

Impact of Climate Change on Arid Region: Case Study of Rajasthan

Abstract

The climate is changing at a very fast rate adding to the increased global concern. During the last one year the novel Coronavirus held the world by a threat which caused massive economic setbacks and loss of lives. At the same time, the climate crisis continued to contribute to extreme weather events. It was predicted by various observers that the lockdown especially shutting down of all economic activities would help to curb the spread of the virus and would bring down the greenhouse gas emission. According to Nature report, the planet was warmer by 1.2 degree Celsius from January to October in 2020 than the preindustrial average measured between 1850 and 1900. Therefore, the prediction done by observers was not completely true. To mitigate the impact of climate change, whole world came together and made various commitments made in various UN conventions, culminating in the Paris Convention to both implement mitigation and adaptation measures to reduce the emissions. The Sustainable Development Goals agenda was accepted by all members of the United Nations in 2012 at Rio De Janeiro with an aim to promote a healthy and developed future of the planet and its people. It was in 2015 the Sustainable Development Goals (SDG) were adopted with 17 goals; with SDG Goal 13 addressing urgent actions to combat climate change and its impact in all geographical features including arid areas. The paper is an attempt to provide an overview of Arid region, climate vulnerability and to identify the main challenges which climate change presents to the region's future development. The paper further investigates the impact of climate change in an arid region and the adaptation and mitigation approaches to address the concerns of climate change; and concludes with ways to mitigate the impact of climate change in an arid Rajasthan.

Keywords: - Sustainable Development Goals, Arid Rajasthan, Mitigation, Adaptation

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1. PhD Scholar, Department of Environmental Planning, School of Planning and Architecture, New Delhi

2. Head, Department of Environmental Planning, School of Planning and Architecture, New Delhi

1. Background

Climate change is the greatest global challenge facing us today which through a multitude of impacts poses a risk to our ecology, economy, and society. The IPCC's Special Report on Climate Change and Land, August 2019; says land-based carbon sinks are not limitless. The report notes that any sequestration gains are "at risk from future loss (or sink reversal) triggered by disturbances such as flood, drought, fire, or future poor management."

Over the past 3.5 billion years, the planet's climate has been altered by volcanic emissions, changes in solar input, continents moving slowly atop shifting tectonic plates, impacts by large meteors, and other factors. Over the past 900,000 years, the atmosphere has experienced prolonged periods of global cooling and global warming. These alternating cycles of freezing and thawing are known as glacial and interglacial periods. The ongoing anthropogenic climate change is mainly caused by an increase in the amount of greenhouse gases, especially carbon dioxide (CO₂) in the atmosphere. (Dhote, De 2021)

India Meteorological Department, Ministry of Earth Science, Government of India had released a statement on "Climate of India during 2020", published on 4th January 2021. According to this document, the annual mean land surface air temperature averaged over India during 2020 was above normal. The year 2020 was the eighth warmest year on record since nation-wide records commenced in 1901. However, this is substantially lower than the highest warming observed over India during 2016 (+0.710C). (Sciences, 2021)

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goals; with SDG Goal 13 addressing urgent actions to combat climate change and its impact in all geographical features including arid areas.

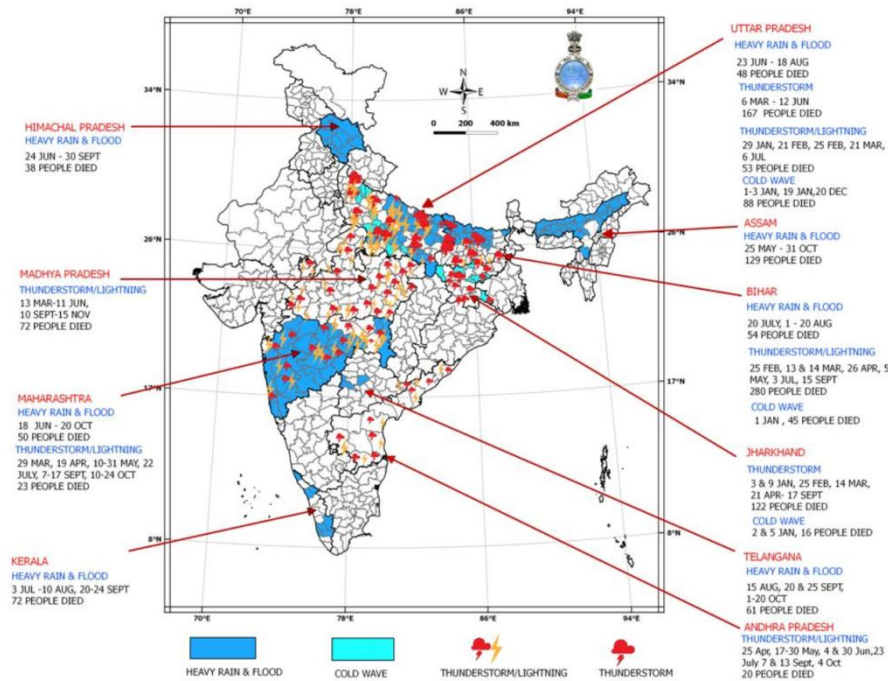


Figure 1: Major extreme weather events occurred during 2020 and associated casualties

Source: - Statement on Climate of India during 2020, India Meteorological Department, Ministry of Earth Science

The Constitution of India clearly demarcated the roles and responsibilities of Centre, State and Local Governments. Government of India is responsible to make necessary laws on subjects listed in the “Union List” and “Concurrent List”. To mitigate the impact of climate change and to keep a track of it, Climate action portal India was launched by India in 2020. The portal will provide information on the different climate initiatives taken by various line ministries enabling users to access updated status on these initiatives. The eight components of the portal are India’s climate profile, national policy framework, India’s NDC goals, adaptation actions, mitigation actions, bilateral and multilateral cooperation, international climate negotiations and reports.

2. Objective of the Study: -

To provide an overview of Arid Rajasthan’s climate vulnerability and to revisits the past to understand the present-day trends.

3. Research Questions: -

To complete this objective, the following questions has been identified for research:

- 1) What is climate change in the context of arid region? What are the adaptation and mitigation approaches addressing the concerns of climate change w.r.t to Rajasthan?
 - a) How does climate change affect the arid region? What are the main challenges which climate change presents to the region with respect to current and future development?
 - b) To what extent does the planning literature on climate change addressed the adaptation and mitigation measures, particularly in relation to planning of arid areas?
 - c) What are the steps taken by various stakeholders to mitigate the impacts of climate change? To what extent do they incorporate climate change concerns?

4. Interrelationship between Climate Change and Arid area: -

Deserts and semi-deserts are the world's most vast land biomes, covering more than 30% of the planet's surface. They are often predicted to be among the most vulnerable species to global warming.

However, there are still major uncertainties regarding the potential effects of increasing concentrations of either CO₂ or future climate change in arid ecosystems. Interpretation of some paleoclimatic data as the analogues to future climates suggest that global climate change may cause many arid regions to experience higher rainfall and therefore to become more productive ecosystems. Despite the great uncertainties about the responsiveness of arid ecosystems to the ongoing climatic changes, scenarios predicting increases in precipitation in present-day deserts are sometimes interpreted as indicators of a likely increase in productivity of arid zones as a result of the CO₂ increases. (Lioubimtseva, 2004)

The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) clearly indicate that the temperature has increased, and it is anticipated to increase further in the future unless measures are taken. Wet areas are likely to become wetter and dry areas will become drier, increasing water scarcity in these dry areas. Climate change will seriously affect the sustainable development challenges that we face not only in

environmental issues but also in other areas. Climate change is going to have a drastic impact on arid ecosystems and its almost 2.5 billion inhabitants.

The arid areas (40% of world land surface) are home to over 2 billion people, accounting for 35% of the world's population. Some 55% of arid inhabitants live in rural areas. More than 90% of arid inhabitants are in the developing world and 70% in rural areas. Approximately half of the poorest people in the world live in the dry areas. Most arid ecosystems are already affected by increasing resource demands and unsustainable management practices, and human-induced climate change adds an important new stress. Most arid systems are sensitive to both the magnitude and rate of climate change, and the vulnerability of the people living in these areas is going to increase if their adaptive capacity is not improved.(El-Beltagy & Madkour, 2012)

5. Study area – Arid Rajasthan: -

Water is scarce in an area dominated by arid and semi-arid lands, and a high percentage of degraded land exists due to aeolian processes. Rajasthan is facing the problem of climate change peril.

5.1. About Arid Rajasthan: -

The Indian hot arid region occurs between 22 30' and 32 05' N latitudes and from 68 05' to 75 45' E longitudes, covering western part of Rajasthan (19.6 Mha, 69%), north-western Gujarat (6.22 Mha, 21%) and south-western part of Haryana and Punjab (2.75 Mha, 10%). The majority of the hot arid zone comes under northern-western part of Rajasthan covering 12 districts. Rainfall distribution in the region is highly uneven over space and time. (Saxena et al., n.d.) This region covers an area of 208,746 sq. kms with a population of 27,115,542 persons as per census 2011. The study area makes up about 60.99 percent area and 39.51 percent population of the state. It consists of districts such as Hanumangarh, Sriganaganagar, Bikaner, Jaisalmer, Barmer, Jalore, Pali, Jodhpur, Nagaur, Churu, Sikar and Jhunjhunu.

Indian researchers have discovered a set of rare wood boring trace fossils in Barmer region which reveal that this area was under tropical forest and even had vast river network 55

million years ago. The rare almond-shaped ‘trace fossils’ of *Asthenopodichnium lignorum* and J-shaped fossils of *Asthenopodichnium lithuanicum* have been discovered for the first time in India in the Barmers and stone formations. (Ravi Mishra, 2018)

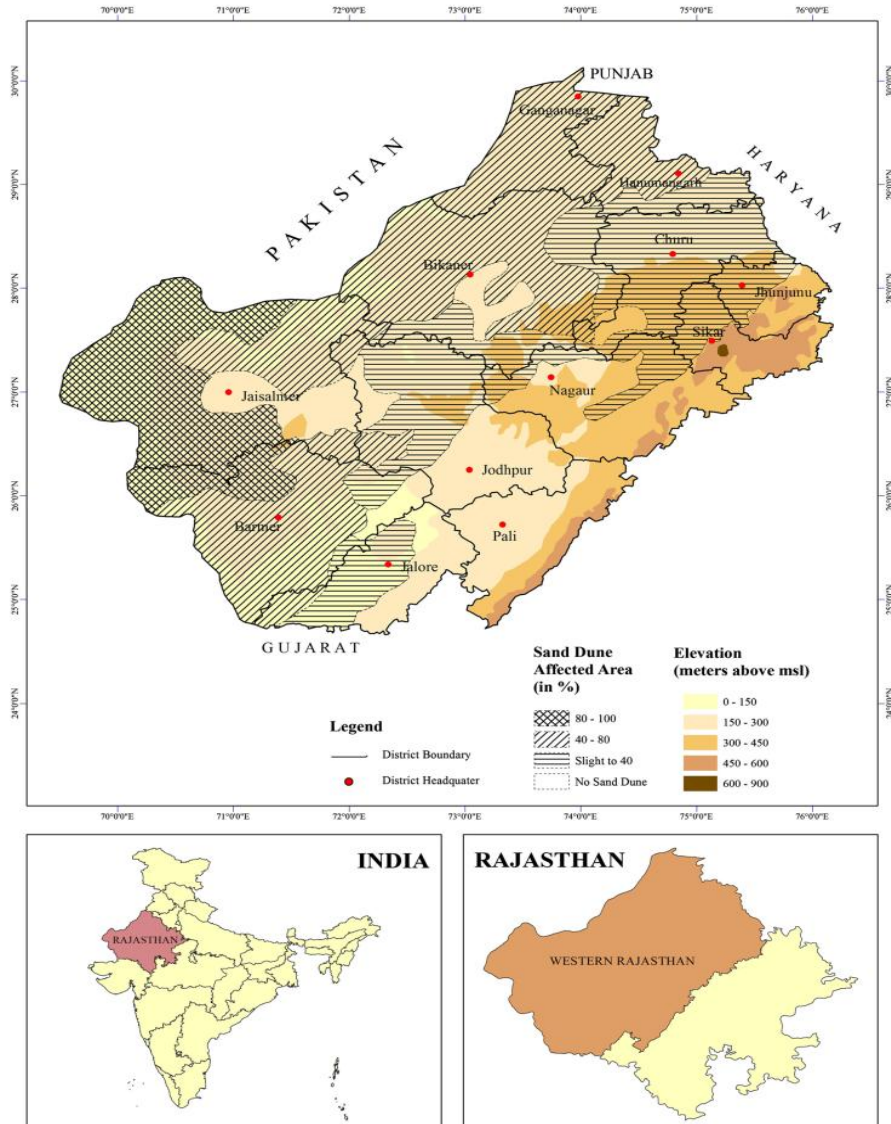


Figure 2: Location, Relief, and sand dunes affected area of the study region

Source - Climate variability and water resource scarcity in drylands of Rajasthan, India

5.2. Impacts of Climate Change on Arid Rajasthan: -

In an era of climate change, Rajasthan is likely to suffer further water shortage due to overall reduction in rainfall. In addition, the State has the maximum vulnerability and lowest adaptive capacity to climate change challenges”. Rajasthan has the maximum

36 sub-divisions of India Meteorological Department. During pre-monsoon 2020 season, Rajasthan had 44.9 mm rain, 114% above normal rains. West Rajasthan had 44.7 mm, 99% above normal rains. East Rajasthan had 45.2 mm or 138% above normal rains.

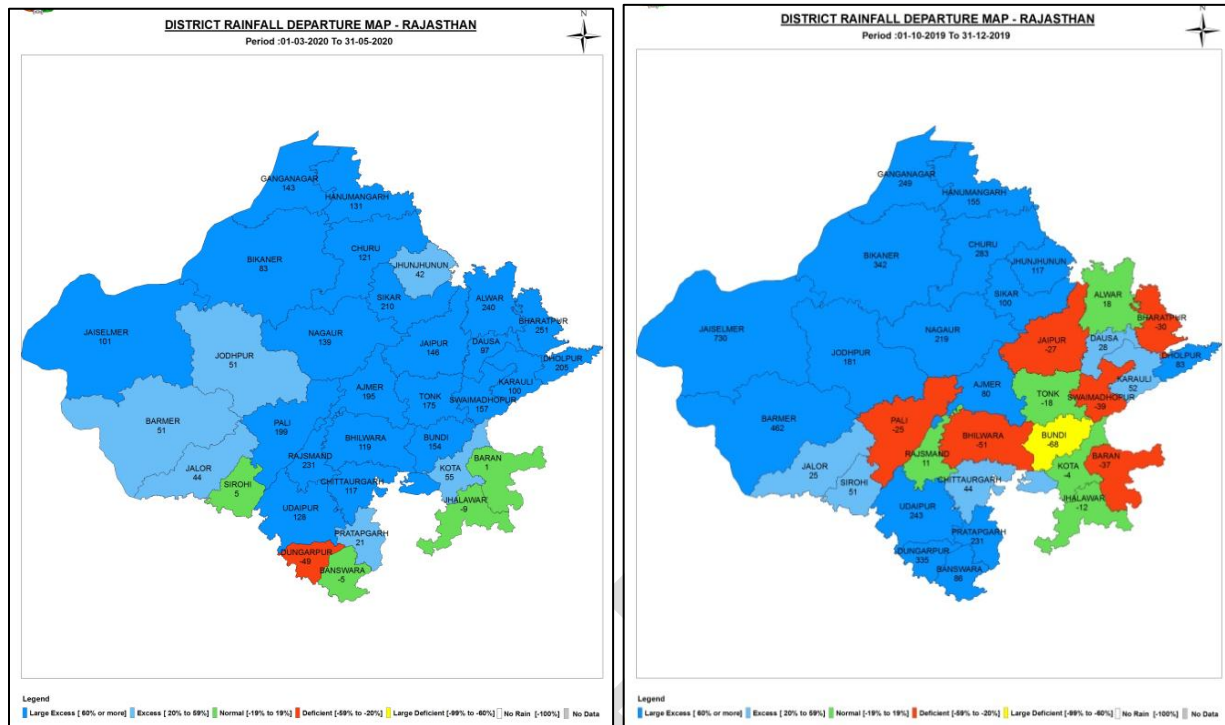


Fig 4: District rainfall departure map of Rajasthan: Pre-Monsoon 2020 and Post Monsoon 2019

Source: - SANDRP - South Asia Network on Dams, Rivers and People

During post monsoon 2019 season, Rajasthan had 42.2 mm or 136% above normal rains. Western or Arid Rajasthan had 45.7 or 294% above normal rainfall, East Rajasthan had 37.8 mm, 47% above normal rain. (SANDRP, n.d.)

The climate over Western Rajasthan is still showing definite signs of change, with decrease in rainfall and increase in temperature and aridity. The arid climate belt has shifted eastward, intensifying the process of land degradation, and causing desertification. The water resources are scarce, adding to vulnerability of region towards climate change. But in last few decades there has been tremendous development of various water sources by government in the region and due to these efforts, the north-western part of region has attained good agricultural production and yield. The development of canal irrigation in some parts has intensified the process of land degradation in form of salinization and

alkalization, which need to be managed at priority basis to mitigate the impact of climate change and its impacts. (Singh & Kumar, 2015)

5.3. Relation between Climate Change and COVID 19 and its relation to Arid Rajasthan:

COVID-19 could well be nature's warning against climate change because microbes are the first to ring an alarm and this could just be the first and second wave of the pandemic with bigger outbreaks likely to follow. (The Hindu, *Bishwanath Ghosh, 2020*)

Last year i.e. in 2020 March onwards, Indian government and Rajasthan state government has imposed various lockdowns when COVID 19 Cases emerges, and growth rate has been increased. But the question is does there is any relation between COVID 19 and Climate Change?

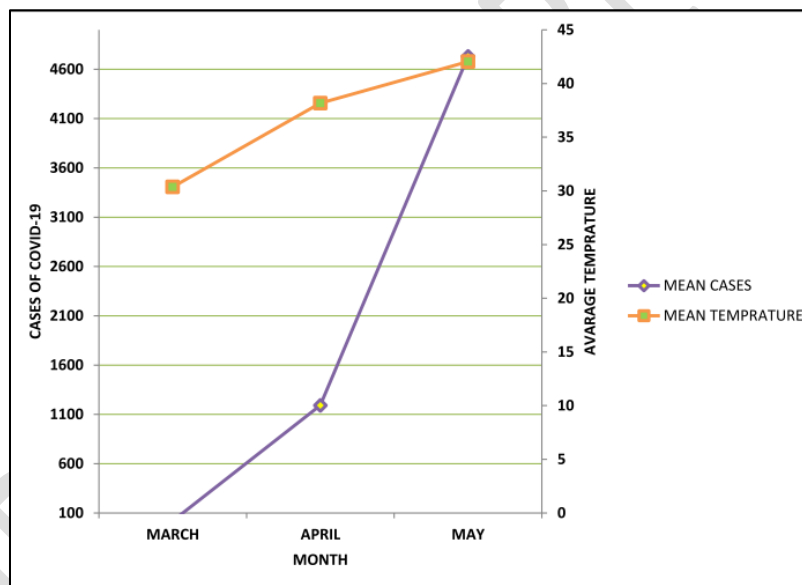


Fig 5: Mean temperature and Number of cases graph

Source: - Dependency of COVID-19 Spread on Temperature in Rajasthan

From the figure 5, it is proved that there is an inclination of the mean graph curve of both the number of cases and temperature. Temperature doesn't directly affect the number of cases. But it plays an important role in increasing the number of cases in Arid Rajasthan.

6. Steps taken by government of Rajasthan to mitigate the impacts of Climate Change:

Formulation of a Climate Change Agenda for Rajasthan (CCAR) in 2010 was an important beginning towards addressing climate risks in the state. Being the largest state in the country with unique vulnerabilities in terms of exposure to climatic extremes and varying capabilities for responding to the likely risks, and opportunities that can be tapped (such as

harnessing solar energy), this was an important initiative by the state government.

Rajasthan released a **State Environment Policy (SEP)** in 2010 identifying the key environmental challenges that the state must address to ensure continued sustainable development and economic growth that is equitable. Within the State Environment Mission, some sectors have been identified as being critical in terms of the climate change impacts on them. These include human health, agriculture and animal husbandry, enhanced energy efficiency including solar energy, and strategic knowledge for climate change. (Swami, 2019)

Under the **Rajasthan Environment Mission**, the CCAR listed a set of state priorities for adaptation and mitigation policy and action during the time between 2010-2014. State-specific missions for Rajasthan were developed highlighting research gaps and needs along with relevant policy measures, considering the state's vulnerabilities and capacities. The CCAR identified a list of strategies under the following seven state level Task Forces constituted under the concerned Principal Secretary/Secretary of the Department i.e. Water Resources, Agriculture and Animal Husbandry, Forestry and Biodiversity, Human Health, Enhanced Energy Efficiency and Solar Energy Urban Governance and Sustainable Habitats Strategic Knowledge for Climate Change.(Swami, 2019)

6.1. Rajasthan State Action Plan on Climate Change: -

The Rajasthan Action Plan on Climate Change (RAPCC) builds on the key areas as identified under the CCAR by prioritizing urgent areas of action in a phased and time-bound manner and is in coherence with the Rajasthan State Environment Policy and Environment Mission. The Rajasthan State Government established a '**Climate Change and Clean Development Mechanism (CDM) Cell**' in the Rajasthan State Pollution Control Board (RSPCB) to act as a nodal agency for coordinating issues related to climate change in the State. The Cell was constituted in April 2010 and was involved in the drafting of the CCAR. The State of

Rajasthan has constituted a team to review the implementation of the Environment Mission.

The vision of RAPCC is to achieve sustainable development by reducing vulnerability to climate change impacts and enhancing resilience of ecological, economic, and social systems in Rajasthan.

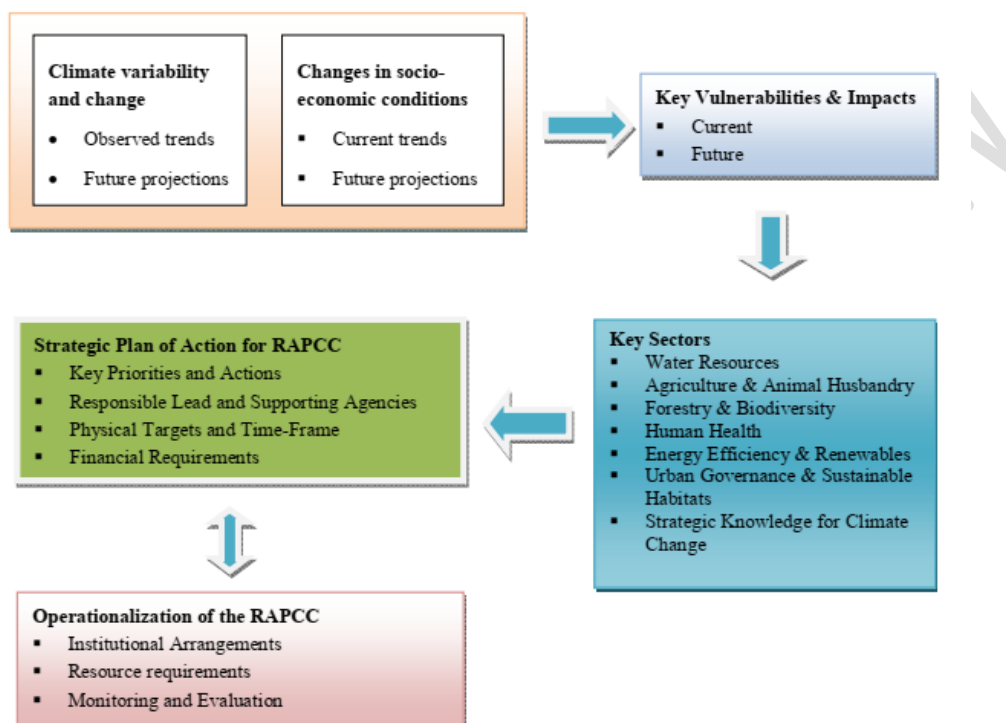


Figure 6: Rajasthan Action Plan on Climate Change: Approach

Source: Rajasthan State Action Plan on Climate Change, Government of Rajasthan

The RAPCC identifies action points/strategies in the context of climate change. These action points or strategies have been developed based on existing scientific knowledge, rich experience available in the form of existing work done in the state and the vast traditional knowledge that grounds the state. Key sectors identified under RAPCC are – Water resources, Agriculture and Animal Husbandry, Forestry and Biodiversity, Human Health, Energy Efficiency and Renewables, Urban Governance and Sustainable Habitats and Strategic Knowledge for Climate change.

Table 1: Strategies to be adopted to mitigate the impact of Climate Change

| Key Sectors | Strategies |
|-------------|------------|
|-------------|------------|

| | |
|---|---|
| In the field of Water Resources | Integrated Water Resources Management; managing the Supply side and demand side relation; creating Integrated Impact Assessment using regional climate models etc. |
| In the field of Human Health | Strengthening health services by regular research and monitoring; creating public awareness and developing outreach programs specially to combat the rising cases of diseases etc. |
| In the field of Renewable energy and Enhanced Energy Efficiency | By setting up energy consumption benchmarks for energy-intensive industry sectors and exploring the solar energy potential in the state. |
| In the field of Sustainable Agriculture | Agriculture practices can be strengthened by improvements in agro-extension services related to seed. development, on-ground demonstrations of new techniques, promotion of better irrigation infrastructure and improvement in reclamation of saline or alkaline soils etc. |
| In the field of Forestry and biodiversity | Effectively engaging forest communities in forest protection and conservation schemes; assessing adaptation potential of the various forest species in the changing climate scenario; and exploring the carbon mitigation potential of forest conservation etc. |
| Strategies for State Mission on Strategic Knowledge on Climate Change | Facilitate studies related to climate change vulnerability and impact assessments for better preparedness in Rajasthan. There is need to assess likely future growth scenarios in the State using an optimization energy environment modelling framework. Mainstreaming climate concerns into ongoing developmental initiatives can offer opportunities for adaptation and mitigation in the State etc. |
| Developing Sustainable Habitats | By capturing methane emissions from landfills; strict enforcement of Energy Conservation Building Codes and Green Certification guidelines for the building and construction sector; Green Fuel-Efficient urban transport system by using Compressed Natural Gas etc. |

Source: compiled by author, adapted by Rajasthan State Action Plan on Climate Change, Government of Rajasthan

6.2. Mukhyamantri Jal Swavlamban Abhiyan :-

Normally in Rajasthan duration of rainfall is large which has adverse effect on crop production. Due to decline in crop production of farmer and conversion of arable land to wasteland, there is scarcity of fuel, fodder, milk resulting for their weak socio- economic

condition. Scarcity of water is the main reason for this situation. As State has 75 percent rural population which depends on agriculture and livestock for their livelihood, hence in light of these conditions of state , Mukhya Mantri Jal Swawlamban Abhiyan was introduced to utilize the Four Waters- Rainfall, runoff, Ground Water & in-situ Soil Moisture keeping watershed or Cluster/ index catchment as a unit for Western Rajasthan where there is scanty rainfall & no defined drainage lines and it's the best example of climate change peril.

The Objectives of “Mukhya Mantri Jal Swawalamban Abhiyan” are: *-(Jal Swavlamban Abhiyan MJSA Donate For Water Rajasthan, n.d.)*

- To ensure effective implementation of water conservation and water harvesting related activities in rural areas through convergence of schemes of various departments keeping in view the existing guidelines.
- Implementation of works through people's participation by motivating villagers & beneficiaries.
- Harvesting of available runoff (rainwater, ground water, under-ground water & in situ soil moisture) in rural area by treatment of catchment, proper utilization of available water harvesting structures, renovation of the non-functional water harvesting structures & creation of new water harvesting structures.
- Development of Forest, land, water & fauna keeping watershed/cluster/index as a unit for natural resource management.
- Permanent Solution of drinking water by making the Village self-sufficient in terms of water.
- To increase the Irrigated area through water harvesting & conservation.

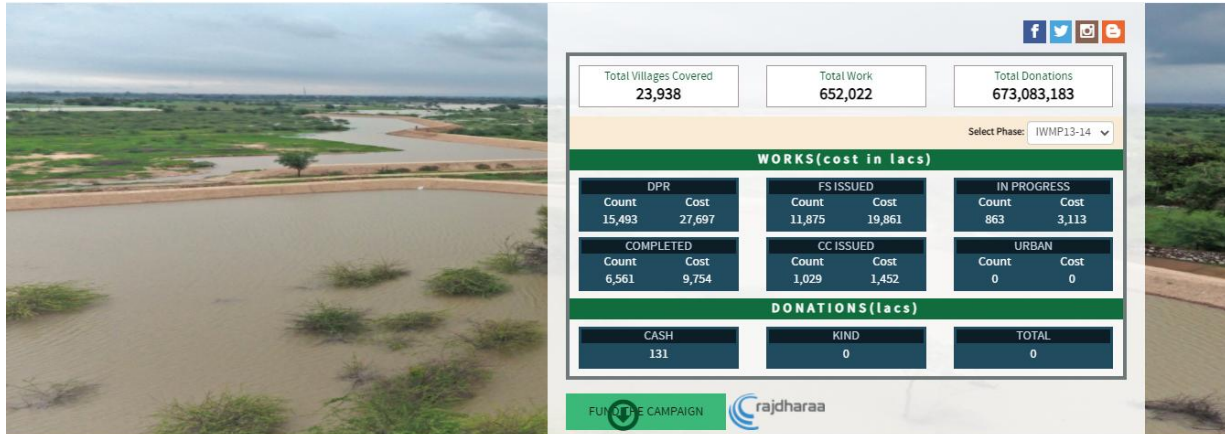


Figure 7 : Project Completion status of Mukhyamantri Jal Swavlamban Abhiyan

Source: - <http://mjsa.water.rajasthan.gov.in/>

The project has reached phase V. The Creation of water storage structures, revival of old structures, watershed development, water conservation and water harvesting-related activities are carried out through convergence of schemes of various departments and works are implemented through people's participation in this Programme.

7. Planning literature related to Climate Change: -

In this section, the discussion will be on planning literature related to climate change. The focus will be to what extent planning literature addresses climate concern.

7.1. Master Plan provision related to Climate Change: -

In this subsection 7.1, various master plans of Western Rajasthan towns and cities are compared to investigate the master plan provision related to Climate change.

Table 2: Provisions related to Climate change in Master Plans of Arid Rajasthan

| City/ Town of Western Rajasthan | National Water Mission | Green India mission | National Solar Mission | National Mission for Enhanced Energy Efficiency | National Mission on Strategic Knowledge for Climate Change | National Mission on Sustainable Habitat | National Mission for Sustainable Agriculture | National Mission for Sustaining Himalayan Ecosystem |
|---------------------------------|--|--|---------------------------------------|---|---|---|---|---|
| Jaisalmer (2011-2031) | Rainwater harvesting | Afforestation Programme, Focus on green highway | Not available | Construction of wind energy power station | Generate awareness among the people | Conservation of water | Krishi Seva Kendra | Not applicable |
| Jodhpur (2013 – 2031)- Draft | Rainwater harvesting, conservation of water bodies, water treatment planning | Afforestation Programme, Focus on green highway , Hill conservation zone | Solar panels in roads for solar light | Construction of wind energy power station | Disaster Management | Affordable housing policy, Rajiv Gandhi Awas Yojana, slum free city, Health care city | Krishi Upaj Mandi Samiti | Not applicable |
| Hanumangarh (2017-2035) - Draft | Rainwater harvesting, Rejuvenation of water bodies, river front development | Conservation of trees, Green Highway, Highway development control belt | Not available | Thermal Power plant | Environmental conservation Programme, Community participation | Sewage Treatment Plant | Krishi seva Kendra, Milk dairy farm | Not applicable |
| Sri Ganganagar (2001 – 2023) | Construction of Jet distributary canal | Public parks, Afforestation Programme | Not available | Thermal Power plant and Bhakra Nangal project | Not available | Not available | Grain distribution center, Indian oil distribution center | Not applicable |
| Bikaner (2001-2023) | Construction of Filter Plant | Parks in every sectors, Afforestation Programme | Not available | Thermal Power plant | Environmental conservation Programme | Community Participation | Dairy farming | Not applicable |

Source: - Compiled by author from various sources

The key findings from masterplan exercises are that it does not address climate change directly, but some provisions are mentioned in the mentioned in the master plan as discussed in the table 2. Another finding is that master Plans after 2008, tried to address almost all the components of National Action Plan on Climate change. But Master Plans before 2008, tried to address basic National Action Plan on Climate change components such as water conservation, afforestation Programme etc. For example, Jodhpur master plan mentioned about Solar panel, health city etc. Hanumangarh master plan mentioned about Environmental conservation Programme, Sewage treatment plant, thermal power plant, Jaisalmer master plan mentioned about indigenous knowledge, generate awareness among the people, green highway and Sri Ganganagar and Bikaner master plans mentioned about afforestation Programme, Community participation etc.

7.2. Gaps mentioned on Rajasthan State Action on Climate Change: -

- Rajasthan State Action on Climate Change not implemented till now.
- None of the policies of the Department of Urban Development and Local Self Government address adaptation measures in terms of climate change directly.
- Policy guidelines only provide for conservation actions in terms of guidelines for conserving and encourage an increase in the green footprint by mandating plantation.
- There is a need to either align/amend the existing policies to address these impacts and/or simultaneously formulate separate policies to focus on critical sectors like urban water supply, transport, storm water drainage, etc.
- There is an inadequate knowledge on the impacts of climate change in different sectors of the state.
- Further there is a lack of clear understanding of important processes like desertification, which requires the monitoring of various parameters such as changes in water quality and quantity, biomass, biodiversity, soil salinity, etc.
- No specific studies have been conducted to monitor this process in the state.

7.3. Climate Change Mitigation and Adaptation for arid areas not mentioned in Urban and Regional development plan formulation and implementation guidelines (URDPFI) Volume 1: -

- There is a Separate Chapter on Sustainability guidelines in (URDPFI) volume 1.
- Case study of Climate Proofing Guwahati, Assam: City Resilience Strategy and Mainstreaming Plan.
- Not specific guidelines about climate proofing in arid areas mentioned.
- Desert ecosystem sensitive planning is crucial at Regional planning stage including mapping of land degradation, drought monitoring and indicating components for the State and District Disaster Management Plan for drought preparedness and warning system groups.
- At Development Plan and local area planning level the key actions suggested in NEP, 2006 as given below to be considered:

- a) Intensive water and moisture conservation through practices based on traditional and science-based knowledge and relying on traditional infrastructure.
- b) Enhancing and expanding green cover based on local species.
- c) Reviewing the agronomic practices in these areas, and promoting agricultural practices and varieties, which are well adapted to the desert eco-system.

7.4. Rural Area Development Plan Formulation and Implementation (RADPFI) Guidelines, 2016 not directly address Climate Change: -

- There is a separate chapter on Environmental sustainability and disaster management
- Mentioned about Climate Change Mitigation and Adaptation in RADPFI, here also mentioned focus should be on water security, use of heat revealing materials in construction and minimizing concrete surfaces.
- The expression “climate proofing” is meant as a process that aims to identify risks that an investment project or development plan or simply people and their assets may face as a result of climate change, and to reduce those risks to levels considered to be acceptable has been defined.
- Community Based Disaster Management (CBDM) also mentioned in that guidelines.

8. Stakeholders: -

Climate Change has impacted almost all sectors of development making almost everyone a stakeholder. Stakeholders play an important role in taking forward environmental concerns. The five 'P's of sustainability – Planet, People, Participation, Peace and Prosperity indicate the important role of people in taking forward the actions. Governmental bodies, Civil Society, Companies and private sector and finally the individuals with their collective efforts and action give shape to the various policies and strategies and finally translate them into actions.

8.1 Governmental bodies - With legally binding power and the strength to enforce decisions, have contributed towards taking forward Climate Action. Rajasthan Climate Change Agenda has been prepared to take forward the provisions of the NAPCC and to prepare detail action plan for adaptation and mitigation at the State level. Priority has been given to those activities in Rajasthan that meet a combined set of seven climate-proofing criteria, which can be verified through measurable indicators for ecological, economic and social sustainability: (i) Reduction and/or sequestration of greenhouse gases, (ii) biodiversity conservation and ecosystem functioning, (iii) enhancing the yield of livelihoods goods and services to local people, (iv) reduction in poverty and vulnerability, and improving the resilience and adaptive capacity, (v) local empowerment and capacity development, (vi) synergy with objectives of international instrument and conventions, and (vii) coherence with local strategies for sustainable development.

8.2 Civil society - constitutes non-governmental organizations, private citizens, informal groups, who organize debates, collect feedback from ground, inform government by making their voices heard and by swaying the public opinion in their favor. Through a multitude of actions and channels, these stakeholders have many times reoriented governments' priorities, funds and agendas. From international NGOs such as World Wide Fund for Nature ,India , ICRIER (Indian Council for Research on International Economic Relations)which works at the National Level, SEWA Mandir, Tarun Bharat Sangh their works cover almost all parts of Rajasthan to local level NGOs there are many organizations working towards addressing the climate change concerns, through inputs into policies, practical and inclusive implementable models.

8.3 Companies and the private sector - have been the vehicles of creating economic value in society. Supply chains that influence people to choose one set of goods over other, originate from these stakeholders, and the largest companies have the potential to transform entire industries in one decision. Consequently, they are also the ones to bear a larger part of the responsibility of climate change and pollution. Coca Cola through its

Corporate Social Responsibility efforts has contributed in water management in the Desert Areas of Rajasthan.

8.4 Individuals – the individuals hold the responsibility as consumers of goods and services and as actors whose actions have impact on Climate Change. Everyone is also a voter, a professional, a colleague, a member of all these previous bodies and arenas. In the end, all social structures – from family to company to government – are made up of individuals, where made by individuals, and only exist because enough individuals believe in climate change as an issue and the need to act upon it whether as a member of an NGO, part of a Private Company or Government Department.

Rajasthan (India) is famous worldwide for its architectural heritage and highly evolved urbanism, created in harsh climatic and territorial conditions. Most of the urban settlements that developed here, (from the 12th to the 19th century) are undisputedly regarded as ecologically sensitive and climatically responsive examples of urban planning and design. The population here is traditionally accustomed to water scarcity, deep, and difficult to draw, ground resources and a highly erratic and sparse rainfall regime. The towns here owed their sustainability largely due to the strength of a culture that ensured that the people and governance systems gave due importance and priority towards the development, maintenance, and management of water structures created alongside, and in harmony with the towns themselves. The respect for water was ingrained in the individual and collective psyche of the local population. Water harvesting, collection, storage, conservation, and its frugal and careful use began at the individual or household level and social as also religious norms and traditions exercised strict control on its judicious use as a common resource at the larger settlement level-be it urban or rural. Urban settlements here developed fairly complex and sophisticated systems to deal with issues of scarce water. This traditional wisdom is he resource which an individual or group of individuals possess which needs to be taken forward to address climate concerns today.

9. Conclusion: -

Rajasthan has the maximum vulnerability and lowest adaptive capacity to climate change challenges. Therefore, it is necessary to mitigate the impact of climate change in arid

Rajasthan with the help of various stakeholders such as Government bodies, Civil societies, Companies, Private sectors, and Individuals.

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