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Impact of Climate Change on the Thar Desert Ecology and Environment in Bikaner District, Rajasthan, India

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Abstract

The Great Indian Thar Desert, located in the northwestern region of India, is one of the largest arid ecosystems in the world. Climate change has emerged as a significant environmental challenge, affecting various ecosystems globally, including desert environments. This paper focuses on the impact of climate change on the Thar Desert and its prominent city, Bikaner. The rising temperatures in the Thar Desert and Bikaner have led to enhanced evaporation rates, resulting in increased aridity. As a consequence, water scarcity becomes more prevalent, affecting human populations, livestock and wildlife. The reduction in water availability poses challenges to agriculture, livelihoods, and overall water security. Bikaner and surrounding areas are witnessing a rise in heatwaves, dust storms, and droughts, which have severe implications for human health, infrastructure, and the overall economy of the region. Solar energy projects are being implemented in the Thar Desert to harness renewable energy. However, the large-scale installation of solar plants can lead to habitat fragmentation, land use changes, and potential disturbance to local flora and fauna. Habitat Destruction and Trees Cutting: Deforestation, habitat destruction, and unsustainable land use practices lead to the loss of vegetation cover and degradation of the desert ecosystem. Changes in land use patterns can disrupt traditional agricultural systems and exacerbate the vulnerability of local communities to climate change. Carbon Emission: The combustion of fossil fuels, industrial processes, and deforestation contribute to the release of carbon dioxide and other GHGs into the atmosphere. These emissions enhance the greenhouse effect, leading to global warming and climate change. Addressing these causes of climate change requires a combination of mitigation measures, such as transitioning to renewable energy sources, sustainable land management practices, afforestation, and reducing carbon emissions. Additionally, adaptation strategies, including water conservation, resilient

agriculture, and sustainable urban planning, are crucial for building resilience in the desert environment of the Thar Desert and Bikaner.

Keywords: Climate Change, Thar Desert, Desert Ecological, Solar Plants, Global Warming, Flora and Fauna

Introduction

Scientific research throughout the past decades has demonstrated how climatic changes have great impacts on livelihood of people around the world. For most of developing countries their level of structural and social vulnerability, are a dangerous combination and a formula for impacts of higher magnitude. Therefore, climatic phenomenon such as tropical storms, floods and droughts, more often becomes tragedies in these countries. The impacts of such phenomenon in the human development across the world are important to understand. Some of the climate change related issues analyzed droughts and water security, tropical cyclones and storms, rising tides, warming areas, coral bleaching, fish stocks, melting glaciers, heat waves and cold spells and the impact on human health, with the differentiated impact on countries in various levels of human development (Anders and Post 2006; Carvajal, 2007). Coasts are highly vulnerable to extreme events, such as storms which impose substantial costs on coastal societies. Tropical cyclones have major economic, Social and environmental consequences for coastal areas. The most exposed countries have densely populated coastal areas, often comprising deltas and mega deltas (China, India, the Philippines, Japan and Bangladesh) (UNDP, 2004). Annually, about 120 million people are exposed to tropical cyclone hazards which had killed more than 270,000 people from 1980 to 2006 (Carvajal, 2007). Similarly studies have shown that these changing climate trends had a negative impact on Indian agriculture. It is identified that the combination of increases in CO_2 concentration, in conjunction with changes in rainfall and temperature, were likely to have significant impacts on grasslands and rangelands, with production increases in humid temperate grasslands, but decreases in arid and semiarid regions (Parry, *et al.* 2007). It appears that some areas of the most populated regions on Earth such as Asia are likely to 'run out of water' during the dry season, if the current warming and glacial melting trends continue for several more decades (Barnett, *et al.* 2005). As the scientific consensus grows that significant climate change, in particular increased temperatures and precipitation, is very likely to occur over the 21st century. Economic research has attempted to quantify the possible impacts of

climate change on society (Christensen and Hewitson, 2007). The regions which are scarce on resources are among the very vulnerable systems of the earth and most of such regions have existing extreme climatic conditions like deserts and snow covered areas (Watson, *et al.* 1996; Ribot, 1996). Droughts, desertification, and water shortages are permanent features of life in dry lands and under such conditions the increase in evapotranspiration has severe impact on agriculture, horticulture and forestry and human activities (Sharma *et al.* 2006; Sen and Singh, 2002). The ongoing global extinction of biodiversity and natural resources has spurred countries with intact natural areas to set aside land to protect their natural capital and prevent further loss. Although human activities undoubtedly jeopardize biodiversity within some protected areas, but the large-scale climate change can regulate biodiversity and natural resources, even within protected areas with no human encroachment. Over a broad region including India, El Niño events trigger heavy rainfall, which can cause bottom-up increase in plant productivity following rain may trigger population increases in herbivores and subsequently carnivores, and La Niña events trigger monsoon failure, which can cause resource limitation, population crashes, loss of genetic diversity and even extinction (Chhangani, 2010 and Hall, *et al.* 2011). India is one of the mega diversity country of the world, with its unique landscapes, distinct geographical entity. Thar Desert is one such region with diverse characteristics on which effects of climate change have been quite revealing. In principle, ENSO (El Niño Southern Oscillation) indices can be used to forecast ecological effects, including population crashes, within protected areas. Lacking data on their activities, we simply cannot evaluate the relative contribution of the drought's direct (e.g. reduced plant growth) vs. indirect impacts (e.g. increased grazing pressure). The potentially complex ways in which multiple factors presumably combined and interacted to produce the observed crash and rebound of the mammal community (Wait, *et al.* 2007a). While any attempt to understand population dynamics should consider the role of climate, human activities sometimes buffer vertebrate populations against climatic vagaries, even protecting them against catastrophic die-off during drought (Waite *et al.* 2007b). The present study is therefore proposed to examine the impact of climate change and ENSO on the wild animals, biodiversity, livestock, agriculture, human health, land use pattern, etc. in Bikaner district of Thar Desert.

Material and Methodology

Study Area

Bikaner is situated in the North-Western part of Rajasthan which is a central part of Great Indian Desert. Its geographical location is 27°11' to 29°3' North and 71°54' to 74°12' East. It is bounded in north by Ganganagar District, east by Hanumangarh and Churu Districts, south by Nagaur and Jodhpur Districts and in the west by Jaisalmer District and shares 168 km International border with Pakistan. The geographical area of the district is 30247 Sq.km. which is about 8.8 % of the state's total area and possess second place after Jaisalmer. It is divided in the eight subdivisions: Bikaner, Lunkaransar, Kolayat, Nokha, Khajuwala, Pugal, Chhatargarh & Dungargarh. Bikaner is in the middle of the Thar desert and has a hot desertic climate (Köppen climate classification BWh) with extreme temperature and low rainfall. The annual rainfall of Bikaner is 290.6 m.m. and the rainfall varies from 260–440 millimetres (10–17 inches). During the summer months of March to June the temperature is on a continuous rise. May and first half of June being the hottest months of the year. The maximum temperature in May & June rises up to 50º C. In the second half of June, normally pre-monsoon showers start which bring down the temperature by 0º C to 50º C. After withdrawal of monsoon by the end of second week of September, days remain hot. The nights become progressively cooler. After mid-November both day and night temperatures drop. During the winters, January is the coldest month. Winds are generally light to moderate. During the pre-monsoon period the north-westerly winds are comparatively strong with occasional dust storms. The north-easterly winds during winters are mild. In the summer season hot winds blow from the direction between SW and NW, and are known as 'loo' & have a desiccating effect. Thunder storms occur during the period from May to September. Hail may also associate thunder storms during the months from February to May. During the hot season, dust storms are also not uncommon. During the month from January to March low pressure waves moving from the west affect the area when the situation of 'cold waves' develop. Droughts are common occurrence in the region. During the drought period there is an acute shortage of fodder inside and outside the core as well as the buffer areas. All the water holes tend to dry up very early and water becomes a limiting factor. It leads to severe conflict between forest staff and the villagers for the use of whatever fodder that is available inside the reserve. During the drought periods, the survival of wild life is at stake.

Methodology

Rajasthan is the largest State of India, having an area of 3, 42,239 sq. km, forming eastern extremity of great arid and semi-arid belt of the World. More than 50 % part of Rajasthan State comes under desertic zone, called "Great Indian Desert". The Great Indian Desert or the Thar Desert is the eastern limit of the Sahara-Arabian desert and extends over 1.3 million sq. km between 22°30' N and 32°05' N and 68°05' E and 75°45' E in India and Pakistan. It is the most populous desert of the World and earlier known as "Thar Parker Desert", based on the name of a district of Sind Province, now in Pakistan. In India, it extends over 2,85,680 sq. km, of which Rajasthan covers 1,96,150 sq. km, Gujarat 62,180 sq. km, Punjab and Haryana 27,350 sq. km. The various data and information for the proposed study will be collected by following methods:

1. The local climate data like rainfall, temperature, humidity and wind velocity for the present study will be collected from the Meteorology Department, Bikaner and Jaipur. During study the climate data will also be collected by the GPRS station of MGSU, Bikaner.
2. For Global Climate data an index of El Niño Southern Oscillation (ENSO), the most important oceanic-atmospheric driver of year-to-year variability in global climate, as a predictor of population dynamics. Specifically, Multivariate ENSO Index (MEI) (available at: http://www.cdc.noaa.gov/people/klaus.wolter/MEI/mei.html#ref_wt1) which is based on six variables observed over the tropical Pacific: sea-level pressure, zonal and meridional components of surface wind, sea surface temperature, surface air temperature, and total fractional cloudiness.
3. Wildlife data will be collected from the State Forest Department census and direct observations in different parts of study area through line transect and point count method. This includes protected areas, different community lands and various agricultural fields.
4. An inventory of the flora (including trees, shrubs and grasses) and fauna (including mammals, birds and reptiles) in the study area after confirmation (with Bhandari, 1990; Kazmierczak, 2000; Daneal, 2002, Prater, 1980 and Menon, 2014).
5. The agriculture and horticulture production, livestock production and human health data will be collected from Directorate of Economics and Statistics Government of Rajasthan, Jaipur and State Agriculture, Animal Husbandry and Health Department of Government of Rajasthan as well as by direct observation and records during field studies.

6. Impact of the anthropogenic human activates like, mining, tree cutting, renewable energy, developmental activities, etc. on the Desert environment and climate.

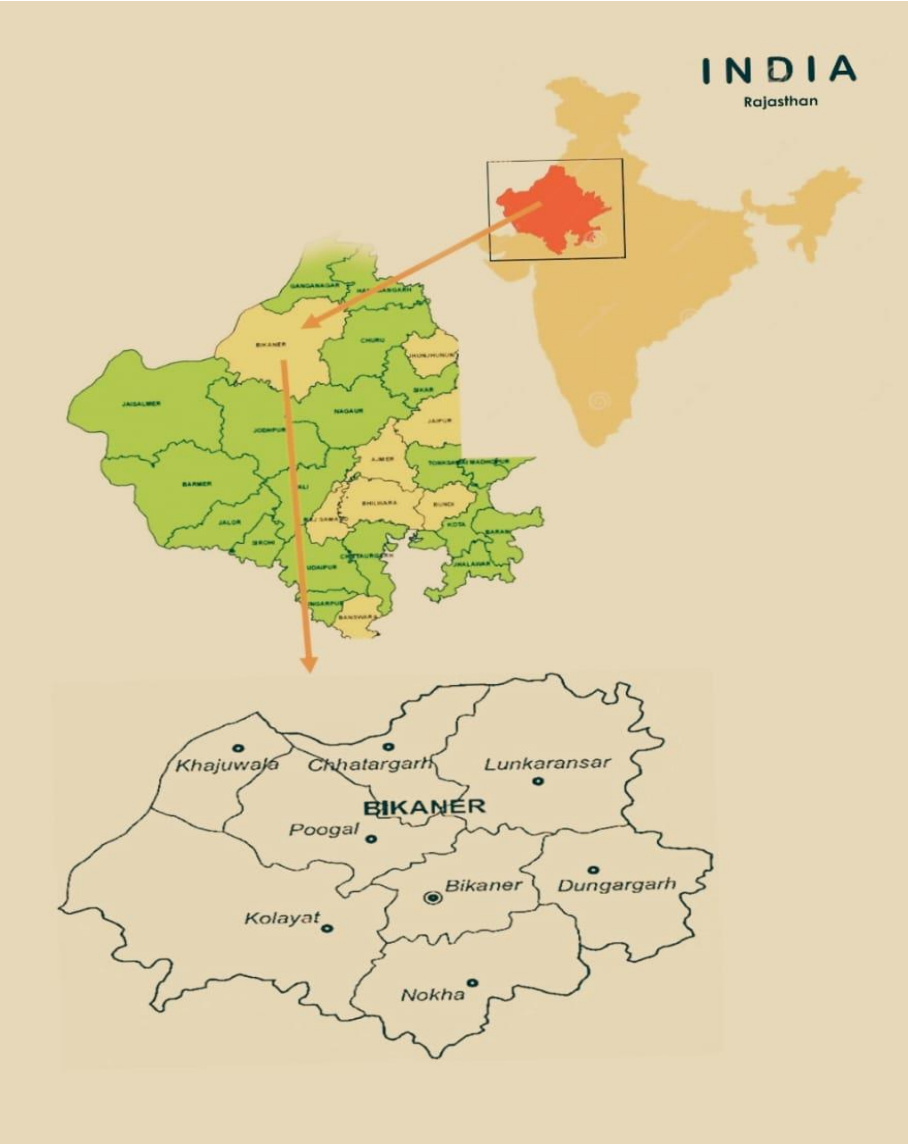

Figure 1: Location of the study area in Bikaner, Rajasthan.

Observations and Results

The Great Indian Thar Desert, located in the northwestern region of India, is one of the largest arid ecosystems in the world. Climate change has emerged as a significant environmental

challenge, affecting various ecosystems globally, including desert environments. This abstract focuses on the impact of climate change on the Thar Desert and its prominent city, Bikaner. The rising temperatures in the Thar Desert and Bikaner have led to enhanced evaporation rates, resulting in increased aridity. As a consequence, water scarcity becomes more prevalent, affecting human populations, livestock and wildlife. The reduction in water availability poses challenges to agriculture, livelihoods, and overall water security. The Thar Desert and Bikaner face numerous environmental and socio-economic consequences as a result of climate change. Rising temperatures, altered precipitation patterns, and increasing frequency of extreme weather events are some of the key manifestations of climate change in this region. Another significant impact of climate change is the increased frequency and intensity of extreme weather events. Bikaner and surrounding areas are witnessing a rise in heatwaves, dust storms, and droughts, which have severe implications for human health, infrastructure, and the overall economy of the region. Solar energy projects are being implemented in the Thar Desert to harness renewable energy. However, the large-scale installation of solar plants can lead to habitat fragmentation, land use changes, and potential disturbance to local flora and fauna. Habitat Destruction and Trees Cutting: Deforestation, habitat destruction, and unsustainable land use practices lead to the loss of vegetation cover and degradation of the desert ecosystem. This not only reduces carbon sequestration but also contributes to soil erosion, desertification, and loss of habitat for native species. Change in Agriculture Land Use Pattern: Shifts in agricultural practices, such as increased irrigation and monoculture farming, impact the water balance and soil fertility in the region. Changes in land use patterns can disrupt traditional agricultural systems and exacerbate the vulnerability of local communities to climate change. Carbon Emission: The combustion of fossil fuels, industrial processes, and deforestation contribute to the release of carbon dioxide (CO_2) and other GHGs into the atmosphere. These emissions enhance the greenhouse effect, leading to global warming and climate change. Vehicular Pollution: Increasing vehicular traffic and emissions from transportation contribute to air pollution and the release of GHGs. Vehicular pollution adds to the overall carbon footprint and air quality degradation in the Thar Desert and Bikaner. Bricks Industry: The bricks industry, prevalent in the region for construction purposes, often relies on inefficient and polluting techniques. Additionally, adaptation strategies, including

water conservation, resilient agriculture, and sustainable urban planning, are crucial for building resilience in the desert environment of the Thar Desert and Bikaner.

Status of The Floral And Faunal Diversity

It's fascinating to learn that a total of 150 plant species were recorded in the study area, with 27 being trees, 20 shrubs, 92 grasses, and 12 climbers. Additionally, exotic species like prosopis juliflora were also observed in various ecosystems. Considering the vegetation diversity, the study area appears to be rich in plant species, with 77 species of trees, shrubs, and grasses combined. This information is valuable for understanding the ecological dynamics of the Bikaner district and can be crucial for conservation efforts and sustainable land management. The faunal diversity in the Bikaner district is indeed quite rich and diverse, as indicated by the recorded number of species. Faunal diversity in the Bikaner district is recorded in a rich number viz. 34 species of mammals, 295 species of Avian and 28 species of reptiles. Many of the observed species of my research are listed in IUCN red data list and in schedule Ist as per Indian wild life act 1972, which implies that these species are granted legal protection due to their conservation significance. It clearly indicates a decisive role of protected areas and common property resources in sustaining faunal diversity of Thar desert. The presence of such a wide variety of mammals, birds, and reptiles signifies the ecological importance of the Bikaner district and its role in sustaining the faunal diversity of the Thar desert region. Protected area and Common property resources play a crucial role in supporting and maintaining this diverse array of wildlife. In the context of the Thar desert, common property resources might refer to natural habitats, water sources, grazing lands, and other ecological niches that are shared and utilized by various animal species in the region. We explore the implications of drought, for the viability of mammal populations in this protected area. Here we document that the wildlife in human landscape is buffered against climate change, compared to the wildlife in the protected areas in the arid region and vulture population decline in the various parts of the Thar Desert of Rajasthan, India.

Ker (*Capparis decidua*)

Kejdi (*Prosopis cineraria*)

Kumth (*Acacia Senegal*)

Jaal (*Salvadoraoleoides*)

Chinkara (*Gazella bennettii*)

Blue bull (*Boselaphustragocamelus*)

Plate 1: Trees and Mammals of the study area

Causes of Climate Change

Climate change is a complex phenomenon influenced by various factors. The primary driver of climate change is the increased concentration of greenhouse gases (GHGs) in the atmosphere. The most significant GHG is carbon dioxide (CO2), but others include methane (CH4), nitrous oxide (N2O), and fluorinated gases. These gases trap heat from the sun in the Earth's atmosphere, leading to the "greenhouse effect" and rising global temperatures. Fossil Fuel Combustion: Burning fossil fuels (coal, oil, and natural gas) for energy and transportation is a major source of carbon dioxide emissions. The combustion of these fuels releases large quantities of CO2 into the atmosphere, contributing significantly to global warming. Clearing forests for agriculture, urbanization, and other purposes reduces the number of trees that absorb CO2 from the atmosphere. Deforestation also releases stored carbon as trees are cut down or burned. Additionally, changes in land use patterns can disrupt natural ecosystems and alter carbon storage capacities. Industrial processes, such as cement production, chemical manufacturing, and certain agricultural practices (like rice paddies and livestock), release greenhouse gases like CO2, methane, and nitrous oxide. The growing global population and increasing levels of consumption have driven up the demand for energy, food, and other resources. Meeting these demands often involves energy-intensive processes and activities that emit GHGs. Methane is a potent greenhouse gas, and its sources include livestock digestion, rice paddies, landfills, and natural gas production and distribution. Permafrost Thawing: As the Earth's temperature rises, the frozen ground in Arctic regions (permafrost) begins to thaw, releasing significant amounts of methane and carbon dioxide stored in the frozen organic matter. Decomposition of organic waste in landfills and certain industrial activities produce methane emissions.

Impact of Climate Change

Some critical manifestations of climate change in the region, and extreme weather events are one of the most noticeable consequences. Rising temperatures lead to more frequent and prolonged heat waves, posing a significant threat to human health. Heat waves can cause heat-related illnesses and even fatalities, particularly among vulnerable populations such as the elderly, children, and those with pre-existing health conditions. Additionally, heat waves can strain

energy resources as the demand for cooling systems increases. The combination of higher temperatures and aridity in the Thar Desert and Bikaner region can lead to the formation of dust storms. These storms and cyclones can damage floral and faunal diversity, infrastructure, disrupt transportation, and create visibility issues, potentially leading to accidents and economic losses. Altered precipitation patterns and increased evaporation rates can result in prolonged droughts, exacerbating water scarcity and impacting agriculture, water resources, and livelihoods. Droughts can lead to crop failures, reduced food production, and economic hardships for rural communities. Extreme weather events, such as dust storms and heat waves, can damage infrastructure like roads, power lines, and buildings. This can lead to costly repairs and disruptions in essential services. The increased frequency and intensity of extreme weather events can have a significant economic impact on the region. Damage to infrastructure, loss of agricultural productivity, and increased healthcare costs can strain local economies and hinder development. Extreme weather events, particularly heatwaves, can have adverse effects on public health. Heat-related illnesses, respiratory problems due to dust storms, and waterborne diseases during droughts can become more prevalent, further burdening healthcare systems. Human activities undoubtedly jeopardize biodiversity within some protected areas, but the large-scale climate change can regulate biodiversity and natural resources, even within protected areas with no human encroachment. In some cases, the severity of climate-induced challenges may force people to migrate or be displaced from their homes. This can lead to social and economic disruptions, as well as create pressure on urban areas that receive climate-induced migrants.

Recommendations

Combining mitigation and adaptation strategies, the region can work towards reducing its vulnerability to the impacts of climate change while also contributing to global efforts to limit further warming. Collaboration between governments, communities, and organizations is key to effectively implementing these measures and ensuring a more sustainable and resilient future for the Thar Desert and Bikaner region. combining both mitigation and adaptation strategies, the region can work towards reducing its vulnerability to the impacts of climate change while also contributing to global efforts to limit further warming. Collaboration between governments, communities, and organizations is key to effectively implementing these measures and ensuring

a more sustainable and resilient future for the Thar Desert and Bikaner region. Joint efforts in addressing climate change in the Thar Desert and Bikaner region. Indeed, a collective approach involving governments, communities, and organizations is essential for effectively implementing mitigation and adaptation strategies. To mitigate climate change, it is crucial to reduce greenhouse gas emissions through various means like transitioning to renewable energy sources, promoting sustainable land management practices, preserving forests, improving energy efficiency, and adopting climate-friendly policies and technologies. Addressing these environmental and socio-economic consequences requires a multi-faceted approach. It involves implementing climate change mitigation strategies at both local and global levels to reduce greenhouse gas emissions. Additionally, adaptation measures such as water conservation, rainwater harvesting, and sustainable agricultural practices can help communities cope with the changing conditions. Collaboration between governments, NGOs, and local communities is essential to developing and implementing effective solutions to combat the challenges posed by climate change in the Thar Desert and Bikaner. The scenario you described highlights the serious consequences of climate change in the Thar Desert and Bikaner region. As temperatures rise and evaporation rates increase, the area becomes drier, leading to water scarcity. This, in turn, affects various aspects of life in the region.

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