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Barley Production in Rajasthan: Examining Growth Rates and Regional Shifts (1980–2020)

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Abstract

This paper analyzes the growth trends and regional variations in barley production in Rajasthan from 1980 to 2020. Using district-wise production data and the semi-log growth model, growth coefficients were estimated for different decades. The findings reveal mixed trends across districts, with several regions showing significant declines, particularly during the 1980s and 1990s, while some northern districts demonstrated positive growth in the 2000s. The study highlights the impact of irrigation practices, technological adoption, and shifting cropping patterns on barley production. The results provide insights into regional disparities and policy implications for strengthening barley cultivation in Rajasthan.

Key words: Barley, Growth coefficient, Semi-log model, Agricultural trends, Regional disparities

Barley (*Hordeum vulgare* L.) is one of the oldest domesticated cereals and the fourth-largest cereal crop globally. Known for its adaptability to diverse agro-climatic conditions, barley thrives in marginal lands with relatively low input requirements. In India, it is cultivated primarily in Rajasthan, Uttar Pradesh, and Haryana, primarily during the Rabi season. Despite its importance in the food, feed, and malting industries, the area under barley cultivation has been declining in recent decades due to the Green Revolution's focus on wheat and rice and a shift toward more profitable crops like oilseeds.

This study evaluates the growth coefficients of barley production in Rajasthan over different decades, from 1980 to 2020. The analysis aims to understand regional disparities, identify factors influencing growth or decline, and provide evidence-based insights for sustainable agricultural planning.

Barley (*Hordeum vulgare* L.) remains an important crop in Rajasthan due to its adaptability, profitability, and multiple uses in the food, feed, and malting industries. Shivaran *et al*. [1] highlighted the resilience of barley in hyper-arid, partially irrigated areas of Rajasthan, demonstrating that improved production techniques increased yields by 19.65% and significantly enhanced profitability compared to traditional practices, thus underscoring its dual role in ensuring food, feed, and income security in resource-scarce regions. Complementing this, Gautam *et al*. [2] emphasized the benefits of sustainable irrigation systems, stating that solar-powered irrigation not only reduced dependence on fossil fuels but also irrigation costs. Conventional and organic barley cultivation in Jaipur district and found that although organic farming involved higher input costs and relatively lower yields, it resulted in higher net returns and farm income, making organic barley economically viable and sustainable, provided adequate policy support such as subsidies, access to quality seeds, and extension services. Verma *et al*. [3] examined the comparative economics of barley and maize production in Rajasthan using cost of cultivation data from 2000-01 to 2015-16, and concluded that barley profitability improved significantly, with returns per rupee invested TE increasing to Rs. 3.23 by 2015, while maize exhibited a decline in net income despite higher gross returns. Collectively, these studies demonstrate that with technological adoption, sustainable irrigation practices, organic farming, and comparative economic advantages over maize, barley remains a resilient and profitable crop in Rajasthan, reinforcing its important role in the state's agricultural economy and highlighting the need for policy measures to further strengthen its production base.

The literature on barley production in Rajasthan reveals a crop with significant resilience and economic value, cultivated extensively on marginal lands in the state and valued for its role in livelihoods, industry (malting, fodder), and its health benefits [4-5]. The historical progress of barley improvement has been fundamentally shaped by institutional efforts, particularly the All India Coordinated Barley Improvement Project (AICBIP), which has led to the development of over 120 varieties specifically developed for stress tolerance and end-use quality, providing the genetic basis for yield potential and regional adaptation [6]. Concurrent agricultural research has established precise recommendations for optimizing this potential, including optimal nitrogen management at 90 kg N/ha in three splits [7], narrow row spacing of 20 cm [8] and balanced phosphorus and zinc application to minimize nutrient conflicts in light soils [9]. Furthermore, studies confirm barley's superiority over alternatives such as oats in dry areas, providing higher dual-purpose forage and grain yields and greater profitability, strengthening its agricultural niche [10]. However, the adoption of these technology packages is not socioeconomically neutral; research indicates the existence of significant yield gaps

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empirically demonstrated by extension studies, where front-line demonstrations consistently achieved 22% higher yields and dramatically higher benefit-cost ratios than local practices, highlighting the crisis.

MATERIALS AND METHODS

The study relies on secondary data of district-wise barley production in Rajasthan, collected from the Directorate of Economics and Statistics, Government of Rajasthan, covering the period 1980–2020.

Analytical model

Semi-logarithmic growth model was used:

$$\ln Yt = a + bt + ut$$

Where;
Yt = Barley production in year t
a = Intercept
b = Growth coefficient
ut = Error term

Estimation was carried out using the Ordinary Least Squares (OLS) method. Statistical significance of growth coefficients was tested using the Student's t-test. R^2 values were computed to assess model fitness.

Significance levels:
- *** Significant at 1%
- ** Significant at 5%
- * Significant at 10%
- NS = non-significant

Analysis and discussion of barley production

Barley (*Hordeum vulgare* L.) is one of the oldest cultivated cereals and is considered the world's fourth-largest crop, accounting for approximately 7% of total cereal production. Barley is known for its remarkable adaptability, thriving in a variety of environments, including marginal lands, and its low input requirements. In India, barley is cultivated primarily in states like Rajasthan, Uttar Pradesh, and Haryana, primarily during the Rabi season. With a total production of approximately 174,300 tons and cultivation on 69,500 hectares, barley plays a vital role in the agricultural sector and is used for a variety of purposes, including food, animal feed, and malting.

Table 1 Growth coefficient of barley production during 1980-2020

District	Intercept	Growth coefficient	t-Value	P-Value	R^2
Ajmer	9.989	0.014	1.817	0.077	0.080
Alwar	10.738	−0.011	−2.152	0.038	0.109
Banswara	8.326	−0.022	−4.727	0.000	0.370
Barmer	6.089	−0.056	−6.000	0.000	0.486
Bharatpur	10.021	−0.036	−7.541	0.000	0.599
Bhilwara	10.166	0.013	1.570	0.125	0.061
Bikaner	4.507	0.134	17.300	0.000	0.887
Bundi	9.364	−0.069	−6.975	0.000	0.661
Chittorgarh	8.760	0.030	4.604	0.000	0.358
Churu	5.893	0.098	4.981	0.000	0.395
Dholpur	8.533	−0.031	−5.36	0.000	0.431
Dungarpur	8.110	−0.009	−1.436	0.159	0.051
Ganganagar	8.477	0.105	13.540	0.000	0.828
Jaipur	11.288	0.024	9.771	0.000	0.715
Jaisalmer	3.305	0.033	1.334	0.192	0.056
Jalore	7.914	−0.038	−7.235	0.000	0.579
Jhalawar	6.929	−0.012	−1.991	0.054	0.094
Jhunjhunu	8.940	0.035	4.490	0.000	0.347
Jodhpur	6.157	0.018	2.883	0.007	0.179
Kota	8.912	−0.043	−9.704	0.000	0.712
Nagaur	9.196	0.029	7.240	0.000	0.580
Pali	9.318	−0.012	−1.540	0.132	0.059
Sawai Madhopur	10.122	−0.067	−13.26	0.000	0.822
Sikar	9.738	0.047	13.140	0.000	0.820
Sirohi	8.418	−0.017	−3.239	0.003	0.216
Tonk	10.086	−0.021	−3.818	0.001	0.277
Udaipur	10.449	−0.007	−0.822	0.416	0.017

Historically, barley has been an important crop due to its adaptability to harsh environmental conditions such as salinity and drought. Its high nutritional value, especially of beta-glucan-rich varieties, has made it a staple food in some regions and is of great importance for health and nutrition. However, the area under cultivation of this crop has declined over the past 45 years, primarily due to the introduction of high-yielding wheat varieties during the Green Revolution and the subsequent shift to more profitable oilseed crops in irrigated areas. Although industrial demand for barley has increased in recent years, leading to higher market prices, only a small portion (20-25%) of total barley production is used for malting. The prevalence of less suitable six-row barley varieties and inappropriate crop management practices pose challenges to malt quality and overall yield. The All India Coordinated Barley Improvement Project (AICBIP) was launched in 1966-67 to strengthen barley cultivation by developing high-yielding and disease-resistant varieties suitable for different agro-climatic conditions. The project focused on improving productivity, addressing the challenges of rain-fed and saline soils, and meeting the growing demand for malt and table barley. Notably, Punjab ranks first in barley production in India, reflecting the positive impact of effective agricultural practices and research initiatives. Barley plays a vital role in animal nutrition, providing a significant source of protein and energy in cattle diets. It is primarily used in the production of malt for alcoholic beverages and can be used in various food products such as bread and soups. Despite its widespread uses, barley cultivation and production have declined due to the dominance of wheat and rice. To address these problems, breeding programs are working to utilize genetic diversity in wild and cultivated barley germplasm. A deeper understanding of trait-yield correlations is essential to develop improved genotypes and sustain barley production amid growing environmental challenges.

Furthermore, the environmental impacts of barley cultivation, especially with regard to irrigation practices, highlight the need for sustainable approaches. Dependence on diesel irrigation, which increases CO_2 emissions, has prompted the government to shift to solar irrigation, supported by relevant initiatives. This shift not only provides a more sustainable solution to reducing emissions but also improves farmers' incomes and aligns agricultural practices with environmental sustainability.

In summary, barley is an important cereal crop in India with immense potential, but its productivity remains below its true potential. The objective of this study is to assess the current status of barley production, explore market dynamics, evaluate the impact of irrigation practices, and promote barley as an important cash crop. By addressing the challenges faced by barley farmers and highlighting the importance of sustainable practices, this study aims to facilitate the development of strategies to increase barley yields and support farmers' livelihoods in Rajasthan and beyond.

Based on statistical analysis of barley production from 1980 to 2020, trends across Rajasthan's districts reveal a dramatic and significant spatial reorganization of crop cultivation.

In (Table 1) it can be seen that districts like Bikaner, Ganganagar, Churu, and Sikar emerge as the epicenters of a large positive shift, exhibiting strong, statistically significant growth coefficients (e.g., 0.134 for Bikaner) and high R^2 values (0.887 for Bikaner), confirming rapid, sustained expansion in these arid western regions.

In contrast, a clear and significant decline is evident in a large eastern and southern belt, including Bharatpur, Sawai Madhopur, Kota, Bundi, Banswara, and Jalore, all showing strong negative growth coefficients. Districts such as Udaipur and Dungarpur experience stagnation and high instability, with low R^2 values and non-significant trends, indicating no clear long-term direction. Bikaner, Ganganagar, Churu, and Sikar districts show the strongest and statistically significant positive growth.

Table 2 Growth coefficient of barley production during 1981-1990

District	Intercept	Growth coefficient	t-Value	P-Value	R^2
Ajmer	10.623	−0.083	−3.518	0.008	0.607
Alwar	11.234	−0.072	−3.417	0.009	0.593
Banswara	8.508	−0.055	−1.876	0.098	0.306
Barmer	6.720	−0.121	−2.186	0.060	0.374
Bharatpur	10.528	−0.114	−3.054	0.016	0.538
Bhilwara	10.505	−0.019	−0.777	0.460	0.070
Bikaner	5.416	−0.018	−0.190	0.854	0.004
Bundi	8.760	0.042	0.896	0.396	0.091
Chittorgarh	9.173	0.001	0.025	0.981	0.000
Churu	8.777	−0.369	−1.521	0.167	0.224
Dholpur	9.196	−0.096	−2.743	0.025	0.485
Dungarpur	8.670	−0.096	−1.873	0.098	0.305
Ganganagar	9.033	0.036	0.465	0.654	0.026
Jaipur	11.472	0.003	0.157	0.879	0.003
Jaisalmer	6.109	−0.597	−1.447	0.385	0.677
Jalore	8.447	−0.121	−2.290	0.051	0.396
Jhalawar	7.145	−0.021	−0.397	0.702	0.019
Jhunjhunu	10.221	−0.178	−2.642	0.030	0.466
Jodhpur	7.191	−0.140	−3.404	0.009	0.592
Kota	8.865	−0.030	−0.710	0.498	0.059
Nagaur	9.492	−0.021	−0.828	0.432	0.079
Pali	10.045	−0.105	−2.306	0.050	0.399
Sawai Madhopur	10.353	−0.081	−2.548	0.034	0.448
Sikar	10.093	−0.0006	−0.020	0.985	0.000
Sirohi	8.681	−0.064	−0.984	0.354	0.108
Tonk	10.358	−0.043	−1.533	0.164	0.227
Udaipur	10.691	−0.026	−1.035	0.331	0.118

As shown in (Table 2), barley production in different districts of Rajasthan showed varying trends during 1981-1990. Most districts experienced a significant decline in barley production over the decade, with only a few districts showing stable or insignificant trends. The data show that some districts showed a significant negative growth in barley production with a low p-value ($p < 0.05$), while other districts showed insignificant trends. For example, Ajmer and Alwar showed a significant decline in production with growth rates of -0.083 and -0.072, respectively, and low p-values (0.008 and 0.009). These declines in production highlight challenges facing these districts, such as water scarcity, soil erosion, or changes in agricultural practices. Similarly, Bharatpur, Dhaulpur, and Jodhpur also experienced significant declines, with growth rates of -0.114, -0.096, and -0.140, respectively, with low p-values (0.016, 0.025, and 0.009). These trends highlight the serious challenges faced by these districts during this period. On the other hand, some districts experienced negligible growth rates, indicating little change in barley production [11]. For example, Bundi and Ganganagar experienced positive but insignificant growth rates of 0.042 and 0.036, respectively, with high p-values (0.396 and 0.654). Similarly, Jaipur and Sikar experienced little change in barley production, with growth rates of 0.003 and -0.0006, respectively, and high p-values (0.879 and 0.985). These districts may have maintained stable production levels due to favorable climatic conditions or effective agricultural practices. However, some districts, such as Jaisalmer and Churu, showed significant declining trends, but with high p-values, indicating that these trends were not statistically significant. For example, Jaisalmer showed a growth rate of -0.597, but with a p-value of 0.385, indicating that this trend was not statistically significant. Similarly, Churu showed a growth rate of -0.369, indicating a declining trend, but with a p-value of 0.167, indicating that this trend was not statistically significant at the 5% level. In summary, between 1981 and 1990, barley production declined significantly in many districts of Rajasthan (e.g., Ajmer, Alwar, Bharatpur, and Jodhpur), while it remained stable in some districts, such as Bundi and Ganganagar [12]. By leveraging this data, policymakers and agricultural experts can develop strategies to increase productivity, ensure food security, and improve the livelihoods of farmers across the state.

Data depicted in (Table 3) below shows the growth rates of barley production in various districts of Rajasthan from 1991 to 2000. The growth rate indicates the annual rate of change in barley production, with positive values indicating growth and negative values indicating decline. The intercept indicates the baseline yield level, while the t-value, p-value, and R^2 value provide a statistical analysis of the significance and reliability of the growth trend. Districts such as Bikaner and Jaisalmer show significant positive growth coefficients (0.128 and 0.451, respectively) with high t-values and low p-values, indicating strong and statistically significant growth in barley production. R^2 values of 0.761 for Bikaner and 0.773 for Jaisalmer indicate this. In contrast, the growth coefficients for districts like Barmer, Bundi, Dholpur, and Udaipur are negative (-0.096, -0.109, -0.082, and -0.096, respectively), indicating a decline in barley production. These trends are statistically significant because their p-values are low and R^2 values are medium to high. Other districts like Ajmer, Alwar, and Tonk also show negative growth, but their trends are less significant due to high p-values and low R^2 values [13].

Overall, the data indicate that barley production in Rajasthan has shown mixed trends over the past decade. Some districts have experienced significant increases while others have declined, which may be due to differences in climatic conditions, agricultural practices, or resource availability. Statistical indicators (t-values, p-values, and R^2) help validate the reliability of these trends.

Table 3 Growth coefficient of barley production during 1991-2000

District	Intercept	Growth coefficient	t-Value	P-Value	R^2
Ajmer	10.478	−0.028	−0.717	0.494	0.060
Alwar	10.237	−0.008	−0.204	0.844	0.005
Banswara	8.033	0.020	0.891	0.399	0.090
Barmer	5.398	−0.096	−2.238	0.056	0.385
Bharatpur	9.396	−0.023	−1.005	0.344	0.112
Bhilwara	10.848	−0.081	−1.673	0.133	0.259
Bikaner	5.514	0.128	5.048	0.001	0.761
Bundi	8.961	−0.109	−2.860	0.021	0.506
Chittorgarh	9.326	−0.046	−1.152	0.283	0.142
Churu	5.685	0.203	1.530	0.164	0.226
Dholpur	8.053	−0.082	−3.442	0.009	0.597
Dungarpur	8.148	−0.019	−0.587	0.574	0.041
Ganganagar	9.312	0.086	1.290	0.233	0.172
Jaipur	11.387	0.031	1.790	0.111	0.286
Jaisalmer	0.770	0.451	4.882	0.002	0.773
Jalore	7.594	−0.048	−2.760	0.025	0.488
Jhalawar	6.703	−0.011	−0.563	0.589	0.038
Jhunjhunu	9.228	0.002	0.037	0.972	0.000
Jodhpur	5.873	0.036	1.059	0.320	0.123
Kota	8.645	−0.060	−2.785	0.024	0.492
Nagaur	9.099	0.076	2.508	0.037	0.440
Pali	9.466	−0.070	−1.888	0.096	0.308
Sawai Madhopur	9.477	−0.098	−2.527	0.035	0.444
Sikar	9.796	0.092	3.107	0.015	0.547
Sirohi	8.610	−0.071	−3.142	0.014	0.552
Tonk	9.768	−0.028	−0.723	0.490	0.061
Udaipur	10.986	−0.096	−2.689	0.028	0.475

The data in (Table 4) shows the growth rates of barley production in various districts of Rajasthan from 2001 to 2010. This growth rate represents the annual rate of change in barley production, with positive values indicating growth and negative values indicating decline. The intercept represents the baseline yield level, while the t-value, p-value, and R^2 value provide statistical information on the significance and reliability of the trend. Ganganagar, Jhunjhunu, and Chittorgarh districts show strong positive growth rates (0.206, 0.128, and 0.119, respectively) due to high t-values and low p-values, indicating statistically significant increases in barley production [14]. The R^2 of 0.640 for Ganganagar and 0.673 for Jhunjhunu indicates that the growth model explains a large portion of the yield fluctuations. Bikaner (0.089) and Churu (0.198) also showed significant positive growth with high R^2 values (0.629 and 0.581, respectively), indicating a reliable trend. In contrast, districts like Bharatpur, Bundi, and Sawai Madhopur had negative growth coefficients (-0.088, -0.077, and -0.052, respectively), indicating a decline in production. However, these trends were of low statistical significance, as reflected by their high p-values. Other districts like Ajmer, Banswara, and Tonk also showed negative growth, but their trends were not statistically robust due to high p-values and low R^2 values. Districts like Jaipur, Jalore, and Jodhpur experienced minimal or negligible growth with coefficients close to zero and high p-values. Overall, this table shows mixed trends in barley production in Rajasthan from 2001 to 2010. Some regions, particularly the north and west, saw significant growth, while others saw stagnation or decline. Statistical indicators (t-values, p-values, and R^2) help verify the robustness of these trends and highlight the diversity of agricultural dynamics in the state during this decade.

Table 4 Growth coefficient of barley production during 2001-2010

District	Intercept	Growth coefficient	t-Value	P-Value	R^2
Ajmer	9.767	−0.024	−0.499	0.631	0.030
Alwar	10.528	0.027	1.036	0.331	0.118
Banswara	7.750	−0.041	−0.930	0.380	0.098
Barmer	4.392	0.088	1.339	0.217	0.183
Bharatpur	9.651	−0.088	−1.694	0.129	0.264
Bhilwara	9.497	0.065	0.859	0.415	0.084
Bikaner	7.705	0.089	3.684	0.006	0.629
Bundi	7.942	−0.077	−1.641	0.162	0.350
Chittorgarh	8.408	0.119	3.390	0.010	0.590
Churu	7.325	0.198	3.331	0.010	0.581
Dholpur	7.291	0.071	2.394	0.044	0.417
Dungarpur	6.948	0.103	2.146	0.064	0.365
Ganganagar	10.143	0.206	3.770	0.006	0.640
Jaipur	11.849	0.002	0.109	0.916	0.001
Jaisalmer	4.571	0.104	1.453	0.184	0.209
Jalore	6.613	0.013	0.403	0.697	0.020
Jhalawar	5.876	0.087	2.012	0.079	0.336
Jhunjhunu	9.099	0.128	4.061	0.004	0.673
Jodhpur	6.675	0.016	0.352	0.734	0.015
Kota	7.813	−0.037	−1.013	0.341	0.114
Nagaur	9.768	0.056	2.958	0.018	0.522
Pali	8.249	0.036	0.744	0.478	0.065
Sawai Madhopur	8.499	−0.052	−1.199	0.265	0.152
Sikar	10.662	0.048	2.528	0.035	0.444
Sirohi	7.903	−0.024	−0.8749	0.407	0.087
Tonk	9.429	−0.029	−1.502	0.172	0.220
Udaipur	9.112	0.103	1.409	0.1964	0.199

Table 5 Growth coefficient of barley production during 2011-2020

District	Intercept	Growth coefficient	t-Value	P-Value	R^2
Ajmer	11.152	−0.027	−0.701	0.504	0.058
Alwar	10.877	−0.089	−7.986	0.000	0.889
Banswara	7.543	0.027	0.970	0.361	0.105
Barmer	3.886	0.059	0.753	0.473	0.066
Bharatpur	9.146	−0.056	−3.721	0.006	0.634
Bhilwara	11.029	0.005	0.182	0.860	0.004
Bikaner	8.880	0.069	1.892	1.892	0.309
Bundi	7.721	0.097	2.053	0.074	0.345
Chittorgarh	9.870	0.055	3.944	0.004	0.660
Churu	9.158	0.085	3.042	0.016	0.536
Dholpur	7.979	−0.062	−11.13	0.000	0.939
Dungarpur	8.041	−0.005	−0.3530	0.733	0.015
Ganganagar	11.876	0.070	2.433	0.041	0.425
Jaipur	12.304	−0.013	−1.233	0.253	0.160
Jaisalmer	5.549	−0.296	−2.828	0.022	0.500
Jalore	6.966	−0.036	−0.989	0.352	0.109
Jhalawar	7.293	−0.101	−3.910	0.005	0.657
Jhunjhunu	10.488	−0.028	−1.875	0.098	0.305
Jodhpur	6.532	0.057	1.902	0.094	0.311
Kota	7.926	−0.071	−2.018	0.078	0.337
Nagaur	10.547	−0.064	−2.283	0.052	0.394
Pali	9.137	0.035	1.266	0.241	0.167
Sawai Madhopur	8.664	−0.121	−5.398	0.001	0.785
Sikar	11.554	−0.014	−1.160	0.280	0.144
Sirohi	8.141	−0.026	−1.073	0.314	0.126
Tonk	10.335	−0.129	−2.916	0.019	0.515
Udaipur	10.493	0.017	0.977	0.357	0.107

The data depicted in (Table 5) lists the growth rates of barley production in various districts of Rajasthan from 2011 to 2020. The growth rate represents the annual rate of change in barley production, with positive values indicating growth and negative values indicating decline. The intercept represents the baseline yield level, while the t-value, p-value, and R^2 value provide statistical information on the significance and reliability of the trend. Chittorgarh, Churu, and Ganganagar districts have positive growth rates (0.055, 0.085, and 0.070, respectively), with moderately high t-values and low p-values, indicating statistically significant increases in barley production. R^2 values of 0.660 for Chittorgarh and 0.536 for Churu indicate that the growth model explains a large portion of the fluctuations in production. Bundi (0.097) and Jodhpur (0.057) also showed positive growth, but with slightly lower significance [15].

In contrast, Alwar, Dholpur, Sawai Madhopur, and Tonk districts show significant negative growth coefficients (-0.089, -0.062, -0.121, and -0.129, respectively), indicating a decline in barley production. These trends are highly statistically significant, as reflected by their low p-values and high R^2 values (for example, R^2 0.889 for Alwar and 0.939 for Dholpur). Other districts, such as Bharatpur, Jhalawar, and Nagaur, also show negative growth, but the statistical significance is moderate. Districts such as Bhilwara, Dungarpur, and Udaipur show minimal or negligible growth, with coefficients close to zero and high p-values, indicating no significant change in barley production during this period [16].

Overall, the table shows mixed trends in barley production in Rajasthan from 2011 to 2020. Some districts, particularly in the central and western regions, have seen increased production, while other districts, particularly in the eastern and southern regions, have seen significant declines. Statistical indicators (t-values, p-values, and R^2) attest to the robustness of these trends and highlight the diversity of agricultural dynamics in the state during this decade.

RESULTS AND DISCUSSION

Analysis of barley production growth coefficients in Rajasthan from 1980 to 2020 reveals stark and persistent regional disparities, largely driven by irrigation access and resilience to climate stress. In the 1980s, districts like Ajmer and Jodhpur experienced sharp declines due to water scarcity and soil erosion, while areas with robust irrigation infrastructure, like Ganganagar, remained stagnant [17]. The following decades saw sharply divergent trajectories: western districts like Bikaner and Jaisalmer saw significant surges in production through technology adoption in the 1990s and 2000s, while eastern districts like Bharatpur and Bundi experienced a continued decline. By the most recent decade, this polarization intensified, with districts like Chittorgarh and Ganganagar achieving significant growth while others like Alwar and Tonk faced sharp negative trends. Addressing these disparities requires region-specific policies focused on sustainable water management and promoting resilient agricultural practices [18]. Chittorgarh and Ganganagar consolidated growth through resilient cropping systems and improved water-use efficiency, while Alwar and Tonk registered steep declines due to climate stress, groundwater depletion, and lack of adaptive practices. This trajectory reveals a widening gap between technologically advanced, irrigation-supported regions and those locked in ecological and infrastructural vulnerability. To bridge this divide, policy interventions must be sharply region-specific emphasizing sustainable water management in water-scarce zones, diversification into less water-intensive and climate-resilient crops, and targeted support for smallholder farmers to adopt modern, resource-efficient practices. Without such tailored strategies, the disparities in Rajasthan’s barley production will likely persist, undermining both equity and long-term agricultural sustainability.

CONCLUSION

A study of barley production growth coefficients in Rajasthan between 1980 and 2020 highlights significant regional disparities in production performance. Districts with access to irrigation facilities and advanced agricultural technologies experienced positive growth, while others faced stagnation or decline due to resource constraints and climate stress. To address these challenges and ensure sustainable barley production growth, there is a need to expand irrigation facilities with a greater focus on solar energy systems, promote disease-resistant and high-yielding barley varieties, strengthen extension services to increase farmer awareness and adoption of modern practices, and encourage organic and sustainable agricultural approaches. These steps can help revive barley production in Rajasthan and enhance its role in food security, livestock nutrition, and industrial demand.

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