

Impact of Climate Change on Lakes of Rajasthan

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ABSTRACT

Climate change is a global challenge with diverse implications at the national and subnational levels, through impacts on various sectors such as agriculture, water resources, forestry & biodiversity, human health, energy and infrastructure. Such diverse impacts require a range of strategies to be deployed for an effective response and for better preparedness towards climate change. In 2008, a National Action Plan on Climate Change (NAPCC) for India was released by the Honourable Prime Minister. In view of the criticality of addressing the challenges posed by climate change along with the imperatives of poverty alleviation and economic growth for India, the NAPCC 'identifies measures that promote development objectives while also yielding co-benefits for addressing climate change effectively'. The focus of NAPCC is to improve the understanding of climate science, adaptation, mitigation, energy efficiency and natural resource management & conservation. The NAPCC, further sets eight priority missions to respond to climate change; these include National Missions on Solar Energy, Enhanced Energy Efficiency, Sustainable Habitats, Water, Sustaining the Himalayan Ecosystem, Greening India, Sustainable Agriculture and Strategic Knowledge for Climate Change, covering a range of response strategies.

In case of Rajasthan, Thirty-six years ago, Rajasthan set up the directorate of environment (DOE) to reduce vulnerability and build resilience to climate change impacts, but it remained only on paper and the directorate never became functional. The Climate of Rajasthan in northwestern India is generally arid or semi-arid and features fairly hot temperatures over the year with extreme temperatures in both summer and winter. Under the Köppen climate classification the greater part of Rajasthan falls under Hot Desert (BWh) and remaining portions of the state falls under Hot Semi Arid (BSh); the climate of the state ranges from arid to semi-arid. Rajasthan receives low and variable rainfalls and thereby is prone to droughts. As Rajasthan is the dry and hot state, Unbelievable hailstorm covered Nagaur, Rajasthan in a thin snow-like icy blanket in December 2019. Later on, it is clarified that this is not a snowfall but a hailstorm, endorse by western disturbances. The climate has changed in winters like never before. Lakes have dried up fishes have died. Aquatic animals died and no water was available for animals drinking.

The desert districts are on the brink of a humanitarian crisis with the rise in surface temperature in Rajasthan. The excessive loss of water due to

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evaporation is leading to mass migration of people, livestock and desertification of the cropped land.

To mark the world environment day, a Central Arid Zone Research Institute (CAZRI), Jodhpur shared its detailed report on the impact of rising temperature in the arid region says that one degree rise in temperature would increase the evapotranspiration by 35 mm to 96 mm. It translates into the additional water requirement of 1.57 lakh MLD water per annum to feed the irrigated land.

Rajasthan state is situated on the north-western part of India. The state is spread over an area of about 340000 sq. km. making it the largest state in the country. The Population of Rajasthan according to the 2011 census at about 68 million, making it the 8th most populated state in India. The state comprises of 33 districts, 39,753 inhabited villages. The forest cover of the State contributes 4.19 percent to the national forest cover with 10.4 percent of the country's area and 5.5 percent of its population. Climate change may alter the distribution and quality of state natural resources and adversely affect the livelihood of its people. With an economy closely tied to its natural resource base and climate sensitive sectors such as agriculture, water and forestry,

Rajasthan state may face a major threat because of the projected changes in climate. It is difficult to detect global warming directly because most people experience changes only in local weather patterns, which are highly variable and may not reflect long-term global climate trends. However, local climate-change experience may play an important role in adaptation and mitigation behaviour and policy support. In this paper the author extent to which respondents in Rajasthan State detects recent changes in average local temperatures. These findings also suggest that public opinion of climate change may shift, at least in part, in response to the personal experience of climate change. Most of people reported that climate is changing and everybody will suffer due to its near future.[1]

Due to lowering of economy the lakes could not be repaired and many villagers still drink dirty water of lakes with scanty amount.

INTRODUCTION

Residents of Karech in Rajasthan sought help from the Foundation of Ecological Security to restore wastelands through community efforts and save their village from desertification and loss of livelihood. Karech, a village around 75 km from Udaipur, is probably the last village in western Rajasthan. The residents belong to tribal communities and their subsistence depends on agriculture, livestock rearing and the sale of firewood from forests. However, in recent years, they have observed increasing desertification threaten their village. It was in early 2000 that residents like Hansa Ram, former village head, noticed degrading common forest lands. The phenomena indicated that the village was moving towards desertification. Factors responsible for this included soil erosion, loss of vegetation, depleting surface water and groundwater resources, and other anthropological aspects such as deforestation. The deteriorating conditions had forced the residents to seek opportunities outside, leading to migration.[2]

People have migrated to other areas and states from Rajasthan, due to unavailability of groundwater, deforestation and loss of vegetation. The lakes have dried and animals have also moved away. Bird migration has stopped towards dried lakes of Rajasthan.



Fig. 1. Rajasthan part Karech (Rajasthan) ecological community efforts

However still, Climate Change is very big issue in water scarce Rajasthan state. State has large part of desert or arid area (58% of total geographical area) and has low water resources in comparison to rest of the country. Any adverse climate change conditions are likely to have catastrophic effect on already fragile water resource system of the state. In this study attempts have been made to understand climate conditions of the state and to highlight isolated events of the past suggesting that climate change may be happening in the state. It is stressed that climate change modeling need to undertaken for different climate zones in the state. State-of-art tools like remote sensing and geospatial tools must be used to develop optimal water resource management strategies for different zones.[3]



Fig.2a. Still climate change is big issue in Rajasthan

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 (CO₂) and other 2 greenhouse 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. [4]

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.**

Western Rajasthan is characterized by low and erratic rainfall, high air and soil temperature, intense solar radiation and high wind velocity. Context-specific interactions of these factors not only give rise to frequent droughts and famines, they also make local livelihoods highly vulnerable. In more recent times, Rajasthan has experienced severe and frequent spells of droughts than any other region in India. Climate change presents a serious risk to poverty eradication and sustainable livelihoods. The adverse impact of climate change is more severely felt by poor people who are more vulnerable than rich. Appropriate policy responses can strengthen adaptation and help build the resilience of communities and households to climate change. Steps to promote the mainstreaming of adaptation into sustainable development may potentially deliver better results when combined with adaptive management of natural resources. Learning from the adaptations employed by the village communities of areas such as Rajasthan can provide insights to design useful policies and public actions.[5]

The climate variability has direct impact on the water resources of the region. The low to medium rainfall in most parts, high evapo-transpiration demands for water, high frequency of occurrence of droughts resulting from the departure of rainfall from mean values, and the high per capita arable land increases the demand for irrigation water. The free power in agriculture continued for many years, and the existing pump horse power based pricing of electricity encourage over-pumping and inefficient and often wasteful use of groundwater.

The advent of Indira Gandhi Canal in the fragile desert ecosystems helps the region to cope with high variability in rainfall. The study suggests that water security in the region can be attained

through expansion of canal network. Rajasthan is a water deficit state, it is one of the driest states with nearly 70 percent of the area classified as arid and semi arid region. Surface water resources in the arid and semi arid regions are limited and in a precarious situation. The rivers of the state are rain-fed and there is no perennial river in the region. Demand for irrigation is high using 83 percent of the total water resources. With a rising demand for water for both agriculture and non-agriculture purposes the share of water for agriculture is set to reduce to 70 percent by 2050. High dependency on ground water has resulted in its over-exploitation with nearly 80 percent of ground water witnessing depletion. The stage of ground water exploitation which was 35 percent in 1984 has reached a level of 138 percent in 2008. Out of the 236 blocks only 30 are in safe category in the region.[6]

DISCUSSION

Scanty and irregular rainfall conditions have resulted in poor recharge to groundwater. Climate projections indicate further decrease in rainfall in the future which will further limit the recharge of ground water resources. Over-extraction of ground water has brought adverse changes in the geochemistry of water and compromised the quality of drinking water with contamination of fluoride, nitrate, chlorine and salt etc. Based on the WHO guidelines for drinking water quality about 56 percent of the water sources in Rajasthan are un-potable. Climate change will further increase ground water extraction due to less availability of surface water and rising demand which would further deteriorate ground water quality and have serious implications for health of people. Increase in temperature will lead to increased evapo-transpiration in the state. A 1 percent increase in temperature from baseline data could result in an increase in evapo-transpiration by 15 mm, resulting into additional water requirement 313.12 mm for entire arid zone of Rajasthan. Being one of the most climate sensitive states with one of the lowest adaptive capacity requires immediate action on climate change crucial for the region. [7]

Characteristically high temperatures, extremely scanty and erratic rainfall and very high frequency of extreme events like droughts make agriculture a high risk activity in the state. Limited sources of surface water and declining groundwater levels due to over exploitation and injudicious use of groundwater resources will further weaken the already fragile resource base for agriculture. Most of the state falls in the semi arid region and the soil is characteristically low in carbon content and alkaline in most areas. In addition widespread land degradation also poses a

persistent challenge. The salts present in the water have also seeped to the groundwater with groundwater becoming more saline. Major irrigation projects are experiencing problems of water logging and salinity build up in large pockets in western Rajasthan. There is also a tendency towards indiscriminate use of agricultural chemicals in irrigated areas. Climate change is likely to further exacerbate the already strained conditions for agriculture in the region. Recent studies have further predicted that due to climate change there may be significant increase in the desert area over India in the next 100 years with potentially disproportionate impact of global warming on humans and natural systems.[8]

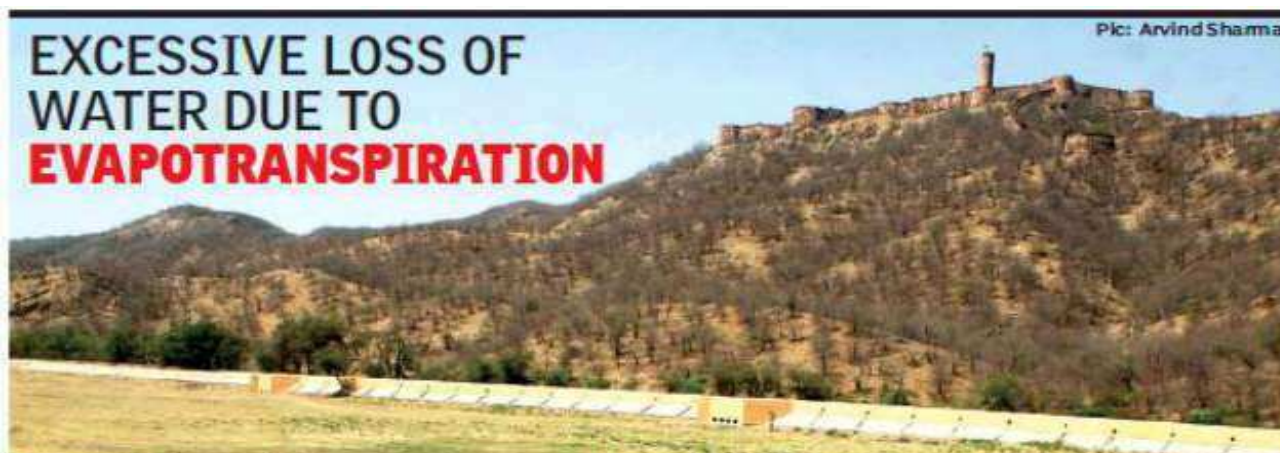
Wetlands develop in areas waterlogged by irrigation system. Serve as habitats for many wetland species of plants and animals. Considerable cost to agriculture and **Considerable cost to agriculture and human health, and loss of biodiversity that is characteristic of arid regions. Disappearance of 53 species of plants, 21% of flora changed in Ganganagar, 22 bird species disappeared, 22 bird species disappeared, Invasion by species of mesic habitats.** Climate change is a reality, it is human-induced. We must take steps for both mitigation and adaptation. but we must not lose sight of what we are doing today. Keoladeo is already threatened not by climate change Keoladeo is already threatened, not by climate change Jamwa Ramgarh has dried, not due to climate change Sambhar lake is degraded, NOT because of climate change but also by human intervention.

In 2003, floods claimed thousands of lives and rendered millions of people homeless in Rajasthan. These climate extremes, apart from health, also damage the public health infrastructure. India, like other developing countries, is poorly equipped to deal with weather extremes. Hence, the number of people killed, injured, or made homeless by natural disasters has been increasing rapidly.[9]

RESULTS

Most of the states in the North, like Rajasthan, and the north east are dependent on river water with origin in the Himalayas. Rising temperatures may cause the snow to melt earlier and faster in the spring, shifting the timing and distribution of run-off. Projections are for a regression of the maximum spring stream-flow period in the annual cycle of about 30 days and an increase in glacier melt run-off by 33–38%. These changes could affect the availability of freshwater for natural systems and human use. Excessive melt water could cause flash floods. If freshwater run-off is reduced in the summer months because of earlier melting, the result will be water insecurity and more interstate conflicts in the region. Rajasthan has minimum rainfall of 10-25mm only. The climatic variation in the country provides a wide range of biological resources in their natural habitat. There is a long list of flora and fauna in the account of the subcontinent due to the favorable climatic conditions. It supports a wide range of biological diversity. Climate change is likely to have a number of impacts on biodiversity from ecosystem to species level. The most obvious impact is the effect that temperature and precipitation have on species, ranges and ecosystem boundaries. Any particular ecosystem consists of an assemblage of species, some of which will be near the edge of their ranges and others of which will not. Those at the edge of their ranges may need to move due to climate change. **The major proximate causes of species extinction are habitat loss and fragmentation etc, extremely accelerated by climate change through various ways.**

A pollen profile obtained from lake sediments at Lunkaransar, Rajasthan, in northwest India was used along with a pollen-climate calibration function to estimate past precipitation. Between 10,500 and 3500 yr B.P., the estimated precipitation was about 500 mm/yr, or about 200 mm/yr above the modern value. A model was used for the energy and hydrologic budget of a lake basin and lake at Sambhar (located 240 km SE of Lunkaransar) to calculate that a 200 mm/yr increase in rainfall above the modern amount would have raised the lake level about 20 m above the modern level.



DISTRICT	EVAPOTRANSPIRATION (ET)				
	Normal ET (mm)	+1°C rise in temp	Net increase in ET (mm)	+2°C rise in temp	Net increase in ET (mm)
Barmer	2,177.2	2,224.9	47.7	2,272.7	95.5
Bikaner	2,009.7	2,055	45.3	2,100.5	90.8
Churu	1,702.2	1,737.4	35.2	1,772.8	70.6
Ganganagar	1,632.4	1,667.5	35.1	1,702.8	70.4
Hanumangarh	1,973.4	2,018.2	44.8	2,063	89.6
Jaisalmer	2,064	2,160	96	2,256	192
Jalore	1,905	1,970	65	2,040	135
Jhunjhunu	1,819	1,883	64	1,950	131
Jodhpur	2,002	2,045.8	43.8	2,089.9	87.9
Nagaur	1,502	1,583	81	1,669	167
Pali	2,071.6	2,117.4	45.8	2,163.5	91.9
Sikar	1,528	1,569	41	1,611	83

Additional water requirement for irrigation if global warming rises by 1°C in western Raj

District	Total cropped area (Ha)	Total irrigated area (Ha)	Net annual groundwater availability (mcm)	Additional water requirement for irrigation (mcm)
Barmer	16,503,76	1,505,40	249.8049	71.81
Bikaner	14,653,05	2,283,55	197.6075	103.44
Churu	11,408,03	58,115	197.6883	20.46
Ganganagar	9,067,59	7,868,59	198.8341	276.19
Hanumangarh	8,826,97	5,498,53	194.6094	246.33
Jaisalmer	4,673,91	90,745	52.5923	87.12
Jalore	7,408,78	2,021,53	423.6140	131.40
Jhunjhunu	6,096,59	2,425,84	243.0369	155.25
Jodhpur	12,278,43	1,765,71	393.1304	77.34
Nagaur	13,654,02	2,948,00	628.1586	238.79
Pali	5,828,84	1,120,59	413.3910	51.32
Sikar	6,715,78	2,718,78	324.5240	111.47
TOTAL	1,17,11,575	31,645,12	3516.9914	1570.92

Fig.2b. Loss of water by evapotranspiration

Many waterbodies in India are now severely polluted, and three of Rajasthan’s most well-known lakes – the Jal Mahal, Jaisamand and Udaisagar – are in the list of most severely-polluted water bodies in the country. **Evapotranspiration has been excessive in lakes which dried and became polluted too causing contamination and death of flora and fauna.**

Groundwater in Rajasthan occurs under water table conditions in the weathered and fractured granite, gneisses. The nitrate concentration increased with increasing rainfall. This may be due to the leaching of nitrogenous fertilizers used for crop production and the other natural nitrates present in the surface soil with rainwater. It is

revealed that TDS and fluoride are the dominant parameters in groundwater for both pre and post monsoon season. Rainfall and temperature directly affect the TDS and EC of water. Keeping the above experiences in view, it can be concluded that the climate may adversely affect the water quality to a great extent and we have to have strategies to mitigate or to have the set of scales to combat these calamities. This study recommend the policy and management enhancement for proper water quality management to support the sustainable water quality management in Rajasthan.[10]



Fig. 3. Sambhar lake in 2018



Fig.4. Sambhar lake dried in 2019

Far from being a wetland, Sambhar in Rajasthan is no more a lake. Anthropogenic pressures have killed a wetland of international importance in the state. Ramsar site number 464 under the Ramsar Convention on Wetlands, the Sambhar Salt Lake, once a large saline lake fed by four rivers set in a shallow wetland, is dangerously close to extinction. The lake has dried up and the flamingoes that used to visit the lake in thousands have reduced to just a few. Salt extraction, earlier done by surface brine, is now done by 1,544 borewells dug all over the lake. Ironically, after being designated as a Ramsar site, a wetland of international importance, on March 23, 1990 Sambhar has not been anybody's baby. "Until now, the GoI has not provided a map showing the boundary of the Sambhar Lake Ramsar Site and this is indicated in the paper update on the status of sites on the list of wetlands of international importance" which was presented at the 53rd meeting of the Standing Committee of the Ramsar Convention in May 2017.

Birds of about 25-30 species have now been found dead, including northern shoveller, Brahminy duck, pied avocet, Kentish plover and tufted duck. The trend began on November 10 when visitors found a large number of dead birds. More and more were found over the next several days. Until Wednesday, November 20, the Rajasthan government had, using various agencies, buried 18,422 bird carcasses to prevent the spread of infection. Of these, 8,825 were disposed of in Jaipur and 9,597 in Nagaur. [8]

The 9-metre deep Rajsamand lake dried up completely in 2001 but it has filled up to 6 metres this year due to excessive rainfall in the catchment area. On October 26, the Water Distribution Committee of the lake declared that 4 metres of water should be released for irrigation and the remaining 1.5 metre retained for the town's consumption. The decision alarmed townspeople since evaporation losses alone are 2 metres per year and they fear that water level would fall below the sill level, the level at

which outlets are provided for consumption of any kind. The level is a little higher than the bed of the lake to allow for siltation, which means that after allowing the water to drain out, there will still be some amount of water left over, known as dead storage.

Many birds and animals succumb to the Loo in the summer months, especially in deforested areas where the Loo blows unhindered and shelter is unavailable. Certain insect-borne diseases, such as malaria, have historically registered dips during the Loo season as insects populations also plummet during this season.

Mass bird deaths in Rajasthan have prompted authorities to take remedial measures, issue alerts, and enhance surveillance. Rajasthan, with its climate ranging from arid to semi-arid to sub-humid, and rapidly depleting natural resources, is already experiencing the effects of climate change. The region's climate is projected to become harsher, with increased average temperatures, intensity of rainfall events, and increased variability in space & time of monsoon rains being consistently projected for the region. Without action in the form of adaptation of social, human, economic, and natural resource management systems, these weather changes are predicted to result in decreasing surface and ground water availability, flash floods, degradation of soil resources, decrease in crop yields, greater vulnerability to crop pest outbreaks, and declines in forest and pastureland ecosystem goods and services, thus rendering agricultural and herding communities extremely vulnerable to weather related losses of life, livelihood, and food security.[9]

In Rajasthan, government is focussing for sustainable development and climate change adaptation by finding and administering alternative methods to deal with issues of poverty and environmental degradation in context of linkage between livelihood and the immediate environment of the people. The livelihoods of the rural poor are directly dependent on environmental resources like land, water, forests — and are vulnerable to weather and climate variability. Climate change affects every aspect of society, environment and economy requiring adjustments in behaviour, livelihoods, infrastructure, laws, policies and institutions in response to experienced based expected climatic events. However, it was found that local coping strategies and traditional knowledge need to be used in synergy with government and local interventions. Solutions must be integrated to address the interrelationships between water, agriculture, forests and pastures, livestock. Finally, there is great

potential for existing policies and schemes to be employed synergistically towards building true adaptive capacity for the rural communities. However, adapting to climate change will entail adjustments and implementation at every level – from community to national and international.[10]

CONCLUSION

Depending upon the natural resources, agriculture sector is vulnerable to climate change and vagaries of nature. Climate change is likely to negatively affect crop production in low latitude countries. Climate change affects agriculture in a number of ways including through change in average temperatures, rainfall and climate extremes (e.g., heat waves); changes in pests and diseases; change in atmospheric carbon dioxide and ground-level ozone concentrations; changes in the nutritional quality of some foods; and change in sea level. Climate change is impacting the natural ecosystems and is expected to have substantial adverse effects in India, mainly on agriculture on which 58% of the population still depends for livelihood.

Rajasthan has been identified as one of the four states most vulnerable due to climate change by State Action Plan On Climate Change (SAPCC). Rajasthan being the largest state in India with two-thirds of its area as Thar Desert is particularly characterized by low and erratic rainfall, high air and soil temperature, intense solar radiation and high wind velocity, and then too the soil of Rajasthan does support a substantial agricultural population (almost 80%) who harvest protein rich crops like Jowar & Bajra. Also, the agricultural sector accounts for almost 22.5% of the States GDP. Rajasthan is the largest producer of Rapeseed & Mustard that accounts for 44.61% of the total national produce. Also, wheat, corn & millets are the three most important crops of the region, along with pulses.

Climate Change is increasing the pressure on already scarce resources and if proper measures are not taken, migration towards the cities will soon reach new heights. Given the fragility of the resource base in much of Rajasthan, agriculture is a high risk activity. Climate change poses formidable challenges to the animal husbandry sector as well. Rajasthan is the second highest producer of milk in the country (amounting to nearly 17lakh kg per day). But the current annual loss in milk production due to heat stress in Rajasthan is 98.65, 40.55 and 29.74 litres per animal per year in crossbred cows, local cows and buffaloes respectively, states the report by Rajasthan State Action Plan on Climate Change(RAPCC). On the other side, it would affect the demand and corresponding changes in crop prices.

The harvest prices of food grains, pulses, vegetables and spices have constantly been on the rise. Yield-temperature response curves show that there is a decrease in grain yield of wheat in Rajasthan at the rate of 2.49 quintals per hectare per degree rise in seasonal temperature, 0.92 quintals per hectare decrease in yield of mustard, reads the report by RAPCC. Shifting cropping patterns to more heat adapted and less water consuming varieties is a strategy already practiced by farmers.[10]

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