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Adopting Agricultural Practices to Address Climatic Variability: A Case Study of Qutbal, District Rawalpindi

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This paper will try to study the effects of climate change on agricultural practices in Qutbal, Rawalpindi, a rural region of Pakistan dependent on rainfall for cultivation. Erratic rainfall and rising temperatures, along with extreme events, have disrupted traditional farming practices and put smallholder farmers at risk. The study took a qualitative exploratory approach, and data were collected through semi-structured interviews from 30 local farmers about their experiences, perceptions, and adaptive responses. Findings show that to some extent, there is diversity in the undertaking of new methods by farmers; however, most receive little institutional support and therefore face challenges in training resources and government assistance. This study underlines the immediate necessity for policy actions, better extension services, and focused aid to build resilience and promote sustainable agriculture in climate-sensitive areas.

Keywords: Climate Change, Adaptive Farming, Climate-Smart Agriculture, Smallholder Farmers, Agricultural Resilience, Drought-Resistant Crops, Sustainable Agriculture

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Title

Adopting Agricultural Practices to Address Climatic Variability: A Case Study of Qutbal, District Rawalpindi

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Contents

Abstract

This paper will try to study the effects of climate change on agricultural practices in Qutbal, Rawalpindi, a rural region of Pakistan dependent on rainfall for cultivation. Erratic rainfall and rising temperatures, along with extreme events, have disrupted traditional farming practices and put smallholder farmers at risk. The study took a qualitative exploratory approach, and data were collected through semi-structured interviews from 30 local farmers about their experiences, perceptions, and adaptive responses. Findings show that to some extent, there is diversity in the undertaking of new methods by farmers; however, most receive little institutional support and therefore face challenges in training resources and government assistance. This study underlines the immediate necessity for policy actions, better extension services, and focused aid to build resilience and promote sustainable agriculture in climate-sensitive areas.

Keywords:

Climate Change, Adaptive Farming, Climate-Smart Agriculture, Smallholder Farmers, Agricultural Resilience, Drought-Resistant Crops, Sustainable Agriculture

Introduction

Climate variability is by now one of the most defining threats to agriculture worldwide. An increase in rainfall variability, plus rising temperatures and altered patterns of seasons, coupled with extreme events like droughts and floods, compound problems for farmers to maintain reasonable levels of crop production and sustain their livelihoods. These conditions are also a great deal about the quality of harvests, not just the quantity, but quality of good soil health, water availability, and how long farming can continue. So, farmers begin to adopt new farming practices that help them adapt to such variability–smart climate or adaptive farming practices: diversification of crops, efficient use of water resources, organic agriculture, and soil conservation methods. All this is a measure, which is meant to alleviate risk, build

strength, and remain productive. The way to support food security and sustainable agricultural production within the changing climate conditions nowadays lies in comprehending and facilitating the possible shift toward adaptive practices. The world is getting more vulnerable to the rising climate uncertainty, including temperature fluctuation, altered rainfall regimes, and more frequent extreme weather changes, as the agricultural line of work becomes fragile against unpredicted climate (IPCC, 2022; FAO, 2013). Responding to this, researchers and farmers are collaborating to investigate and embrace agriculture that is strengthening, safeguarding food resources, sustaining livelihoods, and relevant in the uplifting rural areas (FAO, 2013). Climate change-proofing agriculture refers to the application of viable measures that can guide farmers to adapt to the increasing warmth of weather, variations in rainfall, an increase in the number of extreme weather conditions, and so on.

The effects of climatic variations on socio-economic aspects of smallholder farmers have become clear during the last couple of years. The unpredictable weather not only impacts the crop yield but also increases financial insecurity and food insecurity among those at risk in rural areas (Kumar et al., 2024). The availability of cheap borrowed money, Insurance, and products of technological advancement is also limited, which further limits the capacity of the farmers in dealing with the sudden climatic shocks (Singh & Patel, 2024).

Moreover, the topic of convergence of climatic variations and social disparities, such as gender inequality, is emerging in adaptation studies. Women farmers in general have lower access to land, resources, and climate information and are therefore less adaptive than men (Ndlovu & Moyo, 2024). Policies focused on adaptation that incorporate these social dimensions are important towards promoting equitable resilience within and among communities.

Another critical factor outlined in the recent studies is that climate-induced migration is now quite an urgent problem, and numerous farming households have to move, as they can barely retain their sources of livelihood during long-term droughts and catastrophic flooding (Chen et al., 2025). This tendency puts the emphasis on identifying the adaptive strategies that are not limited to agriculture but include the socially-oriented means of rural development and social protection.

Furthermore, the new digital opportunities, including AI-based climate prediction and advisory apps on phones, have demonstrated potential to help farmers act on time and mitigate the risk (Singh et al., 2025). Nevertheless, the distribution of such innovations lacks uniformity and places marginalized farmers at a disadvantage; hence, the need to enhance the infrastructural capacity and education.

The resolution of climatic variability should therefore be holistic, involving both technological, social, and institutional approaches that should be put in place, keeping in mind the local characteristics which can make the agricultural system sustainable and resilient in the vulnerable environment.

Problem Statement

Due to unstable rainfall, rising temperature, and increased extremes, farmers in the climate-risk regions such as Qutbal, Rawalpindi, are struggling to adapt. Such developments disrupted conventional agricultural practices, decreasing food production and exposing the economic life of small farmers to further dangers. This is because these farmers, whose plight we are seeing, are central to the local economy and thus their plight extends to the development of the rural areas. Despite the fact that agriculture continues to be the primary driver of the region, there is not yet an actual understanding of the perception of farmers on these climate-related issues as well as on the extent to which they are taking action regarding these issues. Climate-smart practices are not implemented regularly due to constraints in resources, support, and access to and availability of timely climate information, among others. This study would look into what triggers farmers to use adaptive practices in Qutbal, thus being able to work out more feasible methods to assist the farmers to improve on how adaptable they can be in the event of climatic challenges.

Review of Literature

As the climate changes, it is not only a source of stress in the lecture halls; it is already redesigning

agriculture globally, and the most vulnerable locations are those that depend on rain. As rainfall becomes more unpredictable, extremes of drought and flood, and then high temperatures, growing food, maintaining top soil, as well as keeping production constant, become far more complex (Lobell et al., 2011; Wheeler & von Braun, 2013). Instead of sweating it out with ancient methods, most farmers are reinventing the old rules to provide their families and immediate communities a chance towards stability.

Climate-Smart Agriculture (CSA) is one of the buzz solutions. The CSA combines various strategies that enable farmers to continue with the same farming activities, avoiding the worst impacts of changing weather. Consider crop diversification, or combination of plants to minimize risk, coupled with minimum tillage, integrated pest management, and planting drought-resistant seeds. Each of them assists farmers in sharing the risk out when skies are unfavorable (Thorpe & Reed, 2016).

Another massive obstacle is stable water supply. Studies continue to reveal how drip irrigation and rainwater harvesting could extend dwindling rain by pumping iron directly to root zones and storing rain during dry times, respectively, which are ideal in dry and semi-arid lands that receive rainfall, which is increasingly becoming erratic (Rockström et al., 2010).

In other words: everywhere farmers, big and small, are being forced to reconsider business as usual since climate is not cooperating. CSA and smarter water use provide actual avenues to remain productive and less destructive to the planet, where we live in a world where weather machines will not allow any one or particular year to come again.

When discussing the process of ways in which people and communities are dealing with the issue of climate change, it is evident that traditional knowledge, or in other words, indigenous knowledge, is equally valuable as any conventional handbook on this issue. The farmer who has been in the same plot of land might have regional solutions to how they combat the vicissitude of the weather. Smit and Skinner (2002) note that by combining this local wisdom and modern methods of science, solutions can be arrived at that work better and that feel more appropriate.

Nevertheless, adaptation of any form is not only determined by having the correct equipment or knowledge, but it is reliant on social and institutional support. According to Adger et al. (2009), farmers who receive the data on climate in good time, are members of well-organized community networks, and have access to local support systems are significantly more likely to implement the new practice. There is also the large looming government policy. Farmers may be encouraged to invest in more climate-resilient practices through limited support (subsidies, agricultural extension services or weather alerts) (Bryan et al., 2013).

The recent literature asserted that implementation of climate-smart agricultural (CSA) practices, which includes precision farming, better water and nutrient management, agroforestry, and crop diversification, is a key element in improving adaptation to climate variability and especially among the smallholder farmers in the vulnerable areas. According to a worldwide survey by Smith et al. (2024), CSA not only improves yields and farmer incomes, but it also enhances a reduction of greenhouse gas emissions. Likewise, Abbott et al. (2024) indicated access to education, extension, and credit services to be of prime importance in the adoption of such practices. In such areas as Sub-Saharan Africa and South Asia, agroecological methods, such as intercropping, composting, and crop-rotation, have come to alleviate soil health and food security in environments with a shift in climatic conditions (Zenda & Rudolph, 2024). Warmer temperatures. The effects of conservation agriculture on wheat yield and soil carbon during warming were found to be positive in a long-term study of permanent soil cover and low tillage (Reddit summary, 2024). In the meantime, technological breakthroughs, including precision application of nutrients and advisory tools that use AI, have increased the efficiency of resource utilization and allowed farmers to make informed decisions in time (Nasiro & Mohammednur, 2024; Vala et al., 2024). Reuters (2025) notes that smallholders in such countries as India are already getting fewer risks and debts due to AI-driven weather forecasting. Adaptation in this case, however, does not seem enough to eliminate adverse effects of climate change on crop productivity. One such study by Nature emphasized the fact that these measures might help prevent cereal yield losses, but they do not exclude them; therefore, both adaptation and

global mitigation are necessary (The Guardian, 2025). In general, recent research emphasizes the value of multi-dimensional approaches that incorporate traditional and regenerative farming and modern digital applications and, at the same time, indicates the presence of potential obstacles, such as poor access to technology and funds that should be mitigated with the help of favourable policies and investment.

Despite such openings, numerous smallholder farmers, particularly in developing nations, are facing impediments such as weak finances, infrastructural problems, and a lack of technical knowledge or training. These barriers still restrain the adoption of climate-smart practices in the areas that need them the most.

Research Objectives

1. To assess the impact of altered weather conditions on agricultural practices in the area and crop yields.
2. To discuss the advantages of climate-smart practices, i.e., crop diversification and use of drought-resistant seeds.
3. To investigate the effects and influences of government policies/support systems on the capacity of the farmers to adapt to climatic change.

Research Questions

1. What effect does variation in temperature, rainfall, and extreme weather have on yields and conventional farming practices?
2. What is the role of climate-smart production practices such as crop diversification, drought-resistant crops in enabling farmers to adapt to climate variability?
3. How can government policies and support systems help farmers to use climate-resilient farming methods?

Materials and Methods:

Locale

The information for this study was gathered from Qutbal, a village situated in the Rawalpindi district of Punjab, Pakistan. Qutbal is a countryside community where farming is essential to the lives of its inhabitants. The village mainly depends on rain-dependent agriculture, where local farmers grow crops like wheat, maize, and different vegetables. Nonetheless, the area is becoming more susceptible to climate variability, such as unpredictable rainfall and temperature changes, which have started to impact agricultural output.

Data Collection Method

The research will use the semi-structured interview to gain a deeper understanding of the topic from Qutbal. There will be open-ended questions, and data will be collected through face-to-face interviews.

Methodology

The study will adopt an exploratory method to gain insights into how farmers in Qutbal are modifying their agricultural practices due to climate change. Given that this is a fairly recent field of research, the objective is to understand the actual experiences and difficulties encountered by farmers. This research adopted a descriptive method, recording the various farming strategies and techniques employed by the farmers.

Methods

I employed a qualitative method since it enabled me to achieve an in-depth understanding of how smallholder farmers modify their farming practices in response to climate change.

Tools

In this study, a qualitative research approach was used. I used semi-structured interviews as a tool to conduct in-depth interviews for the collection of data.

Sample Size

For this study, the sample size was 30 participants who are farmers, using a non-random sampling technique.

Data Analysis

For data analysis, a qualitative thematic analysis approach was used. This helped me to find common patterns and deeper meanings in what participants shared during the interviews and focus groups.

Results and Analysis

Many of the farmers who participated in the survey reported that they have experienced significant changes in weather in recent years. Rainfall has become irregular; sometimes there is more than enough, sometimes there is a shortage, and the climate is no longer following usual patterns. These climate variations have made agriculture more arbitrary. Farmers were talking of their crops declining, lands being eroded, and how it is harder to cope with excessive rainfall, floods, or droughts lasting too long. To many, these problems do not remain on the crops- they affect their day-to-day lives, their income, and the ability to support their families. Some of the farmers have started changing their working practices in response to these developments. They are trying different things like raising a diversified crop, implementing organic or regenerative agriculture, and using water-saving practices to keep their soil healthy and viable. Many people reported that these new methods helped them to cope with the changing climatic conditions in a better way. Practices like crop rotation, planting of crops together with trees (agroforestry), and organic farming methods were often cited as good means of achieving a more sustainable agriculture. Regardless of these initiatives, most farmers reported that they have not received much help and support from government and local agriculture departments. Few of them cite receiving support via schemes like Kisan Dost. In most cases, they felt they were managing alone; they did not have a support system or proper guidance, which they were probably in need of. They pointed out the importance of access to proper training, economic support, and resources that would enable them to serve the climate challenges better. Many believe that with greater support of the government and their agricultural experts, they would be much better prepared to protect their agriculture and secure their future with climate change.

Conclusion and Recommendations

It is apparent that farmers in Qutbal are simply attempting to survive the fluctuating climate, but they require a lot more help in order to deal with it successfully. A more widespread and practical training and advice based on their local circumstances is one of their greatest requirements. But the message must be simple and feasible so that the farmers must be able to put the agricultural expertise and the government programs in touch with easily-applied and practical information on climate-smart farming, including planting a variety of crops and working with drought-resistant seeds, soil conservation, and water savings. It is also noteworthy that these trainings take pride in incorporating their own knowledge and experience on the part of the farmers, involving the conventional wisdom of traditional wisdom and modern methods of integration in order to produce solutions that actually reflect the ground reality. With this, farmers should be capable of getting the correct seeds and low-cost technology, such as the techniques of drip irrigations or the rain harvesting tools, which can have a significant change in instances when there is little or irregular rain. The financial burden could be alleviated with subsidies or local seed banks, and increase the spread of these beneficial measures.

Risk and money are the main barriers, and therefore providing broader credit lines, cheap loans, and in particular crop insurance will provide farmers with a protective blanket against losses attributable to drastic weather patterns. Clearer and more reliable government policies are also required by the farmers. The better and more accessible the programs (such as the Kisan Dost) are, the easier it can be for the farmers to utilize them. Empowerment of farmers is possible through community action, including the establishment of affordable cooperative groups or associations of water users who can share resources, knowledge, and risks, and who are stronger together. It is important to note that gender differences between men and women in terms of land, money, and training are respected more; so, women farmers tend to experience more difficulties. Climate adaptation needs to be inclusive and accommodating in facilitating participation of women at all levels.

Farmer planning and risk mitigation could be aided by ensuring access to information on timely weather forecasts and early warnings in the simple and local languages. Lastly, there will be continuous research and observation, and the participation of the farmers will make sure that adaptation strategies will remain relevant and

appropriate in the future. All of this together helps the farmers in Qutbal to become resilient and safeguard their way of making a living in the face of unpredictable weather conditions due to changing climate.

This experiment also demonstrates that climate change is directly manifesting itself on a daily basis for farmers. Farming is now becoming very difficult compared to a few years ago because of unpredictability of rainfall, fluctuating temperatures, and increased incidences of such natural occurrences as floods and droughts. The size of harvests and the amount of damage to land are already reducing the number of crops and hurting the income and food security of many farmers. Some are thus beginning to change tactics, experimenting with crop diversification, shifting towards natural production, and discovering means to conserve water. Though these are the steps forward, the majority of farmers stated that they are attempting to manage alone with limited external support. Some expressed that they were assisted by government programs or agricultural organizations, but few did.

The results indicate that farmers require a lot more assistance to adjust effectively as mentioned above. They need working training, economic support, and improved farming equipment to tackle the increasing hurdles of climate change. Judging by their comments, they obviously desire to receive simple, practical instructions, particularly in green practices and more available access to such things as drought-resistant seeds, water-saving tools, and natural fertilizers. Activities of the government, including Kisan Dost program, must be increased and farmer-friendly, having transparent procedures and improved outreach.

Some of their economic ailments could be alleviated by financial assistance in the form of subsidies, cheap loans, and crop insurance. More localised assistance is also necessary, better facilitated by agricultural extension workers, community-based programmes, and research which concentrates on the very issues that these farmers have. The combination of these efforts can be beneficial to the efficient adaptation of farmers and enable them to retain their farms productive and sustainable amid the continuous climate issues.

References

Abbott, E., et al. (2024). Climate-smart agricultural practices: A meta-analysis. *Mitigation and Adaptation Strategies for Global Change*.
Google Scholar Worldcat Fulltext

Adger, W. N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D. R., ... & Wreford, A. (2009). Are there social limits to adaptation to climate change? *Climatic Change, 93*(3–4), 335–354. http://dx.doi.org/10.1007/s10584-008-9520-z
Google Scholar Worldcat Fulltext

Bryan, E., Ringler, C., Okoba, B., Koo, J., Herrero, M., & Silvestri, S. (2012). Can agriculture support climate change adaptation, greenhouse gas mitigation, and rural livelihoods? Insights from Kenya. *Climatic Change, 118*(2), 151–165. https://doi.org/10.1007/s10584-012-0640-0
Google Scholar Worldcat Fulltext

Chen, L., Kumar, S., & Gupta, R. (2025). Climate-induced migration and rural livelihoods: Emerging trends and policy responses. *Journal of Climate Policy, 17*(1), 45-62.
Google Scholar Worldcat Fulltext

FAO. (2013). *Climate-smart agriculture sourcebook*. Food and Agriculture Organization of the United Nations. https://www.fao.org/climate-smart-agriculture-sourcebook/en/
Google Scholar Worldcat Fulltext

IPCC. (2022). *Climate change 2022: Impacts, adaptation and vulnerability (Working Group II contribution to the Sixth Assessment Report)*. Cambridge University Press.
Google Scholar Worldcat Fulltext

Kumar, P., Singh, A., & Sharma, R. (2024). Financial inclusion and climate resilience: Challenges for smallholder farmers. *Agricultural Economics Review, 36*(2), 112-129.
Google Scholar Worldcat Fulltext

Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. *Science (New York, N.Y.), 333*(6042), 616–620. https://doi.org/10.1126/science.1204531
Google Scholar Worldcat Fulltext

Nasiro, A., & Mohammednur, A. (2024). Precision nutrient management in climate-vulnerable areas. *Science Frontiers, 5*(3), 12. http://dx.doi.org/10.11648/j.sf.20240503.12
Google Scholar Worldcat Fulltext

Ndlovu, T., & Moyo, F. (2024). Gender and climate change adaptation in smallholder farming systems. *Climate and Development, 16*(3), 251-263.
Google Scholar Worldcat Fulltext

Reddit Summary. (2024). *Conservation agriculture boosts yield and soil health in warming climate*. Summarized from *Nature Communications* study. https://www.reddit.com/r/climate/comments/1g5rta1/conservation_agriculture_improves_soil_health_and/
Google Scholar Worldcat Fulltext

Reuters. (2025). *Empowering smallholder farmers with AI tools to bolster food security*. https://www.reuters.com/sustainability/land-use-biodiversity/comment-how-empowering-smallholder-farmers-with-ai-tools-can-bolster-global-food-2025-01-10/
Google Scholar Worldcat Fulltext

Rockström, J., Karlberg, L., Wani, S. P., Barron, J., Hatibu, N., Oweis, T., ... & Qiang, Z. (2010). Managing water in rainfed agriculture—The need for a paradigm shift. *Agricultural Water Management, 97*(4), 543–550. http://dx.doi.org/10.1016/j.agwat.2009.09.009
Google Scholar Worldcat Fulltext

Singh, D., & Patel, V. (2024). Enhancing adaptive capacity through credit and insurance: Evidence from South Asia. *Environmental Economics and Policy Studies, 26*(4), 799-814.
Google Scholar Worldcat Fulltext

Singh, R., Mehta, S., & Joshi, A. (2025). Digital technologies for climate-smart agriculture: Opportunities and challenges. *Computers and Electronics in Agriculture, 207*, 107800.
Google Scholar Worldcat Fulltext

Smit, B., & Skinner, M. W. (2002). Adaptation options in agriculture to climate change: A typology. *Mitigation and Adaptation Strategies for Global Change, 7*(1), 85–114. http://dx.doi.org/10.1023/A:1015862228270
Google Scholar Worldcat Fulltext

Smith, R., et al. (2024). Climate-smart agriculture: Adoption and impact assessment. *Mitigation and Adaptation Strategies for Global Change*.
Google Scholar Worldcat Fulltext

The Guardian. (2025). *Crop yields will fall even if farmers adapt to climate crisis, study finds*. https://www.theguardian.com/environment/2025/jun/18/crop-yields-climate-crisis-adaptation
Google Scholar Worldcat Fulltext

Thorpe, A., & Reed, M. (2016). Climate change adaptation in agriculture: Practices and technologies. *International Journal of Agricultural Sustainability, 14*(3), 296–313.
Google Scholar Worldcat Fulltext

Vala, P., et al. (2024). AI and agronomic decision support systems in smallholder farming. *Journal of Experimental Agriculture International, 46*(7).
Google Scholar Worldcat Fulltext

Wheeler, T., & von Braun, J. (2013). Climate change impacts on global food security. *Science (New York, N.Y.), 341*(6145), 508–513. https://doi.org/10.1126/science.1239402
Google Scholar Worldcat Fulltext

Zenda, T., & Rudolph, N. (2024). Agroecological strategies for climate adaptation in smallholder farming systems. *Climate, 12*(3), 33. http://dx.doi.org/10.3390/cli12030033
Google Scholar Worldcat Fulltext