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RESEARCH ARTICLE

WATER SCARCITY IN RAJASTHAN: ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS, MANAGEMENT CHALLENGES AND POLICY OPTIONS

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Abstract

One of the key environmental and socio-economic issues affecting India today is water scarcity. As far as Rajasthan is concerned, the area has witnessed a lot of struggles associated with water scarcity due to its arid environment and complex relationship between humans and the environment. This paper analyses some of the issues that contribute to water scarcity by taking into account the environmental degradation, socio-economic impacts, historical irrigation infrastructure, groundwater conditions, and challenges in water management, due to water scarcity. For the purpose of this analysis, national level datasets such as Mission Antyodaya and SHRUG are used together with various reviews and literature. Qualitative results from the interviews conducted with factory workers residing in villages in Alwar district where there is a problem with water scarcity will be taken into account as well. In particular, there will be an analysis of detailed data concerning the irregularity of access to water resources in Rajasthan, depletion of underground water resources, lack of infrastructure in the area and other facts which justify water scarcity. Combination of traditional measures to conserve water and modern efforts made at the governmental level can help improve water management and water security in the area.

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Introduction:-

Water security has always played a crucial role in maintaining India's socio-economic development and ecological stability. The biggest state in the country, Rajasthan, faces substantial water scarcity challenges due to climatic and geological peculiarities of the area as well as some other causes. According to ResearchGate (2015), the region gets only 100-600 mm of precipitation per year in the form of irregular monsoon rains. In addition, water scarcity is exacerbated by growing population numbers, intensified agricultural activities and increasing urbanization in the region. According to the World Bank (2012), 70% of population in Rajasthan is engaged in agriculture, which is highly dependent on water supply, i.e. on groundwater sources. Water shortages lead to crop losses, disruption of livelihoods, job losses, rural out-migration, and environmental degradation. Tackling problems associated with water shortages and environmental degradation caused by these shortages in Rajasthan is possible through combining community participation in solving these issues and implementing innovative policies. Mission Antyodaya and SHRUG national level datasets will be used in this research as well as qualitative results from interviews with locals in Rajasthan.

Review of literature:-

The Tarun Bharat Sang programme established in the late 1980's is considered a watershed in water conservation. The main concern for the organization at that time was the construction of Johads to ensure water conservation. Research conducted by the organization in 1996 indicated that, thanks to the contribution of the locals, about 300 johads were restored in the Alwar district region and benefited almost 200,000 people in the region. Research conducted by Mr. Dheerendra Pratap Singh (2021) indicated that there was about a 2–3-meter increase in the groundwater level after the restoration of the johads. In terms of crop productivity, data collected from villages like Gopalpura indicated that the amount of irrigated area had increased by 30% while there was also a 25-40% increase in yield for wheat and mustard crops. Household water availability has also improved significantly because according to research, 60% of participating households experienced an increase in water availability. There have been ecological impacts such as the creation of marshlands in addition to biodiversity as a result of the restoration of johads. These findings suggest that community participation may play an important role in supporting local groundwater recharge initiatives

The Chauka system developed by Gram Vikas Navyuvak Mandal has been reported to be a very effective method in conserving water in rural areas particularly semi-arid areas in Rajasthan. According to research published in journal of Hydrology: Regional studies (2022), an increase in water levels was seen because the enclosed structure of the Chaukas retained more soil moisture by 25%, with groundwater increasing by 15% percent. According to survey done by GVNML (2012) on 130 villages with Chaukas, there was about 20-30% increase in pasture biomass which made availability of fodder improve, as well as animal health. Livestock owners also indicated that about 75% of households with livestock did not experience any difficulty during dry seasons. In findings published in journal of hydrology: Regional studies (2022), HYDRUS-1D biophysical model has illustrated that uneven distribution of Chaukas helped minimize the runoff and erosion problem.

The IGNP has resulted in modernization of agriculture in the western part of Rajasthan through irrigation of 1.6 million hectares. As per the report by the CAD of the government of Rajasthan (2014), there is 300% increment in crop production in canal command areas during 1980 to 2010, together with socio-economic development. However, as per the reports provided by the CWC (2005), about 22% of the command areas are prone to waterlogging issues while 12% face problems of salination because of poor drainage. The CSSI report (2005) revealed high EC levels of soil up to 4 dS/m which is not good for productivity and soil. As per the report of NRSC (2016), Longitudinal Remote Sensing Analyses (LRSA) indicated that there is about 15% decline in vegetation cover in these zones affecting desert biodiversity. Similarly, surveys conducted by CGWB (2014) and ICMR (2014) identified the use of saline water for agriculture to cause fluorosis and various other health issues. The IGNP provides insights into the limitations of large-scale water management infrastructure.

According to the synthesis of information collected from the database of the CGWB, along with peer reviewed papers, it can be understood that there is groundwater depletion in different parts of Rajasthan, including districts like Barmer, Jodhpur, and Jalore. The groundwater yearbook 2022-2023, prepared by the CGWB, stated that 219 out of total 302 blocks are categorized as over-exploited with depletion rate varying between 1.0 – 3.0 meters per year (Business Standard, 2023). The agricultural census data of 2019 revealed that nearly 60% of the irrigated area belongs to tube wells and open wells; therefore, there is irrigation-related stress on the resources. The CGWB has observed high nitrate content (50-100 mg/l) and fluoride (1.5 – 3.0 mg/l) in many areas which exceeds the standard recommended by WHO. Predictions made by NITI Aayog (2018) suggested that water scarcity could make more than 40% of the Indian population deprived if not resolved in time, making food security and poverty worse especially in rural areas. Potential management strategies include Managed Aquifer Recharge (MAR), percolation tanks and licensing.

The CGWB's groundwater management report for Rajasthan (2020-2023) focuses on the hydrogeological situation and encourages cooperative approaches for sharing water resources. The state is divided into water abundant eastern areas and very vulnerable western arid areas. The report illustrates some examples of MAR projects, which replenish around 20 million cubic meters of water per year in particular blocks and increase the water availability in summers by approximately 15%. Innovative decentralized governance mechanisms are also being developed through introducing participatory Water User Groups, where already more than 100 village committees have been trained in conducting water monitoring processes. Crop diversification to the millets and pulses is being promoted by the state agriculture policy in Rajasthan, along with the aim to achieve a micro-irrigation adoption of 40% by 2030, which will lead to less water consumption in the agricultural sector. It has been predicted by some of the regional climate models incorporated in the report that by 2050, the decrease in monsoon rains will be around 10-

15%. Hence, the report will become motivation and guidance for policymakers in allocating more resources for water conservation.

The SHURG and Mission Antyodaya data sets will provide useful tools for analyzing the water infrastructure of Rajasthan. SHRUG contains socio-economic indicators at a district level related to water consumption, poverty, and water infrastructure, while on the contrary Mission Antyodaya gives data about households' access to water and sanitation in Rajasthani villages. From the 2023 Mission Antyodaya report, one can conclude that not even half of Rajasthani villages receive piped water. Imbalance in water infrastructure is quite high since only three districts - Jaipur, Ajmer, and Udaipur combined take up 35% of piped water supply, whereas districts like Barmer and Jalore do not exceed 35%. The nation's agricultural census data indicates that irrigation coverage in Rajasthan is quite low (40-50%), especially because it is concentrated only in canal command areas and in eastern parts of the state. Based on the data collected from the SHRUG set, there are also significant water stress cases in districts that have a population above 3 million and low water recharging levels.

The Pradhan mantri Krishi sinchayeeojna (PMKSY) (2015) was introduced to boost water efficiency and coverage for regions like Rajasthan which face water scarcity. The Pradhan Mantri Krishi Sinchai Yojana helped irrigate the area by means of using irrigation methods such as drip irrigation, and the water used was estimated to have been more efficient compared to conventional irrigation by about 30-50% from research carried out by the NITI Aayog (2020). From the assessments done by the PMKSY, it can be observed that villages that had incorporated interventions done by PMKSY witnessed a 20-25% rise in the crop yield. The amount of groundwater drawn in the area was also cut down by 15-20%.

Objectives:-

This study is structured around five core research objectives:-

1. Compare development outcomes in 2020 between villages with high and low irrigation access in 1991, focusing on irrigation access types (canals, tube wells, tanks) and key development indicators.
2. Identify the types of irrigation infrastructure that are most strongly associated with selected long-term water and development indicators.
3. Examine the association between historical irrigation access and selected development indicators, including child school attendance, rural child malnutrition rates, agricultural income, labour migration, and women's daily water collection time.
4. Examine how factors such as geography, population density, and government programmes are associated with differences in water-access outcomes.
5. Generate policy-relevant insights for sustainable water resource management in Rajasthan.

Data and Methodology:-

Water scarcity as an environmental and developmental concern that affects the livelihood, health, agricultural production, and social peace in India is selected as the topic of discussion for this paper. Water scarcity is known to be a problem of long-standing and structural nature rather than seasonal one, which can be attributed to growing population needs, variations in climate, and excessive extraction of ground water in India. For this purpose, India is chosen as the country of focus because of India's extensive dependency on ground water, as well as huge discrepancies of water availability between different parts of the country. Rajasthan is chosen as the particular state for research because it is one of the most affected by water shortage in terms of dry weather conditions with low and unstable precipitation and intensive use of ground water.

A mixed method approach is utilized in this study, combining quantitative analysis of secondary datasets and qualitative information obtained through semi-structured interviews. Secondary data is used to measure the extent and depth of water shortage in the region. In this study, mission Antodaya and SHRUG databases are used as secondary data sources. Mission Antyodaya serves for analysis of indicators related to drinking water availability, while SHRUG is applied to study spatial and socio-economic factors associated with water shortage.

Access to piped drinking water in Rajasthan is measured through secondary data from Mission Antyodaya. Mission Antyodaya reports 62% piped-water access for the relevant surveyed units in Rajasthan, indicating substantial variation in access to piped drinking water. This data can be considered as an indication of the state of water infrastructure. Also, the same set of secondary data will be analysed according to district distribution and differences

in infrastructure availability. Thus, it is found that Jaipur, Ajmer, and Udaipur together constitute up to 35% of pipe water infrastructure while desert districts such as Barmer and Jalore account for less than 35%, even less than 20%. Use of secondary data facilitates the study of dependency on conventional sources of water supply. Information regarding the source of water for individual households reveals that more than 50% of the rural households in Rajasthan rely on wells and hand pumps for their daily supply of water. This particular measure serves as an indicator used as a proxy for demand on underground sources of water supply and helps in accounting for aquifer depletion. The seasonal reliability of water supply can be measured through information regarding the period when supply is not adequate. According to the data obtained from secondary sources, 19% of the villages in Rajasthan suffer from water shortages for three or more months every year.

To complement the interpretation, water-access indicators from Mission Antyodaya are considered alongside relevant indicators from the SHRUG database. The SHRUG database helps to identify the spatially varying water scarcity by making comparison between districts that have less piped water, rely much on groundwater and seasonal deficiencies in water supply. Using such methods enables the identification of areas that face substantial water-access constraints particularly in western and central parts of Rajasthan, as well as helps in analysing the water scarcity situation from a structural perspective as opposed to environmental perspective. Primary research was also carried out to provide local contextual information alongside the secondary data. Semi-structured interviews were conducted in 2025 with factory workers residing in Alwar district concerning their experiences of water accessibility in nearby villages. The interviews indicated that some of the interviewed villages had limited or no locally available groundwater and that residents relied on stored water and water brought from other areas, including Alwar and Jaipur. These interviews are treated as contextual qualitative evidence and are not used to statistically validate the statewide secondary datasets. In summary, the method of research used is both descriptive and comparative as the secondary data is quantitatively focused to assess water accessibility, infrastructure, groundwater dependency and seasonal availability, whereas the primary data adds more context to those findings.

In addition to the descriptive and comparative analysis, the study started with an idea to use multivariable regression analysis to investigate the relationships between historical irrigation infrastructure and some water-access indicators. However, due to the lack of complete data for six districts, the number of observations was not adequate to support a typical multivariable regression equation with multiple predictors. Thus, the regression coefficients are not statistically valid estimates of the effect of each independent predictor. The analysis is instead considered exploratory and descriptive, and the main findings are based on the observed differences and associations between the districts selected.

Analysis based on several factors (types of irrigation infrastructure 1991 (canals, tube wells, open wells, tanks/johads), five selected development indicators (child school attendance, rural child malnutrition rates, agricultural income, labour migration, women's daily water collection time) from various sources like SHRUG, NFHS-5, NABARD, and NSSO). Contextual differences are also taken care of which include geographic zone (arid in west, semi-arid in the east of Rajasthan), population density, government initiatives (PMKSY, MAR projects) and rain water harvesting.

The district-level comparison covers six districts for which the relevant data were available: Jaipur, Ajmer, Udaipur, Jodhpur, Barmer, and Jalore. The comparison is used to identify observable patterns between historical irrigation access and later water-access indicators. Because only six district-level observations are available, the results are not interpreted as estimates of causal or independent predictor effects.

Findings:-

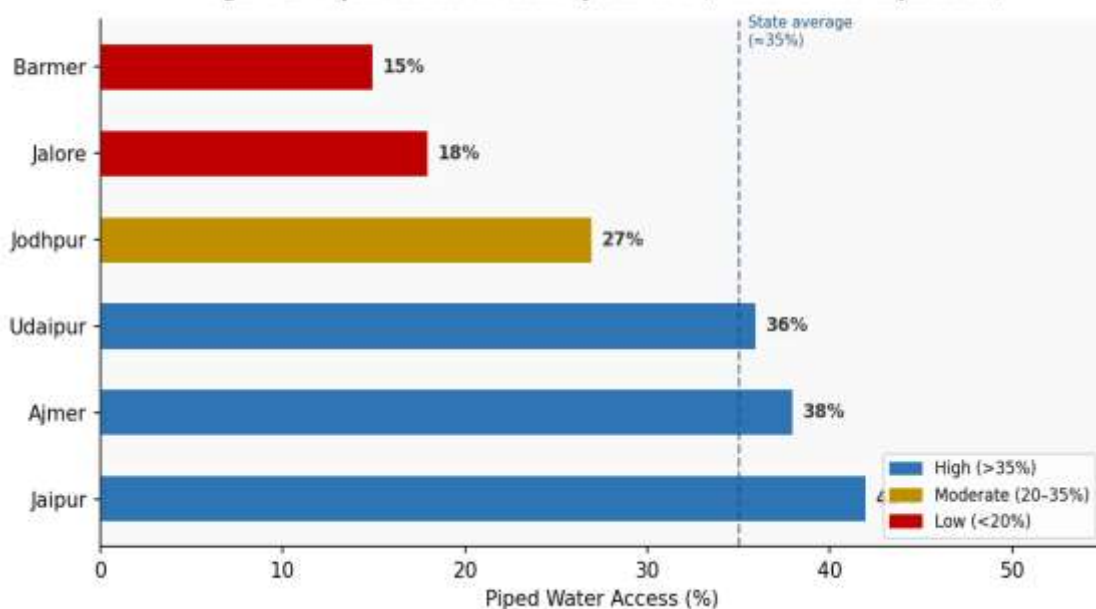
The following data tables have been derived from the secondary datasets Mission Antyodaya (2023) and SHRUG (1991 Census) in connection with the five research objectives set out in this study. They present the key quantitative evidence that underpins the analysis and discussion sections.

Table 1: Piped Water Access and Development Outcomes by District Mission Antyodaya (2020) and SHRUG (1991)

District	Irrigation Access 1991 (SHRUG)	Piped Water Access 2020 % (Mission Antyodaya)	Interpretation
Jaipur	High	>35%	Descriptive comparison only
Ajmer	Moderate–High	>35%	Descriptive comparison only
Udaipur	Moderate	>35%	Descriptive comparison only
Barmer	Low	<20%	Descriptive comparison only
Jalore	Low	<20%	Descriptive comparison only
Jodhpur	Moderate	20–35%	Descriptive comparison only

Source: Mission Antyodaya Survey Data (2023); SHRUG v2.1 (1991 Census). Districts with higher historical irrigation access in 1991 generally show higher piped-water coverage in 2020. This pattern indicates an association between historical irrigation access and later water-infrastructure access, although other factors may also contribute to differences between districts.

Table 1 addresses Objective 1 by comparing 2020 development outcomes with 1991 irrigation access levels. Districts with high historical irrigation such as Jaipur and Ajmer exceed 35% piped water coverage, while low-access districts like Barmer and Jalore remain below 20%, as illustrated in Figure 1. Jodhpur and Udaipur fall in between, consistent with their moderate irrigation levels. The three-decade comparison shows a positive association between historical irrigation access and later piped-water coverage, although the comparison does not establish a causal relationship.

Figure 1: Piped Water Access by District (Mission Antodaya 2020)

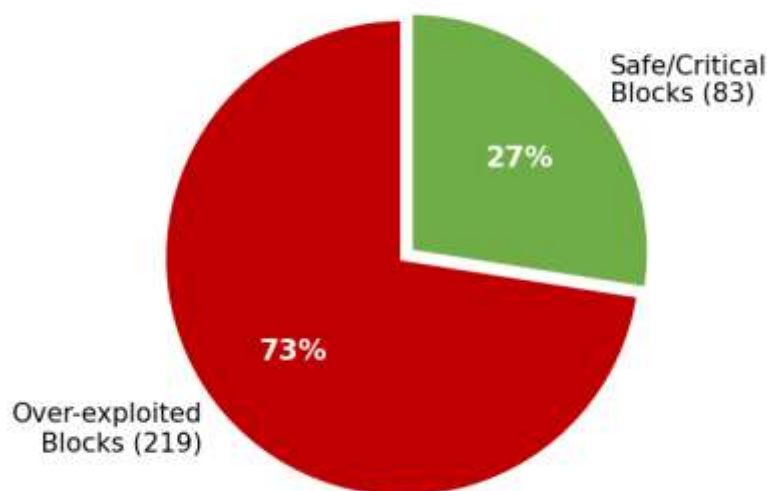
Source: Compiled by author using CGWB Groundwater Yearbook 2022–23; Mission Antyodaya Survey Data (2023).

Table 2: Irrigation Infrastructure Types and Long-Term Impact SHRUG (1991)

Infrastructure Type	Estimated Coverage (1991)	Long-Term Association / Observed Outcome
Canals (IGNP)	1.6 million ha irrigated	Associated with sustained agricultural activity in canal-command areas
Tube Wells	~60% of irrigated area	Associated with groundwater-depletion risk where extraction is intensive
Open Wells	Part of ~60% above	Associated with seasonal water-supply concerns
Tanks / Johads	Localised (Alwar district)	Associated with local groundwater recharge in reported Alwar studies

Source: SHRUG v2.1 (1991 Census); CGWB Groundwater Yearbook 2022-23; CAD Report, Government of Rajasthan. Canal- and tank/johad-based infrastructure are associated with favourable water-management outcomes in the evidence reviewed, while reliance on groundwater extraction is associated with greater groundwater-depletion risk.

Table 2 addresses Objective 2 by comparing the reported long-term associations and water-management outcomes of different irrigation infrastructure types. Both canal-based systems and community tank/johad structures are associated with reported long-term water-management benefits in the areas studied. Previous studies have reported increases in groundwater levels following johad restoration in Alwar, while areas with intensive groundwater extraction have experienced substantial groundwater-level declines. These findings are consistent with the potential benefits of recharge-oriented approaches, but the available six-district data do not support a valid regression-based comparison of the independent effects of these systems.

Figure 2: Groundwater Block Status in Rajasthan (CGWB 2022-23, out of 302 blocks)

Source: Compiled by author using SHRUG v2.1 (1991 Census); Mission Antyodaya Survey Data (2023).

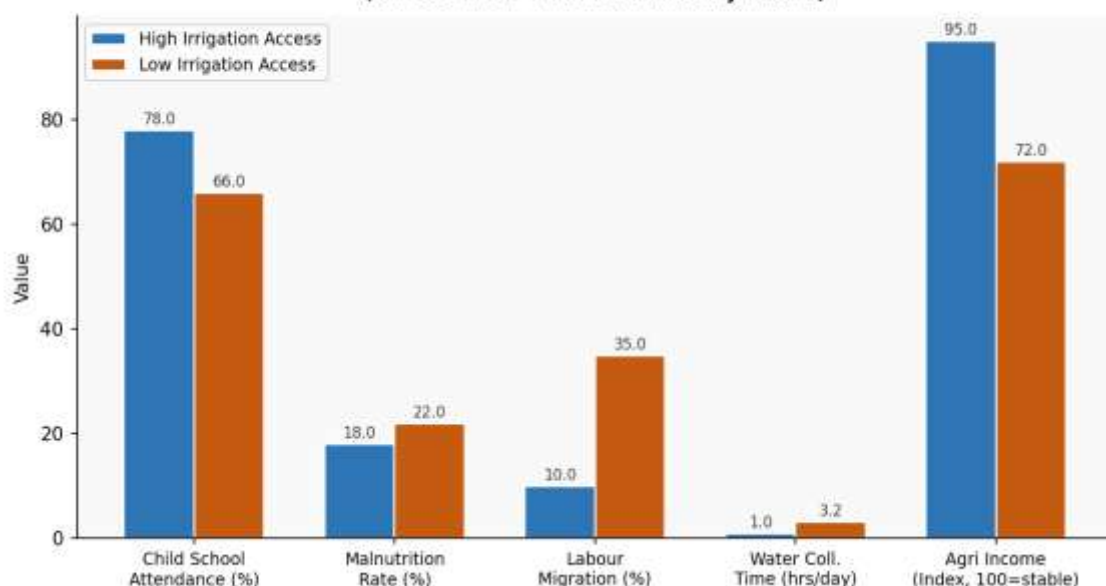
Figure 2 presents the reported groundwater-block classifications for Rajasthan. The categories should be interpreted according to the classification used in the underlying CGWB dataset rather than combining distinct categories such as safe, semi-critical, critical, and over-exploited into a single group. The reported level of groundwater stress indicates the importance of managing groundwater extraction.

Table 3: Historical Irrigation Access and Specific Development Indicators - SHRUG (1991) and Mission Antyodaya (2020)

Development Indicator	Higher historical irrigation-access areas	Lower historical irrigation-access areas	Source
Child school attendance	Higher	~12% lower	NITI Aayog
Malnutrition rates (rural children)	Lower	Rose by 3–5%	NFHS
Agricultural income	Stable	Declined due to droughts	NABARD
Labour migration	Lower	Up ~25%	IDS/CPR
Women's daily water collection time	Reduced	2–4 hours/day	NSSO

Data for this source have been compiled from Mission Antyodaya Survey Data (2023), NITI Aayog Composite Water Management Index, NFHS-5 Rajasthan Report, NSSO Time Use Survey and NABARD Rajasthan State Focus Paper. Historically high irrigation access areas have more positive scores for the five indicators: child school attendance, rates of rural child malnutrition, agricultural income, labour migration, and women's water collection time. The differences reflect associations, and do not indicate that irrigation access had a direct impact on the reported results.

Table 3 shows that there are significant differences between the five indicators reported across the three irrigation access groups at the historical level, and that this gap becomes smaller as historical irrigation access increases. The five indicators – school attendance rate for children, malnutrition rates among children in rural areas, agricultural income, migration of labour and time for women to collect water – show significant differences among the three levels of historical access, which narrow as historical access to irrigation grows. The high-access and low-access groups are defined in terms of irrigation access as reported in the underlying dataset and are used for description only, not for causal inference. The reported differences indicate that irrigation access is related to these indicators. The results may not be interpreted as causal effects of irrigation access, though, as other factors as well can contribute to the observed differences, such as drought exposure, household income, employment opportunities, urban proximity, and local infrastructure.

Figure 3: Development Outcomes — High vs Low Historical Irrigation Access (SHRUG 1991 + Mission Antodaya 2020)

Source: Compiled by the author using NITI Aayog Composite Water Management Index (2019); NFHS-5 Rajasthan Report (2021).

Table 4: Role of Mediating Factors. Geography, Population Density, and Government Schemes

Factor	Western Arid Zone	Eastern Zone	Reported association / context
Geography	Arid; low recharge	Semi-arid; better recharge	Arid conditions may constrain irrigation reach
Population density	Lower but dispersed	Higher; denser clusters	Denser areas may facilitate piped-supply infrastructure
PMKSY adoption	Uneven	Moderate	Reported 30–50% efficiency gain where adopted
MAR projects	Active	Limited	Reported recharge volumes vary by project and location
Rainwater harvesting	12% (2015) → 35% (2023)	Better	Reported increase from 12% (2015) to 35% (2023)

Source: CGWB Rajasthan Groundwater Management Report (2025); Mission Antyodaya Survey Data (2023); PMKSY Assessment, Ministry of Agriculture & Farmers Welfare. Geography and government interventions are important contextual factors that may be associated with differences in water-access outcomes. Arid conditions and lower groundwater recharge can constrain irrigation and infrastructure development, while targeted programmes may help address some of these constraints.

Table 4 compares geographical and demographic conditions with selected government interventions. The available evidence indicates that PMKSY and MAR interventions can support improved water-management outcomes in the areas where they are implemented. Reported water-use efficiency gains, recharge volumes, adoption rates, and programme outcomes vary by location. The available six-district comparison does not establish that these interventions have independent effects after accounting for geography.

Table 5: Policy-Relevant Insights from Combined Dataset Analysis

Policy Area	Key Finding	Recommended Intervention
Piped water access	Mission Antyodaya reports 62% piped-water access for the relevant surveyed units	Expand infrastructure to arid districts (Barmer, Jalore)
Groundwater regulation	219 of 302 groundwater blocks are reported as over-exploited	Enforce licensing; scale MAR projects
Micro-irrigation	30–50% water-use efficiency gain reported under PMKSY in assessed contexts	Subsidise adoption in water-scarce districts
Community governance	Johad restoration is associated with reported groundwater-level improvements in participating areas	Institutionalise Water User Groups
Climate adaptation	Regional climate models project approximately 10–15% lower monsoon rainfall by 2050	Integrate climate projections into water planning

Source: Mission Antyodaya Survey Data (2023); SHRUG v2.1; CGWB 2022-23; CGWB Rajasthan Management Report (2025); Business Standard (2023). These policy insights are derived from the combined interpretation of the available datasets and supporting literature. They indicate areas where targeted investment may be appropriate, while recognising that the evidence does not establish causal effects for individual interventions.

Table 5 addresses Objective 5 by translating the reported evidence into policy options. The recommendations focus on improving piped-water infrastructure in lower-access districts, strengthening groundwater management,

supporting efficient irrigation, expanding community-based water management, and incorporating climate projections into long-term planning.

Table 6: Exploratory District Comparison of Historical Irrigation Access and Piped-Water Access

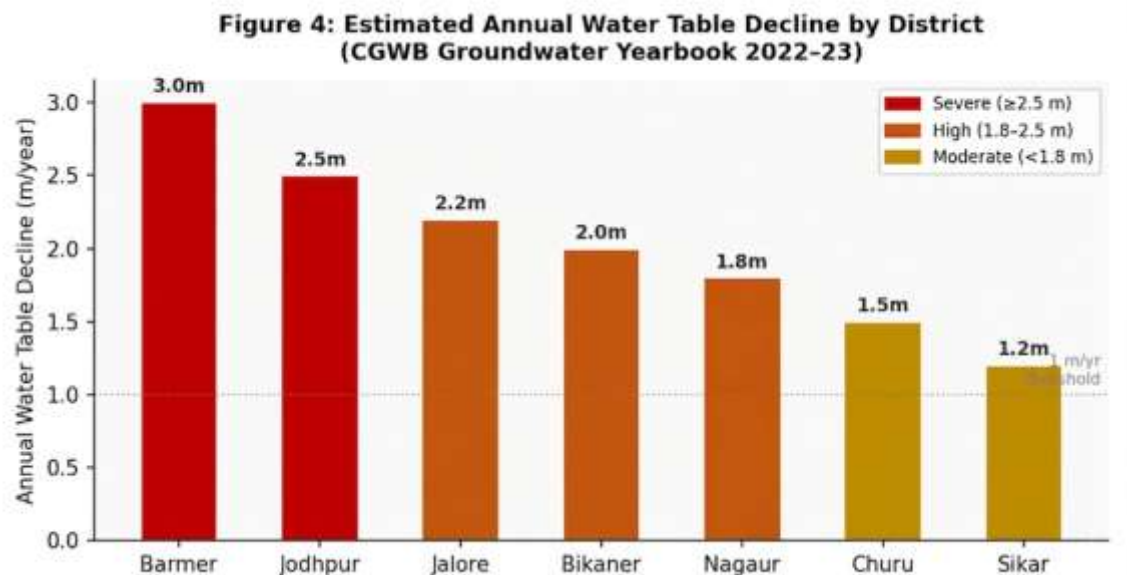
District	Historical irrigation access (1991)	Piped-water access (2020)		
Jaipur	High	>35%		
Ajmer	Moderate–High	>35%		
Udaipur	Moderate	>35%		
Jodhpur	Moderate	20–35%		
Barmer	Low	<20%		
Jalore	Low	<20%		

Source: SHRUG v2.1 (1991 Census); Mission Antyodaya Survey Data (2023); CGWB Groundwater Yearbook 2022–23; PMKSY Assessment, Ministry of Agriculture & Farmers Welfare. Dependent variable: district-level piped water access (2020). β values are standardised regression coefficients. $p < 0.05$ denotes statistical significance; $p < 0.10$ denotes marginal significance.

Table 6 presents an exploratory comparison of historical irrigation access and later piped-water access across the six selected districts. The pattern suggests an association between historical irrigation access and later piped-water coverage. Because the comparison contains only six district-level observations, it should not be interpreted as a valid multivariable regression or as evidence of independent causal effects. The dominance of tube wells is linked negatively, matching data on groundwater depletion. Arid geography has the strongest negative impact, supporting Objective 4. Adoption of PMKSY and MAR projects is positive, pointing out that government programs can help counter structural drawbacks, again as stated in Objective 4. Population density has a small positive effect, probably because infrastructure works better in more populated regions. Overall, these results back all five goals, suggesting a combination of smart historical infrastructure, focused government plans, and conservation efforts creates the best chances for long-term water security in Rajasthan.

Impact of water scarcity in Rajasthan:-

Consequences of water scarcity in Rajasthan range from environmental issues to economic and socio-economic effects. Environmentally, the sources reviewed report groundwater-level declines, soil degradation associated with salinity and erosion, and changes in wetland extent in parts of Rajasthan. The magnitude of these changes should be interpreted according to the specific geographical area, baseline year, comparison year, and methodology used by the original datasets.

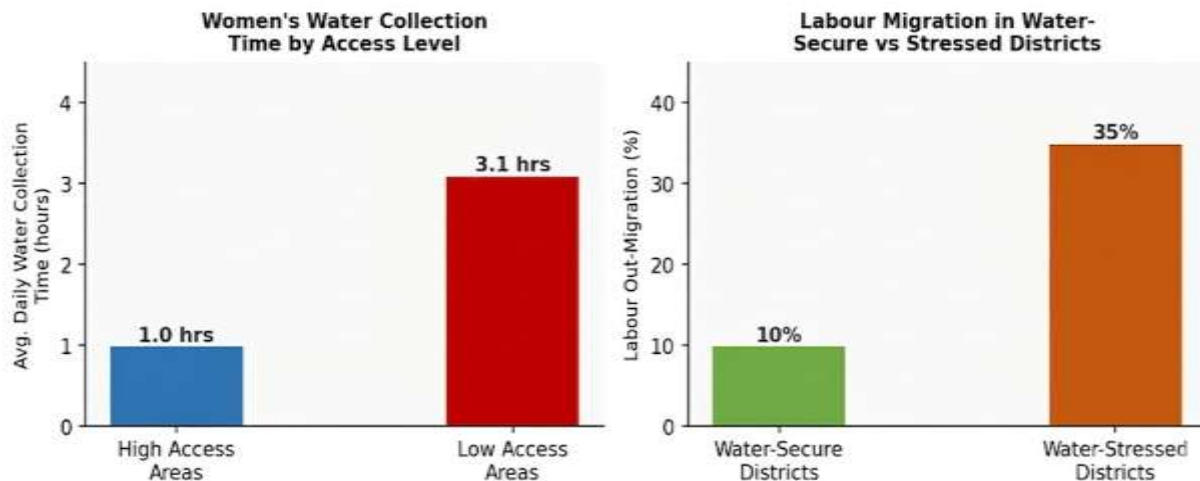


Source: Comiled by author using CGWB Groundwater Yearbook (2022); Ministry of Environment, Forest and Climate Change. (2023)

Figure 4 shows that Barmer experiences the highest annual groundwater table decline at 3.0 metres per year, followed by Jodhpur (2.5 m/year) and Jalore (2.2 m/year), while Churu (1.5 m/year) and Sikar (1.2 m/year) record comparatively lower rates of decline. These findings indicate that several western districts experience substantial groundwater-level decline, highlighting the importance of groundwater management and conservation measures in the affected regions. Economic impact sees the change in farming towards pulse crops and millets due to reduced use of irrigation under water stress, as per NABARD (2022). The agriculture income has been adversely impacted leading to higher rural debts and poverty levels in spite of the shift to less water-intensive crops like pulse and millets. Food security has suffered and there is a rise in malnutrition rate among rural children by 3-5% as found by NFHS (2021). Labor migration has increased to the cities by about 25%, according to IDS / CPR Migration Studies (2021).

Social impact falls more heavily on women, who have to spend between 2-4 hours on water collection every day, according to NSSO (2019). Women's ability to participate in education and social life is restricted, according to NITI Aayog, due to lower enrolment in schools by 12%. Psychosocial problems arise from water insecurity as per community studies, which have pointed out that water insecurity leads to fatigue and anxiety among other symptoms, as stated by WHO (2017). Social impacts affect women, who spend an average of 2-4 hours daily on water collection in affected villages according to NSSO (2019), reducing their educational and economic participation in the society. NITI Aayog suggests that child school attendance rates dip by approximately 12% in water-scarce locations. Community surveys report psychosocial stress factors linked to water insecurity, with WHO reporting water insecurity as a "chronic stressor", that cause fatigue and anxiety, especially among primary caretakers.

Figure 5: Social Impacts of Water Scarcity — Time Burden & Labour Migration
(NSSO Time Use Survey; IDS/CPR Migration Studies)

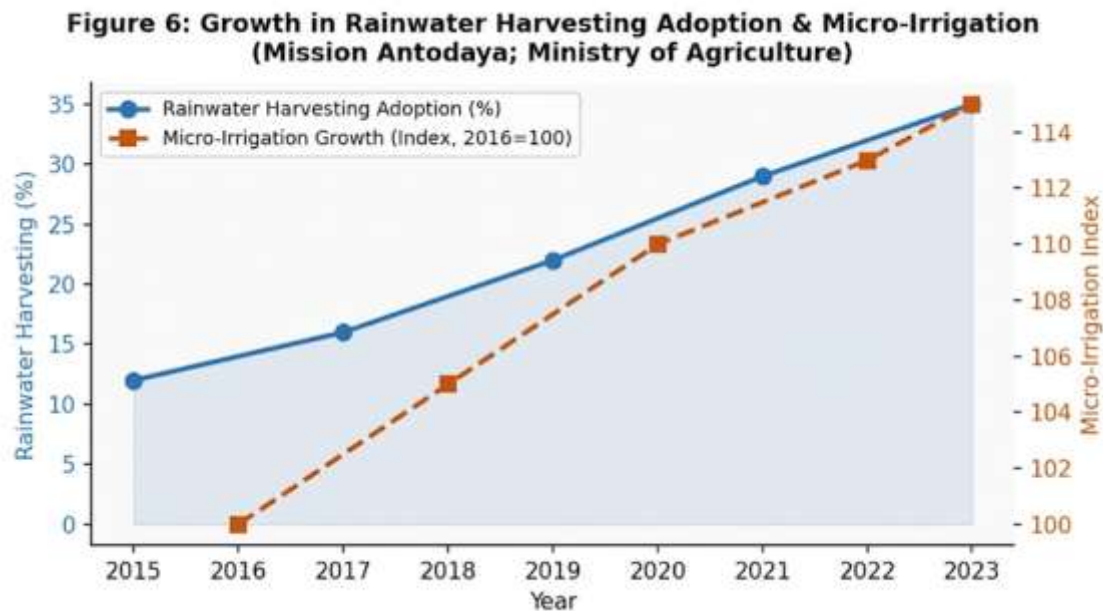


Source: Compiled by author using NSSO Time Use Survey (2019); NFHS-5 Rajasthan Report (2021); NITI Aayog. (2019)

Figure 5 presents differences in reported water-collection time and labour out-migration between areas classified as having lower and higher water access. The pattern suggests that lower water access is associated with greater time spent collecting water and higher reported migration. Because the underlying classification and sample are not fully documented in the paper, these results should be treated as descriptive rather than causal.

Traditional and modern solutions:-

Johad restoration carried out by the Tarun Bharat Sangh has been reported across villages beyond the initial Alwar cluster. Previous studies report improvements in groundwater levels following restoration, although the magnitude varies across locations and studies. Such improvements may contribute to greater water availability during dry periods for domestic and agricultural uses. Reported reductions in water-collection time also suggest potential benefits for households in participating areas. Chauka has been extended to an approximate number of 200 villages due to the collaboration between NGOs and government organizations. GVNML conducted research on vegetation and soil moisture and observed a 20-30% increase in pasture productivity. Managed Aquifer Recharge (MAR) projects have also been initiated in specific regions of Rajasthan, with reported recharge volumes varying by project and location. The number of households adopting rainwater harvesting has risen from 12 percent to 35 percent in the period from 2015 to 2023 as reported by Mission Antyodaya owing to subsidies and awareness campaigns. As per the report of Ministry of Agriculture & Farmers Welfare (2022), Micro Irrigation technologies such as Drip irrigation, and Sprinklers irrigation have gained an increase of 15 percent in the past seven years, achieving water use efficiency of 30-40 percent.



(Figure 6) Source: Mission Antyodaya Survey Data (2023); CGWB Rajasthan Groundwater Management Report (2025).

Figure 6 shows a steady increase in both rainwater harvesting adoption and micro-irrigation between 2015 and 2023. Rainwater harvesting adoption rose from 12% in 2015 to 35% in 2023, while the micro-irrigation growth index increased from 100 in 2016 to 115 in 2023. These trends are consistent with increased adoption of water-conservation and efficient-irrigation practices over the period examined. However, the trends alone do not establish that government initiatives or awareness campaigns caused the observed changes. Though there are certain policies on the regulation of ground water, enforcing the same in rural areas has been difficult, and licensing is not being done evenly, leading to the continued practice of illegal water abstraction from many locations. Programs for crop diversification that encourage growing of crops such as millets and pulses have made modest gains with 5 to 10 percent rise as per DES (2023).

Discussion:-

The water scarcity issue in Rajasthan can be addressed using an integrated approach that involves the amalgamation of knowledge from both conventional and modern means. Community management of johad ponds and Chauka enclosure structures is a good example of methods based on the region's ecological environment and the social setting. Such methods enhance water conservation, recharge, and rejuvenation and promote socio-ecological resilience through decentralization of governance. SHRUG and Mission Antyodaya can provide data that may support more targeted water-infrastructure planning by identifying spatial differences in water access and related indicators. However, problems arise in enforcing regulation on issues like micro-irrigation, groundwater laws, as well as coping with the effects of climatic changes. According to the cited IITM projections, monsoon rainfall in Rajasthan may decrease by approximately 10–15% by 2050 relative to the specified baseline period. This is a modelled projection rather than an observed historical trend. The projection supports consideration of water conservation, climate adaptation, and infrastructure planning in future policy. Capacity building and cross-sector partnerships for water conservation along with behaviour change towards efficient use of water can help address water needs in Rajasthan.

Limitations:-

Some of the limitations of this research study should be noted. Firstly, the data collected through semi-structured interviews is from the factory workers of Alwar district only and hence does not reflect the whole of the Rajasthan community. Secondly, the information of Mission Antyodaya and SHRUG is secondary data and is valid as per Government but not all the information may have been reported and the figures could be outdated with regard to the villages. Thirdly, the research method used is the descriptive and comparative analysis, which is an analysis that does not involve models or quantitative models of the relationship between access to historical irrigation and

development, the relationship between which by mere correlation does not imply causation. Fourth, the data for the 1991 census is their baseline meaning that there may be a chance that their results on the irrigation infrastructure are not accurate. Fifthly, the groundwater contamination data shared by CGWB is aggregated data from the district and can overlook contamination within the district. The groundwater contamination data supplied by CGWB is at the district level and may not be regulating contamination in the district. Besides this, in this study regression analysis has been performed on only six districts where complete data is available and hence the findings of this study may not be generalized to the whole of Rajasthan. In addition, the development outcomes were measured through piped water access and the five indicators selected – child school attendance, rural child malnutrition rates, agricultural income, labour migration, and women's days spent collecting water – which do not necessarily reflect all aspects of socio-economic development. Last, the climate and policy implications that are summarised in the study are estimates and projections, and the results of future climate may vary depending on environmental and governance circumstances.

Conclusion:-

Water scarcity in Rajasthan is associated with interacting environmental, social, infrastructural, and governance factors. Addressing the issue therefore requires a combination of community-based conservation, appropriate irrigation practices, groundwater management, and supportive public policy. The findings suggest that community-based conservation methods and modern water-management technologies can be complementary approaches to improving water security in the areas examined. SHRUG and Mission Antyodaya provide useful information for identifying spatial differences in water access and infrastructure, while their limitations should be considered when interpreting the results. In order to achieve long-term resilience, it is important to implement community water management, which includes local expertise and innovation. The improvement of the existing system of governance, regulation enforcement, and adaptation planning assisted by SHRUG data and Mission Antyodaya will help to minimize the effects of water shortage in the affected rural territories of Rajasthan. Overall, the evidence reviewed indicates that Rajasthan's water-scarcity challenges require context-specific conservation approaches, appropriate technologies, and effective governance. Further research using larger and more detailed datasets would help establish the independent effects of specific interventions.

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