Journal of Environmental Science and Economics
https://doi.org/10.56556/jescae.v3i1.731
ISSN: 2832-6032

REVIEW ARTICLE

Climate change and its impacts in rural areas of Pakistan: a Literature review

Abdul Rasool Khoso[1], Gu Jintu[1], Shahnaz Bhutto[1*], Muhammad Javed Sheikh[2], Kainat Vighio[2] Arshad Ali Narejo[2]

[1]Department of Sociology, School of Public Administration, Hohai University Nanjing Jiangsu P.R China
[2]Department of Rural Sociology, Faculty of Agricultural Social sciences, Sindh Agriculture University Tandojam Sindh Pakistan

Corresponding author: Shahnaz Bhutto: shahnaz.socio.95@gmail.com
Received: 15 December, 2023, Accepted: 18 January, 2024, Published: 21 January, 2024

Abstract
Pakistan, which is located in Southeast Asia, is one of the nations that is most susceptible to the effects of climate change, as seen by the increased frequency of floods and droughts. Variations in climate have a negative impact on a number of areas, such as the agricultural industry, groundwater levels, dietary resources, soil quality and organic matter content, public health, and poverty rates. This study's main goal is to evaluate the impact of climate change and the adaptations farms have made in response to variations in precipitation and temperature. Pakistani farmers have responded to climate change by implementing a variety of adaptive techniques. These tactics include changing the way that fertilizer is used, changing crop varieties, using pesticides, improving seed quality, diversifying the farm, planting shade trees, changing irrigation techniques, engaging in off-farm activities, and migrating both permanently and temporarily. As an additional adaptive step, some farmers have turned to asset sales. Additionally, research indicates that agricultural households in wetland areas experience less volatility in climate than those in arid regions.

Keywords: Climate Change; Impacts; Rural Areas; Pakistan

Introduction

Global warming has far-reaching consequences that can harm natural ecosystems and eventually have an influence on highland economies (Wang, 2024; Chow et al., 2024). Climate is a major factor in agricultural output; temperature and precipitation are two major factors that influence farm productivity (Ozdemir, 2022). The agriculture industry is by its very nature complicated, full of dangers, and unpredictable. Farmers must contend with the unpredictable nature of returns on their investments in agriculture as well as the possibility of declining agricultural output as a result of climate change (Syed, et al. 2022). The most vulnerable people to climate changes in emerging countries are small subsistence farmers and rural residents. They encounter difficulties as a result of restricted access to productive alternatives and weak adaptation abilities (Sohail, et al, 2022). Climate change consequences are very geographically varied, with large differences within and across places, particularly in non-industrialized and humid countries (Singh et al., 2024; Ma et al., 2023). These differences in climatic circumstances are predicted by researchers like, Abbass, et al. (2022); Kaiser, et al. 2022) to result in a higher frequency of unpredictable climate events and calamities such storms, cyclones, floods, and droughts.

These difficulties may be related to the global geographic distribution of vulnerable areas, resource scarcity, increased climate exposure, and the rapid population rise (Isfat and Raihan, 2022). Pakistan is one of the areas that is most susceptible to the effects of climatic catastrophes. Temperature changes, variations in rainfall, and a propensity for hazardous situations are only a few examples of these events (IPCC, 2014; Fahad, et al. 2022). Floods and droughts are the main natural disasters that put people at risk for economic and social problems, and they frequently result in fatalities. Because they have fewer resources and adaptive capacity, rural communities in underdeveloped nations are more vulnerable to floods (Fahad and Wang, 2020). Ecological and climatic changes have a significant impact on these nations' flood severity and intensity. Pakistan's agricultural sector has had significant challenges while making a significant economic contribution to the nation, mostly as a result of devastating floods (Ahmed et al., 2023; Rasool et al., 2021). Consequently, it is critical to modify the agricultural sector to address the effects of flooding in order to protect farming communities' means of subsistence. In terms of exposure to the effects of climatic variability, Pakistan was placed 12th in 2012, 8th in 2015, and 7th overall (Kreft and Eckstein, 2013). Pakistan has seen several extreme weather events in the past few years, such as storms, cyclones, droughts, and floods (Hussain, et al., 2020; Tingju et al., 2014). These natural disasters are occurring more often and resulting in larger losses (Ullah & Takaaki, 2016). Numerous rural residents in Pakistan have been severely affected by natural catastrophes, such as the floods that occurred between 2010 and 2014 (Fahad and Wang, 2020). Several studies have demonstrated how highly susceptible Pakistani farming communities are to fluctuations in the country's climate (Wade, & Jennings,2016; Elahi, et al., 2022). Scholars across have repeatedly recognized how these communities are affected by differences in the climate (Wheeler, & von Braun, 2013; Khan et al., 2023). The recurring occurrence of climate risks is a persistent concern for Pakistan; in spite of advancements in guidelines, regulations, affordable instruments, and feasible interventions, the nation still lacks proper implementation (Hussain, et al., 2023). Therefore, this research examines how Pakistani agricultural households have responded to changes in climate, adaptability, and variability.

Pakistan's rural regions are becoming more and more susceptible to the negative impacts of climate change, such as increased temperatures, altered precipitation patterns, and extreme weather events. Significant obstacles to Pakistani rural populations' livelihoods, agriculture, and general well-being are presented by these environmental changes (Mahmood & Hassan, 2022). Comprehensive study is yet desperately needed to determine the precise nature and scope of these effects, as well as to design and put into practice efficient plans for these regions' adaptation and mitigation to climate change. The purpose of this research is to examine the many effects of climate change in Pakistan's rural areas and evaluate current and future approaches to mitigating these issues. The study on the effects of climate change in Pakistan's rural regions innovates by addressing a perspective that is usually ignored and concentrating specifically on the unique difficulties that rural populations experience. In order to fully comprehend the complex consequences of climate change on rural communities, the research integrates ideas from environmental science, sociology, and economics through an interdisciplinary approach. The study promotes participatory approaches and community participation to include local viewpoints, hence promoting a more comprehensive and context-specific analysis. The research also seeks to offer practical suggestions and policy implications, focusing on solutions specific to the vulnerabilities noted in the literature review. This will help to create a more comprehensive and successful response to climate change in Pakistan's rural areas.

The paper will commence with an introduction offering a comprehensive overview of climate change in rural Pakistan, followed by a literature review that systematically analyzes the multifaceted impacts of climate change on agriculture (water, livelihood and community), poverty and health in these rural areas.

Methodology

A comprehensive literature search was conducted across various electronic databases, including Academic Search Complete, CAB abstracts, GEOBASE, Google Scholar, Sci ELO, Scopus, and Science Direct (de Araujo et al., 2021). Specific search terms such as "Climate Change," "Impacts," "Rural Areas," "Pakistan," and "Asia" were employed to identify pertinent peer-reviewed articles. In addition to academic databases, supplementary sources from the internet and organizational databases like the World Health Organization, UNFCCC, and the International Development Research Centre were also consulted. This dual-pronged approach aimed to encompass a diverse range of literature, including grey literature, reports, books, and other relevant publications pertaining to the impacts of climate change in rural areas of Pakistan. The criteria for inclusion were based on a direct and clear reference to the topic of climate change and its ramifications in rural regions. Harari et al., (2020) articulated that, the comprehensive search strategy across both academic and non-academic sources ensures a thorough and inclusive overview of the existing literature on the subject.

Results and Discussion

The combined search of publicly available reports and peer reviewed articles generated a total of 61 reports, of which 49 were found to be relevant to this review. The selected documents are predominantly case studies that have discussed agricultural practices and the effects of these on climate change. Most also documented the negative effects of climate change, temperature variations at the local level, often linking those effects with agricultural back off problems. Which were causing the damage to agricultural crops as well as local lives at greater extent.

Effects of climate change on agriculture

A vital industry in every country, agriculture constantly suffers from the negative effects of climate change. In recent decades, these effects of climatic variability have become more subtle (Patt et al., 2009). Climate change has profound implications for agriculture, affecting various facets of crop production, livestock management, and overall food security (Mutengwa et al., 2023). Predictions on climatic variability point to a dynamic climate characterized by increased susceptibilities, particularly in areas with lower incomes (Roy, et al., 2023; Celis, et al., 2023). The capacity to adjust to these threats substantially influences the magnitude of these climatic events' consequences (Ahmed, et al., 2021). The influence of non-climatic factors on adaptation decisions is a critical component of the adaptation process at the farm level. Decision-makers in agriculture, farm households traverse a multifaceted terrain made up of institutional, political, biophysical, and economic factors (Debelle, 2019). Furthermore, climate change can influence the proliferation of pests and diseases, introducing new threats to agricultural productivity. Crucial to mitigating these adverse effects is the implementation of adaptation strategies, including the development of climate-resilient crops, enhanced water management, and the adoption of sustainable farming practices, all of which are essential for ensuring global food security (Balasundram et al., 2023). Regarding the effects of climate change, Pakistan stands out as one of the developing nations most at risk (Parveen & Sharma, 2019). The frequency and intensity of climate disasters, such as floods, droughts, high temperatures, water scarcity, and an increase in pests and illnesses in some areas, have already increased throughout the country (Aslam, et al., 2020). Pakistan moved up to the 16th most susceptible position in 2010–2011, from its 2009–2010 ranking of 29th among the most vulnerable areas, according to the Global Climate Change Vulnerability Index (CCVI) study (Khan and Fee, 2014). Prominent meteorological incidents in Pakistan, such the floods that occurred in 2010, and 2014 and 2022, together with a protracted drought that lasted from 1999 to 2003, provide dramatic illustrations of the growing frequency of meteorological issues.

Due to high rates of poverty and a lack of material and financial resources, Pakistan struggles to adapt (Abid et al., 2015; Naureen, et al., 2022). Farmers' decisions on how to adjust to climatic variability and related hazards are influenced by these diverse experiences, either directly or indirectly (Abid et al., 2015; Adger et al., 2005; Ahmed, et al., 2019)."

The responses of farmers and their capacity for adaptation are further explained by a number of additional elements, such as agricultural methods, personal traits, and particular situations (Bryan et al., 2009). Extreme climate variability has a significant impact on social, economic, and natural ecosystems and adds to upcoming problems (Seddon et al., 2020). Climate variability increases the severity and frequency of natural events; indirect effects of climate variability include changes to the properties of land and water, variations in the rates of insect infestation, adjustments to the amount of moisture in the soil, and changes to the distribution of diseases. In less developed, agriculturally based economies, increased temperatures, erratic precipitation patterns, and lower crop yields directly affect food security. According to Godde et al. (2021), areas where agriculture is the main source of income are therefore especially susceptible to the negative consequences of climatic variability.

According to Thornton et al., (2014), climatic variability has a substantial effect on the agricultural industry by changing or reducing productive dimensions and by increasing risks associated with production, both direct and indirect. Wide-ranging effects of climate variability are seen in the environment and many socioeconomic areas, including as agriculture, food security, water resources, terrestrial ecosystems, biodiversity, and human health. Changes in the patterns of precipitation are probably going to make floods and water scarcity worse. Increased temperatures alter agricultural growing seasons, which affects food security and the spread of illnesses, raising the danger of diseases like malaria. According to UNFCCC (2008), rising temperatures also accelerate the rate of habitat damage and species extinction. Ahmed et al., (2023) further elaborated that, elevated temperatures can impact crop growth and development, leading to shifts in yield patterns and the geographical distribution of crops. Altered precipitation patterns may result in both water scarcity and excess, affecting crop irrigation and livestock water supply.

Climate Change and its impacts on poverty and health

Temperature variations can have a big effect on people's health. In 2000, it was discovered that variations in climate were accountable for around 2.4% of diarrhea cases worldwide and 6% of malaria instances in different low-income areas (WHO, 2002). Pakistan stands out among developing nations, especially those in Southeast Asia, backward in health (Khoso et al., 2022), for being very vulnerable to climate-related disasters including floods and droughts. Devastating floods occurred in Pakistan between 2010 and 2014, causing significant loss of life and property along with widespread population relocation. In Pakistan, insect infestations, seasonal and flash floods, and droughts are only a few other climate-related phenomena. Casson et al., (2023) stated that Climate change introduces various health risks. Increased temperatures can lead to heat-related illnesses, while altered precipitation patterns may result in waterborne diseases and the spread of vector-borne diseases like malaria and dengue. Extreme weather events can disrupt healthcare infrastructure, limiting access to medical services and exacerbating health disparities.

Strategies for adapting to climate change in Pakistan

The agricultural industry demonstrates a capacity to quickly adopt new technologies, modifications to resource management practices, and adaptable tactics (Rehman et al., 2022). Researchers Fahad and Wang (2020) used household surveys to study adaptation strategies in rural Khyber Pakhtunkhwa province, Pakistan. The study found that the region's main adaptation strategies included changing crop types and varieties, managing pesticides,

improving seed quality, planting shade trees, diversifying farming activities, and storing water. It is a common occurrence for people to adapt to the effects of climatic fluctuation in general and on the farming industry in particular. Effective adaptation to climatic variability requires modifications and adaptations at all scales, from the local community to the national and international levels (Kalogiannidis et al. 2022).

In order to handle current and future climatic challenges, it is crucial to build community resilience through the adoption of appropriate technologies, the preservation of traditional knowledge, and the diversification of livelihoods. The need of appropriate crop replacement was also stressed by Mendelsohn et al. (2007) in their analysis of how climatic variability affects agriculture. The IPCC Third Assessment Report states that although adaption strategies are not foolproof and have a cost associated with them, they can lessen the negative consequences of climate variability and increase positive outcomes. Additionally, it is contended that strategic adaptation can support autonomous adaptation and that both human and natural systems will adapt to some degree spontaneously. So far, the implementing afforestation programs to enhance carbon sequestration and promote biodiversity. Restore degraded ecosystems to improve resilience against climate impacts and sustain ecosystem services (Sargani et al., 2023).

However, the potential for adaptation for human systems is greater than that for the preservation of natural systems (Solomon , 2007). It is essential to combine community and governmental actions with traditional knowledge and local coping strategies. Governmental and non-governmental organizations (NGOs) should include climate variability into their policies at all levels of decision-making in order to promote successful adaptation measures. Farmers use a variety of tactics, such as changing planting and harvesting times and applying a range of agronomic techniques, to deal with climatic unpredictability and optimize earnings (Agesa et al., 2019). Robert et al. (2016) conducted a research that employed household survey methodologies to identify major adaptation measures in the study region. These tactics included planting trees, changing planting dates, conserving soil, and utilizing various crop kinds. Nevertheless, even though there were discernible variations in temperature and precipitation, a sizable proportion of farm households did not make any changes to their farming methods. Crop diversity is an adaptation technique that focuses on reducing the risk of total crop failure instead than only increasing the production of a particular crop (Huong et al., 2017). Crop diversification is a commonly used adaptation method in Pakistan to mitigate the effects of climate events (Fahad and Wang, 2018). According to earlier research (Kristiansen, 2022), using a variety of crop kinds in the same season may help farm households save money and have more access to resources. Farmers can be less vulnerable to climate change, particularly if they have income sources other than farming (Johnston & Cooper, 2022).

Off-farm pursuits might involve labor or ancillary enterprises like Pakistani stores. Pakistani farmers have frequently used a variety of soil and water conservation techniques in an attempt to mitigate soil erosion and degradation, with the goal of restoring their fields as a result (Fahad and Wang, 2020; Fahad and Wang, 2018). Pakistani farmers acknowledge that one way they cope with climate dangers is by selling assets. One of the most important adaptation measures used in Pakistan is irrigation, which is also widely used.

A significant fraction of farmers in Pakistan live in distant locations, own tiny landholdings, and have no formal education. The best way to determine how farm households perceive climate change is through household surveys. Research by Abid et al. (2015) and Fahad and Wang (2018) has demonstrated a substantial relationship between the perception of climate change and the household head's age and agricultural experience. For example, compared to less educated and less experienced farmers, educated and experienced farmers are more likely to recognize climate change. It is also thought that knowledge of climatic fluctuations is favorably correlated with the education degree of the family head. Access to extension services and information on climate problems for farmers increases knowledge and creates a favorable environment for the adoption of new cropping patterns.

Conclusion

In conclusion, the literature analysis on the effects of climate change in Pakistan's rural regions highlights the necessity of using an interdisciplinary approach to address the unique problems that these people confront. The report calls for community participation to include local viewpoints into solutions by highlighting the complex relationships between environmental, social, and economic elements that contribute to vulnerabilities in rural areas. It suggests a holistic approach that encompasses community-based adaption strategies, policy lobbying, and the promotion of sustainable behaviors, and it asks for context-specific suggestions and policy implications. In order to improve resilience and promote sustainable development in the face of climate change in rural Pakistan, this review offers insightful information for next studies and useful solutions. By emphasizing the importance of considering local nuances and collaborating with communities, it paves the way for more effective and culturally sensitive interventions in the ongoing battle against the impacts of climate change.

Declaration: We (all authors) declare that the paper is our original work and is not published anywhere.

Acknowledgement: I would like to express my sincere gratitude to all my Co-Authors for their invaluable guidance, unwavering support, and insightful feedback throughout the entire research process. Their expertise and encouragement played a pivotal role in shaping the direction of this study. Additionally, I extend my appreciation to all the authors for their constructive discussions and collaborative efforts that enriched the quality of this work. Lastly, I want to acknowledge the participants of this study, whose willingness to share their experiences was instrumental in the successful completion of this research."

Fundings: There is no funding for this study

Conflicts of Interests: Authors declare no conflict of interests

Authors contribution: All authors contributed equally, including review literature, data write-up, data collection from various sources as well as final checkups.

Data Availability: All the secondary/ literature based data is available in the paper.

References

Abbass, K., Qasim, M. Z., Song, H., Murshed, M., Mahmood, H., & Younis, I. (2022). A review of the global climate change impacts, adaptation, and sustainable mitigation measures. *Environmental Science and Pollution Research, 29*(28), 42539-42559.

Abid M, Scheffran J, Schneider UA, Ashfaq M (2015) Farmers' perceptions of and adaptation strategies to climate change and their determinants: the case of Punjab province, Pakistan. Earth Syst Dyn 6:225–243.

Adger WN, Arnell NW, Tompkins EL (2005) Successful adaptation to climate change across scales. Glob Environ Chang 15:77–86.

Agesa, B. L., Onyango, C. M., Kathumo, V. M., Onwonga, R. N., & Karuku, G. N. (2019). Climate change effects on crop production in Yatta sub-county: farmer perceptions and adaptation strategies. *African Journal of Food, Agriculture, Nutrition and Development, 19*(1), 14010-14042.

Ahmad, S., Jia, H., Ashraf, A., Yin, D., Chen, Z., Xu, C., ... & Ahmed, R. (2023). Water resources and their management in Pakistan: A critical analysis on challenges and implications. Water-Energy Nexus.

Ahmed, M., Asim, M., Ahmad, S., & Aslam, M. (2023). Climate Change, Agricultural Productivity, and Food Security. In Global Agricultural Production: Resilience to Climate Change (pp. 31-72). Cham: Springer International Publishing.

Ahmed, Z., Guha, G. S., Shew, A. M., & Alam, G. M. (2021). Climate change risk perceptions and agricultural adaptation strategies in vulnerable riverine char islands of Bangladesh. *Land use policy*, *103*, 105295.

Ahmed, K., Shahid, S., Chung, E. S., Wang, X. J., & Harun, S. B. (2019). Climate change uncertainties in seasonal drought severity-area-frequency curves: Case of arid region of Pakistan. *Journal of Hydrology*, *570*, 473-485.

Aslam, H. M. U., Butt, A. A., Shabir, H., Javed, M., Hussain, S., Nadeem, S. & Arshad, S. (2020). Climatic Events and Natural Disasters of 21st Century: A Perspective of Pakistan. *International Journal of Economic and Environmental Geology*, *11*(2), 46-54.

Balasundram, S. K., Shamshiri, R. R., Sridhara, S., & Rizan, N. (2023). The Role of Digital Agriculture in Mitigating Climate Change and Ensuring Food Security: An Overview. Sustainability, 15(6), 5325.

Bryan E, Deressa TT, Gbetibouo GA, Ringler C (2009) Adaptation to climate change in Ethiopia and South Africa: options and constraints. Environ Sci Pol 12:413–426.

Casson, N., Cameron, L., Mauro, I., Friesen-Hughes, K., & Rocque, R. (2023). Perceptions of the health impacts of climate change among Canadians. BMC Public Health, 23(1), 1-13.

Celis, N., Casallas, A., Lopez-Barrera, E. A., Felician, M., De Marchi, M., & Pappalardo, S. E. (2023). Climate Change, Forest Fires, and Territorial Dynamics in the Amazon Rainforest: An Integrated Analysis for Mitigation Strategies. *ISPRS International Journal of Geo-Information*, *12*(10), 436.

Chow, T. N., Tam, C. Y., Chen, J., & Hu, C. (2024). Effects of Background Synoptic Environment in Controlling South China Sea Tropical Cyclone Intensity and Size Changes in Pseudo-Global Warming Experiments. Journal of Climate.

de Araujo, P. C., Gutierres, R. C., & Hjørland, B. (2021). Citation indexing and indexes. KO KNOWLEDGE ORGANIZATION, 48(1), 72-101.

Debelle, G. (2019, March). Climate change and the economy. In *Speech at public forum hosted by Centre for Policy Development, Sydney, Australia, March* (Vol. 12).

Elahi, E., Khalid, Z., Tauni, M. Z., Zhang, H., & Lirong, X. (2022). Extreme weather events risk to crop-production and the adaptation of innovative management strategies to mitigate the risk: A retrospective survey of rural Punjab, Pakistan. *Technovation*, *117*, 102255.

Fahad, S., Adnan, M., Saud, S., & Nie, L. (Eds.). (2022). *Climate change and ecosystems: challenges to sustainable development*. CRC Press.

Fahad, S., & Wang, J. (2020). Climate change, vulnerability, and its impacts in rural Pakistan: a review. *Environmental Science and Pollution Research*, *27*, 1334-1338.

Fahad, S., & Wang, J. (2018). Farmers' risk perception, vulnerability, and adaptation to climate change in rural Pakistan. *Land use policy*, *79*, 301-309.

Godde, C. M., Mason-D'Croz, D., Mayberry, D. E., Thornton, P. K., & Herrero, M. (2021). Impacts of climate change on the livestock food supply chain; a review of the evidence. *Global food security*, *28*, 100488.

Harari, M. B., Parola, H. R., Hartwell, C. J., & Riegelman, A. (2020). Literature searches in systematic reviews and meta-analyses: A review, evaluation, and recommendations. Journal of Vocational Behavior, 118, 103377.

Huong,T,L,N., Shun Bo, Y., & Fahad, S. (2017). Farmers' perception, awareness and adaptation to climate change: evidence from northwest Vietnam. *International Journal of Climate Change Strategies and Management*, *9*(4), 555-576.

Hussain, M., Butt, A. R., Uzma, F., Ahmed, R., Irshad, S., Rehman, A., & Yousaf, B. (2020). A comprehensive review of climate change impacts, adaptation, and mitigation on environmental and natural calamities in Pakistan. *Environmental monitoring and assessment*, *192*, 1-20.

Hussain, M. A., Shuai, Z., Moawwez, M. A., Umar, T., Iqbal, M. R., Kamran, M., & Muneer, M. (2023). A Review of Spatial Variations of Multiple Natural Hazards and Risk Management Strategies in Pakistan. *Water*, *15*(3), 407.

IPCC (2014) Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change

Isfat, M., & Raihan, A. (2022). Current practices, challenges, and future directions of climate change adaptation in Bangladesh. *Journal homepage: www. ijrpr. com ISSN*, *2582*, 7421.

Johnston, W., & Cooper, A. (2022). Small islands and climate change: analysis of adaptation policy in the Cayman Islands. *Regional Environmental Change*, *22*(2), 45.

Kaiser, H. M., Riha, S. J., Wilks, D. S., & Sampath, R. (2022). Adaptation to global climate change at the farm level. In *Agricultural dimensions of global climate change* (pp. 136-152). Routledge.

Kalogiannidis, S., Kalfas, D., Chatzitheodoridis, F., & Papaevangelou, O. (2022). Role of crop-protection technologies in sustainable agricultural productivity and management. *Land*, *11*(10), 1680.

Khan JA, Fee L (2014) Cities and climate change initiative-abridged report: Islamabad Pakistan, climate change vulnerability assessment. United Nations Human Settlements Programme (UN-Habitat).

Khan, S., Gaira, K. S., Asgher, M., Verma, S., Pant, S., Agrawala, D. K., ... & Kesawat, M. S. (2023). Temperature Induced Flowering Phenology of Olea ferruginea Royle: A Climate Change Effect. Sustainability, 15(8), 6936.

Khoso, A. R., Akhtar, F., Narejo, A. A., Mallah, S. A., Vighio, K., & Sanjrani, D. K. (2022). COMPARATIVE ANALYSIS OF SERVICE QUALITY BETWEEN PUBLIC AND PRIVATE HOSPITALS, USING SERVQUAL MODEL: A CASE STUDY OF PESHAWAR, PAKISTAN. *MEDFARM: Jurnal Farmasi dan Kesehatan*, *11*(2), 240-252.

Kreft S, Eckstein D (2013) Global Climate Risk Index 2014: who suffers most from extreme weather events? Weather-Related Loss Events in 2012 and 1993 to 2012. Germanwatch eV, Bonn.

Kristiansen, K. (2022). Archaeology and the genetic revolution in European prehistory. *Elements in the Archaeology of Europe*.

Ma, L., Zhu, Z., Li, S., & Li, J. (2023). Analysis of spatial and temporal changes in human interference in important ecological function areas in China: the Gansu section of Qilian Mountain National Park as an example. Environmental Monitoring and Assessment, 195(9), 1029.

Mahmood, S., & Hassan, Q. (2022). CLIMATE CHANGE: ITS IMPACTS ON PAKISTAN. *International Research Journal of Social Sciences and Humanities*, *1*(2), 20-32.

Mendelsohn, R. (2007). Measuring climate impacts with cross-sectional analysis. *Climatic Change*, *81*(1), 1.

Mutengwa, C. S., Mnkeni, P., & Kondwakwenda, A. (2023). Climate-Smart Agriculture and Food Security in Southern Africa: A Review of the Vulnerability of Smallholder Agriculture and Food Security to Climate Change. Sustainability, 15(4), 2882.

Noureen, A., Aziz, R., Ismail, A., & Trzcinski, A. P. (2022). The impact of climate change on waterborne diseases in Pakistan. *Sustainability and Climate Change*, *15*(2), 138-152.

Ozdemir, D. (2022). The impact of climate change on agricultural productivity in Asian countries: a heterogeneous panel data approach. *Environmental Science and Pollution Research*, 1-13.

Patt A, Peterson N, Carter M, Velez M, Hess U, Suarez P (2009) Making index insurance attractive to farmers. Mitig Adapt Strateg Glob Chang 8:737–753.

Praveen, B., & Sharma, P. (2019). A review of literature on climate change and its impacts on agriculture productivity. *Journal of Public Affairs*, *19*(4), e1960.

Rasool, A , Ali A, Ahmad I, Anwar M. (2021). TO STUDY THE AWARENESS AND ADOPTION OF PRODUCTION PRACTICES OF RICE GROWERS IN TALUKA SHAHDADKOT, SINDH, PAKISTAN Volume 10, Issue 04, Pages: 583-589.

Rehman, A., Saba, T., Kashif, M., Fati, S. M., Bahaj, S. A., & Chaudhry, H. (2022). A revisit of internet of things technologies for monitoring and control strategies in smart agriculture. *Agronomy*, *12*(1), 127.

Robert, M., Thomas, A., & Bergez, J. E. (2016). Processes of adaptation in farm decision-making models. A review. *Agronomy for sustainable development*, *36*, 1-15.

Roy, T., Kalambukattu, J. G., Biswas, S. S., & Kumar, S. (2023). Agro-climatic Variability in Climate Change Scenario: Adaptive Approach and Sustainability. In *Ecological Footprints of Climate Change: Adaptive Approaches and Sustainability* (pp. 313-348). Cham: Springer International Publishing.

Sargani, G. R., Jiang, Y., Chandio, A. A., Shen, Y., Ding, Z., & Ali, A. (2023). Impacts of livelihood assets on adaptation strategies in response to climate change: Evidence from Pakistan. Environment, Development and Sustainability, 25(7), 6117-6140.

Seddon, N., Chausson, A., Berry, P., Girardin, C. A., Smith, A., & Turner, B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. *Philosophical Transactions of the Royal Society B*, *375*(1794), 20190120.

Singh, S. V., Jha, R., Singh, A. K., Ranjan, R., & Pandey, S. (2024). Sustainable Tourism Perspective in the Sustainable Development Goals: A Case Study of Heritage Sites in Uttarakhand. In Implementing Sustainable Development Goals in the Service Sector (pp. 91-107). IGI Global.

Sohail, M. T., Mustafa, S., Ali, M. M., & Riaz, S. (2022). Agricultural communities' risk assessment and the effects of climate change: a pathway toward green productivity and sustainable development. *Frontiers in Environmental Science*, *10*.

Solomon, S. (2007, December). IPCC (2007): Climate change the physical science basis. In *Agu fall meeting abstracts* (Vol. 2007, pp. U43D-01).

Syed, A., Raza, T., Bhatti, T. T., & Eash, N. S. (2022). Climate Impacts on the agricultural sector of Pakistan: Risks and solutions. *Environmental Challenges*, *6*, 100433.

Thornton, P. K., Ericksen, P. J., Herrero, M., & Challinor, A. J. (2014). Climate variability and vulnerability to climate change: a review. *Global change biology*, *20*(11), 3313-3328.

Tingju Z, Xie H, Waqas A, Ringler C, Iqbal MM, Goheer MA, Sulser T (2014) Climate change and extreme events, impacts on Pakistan's agriculture. International Food Policy Research Institute (IFPRI) (PSSP Policy Note 002).

Ullah, W., & Takaaki, N. (2016). Climate change vulnerability of Pakistan towards natural disasters: a review. *International Journal of Environmental Protection and Policy*, *4*(5), 126.

UNFCCC. (2008). United Nations Framework Convention on Climate Change. November-26-2008. Climate Change. Poznan Climate Change Conference.

Wang, S. (2024). Opportunities and threats of cryosphere change to the achievement of UN 2030 SDGs. Humanities and Social Sciences Communications, 11(1), 1-13.

Wade, K., & Jennings, M. (2016). The impact of climate change on the global economy. *Schroders Talking Point*.

Wheeler, T. and von Braun, J. (2013) 'Climate change impacts on global food security', Science. American Association for the Advancement of Science, pp. 508–513. doi: https://doi.org/10.1126/science.1239402.

WHO (2002) World Health Report 2002. Reducing Risk and Promoting Healthy Living. World Health Organization, Geneva.