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Regional Disparities In Agricultural Land Use, Cropping Intensity And Irrigation Development In Rajasthan

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ABSTRACT
There are high regional disparities in agricultural development in Rajasthan, with regional differences in the use of land, the supply of irrigation and physical geography. The four indicators used in this study on regional differences in agriculture in Rajasthan are the percentage of land that is actually farmed compared to the total area, the percentage of that land that is farmed twice a year, the percentage of irrigated land compared to the total farmed land compared to the total area farmed. The results indicate a three-fold regional division, with higher agrarian development in the east and south-east (districts of Kota, Baran, Alwar and Bharatpur) due to rich agricultural soils and large-scale regulated irrigation; intermediate advancement in districts in the centre (such as Ajmer, Jaipur and Nagaur) with a transitional character; and lower development in west desert districts (Barmer, Jaisalmer and Churu) and south hilly/tribal districts (Udaipur, Pratapgarh and Sirohi).
The analysis finds that the main factor causing differences in agricultural development is irrigation, with the canal-irrigated northwestern districts (Hanumangarh, Ganganagar) showing how human efforts can overcome environmental challenges. Cropping intensity and irrigation efficiencies are seen to be best in the eastern plains and very vast areas in the western and southern Rajasthan still depend on rainfall variability and subsistence agriculture.
The paper highlights the relevance of locally based agricultural policies: irrigation in the arid areas, watersheds in tribal regions, and diversification in the well-developed agricultural regions to make it sustainable. The implications of these disparities are wider in terms of rural livelihoods, food security, and balanced socioeconomic development in the state than being limited to agriculture. A future study could be designed to incorporate changes over time, climate Analyse the effects of socio-economic factors, enhanced by GIS and first-hand surveys, to develop a comprehensive outlook on fair and sustainable agricultural development in Rajasthan.
Keywords – Regional Disparities, Agricultural Land Use, Cropping Intensity, Net Area Sown, Double Cropped Area, Net Irrigated Area.

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1 Introduction

Agriculture is the mainstay of the economy of Rajasthan, which supports most of the rural population and makes an enormous contribution to the livelihood and food security of the state (Jhajhria, 2023). Nevertheless, the agricultural landscape of Rajasthan is highly nonhomogeneous because of a combination of various agro-climatic regions, which include arid deserts in the west and fertile plains in the east, which has led to the existence of significant regional disparities (Sharma & Vyas, 2019). Patterns of land use, crop intensity, and agricultural productivity are highly affected by the uneven distribution of natural resources, especially water supply via irrigation (Archana, 2021). Such variation has resulted in a situation where the amount of net area under cultivation and the intensity of cropping differ significantly across districts, though there is a lot of land which is classified as cultivable. This variation is not only a product of physical processes like soil type, topography and rainfall, but it is also human mediated through canal irrigation networks and groundwater management initiatives (Jhajhria, 2023). It is important to understand these spatial differences to devise policies that would lead to sustainable and equitable agricultural development in Rajasthan.

The paper explores three important aspects of agricultural modernisation: the extent of the net area sown as a proportion of the reporting area (intensity of land use), the ratio of the area under double cropping to the net sown area (intensity of cropping), and the ratio of the net and gross irrigated areas (development of irrigation). Environmental constraints and infrastructural investments determine the underlying regional inequalities, as the study demonstrates using district-level data. Eastern and northwestern canal-irrigated regions have high agricultural intensity and irrigation coverage, whereas western desert and southern tribal regions are at the margins with low irrigation and agricultural intensity (Jhajhria, 2023; Archana, 2021). Such spatial disparity has consequences regarding rural livelihood, agricultural sustainability and food security in the state.

The state of Rajasthan is typified by pronounced regional differences in agriculture because of the diverse topography and climatic conditions, which are arid deserts, semi-arid plains, and hilly areas. The productivity of agriculture and land use in the state has been well reported as unequal, with the eastern part of the state, like Bharatpur, Alwar, and Kota, having a better agro-climatic situation and well-developed irrigation systems, which have led to better productivity and crop intensity (Jain & Gupta, 2010; Jhajhria, 2023). Western and southern districts, on the other hand, have continued to struggle due to limited rainfall, limited irrigation coverage, and weak soils (Sharma & Vyas, 2019). Such imbalances are starkly reflected in indicators like net area sown and crop intensity, in addition to irrigation intensity, that are lower than the state averages in the arid and tribal regions.

Canal irrigation, especially the Indira Gandhi Canal Project in the northwest, has brought significant changes to the desert lands, increasing the cropping intensity and diversification (Archana, 2021). However, groundwater depletion and irregular rain patterns remain a challenge to the sustainability of irrigation in some of the districts, with recent reports pointing at critical

groundwater stress and poor use of water-saving micro-irrigation systems (Kanwar, 2025). In addition, the cropping pattern in the state indicates the adaptation to the availability of water, as single cropping is more common in water-scarcity areas as compared to multiple cropping in the irrigated districts (Jhajhria, 2023).

Recent policy initiatives by the Rajasthan government focus on crop diversification, increasing irrigation infrastructure, and sustainable water management so as to overcome these regional imbalances (Government of Rajasthan, 2024). Nevertheless, the continued large disparities warrant a descriptive spatial analysis that combines land use, cropping intensity, and irrigation indicators to establish region-specific constraints and opportunities for balanced agricultural development. This paper, therefore, complements existing literature by adopting a multi-dimensional perspective to study the geographical distribution of agricultural inequalities in Rajasthan and their causes.

2 Review of Literature

A detailed study by Baig and Salam (2019) found that agricultural success can be very different even in small areas of Rajasthan, depending on how much access there is to irrigation, resources, and support services. Their results indicate that land use efficiency and cropping intensity are also affected in a significant manner by inequities in landholding patterns and local socio-economic conditions. The paper emphasises the importance of a decentralised policy framework that focuses on micro-level heterogeneity instead of the regional average, which serves to conceal intra-district inequality.

Banerjee and Kuri (2014) conduct convergence analysis of agricultural growth across the regions of India and show that, although the country has experienced growth on average, poorer regions have not been able to narrow the gap in terms of resource endowment and infrastructure. Rajasthan, as a state with climatic variability and resource limitations, is one of the best examples of such a case, where irrigation inequities have been a major concern. According to their research, without specific investment in irrigation infrastructure and diffusion of technology, regional differences in cropping density and land use will remain. Bhati et al. (2017) pay attention to Western Rajasthan and its dryland agricultural systems, evaluating the suitability of the available technologies to enhance production. They have described their case study as having constraints in terms of unpredictable rainfall and inadequate irrigation, and they recommend the use of drought-resistant varieties, water harvesting, and conservation agriculture to increase cropping intensity in such delicate ecosystems. The authors emphasise that technological adaptation should be conditioned by regions and take into account socio-economic and agro-ecological situations.

Birkenholtz's (2009) sociological approach to the problem of irrigation landscapes in Rajasthan creates both agricultural productivity and social scarcity. His ethnographic depth shows that irrigation infrastructure enlarges the land under cultivation but also introduces a competition in terms of water resources, which at times culminates in a conflict. Adaptive institutional arrangements tend to be developed to regulate the sharing of resources, but these are greatly

differentiated across regions, shaping the uneven development of intensity in cropping and land use patterns within the state. Chadha, Meena, and Sharma (2019) investigated the geographical and temporal changes in fertiliser use and were able to find significant correlations with irrigation coverage and cropping intensity. Their study at the district level indicates that the eastern and canal-irrigated districts of Rajasthan apply very high levels of fertiliser, which makes intensive cultivation viable, but the western districts are behind because of limited irrigation and low economic potential. They We propose enhancing access to fertilisers and advisory services in poor regions to sustainably increase crop productivity.

Chauhan and Thakur (2022) conduct a quantitative study of the disparity in agricultural development processes at the district level in Rajasthan. Their findings prove that there are deep-seated inequalities with high land use and cropping intensity in the northern and eastern districts, namely Bharatpur and the dry southern and tribal districts. The study suggests that such disparities are strongly attributed to the availability of irrigation infrastructure, and therefore, targeted infrastructural investments, in addition to socio-economic development policies, are required in underdeveloped districts. Das (2006) gives a detailed description of crop patterns and yield gaps in the agricultural and horticultural regions of Rajasthan. Based on his general evaluation, he identifies major bottlenecks as low levels of irrigation, low utilisation of inputs, and climatic fluctuations that are involved in regional yield variation. The report recommends some strategic interventions to ensure that cropping patterns are optimised and yields increase; one of them is to expand irrigation coverage and use improved crop varieties in underdeveloped areas.

Jangid, Sharma, and Singh (2018) discuss the land use transformation and crop diversification in the humid south-eastern plains and claim to see the positive changes related to irrigation and access to the market. Their analysis reveals that there is also a rising trend in cropping intensity and the diversification of high-value crops, which points to the positive effects of infrastructural and policy support. The paper compares it with arid zones, where Jangid et al. (2018) also indicate a lack of diversification and intensive cropping due to the unavailability of irrigation and other resources. Kiran and Punia (2025) perform a recent district-level analysis of land use and crop combinations in Rajasthan through spatial mapping. Their results demonstrate specific crop combination zones that have high correlations to availability of irrigation and soil properties. They identify regions where support for diversifying crops and improving farming practices could significantly increase productivity, particularly by enhancing irrigation systems in underdeveloped districts to allow for growing multiple crops.

Kumar and Jain (2013) analyze the growth of agricultural productivity and its variability at the district level using the data on the irrigation infrastructure as a proxy of growth and its variability. Their econometric analysis highlights the importance of irrigation in stabilizing the production that leads to an upsurge in cropping intensity and hence food security. The paper indicates that policies directed at the expansion of irrigation might mitigate the regional inequality across the semi-arid region of Rajasthan.

Meena, in her econometric analysis of growth, instability, and crop diversification in the semi-arid eastern plains, concludes that irrigation adoption and other technology inputs have triggered moderate growth and diversification. Climatic constraints and lack of consolidated landholdings, however, continue to restrict the high potential of agriculture. The research suggests integrated approaches that increase access to irrigation, diversification to reduce risks, and delivery of inputs. The paper by Mishra et al. (2023) evaluates irrigation land suitability in semi-arid Rajasthan through the integration of climatic, soil, and hydrological data. Their spatial analysis provides details on areas that cannot be subjected to conventional irrigation expansion because of water shortages or deteriorating soil quality. This offers a scientific foundation to resource allocation and irrigation investment targeting, in determining sustainable water use practices to alleviate inequalities.

The district-wise analysis by Newar and Sharma shows how land use has changed over the years and found that the land use has increased due to institutional interventions such as canal projects, increasing the cropping intensity in the area. They however report continued degradation of land and diminishing productivity in other districts, showing that benefits are not distributed equally. The paper recommends integrated land and water management in order to make agricultural growth sustainable in the various agro-ecologies in Rajasthan. Panchal (2024) dwells on the new developments in the irrigation infrastructure in Rajasthan. This analysis shows that there has been significant upgrading in terms of canal and micro-irrigation schemes in certain districts leading to increment in cropping intensity. However, some inequalities still exist because of unequal investment and differences in institutional capacity in remote and arid areas. In the report, local water governance and investment in drip and sprinklering systems are highlighted as a means to optimize the limited water resources.

Sen and Gupta (1982) present a very basic ecological typology of western Rajasthan, which is still important in comprehending the cropping and irrigation patterns of disparities. Their definition of agro-ecopotentials and potentials further informs spatially differentiated policy approaches. Sharma, Burark, and Meena (2015) address the issue of land degradation and its effects on sustainable agriculture in Rajasthan, stating that degraded soils reduce the efficiency of irrigation and crop yield, mainly in the south and the west parts of the state. Their work emphasises the importance of reclamation and conservation agriculture in restoring productive capacity, which is essential for narrowing the regional disparity gap and enabling more intense land use. Singh et al. (2018) and Singh and Aneja (2025) examine growth patterns and regional convergence in agriculture, observing that northeast Rajasthan is slowly narrowing productivity gaps through special irrigation and input subsidy, whereas western dry regions are far behind. Their results indicate that, despite the existence of regional disparities, policies' effects are evident in some growth corridors.

Tiwari and Mathur (2010) break down economic disparities in Rajasthan, correlating wider socio-economic indicators with agricultural development and point out that disparities in cropping

intensity and irrigation development are compounded by infrastructure deficits and pressure of population in rural areas. Their work reiterates the importance of multi-sectoral development to agricultural parity. Rajasthan has long been confronted by agricultural issues, which Vijayshankar (2017) places in the broader context of political economy in India and the impact of policy developments and institutional changes on irrigation and cropping patterns. The author observes that inconsistent policy support and resource allocation have been underlying factors to persistent regional inequality.

Yadav (1965) provides a historical perspective of the cropland use in Rajasthan, which depicts early spatial inequalities as can be seen decades ago. Such a long-term view assists in putting current issues of irrigation and intensive cropping into perspective by highlighting the structural limitations of the past that require policy intervention.

3 Methodology

The present study, entitled "Regional Disparities in Agricultural Land Use, Cropping Intensity and Irrigation Development in Rajasthan", was undertaken with the objective of examining the spatial variations in agricultural performance across different districts of Rajasthan. The state, with its vast geographical expanse and contrasting agro-climatic regions, provides a unique setting to study how land use patterns, intensity of cropping, and the availability of irrigation facilities determine agricultural development. To ensure meaningful comparison and spatial clarity, the district has been adopted as the basic unit of analysis, as it provides a standard administrative framework and allows the representation of local-level variations within a broader regional context.

We have entirely based the study on secondary data collected from the Department of Statistics, Government of Rajasthan, for the year 2023. This particular year was selected to provide a recent and up-to-date picture of agricultural development, thereby enabling the study to reflect the present scenario of land use and irrigation practices in the state. The reliance on official government statistics ensures uniformity, reliability, and comparability of data across districts.

To analyse the regional disparities systematically, four major agricultural indicators were selected. First, net area sown as a percentage of reporting area has been taken as a measure of agricultural land use, reflecting the extent of land resources brought under cultivation in each district. Second, double-cropped area as a percentage of Net Area Sown serves as an indicator of cropping intensity, showing how intensively the available agricultural land is being utilised and thereby highlighting differences in agricultural practices between regions. Third, Net Irrigated Area as a percentage of Net Area Sown has been included to assess the spread and availability of irrigation facilities, which play a crucial role in determining agricultural stability in a predominantly arid and semi-arid state like Rajasthan. Finally, the gross irrigated area as a percentage of the gross area sown has been used to evaluate irrigation efficiency, reflecting both the reliability of irrigation systems and the sustainability of water use in agricultural production. Together, these indicators offer an extensive framework for assessing disparities in land use, cropping intensity, and irrigation development.

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For analysis, simple yet effective statistical techniques were employed. Ratios and percentages were computed for each indicator in all the districts to normalise the data and allow meaningful comparison, despite differences in geographical size and natural resource base. Based on these Results: the districts were categorised into groups such as high, medium, and low performance, enabling a clear visualisation of spatial disparities. Further, the districts were grouped into broader geographical regions such as eastern, western, southern, and central Rajasthan to bring out the regional contrasts shaped by environmental and infrastructural factors. Maps, tables, and charts were prepared to support the statistical findings and to highlight the geographical dimension of agricultural development.

It is important to acknowledge that this study has certain limitations. Since the analysis is based exclusively on secondary data for a single year (2023), it provides only a static picture of agricultural development and does not capture temporal trends or farmers' socio-economic conditions. However, the selected indicators and the method used create a clear and scientific way to assess the differences in land use, cropping intensity, and irrigation development throughout Rajasthan. By integrating quantitative indicators with regional analysis, the study seeks to provide a comprehensive understanding of the present state of agricultural development and highlight the geographical inequalities that characterise Rajasthan's rural landscape.

4 Regional Disparities in Net Area Sown / Reporting Area

Table 1 - Regional Disparities in Net Area Sown / Reporting Area in Rajasthan

District	Net Area Sown / Reporting Area
Ajmer	53.33
Alwar	63.1
Banswara	51.67
Baran	50.04
Barmer	59.16
Bharatpur	77.43
Bhilwara	44.29
Bikaner	54.96
Bundi	48.29
Chittorgarh	42.8
Churu	81.72
Dausa	64.36
Dholpur	52.46
Dungarpur	53.4
Ganganagar	78.54
Hanumangarh	87.54
Jaipur	59.37
Jaisalmer	29.89
Jalore	64.33
Jhalawar	57.78
Jhunjhunu	81.39
Jodhpur	62.33
Karauli	52.64
Kota	52.94
Nagaur	79.97
Pali	53.91
Pratapgarh	35.9
Rajsamand	70.95
S.Madhopur	57.35
Sikar	67.46
Sirohi	37.61
Tonk	54.26
Udaipur	18.36
Raj. State	53.74

Agricultural development in Rajasthan is highly uneven, largely due to variations in physical conditions, irrigation facilities, and socio-economic factors. The indicator of Net Area Sown as a percentage of Reporting Area provides a useful measure to examine the extent of agricultural land use across districts and highlights regional disparities. At the state level, the average stands at 53.74 percent, but the district-wise data reveals sharp contrasts, ranging from as low as 18.36 percent in Udaipur to as high as 87.54 percent in Hanumangarh.

The northern and northeastern districts exhibit the highest levels of agricultural development in terms of land use. Hanumangarh (87.54%), Churu (81.72%), Jhunjhunu (81.39%), Nagaur (79.97%), Ganganagar (78.54%) and Bharatpur (77.43%) represent regions where agricultural intensity is far above the state average. These districts benefit from irrigation networks, particularly the Indira Gandhi Canal in the north-western arid zones, which has transformed desert landscapes into productive agricultural tracts. Fertile soils in Bharatpur and Alwar further contribute to increased land utilisation. This region reflects the core agricultural zone of Rajasthan, where dependence on agriculture is strongest.

By contrast, a number of central districts such as Ajmer, Jaipur, Kota, Jodhpur, and Jalore record values around the state average, ranging between 50–60 percent. While agriculture plays a significant role in these areas, other land uses balance it out. Semi-arid climatic conditions, expanding urban settlements, and mixed economic activities explain the moderate extent of cultivated land.

Conversely, the southern and southeastern districts, such as Udaipur (18.36%), Pratapgarh (35.9%), Sirohi (37.61%), Chittorgarh (42.8%), and Bhilwara (44.29%), exhibit significantly lower percentages of net sown area. Here, hilly terrain, dense forests, and tribal-dominated regions limit the availability of cultivable land. Similarly, the western desert district of Jaisalmer (29.89%) shows minimal cultivation due to extreme aridity and sparse irrigation. These regions highlight the geographical constraints that inhibit agricultural expansion, reflecting a peripheral agricultural zone with relatively low development.

Thus, the data underlines the presence of regional disparities in agricultural development within Rajasthan. The canal-irrigated northern plains and fertile eastern tracts emerge as agriculturally advanced regions, while the hilly, forested, and desert districts remain lagging behind. This uneven distribution of cultivated land not only reflects variations in physical geography but also emphasizes the role of human interventions, particularly irrigation infrastructure, in shaping agricultural development. In conclusion, Rajasthan presents a classic case of geographical disparity, where natural constraints and infrastructural advantages together produce a stark contrast in levels of agricultural development across its districts.

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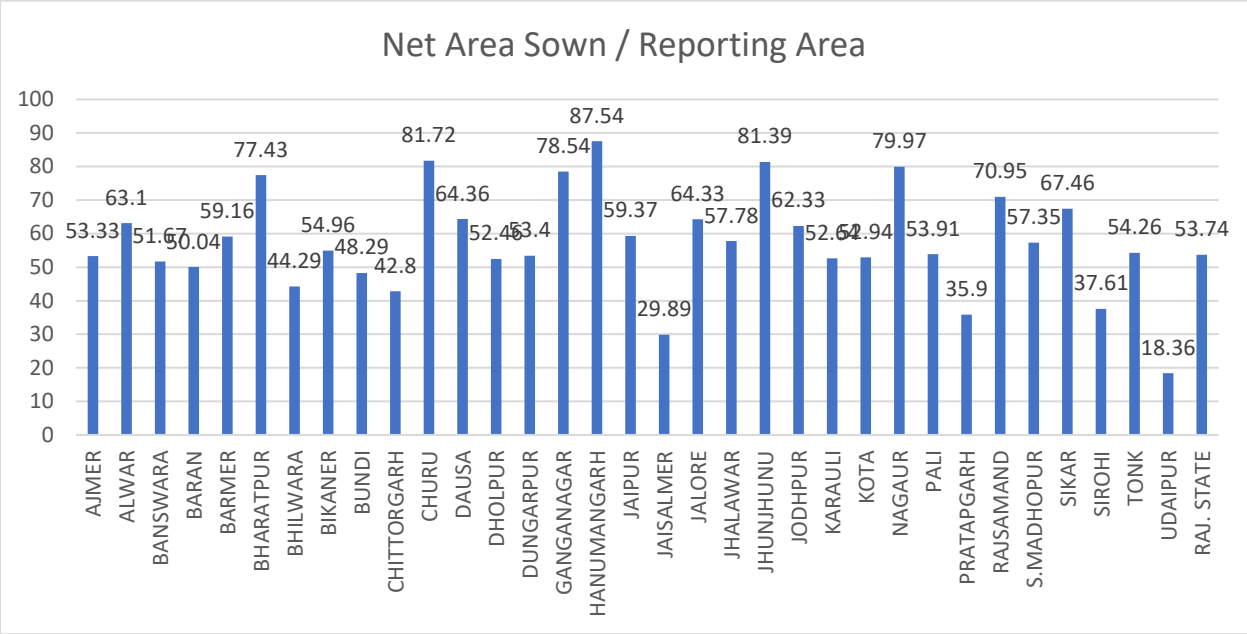
Figure 1 - Regional Disparities in Net Area Sown / Reporting Area in Rajasthan



5 Regional Disparities in Cropping Intensity

Table 2 - Regional Disparities in Cropping Intensity

District	Double Cropped Area / Net Area Sown
Ajmer	70.1
Alwar	85.76
Banswara	77.63
Baran	89.86
Barmer	16.53
Bharatpur	60.4
Bhilwara	45.46
Bikaner	63.98
Bundi	79.37
Chittorgarh	66.41
Churu	50.76
Dausa	73.29
Dholpur	64.45
Dungarpur	67.85
Ganganagar	69.1
Hanumangarh	65.69
Jaipur	67.47
Jaisalmer	34.85
Jalore	65.44
Jhalawar	80.33
Jhunjhunu	39.67
Jodhpur	54.52
Karauli	71.94
Kota	71.91
Nagaur	49.51
Pali	59.44
Pratapgarh	37.02
Rajsamand	57.33
S.Madhopur	63.57
Sikar	47.77
Sirohi	59.4
Tonk	64.94
Udaipur	50.84
Raj. State	52.92

Agricultural development is shown by both the amount of land cultivated and the intensity of its use. The ratio of the double-cropped area to the net area sown serves as a key indicator of cropping

intensity, reflecting the degree to which farmers are able to take multiple crops from the same piece of land within a year. At the state level, Rajasthan records an average of 52.92 percent, which indicates that nearly half of the net sown area is used for more than one crop annually. However, this average conceals significant regional disparities across districts.

The eastern and southeastern districts exhibit the highest levels of cropping intensity. Baran (89.86%), Alwar (85.76%), Jhalawar (80.33%), Bundi (79.37%), and Banswara (77.63%) are the top five districts, all with scores above 75 percent. The presence of fertile soils, relatively higher rainfall, and better irrigation infrastructure in the eastern plains and south-eastern plateau regions explain this high cropping intensity. These districts represent the agriculturally progressive zones of Rajasthan, where favourable natural conditions combine with human efforts to maximise land productivity.

A group of districts such as Karauli (71.94%), Kota (71.91%), Dausa (73.29%), Ganganagar (69.1%), Jaipur (67.47%), and Dungarpur (67.85%) also record values above the state average, signifying a strong agricultural base. In particular, Ganganagar, though located in the arid west, benefits from the Indira Gandhi Canal, enabling higher cropping intensity despite natural constraints. These regions represent areas of moderately high agricultural development.

By contrast, several districts record values much below the state average, highlighting lagging agricultural development. Pratapgarh (37.02%), Jhunjhunu (39.67%), Bhilwara (45.46%), Sikar (47.77%), and Nagaur (49.51%) are examples of low cropping intensity regions. Here, a combination of semi-arid conditions, dependence on monsoonal rains, and limited irrigation restricts the scope of multiple cropping.

The western desert districts, notably Barmer (16.53%) and Jaisalmer (34.85%), remain the least developed in terms of cropping intensity. Harsh arid conditions, sandy soils, and extreme water scarcity limit farmers to a single crop in most years. Even though Jaisalmer has slightly higher values than Barmer, both districts reflect the peripheral agricultural zones of Rajasthan.

Interestingly, some southern hilly districts such as Udaipur (50.84%) and Rajsamand (57.33%) fall around the state average. Here, terrain and forest cover restrict agricultural expansion, but wherever irrigation is available, double cropping has been adopted to some extent.

In conclusion, the data on Double Cropped Area as a percentage of Net Area Sown brings out a clear picture of regional disparities in agricultural development in Rajasthan. The eastern and southeastern districts are the most productive for farming, while the desert west is far behind. The canal-irrigated tracts of northwestern Rajasthan stand out as exceptions, demonstrating how infrastructural interventions can overcome geographical constraints. Overall, cropping intensity serves as a vital indicator of how uneven agricultural development is across Rajasthan, reflecting both natural endowments and human efforts in transforming land use.

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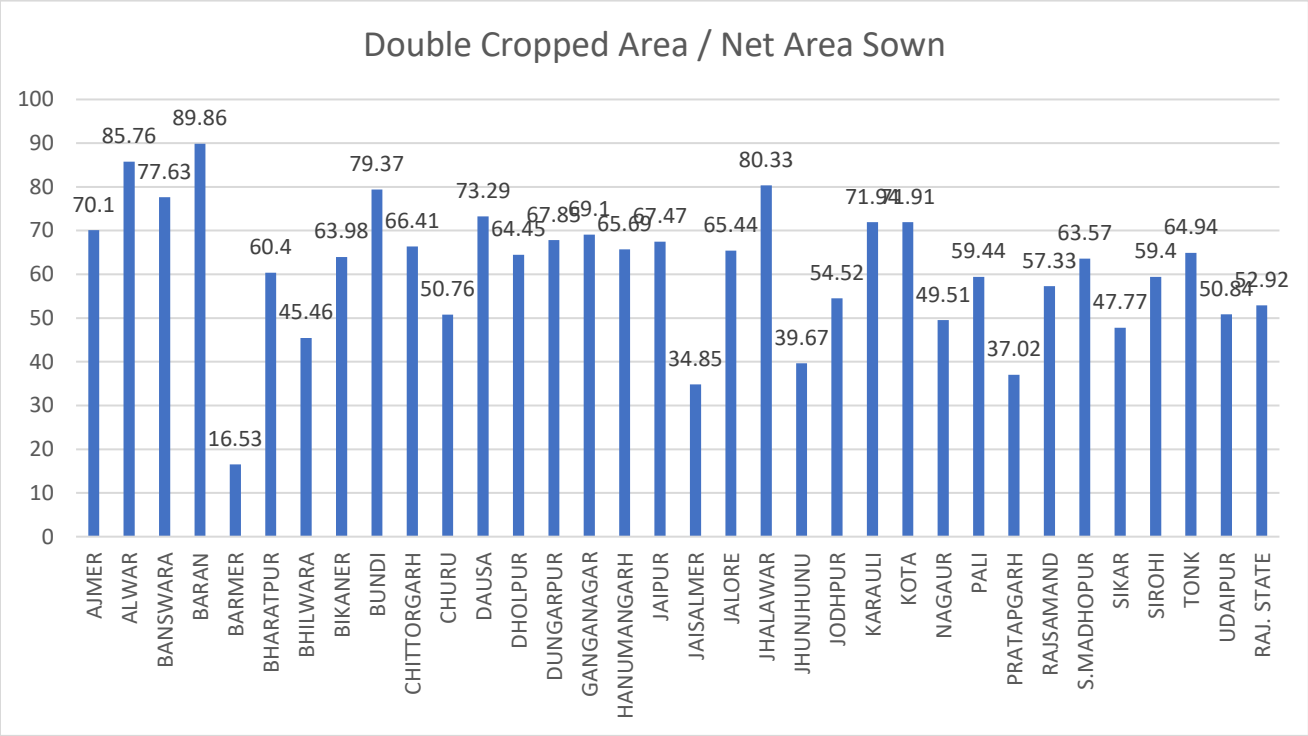
Figure 2 – Regional Disparities in Cropping Intensity



6 Regional Disparities in Net Irrigated Area

Table 3 – Regional Disparities in Net Irrigated Area

District	Net Irrigated Area / Net Area Sown
Ajmer	61.16
Alwar	93.13
Banswara	66.68
Baran	96.93
Barmer	16.25
Bharatpur	93.85
Bhilwara	57.7
Bikaner	41.76
Bundi	89.48
Chittorgarh	88.61
Churu	37.17
Dausa	94.67
Dholpur	91.01
Dungarpur	61.11
Ganganagar	86.74
Hanumangarh	84.1
Jaipur	87.5
Jaisalmer	34.64
Jalore	41.44
Jhalawar	96.34
Jhunjhunu	67.46
Jodhpur	45.54
Karauli	67.14
Kota	97.61
Nagaur	56.02
Pali	46.94
Pratapgarh	50.97
Rajsamand	50.21
S.Madhopur	88.49
Sikar	41.75
Sirohi	49.12
Tonk	79.48
Udaipur	68.67
Raj. State	51.57

Irrigation plays a central role in determining the pace and extent of agricultural development, particularly in a state like Rajasthan where rainfall is erratic and unevenly distributed. The indicator of Net Irrigated Area as a percentage of Net Area Sown clearly reveals the geographical disparities in the spread of irrigation facilities across districts. At the state level, the average stands at 51.57 percent, suggesting that nearly half of the cultivated land in Rajasthan depends on assured irrigation. Yet, district-wise data demonstrates a striking imbalance, with irrigation levels ranging from as low as 16.25 percent in Barmer to as high as 97.61 percent in Kota.

The eastern and southeastern districts of Rajasthan emerge as the most irrigation-developed regions. Kota (97.61%), Baran (96.93%), Jhalawar (96.34%), Dausa (94.67%), Bharatpur (93.85%), Alwar (93.13%), and Dholpur (91.01%) record irrigation coverage well above 90 percent. These districts, part of the eastern plains and the Hadoti plateau, benefit from perennial rivers such as the Chambal and its tributaries, as well as extensive canal and well irrigation systems. Their high irrigation coverage has facilitated intensive cultivation and high cropping intensity, making them the most agriculturally advanced parts of Rajasthan.

Another set of districts, such as Bundi (89.48%), Chittorgarh (88.61%), Jaipur (87.5%), Sawai Madhopur (88.49%), Ganganagar (86.74%), and Hanumangarh (84.1%), also record very high irrigation levels, establishing them as irrigation-dominant zones. The northwestern districts of Ganganagar and Hanumangarh deserve special mention, as their high irrigation intensity is a result of the Indira Gandhi Canal Project, which has transformed the desert landscape into one of the most productive agricultural belts of the state.

In contrast, the western desert districts of Barmer (16.25%), Jaisalmer (34.64%), Churu (37.17%), Sikar (41.75%), Jalore (41.44%), and Bikaner (41.76%) remain severely lagging behind, with irrigation coverage far below the state average. Their dependence on uncertain monsoon rains and scarcity of perennial water sources makes agriculture highly vulnerable and subsistence-orientated. These regions represent the peripheral agricultural zones of Rajasthan, where natural limitations continue to dominate despite efforts at infrastructural expansion.

The southern hilly and tribal districts, such as Udaipur (68.67%), Banswara (66.68%), Dungarpur (61.11%), Rajsamand (50.21%), Pratapgarh (50.97%), and Sirohi (49.12%), show moderate irrigation levels. Here, terrain and forest cover restrict large-scale irrigation networks, but localised wells, tube wells, and minor irrigation projects provide partial support. Despite relatively better rainfall than western Rajasthan, these districts are unable to fully capitalise on irrigation potential due to geographical constraints.

Thus, the analysis highlights a stark regional disparity in irrigation coverage across Rajasthan. The eastern and southeastern districts, which are supported by rivers and canals, are the main agricultural area. The northwestern tract, which is irrigated by canals, is a great example of how people can overcome environmental challenges. In sharp contrast, the western arid districts and hilly southern belts continue to remain backward in terms of irrigation development. This unequal distribution of irrigation resources has a direct bearing on cropping intensity, land usage, and overall agricultural development in Rajasthan, reinforcing the geographical disparities that define the state's agrarian structure.

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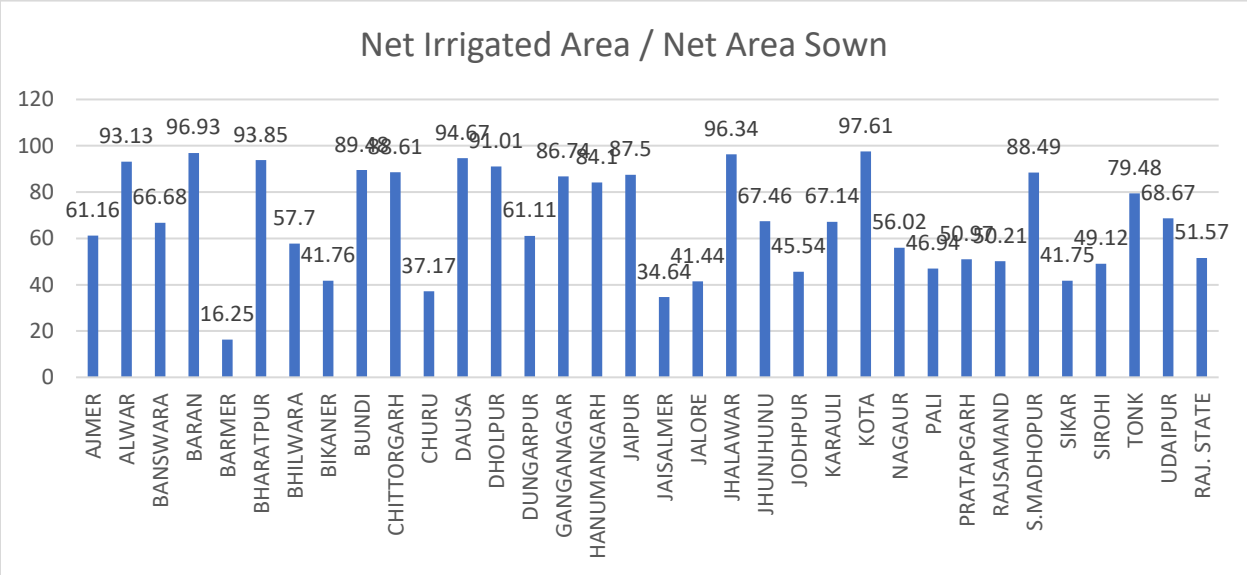
Figure 3 - Regional Disparities in Net Irrigated Area



7 Regional Disparities in Gross Irrigated Area

Table 4 - Regional Disparities in Gross Irrigated Area

District	Gross Irrigated Area / Gross Area Sown
Ajmer	55.82
Alwar	58.62
Banswara	39.81
Baran	54.21
Barmer	13.04
Bharatpur	86.61
Bhilwara	48.03
Bikaner	38.03
Bundi	67.05
Chittorgarh	48.03
Churu	33.08
Dausa	63.06
Dholpur	56.78
Dungarpur	36.7
Ganganagar	61.06
Hanumangarh	56.7
Jaipur	52.34
Jaisalmer	29.4
Jalore	41.17
Jhalawar	51.81
Jhunjhunu	48.77
Jodhpur	39.21
Karauli	49
Kota	56.41
Nagaur	50.86
Pali	35.79
Pratapgarh	27.33
Rajsamand	37.81
S.Madhopur	53.22
Sikar	33.61
Sirohi	45.02
Tonk	51.99
Udaipur	37.72
Raj. State	44.67

Accessibility and utilization of irrigation are central to agricultural growth, particularly in a semi-arid state like Rajasthan. Gross Irrigated Area, as a percentage of Gross Area Sown, gives an idea of the extent to which the total area under the crop (including that sown more than once) is

irrigated. The average of Rajasthan is 44.67 percent, which means that less than half of the total cropped area is assured of irrigation. District-wise differences, however, bring into sharp focus some regional inequalities, with the lowest being 13.04 percent in Barmer and the highest being 86.61 percent in Bharatpur.

The gap is evident because the eastern districts have a clear dominance as far as efficiency in irrigation is concerned. Bharatpur (86.61%), Bundi (67.05%), Dausa (63.06%), Ganganagar (61.06%), Hanumangarh (56.7%), and Hanumangarh (56.7) are some of the districts that give values much higher than the state average. This is indicative of the high irrigation potential of perennial rivers, canals, and groundwater extraction in the eastern plains and the canal-irrigated northwestern belt. These regions are the most irrigation-intensive areas of Rajasthan with both net sown area and multiple crops facilitated by the irrigation infrastructure and thus, they are more productive in agricultural terms.

The above-average values can also be found in such districts as Alwar (58.62%), Dholpur (56.78%), Kota (56.41%), and Jaipur (52.34%), which proves the irrigation-dominated character of the eastern and southeastern agricultural zone. In such districts, irrigation not only facilitates single cropping but also enables high cropping intensity, which represents a mature stage of agricultural development.

The arid areas in the west are by far the most inadequately irrigated regions. Barmer (13.04%), Jaisalmer (29.4%), Churu (33.08%), and Sikar (33.61%) rank as the lowest on the scale. These regions fall into the desert, where there is low rainfall, groundwater is scarce, and canal coverage is either nonexistent or inadequate. Agriculture in these areas is mostly subsistence-oriented and based on monsoonal variability, which further underscores their peripheral position as agricultural areas.

Likewise, hilly and tribal districts in the south like Pratapgarh (27.33%), Dungarpur (36.70%), Udaipur (37.72%), Banswara (39.81%) and Rajsamand (37.81%) all have below-average figures. Although the rainfall is relatively good, the mountainous character and the scattered settlement do not allow irrigation to expand much. Agriculture in this region remains rain-fed and so the districts are relatively backward in terms of irrigation efficiency.

Such districts as Bhilwara (48.03%), Jhalawar (51.81%), Nagaur (50.86%), and Sawai Madhopur (53.22%) are in the intermediate area near the average. Irrigation, in these districts, encourages agriculture to a certain degree, but still there is a difference when compared to the more advanced eastern districts.

In short, the Gross Irrigated Area to Gross Area Sown shows a definite geographical distribution of Rajasthan. The irrigated plains in the east and the canal-irrigated northwest would become the zones of irrigation intensity with multiple cropping and productivity. The western desert districts and southern hilly belts, on the other hand, remain behind due to both natural lagging and infrastructural shortages. This difference in irrigation efficiency highlights the unequal availability of agricultural growth within the state and demonstrates that assured water sources are the most important factor in determining agricultural inequality among regions in Rajasthan.

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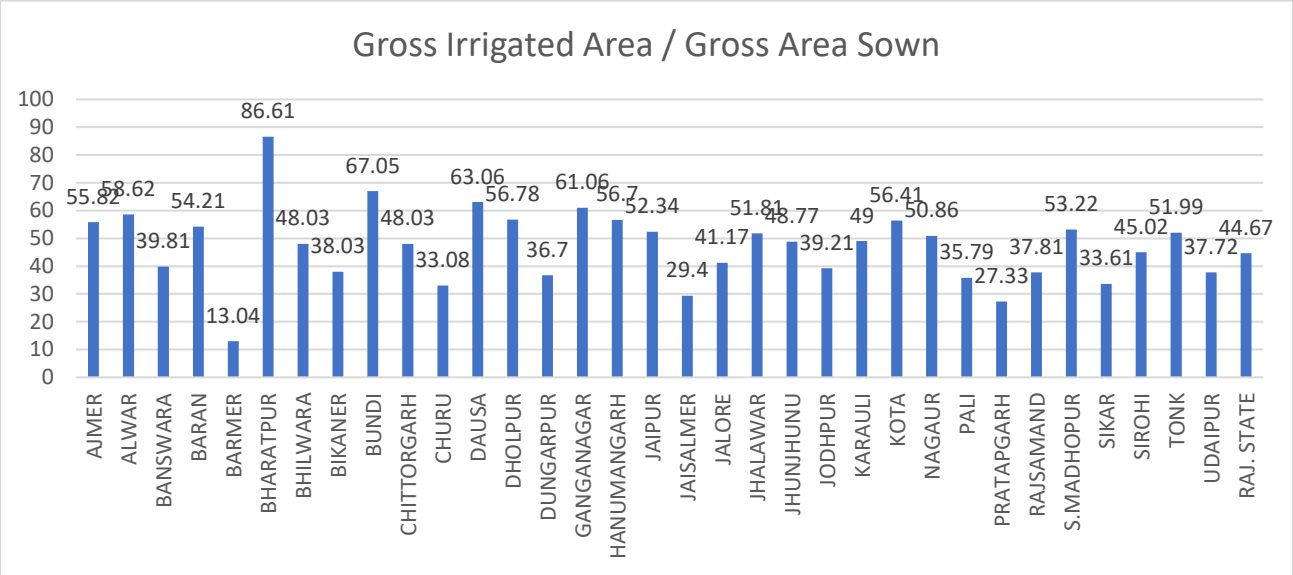
Figure 4 - Regional Disparities in Gross Irrigated Area



8 Conclusion

The discussion on agricultural indicators of the districts in Rajasthan brings out an alarming level of regional inequality in agricultural development, which has been influenced by both geography and man. The four indicators Net Area Sown as a percentage of Reporting Area, Double Cropped Area as a percentage of Net Area Sown, Net Irrigated Area as a percentage of Net Area Sown, and Gross Irrigated Area as a percentage of Gross Area Sown correlate to bring out various aspects, but the disparity between the districts is intense. Canal-irrigated northwestern areas like Hanumangarh, Ganganagar, and Churu, as well as eastern states like Bharatpur, have very high landholding percentages. Conversely, the southern hilly regions (Udaipur, Pratapgarh, and Sirohi) and the barren desert belt (Jaisalmer, Barmer) are at the bottom, and this is due to the restrictions geographically imposed such that there is limited cultivable land.

The ratio of double-cropped area to net area sown is the second indicator of the intensity of land use. In this, the eastern and south-eastern regions, including Baran, Jhalawar, Bundi, and Alwar, have a cropping intensity of more than 75 percent, which indicates fertile soils and availability of water through irrigation. Conversely, western desert districts (Barmer, Jaisalmer) and semi-arid regions of Nagaur, Jhunjhunu and Sikar are still far behind, implying that multiple cropping is not widespread over large areas in Rajasthan.

Thirdly, the net irrigated area/net area sown shows the level of the guaranteed water supply to agriculture. The eastern districts (Kota, Baran, Jhalawar, Alwar, Bharatpur) gain irrigation coverage of more than 90 percent, constituting the core of the irrigation-based Rajasthan. Success stories also occur in the arid west in the canal-irrigated districts of Ganganagar and Hanumangarh. In comparison, the western part of Rajasthan (Barmer, Jaisalmer, Churu, and Bikaner) and hilly southern districts are still rain dependent, with net irrigation levels well below the state average.

Lastly, the gross irrigated area/gross area sown indicates the efficiency of irrigation and its contribution to multiple cropping. The eastern plains, especially Bharatpur, Bundi, and Dausa, are highly efficient, where much of the gross cropped area is facilitated by irrigation. The western

desert and southern tribal belts, however, are poorly developed, with values as low as 13 percent in Barmer and less than 30 percent in Pratapgarh and Jaisalmer.

Combined, these indicators highlight a threefold regional trend in the agriculture of Rajasthan:

- Agriculturally advanced areas: eastern and south-eastern districts that are characterised by high net-sown areas, extensive double cropping, and virtually universal irrigation (e.g., Kota, Baran, Alwar, Bharatpur, and Bundi).
- Moderately developed areas – central districts (Ajmer, Jaipur, Nagaur, Jhalawar, Bhilwara) with moderate cultivation and irrigation as an intermediate development of rural land.
- Sluggish areas – arid districts of the west (Barmer, Jaisalmer, and Churu) and hilly-tribal districts of the south (Udaipur, Dungarpur, Pratapgarh, and Sirohi) that have restricted agriculture by natural obstacles and poor irrigation infrastructure.

Therefore, the paper affirms that regional imbalances in agricultural development in Rajasthan are a direct result of unequal natural resources, irrigation facilities, and infrastructural interventions. Eastern and canal-irrigated northwestern Rajasthan have become agriculturally intensive, but large areas of the desert west and hilly south remain comparatively backward. This disparity further justifies the necessity of region-specific agricultural policies – i.e., expansion of irrigation in desert regions, watershed management in tribal belts and diversification in agriculturally developed regions – to bring a balance in the agricultural development of Rajasthan.

9 Study Implications

The implications of the present study on regional disparities in agricultural land use, cropping intensity and irrigation development in Rajasthan are important to agricultural planning and policymaking. The results indicate that agricultural development in the state is very unequal, with eastern and canal-irrigated northwestern districts being much more intensively cultivated and highly irrigated compared to desert areas to the west and the hilly tribal areas to the south. This clearly shows that irrigation is still the most decisive determinant of agricultural disparities and hence region-specific interventions are very important. The policymakers should focus on backward areas to invest in canal widening facilities, rainwater harvesting, watershed management, and groundwater control, as well as to make the most use of available resources in well-developed agricultural territories. Meanwhile, the aim to diversify crops and use sustainable farming practices should be promoted in areas where cropping intensity is high (Baran, Kota, and Bundi). These implications go beyond farming in the sense that regional disparities in farming directly impact rural livelihoods, food security, and socio-economic development; therefore, narrowing the gaps will also help to balance the growth of living standards across the state. Moreover, the methodological design of multiple indicators of development offers a more holistic platform on which further research and policy tracking can be done to help in gaining insight on long-term transitions in agricultural transformation. On the whole, the paper indicates that only with decentralised, region-specific and environmentally sustainable planning is it possible to achieve balanced agricultural growth in Rajasthan that will address inequality in terms of irrigation, crop patterns and infrastructural support, thus ensuring equitable and sustainable agricultural development of the state.

10 Future Scope of the Study

The current research paper leaves many opportunities to explore further research in the area of agricultural development in Rajasthan. Although the analysis has shown spatial differences in irrigation, cropping intensity, and land use, subsequent research may be taken in a temporal direction, where they may look at how these disparities change over the decades due to changing rainfall patterns, the adoption of technology, and government interventions. Using remote sensing and GIS tools along with on-the-ground surveys can provide more precise maps of agricultural resources and reveal small differences that might be missed when looking at averages for entire districts. In the future, it is also possible to go beyond physical and infrastructural determinants to the socio-economic factors like literacy, income levels, landholding size, access to credit, market linkages, and so on that are also known to have a strong influence on agricultural performance. The second key area of research would be to examine the effects of climate change on regional inequality, especially in drought-affected western districts where climatic changes are posing significant challenges to agricultural sustainability. Moreover, a comparative analysis of other states experiencing similar agro-climatic diversity may be used to add more depth to the discussion of policy efficacy and offer Rajasthan a model that could be easily replicated. Finally, it would be best to involve farmers in the research by conducting primary surveys to confirm the statistical data and gain practical knowledge regarding the agricultural planning of the region. In that way, the future direction of this research will be in increasing the methodological depth, integration of other disciplines, as well as a policy-orientated direction that would provide a more comprehensive view of the agricultural development in Rajasthan.

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