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Impact of drought on cotton production in Marja District of Helmand Province, Afghanistan

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Abstract: This study examines the effects of drought on cotton production in Marja District, Helmand Province, Afghanistan. Using data collected from 70 growers across seven villages through surveys and interviews, the study compares cotton production costs, yields, and profitability under irrigation versus drought conditions. Results show that drought increases production costs from 13,900 AFN to 21,170 AFN per jerib, while revenue decreases from 31,725 AFN to 25,920 AFN. Net income drops by over 70%. These findings highlight the urgent need for water conservation strategies, drought-resilient practices, and targeted support for affected farmers.

Keywords: Cotton production, drought, impact, economy, Helmand

1. Introduction

Agriculture is a critical sector in Afghanistan, providing livelihoods for nearly 80 percent of the population, and it has been severely impacted by drought (Mohammad et al., 2018; Wafa et al., 2024). The effects include insufficient food supplies, loss of assets, migration due to drought, reduced planting areas, and the urgent sale of livestock. Although Afghanistan has a semi-arid climate, approximately 80% of its water resources come from snowmelt from the mountainous regions (Akhtar et al., 2017). The country has five major river basins: Kabul, Helmand, Hari Rod, Murghab, and Panj-Amu, along with the Northern basin. With the exception of the Northern basin, the other four are transboundary and flow into neighbouring countries (Akhtar et al., 2017).

Afghanistan faces significant challenges due to institutional failures and inadequate capacity in water resource management. The country experiences water scarcity, with per capita water availability at 2,500 m^3/s; much of this water remains underutilized, highlighting the severe food security issues (Aliyar & Esmailnejad, 2022).

To meet the recommended food and water demands, reliance on crop water productivity is essential, which is closely linked to irrigated agriculture that suffers from various management and technical shortcomings (Kreft et al., 2015). Drought affects agriculture by connecting agricultural drought definitions with seasonal drought characteristics. It emphasizes reduced rainfall, plant stress, and several seasonal factors such as evapotranspiration and the water demand of plants under current climatic conditions. The impact of drought varies depending on the growth stage of crops and the physical and biological properties of the soil (Zafar et al., 2023).

Afghanistan is considered one of the least developed countries, facing extreme poverty, economic instability, and a fragile agricultural system. Limited government capacity and a lack of extension services hinder growers from

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managing water resources effectively. Drought significantly impacts cotton yields and profitability, exacerbated by rising input costs, pest infestations, and inadequate farmer training (Ahmad et al., 2017).

Afghanistan's agricultural sector includes both food and industrial crops. Cotton, one of its major exports, thrives in the region's climatic conditions, which include cold winters and hot summers. However, drought jeopardizes its production, especially in key producing regions such as Marja District. Drought is one of the most devastating natural hazards affecting agriculture around the world (FAO, 2021). It reduces crop yields, threatens food security, and destabilizes rural economies. As climate change intensifies, droughts have become more frequent, prolonged, and severe in many regions. Developing countries, especially those with fragile institutions and limited capacity to adapt, are disproportionately affected. Afghanistan is one such country. Despite contributing minimally to global greenhouse gas emissions, it ranks among the ten most climate-vulnerable nations. Its reliance on rain-fed agriculture and weak water management systems makes it highly susceptible to climate-related shocks. In recent years, the frequency and severity of droughts in Afghanistan have increased significantly, leading to widespread crop failures, loss of livestock, and deepening food insecurity. The province of Helmand, located in southern Afghanistan, is among the hardest-hit regions. Known for its cotton production, Helmand's agricultural economy has been severely affected by prolonged dry spells and diminishing water availability, particularly in the Marja District. This district plays a crucial role in cotton cultivation and serves as a key area for understanding the local impacts of drought on farming systems. This study aims to assess the effects of drought on cotton farmers in Marja District, providing insights into local challenges and potential strategies for climate adaptation and agricultural resilience.

2. Materials and Method

This qualitative and quantitative research was conducted in Marja District of Helmand Province in 2023, entitled "The Effects of Drought on Cotton production" A cross-sectional design was used for data collection. The research was carried out in seven villages within the district. Marja District was purposefully selected because it is one of the largest districts in the region and has the highest concentration of cotton cultivation. However, since the district includes many villages, it was not feasible to survey every village due to time and resource constraints. Therefore, a random sampling method was employed to select a representative number of villages within the district. This approach ensured manageability while maintaining the reliability and generalizability of the data collected. A total of 70 respondents (growers) were also randomly selected to provide relevant information regarding their land and farming conditions. Data collection was conducted through structured questionnaires and interviews with the growers. The questionnaire includes Demographic Information, cotton farming and production information, production cost, total revenue, profitability, Economic Impact of Drought on Cotton Farming, Adaptation and Coping Strategies, and perceptions. The questionnaire covers General Questions, open-ended questions, and closing questions. Clear instructions were given to the participants during data collection to ensure accurate responses, and ethical considerations, such as confidentiality and informed consent, were strictly followed. The main limitation of this study is that data were collected from a single agricultural season, with limited record-keeping and low education levels among respondents.

3. Results and Discussion

3.1 Respondents' Demographics

The study gathered information from 70 growers in Marja District. After analyzing the data, 23 respondents (31.45%) were aged between 20 and 30 (Table 1).

Table 1: Respondents' Demographic Information

Category	Frequency	Percentage (%)
Age Group		
20-30 years	23	31.45
30-40 years	21	30
40-50 years	19	27.14
Above 50 years	7	11.42
Education Level		
Illiterate	40	57.1
Primary Education	18	25.7
High School Graduate	2	2.8
14th Grade Graduate	6	8.5

continued

Bachelor's Degree	4	5.7
Distance from Market		
5-10 km	10	14.2
10-15 km	20	28.5
15-20 km	8	11.4
More than 20 km	32	45.7
Total	70	100

The results indicate that most growers (57.1%) are illiterate, which may limit their ability to access modern agricultural knowledge and techniques. Additionally, 45.7% of the growers are located more than 20 km away from the market**,** making it difficult for them to sell their cotton products efficiently.

3.2 Analysis of Cotton Production Costs and Yields per Jerib (0.2 ha) Under Irrigation

The data analysis collected from cotton growers in Marja District revealed that, on average, 675 kg of cotton is obtained per jerib of land, and the total revenue per jerib amounts to 31,725 AFN (Table 2).

Table 2: Cotton Production Under Irrigation (Per Jerib)

No.	Description	Amount (AFN)
1	Cotton yield per jerib	675 Kg
	Selling price per kg	47 AFN
	Total revenue	31,725 AFN
2	Production Costs Per Jerib	
	Land preparation cost	500 AFN
	Irrigation cost	300 AFN
	Chemical fertilizers (DAP & UREA)	6,000 AFN
	Chemical pesticides	700 AFN
	Animal manure cost	1,000 AFN
	Seed cost	1,200 AFN
	Labor (daily wages)	200 AFN
	Farming cost	2,500 AFN
	Other expenses	1,500 AFN
	Total costs	13,900 AFN
3	Net profit per jerib	17,825 AFN
	Profitability Ratio	1.28
	Benefit-Cost Ratio (BCR)	2.28

Under irrigation conditions, cotton production costs are lower since growers use canal water. Unlike drought conditions, where growers must rely on solar-powered pumps or generators, these additional costs are absent under normal irrigation. The findings indicate that cotton farming under normal irrigation conditions in Marja District is profitable, with a BCR of 2.28**,** meaning that for every 1 AFN spent, growers earn 2.28 AFN in return**.** However, under drought conditions, additional irrigation costs significantly reduce profitability. A study by Ahmad et al. (2017) in Marja District reported an average cotton yield of 1,480.33 kg per farm under normal irrigation. Research by Tsakiris et al. (2014) in Telangana, India, found that the cost of cotton production per farm was 75,642.53 INR (Indian Rupees).

3.3 Analysis of Cotton Production Costs and Yields per Jerib (0.2 ha) During Drought

The data collected from cotton growers in Marja District during drought conditions indicate that, on average, 480 kg of cotton is obtained per jerib of land. The total revenue per jerib amounts to 25,920 AFN. However, due to increased irrigation costs**,** the overall cost of production rises significantly compared to normal irrigation conditions (Table 3).

Table 3: Analysis of Cotton Production Costs and Yields per Jerib During Drought

No.	Description	Amount (AFN)
	Cotton yield per jerib	480 Kg
1	Selling price per Kg	54 AFN
	Total revenue	25,920 AFN
	Production Costs Per Jerib	
	Variable Costs	
	Land preparation cost	500 AFN
	Increased irrigation cost	700 AFN
	Chemical fertilizers (DAP)	2,100 AFN
	Chemical fertilizers (UREA)	1,200 AFN
2	Chemical pesticides	770 AFN
	Animal manure	500 AFN
	Seed cost	1,200 AFN
	Farming labor cost	1,500 AFN
	Zakat	200 AFN
	Daily wage labor	200 AFN
	Other variable expenses	300 AFN
	Total variable costs	9170 AFN
	Fixed Costs	
	Water extraction cost (Solar System)	3,400 AFN
3	Wiring cost (Layn)	700 AFN
	Solar panels purchase	1,400 AFN
	Pipeline installation cost	500 AFN
	Total fixed costs	12000 AFN
	Total production costs per jerib	21170 AFN
	Net profit per jerib	4750 AFN
4	Profitability Ratio	0.22
	Benefit-Cost Ratio (BCR)	1.22

During drought conditions, cotton production in Marja District is significantly less profitable than normal irrigation. The BCR drops from 2.28 (under irrigation) to 1.22 (under drought)**,** indicating a lower return on investment. Additional costs, such as solar system setup and maintenance, further reduce growers ' net profits. Consequently, drought conditions pose a serious economic challenge for cotton growers in this region. Aggarwal et al. (2012) conducted a study in India**,** which found that 477 kg of cotton was obtained per farm under normal irrigation conditions. However, the yield dropped significantly to 195 kg per Jerib under drought conditions.

3.4 Comparison of Cotton Production Costs and Yields per Jerib (0.2 ha) During Drought and Irrigation

During drought conditions, fixed costs (12000 AFN) arise due to solar-powered irrigation system installation, which is unnecessary during normal irrigation conditions. Drought conditions reduce variable costs to 9170 AFN, compared to 13,900 AFN during irrigation. This reduction may be due to lower input usage as growers cut back on expenses. Overall, total costs remain different (21170 AFN in drought vs. 13,900 AFN in irrigation), but the distribution of expenses differs. Higher revenue is achieved during irrigation (31,725 AFN per jerib) than drought (25,920 AFN per jerib), as better water availability results in higher cotton yields. Growers earn a higher profit per jerib during irrigation (17,825 AFN) compared to drought (4750 AFN), highlighting the economic impact of water shortages on cotton farming. The lower production costs observed during drought periods are mainly due to farmers using fewer inputs, such as water, fertilizers, seeds, and labor, because of limited availability or affordability. This reduction in costs does not indicate that farming became more efficient; rather, it reflects a cutback in necessary resources, which often leads to lower overall productivity and yields. (Table 4).

Table 4: Comparison of Cotton Production Costs and Yields per Jerib During Drought and Irrigation

Condition	Fixed Costs (AFN)	Variable Costs (AFN)	Total Costs (AFN)	Total Revenue (AFN)	Net Profit (AFN)
Drought	12000	9170	21170	25,920	4750
Irrigation	0	13,900	13,900	31,725	17,825

Water access significantly improves profitability, as seen in the higher yields and revenue during irrigation periods. Drought conditions force growers to invest in alternative water sources (e.g., solar irrigation), reducing overall profit margins. Findings align with studies from Pakistan (Raza, 2015), where irrigation improved both yield and profitability, reinforcing the importance of efficient irrigation management to sustain cotton production during dry periods.

3.5 Comparison of Profitability Ratios, Benefit-Cost Ratios, and Profit Margins for Cotton Production per Jerib (0.2 ha) During Drought and Irrigation

The profitability ratio is lower during drought (0.22) compared to irrigation (1.28), indicating that irrigation leads to higher profits per unit of cost. Similarly, the benefit-cost ratio (BCR) is 1.22 during drought and 2.28 under irrigation. Profit margins are also higher during irrigation (0.561) than during drought (0.18), reflecting the greater efficiency and yield obtained when water is readily available.

Table 5: Comparison of Profitability Ratios, Benefit-Cost Ratios, and Profit Margins for Cotton Production per Jerib During Drought and Irrigation

Condition	Profitability Ratio	Benefit-Cost Ratio	Profit Margin
Drought	0.22	1.22	0.18
Irrigation	1.28	2.28	0.561

Irrigation leads to significantly higher profitability and better returns than drought, as water availability boosts cotton yields and reduces costs. Drought's negative effects on production costs and cotton yield make irrigation essential for maximizing profit in cotton farming. This analysis confirms the importance of a consistent water supply for growers to maintain profitable cotton production, as studies like Kossivi (2019) and Raza (2015) in different regions indicate.

3.6 Impact of Drought on Cotton Costs and Yields

The cost of cotton production during drought is significantly higher than during irrigation. This is due to the additional costs associated with solar-powered irrigation systems and reduced crop yields. Drought increases production costs and reduces cotton yields, lowering overall revenue. The net income from a jerib of land is higher during irrigation.

4. Conclusion

The study reveals that drought significantly increases production costs and reduces cotton yields and farmers' income in Marja district. During irrigation, net income per jerib is 17,825 AFN, dropping sharply to 4,750 AFN under drought. These findings highlight the importance of irrigation for profitability. To mitigate drought effects, strategies such as efficient irrigation, drought-resistant varieties, organic fertilization, and soil improvement are recommended. Additionally, investing in water infrastructure, farmer training, and regional drought management plans can enhance agricultural resilience and sustainability.

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Conflict of Interest

The authors declare no conflicts of interest.

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