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Impact of Climate Change in the Southern Rajasthan, India

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Abstract: Climate change is one of the greatest challenges of our time. Fossil fuel burning and deforestation have emerged as principal anthropogenic sources of rising atmospheric carbon dioxide (CO_2) and other green-house gases and consequential global warming. Rajasthan, the largest state of India area-wise falls within the areas of great climate sensitivity. The vicissitudes of climate are likely to have a considerable impact on the physical and socio- economic fabric of the state. In more recent times, Rajasthan has experienced severe and frequent spells of droughts than any other region in India. The Aravalli hill region of South Rajasthan served its area and the people as a rich resource area providing forest products; fuel wood; fodder; timber; water through springs, streams and rivers; minerals, rich forest clad habitat; safe and secured locations to former rulers and their public. The environmental status has changed alarmingly during last six decades with ruthless destruction of forest cover over the hills followed with increase in soil erosion, sediment transportation, siltation, drying-up of lakes, dams and surface water sources, lowering of water table from 5 to 10 m to 50 to 100 m. The continuous change in the nature of rainfall, increasing pressure of population and livestock on the water resources in the South Rajasthan and depletion of environmental resources particularly, vegetation, soil resources have led to decline to water-table.

Key words: Aravallis · Climate Change · Deforestation · Great watershed · Mewar

INTRODUCTION

Climate change is one of the greatest challenges of our time. Fossil fuel burning and deforestation have emerged as principal anthropogenic sources of rising atmospheric carbon dioxide (CO_2) and other green-house gases and consequential global warming. Proxy records of variability in temperature, precipitation, sea level and extreme weather events provide collateral evidence of global climate change. Observational data from land and oceans as well as model results suggest that several ecological, economic and social systems are being affected by climate change [1]. Rajasthan, the largest state of India area-wise falls within the areas of great climate sensitivity. The vicissitudes of climate are likely to have a considerable impact on the physical and socio-economic fabric of the state. In more recent times, Rajasthan has experienced severe and frequent spells of droughts than any other region in India. According to a study recently undertaken by the state control board Rajasthan is likely to suffer from further increased water shortage due to overall reduction in rainfall and increased evapo-transpiration due to global warming. There is also a rising trend in temperature at Barmer, Jodhpur, Ajmer and Pali in Luni river basin of arid western Rajasthan.

Southern Rajasthan is an important physiographic unit of the state, lying in the lap of the Aravalli mountain ranges it has a complex topography [2] characterized by dissected plateaus, hills, ridges and lakes. Administratively six districts namely Banswara, Chittorgarh, Dungarpur, Rajsamand, Udaipur and Pratapgarh constitute the core of the Mewar and Wagad Region forming the Udaipur division. The region constitutes 14.31 percent area and houses 12.39 percent (Census 2011) of the state's population, Bhilwara district though; not lying in Udaipur division is also a part of southern Rajasthan. This paper is an attempt to study the causes and impact of climate change in southern Rajasthan.

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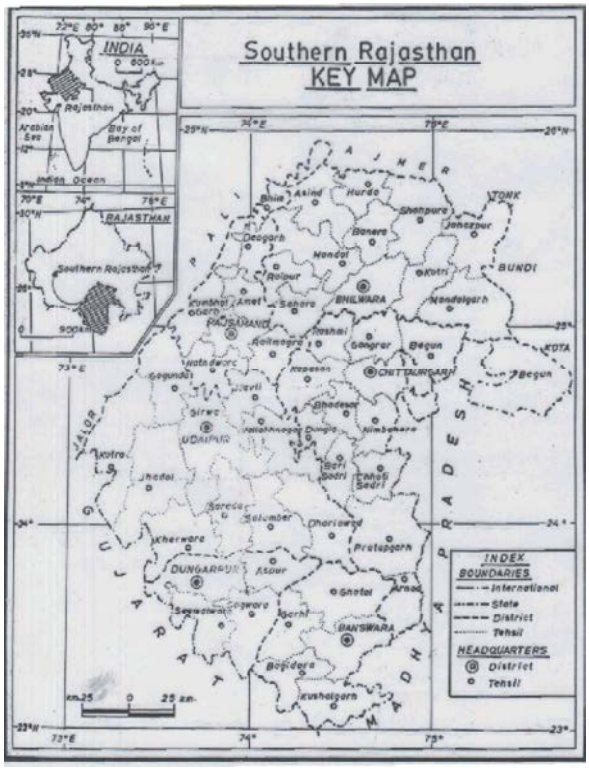

Fig. 1: Location Map of the Study Area

Location of Study Area: The region lies in the southern part of the north western state of Rajasthan. The study area comprises seven southern districts of the state, namely Banswara, Bhilwara, Chittorgarh, Dungarpur, Rajsamand, Udaipur and Pratapgarh. Geographically the region is located between 23°1'10" to 26°1'15" north latitude and 73°1'10" to 75°43'30" east longitude occupying an area of 47397 square kilometer. It extends nearly 210 km in north south and 240 km in east west direction. The region is bounded by Bundi and Kota districts, in the east. Mandsor, Ratlam and Jabua district of Madhya Pradesh, in the south east and Banaskanta, Sabarkanta and Panchmahal districts of Gujarat in the south. Its western Pali and Sirohi districts lie to its west and the whole of the northern boundary of the region is common with the Ajmer district of Rajasthan, over a few km Tonk district also touches its north eastern boundaries (Fig. 1).

Relief: The study of any areas' relief is highly significant not only from the point of view of the analysis of the nature and extent of its physical layout drainage and vegetation but also the utilization of land and human settlements there in. The major part of the region is characterized by rugged terrain. The NE-SW to N-S trending Aravalli hill ranges is the principal and the dominant landform of the region. The region, largely occupying the southern and the south-eastern slopes of the Aravalli range has varied topography. The average elevation of range is more than 500m above sea level. The western half of the region has above 450m contour consisting of rugged hills and plateau. The north and north-east has pediment plain of Banas and in the south-east lies the Mahi basin and part of upper Chambal Shipra basin. Physiographically, south Rajasthan region may be sub-divided into two groups: "Mewar rocky region and Bhorat Plateau canvassing Udaipur, Rajsamand and part of Dungarpur. South -East Plateau and Mahi plains engulfing Banswara and parts of Dungarpur.

Geological Setting: Geologically, south Rajasthan is made-up of diverse rock types ranging from oldest archean metamorphytes to Deccan volcanoes. However, majority of the region is covered by the rock of Aravalli super group and archean gneiss. The region forms a part of the ancient stable block displaying rock systems ranging from the Achaean to the Tertiary. The main formations, however, belong to the Dharwarians to the Aravallis and Vindhyans. The region displays a variety of rocks of which the most common are phyllites, micashists and quartzites. These rocks occur in the western and eastern tehsils of Banswara and Dungarpur districts, south central and northern parts of Udaipur district and north-western and western part of Chittaurgarh and Bhilwara districts.

Drainage: Relief and slope are determined by the geological structure and its history act as dominating factors shaping the drainage pattern in any area. These not only account for the amount and flow of water in streams but also control the consequent drainage pattern, its direction, density etc. three factors viz., the geological history, the existence of the Aravalli axis and the location of great watershed of India have highly influenced the drainage of the southern Rajasthan. The layout of the streams has been determined by the great Indian watershed, which divides the regional drainage into two. The northern streams viz. Banas, Breach, Khari, Kothari, Mausi, Gambhiri and other tributaries drain into the Bay of Bengal. The total length of these rivers is about 3162 km. The southern streams including Mahi, Jakham, Wakal, Som and Sabarmati with other tributaries drain into the Arabian Sea [3]. The total length of all the stream segments is about 985 kms.

Climate: To understand the climatic condition of any area the best method is to analyze rainfall, temperature and humidity conditions and their long period behaviour. The climate of southern Rajasthan is determined to a great extent by the location of Aravalli mountain range. Yet, as this region falls within the broader monsoon climate zone, it endows the general characteristics of seasonality. The region acts as a transitional zone between two major climate regions of the "humid east" and "Arid west". Tropic of cancer passes through the fringe area of southern Rajasthan, giving it an extra tropical location but with least of its characteristics.

Changing Environmental Status: The Aravalli hill region of South Rajasthan served its area and the people as a rich resource [4] area providing forest products; fuel wood; fodder; timber; water through springs, streams and rivers; minerals, rich forest clad habitat; safe and secured locations to former rulers and their public and above all dependable and timely rainfall and healthy environment with more moisture and much less temperature in comparison to present higher radiation. The water reservoirs and ground aquifers used to remain full with water and the hills green and well stocked. The environmental status has changed alarmingly during last six decades with ruthless destruction of forest cover over the hills followed with increase in soil erosion, sediment transportation, siltation, drying-up of lakes, dams and surface water sources, lowering of water table from 5 to 10 m to 50 to 100m with increasing exploitation of ground water without considering recharge capacity of the ground water aquifers. Now, the last resort of deep mining group water is being initiated without any consideration for maintenance of discharge-recharge balance.

Emergence of Rocky Structures and Conversion of South Aravalli Hills into Rocky Desert: The Aravalli hill region had thick forest cover during earlier decades. It helped in protecting the soil cover and water aquifers and provided favourable conditions for the regeneration of tree-stock and pastures. The massive deforestation in the South Rajasthan and in the Tribal Sub-Plan [5] area in Banswara, Dungarpur, Udaipur, Pratapgarh and Chittaurgarh districts has accelerated the process of soil erosion causing emergence of rocky structures. Consequently, the major parts of Aravalli hill region in the steeper slope tracts have already converted into Rocky Desert and the process is still active on the lower slope hill tracks.

Decline in the Actual Forest Area: Earlier, the Aravalli hills of South Rajasthan had dense forests and high density of tree cover along with a rich habitat for wild-life extending in the vast tracts of higher hills and valleys. However, massive felling of trees, on account of greed of human beings and increasing demand for timber, fuel wood, fodder, etc., have caused severe strain on the eco-system, affecting all the river valleys situated down the hills. The forests in the South Rajasthan are mostly degraded ones and require enormous efforts for the restoration of ecological balance. The interpretation of multi-date RS data products had revealed that the parts of sixteen Aravalli districts recorded only 10,462 sq km of area under various categories of forest cover during 1972-75. The actual forest area left was only 6,116 sq km, in 1982-84 [6, 7] period as per RS data products of the South Rajasthan Aravalli hill region.

Table 1 shows the increase/decline in Well-Stocked Forest and Pasture Area in south Rajasthan during 1972-75, 1982-84, 1995-96 and 2005-06 (Based on RS data). From the table it can be observed that barring Banswara district there is an increase in the forest cover in all the districts of Southern Rajasthan that may sound very good, however this increase in forest cover is only the result of social forestry. The natural forest cover that constitutes the real biomass has actually declined considerably during the period of observation.

Decline in Water-Table: The continuous change in the nature of rainfall, increasing pressure of population and livestock on the water resources in the South Rajasthan and depletion of environmental resources particularly, vegetation, soil resources have led to decline to water-table. This process has further been intensified by the removal of the forest cover from the hill areas, acceleration in soil erosion and siltation of river channels and water reservoirs. Consequently, the drinking water crisis along with the shortage of water for irrigation and other purposes is being felt very seriously. At may a places, hills are robbed of soil cover and are left with bare rocks making regeneration most difficult. Since top-soil is formed of centuries of weather action, its erosion would lead to unload consequences and miseries in the form of chronic droughts, famines, occasional sheet floods followed by cloud bursts etc.

Increase in Famine and Drought Prone Area: The Aravalli hills forms fringe on the eastern margin of the 'Great Indian Desert'. The alarming deforestation and the

Table 1: Forest Cover Change in South Rajasthan 1972-75 to 1982-84 and 1995-96 to 2005-06

Sl. No.	District (only Aravalli Hill Portion)	Forest and Pastures (in sq.km.) 1972-75	Forests and Pastures (in sq.km.) 1982-84	Percentage increase/ decrease during 1972-75 and 1982-84	Forests and Pastures (in sq.km.) 1995-96	Forests and Pastures (in sq.km.) 2005-06	Percentage increase/ decrease during 1972-75 and 1982-84
1-	Dungarpur	509	367	-45.69	439	439	nil
2-	Banswara	648	497	-44.40	305	300	-1.63
3-	Udaipur	4266	2415	-43.39	3955	4155	+5.05
4-	Chittaurgarh	787	689	-16.70	540	585	+8.33
5-	Pratapgarh	-	-				
6-	Bhilwara	235	224	-31.43	195	225	+15.38
7-	Rajsamand	-	-	-	-	-	
	Total	6445	4192	-36.37	5430	5704	+5.04

Source: Forest Department, Govt. of Rajasthan

Table 2: Duration of Rainy Season: 1973-2010

Year	Date of Onset of Monsoon	Date of Withdrawal of Monsoon	Duration (No. of days)
1973	02.07.73	10.10.73	101
1974	01.07.74	12.09.74	74
1975	21.06.75	25.09.75	96
1976	12.07.76	21.09.76	71
1977	24.06.77	26.09.77	94
1978	20.06.78	26.09.78	98
1979	26.06.79	23.09.79	88
1980	22.06.80	23.09.80	93
1981	25.06.81	11.09.81	78
1982	13.07.82	15.09.82	64
1983	04.07.83	16.09.83	84
1984	02.07.84	23.09.84	83
1985	13.07.85	15.09.85	64
1986	23.06.86	18.08.86	57
1987	14.07.87	06.09.87	55
1988	16.07.88	05.09.88	40
1989	25.06.89	20.09.89	42
1990	18.06.90	25.09.90	45
1991	20.06.91	20.09.91	42
1992	25.06.92	18.09.92	43
1993	20.06.93	15.09.93	42
1994	15.06.94	20.09.94	45
1995	18.06.95	23.09.95	47
1996	20.06.96	26.09.96	48
1997	24.06.97	20.09.97	42
1998	19.06.98	20.09.98	42
1999	22.06.99	22.09.99	43
2000	25.06.00	25.09.00	42
2001	21.06.01	21.09.01	42
2002	25.06.02	15.09.02	44
2003	30.06.03	10.09.03	40
2004	05.07.04	15.09.04	40
2005	15.06.05	19.09.05	42
2006	18.06.06	25.09.06	45
2007	19.06.07	27.09.07	45
2008	22.06.08	20.09.08	43
2009	20.06.09	20.09.09	44
2010	18.06.10	28.09.10	46

Source: Dept. of Irrigation, Govt. of Rajasthan

Table 3: Variation in Monsoon Rainfall based on percentage variation from normal rainfall figures between 1951-2010

Sl. No.	District	Percentage	Variation (in cm)
1	Banswara		15
2	Bhilwara	[-]	17
3	Chittaurgarh	[-]	25
4	Dungarpur		07
5	Udaipur	[-]	10

Source: Twenty Five monsoon in Rajasthan, 1961to 1985, A Systematic Study; Irrigation Department and Irrigation Circle Udaipur 1986-2010

removal of soil cover from most of the hill slopes have caused micro-climatic changes, particularly in the nature of rainfall. The analysis of meteorological data has also revealed that the duration of rainy season has shrunk from 101 days in 1973 to only 64 days in 1985 and 55 days in 1987. In the year 1995 only 47 rainy days in 2003 and 2004 and rainy days was only 40 days. The calculation of the duration of rainy season has been done from the data of onset of monsoon and the data of withdrawal of monsoon each year. The decline in the number of rainy days and shrinkage in rainy season has adversely affected the agricultural production and the production of crop residue in the form of forage.

This situation has caused occurrence of droughts and famines with increasing intensity and frequency year after year. Worst of these famines during last one century have been recorded in 1986-87 and 1987-88, 2003 and 2004-05. All the 06 districts of the state of South Rajasthan have been affected by famine hazard. This process has further extended its tentacles into the 'Granary of India' in eastern Rajasthan, south-east Punjab, south-west Haryana, western Uttar Pradesh, Malwa and Madhya Pradesh, Kutch and Saurashtra in Gujarat. The environment improvement programmes in the hill areas should be given top priority for arresting the menace of drought and famine hazards.

The analysis of monthly normal rainfall data for monsoon periods from 1901 to 50, 1961 to 85 and 1986 to 2010 reveals that the average rainfall has declined by 1.5 per cent in the month of September. The last arrival and early withdrawal of monsoon has severely affected the agricultural production and the dependence on irrigation has increased significantly even during the rainy season.

A comparison of the rainfall data for 1901-50, 1961-85 and 1986 to 2010 periods further reveals that the normal rainfall during monsoon period [June to Sep.] has declined in all the 7 districts, namely Bhilwara [from 73 Cm to 45 Cm]; Chittaurgarh [from 96 Cm to 46 Cm]; Udaipur (from 64 cm to 42 cm) and Rajsamand (from 62cms to 42cms). The above cited meteorological data clearly indicates that the nature of rainfall is fast changing in Southern Rajasthan, particularly in the hill areas where the degradation of environment has been observed distinctly due to massive deforestation, soil erosion and emergence of rocky structures. The analysis of the meteorological data further reveals that the variation has increased sharply in the degraded hills and the adverse impact has distinctly been observed in the high altitude areas i.e. in the skyline of the state.

CONCLUSION

The vicissitudes of climate, owing to various anthropogenic activities have a considerable impact on the physical and socio- economic fabric of Southern Rajasthan. Massive felling of trees, on account of greed of human beings and increasing demand for timber, fuel wood, fodder, etc., have caused severe strain on the eco-system, affecting all the river valleys situated down the Aravalli hills. The alarming deforestation and the removal of soil cover from most of the hill slopes have caused micro-climatic changes, particularly in the nature of rainfall. The duration of rainy season has shrunk from 101 days in 1973 to only 46 days in 2010. The continuous change in the nature of rainfall, increasing pressure of population and livestock on the water resources [8] in South Rajasthan and depletion of environmental resources [9] particularly, vegetation, soil resources have led to decline in water-table. Consequently, the drinking water crisis along with the shortage of water for irrigation and other purposes is being felt very seriously.

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REFERENCES

1. Singh, V.S., D.N. Pandey, A.K. Gupta and A.K. Ravindranath, 2010. “Climate Change Impacts, Mitigation and Adaptation: Science for Generating Policy Options in Rajasthan, India” Rajasthan Pollution Control Board (RPCB), Jaipur, Rajasthan.

2. Bhattacharya, A.N., 2000. Human Geography of Mewar, Himanshu Publication, Udaipur - 313001 (Raj.) India.
3. Rathore, N.S., 2010. A Historical Perspective of the Development of Rain Water Harvesting Techniques in the Mewar Region, Udaipur, Rajasthan, India. Conference Proceeding; 4th International Conference on Water Resources and Arid Environments 2010, Riyad, Kingdom of Saudi Arabia, pp: 429-438.
4 Dhabriya, S.S., K.N. Joshi and N.S. Rathore, 1985. Hill Area Development Programme in Rajasthan, Project Profile, BISR, Jaipur (Raj.) India.
5. Seventh Five Year Plan Vol. II., (1985-90); 1985. Sectoral Programmes of Development; Special Area Development Programmes, Govt. of India Planning Commission, New Delhi, pp: 339-340.
6. NRSA Summary Report, 1984. Mapping of Forest cover in India from Satellite Imagery 1972-75 and 1980-82, Summary Report of Rajasthan, NRSA, Hyderabad, 1984.
7. Rathore, N.S., 2006. Deforestation in Great Aravallis Mountain Region of India. Annals of the Rajasthan Geographical Association, Vol. XIII, Bhilwara - 311001 Raj. India 2006 pp: 21-24.
8. Rathore, N.S., 1992. Natural Resources Base Development, Scientific Publications, Jodhpur - 342003 (Raj.), India.
9. Vaish, A.K. and P. Vaish, 1990. Impact of Environment Pollution on Tribal Population in the Mineral Activities of TSP region of Rajasthan Raj. Min. Bul., 19(1): 1-13.