa, Pakistan.
***** Correspondence Email: drjavaidenv@gmail.com

ZARAK KHAN
Department of Environmental Sciences, University of Peshawar, Khyber Pakhtunkhwa, Pakistan.

HINA
Department of Environmental Sciences, University of Peshawar, Khyber Pakhtunkhwa, Pakistan.

AAMIR IQBAL
Institute of Biotechnology & Genetic Engineering (IBGE), The University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan.

NOWSHER YOUSAF
Department of Environmental Sciences, University of Peshawar, Khyber Pakhtunkhwa, Pakistan.

Abstract

Climatic parameters such as temperature and rainfall have a significant impact on crop yields, vegetables, fruits, and water resources all over the world, including Pakistan. This study focuses on the effects of temperature and rainfall fluctuations on crop yields, specifically Maize (*Zea mays*) and Rice (*Oryza sativa*), in Mingora City of District Swat, Khyber Pakhtunkhwa (KP), and Pakistan. Primary data was collected through a semi-structured questionnaire. A total of 60 questionnaires were designed and filled to examine the effects of temperature and rainfall on maize and rice in the last 18 years. The survey indicated that the high yield of maize was recorded due to an increase in mean temperature and heavy rainfall during the period 2000-2006, while the minimum yields of maize were found due to a decrease in the mean temperature and rainfall pattern during 2007-2012. Moreover, no significant impacts were observed with increasing temperature on rice yields. However, the yield of rice increased with an increase in rainfall pattern during 2000-2006. The resultant analysis indicates that water availability shows a strong association with rice yield. The survey concludes that a better yield is obtained with an increase in temperature and rainfall, while in areas where there is a decrease or no change in temperature and rainfall occurrence, a decline or no change in crop yields is observed. One reason for the decline is the lack of proper irrigation systems in agricultural land due to the topography, as the agricultural land is located at a high altitude compared to the River Swat. Therefore, a proper irrigation system is needed in the rain-fed areas to improve maize and rice yields through proper channel construction from the Swat River. Furthermore, research is required to analyze long-term data of changing climate and crop yields to provide adaptation measures to farmers from the adverse effects of rainfall and temperature.

Keywords: Rainfall pattern, Temperature fluctuation, Yield, Mingora, Khyber Pakhtunkhwa.

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

INTRODUCTION

Globally, climate change is a prime issue, which resulted in drastic changes in the average atmospheric conditions due to anthropogenic activities since the mid-21st century. High temperature and decrease in the rainfall pattern reduces the life expectancy in this modern era (Ortiz et al., 2008). Crop growth is severely affected by changing temperature and rainfall. These changes vary region to region (Kimball et al., 2008). Farming in the vulnerably delicate environment is very sensitive to slight climatic conditions, which reduce crop production (Alteiri and Nicholls, 2017). Decreasing in agricultural production can diminish the food surety (Smith et al., 2007; Amjathet al., 2016; Nelson et al., 2014; Olesen and Bindi, 2002 Wheeler and Von Braun 2013). The impacts of climate change on crop yield, temperature and precipitations are the variables and are not constant at all (Adams et al., 1998). It is reported that geographic differences across countries are experiential, most of them are in non-industrialized countries and tropical regions of the world (Wheeler and Von 2013; Ruamsukeet al., 2015). These climatic variations cause severe calamities such as heat waves, floods, droughts and desertification in arid and semiarid regions which reduces the crops production and biomass (Lobellet al., 2008). Pakistan comes under arid and semi-arid region and it is a more vulnerable area under climate change scenario. Countries like Pakistanis prone to climate change, where sever atmospheric conditions are threatening food security. Precipitation and temperature are the two main climatic factors which are very important for agriculture practices (Von and Wheeler, 2013). It is investigated experimentally that an increase in temperature and precipitation can adversely affect the food productivity. An attempt has been made to evaluate the impacts of climate change on the agronomic values and crop production rate by applying different methodologies including time arrangement, examination, crop simulation modeling and spatial analysis of yield trends (Khattaket al., 2012; Pathak et al., 200; Lobell and Asner, 2003). Greenhouse gases such as ChloroFloro Carbon (CFCs), methane, carbon dioxide,andnitrous oxide is responsible for the change in the climate. The effects of climate change are more in developing countries as compared to developed countries due to their higher susceptibility and lesser ability to reduce the negative effects of climate change. Most of the developing countries including Pakistan depends on their agriculture-based economies but this has prone to the direct effects of climate change such as temperature and rainfall variability (Ying Liu et al 2007).

Rice and Maize are the important food products; their production has affected due to change in the climatic variables such as rainfall and temperature. (Maximilian et al., 2012). The rainfall pattern changed but the amount of rainfall is the same all over the years. Drought and floods are occurring respectively due to increasing and decreasing rainfall at a particular time. Enough water is required for the Rice crops during cultivation and flowering stages in the rain-fed areas. The Rice is cultivated during the monsoon season and if the pattern changes the yields are affected (Rashid et al., 2011). The suitable temperature for the Maize growth is 32^{o}C and for its propagation is 21^{o}C. Changes in temperature and rainfall effect process of pollination due to which Maize

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

flowers is not occurring properly (Shahid Ali et al., 2018). In the rain-fed areas, the Maize crop is totally depends on the rainfall pattern. Increase in rainfall results in the increase of Maize yield up to some extent. (Rashid and Rasul 2011). The rainfall pattern changes and its decrease is the real cause of the drought. Drought is the major agro-meteorological disaster because it occurs more frequently. The loss in the production of the Maize is due to the drought from 1949-1990. The adverse impacts of the changing of Maize production are due to the agro-meteorological disasters, in which 60% of Maize yield fluctuation was resulted due to the change in rainfall i.e. drought (Jiquan Zhang 2003).

Farmers perceived that the main cause of the fluctuation in temperature and rainfall is the anthropogenic activates such as pollution, combustion of fossils fuels, deforestation, greenhouse gases, and industrial pollution. During the last 10 years, more severe hazards were investigated i.e. increase in hot days and decrease in winter days, especially the havoc flood in July-2010. The respondents perceived that 35% reduction in the yields of major crops i.e. Rice, Maize, wheat, vegetables, and fruits were estimated in the proposed research area (Bacha et al., 2018).The present study was conducted with the aim to check the effect of changing temperature and rainfall pattern (last 18 years) on the Maize and Rice yields and the former perceptions regarding these climatic changes.

STUDY AREA

This research study was conducted in seven villages surrounding the city of Mingora in Swat, KP, and Pakistan. These villages are Qambar, Takhtaband, NaweKali, Kanju, Damghar, Koza Bandi, and Bara Bandai. Mingora itself is located at 34°46'59.99" N 72°21'59.99" E and has an altitude of 984 meters. It is situated 2 kilometers away from the town of Saidu Sharif. The climate of Mingora is humid and subtropical, with an average annual temperature of 19.3 °C. The hottest month of the year is June, with an average temperature of 29.2 °C, while the coldest month is January, with an average temperature of 7.6 °C. The driest months are October and November, with an average rainfall of 22mm, while the wettest months are July and August, with an average rainfall of 134mm (as of January 2015).

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

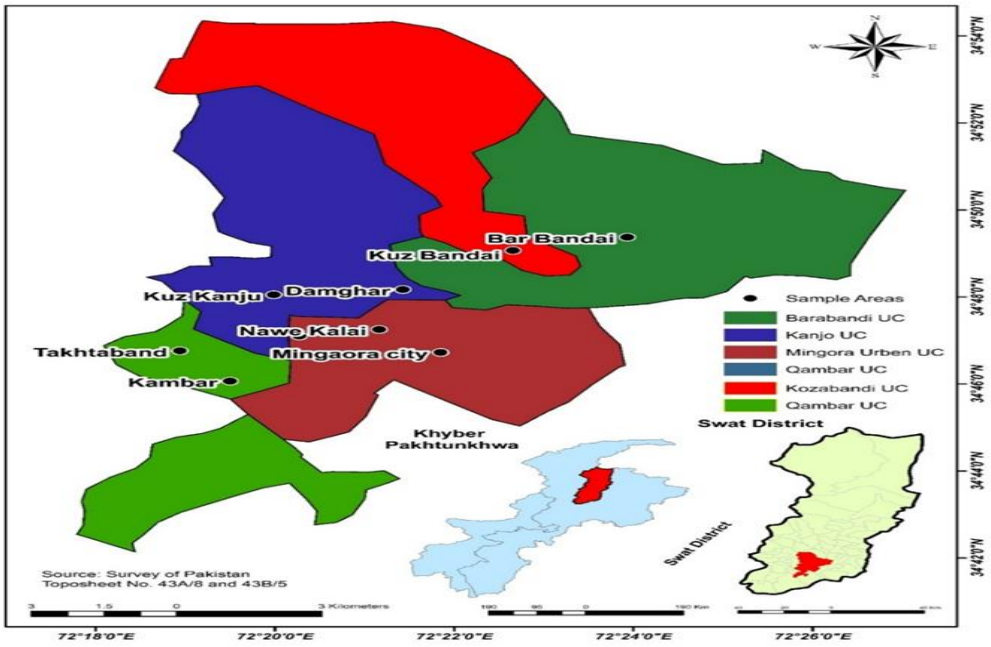

Fig 1: Mingora city and its landscape showing the surrounding villages

MATERIAL AND METHODS

For this study, data were obtained from both primary and secondary sources. The primary data was collected from the farmers and agricultural research officers through semi-structured questionnaires. In this social survey, 60 questionnaires were distributed among the respondents, in which 10 questionnaires were filled by the agricultural researchers and the remaining 50 by the farmer's community. The targeted areas were the surrounding seven villages of Mingora city focusing on the public, main agricultural resources, water and land. The land where different environmental factor like soil fertility, sunshine, herbicides pesticides, etc. are kept constant). The open conversation was held into regional people, agricultural research officer in Agriculture Research Institute (ARI), Mingora and farmers in the surrounding villages to assess their responses and behaviors towards changing temperature and precipitation and yields of the selected crops.

In terms of secondary data, the data about Rice and Maize yields of Swat was collected from Agricultural Statistics Department of KP, Peshawar. Rainfall and temperature data were collected from the Agriculture Research Institute Mingora, Swat. The eighteen years data of concerned parameters were categorized into three major groups including duration (2000-2006), duration (2007-20012) and duration (2013-2018). Moreover, the comparative analysis was carried out for the possible effects of temperature and rainfall fluctuation over the yield of Rice and Maize.

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

The data were statistically analyzed through phi and Cramer Comparison amongst the18 years of average rainfall, temperature and at the same time, yields of Maize and Rice was determined by Kendall's tau b application of SPSS IBM version 23.

RESULTS AND DISCUSSION

Farmer's perception of precipitation and temperature fluctuation and status of the land the data was collected by questionnaires survey from the key respondents regarding fluctuation in temperature and rainfall pattern, land status, and the impacts of changing temperature and precipitation are shown below in the graphs.

View of the respondents about land status (Irrigated, rain-fed)

The survey result shows that 80% of respondents were of the view that Rice and Maize crops were irrigated through proper channels from River Swat, in local language they told it obbakhur, While 20% of farmers were of the view that crop fields are rain-fed and not irrigated from the river Swat due to the topography of those areas. The farmers also agreed that the Maize and Rice crops are cultivated in the summer because the amount of water in river is high, so the scarcity of water for the Rice and Maize is negligible. The 20% of farmers said that sometimes due to fluctuation in rainfall pattern the Maize yields were affected. The farmers in the rain-fed areas have also held a view that in the rain-fed areas due to the lack of water, the Rice is not cultivated because this crop requires a lot of water during the sowing stages up to its harvesting stage. However, Maize is cultivated in the rain-fed areas but it depends on the rainfall pattern. Anwar Hussain, 2012 also found the same results that area under the availability of water had a positive and statistically significant impact on Rice yield. Dixit et al., 2007 also stated that 1% enhancement in water availability enhanced total Rice yield by 0.87 %.Therefore, sustainable water use is necessary for both the Maize and Rice crops which requires a high amount of water throughout the growing stages.

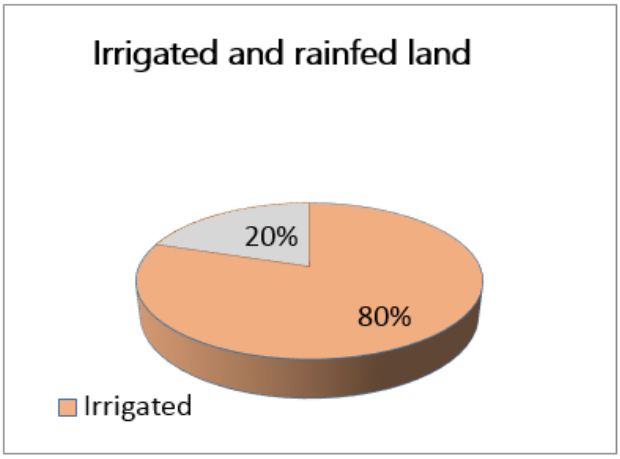

Fig 2: Types of land for Rice and Maize cultivation in the study area

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

View of respondents about the fluctuation in temperature in the last 18 years (2000-2018)

According to the survey, about 95% of the farmers were of the view that change in the temperature occurred from 2000 to 2018. However, 4% of the farmers did not agreed with increase in temperature, while 1% agreed with no change in average temperature was occurred. The researchers in the ARI Mingora, Swat were also in the favor and gave the evidence such as changing in the sowing and harvesting time of Maize and Rice, reduction in the apple yields in the lower Swat due to change in temperature. Our survey results are in accordance with Mensah et al., 2010, WHO also worked on farmer's perception about changing temperature and rainfall in which they interviewed the farmers and found that 88% of farmers were on the view of increasing temperature in the last 36 years, while 3.3% of farmers were on the contradictory of this opinion. Majority of them perceived that the increase in temperature is due to an increase in deforestation and population.

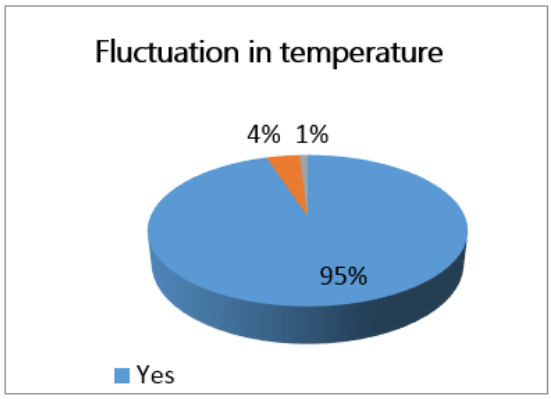

Fig 3: Average fluctuation in temperature from 2000 to 2018

View of the respondents regarding changing in rainfall pattern in the last 18years (2000-2018)

Survey results show that 67% of the farmers agreed that decrease in the rainfall has occurred from the last eighteen years. The farmers also gave the evidence that due to decreasing the rainfall, the yields of rainfed areas have also decreased. 30% farmers were on the view that no changes have occurred in the frequency of rainfall but the time pattern of the rain fall has changed that effected the sowing time of the crops in the rain fed areas, while 3% respondents agreed with no change was occurred in rainfall pattern. The current results are in accordance with Bacha et al., 2018, who studied that the time of rainfall pattern has changed, and the duration of winter rainfall (Jarai) have decreased. While the monsoons rainfall pattern has increased due to which flash flood occurs (Patrick Gwimbi., 2009). Farmers 52% were of the view that both rainfall and temperatures have changed from average levels, while 15% reported that there was no change. But almost 75% were agreed that the decrease in water has occurred due to fluctuations in the rainfall

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

pattern. It was investigated that most of the respondents were agreed that precipitation has decreased over the last 40 years, farmers' perceptions of precipitation are related to the time when the crops such as rice, maize, and wheat, require water during the sowing, flowering and harvesting stages, as the pattern of rainfall has changed so the requirements of water for crops growth is deficient (Mira and Lindqvist., 2000).

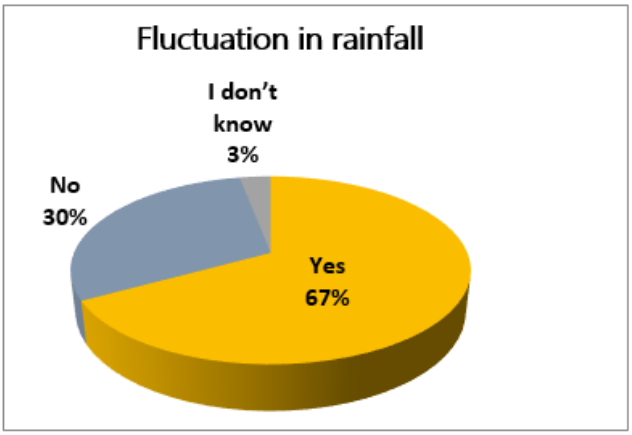

Fig 4: Average fluctuation in rainfall from 2000 to 2018

Farmer's perception of the fluctuation in temperature and its impacts on Rice and Maize yield

By primary data collection through a questionnaire survey, 61% of the respondent's claimed that increase in temperature has medium impacts on the yield of Rice and Maize, while 26% respondents were of the view that high temperature decrease the yields of Rice and Maize yields. The 13% of respondents said that the temperature has low impacts, where as 3% of respondents were of the view that increases in temperature have no impacts on the yields of Rice and Maize. The present results are in accordance with Lobell et al. (2008), who found that increase in temperature has improved the yields of Rice but up to some limits i.e. 32.2°C.When this limit exceeds the yield of crop decreases which means increasing in temperature have negative impacts on the yields of Maize.

Farmer's perception about the fluctuations in precipitation and its impacts on Rice and Maize yields

According to the research survey, 53% of the respondents said that the impacts of rainfall are medium, 42% of the respondents told that the impacts of precipitation are high,while 5% of the respondents were of the view that the impacts in the rainfall pattern on the yield of Rice and Maize are low.

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

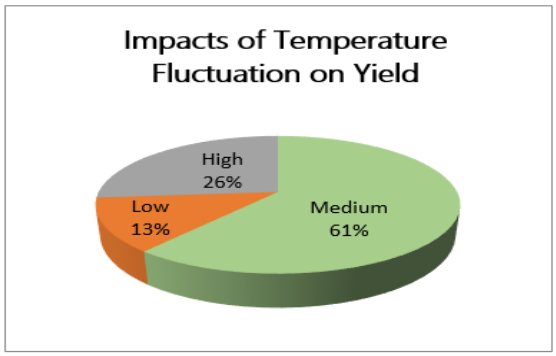

Fig 5: Temperature impacts on Rice and Maize yield

Majority of the respondents were agreed that the flood in 2010 due to severe rainfall have reduced the yields of Maize and especially the yields of Rice. Theis analysi have the same results toIshaqet al., 2017, whose finding tells thathigh rainfall have negative impacts on the yields of Rice but the normal rainfall increased the yield. Similarly, in the rain-fed areas, the amount of rainfall increased the yield, while in irrigated areas the yield is decreasing with a great amount of rainfall (Rehmanet al., 2011). The reported negative effects of the precipitation have been observed in Pakistan in the form of floods and droughts which have badly affected human settlements, water management, and agricultural yield. It has been estimated during the 1998-2001 that 1.18 mm/decade of rainfall decreasing.

Temperature and Rainfall Fluctuation and Crops Yield (2000-2018)

The Fig 6 and 7 (a, b, c, d) shows the actual fluctuations in rainfall, temperature, and the yield of Rice and Maize for the last eighteen years. On the basis of duration among the three groups D1 (2000-2006), D2 (2007-2012) and D3 (2013-2018).

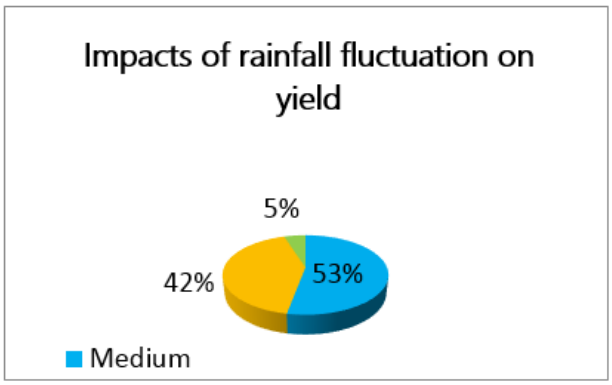

Fig 6: Rainfall impacts on Rice and Maize

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

According to graph 6 (a), the maximum temperature (25.01°C) observed in D1 (2000–2006), while the minimum temperature (19.45°C) in D2 (2007-2012). Figure 6 (b) represents the rainfall pattern in which the highest rainfall (76.21mm) experienced in the D1 (2000-2006), whereas minimum rainfall occurred in the D2 (2007-2012). Similarly, the maximum yield (93580 tons) of Maize was found in the duration D1 (2000-2006), however minimum yields of Maize as 44572 tons found in D2 (2007-2012). Likewise, the Maximum yields of Rice as 13736 tons was found in the D1 (2000-2006) and D2 (2000-2012), while minimum yields of Rice 11117 tons were found in D3 (2013-2018). Fatima and Shabbierin 2013 determined that the yield of Rice and Maize have decreased in Khyber Pakhtunkhwa and Sindh after 2000 and increasing with the passage of time. The current result is similar to Bacha et al., 2008 who found that the yields of Maize and Rice have been decreased due to change in the temperature. It is reported that Maize and Rice yield have reduced to 3.8 and 5.5% due to the highest maximum temperature recorded in 2001 (Rehman et al., 2012). According to the available literature, rainfall has decreased at the rate of (-1.18mm/decade) all over in Pakistan during 1998-2001 that finally resulted in drought condition. The yields of the Rice and Maize have been reduced as a result of fluctuation in the climatic parameters due to the changing pattern of rainfall in the monsoon sessions. The decrease in rainfall has occurred by analyzing 31 years data of Swat weather. It was also found that the high decrease in the rainfall is in the post Monsoons (Bacha et al., 2018). Hussain et al., the variation and change in temperature of Karachi and shown significant results. The perceived change in temperature is positive which has clear increasing trends. The urban temperature of Karachi has the greatest variation but it has a regular increase from 1975 to 2005. Mudasser et al., 2005 documented that in the mountain areas the temperature has increased during the last thirty years. The winter temperature in the high-mountains and Lower Mountain have also increased during the last 30 years. They also concluded that the rising temperature has positive impacts in the mountains areas and the yield of the crops have improved. However, increasing temperature enhance the melting of snow in the mountains areas during the winter season. Therefore, the overall de-glaciations process could well endanger the country's sustained sources of fresh water from glaciers and snow melting (Schmitz et al., 2015). The increase in mean annual temperature in the northern areas of Pakistan was found to be higher with a value of 0.8°C as compared to the country as a whole with 0.6°C, during the period 1901 to 2000. Furthermore, data from the Climate Research Unit (CRU) in the UK relative to the national scale indicates a higher increase in mean annual temperature in Northern Pakistan.

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

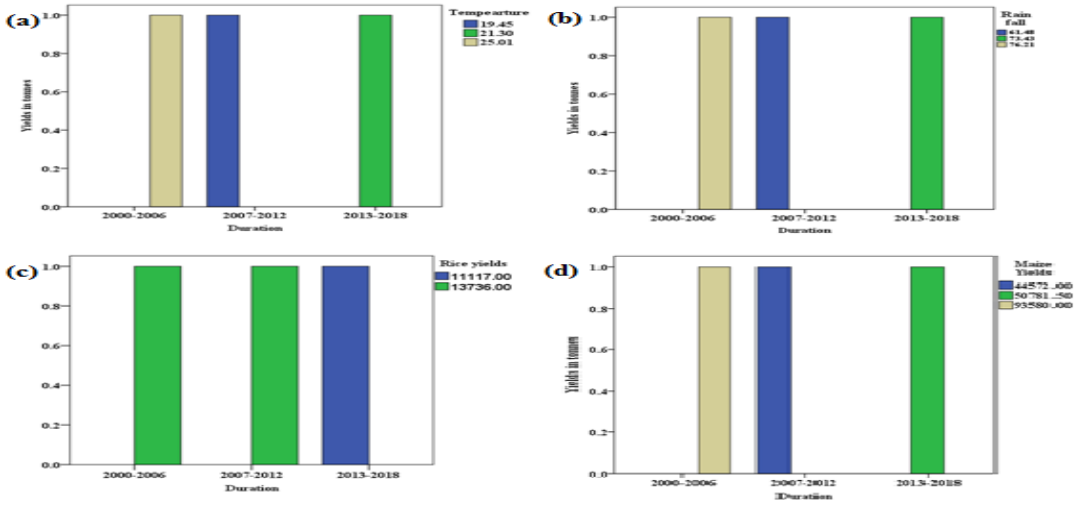

Fig 7: Graphical representation of temperature (a), rainfall (b) and Rice(c) and Maize (d) crops yield (2000-2018)

Temperature and rainfall impacts on Maize yield

Generally, as Mongora city hold low elevation therefore, the temperature is hot as compared to the areas which is located in the proximity (Rahman and Dawood, 2017). The temperature and rainfall fluctuation is due to the forest cover and low altitude. The comparative study of temperature and rainfall over the yield of Maize is represented in Fig. 7 (a) and (b). The data analysis indicated that high yield of Maize has been observed in the duration of 2000-2006 due to increase in temperature, while the minimum yields of Maize were found during 2007-2012 due to decrease in the temperature. Similarly, in fig 7. (b), the maximum yield of Maize was found with heavy rainfall in the duration of 2000-2006, whereas minimum yields of Maize were observed in the duration of 2007-2012 due to decrease in the rainfall). It was found that Maize production was increased in the mountains areas with an increase in temperature. Thus, the response of temperature to Maize crop is more favorable in the mountains than in the plane areas (Malla, 2008). Kirimi, (2016) also documented that temperature has a negative impact on Maizeyield. However, the rainfall has a positive effect on Maize yield. It was also investigated that the long-term effects of temperature on crop production. Are larger than short-term effects. Some researchers also suggested that farmer awareness is required to adopt mitigation measures against the negative effect of climate change. Rashid and Rasul (2011) reported that the Maize crop is consist of two phases such as the vegetative and the reproductive rainfall is needed in these two phases, shortage or excess during reproductive or vegetative phase decline the Maize yields.

Temperature and rainfall impacts over the yield of Rice

The comparative study of temperature and rainfall over the yield of Rice is represented in Fig 8 (a) and (b). The data analysis (2000-2018) indicated that no significant impacts were observed with the increasing temperature with Rice yields in this research study.

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

However, the yields of Rice have been increased with increased in rainfall pattern during 2000-2006 with the availability of water as it indicates a strong association with the Rice yield. Singh et al. (2000) reported that the rainfall sensitivity experiments have shown that an increase in Rice yield is due to the increase in rainfall above the observed value. But decrease in rainfall results in yield loss at a constant rate of about 8% per 2 mm/day, up to about 16 mm/day. Asada and Matsumoto (2009) reported his results that the effects of fluctuation in rainfall on the yield of Rice changes with the passage of time. However, the mechanism that causes the changes is not clear and still there are many uncertainties in the relationship between rainfall and Rice yield. It is also reported that temperature has negative effects during both the vegetative and ripening phases of the Rice plant. Higher minimum temperature reduced yield, whereas higher maximum temperature raised it (Welch et al., 2010).

CONCLUSION

This study explored the farmers' perception of the impact of temperature and precipitation fluctuations on Rice and Maize yield. The questionnaire data showed that reduced temperature and rainfall had an adverse effect on yield. However, statistical analysis of meteorological data in Swat indicated that fluctuations in rainfall and temperature also affected crop yield. The study analyzed 18 years of yield data for Maize and Rice, dividing them into three groups and comparing them with the same group patterns of rainfall and temperature. The results showed that the highest Rice yield of 13736 tons was found in D1 (2000-2006) and D2 (2007-2012), with an average temperature fluctuation of 25.01°C and 19.45°C, respectively. Similarly, Rice yields increased with increased rainfall during 2000-2006, indicating a strong association between water availability and Rice yield. The study also found that the highest Maize yield of 93580 tons was recorded in 2000-2006 with heavy rainfall, while the lowest yield of 44572 tons was observed in 2007-2012 due to a decrease in rainfall.

In conclusion, it is clear that the effects of climate change on wheat and maize crops in Pakistan are a significant concern. To address this issue, there is a need for concerted efforts to develop and implement adaptation strategies. These strategies should include the development of heat and drought-resistant crop varieties, improved irrigation techniques, and the use of sustainable agricultural practices that promote soil health and water conservation. In addition, there is a need for increased investment in research to better understand the effects of climate change on agriculture and to develop innovative solutions to these challenges. The study recommended the upgrade of the irrigation system in Swat.

In light of these recommendations, it is important that policymakers, researchers, and farmers work together to address the impacts of climate change on wheat and maize crops in Pakistan. By taking proactive steps to mitigate the effects of climate change and develop adaptation strategies, it is possible to ensure food security and support the livelihoods of millions of farmers in Pakistan.

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

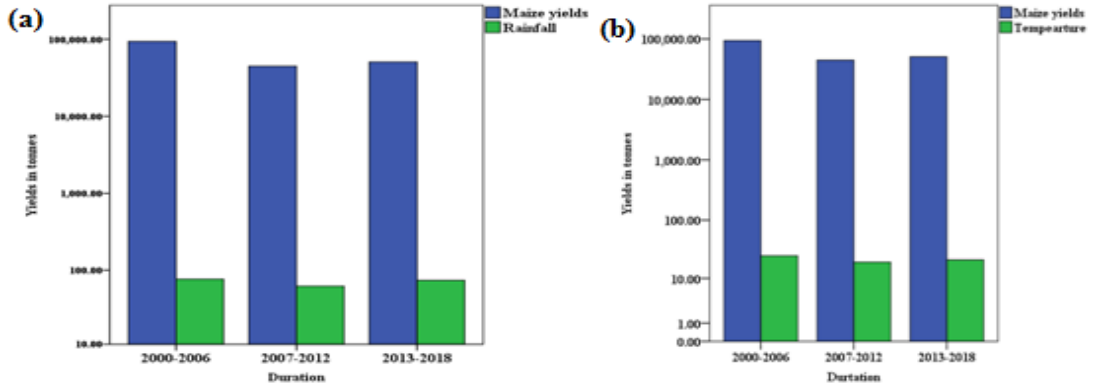

Fig 8: Impacts of rainfall (a) and temperature (b) on Maize yield

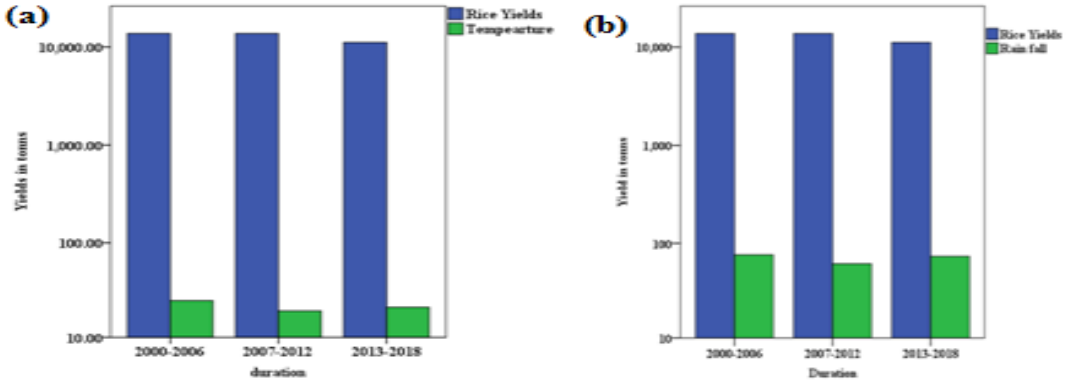

Fig 9: Impact of temperature (a) and rainfall (b) on Rice yields

Competent Interest declaration: The authors declares no conflict of interest.

References

1. Abid, M., Scheffran, J., Schneider, U. and Ashfaq, M. (2015). Farmers' perceptions of and adaptation strategies to climate change and their determinants: the case of Punjab province, Pakistan. Earth System Dynamics, 6(1), 225-243.
2. Adams, R. M., Hurd, B. H., Lenhart, S and Leary, N. (1998). Effects of global climate change on agriculture: an interpretative review. Climate research, 11(1), 19-30.
3. Ahmad, P., Ashraf, M., Younis, M., Hu, X., Kumar, A., Akram, N. A., and Al-Qurainy, F. (2012). Role of transgenic plants in agriculture and biopharming. Biotechnology advances, 30(3), 524-540.
4. Ahmed, M. N., and Schmitz, P. M. (2015). Climate change impacts and the value of adaptation-can crop adjustments help farmers in Pakistan International Journal of Global Warming, 8(2), 231-257.
5. Alexandrov, V. A and Hoogenboom, G. (2000). The impact of climate variability and change on crop yield in Bulgaria. Agricultural and forest meteorology, 104(4), 315-327
6. Ali, S., Liu, Y., Ishaq, M., Shah, T., Ilyas, A., and Din, I. U. (2017). Climate change and its impact on the yield of major food crops: Evidence from Pakistan. Foods, 6(6), 39.
7. Altieri, M. A and Nicholls, C. I. (2017). The adaptation and mitigation potential of traditional agriculture

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

in a changing climate. Climatic Change, 140(1), 33- 45.

8. Altieri, M. A. (2002). Agroecology: the science of natural resource management for poor farmers in marginal environments. Agriculture, ecosystems and environment, 93(1-3), 1-24.
9. Amjath-Babu, T. S., Krupnik, T. J., Aravindakshan, S., Arshad, M and Kaechele, H. (2016). Climate change and indicators of probable shifts in the consumption portfolios of dryland farmers in Sub-Saharan Africa: implications for policy. Ecological indicators, 67, 830-838.
10. Amjath-Babu, T. S., Krupnik, T. J., Aravindakshan, S., Arshad, M., and Kaechele, H. (2016). Climate change and indicators of probable shifts in the consumption portfolios of dryland farmers in Sub-Saharan Africa: implications for policy. Ecological indicators, 67, 830-838
11. Arshad, M., Kachele, H., Krupnik, T. J., Amjath- Babu, T. S., Aravindakshan, S., Abbas, A and Müller, K. (2017). Climate variability, farmland value, and farmers' perceptions of climate change: implications for adaptation in rural Pakistan. International Journal of Sustainable Development and World Ecology, 24(6), 532-544.
12. Asada, H., and Matsumoto, J. (2009). Effects of rainfall variation on rice production in the Ganges-Brahmaputra Basin. Climate Research, 38(3), 249-260.
13. Ashraf, S., Iftikhar, M., Shahbaz, B., Khan, G. A., and Luqman, M. (2013). Impacts of flood on livelihoods and food security of rural communities: a case study of southern Punjab, Pakistan. Pakistan Journal of Agricultural Sciences, 50(4).
14. Auffhammer, M., Ramanathan, V., and Vincent, J. R. (2012). Climate change, the monsoon, and rice yield in India. Climatic Change, 111(2), 411-424.
15. Babar, S., and Amin, A. (2014). Climate Change Impact on Rabi and Kharif Crops of Khyber-Pakhtunkhwa. Putaj Humanities and Social Sciences, 21(1), 49-56.
16. Bacha, M. S., Nafees, M and Adnan, S. (2018). Farmers' Perceptions about Climate Change Vulnerabilities and their Adaptation Measures in District Swat. Sarhad Journal of Agriculture, 34, (2), 311-326
17. Barrett, B., Charles, J. W and Temte, J. L. (2015). Climate change, human health, and epidemiological transition. Preventive medicine, 70, 69-75.
18. Bernoux, M., Branca, G., Carro, A., Lipper, L., Smith, G and Bockel, L. (2010). Ex-ante greenhouse gas balance of agriculture and forestry development programs. Scientia Agricola, 67(1), 31-40.
19. Bocchiola, D., Nana, E and Soncini, A. (2013). Impact of climate change scenarios on crop yield and water footprint of maize in the Po valley of Italy. Agricultural Water Management,116, 50-61
20. Budhathoki, N. K. (2017). Climate Change: Perceptions, Reality and Agricultural Practice: Evidence from Nepal (No. id: 11903).
21. Cairns, J. E., Hellin, J., Sonder, K., Araus, J. L., MacRobert, J. F., Thierfelder, C., and Prasanna, B. M. (2013). Adapting maize production to climate change in sub-Saharan Africa. Food Security, 5(3), 345-360
22. Fatima, N., and Shabbir, R. (2013). Temporal Analysis of Rice Yield and Climatic Trends in Pakistan. World Applied Sciences Journal, 24(10), 1330-1338
23. Fazal, A. (2015). Challenges faced by rural women while defending violence: With special reference to Malakand division, KPK province. Abasyn University Journal of Social Sciences, 8(2). 331-340.
24. Fosu-Mensah, B. Y., Vlek, P. L., and MacCarthy, D. S. (2012). Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana. Environment, Development and Sustainability, 14(4), 495-505.

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

25. Gwimbi, P. (2009). Cotton farmers' vulnerability to climate change in Gokwe District (Zimbabwe): impact and influencing factors. JÀMBÁ: Journal of Disaster Risk Studies, 2(2), 81-92
26. Hussain, A. H. (2012). Impact of credit disbursement, area under cultivation, fertilizer consumption and water availability on rice production in Pakistan (1988-2010).
27. Hussain, A., and Bangash, R. (2017). Impact of Climate Change on Crops' Productivity across Selected Agro-ecological Zones in Pakistan. The Pakistan Development Review, 56(2), 163-187
28. Hussain, S. S., Mudasser, M., Sheikh, M. M., and Manzoor, N. (2005). Climate change and variability in mountain regions of Pakistan implications for water and agriculture. Pakistan Journal of Meteorology, 2(4).
29. Ilyas, M., Shinwari, Z. K and Qureshi, R. (2012). Vegetation composition and threats to the montane temperate forest ecosystem of Qalagai hills, Swat, Khyber Pakhtunkhwa, Pakistan. Pak. J. Bot, 44, 113-122.
30. Imran, A., Zaman, Q and Afzal, M. (2013). Temporal trends in the peak monsoonal precipitation events over Northeast Pakistan. Pakistan journal of Meteorology, 10(19). 19-30.
31. Jan, F. Palynological studies and Holocene ecosystem dynamics in north western Khyber Pakhtunkhwa Province of Pakistan in the Hindu Kush Himalayan region.
32. Karaba, A., Dixit, S., Greco, R., Aharoni, A., Trijatmiko, K. R., Marsch-Martinez, N. and Pereira, A. (2007). Improvement of water use efficiency in rice by expression of HARDY, an Arabidopsis drought and salt tolerance gene. Proceedings of the National Academy of Sciences, 104(39), 15270-15275.
33. Khan, A., Ali, S., Shah, S. A., and Fayaz, M. (2018). Impact of temperature and precipitation on net revenue of maize growers in Khyber Pakhtunkhwa, Pakistan. Sarhad Journal of Agriculture, 34(4), 729-739.
34. Khattak, P and Shabbir, R. (2012). Temporal analysis of wheat yield and climatic trends in Pakistan. Elixir Agriculture, 52, 11598-11603.
35. Kimball, B. A. (2008). Climate Variability and the Global Harvest: Impacts of El Niño and Other Oscillations on Agroecosystems. Crop Science, 48(5), 2049-2050.
36. Kurukulasuriya, P and Ajwad, M. I. (2007). Application of the Ricardian technique to estimate the impact of climate change on smallholder farming in Sri Lanka. Climatic Change, 81(1), 39-59.
37. Lobell, D. B and Field, C. B. (2007). Global scale climate–crop yield relationships and the impacts of recent warming. Environmental research letters, 2(1), 014002.
38. Lobell, D. B., and Asner, G. P. (2003). Climate and management contributions to recent trends in US agricultural yields. Science, 299(5609), 1032-1032.
39. Lobell, D. B., Schlenker, W., and Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. Science, 1204531.
40. Luo, Q., Bellotti, W., Williams, M and Bryan, B. (2005). Potential impact of climate change on wheat yield in South Australia. Agricultural and Forest Meteorology, 132(3-4), 273-285.
41. Malla, G. (2008). Climate change and its impact on Nepalese agriculture. Journal of agriculture and environment, 9, 62-71.
42. Nafees, M., and Asghar, A. (2009). Forest fire events in Swat valley, Pakistan. Pak J. Plant Sci, 15(1), 31-37.
43. Nelson, G. C., Valin, H., Sands, R. D., Havlík, P., Ahammad, H., Deryng, D and Kyle, P.(2014). Climate change effects on agriculture: Economic responses to biophysical shocks. Proceedings of

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

the National Academy of Sciences, 111(9), 3274-3279.

44. Ochieng, J., Kirimi, L., and Mathenge, M. (2016). Effects of climate variability and change on agricultural production: The case of small scale farmers in Kenya. NJAS-Wageningen Journal of Life Sciences, 77, 71-78
45. Olesen, J. E., and Bindi, M. (2002). Consequences of climate change for European agricultural productivity, land use and policy. European journal of agronomy, 16(4), 239-262.
46. Ortiz, R., Sayre, K. D., Govaerts, B., Gupta, R., Subbarao, G. V., Ban, T and Reynolds, M. (2008). Climate change: can wheat beat the heat. Agriculture, Ecosystems and Environment, 126(1-2), 46-58.
47. Ovuka, M., andLindqvist, S. (2000). Rainfall variability in Murang'a District, Kenya: Meteorological data and farmers' perception. Geografiska Annaler: Series A, Physical Geography, 82(1), 107-119.
48. Rahman, A., & Dawood, M. (2017). Spatio-Statistical analysis of temperature fluctuation using Mann-Kendall and Sen's Slope Approach. Climate dynamics, 48(3-4), 783-797.
49. Rashid, K., and Rasul, G. (2011). Pakistan Journal of Meteorology, 8(15), 63-74.
50. Rashid, K., and Rasul, G. (2011). Rainfall variability and maize production over the potohar plateau of Pakistan. Pakistan Journal of Meteorology, 8(15), 63-74.
51. Rasul, G., Mahmood, A., Sadiq, A and Khan, S. I. (2012). Vulnerability of the Indus delta to climate change in Pakistan. Pakistan journal of meteorology, 8(16). 89-107.
52. Rosenzweig, C., Elliott, J., Deryng, D., Ruane, A. C., Müller, C., Arneth, A. and Neumann, K. (2014). Assessing agricultural risks of climate change in the 21st century in a global gridded crop model inter comparison. Proceedings of the National Academy of Sciences, 111(9), 3268-3273.
53. Rowhani, P.,Lobell, D. B., Linderman, M., and Ramankutty, N. (2011). Climate variability and crop production in Tanzania. Agricultural and Forest Meteorology, 151(4), 449-460.
54. Ruamsuke, K., Dhakal, S and Marpaung, C. O. (2015). Energy and economic impacts of the global climate change policy on Southeast Asian countries: A general equilibrium analysis. Energy, 81, 446-461.
55. Sajjad, S. H., Hussain, B., Khan, M. A., Raza, A., Zaman, B., and Ahmed, I. (2009). On rising temperature trends of Karachi in Pakistan. Climatic change, 96(4), 539-547.
56. Salma, S., Rehman, S., and Shah, M. A. (2012). Rainfall trends in different climate zones of Pakistan. Pakistan Journal of Meteorology, 9.
57. Salma, S., Shah, M. A and Rahman, S. (2012). Rainfall trends in different climate zones of Pakistan. Pakistan Journal of Meteorology, 9(17). 37-46
58. Saseendran, S. A., Singh, K. K.,Rathore, L. S., Singh, S. V., and Sinha, S. K. (2000). Effects of climate change on rice production in the tropical humid climate of Kerala, India. Climatic Change, 44(4), 495-514.
59. Sarker, M. A. R., Alam, K., andGow J. (2012). Exploring the relationship between climate change and rice yield in Bangladesh: An analysis of time series data. Agricultural Systems, 112, 11-16.
60. Seo, S. N., and Mendelsohn, R. (2008). An analysis of crop choice: Adapting to climate change in South American farms. Ecological economics, 67(1), 109-116.
61. Shakoor, U., Saboor, A., Ali, and Mohsin, A. Q. (2011). Impact of climate change on agriculture: empirical evidence from arid region. Pak. J. Agri. Sci, 48(4), 327-333.
62. Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P and Scholes, B. (2007). Policy and

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 66 Issue 06 | 2023
DOI 10.17605/OSF.IO/FN2GY

technological constraints to implementation of greenhouse gas mitigation options in agriculture. Agriculture, Ecosystems and Environment, 118(1-4), 6-28.

63. Stevenson, J. R., Villoria, N., Byerlee, D., Kelley, T and Maredia, M. (2013). Green Revolution research saved an estimated 18 to 27 million hectares from being brought into agricultural production. Proceedings of the National Academy of Sciences, 110(21), 8363-8368.
64. Schlenker, W., and Lobell, D. B. (2010). Robust negative impacts of climate change on African agriculture. Environmental Research Letters, 5(1), 014010.
65. Tao, F., Yokozawa, M., Xu, Y., Hayashi, Y and Zhang, Z. (2006). Climate changes and trends in phenology and yields of field crops in China, 1981–2000. Agricultural and Forest Meteorology, 138(1-4), 82-92.
66. Theurillat, J. P., and Guisan, A. (2001). Potential impact of climate change on vegetation in the European Alps: a review. Climatic change, 50(1-2), 77-109.
67. Trnka, M., Rötter, R. P., Ruiz-Ramos, M., Kersebaum, K. C., Olesen, J. E., Žalud, Z and Semenov, M. A. (2014). Adverse weather conditions for European wheat production will become more frequent with climate change. Nature Climate Change, 4(7), 637.
68. Vedwan, N and Rhoades, R. E. (2001). Climate change in the Western Himalayas of India: a study of local perception and response. Climate research, 19(2), 109-117.
69. Wang, J., Mendelsohn, R., Dinar, A., Huang, J., Rozelle, S., and Zhang, L. (2009). The impact of climate change on China's agriculture. Agricultural Economics, 40(3), 323-337.
70. Webb, P., Block, S and Valenzuela, E. Projected Impacts of a Regional Nuclear Conflict on Global Food Supply, Consumption and Under nutrition.
71. Welch, J. R., Vincent, J. R., Auffhammer, M., Moya, P. F., Dobermann, A and Dawe, D. (2010). Rice yields in tropical/subtropical Asia exhibit large but opposing sensitivities to minimum and maximum temperatures. Proceedings of the National Academy of Sciences, 107(33), 14562-14567.
72. Wheeler, T and Von Braun, J. (2013). Climate change impacts on global food security. Science, 341(6145), 508-513.
73. Wolt, J. D., Wang, K., and Yang, B. (2016). The regulatory status of genome-edited crops. Plant biotechnology journal, 14(2), 510-518.
74. Zhang, J. (2004). Risk assessment of drought disaster in the maize-growing region of Songliao Plain, China. Agriculture, ecosystems and environment, 102(2), 133-153.