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Impact of Climate on Agriculture in Rajasthan

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ABSTRACT: For the first time in nearly 50 years, Mohan Lal was determined to go against his traditional wisdom and grow mung (green gram) this kharif. So did several farmers in his village Sodawas in Pali district. Traditionally, the arid district along Thar desert received good rainfall once in every three years. Accordingly, say farmers, they would grow millets for three years and then mung or sesame for a year. "But of late, Pali has been receiving heavy rainfall. Besides this year, the government hiked the minimum support price for kharif crops, and we wanted to cash in on these," says Lal, who grew mung on 2 ha. But a sudden spell of unexpected rain in the last week of September played spoilsport for the crop, which would have been harvested in about a week. "My entire crop has turned black," says Lal, adding that last year, too, heavy floods damaged his standing mung crop. "Over the past three years, the amount of rainfall has almost doubled in the region. Earlier, the annual average used to be around 400 millimetres (mm)," says Deepak Gupta, scientist at the Jodhpur-based Central Arid Zone Research Institute. Due to heavy downpour, Pali and Jalore witnessed massive floods last year. To tackle such unprecedented events, Pali's disaster management department for the first time acquired boats and life jackets. The state government is also looking for trained swimmers for joining its relief force.

KEYWORDS: crops, rainfall, disaster, Rajasthan, government, scientists, climate, agriculture

I. INTRODUCTION

Increased rainfall has also given rise to pest infestation. "Some pests like whitefly, which did not pose any major threat to crops earlier, is now causing excessive damage. The instances of wilt infection in cumin and chickpea; and powdery mildew, a fungal disease among mustard, have also gone up. In fact, we have been observing a rise in these diseases over the past four to five years. The population of aphids, small sap-sucking insects, is also increasing," says Singh. Rabi crops like wheat fare no better. Their sowing is now a delayed affair as temperatures of western Rajasthan continue to remain high even after the end of August. A warmer climate makes crops prone to spotted bug infestation. [1,2] Dheeraj Singh, scientist at the Krishi Vigyan Kendra in Pali, says currently, the region gets more rainfall spread over a lesser number of days. "Since the region's soil type does not allow easy percolation, heavy rains lead to waterlogging in the fields and do more harm than good to the crops." Gupta says the impact of changing climate is evident on the region's vegetation. In the past 15 years, when the rainfall pattern has become highly unpredictable, rohida (*Tecomella undulata*) and khejri (*Prosopis cineraria*) trees have started flowering earlier—almost by a month. From millets to cash crops. Troubled by unpredictability of weather, farmers are turning to horticulture crops that can be sustained through techniques like drip irrigation. "Pomegranate is one such crop that has piqued the interest of many farmers in western Rajasthan in the past six to seven years," says Ramavtar Chaudhary, deputy director, horticulture department in Pali. Data with the agriculture department shows area under the crop in Pali has increased by 78 per cent from just 15 ha in 2011. [3,4] "The profit margin is huge," says Morehdwaj Singh, Pali coordinator of Saini Agri Consultancy Services in Jaipur, which provides technical knowhow to interested farmers. A farmer can earn up to Rs 8 lakh from a hectare of the crop, he says. There is a downside to the success story. This new wonder crop is being mostly taken up by affluent farmers. "Growing pomegranate involves a long-term investment of Rs 4-5 lakh per ha. The

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saplings are expensive and farmers need to set up drip irrigation system. The saplings take at least three years to mature and yield. I don't have that kind of money," says Bhola Ram, a farmer from Sodawas. As part of coping mechanism, small farmers are turning to livestock rearing. "As per preliminary observation, we have witnessed an increase in cattle population," says Hari Singh, animal husbandry officer of Pali. Warns Gupta: Too much dependence on livestock can create problems in a region where soil organic carbon content is low. In case of prolonged dry spells, overgrazing can further decrease soil productivity. [5,6]

II. DISCUSSION

Since the beginning of the summer season, several northern-Indian regions including Rajasthan, have been experiencing extremely dry weather. Rajasthan is the largest state in India and its main economic drivers are agriculture and farming. Based on the alternative data we process at QuantCube we observed the historical trend in average temperatures and rainfall levels in Rajasthan. Exhibit 2 indicates historical data for the month of April, while Exhibit 3 shows the month of May. Our analysis indicates that April 2022 was the second hottest month in the observation sample. It was also identified as the period with the highest deficiency in rainfall. The analysis for the month of May shows a similar pattern. May 2022 was the fourth hottest month in the observation sample. The month recorded the highest rainfall deficiency in our observation. [7,8]

Exhibit 1 – Rajasthan location (India)



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Exhibit 2 - Average Temperatures and cumulative precipitation in Rajasthan
for the month of April (Period: 2000 to 2022)

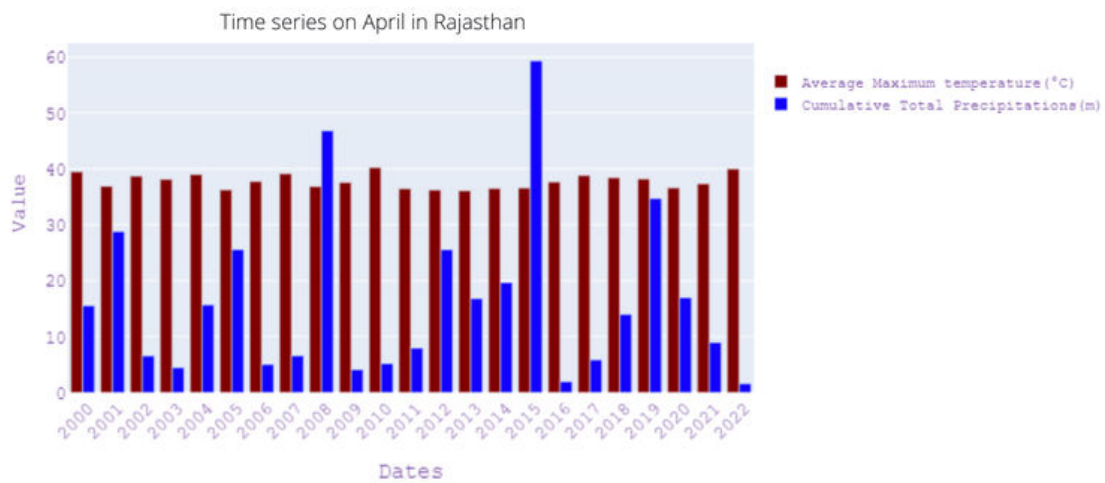
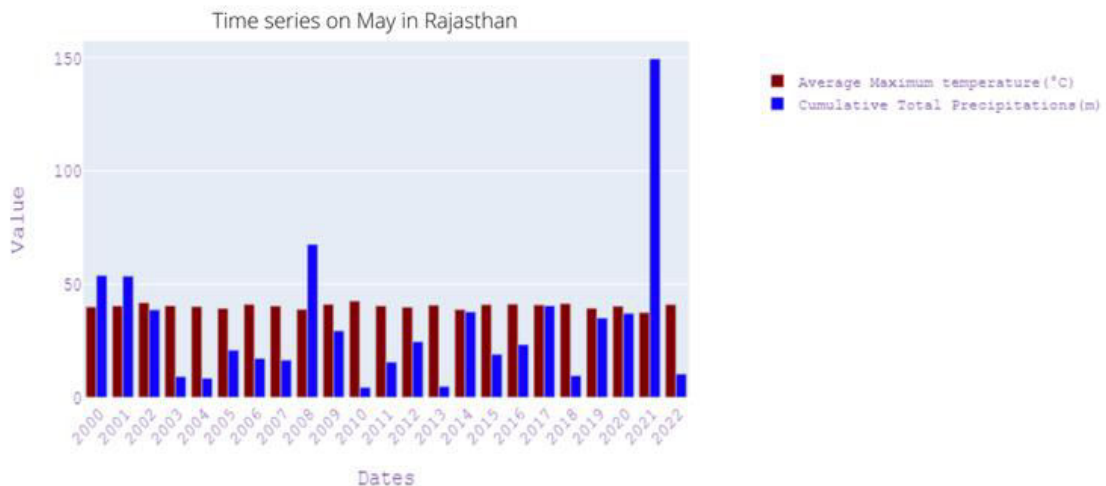


Exhibit 3 - Average Temperatures and cumulative precipitation in Rajasthan
for the month of May (Period: 2000 to 2022)



Our research indicates that elevated temperatures and insufficient rainfall cause stress on water resources, therefore, increase the risk of drought. Leveraging satellite images, we examined the changes in lake surfaces in near real-time. As Exhibit 4 and 5 indicate, most lakes and reservoirs in Rajasthan have been drying up in the last months. The area inside the green perimeter corresponds to the surface covered by water, while the area inside the white one corresponds to the original dimensions of the lake.[9,10]

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Exhibit 4 – Water stress level for “Nibhi ka Taal” in Rajasthan



Exhibit 5 – Water stress level for “Soorwal Dam” reservoir in Rajasthan



Exhibit 6 shows the average temperatures and cumulative precipitations in Rajasthan historically during the first 9 days of the month in June. The latest QuantCube data for June 2022 suggests that rainfall deficits continue, and temperatures remain elevated. Historically, the weather conditions improve in mid-June with the arrival of the monsoon season that brings torrential rains and reduces temperatures. This usually replenishes rivers, lakes and groundwater tables.

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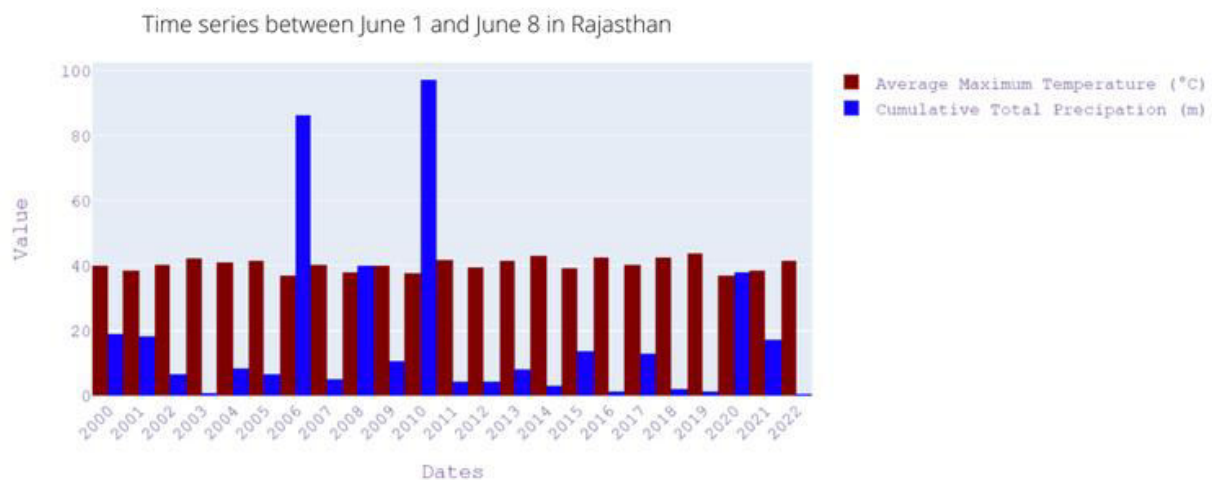
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However, we are yet to see the sign of monsoon and water stress risk continues to be high. This needs to be monitored closely. The evolution of climate and meteorological conditions in the upcoming weeks/months will be key for the Rajasthan economy and the Indian economy as a whole. Indeed, India heavily depends on the rainfall that monsoons bring to satisfy its water demand. Agriculture, [11,12] the backbone of the Indian economy that accounts for over 20 % of global GDP, requires sufficient rainfall. Consequently, good monsoons usually encourage abundant crops, therefore, tend to boost economic growth. On the contrary, persistent droughts and erratic monsoons may hinder agricultural yields and translate into economic losses. Will this year's monsoon be a good one and bring sufficient water to satisfy demand? With climate change, droughts and floods are likely to increase in frequency and intensity. To what extent will it impact the country's agriculture and overall economy in the near future? QuantCube continues to monitor the situation in the upcoming months since it may potentially contribute to social-political and geopolitical instability.[13,14]

Exhibit 6 - Average Temperatures and cumulative precipitation in Rajasthan based on QuantCube alternative data – from 2000 to 2022 – June



III.RESULTS

The QGIS mapping computer application and quintile method were used to map districts into low, medium, high, and very high categories. Furthermore, multiple regression analysis was applied to find out the significant determinants of food security and its respective components. The results confirm that there is a wide range of inequalities in terms of food security and its components of availability, accessibility, and stability across districts. It was found that the Ganganagar district (0.407) was rated the most food-secure district due to relatively higher food stability (0.401) in the Rajasthan state according to its climate. On the contrary, lower food availability (0.084) and accessibility (0.183) contributed to the lowest food security in the Dungarpur district. Moreover, districts associated with dry regions are highly vulnerable and relatively less food secure compared to districts having surface irrigation facilities. Hence, the study recommends; [15,16] diversification from farm to non-farm activities; sufficient storage capacity to control price fluctuations throughout the year, formulation and dissemination of climate-resilient technologies; investment in infrastructure, promotion of water management, conservation technologies, regulation and replenishment of

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groundwater in rural areas for augmenting cropping intensity; district-specific policies to arrest food insecurity; and strengthening the coverage of rural employment programme, i.e. MGNREGA in Rajasthan climate.[17,18]

Rajasthan is situated in the north-western region of the Indian sub-continent and possesses huge tracts of a desiccated area with more than 70% of the region covered by the Thar desert (Figure 1). With a total area of 342,239 square kilometers, the state consists of three agro-climatic zones: Trans-Gangetic Plains, Central Plateau & Hills, and Western Dry Region, along with 33 districts, 268 tehsils, 295 development blocks, and 44,672 revenue villages. The state has semi-arid to arid climatic conditions with the mean temperature varying between 0 and 50°C and a normal annual rainfall of 463.80 millimeters. The majority of Rajasthan's population resides in rural areas and is primarily dependent on agriculture and allied activities for livelihoods. Compared to the national average of 2,153 kg/ha, the state has a lower food grain yield of 1,367 kg/ha (GoI, 2017). Low and erratic precipitation patterns in Rajasthan coupled with the arid environmental/climatic conditions further result in a lower groundwater recharge rate (Central Ground Water Board, 2017). Besides the deteriorating quality of land owing, climate increased magnitude of desertification pose a serious challenge to food security in the state. The future climate projections indicate that accelerated warming with annual mean temperature is likely to increase by 2.0–2.5°C by 2021–2050 (Gopalakrishnan et al., 2011), whereas a decline is projected for rainfall (Kumar et al., 2016). Further, 11 out of 33 districts were found to be highly vulnerable to the changing climatic conditions with Hanumangarh, Jaisalmer, and Ganganagar being the most vulnerable districts (Singh et al., 2019). Furthermore, 3% of children under the age of five are stunted (IIPS and ICF, 2017) which indicates the severity of malnutrition in Rajasthan.

The study attempted to assess the food security status of different districts in Rajasthan according to climate and agricultural cropping, which facilitated in identifying and prioritizing the food insecure regions and the corresponding socio-economic factors that contributed to such inefficiency and vulnerability. The results revealed significant inter-district variations across the three major dimensions of food security: availability, accessibility, and stability. Districts belonging to the dry regions are relatively higher food insecure compared to the districts belonging to the irrigated regions. Index validation results show that all three components of food security are positively and significantly associated with the food security. Further, empirical regression results confirm that variability in rainfall and temperatures are negatively associated with the FSI indicating that any change in rainfall and temperature can lead to lower food security in the dry districts of Rajasthan. Furthermore, the population belonging to the below poverty line are also relatively more food insecure than that of the population belonging to the above poverty line. It also further indicates that rural development programmes such as MGNREGA have played a vital role in promoting food insecure districts into food secure districts in Rajasthan. Rapid urbanization in irrigated districts has led to better food security compared to dry regions in Rajasthan. Moreover, quintile estimation results portray that lower food production and inadequate market access in districts, namely Dungarpur, Jalore, and Churu, fall into the low food security category. Hence, lower food accessibility reflects the need to increase the literacy rate for not only improving the access but also to promote an increase in the adoption of better farm technologies.[19]

Hence, this study recommends the following policy suggestions. First, increasing climate aberrations significantly impact rural/agro-based livelihood and diversification from farm to non-farm activities helps moderate vulnerability to livelihood shocks. Secondly, sufficient storage capacity needs to be created to avoid possible wastage in the harvesting season and price fluctuation across seasons. Thirdly, focus needs to be made on the development and dissemination of climate-resilient technologies, investment in infrastructure, promotion of water management, conservation technologies, and regulation and replenishment of groundwater in rural areas for augmenting cropping intensity. Fourthly, there is a dire need for district-specific policies to arrest food insecurity in backward districts. Fifth, migration from rural areas to urban centers is increasing stress on the urban resources, therefore, coverage of rural employment programmes could be increased to urban areas to ensure employment opportunities in both rural and urban areas of Rajasthan.[20]

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IV. CONCLUSIONS

Though this study tried to capture all the aspects of food security and highlighted the constraints of food security at district level in Rajasthan according to climatic conditions, the results need to be interpreted with caution because of certain limitations. Firstly, the present study has only used spatial data to map the food security status of districts in Rajasthan by excluding temporal variations due to data constraints, [21,22] while from the policy perspective, it is imperative to capture spatial-temporal variability in food security. Secondly, unemployment and poverty are also key factors responsible for food insecurity especially in dry districts such as Jodhpur, Bikaner, and Ajmer. Data for employment and poverty was collected only in the 68th NSSO round (2012–13), which is not comparable with current data. Hence, this study has excluded unemployment and poverty aspects from the analysis. Thirdly, the present study has identified that districts belonging to the dry regions are relatively more food insecure compared to districts belonging to the irrigated regions of Rajasthan. Hence, it is also important to assess regional-specific food security status, while the present study excluded this dimension. Finally, Rajasthan society is divided based on castes, classes, religions, regions, and many stratifies, hence, it generates scope for future research on food security along with rational indicators and estimation methods.[23,24]

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