

The Impact of Climate Change on Water Resources: Lessons from Villages of Tonk District of Rajasthan, India

Rajeev, M.M.

Department of Social Work, School of Social Sciences, Central University of Rajasthan, Rajasthan
✉ rajeevmm@curaj.ac.in

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Abstract: Climate change is a major concern in Rajasthan's water-stressed state. Climate change has a direct impact on the water resources in many parts of the state. In comparison to the rest of the country, the state has a larger portion of desert or arid lands (58% of the total geographical area) and limited water resources. Therefore, any adverse climate change conditions will likely have a catastrophic impact on the state's already vulnerable water resource system. Attempts have been made in this study to understand the state's climate conditions and highlight isolated past events that suggest climate change may occur in the state. It is emphasised that climate change modelling for various types of climate is required. To develop optimal water resource management strategies for different zones, cutting-edge tools such as remote sensing and geospatial tools must be used. The study's overarching goal is to comprehend the impact of climate change on the study area's water resources. The study's objectives are as follows: (1) to determine the effects of climate change on the water resources of the study location, (2) to investigate the nature and impact of climate change-induced drought disasters in the study area, (3) to identify methods and strategies for mitigating potential risks and vulnerabilities due to climatic variations and (4) determine the scope of research and policy action in response to identified current and future vulnerabilities, as well as the anticipated effects of climate change. The descriptive study used both quantitative and qualitative data collection methods. A total of 100 respondents were chosen from the villages of Rajasthan's Tonk district for quantitative data collection and 05 in-depth interviews with various stakeholders were conducted for qualitative analysis. The study revealed that indigenous knowledge systems have allowed various communities in the area to live in harmony with their environments for generations and that their traditional knowledge systems are essential tools in environment conservation and natural disaster management. Again, according to the study, the majority of respondents believe that climate change is a cause of drought disasters, which should be addressed through effective participatory research. The qualitative interviews made known themes such as stakeholder participation, climate modelling, the impacts of climate change on key development sectors, adaptation needs, initiatives, opportunities, and so on. The findings imply that climate change is one of the critical reasons for the occurrence of drought disasters in the study area and the state as a whole; drought and climate change have severely impacted water resources. To conclude, the study emphasises the emerging need for research, policy, and action to mitigate the impact of climate change on water resources and related areas.

Keywords: Climate change modelling; Water resource management; Natural disaster management; Participatory research.

Introduction

Climate change is no more a distant threat, and its impacts are being experienced all over the world.

The climate system is a complex, interactive system consisting of the atmosphere, hydrosphere, biosphere, cryosphere, lithosphere, and outer space. The fourth assessment report (AR4) of the Intergovernmental Panel

for Climate Change (IPCC, 2007) has indicated changes in the temperature, both over the land and ocean. As a result, the impact of disasters such as tropical cyclones, droughts, floods, extreme temperature events, etc. has seen an increasing trend with time. Two-thirds of the catastrophes in the South Asian region experiences are climate-related, and there has been a phenomenal increase in their frequency, severity, and unpredictability in recent times. The societal vulnerabilities are aggravated by stresses on water availability, agriculture, and the environment.

The main climate change consequences related to water resources are increases in temperature, shifts in precipitation patterns and snow cover, and a likely increase in the frequency of flooding and droughts (European Environment Information and Observation Network) (Eionet, 2020). Water and climate change are inextricably linked. Extreme weather events are making water scarcer, more unpredictable, more polluted, or all three. These impacts throughout the water cycle threaten sustainable development, biodiversity, and people's access to water and sanitation (United Nations, 2020).

Countries ratified the Paris Agreement, at COP21 in Paris (The Paris Agreement 2015), which became effective in November 2016, to enhance the global response to the issue of climate change. In the accord, all nations committed to work together to keep the increase in global temperature to well below 2 degrees Celsius. The Paris Agreement had been approved by 194 parties as of November 2020. Decentralised planning for climate change mitigation and adaptation is necessary in light of this. Wetland preservation and biodiversity conservation are essential components of environmental planning. Biological diversity planning is justified by the fact that it is fundamental to ecosystem health and the supply of services vital to human well-being. It guarantees the availability of clean water and air, as well as food security and human health. It supports economic growth and local livelihoods and is crucial for achieving the Millennium Development Goals, which include eradicating poverty. In a small region of Rajasthan, people have managed to adapt or cope with it.

The State of Rajasthan is situated in the western part of India, faces severe water scarcity, has poor rainfall, and is classified as an arid/semi-arid region. Administratively, the State comprises 33 districts, 39,753 inhabited villages, 249 Panchayat Samities, and 9168 Gram Panchayats. Geographically, deserts in the State constitute a large share of the landmass. The forest cover of the State contributes 4.19% to the national forest cover. Three major rivers are flowing

through Rajasthan, the Chambal, Tapi, and Luni. The State is severely deficient in the most critical resource, that is, water. With 10.4% of the country's area and 5.5% of its population, Rajasthan has only about 1% of the country's water resources. By climatic conditions and agricultural practices, Rajasthan is divided into ten agro-climatic zones ranging from arid western to flood-prone eastern. Rajasthan is the largest state of India, comprising 10.4% of the country's total area. Nearly 76% of the state's population resides in rural regions. Rajasthan produces 5.49% of the nation's entire food grains production and 21.31% of its oilseeds. The state has 49 million livestock—mainly cows, buffaloes, and goats—comprising 10.13% of the country's livestock population (RSAPCC, 2010).

The Economic Survey 2018/19 observed that minimising susceptibility to climate change requires drastically extending irrigation via efficient drip and sprinkler technologies (Lahiry, 2018). At present, about 45 percent of farmland is under irrigation. The Inds Co-Gangetic plain and parts of Gujarat and MP are well irrigated. But parts of Karnataka, Maharashtra, MP, Rajasthan, Chhattisgarh, and Jharkhand are extremely vulnerable to climate change for not being well irrigated. India has experienced several devastating climate extremes in recent decades. For instance, the drought of 2016 covered about 10 states and affected about 330 million people, causing an economic loss of \$100 billion (ASSOCHAM Report 2016).

Drought is a spatially extensive event that affects a large number of populations in India every year. It is a source of concern for food security and socioeconomic vulnerability given that about 33% of the geographical area is subjected to drought conditions (Mishra and Desai, 2005), largely driven by erratic monsoon rains (Shah and Mishra, 2015). Drylands (arid, semi-arid, and dry subhumid) spanning from northwestern to southern India cover about 2.28×10^6 km² (Ministry of Environment and Forests, 2010). The Indian Meteorological Department identifies the arid western meteorological subdivision. The Indian Meteorological Department identifies West Rajasthan and Saurashtra and Kutch as the most drought-affected region in India.

India is a developing country with the largest population of the global poor (30%) and has an agrarian economy, larger coastal lines of 7,517 km, the Himalayan region, and islands. The water resources in the country are also under the severe threat of climate change in terms of changes in the magnitude and intensity of rainfall, groundwater recharge, floods, and drought disasters, including contamination of surface

water and groundwater resources. The National Water Policy of the Government of India was first enunciated in 1987. The National Water Policy of 2002 emphasised the ecological and environmental aspects of water allocation in the rapidly changing scenario. The National Water Policy (National Water Policy of India 2012) stressed that water needs to be considered a common-pool resource for the planning and management of water resources. Despite different policies adopted by the government at different levels, water law continues to remain inconsistent, and somewhat inadequate, in the 21st century (Kumar and Bharat, 2014) because of various elements at local, regional, national, and international echelons and their enforcement issues. Reduction in the vegetation fraction and increase in the urban and bare soil fractions have been observed in India. Incorporation of land use and land cover changes can help improve weather prediction and water resources management (Unnikrishnan et al., 2016).

The impact would be particularly disastrous for developing countries, including India, and further degrade the resilience of poor, vulnerable communities, which make up between one-quarter and one-half of the population of most Indian cities. Low-level technology development in the villages together with social, economic and gender inequities enhance the vulnerability and sufferings of the most illiterate, unskilled, and resource-poor fishing, farming, and landless labour communities. Their resilience to bounce back to the pre-disaster level of normality is highly limited. These, in turn, impede sustainable development widely undertaken by the Millennium Development Goals (MDG). Under these circumstances, the mainly modern science and technology-based sophisticated early warning systems are unlikely to be of help to their fullest potential. The Super Cyclone in 1999, the Drought in 2002/2009, Tsunami in 2004, Heat & cold waves, and Flood/flash floods in recent years in rural and urban areas are a 'wake-up call' from technological, social, and economic points of view. This brings out the urgent need to address sustainable alternative livelihoods to enhance resilience. In these circumstances, vulnerability assessment is a powerful tool in the examination of societal well-being in the face of climatic change for better management. This must integrate knowledge about the environment (climate, ecosystems, water, associated pollution, and change) with knowledge about humans and their activities (agriculture/forestry/fishing, resource management, political governance, energy use, culture) to determine a holistic picture of how sensitive particular places are

and how resilient to the kinds of changes that might be associated with climate change.

Rajasthan is a unique region with the major part being a sandy desert, and some parts as mountainous, which has not to investigate extensively. There are few studies conducted regarding the metrology, groundwater recharge, and existence of palaeodrainage basins. But these studies are highly insufficient to understand the hydrology of the region correctly. The region encounters extreme weather phenomena. Dhar and Rakhecha (1979) studied the incidences of heavy rainfall in the Indian desert reporting occasional rain of 250-500 mm in a single day. Groundwater recharge studies using Isotope tracers have been carried out by Sharma and Gupta (1980), Navada et al. (1993), and Sukhija et al. (1996) suggesting 3-15% recharge under different geological and meteorological conditions. Some recent studies on canal water management and waterlogging have been done by Sharma (2001) and Arora and Goyal (2012). Studies related to water conservation and harvesting and agroforestry were done by Narain et al. (2005) and Khan et al. (2006). There is a need for further investigation of other studies conducted by other investigators regarding the hydrology of this region before starting additional work on the hydrological modeling of the area.

Various studies of climate, owing to various anthropogenic activities have a considerable impact on the physical and socio-economic fabric of Southern Rajasthan, especially in the study areas and nearby places. The continuous change like rainfall, increasing pressure of population and livestock on the water resources in South Rajasthan, and depletion of environmental resources particularly, vegetation, and soil resources have led to a decline in the water-table. Consequently, the drinking water crisis along with the shortage of water for irrigation and other purposes is being felt very seriously. Therefore, it is imperative to comprehend the various dimensions of climate change and how they affect the water issue in the study area with plenty of examples.

The overall aim of the study is to understand the impact of climate change on the water resources of the study area. The study objectives are (1) to find out the effect of climate change on the water resources of the study area, (2) to study the nature and impact of climate change-induced drought disasters in the study area, (3) to find out the ways and strategies for the reduction of possible risk and vulnerabilities due to climatic variations, and (4) to find out the scope for research and policy action in response to identified current and

future vulnerabilities and the anticipated impacts of climate change in the study area.

Materials and Methods

Profile of the Study Area

Tonk district is located in the eastern part of Rajasthan. It is bounded in the north by Jaipur district, in the east by Sawai Madhopur district, south by Bundi, and by Ajmer district in the west. It stretches between 25° 40' 31.58" and 26° 33' 51.29" north latitude and 75° 06' 46.84" and 76° 19' 38.24" east longitude covering an area of 7,190.5 sq km. Apart from small areas being part of the Chambal River basin in the south and southeast, the remaining part of the whole district is part of 'The Banas River Basin.' The district is drained mainly by the Banas River and its tributaries. The climate of Tonk district is different from typical semi-arid Rajasthan and is more akin to Madhya Pradesh's sub-humid climate. The area does remain dry for a good part of the year, and humidity increases only during the monsoon months. Summers are hot, and during the peak summer months of May-June, the temperature soars to more than 45°C. In winter months that stretch from November to February, the mean temperature is low, around 22°C but the weakest temperatures dip to approximately 4-5°C. Rainfall is moderate as the average annual rainfall in this district is about 508 mm and rain is received during the monsoon months of July to September. There is no natural lake in the district. However, several tanks formed by harnessing the feeders of the Mashhi and the Banas are available. The biggest of such tanks is Tordi Sagar in Tehsil Malpura irrigation of an area of more than 5 thousand hectares, followed by Bhairon Sagar,

irrigating an area of about 1295 hectares. Others are very small tanks which are individually a very small area.

The descriptive study adopted both quantitative and qualitative methods of data collection. A total of 100 respondents from quantitative data collection were selected from the villages of the Tonk district of Rajasthan. For qualitative analysis: 05 in-depth interviews were conducted with various stakeholders. The collected data was analyzed through the content analysis method and later converted into detailed findings. The author undertook a review of various published and unpublished literature sources relating to indigenous knowledge of weather events and significant climatic disturbance, consulting traditional religious textbooks in local languages and English, and research papers and other written materials. Adaptations and coping strategies followed by tribal peoples from across the state were documented, along with oral history and ethnographic reports.

Results and Discussion

The researcher collected data from the respondents, the majority of falls in the age group of 25 to 35 (56%). Out of 100 respondents, 30 respondents were from 36 to 45 age range, the rest of the respondents were from 46 to 55 age group and 7% were above 56 age. This table shows that the education status of the respondents thirty-five percent belong to primary, 22% from secondary, 36% from high education and seven percent are illiterate. Out of the hundred families of the respondents, the majority of the families belonged to the typical (38%) and the rest of the families belonged to the nuclear which is the 58% and nuclear 4% of the sample size.

Agriculture production is impacted by climate change as a result of climatic fluctuations. 30% agree and 70% strongly agree with this findings. Climate change is a serious cause for the environment 54% strongly agree, 45% agree, and the rest of the respondents can't say 1%. Climate change is one of the reasons for deforestation 46% strongly agree, and 52% agree, or the rest of the respondents can't say 2%. Climate change is affecting the health of people 30% strongly agree, and 60% agree, or the rest of the respondents can't say 9% and disagree 1%. Climate change affects the local economy of the village 39% strongly agree and 57% agree, or the rest of the respondents can't say 4%. Climate change affects the food culture or patterns of the people - 36% strongly agree, 45% agree, or the rest of the respondents can't say 18% and of disagree 1%. Drought is affecting the



Figure 1: The study location - Tonk district, Rajasthan.
Source: Government of India, Ministry of Water Resources Central Ground Water Board

production of grains: 35% strongly agree, 51% agree, and the rest of the respondents can't say, i.e., 14 %.

According to the available resources, the principal cereal crops of the Kharif season in Tonk District are jowar and bajra, and the area devoted to these has altered over time. Kharif pulses are becoming more popular as the area increased from 3% in 1992 to 31% in 2014. Groundnut crop is losing area as water scarcity is increasing in the district. The maize and Sesamum area did not change much, while the area under other crops was 10% in 1992 has declined to only 1% in 2014. Wheat, Mustard, and Gram are the main crops grown in the Rabi season. Due to climate changes, the area under wheat crop has declined from 37% in 1992 to 16% in 2014, mainly because of the depletion of groundwater in the area. The area of the Mustard crop increased from 43% in 1992 to 70% in 2014. This significant change has been because it is a low water-demanding crop and has replaced wheat which is relatively high water-demanding. The other important factor responsible for this major change is the better farm gate price of the mustard crop. Gram is mostly a rainfed crop and if there is winter rains area under gram and mustard increases.

Due to drought migration increasing: 32% strongly agreed and 55% agree, or the rest of the respondents can't say 12% and disagree, i.e., 1%. Due to seasonal drought diseases increasing 18% strongly agreed and 62% agree, or the rest of the respondents can't say, i.e., 20%. For rainwater harvesting: 44% strongly agree and 52% agree, or the rest of the respondents can't say, i.e., 4 %. Rainwater harvesting helps prevent drought in the village harvesting 56% strongly agree, 41% agree, or the rest of the respondents can't say, i.e., 3 %. You have less potable water during the drought 30% strongly agree, and 53% agree, or the rest of the respondents can't say 17%.

The below diagram depicts the relationship between climate change and drought disasters in the targeted area. The study found that climate change can be a

reason for drought: 38% strongly agree and 53% agree, or the rest of the respondent can't say 9%.

Due to drought, water shortage arises: 32% strongly agree and 54% agree, or the rest of the respondents can't say, i.e., 14%. Drought is the most important cause of food insecurity: 22% strongly agree, 56% agree, or the rest of the respondents can't say 20% and disagree 2%. Due to drought, much more water is required for the land: 39% strongly agree and 56% agree, or the rest of the respondents can't say, i.e., 5%. Unemployment increases during the drought 22% strongly agree and 61% agree, or the rest of the respondents can't say 12% disagree 4%. During less rain, drinking and other water problems are faced: 45% strongly agree, 51% agree, and the rest of the respondents can't say, i.e., 4%. Local Government Institutions like Panchayat, village, and gram sabha is helping people during drought 28% strongly agree, 51% agree, or the rest of the respondent can't say 18% disagree 1% rest the respondent strongly disagree.

Qualitative Findings of the Study

People in rural areas mostly respond to climate variability based on their generational sharing of knowledge/experience about the occurrence of events and the success and failure of their responses. People have evolved some broad strategies to deal with climatic risk by adopting mix farming system in agriculture, diversification of occupations, managing their accumulated assets as per the intensity/severity of risk, use of social capital. The strategies guided by NGOs and State Government policies and programmes were to some extent robust enough to address the climatic risks and because of that only climate-resilient development in the Basin was possible. Water resource availability plays a major role in shaping household coping strategies as people are forced to migrate during drought years. Presently, people are managing water resources either individually in their private capacity and/or as community resources at the village level. The watershed or river basin level management does not figure out in their household strategy of community level management strategy.

The qualitative interviews provided the basis for the formulation of themes including stakeholder involvement, climate modelling, consequences of climate change on important development sectors, needs for adaptation, community actions and opportunities. The participation of all stakeholders including gram panchayat members, sarpanch, civil society organizations, social institutions, and government

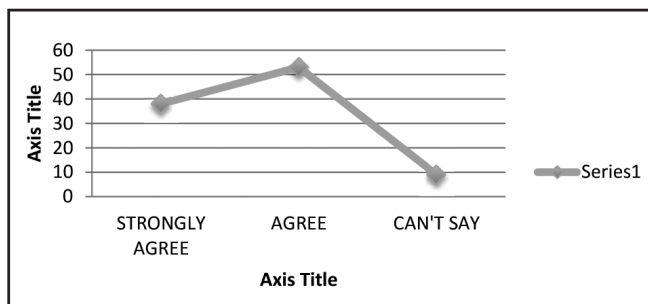


Figure 2: Relationship between climate change and disasters.

agencies is most important to the management of climate-related issues. In general terms, a climate model can be defined as a mathematical representation of the climate system based on physical, biological, and chemical principles. Disaster risk reduction and climate change adaptation cannot be dealt with in isolation. Risks due to disasters and climate change must be known and measured. Disaster and climate change risk analysis must be integrated into national planning processes, including the poverty reduction strategy process, in each country. An action that addresses the interlinked challenges of disaster risk, sustainable development, and climate change is a core priority given that 90% of recorded significant disasters caused by natural hazards from 1995 to 2015 were linked to climate and weather including floods, storms, heatwaves, and droughts. The five countries hit by the highest number of disasters were the United States (472), China (441), India (288), the Philippines (274), and Indonesia, (163). UNISDR focus on achieving stronger recognition of disaster risk reduction and climate change adaptation as essential elements of climate risk management and sustainable development.

The study found that indigenous knowledge systems have enabled various communities in the area to live in harmony with their environments for generations and that their traditional knowledge systems are essential tools in environmental conservation and natural disaster management. Based on this traditional knowledge and experiences of the communities related to concerning cloud formation, lightning wind direction, and the occurrence of rains in a particular period of the lunar calendar, the native rain forecasters predict the reasonably exact nature of rainfall for the entire season, including excellent and undesired effects such as disasters and related hazards. There are well-known Sutras given in ancient books to predict the monsoon and inform people about the prospects of agriculture in a given year. Even in villages, it is widespread for farmers to consult Brahmins about the monsoon in a year. Monsoon predictions are also made according to the nature, colour, and direction of the flow of clouds and lightning in the clouds (Pareek et al., 2011). Traditional skills are seen in areas such as agriculture, livestock rearing, housing, clothing, etc.

Understanding the ways and strategies for the reduction of possible risks and vulnerabilities due to climatic variations is one of the main areas discussed in the interviews with the stakeholders. Almost all the respondents in the qualitative interviews shared that the active involvement of the various groups in the

community including older adults those who can share traditional knowledge and skills, community-based organisations, local government institutions, youth clubs, women headed groups are inevitable to deal the climate-related issues in the villages. They can be involved in decisions making processes, activities about water conservation, rainwater harvesting, proper utilization of water, etc. They shared that in Ladnun, Nagar district, individual households are having storage facilities for rainwater, and they will use the same in the summer if it's finished with the surrounding families having common facilities for at least five to 10 houses. Apart from this, the community water storage Centre can be used in the last part of the summer. This way community can work, and share can reduce the intensity of the water shortage during the time of peak summer.

Suggestions and Conclusion

Disaster risk reduction is a powerful tool for climate change adaptation. The link between natural disasters and climate change is the most important nowadays. Disaster risk reduction measures need to harmonise climate change adaptation. Harmonisation of the DRR and the Climate change adaptation policies and practices to prepare for the effects of climate change is the need of the hour. On the guidelines of the National Action Plan on Climate Change, Rajasthan has formulated a State Action Plan on Climate Change to address the projected impacts of climate change locally. This plan aims to reduce vulnerability to climate change by reducing its effects and enhancing the resilience of economic, and ecological. Ultimately climate reduction will be the responsibility of the State, Government, and the people. So there is a higher necessity for proper planning, and policy advocacy actions are needed to jointly execute better mitigation activities or reduce the impact of climate change and thereby increase the water storage capacity and resilience of the people.

More than 60% of the world's population lives in Asia, where natural resources are already under strain, and few industries are resilient to climate change. Natural resources including water, forests, grasslands, and fisheries are crucial for the socioeconomic well-being of many nations, so any changes brought on through climate change will have a significant impact on these resources. For instance, South Asia's human settlements, food and fiber production, biodiversity, water resources, and coastal ecosystems are all regarded to be extremely vulnerable to climate change. The effects of climate change are anticipated to differ

greatly across the many sub-regions and nations of Asia, and some nations will be better able to adapt than others. Because of their weak economies, inadequate institutional capacity, and greater reliance on resources that are sensitive to climate change, the Least Developed Countries (LDCs), which are already struggling to address issues of poverty, health, and education, are anticipated to be among those most vulnerable to climate change and extreme events. Realistic adaptation strategies must be created for these vulnerable nations and included in their overall development plans. The studies consistently remind us that the distribution, kind, and quality of the country's natural resources will change and be profoundly impacted by the consequences of climate change.

References

- Arora, A.N. and Goyal, R., 2012. Groundwater model of waterlogged area of Indira Gandhi Nahar Pariyojna, Stage I. *ISH Journal of Hydraulic Engineering*, **18**: 45-53. 2ISBN: 0971-5010
- ASSOCHAM, 2016. Drought situation to cost Rs 6.5 lakh crore to economy. ASSOCHAM. The Associated Chambers of Commerce & Industry of India, Newsletter. 5678. Accessed 26.05.19. pp 01-02.
- Climate impacts on Water Resources, 2020. European Environment Information and Observation Network (Eionet), partnership network of the European Environment Agency (EEA). pp. 02.
- Datta, P.S., Gupta, S.K. and Sharma, S.C., 1980. A conceptual model of water transport through unsaturated soil zone. *Mausam*, **31(1)**: 9-18.
- Dhar, N., Rakhecha, P.R. and Kulkarni, A.K., 1982. Trends and fluctuations of seasonal and annual rainfall of Tamilnadu. *Proceedings of Indian Academic of Sciences (Earth and Planet Science)*, **91**: 97-104.
- IASC, 2010. Summary and action points of IASC TF on Climate Change meeting, IASC. PP 0-05.
- IFRC, I.F.O.R.C.A.R.C.S., 2009. Climate Change Adaptation Strategies for Local Impact: Key Messages for UNFCCC Negotiators. International Federation of Red Cross and Red Crescent Societies. pp. 3.5.
- IMD (India Meteorological Department), 2016. Statement on Climate of India during 2016. Earth System Science Organization, Ministry of Earth Sciences, Govt of India. pp. 03.
- India: Rajasthan Urban Sector Development Investment Program, 2016. —Bundi Solid Waste Management Subproject, Prepared by Local Self Government Department. pp. 6-10.
- IPCC: Climate Change, 2007. Synthesis Report- Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, Pp.104.
- Khan, M.A., Tewari, J.C., Singh, R. and Narain, P., 2006. Structure, production attributes and management strategies in a traditional extensive agroforestry system in an arid region watershed of India, *Forests, Trees and Livelihoods*, **16(3)**: 227-246.
- Kumar, V.S. and Bharat, G.K., 2014. Perspectives on a water resource policy for India. Discussion Paper 1. New Delhi, India: Energy and Resources Institute. pp. 5-18.
- Kumar, V., 2014. Role of indigenous knowledge in climate change adaptation strategies: A study with special reference to North-Western India. *Journal of Geography & Natural Disasters*, **5**: 1.
- Lahiry, S.C., 2018. Climate change and its impact on water resources, India Water Portal. pp. 2-4.
- Ministry of Environment and Forests, 2010. Elucidation of the 4th National Report submitted to UNCCD Secretariat. New Forest, India: Indian Council of Forestry Research and Education. pp. 1-2.
- Mishra, A.K. and Desai, V.R., 2005. Spatial and temporal drought analysis in the Kansabati river basin, India. *International River Basin Management*, **3(1)**: 31-41.
- Narain, P., Khan, M.A. and Singh, G., 2005. Potential for water conservation and harvesting against drought in Rajasthan, India. Colombo, Sri Lanka: International Water Management Institute (IWMI). vi, 25p. (IWMI Working Paper 104/Drought Series: Paper 7), pp. 2-9. doi: <http://dx.doi.org/10.3910/2009.554>
- Navada, S.V., et al., 1984. Potentialities of isotope technique in groundwater recharge studies in Rajasthan - Some field experience. In: Proc. Symp. on Challenging Problems of Desert Environment, pp. 9-13.
- Pareek, A. and Trivedi, P.C., 2001. Cultural values and indigenous knowledge of climate change and disaster prediction. *Indian Journal of Traditional Knowledge*, **10**: 183-189.
- Sharma, K.D., 2001. Indira Gandhi Nahar Pariyojana— lessons learnt from past management practices in the Indian arid zone Regional Management of Water Resources (Proceedings of a symposium held during die Sixth IAHS Scientific Assembly at Maastricht, The Netherlands, July 2001) . IAHS Publ .no. 268, pp. 6.
- Shah, R. and Mishra, V., 2015. Development of an Experimental Near-Real-Time Drought Monitor for India. *Journal of Hydrometeorology*, **16**: 327-345.
- Singh, R. and Kumar, A., 2015. Climate variability and water resource scarcity in drylands of Rajasthan, India. *Geoenvironmental Disasters*, **2**: 1-14. 10.1186/s40677-015-0018-5
- State Disaster Management Plan (SDMP), 2014. Government of Rajasthan Disaster Management & Relief Department, Jaipur. pp. 37-55.

- Sukhija, B.S., et al., 1996. The use of environmental isotopes and chloride as natural tracers to investigate the effects of depressurization of a coastal aquifer for lignite mining. *India Hydrogeology J.*, **4**: 70-88.
- TERI, 2010. Draft Rajasthan State Action Plan on Climate Change New Delhi, RSAPCC: The Energy and Resources Institute. p.3.
- The Paris Agreement 2015. UNFCCC Process, The Secretariat of the United Nations Framework Convention on Climate Change is located in Bonn, Germany. pp. 1-2.
- Unnikrishnan, C.K., Gharai, B., Mohandas, S., AshuMamgain, A., Rajagopal, E.N., Iyengar, G.R. and Rao, P.V.N., 2016. Recent changes on land use/land cover over Indian region and its impact on the weather prediction using Unified model. *Atmos. Sci. Lett.*, **17**(4): 294-300.
- UN Water (United Nations), 2020. Water and Climate Change United Nations - UN World Water Development Report 2020: Water and Climate Change. pp. 2.