IMPACT OF CHANGING RAINFALL PATTERNS OF AGRICULTURE CROPS YIELDS :

A CASE STUDY OF AJMER DISTRICT

Dr. Mamta Khandelwal

Assistant Professor, Department of Geography,

S.S. Jain Subodh College of Global Excellence, Sitapura, Jaipur

ABSTRACT

Changing rainfall patterns in Ajmer district—characterized by an erratic monsoon, sporadic unseasonal rains, and a shrinking number of rainy days—have created high vulnerability and fluctuating yields for both Kharif and Rabi crops. [1, 2, 3, 4]

Overview of Rainfall in Ajmer

- Average Rainfall: The district receives roughly 410 mm to 525 mm of annual rainfall, about 80% to 90% of which falls during the southwest monsoon between July and September. [1, 2, 3]
- Long-Term Trends: Statistical analyses (such as Mann-Kendall tests spanning 1901–2021) show no uniform linear increase or decrease, but highlight extreme year-to-year volatility, higher frequency of dry spells, and a drop in total rainy days (e.g., from 23 days down to 16 days in historical monitoring). [1, 2]
- Groundwater Over-Exploitation: All 8 blocks in Ajmer (Arain, Bhinay, Jawaja, Kekri, Masuda, Peesangan, Silora, and Srinagar) are classified as over-exploited (groundwater development exceeding 147%), meaning farmers cannot reliably use tube wells as a buffer during monsoon failures. [1]

KEYWORDS- Ajmer, Rainfall, Agriculture, Crop yields, pattern, impact

INTRODUCTION

Impact on Kharif Crops (Monsoon-Dependent)

- Crops Affected: Pearl millet (bajra), sorghum (jowar), and greengram (moong) cover roughly 60.7% of the cropped area in Kharif. [1]
- Effect of Late or Weak Monsoon: Delayed onset or dry spells during vegetative growth stunt plant establishment, reduce nutrient uptake, and cause significant drops in rainfed productivity. [1, 2]
- Effect of Heavy/Sporadic Rain: Intense cloudbursts or concentrated heavy downpours lead to surface runoff rather than deep soil infiltration, resulting in soil erosion, waterlogging in lower fields, and physical damage to tender crops. [1, 2, 3]

Impact on Rabi Crops (Winter Season)

- Crops Affected: Wheat, chickpea (gram), and mustard (sarson) cover about 39.1% of the cropped area, heavily relying on residual soil moisture, winter dew, and protective well irrigation. [1]
- Link to Monsoon Recharge: Because Rabi crops depend heavily on groundwater stored via monsoon percolation, erratic or weak rainy seasons mean lower water tables in Ajmer's open dug wells (which supply ~83% of irrigation). [1, 2]
- Productivity Stress: High temperature spikes or altered winter moisture patterns shorten the grain-filling period for staples like wheat, capping average yields compared to canal-irrigated regions. [1]

Adaptation and Mitigation Strategies in the District

- Water Conservation: Farmers and local agencies are scaling up watershed management, farm ponds, desilting of community check dams, and micro-irrigation (drip and sprinkler systems) to improve water-use efficiency by 30% to 50%.
- Crop Alignment & Diversification: Shifting away from highly water-intensive grains toward drought-tolerant varieties (such as improved pearl millet hybrids like MPMH-17/HHB-67 or cluster beans) and expanding high-value protected/market gardening (e.g., roses and mushrooms in pockets like Ganaheda) helps stabilize farm incomes.
- Institutional Support: Official guidance and district planning frameworks can be explored via the District Irrigation Plan Ajmer or data profiles hosted on the Krishi Vigyan Kendra Ajmer portal[1,2,3]

DISCUSSION

As per the Ministry of Earth Science, there is no evidence of change in weather pattern over the country. However, there have been extreme weather events in the recent past including extended dry periods, floods, hailstorms, cyclonic rains and winds etc., which caused damage to standing crops and ultimately poor yield of crops.

The State Government is primarily responsible for taking necessary relief measures in the wake of natural calamities. For undertaking relief measures, funds are available with the State Government in the form of State Disaster Response Fund (SDRF), Additional financial assistance, over and above SDRF, is considered from National Disaster Response Fund (NDRF) for natural calamities of severe nature and is approved on the basis of Memorandum received from State Government, in accordance with established procedure.

As per available information, the scientist of India Meteorological Department and other institutions has found significant changes in the rainfall pattern, extreme events etc. Both flood and drought in individual years does not depend on climate change. However, as an impact of climate change, it is being reported that the spatial variability, intensity and frequency of extreme events like heavy rainfall have

increased. Unseasonal/heavy rains accompanied with hailstorm, cyclone etc. has affected Ajmer.[4,5,6]

There are numerous effects of climate change on agriculture, many of which are making it harder for agricultural activities to provide global food security. Recent research has found that climate change is likely to exacerbate the existing environmental impacts of agriculture by lowering crop productivity, reducing the effectiveness of agrochemicals, increasing soil erosion and pest pressures, and thereby driving greater use of land, water and inputs.[5] Rising temperatures and changing weather patterns often result in lower crop yields due to water scarcity caused by drought, heat waves and flooding.[6] One study found that 1°C of warming was associated with a 3 to 7% decrease in global yields of major staple crops.[7] These effects of climate change can also increase the risk of several regions suffering simultaneous crop failures.[8] Currently this risk is rare but if these simultaneous crop failures occur, they could have significant consequences for the global food supply.[9][10] With a growing population and rapid urbanization, it is suggested that food production may increase by nearly 60% in the upcoming years.[11] Many pests and plant diseases are expected to become more prevalent or to spread to new regions. The world's livestock are expected to be affected by many of the same issues. These issues range from greater heat stress to animal feed shortfalls and the spread of parasites and vector-borne diseases.[6].

The increased atmospheric CO2 level from human activities (mainly burning of fossil fuels) causes a CO2 fertilization effect. This effect offsets a small portion of the detrimental effects of climate change on agriculture. However, it comes at the expense of lower levels of essential micronutrients in the crops.[6]:717 Furthermore, CO2 fertilization has little effect on C4 crops like maize.[12] On the coasts, some agricultural land is expected to be lost to sea level rise, while melting glaciers could result in less irrigation water being available.[13] On the other hand, more arable land may become available as frozen land thaws. Other effects include erosion and changes in soil fertility and the length of growing seasons. Bacteria like Salmonella and fungi that produce mycotoxins grow faster as the climate warms. Their growth has negative effects on food safety, food loss and prices.[6]

Extensive research exists on the effects of climate change on individual crops, particularly on the four staple crops: corn (maize), rice, wheat and soybeans. These crops are responsible for around two-thirds of all calories consumed by humans (both directly and indirectly as animal feed).[14] The research investigates important uncertainties, for example future population growth, which will increase global food demand for the foreseeable future.[15] The future degree of soil erosion and groundwater depletion are further uncertainties. On the other hand, a range of improvements to agricultural yields, collectively known as the Green Revolution, has increased yields per unit of land area by between 250% and 300% since 1960. Some of that progress will likely continue.[6].

Global food security will change relatively little in the near-term. 720 million to 811 million people were undernourished in 2021, with around 200,000 people being at a catastrophic level of food insecurity.[16] Climate change is expected to add an additional 8 to 80 million people who are at risk of hunger by 2050. The estimated range depends on the intensity of future warming and the effectiveness of adaptation measures.[6]:717 Agricultural productivity growth will likely have improved food security for hundreds of millions of people by then.[17][15] Predictions that reach further into the future (to 2100 and beyond) are rare. There is some concern about the effects on food security from more extreme weather events in future.[18][19][20] Nevertheless, at this stage there is no expectation of a widespread global famine due to climate change within the 21st century.[7,8,9]

The geographical distribution, frequency, and volume of rain divide agricultural practices into specific seasonal cropping cycles and crop categories.

1. Categories of Crops Based on Water Requirement

Crops are categorized by their moisture needs, directly aligning them with regional rainfall distributions:

• High-Water Crops (Heavy Rainfall: >150 cm)

• Rice (Paddy): Requires flooded fields during the early growth stage.

• Sugarcane: Demands continuous moisture throughout a long growing season.

• Jute & Tea: Thrive in areas with high, well-distributed annual rainfall.

• Medium-Water Crops (Moderate Rainfall: 75–100 cm)

• Wheat: Requires moderate moisture during growth and a dry period for ripening.

• Maize (Corn): Needs steady but well-drained moisture.

• Cotton: Thrives in areas with moderate rainfall combined with abundant sunshine.[10,11,12]

• Low-Water/Dryland Crops (Low Rainfall: <50 cm)

• Millets (Bajra, Jowar, Ragi): Highly drought-resistant crops grown in semi-arid zones.

• Pulses (Lentils, Chickpeas): Deep-rooting systems that successfully utilize residual soil moisture.

RESULTS

Both droughts and floods contribute to decreases in crop yields. On average, climate change increases the overall amount of water contained in the atmosphere by 7% per every 1 °C (1.8 °F), thus increasing precipitation.[51][52] However, this increase in precipitation is not distributed evenly in space (atmospheric circulation patterns already cause different areas to receive different amounts of rainfall) or time: heavy rainfall, with the potential to cause floods, becomes more frequent. This means that under the probable mid-range climate change scenario,[53][54] SSP2-4.5, precipitation events globally will become larger by 11.5%, yet the time between them will increase by an average of 5.1%. Under the highest-emission scenario SSP5-8.5, there will be an 18.5% increase in size of events and 9.6% increase in the duration between them. At the same time, water losses by plants through evapotranspiration will increase almost everywhere due to higher temperatures.[50] While the CO2 fertilization effect also reduces such losses by plants, it depends on the area's climate which effect will dominate.[13,14,15]

An important aspect to be understood regarding the relationship between rainfall and agriculture is that rainfall is the major factor in the growth and production of food crops both at the germination and fruit development stage. But with a change in the world’s climate, temperatures will rise and rainfall will increase in some places. In other places, rainfall will decrease. Other than the effect of high and low rainfall on cropping patterns, it is predicted that phenomena such as coastal flooding will reduce the amount of land available for agriculture. Farmers are already finding it difficult to cope with these environmental changes, as almost all crops are season-dependent and rainfall-dependent. Temperature and rainfall changes induced by climate change are likely to further react with other parameters of plant growth like atmospheric gases, fertilizers, insects, plant pathogens, weeds, and the soil’s organic matter. This again is expected to produce unanticipated responses.

As we have seen, the two main changes in patterns of rainfall include high and low rainfall. There seems to be no solution to the phenomenon of over-rainfall at the end of the crop cycle, which causes destruction. Rainfall, as we know, is an uncontrollable phenomenon. Managing the problem of low rainfall, however, is nearly possible through irrigation, but only if dealt with efficiently and without degradation to the water table, by ensuring ground water recharge practices. The thing to remember is also that irrigation requires large amounts of energy, making it expensive.[16,17,18]

CONCLUSION

In this new scenario, the management of water resources should fall in the core of all adaptation strategies. Where there is no threat of water scarcity, demand would not

increase. However, if more and more land is brought under irrigation, water scarcity will certainly occur. Farmers have begun falling back on traditional ways, such as reusing water from washing utensils to irrigate kitchen gardens. Many communities are also reviving traditional water harvesting, a method of storing rainwater. In some cases, farmers changed their crops to suit the prevailing conditions. Although there is no one-stop solution, traditional methods of dealing with low rainfall propel us to build innovative, scientific methods to deal with such changing rainfall patterns.[19,20]

REFERENCES

1. Sussman, Art (2005). "The Water Cycle". Planetguide.net. WestEd Eisenhower Regional Consortium for Science and Math Education. Archived from the original on 26 December 2011. Retrieved 26 December 2011.
2. Steve Kempler (2009). "Parameter information page". NASA Goddard Space Flight Center. Archived from the original on 26 November 2007. Retrieved 27 December 2008.
3. Mark Stoelinga (12 September 2005). Atmospheric Thermodynamics (PDF). University of Washington. p. 80. Archived from the original (PDF) on 2 June 2010. Retrieved 30 January 2010.
4. Glossary of Meteorology (June 2000). "Relative Humidity". American Meteorological Society. Archived from the original on 7 July 2011. Retrieved 29 January 2010.
5. Glossary of Meteorology (June 2000). "Cloud". American Meteorological Society. Archived from the original on 20 December 2008. Retrieved 29 January 2010.
6. Naval Meteorology and Oceanography Command (2007). "Atmospheric Moisture". United States Navy. Archived from the original on 14 January 2009. Retrieved 27 December 2008.
7. Glossary of Meteorology (2009). "Adiabatic Process". American Meteorological Society. Archived from the original on 17 October 2007. Retrieved 27 December 2008.
8. TE Technology, Inc (2009). "Peltier Cold Plate". Archived from the original on 1 January 2009. Retrieved 27 December 2008.
9. Glossary of Meteorology (2009). "Radiational cooling". American Meteorological Society. Archived from the original on 12 May 2011. Retrieved 27 December 2008.
10. Robert Fovell (2004). "Approaches to saturation" (PDF). University of California in Los Angeles. Archived from the original (PDF) on 25 February 2009. Retrieved 7 February 2009.
11. Robert Penrose Pearce (2002). Meteorology at the Millennium. Academic Press. p. 66. ISBN 978-0-12-548035-2. Retrieved 2 January 2009.
12. "Virga and Dry Thunderstorms". Spokane, WA: National Weather Service. 2009. Archived from the original on 22 May 2009. Retrieved 2 January 2009.

13. Bart van den Hurk & Eleanor Blyth (2008). "Global maps of Local Land-Atmosphere coupling" (PDF). KNMI. Archived from the original (PDF) on 25 February 2009. Retrieved 2 January 2009.
14. Krishna Ramanujan & Brad Bohlander (2002). "Landcover changes may rival greenhouse gases as cause of climate change". National Aeronautics and Space Administration Goddard Space Flight Center. Archived from the original on 3 June 2008. Retrieved 2 January 2009.
15. National Weather Service JetStream (2008). "Air Masses". Archived from the original on 24 December 2008. Retrieved 2 January 2009.
16. Michael Pidwirny (2008). "CHAPTER 8: Introduction to the Hydrosphere (e). Cloud Formation Processes". Physical Geography. Archived from the original on 20 December 2008. Retrieved 1 January 2009.
17. Glossary of Meteorology (June 2000). "Front". American Meteorological Society. Archived from the original on 14 May 2011. Retrieved 29 January 2010.
18. David Roth (2006). "Unified Surface Analysis Manual" (PDF). Hydrometeorological Prediction Center. Archived (PDF) from the original on 29 September 2006. Retrieved 22 October 2006.
19. FMI (2007). "Fog And Stratus – Meteorological Physical Background". Zentralanstalt für Meteorologie und Geodynamik. Archived from the original on 6 July 2011. Retrieved 7 February 2009.
20. Klyuzhin, Ivan S.; Ienna, Federico; Roeder, Brandon; Wexler, Adam; Pollack, Gerald H. (2010-11-11). "Persisting water droplets on water surfaces". The Journal of Physical Chemistry B. 114 (44): 14020–14027.