



Water Related Disasters (Floods & Drought)

Implications for Health Adaptation & Resilience



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A Thematic Paper prepared under the HERCAP project supported by WHO India



National Institute of Disaster Management
(Ministry of Home Affairs, Government of India)



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National Institute of Disaster Management (NIDM)

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FOREWORD

India faces high exposure to climate-related disasters, and is one of the most vulnerable countries in the world to extreme weather events in the world. A land of such diverse topography and microclimates, it is exposed to a wide spectrum of climate risks. India's vulnerability is in part due to its sensitivity to a wide range of climate impacts including droughts, floods, storms, and extreme temperatures. Droughts occur less frequently, but impact the highest number of people in the country whereas floods are the most economically damaging climate impact, costing more than all other disaster events combined.



This paper focuses on understanding the vulnerability of India to two prominent climate extremes that India is affected by repeatedly: drought and floods and also presents growing threats to public health security. Vector-borne diseases such as Malaria, diarrhea, dengue and malnutrition are major public health problems. Any further increase, as projected in weather-related disasters and related health effects, may cripple the already inadequate public health infrastructure in the country.

Hence, there is an urgent need to respond to the situation. Response options to protect health from effects of climate change include mitigation, adaptation as well as preparedness, which can significantly reduce the risks of extreme weather events.



A handwritten signature in blue ink, appearing to read "MKB Bindal", followed by a solid horizontal line underneath.

(Manoj Kumar Bindal)





PREFACE

Climate change is a significant and emerging threat to public health. Hence, it is finding an increasingly central position on the international agenda as well.



Extreme weather events such as severe floods and drought have claimed thousands of lives during the last few years and have adversely affected the lives of millions and cost significantly in terms of economic losses and damage to property. Both floods and droughts increase the risk of vector-borne and food-borne diseases. Any increase in frequency and severity of these extreme climate events also leads to cause population displacement. These displaced people are also likely to face various health consequences like traumatic, infectious, nutritional, psychological, and others.

This thematic paper has been developed under the project “Health Adaptation and Resilience: Advancing Strategic Knowledge and Capacities” (HER-CAP) with the support of World Health Organization (WHO) India, describing the process of extreme weather events like floods and drought, its current and future impacts on human health and how we can reduce those adverse impacts by various mitigation and adaptation strategies.



(Prof. Anil K Gupta)

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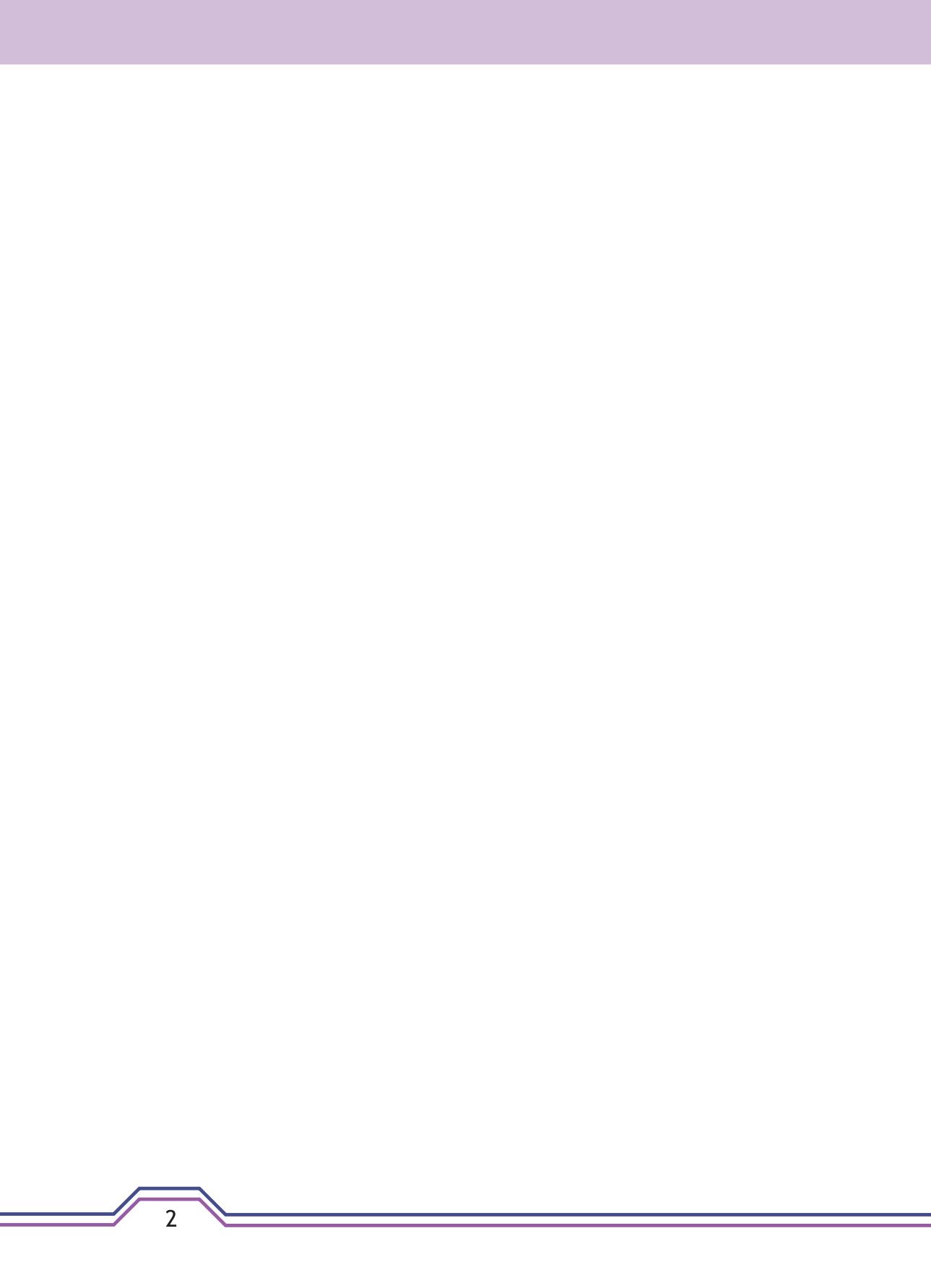
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Abstract

Floods and droughts are expected to increase with climate change and global warming. Many places across the globe, these are already taking place and the world is ill-prepared to respond to such disasters. In India, due to different climatic and rainfall patterns in different regions, some parts are suffering devastating floods, whereas, other parts are suffering drought at the same time. This paper explores the nature of water-related disasters, flood and drought, in several dimensions; provide an insight on the implications of such disasters on human health, healthcare resources and food security. It also discusses that there is a need to address knowledge and policy gaps, strengthen institutional coordination and participation, and implementation of new activities to prevent water related disasters as well as reduce their impact through post disaster management policies. Floods and Droughts are a common occurrence and their co-existence poses a potent threat to human and environment health, which may be eliminated but need to be managed.

Keywords: Climate Change; Disasters; Floods; Droughts, Health Resilience; Water-borne Disease; Vector-borne Disease



1. Introduction

Water is indispensable for every living organism. Nevertheless, in some situations water may produce undesirable impacts on human beings or the environment and even pose a threat to life (Grayman, 2011). When these impacts rise to some high undefined level we designate the event as a disaster. Likewise, water-related disasters may rise primarily as a result of surplus water such as floods, flashfloods, and dam - failure or by scanty water leading to droughts, difficulties in public supply of potable water, impacts on agriculture or industries. Changing climate and global warming are expected to result in increased frequency and intensity of floods and drought. The increase of these events is already evident in many places across the globe, where majority of states are still ill-prepared to respond and manage them (Water and Disaster Risk, 2015). Figure 1 and Figure 2 represents the number of droughts and floods affected countries across the globe.

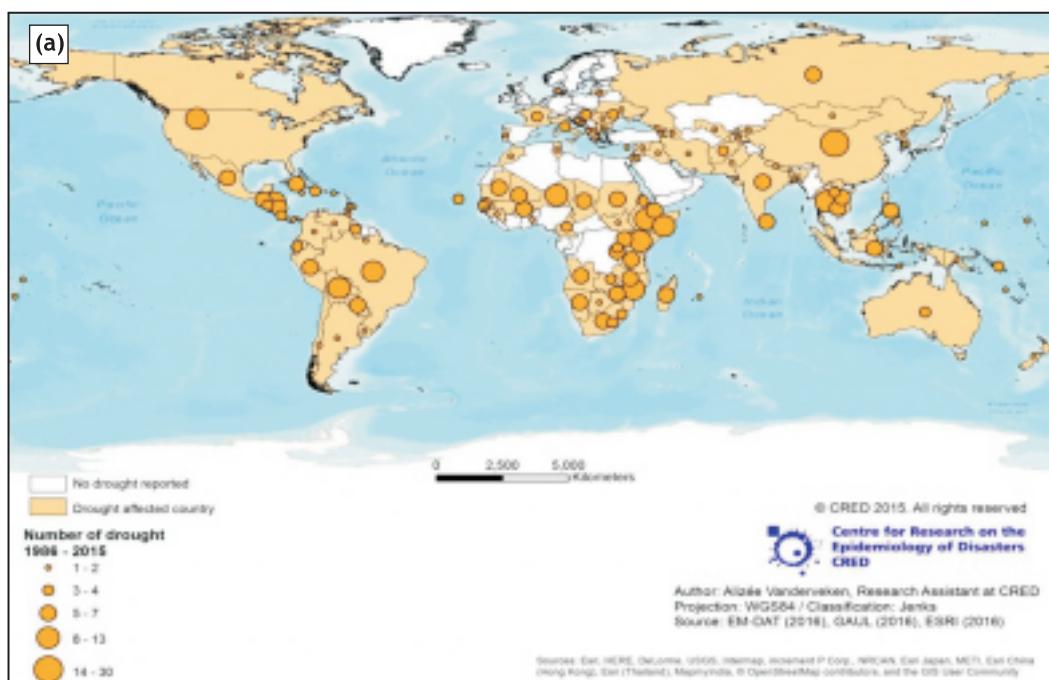


Figure 1 Drought affected countries across the globe
(Source: CRED 2015)

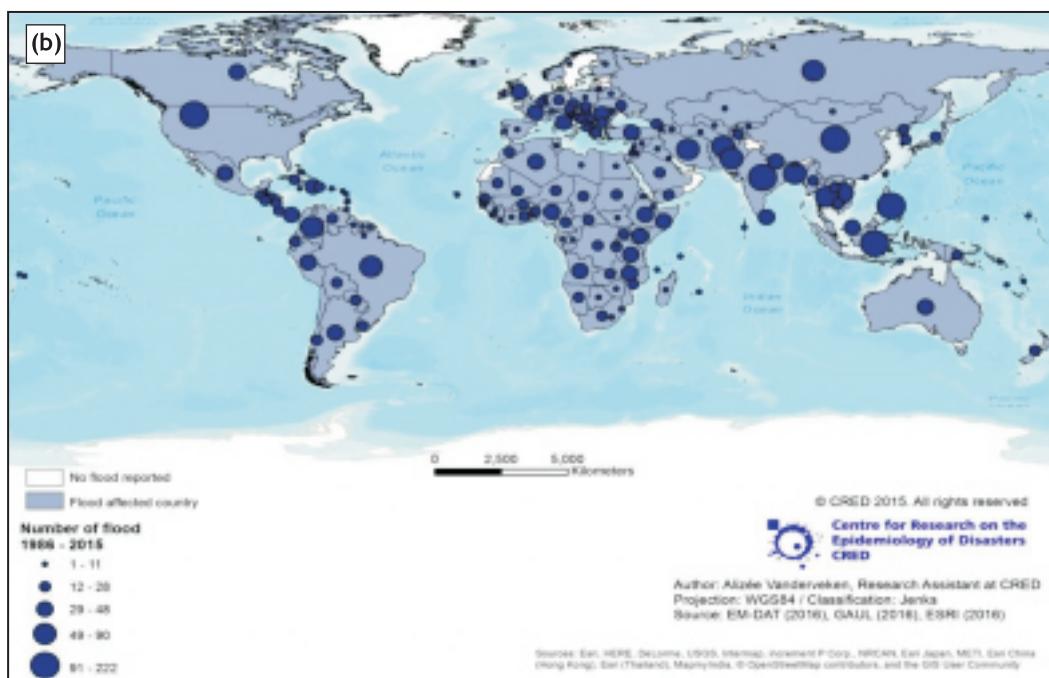


Figure 2 Flood affected countries across the globe
(Source: CRED 2015)

During the last several decades, disasters have not only killed millions of people but they have adversely affected the lives of many. The damaging impacts of a disaster ripple much longer after the actual event as many people end up losing their closed ones, their homes, livelihoods and need to live in rehabilitation camps for longer period of time; the transportation infrastructure gets damaged and there is inadequacy of healthcare services and resources etc. All these are key issues which results in economic problems and severe health-related issues in disaster - stricken areas (Armstrong, 2017).

India is a developing country and prone to a number of natural hazards owing to its geographical spread. Water disasters in India are on a rise due to global warming, reckless and unplanned urbanization, and environmental and ecosystem degradation (Chandrashekhar, 2019). India added 90 million people to its urban population between 2001 and 2011, and will add another 416 million more by the year 2050 as per UN report. Concretization of cities especially taking over the greens has restricted the flow of rain water into the ground due to permeable soil

being replaced by impervious surfaces. Furthermore, mushrooming Indian cities have been building on the wetlands and expanding into the vulnerable floodplains and marshy areas along with the process of urbanization itself affecting the rainfall patterns. This will cause a rise in flash floods resulting in large scale landslides and loss of agriculture area affecting overall food security (Down to Earth, 2019).

The purpose of this paper is to explore the nature of water-related disasters, categorize water-related disasters, floods and droughts, in several dimensions, provide insights on the implications of such disasters on human health, healthcare resources and food security. It also discusses that there is a need to address knowledge and policy gaps, strengthen institutional coordination and participation, and implementation of new activities to prevent water related disasters as well as reduce their impact through post disaster management policies.

In India, two of the major disasters faced are floods and droughts, which are discussed in the succeeding paragraphs.

1.1 Flood: Situation of surplus water

Global rainfall data for over the last century shows an alarming trend. The numbers of rainy days are decreasing while intense rainfall events of 10-15 cm per day are increasing. This means that more amount of water is pouring down in lesser time. For example, globally, 50 percent of annual precipitation (rain, snow and ice) was received in just 11 days(Down to Earth, 2019).Global disaster epidemiological pattern shows that Asia has the highest frequency of natural disaster occurrences in floods, cyclones and earthquakes(Chan et al. 2019).Floods alone accounts for 50percent of all weather-related disasters. The frequency of extreme floods is on the rise in Bangladesh, India and Pakistan. Past extreme floods fall within the range of climate variability but frequency, magnitude and extent flooding has certainly increased in South Asia due to climate change (Mirza 2011).

India, being a peninsular country, and surrounded by the Bay of Bengal, the Arabian Sea and Indian Ocean, is quite prone to flood. Every year, the flood causes immense loss to the nation's infrastructure, agricultural activities and lives. The major flood prone regions in India are Uttar Pradesh, Bihar, Punjab, Rajasthan,

Assam, West Bengal, Haryana, Orissa, Andhra Pradesh, Gujarat and Kerala (Figure 3). During the first week of September 2014, the Kashmir region witnessed disastrous floods across the majority of its districts caused by torrential rainfall across the Indian administrated Jammu and Kashmir (Mishra, 2015; Ray et al. 2015).



Figure 3 Flood prone areas of India (Source: BMTPC, India, 2020)

Kerala Flood, 2018

In relation to flooding, the main risk relates to the water may be contaminated with raw sewage, animal waste and other hazardous or industrial toxic substances. Early symptoms from exposure to contaminated flood water may include diarrhea, dysentery, intestinal problems, headache and other flu-like discomfort. In year 2018, due to unusually high rainfall (116% more than the usual rainfall) during the monsoon season, Kerala state experienced the severe flood in 13 districts, which affected millions of people and caused more than 400 deaths. According to the India Meteorological Department (IMD), there was 2346.3 mm of rainfall, instead of an average 1649.55 mm. One sixth of the total population of Kerala had been directly affected by the floods. A few days after receiving one of the highest rainfalls, Kerala was caught under the threat of severe drought. Water level in wells, ponds and rivers had recorded lowest levels and some wells even collapsed. The water level in wells, especially in high ranges of Idukki district had come down by 20 feet in merely 15 days. With the water receding in many parts of Kerala, residents started facing the drinking water crisis due to contamination of wells and damage to pumping stations in the flood-hit areas. Drinking water scarcity was also reported in many other districts of Kerala. An NGO, People for Animals, estimated that around 40,000 animals such as dogs, rats, and cows died in the floods. Their bodies contaminated the water, thus increased the risk of leptospirosis (rat fever), cholera, typhoid, diarrhea, and hepatitis among others. Cases of leptospirosis had been reported in at least five of the thirteen flood-hit districts.

1.2 Drought: Situation of scanty water

Drought is likely to become more destructive, frequent and severe in many parts of the world due to the changing climate with growing risks of wildfires, or extreme precipitation and their consequent impact on agricultural production, food prices and food security. Drought conditions usually remain undetected until water scarcities become severe and have adverse impacts on environment and society. The impact of droughts may be affected by adaptive buffers like water storage, land and ecological conditions or can continue long after precipitation has returned to normal such as owing to groundwater, soil moisture or reservoir

deficits etc. The gradually developing nature and long duration of drought, together with a large variability of impacts beyond direct and visible agricultural losses, typically make the task of quantifying drought impact challenging (MIDIMAR, 2015).

Drought has been recognized as a complex hazard owing to its slow-onset characteristic with widespread risk and cascading impacts often accumulating slowly over an extended period. Drought effects are non-structural and can spread over large geographic areas and temporal scales with impacts moving more strongly the secondary effects like lost livelihoods, forced migration, top soil and nutrient erosion than in the primary effects. Although droughts have no damage to structures, however, their economic cost in direct and indirect terms could be devastating.

Wildfires of Australia, 2019-20

Australia has been dealing with the consequences of a warming planet. Since 1910, the average temperature for the country has warmed by 1.0 °C. Preliminary data from Australia's Bureau of Meteorology (BoM), suggests that in 2019, the annual temperature in that country was 1.52 °C above average. The duration, frequency and intensity of heat waves have increased across large parts of Australia since 1950. The country has been experiencing extreme fire weather, and a longer fire season, across large parts of Australia since the 1970s. In Eastern Australia, the fires are the worst with lowest rainfall on record. New South Wales alone has been the driest on record with rainfall 36 percent below the 1961-1990 average, according to Australia's weather and climate agency.

Many parts of Australia have been in prolonged drought conditions, some for years, which made it easier for the fires to spread and become more frequent and more intense especially in hotter and drier climate. One of Australia's worst fires, known as Black Saturday in 2009 killed 173 people in Victoria, injured 414 and killed more than a million animals, both wild and domesticated. The recent bushfires in Australia burned over 18 million hectares in the Australian bushfire season 2019-2020 as of mid-January destroying over 5,900 buildings including over 2,800 homes and resulting in human fatalities and killing many millions of animals, insects, birds directly through loss of habitat and food sources. The wildfire had not just physical impact but economic as well with impact extending to industries such as farming and tourism with some businesses and institutions being forced to close down during periods of excessive levels of air pollution.

Fire induced intense smoke and air pollution resulted in Canberra measuring the worst air quality index of any major city in the world. Wildfires produce harmful smoke and fine particle air pollution which can cause fatalities and threaten human health. It poses a health risk as it contains a mixture of hazardous gases and particles that can irritate the eyes and the respiratory system. Exposure to particulate matter is the main public health threat from short-term exposure to wildfire smoke. Not only this, many people across affected communities experience lasting mental health impacts and mental stress owing to lose homes, livelihood sources, pets, belongings, livestock etc. Some were forced to seek safety in temporary shelters, on beaches and on boats while witnessing unprecedented firestorms.

Drought: Gujarat, 2012

The probability of drought-related health impacts varies widely and largely depends upon drought severity, baseline population vulnerability, existing health and sanitation infrastructure, and available resources with which to mitigate impacts as they occur. The socio-economic environment in which drought occurs influences the resilience of the affected population. For instance, in 2002, 13 districts of Gujarat received less than normal rainfall which resulted in reduction in the agriculture production and also slowed down the small and medium industries affecting crop production, employment opportunities, hydropower projects etc. There was some improvement in August and September but the large deficit could not be made up. The inadequate rainfall had a severe impact on drinking water situation and 83 talukas were facing drinking water problem. Even the level in the water reservoirs of Saurashtra, Kutch, and North Gujarat was almost zero.

Almost all villages in the region were facing acute drinking water crisis in the Kutch region and the situation of coastal areas in the district of Junagarh was critical due to non availability of surface water as well as ground water. In this condition, children and women were the worst sufferers from the point of view of their nutritional level and basic food requirements. The expecting, and lactating mothers were the worst sufferers and so were the aged and children. It was reported that 6436 pregnant women and children were directly affected by the drought in Gujarat. The farmers and traditional artisans dependent on agriculture, suffered due to reduced employment opportunities in regular work. Consequently, people either became jobless or transferred to marginal works. Hence, 16 lakh workers were without employment for a period of eight months. It affected the economy of the State and development.

As per the Drought Early Warning System (DEWS), a real-time drought monitoring platform, about 42% of India's land area is facing drought, with 6% exceptionally dry-four times the spatial extent of drought. States of Andhra Pradesh, Bihar, Gujarat, Jharkhand, Karnataka, Maharashtra, parts of the North-East, Rajasthan, Tamil Nadu and Telangana are the worst hit. These states are home to 500 million people, almost 40% of the country's population. Lesser rainfall has reduced water

levels in reservoirs across the country (Gogoi & Tripathi, 2019). Figure 4 shows the drought prone areas of India.



Figure 4 Drought prone areas of India (Source: NROER 2020)

2. Climatic impacts and public health challenges

Changing climate between 2002 and 2011 and consequent rise in disaster risks has resulted in urban population getting more exposed to harmful events (IPCC, 2012) over time such as intense floods, storms, cyclones and droughts. Impacts induced by such disasters are on a rise affecting people all across the globe (Gaillard and Texier, 2010). In particular, droughts threaten human security by undermining livelihoods, compromising culture and individual identity, and increasing migration. Impact of droughts can be classified as direct or indirect (UNISDR, 2013). Examples of direct impacts include limited public water supplies, crop loss and damage to buildings due to terrain subsidence and reduced energy production. Because of the dependence of livelihoods and economic sectors on water, most drought impacts are indirect. These indirect effects can propagate quickly through the economic system, including trade, affecting regions far from where the drought originates. Indirect impacts may affect ecosystems and biodiversity, human health, commercial shipping and forestry. In extreme cases, drought may result in temporary or permanent unemployment or even business interruption, and lead to malnutrition and diseases in more vulnerable population in affected countries.

The most apparent and immediate public health concern with a disaster or an emergency situation is always the scarcity of adequate number of medical representatives, health functionaries and resources. The particular concern is the access to health services, drugs and dialysis which get affected in disasters. Those who are forced to evacuate their homes often struggle to acquire medications especially patients with chronic conditions. Lack of access to medications force already oversaturated hospital emergency departments to treat and manage complications of chronic illnesses like diabetes, hypertension, chronic kidney disease, chronic obstructive pulmonary disease and asthma. Other common causes of death during flood include electrocution, heart attacks, hypothermia, trauma and human encounter with venomous snake bites, fire ants and stinging insects flooded out of their nests.

3. Implications of water-related disasters for human health and food security

Climate change alters the frequency and intensity of rainfall resulting in floods and droughts, causing significant impacts on health, livelihood, agriculture, food production etc. The health of human population is sensitive to shifts in weather patterns and other aspects of climate change such as changes in temperature, precipitation, heat-waves and droughts. Human health may be affected indirectly by ecological disruptions related to climate change (e.g. crop failures or shifting patterns of disease vectors) or by social responses to climate change (e.g. displacement of following prolonged drought) and the elderly face disproportional physical harm from heat stress and drought.

3.1 Water-borne and water-related diseases

Climate change adversely affects availability and quality of drinking water, and the performance of sanitation, wastewater and hygiene services. Both flood and drought may limit sanitary practices such as hand and face washing (increasing transmission of certain diseases) or result in the use of unsafe contaminated/polluted water causing increase in a range of ailments. Droughts often trigger and exacerbate malnutrition and famine, in times of inadequate water supply. One of the primary impacts of droughts is the intensification of the use of poorly treated wastewater for peri-urban agriculture causing ill-health and deaths. Drought impacts may possibly include arsenic poisoning and fluorosis, if alternative problem sources are returned to service to maintain supply during drought periods.

Floods have an increasing impact with the spread of communicable diseases, many of which are waterborne presenting a major burden to vulnerable populations across the globe. As an example, more-frequent combined sewer overflows can flood and pollute low-lying densely populated areas such as marshy areas, floodplains and receiving waters, resulting in increase in waterborne diseases, such as Typhoid Fever, Cholera, Leptospirosis and Hepatitis-A(diarrheal disease outbreaks) through pollution/contamination of drinking water sources and increases in vector-borne diseases, such as malaria, dengue and Japanese encephalitis. The risk for diarrheal disease outbreaks following natural disasters is

higher in the developing countries than in the developed countries. Epidemics among victims are usually related to polluted or contaminated water resources during transportation and storage. Disease outbreaks have also been related to shared water containers, contaminated food, cooking pots, scarcity of soaps and poor sanitary infrastructures, safe water supply and sewerage systems (Asian Development Bank, 2015).

3.2 Vector-borne diseases

Flooding affects vector-breeding sites and transmission of vector-borne disease. While initial flooding may wash away existing mosquito-breeding sites whereas standing water can produce new breeding sites resulting in an intensification of vector population and potential for disease transmission, subject to the local mosquito vector species and its preferred habitat. Risk factors for vector-borne disease transmission include the crowding of infected and susceptible hosts, a weakened public health infrastructure, and interruptions of ongoing vector control programs (UN Water, Trans boundary Waters, 2008; UN Water Policy Brief, 2019).

Malaria and dengue outbreaks in the wake of flooding are a well-known phenomenon. Dengue transmission is not directly associated with flooding but influenced by meteorological conditions, including rainfall and humidity. Such events may coincide with periods of high risk for transmission and may be exacerbated by increased availability of the vector's breeding sites caused by disruption of basic water supply and solid waste disposal services. The risk for outbreaks can be influenced by other factors, such as changes in human behavior (increased exposure to mosquitoes while sleeping in open, movement from dengue from non-endemic to endemic areas, overcrowding) or changes in the habitat that encourage mosquito breeding.

3.3 Communicable diseases associated with migration

Crowding is common in populations displaced by disasters and emergency situations. Crowded living conditions facilitate transmission of measles, meningitis, respiratory infections, skin infections and necessitate even higher immunization coverage levels to prevent outbreaks. For example, the risks for transmission after a natural disaster are dependent on baseline immunization coverage among the affected population, and in particular among children less

than 15 years of age. Acute respiratory infections (ARI) are a major cause of illness and death among displaced populations, particularly in children less than 5 years of age. Lack of access to health services and to anti-microbial agents for treatment further increases the risk for death from ARI.

Skin diseases are also common in overcrowded shelter and camps. Risk factors among displaced persons include exposure to indoor cooking using open flame, and poor nutrition. Lack of privacy which is another risk factor for depression and anxiety is quite common among people in overcrowded places. The financial implications of disaster conditions caused by loss of livelihoods, assets etc. can have adverse effects such as psychosocial disorders in people who depend on rainfall for economic survival. One partner in a family may have to migrate to more remote areas in search of a job or to find a new source of income to meet the family's needs, often generating more anxiety, stress and depression.

In some cases, mass movement of people spurred by long-standing drought and food shortages can lead to over-crowding and poor hygiene. Over-crowding can easily lead to an increase in the transmission rates of communicable diseases such as tuberculosis or gastro- intestinal infections. For example, the caravan of asylum seekers moving north through Central America in the later part of 2018 were forced by historic drought conditions over multiple years, exacerbated by climate-induced shifts in weather patterns to move. Absence of shift in human behavior policy or infrastructure development was an underlying risk driver. When people migrate from disease-free areas to endemic regions, they typically lack immunity, making them susceptible to infection and transmission of the disease, resulting in cases in excess of normal expectancy. The risk may also change when emergencies such as droughts, floods, earthquakes and conflicts arise, exacerbate the conditions favorable for disease transmission and causing population displacement. Old diseases such as plague and cholera continue to reappear, and new ones invariably emerge to join them.

3.4 Disaster-related interruption of services

Power cuts related to disasters may disrupt water treatment and supply plants, thereby increasing the risk for waterborne diseases. Lack of power may also affect proper functioning of health facilities, including preservation of the vaccine cold chain, and other important laboratory reagents for diagnostics.

3.5 Water stress, food & nutrition

Drought and water stress respond to several factors, including precipitation and evaporation (which is a function of temperature, isolation, humidity, and wind), and land use and management, which affect land cover and infiltration. With the changing climate, both precipitation and temperature are projected to increase, indicating that water stress and drought will become worse in days to come. Drought will increase competition for water from growing demands and will also result in rise of the entrainment of dust and fine particulate matter in the air, causing many human health impacts, particularly for children and the elderly.

Drought has significant implications for hunger and malnutrition as mortality may increase sharply due to protein deficiency (Kwashiorkor) or calorie deficiency (Marasmus). Certain vitamin deficiencies, such as a lack of Vitamin A, can lead to specific consequences such as xerophthalmia and child blindness. Long standing malnutrition can easily lead to increased rates of disease and mortality, and limit the general population's functionality. In 2017, in Afghanistan, a drought that caused scarcities of water and food exacerbated already high malnutrition rates among children, and pregnant and lactating women (UNICEF, 2018). This is a serious risk for young children; malnutrition not only threatens their survival but also affects brain development, increases the risks of infection, and reduces educational attainment and productivity.

Therefore, planning for water resource management is required in pre-disaster phase. This will ensure food security, i.e., encompassing food production, preparation distribution, consumption and waste. Similarly, solar pumps can be used to avoid scarcity due to disruption of power supply. Practicing conservation agriculture to improve soil organic matter is another method to retain water in soil. The food systems will also need to produce more food with increased nutritional value, while becoming more efficient in the use of resources including land, soil, water, energy and chemicals.

3.6 Plant poisoning

More than eighty significant plant species and crops are known to result in poisoning when environmental conditions trigger nitrate accumulation at the plant cellular level. Droughts are known to exacerbate this in key staple crops (such as pea as they trigger a defense mechanism at the cellular level, which produces prussic acid and other toxins as a side effect). Even after a drought, the

growth in water stressed crops can result in accumulation of such toxins, making some plants poisonous to humans and livestock. Over 100,000 people had suffered from paralysis caused by oxalyldiaminopropionic acid (UNDP 2016) accumulation due to water stress in certain legumes during the drought in Ethiopia in 1995-1997(Surya and Rao, 2013).

Impact of drought on systems, services and health is mentioned below in Table 1.

System/ Services	Characterization	Health Impacts
Water	<ul style="list-style-type: none"> Quantity and quality of water affected in many ways that can be detrimental to aquatic life and drinking water. Impact on food production, mainly on fishing and subsistence farming. 	<ul style="list-style-type: none"> Diseases transmitted by water and food Diseases transmitted by vectors and zoonoses increased population density because of population displacement.
Food and nutrition	<ul style="list-style-type: none"> Quantity and quality of food may be affected due to the shortage and/ or contamination of water, the lack of sanitation, and increased population density because of population displacement. 	<ul style="list-style-type: none"> Diseases transmitted by water and food Malnutrition and dehydration Disease transmitted by vectors Zoonoses
Air quality	<ul style="list-style-type: none"> Low humidity, heat and dust, which are common during drought, represent a serious problem for people with respiratory diseases. 	<ul style="list-style-type: none"> Respiratory diseases (allergic rhinitis and asthma) Acute respiratory infection (bronchitis, sinusitis and pneumonia) Fungal infectious diseases (mycoses) Allergic reactions

System/ Services	Characterization	Health Impacts
Sanitation and Hygiene	<ul style="list-style-type: none"> Availability of water for cleaning, sanitation and hygiene is directly linked to the reduction or control of various diseases. Drought conditions generate water scarcity and/or the need to save water, some sanitary and hygiene measures can be prevented from being performed. 	<ul style="list-style-type: none"> Infectious diseases (dermatological, parasitic respiratory)
Mental and Behavioral Health	<ul style="list-style-type: none"> Financial implications of drought conditions cause adverse effects such as psychosocial disorders in people who depend on rainfall for economic survival. One member in a family may have to move to more remote areas in search of a job or a new source of income to meet the family's needs, often generating more anxiety, stress and depression. 	<ul style="list-style-type: none"> Anxiety, stress and depression. Behavioral changes such as aggression and suicides
Disruption of Health Services	<ul style="list-style-type: none"> The lack of water supply in health services can generate impacts such as the increased likelihood of contamination of instruments and equipment and the inability of the health professional to perform their work. There is a possible risk of disruption to healthcare, which may further worsen the health conditions of the affected population. Power supplies can also be affected impairing the use of medical equipments and the refrigeration of medicines and vaccines. 	

Table 1Impact of drought on systems, services and health
 (Source: Adapted from WHO, 2012 and Grigoletto et. al., 2016)

4. Prevention, preparedness & mitigation measures

Given the increase in the number and frequency of water related disasters in India, holistic mitigation measures must be undertaken at all levels including policy and planning, science and technology, environment and community actions, healthcare system, businesses and industries, urban local bodies and panchayats, research and capacity building. Several policy measures have been undertaken by the Government of India (GoI) to mitigate the impact of droughts and to build capacity for drought prevention, preparedness, mitigation and management.

The national vision is to minimize the vulnerability to floods and drought and the consequent loss of lives, livelihood systems, property and damage to infrastructure and public utilities and to build safer India by developing a holistic, proactive, multi-disaster and technology driven strategy for disaster management (NDMA Guidelines, 2008). This is to be achieved through a combination of preventive, mitigative and preparatory measures to develop an efficient response system after the occurrence of such extreme weather events. Furthermore, India needs significant efforts and initiatives in minimizing the health impact due to extreme weather events in various aspects discussed below in brief.

4.1 Policy & Planning:

India's first National Action Plan on Climate Change (NAPCC) was released in June 2008 outlining various policies and programs addressing climate mitigation and adaptation. Later in year 2014, a National Mission on Health was introduced in it to address the climate change related illnesses through multi-pronged approach. India has prepared its comprehensive guidelines for the management of floods (NDMA Guidelines, 2008) and management of drought (NDMA Guidelines, 2010). There is a need for proper integration of specific action plan for climate change related disasters and human health and National Health Adaptation Plan (NHAP) with respective state and district Disaster Management Plans (DMP). Also, there is a need for capacity enhancement and to further strengthen the real time monitoring and seasonal forecasting (medium and long range) through joint monitoring programmes to bridge the gap between the current and expected meteorological and hydrological monitoring network. Further, to tackle the

challenge at various spatial scales, ICT needs to be enhanced in an integrated manner.

4.2 Community awareness and indigenous knowledge:

The state governments, State/District Disaster Management Authorities shall take steps to create awareness to the communities, medical and paramedical staff etc. at large scale to the type of diseases and other health associated issues that can result in the aftermath of water related disasters. Hygienic practices and safe food cooking methods shall be promoted. Communities also need to be made aware of efficient use of water, appropriate and sustainable agricultural practices by the government. For better understanding about water related disasters and its impact over short and extended period of time, specific mechanism needs to be established especially in people's local/vernacular language. There is huge potential for harnessing the Indigenous Technical Knowledge (ITK) accumulated over centuries on cloud formation, lightning, wind direction, rains and drought for alleviating drought impacts. Time tested knowledge of people can be extrapolated to understand the modern concepts of disaster risk management (Gupta & Singh 2011).

4.3 Training to first responders:

All the involved stakeholders including medical first responders need to be trained and prepared in advance for improved resilience towards flood and drought and its consequent impacts such as scarcity of food, water, unclean water, heatwave, disruption in livelihood options etc. First responders further need to be trained to effectively strengthen and manage water and commodities supply system during any flood and drought event. Paramedical staff must be trained for resuscitation, triage and to maintain vital parameters like pulse, blood pressure, respiration and intravenous drip during evacuation. Heli-ambulances need to be deployed to aid in the evacuation of flood casualties collected at high points(NDMA Guidelines, 2008).

4.4 Medical Inventories:

Most commonly required medical inventories like Intravenous (IV) fluid, blood, ventilators, oxygen, dressing materials, tetanus toxoid, antibiotics, vaccines, anti-snake venom, anti-diarrhea drugs, oxygen cylinders, continuous positive air

pressure (CPAP) ventilators, etc. must be stocked and updated for the management of casualties. Large scale medical stores from where these materials can be procured must be pre-identified.

4.5 National Health Adaptation Plan for climate change related health issues:

A National Health Adaptation Plan (NHAP) has been drafted to address the climate change related health illnesses. It addresses that hospitals must nominate a suitable officer for coordinating management for disaster related casualties. Contingency plans should be made ready for providing additional beds. It should also ensure safe water supply and clean food availability along with maintenance of hygiene and sanitation by proper bio-waste disposal. Water testing and food inspection is required to be carried out regularly to prevent outbreak of any epidemic.

4.6 Climate-resilient water resource management:

Climate-resilient water resource management is a potentially powerful process to achieve local, and possibly global, food security (encompassing food production, preparation distribution, consumption and waste). On the mitigation side, interventions related to the increased utilization of solar pumps, practicing conservation agriculture to improve soil organic matter (needed for the soil to retain water), reducing post-harvest losses and food waste, and transforming waste into a source of nutrients or biofuels/biogas can address food security and climate change.

5. Conclusion and recommendations

Climate change negatively impacts drinking water availability and quality. Enhancement in infrastructure for water supply, sanitation and hygiene (WASH), sewerage, and treatment systems in health services need to be adapted to make them sustainable, safe and resilient to growing climate-related risks. Likewise, there is a need for improved monitoring, increased transparency, and regulatory oversight to better estimate the effects of floods and droughts such as contaminated water, and poor sanitation and hygiene on human health. Simultaneously, it is also imperative to ensure investments in resilient WASH systems in areas identified as being at highest risk contribute to building community resilience to the impacts of climate change. It is essential to address knowledge and policy gaps, strengthen institutional coordination and participation, and implementation of new activities to prevent water related disasters as well as reduce their impact through timely and proactive disaster management policies. Roles and responsibilities between departments, agencies, ministries, and levels of government should be clearly defined and delineated.

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About CECR and HER-CAP Project

Centre of Excellence on Climate Resilience (CECR)

National Institute of Disaster Management (NIDM) has a dedicated division for Environment, Climate and Disaster Risk Management (ECDRM) which has been designated as a Centre of Excellence on Climate Resilience (CECR) under the National Action Plan for Climate Change and Human Health (NAPCCHH). CECR is implementing six research projects namely Climate Adaptive Planning for Resilience and Sustainable Development in Multi-hazard Environment (CAP-RES) with support of DST-Govt of India, National Agriculture Disaster Management Plan (NADMP) funded by the Ministry of Agriculture & Farmers Welfare, Health Resilience and Capacity Building (HER-CAP) with World Health Organization India, Crisis Management Plan for Dealing with Contamination of Water Bodies (CMP-WB) funded by CPCB, Disaster Management Plan for Ministry of Environment, Forest and Climate Change (NEFC-DMP) with the support from MoEFCC and the Disaster Management Plan for Dept. of Chemicals and Petrochemicals (NCP-DMP) supported by DCPC-MoC&F. It also collaborates with a number of international and national organizations working in the areas of climate change adaptation, resilience and disaster risk reduction.

HER-CAP Project

NIDM in collaboration with WHO India has implemented the project "Health Adaptation and Resilience: Advancing Strategic Knowledge and Capacities" (HER-CAP). Under this project, the following documents have been drafted.'

- National Health Adaptation Plan for disasters related illnesses' for Ministry of Health and Family Welfare.
- Training Manual on 'Health Adaptation and Resilience to Climate Risks'.
- A compendium of case studies on 'Climate Change related Disasters and Health Resilience'.
- Four Policy briefs on Regional Issues and Opportunities for Health System Resilience to Climatic Disasters. (For North, East & North-East, West and South Region of India).

- Along with this, four thematic papers on key areas are as follows:
 - Temperature related disasters: Heat and Cold Wave - Implications for Health Adaptation and Resilience.
 - Water related disasters: Floods and Drought - Implications for Health Adaptation and Resilience.
 - Air Pollution and Health: Special Focus on Air Quality Emergencies.
 - Disaster Waste Management and Health Risk Reduction.



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