The Pharma Innovation Journal 2022; SP-11(5): 1842-1853

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(5): 1842-1853

www.thepharmajournal.com
Received: 06-03-2022
Accepted: 09-04-2022

Shivam
Department of Agronomy, School of Agriculture, Lovely Professional University, G. T. Rd, Phagwara, Punjab, India

Rajesh Kumar
Assistant Professor, Department of Agronomy, School of Agriculture, Lovely Professional University, G.T. Rd, Phagwara, Punjab, India

Corresponding Author
Rajesh Kumar
Assistant Professor, Department of Agronomy, School of Agriculture, Lovely Professional University, G.T. Rd, Phagwara, Punjab, India

Climate change and its smart management

Shivam and Rajesh Kumar

Abstract
Climate change is now becoming one of the most complex environmental and socio- economic issues impacting on the livelihood of all over the world. It is harmful to every country on every continent. (UNSDG/2020) It is affecting national economies and affecting lives. People are experiencing the many impacts of global climate change, which include changing weather patterns, rising water level, and more extreme weather events. Climate change is more than global warming. The rise in average temperature is merely one indicator of broader changes also translating into extreme temperatures, drought, flooding, storms, rising sea levels, impacts on food production, and infectious diseases. Although the scientific community has been conscious of the link between greenhouse gases (GHGs) and global climate change for several years, world leaders are slow to react and implement measures to mitigate the risks. Key sources of data on global climate change are synthesized by the successive reports of the Intergovernmental Panel on global climate change (IPCC) created by the United Nations and therefore the World Meteorological Organization in 1988. In recent time global climate change and its impact on human health and awareness constitute a gaggle of complex and high consequences to be tackled by a personal country. Climate change isn't merely an environmental issue, but also it's a threat that goes beyond national borders. India is both a big greenhouse emission emitter and one among the foremost vulnerable countries within the earth to projected global climate change. The country is already experiencing changes in climate and therefore the impacts of global climate change, including water stress, heat waves and drought, severe storms and flooding, and associated negative consequences on health and livelihoods. With a 1.2 billion but growing population and dependence on agriculture, India probably are becoming to be severely impacted by continuing global climate change. (NIC/2009) Global observations of melting glaciers suggest that global climate change is well under way within the region, with glaciers receding at a mean rate of 10–15 meters per annum. If the speed increases, flooding is probably going in river valleys fed by these glaciers, followed by diminished flows, leading to water scarcity for drinking and irrigation.

Keywords: Climate change, glaciers, precipitation, IPCC, MoES, WHO

Introduction
The meaning of climate change is comprising with evidences such as sea levels are rising, glaciers are retreating, change in precipitation patterns, and the world is getting warmer by increasing the temperature. According to the Intergovernmental Panel on global climate change (IPCC), the present rate of greenhouse emission emissions is probably going to cause average temperatures to rise by 0.2 ˚C per decade, reaching by 2050 the edge of 2 ˚C above pre-industrial levels (IPCC, 2020) Recent evidence suggests even more rapid change, which can greatly, and in some cases irreversibly, affect not just people, but also species and eco-systems.

Climate change is already beginning to transform life on Earth
Around the globe, seasons are shifting, temperatures are climbing and sea levels are rising. And meanwhile, our planet must still supply us – and all living things – with air, water, food and safe places to live. If we don't act now, climate change will rapidly alter the lands and waters we all depend upon for survival, leaving our children and grandchildren with a very different world.
Some of the most dangerous consequences of climate change are listed here. Which one will have the most impact on your life, or on the places you care about?

The five hottest years on record have all occurred since 1997
Heat-trapping gases emitted by power plants, automobiles, deforestation and other sources are warming up the planet. In fact, the five hottest years on record have all occurred since the 10 hottest since 1990, including the warmest years on record – 2005 and 2010.

High temperatures are to blame for an increase in heat-related deaths and illness, rising seas, increased storm intensity, and many of the other dangerous consequences of climate change.
During the 20th century, the Earth's average temperature rose one degree Fahrenheit to its highest level in the past four centuries – believed to be the fastest rise in a thousand years.
Scientists project that if emissions of heat-trapping carbon emissions aren't reduced, average surface temperatures could increase by 3 to 10 degrees Fahrenheit by the end of the century.

Don't let average temperatures fool you: A one-degree increase may be found in one place, a 12-degree increase in another place, and yet other areas may become much colder.
The planet's oceans are also warming, which is causing dangerous consequences such as stronger storms, coral bleaching and rising seas.

India seventh most suffering from global climate change in 2019 globally

Between 2000 and 2019, over 475,000 people lost their lives as a flash results of quite 11,000 extreme weather events globally and losses amounted to around US $2.56 trillion (in purchasing power parities)
According to the worldwide Climate Risk Index 2021, India was the seventh most-affected by the devastating impact of worldwide global climate change globally in 2019. (CRI, 2021)
German watch, in his report said that a Bonn-based environmental organization, India was preceded by Mozambique, Zimbabwe, Bahamas, Japan, Malawi and Afghanistan within the list of nations most affected by the impacts of utmost weather events in 2019.
The report tells that, in 2019, monsoon continued for a month longer than normal in India. From June to the very best of September 2019, 110% of the long-period average was recorded. Flooding caused by heavy rain was liable for 1,800 deaths across 14 states and led to the displacement of 1.8 million people. Overall, 11.8 million people were suffering from the acute monsoon with the economic damage estimated to be US $10 billion. There are eight tropical cyclones in India. Six of the eight cyclones intensified to become "very severe." Extremely severe cyclone Fain affected 28 million people, killing nearly 90 people in India and Bangladesh, and causing economic losses folks $8.1 billion.

The 10 most affected countries in 2019

RANKING 2019 (2018)	COUNTRY	CRI SCORE	FATALITIES	FATALITIES PER 100,000 INHABITANTS	ABSOLUTE LOSSES (IN MILLION US$ PPP)	LOSSES PER UNIT GDP IN %	HUMAN DEVELOPMENT INDEX 2020 RANKING
1 (54)	MOZAMBIQUE	2.67	700	2.25	2.25	12.16	181
2 (132)	ZIMBABWE	6.17	347	2.33	2.33	4.26	150
3 (135)	THE BAHAMAS	6.5	56	14.7	14.7	31.59	58
4 (1)	JAPAN	14.5	290	0.23	0.23	0.53	19
5 (93)	MALAWI	15.17	95	0.47	0.47	2.22	174
6 (24)	ISLAMIC REPUBLIC OF AFGHANISTAN	16	191	0.51	0.51	0.67	169
7 (5)	INDIA	16.67	2267	0.17	0.17	0.72	131
8 (133)	SOUTH SUDAN	17.33	185	1.38	1.38	0.74	185
9 (27)	NIGER	18.17	117	0.5	0.5	0.74	189
10 (59)	BOLIVIA	19.67	33	0.29	0.29	0.76	107

One-fourth of the Earth's species might be headed for extinction by 2050 thanks to global climate change

Rising temperatures are changing weather and vegetation patterns across the world, forcing animal species to migrate to new, cooler areas so as to survive.
The rapid nature of global climate change is probably going to exceed the power of the many species to migrate or adjust. Experts predict that one-fourth of Earth's species are going to be headed for extinction by 2050 if the warming trend continues at its current rate.
Many species are already feeling the heat:

- In 1999, the death of the last Golden Toad in Central America marked the primary documented species extinction driven by global climate change.
- Thanks to melting ice within the Arctic, polar bears could also be gone from the earth in as little as 100 years.
- Within the tropics, increased sea temperatures are causing more coral reefs to "bleach," because the heat kills colorful algae that are necessary to coral health and survival.

Several U.S. states may even lose their official birds as they head for cooler climates — including the Baltimore oriole of Maryland, blackcap of Massachusetts, and therefore the American gold finch of Iowa.

Sea level rise from global climate change could displace tens of many people

As the Earth heats up, sea levels rise because warmer water takes up more room than colder water, a process referred to as thermal expansion. Melting glaciers compound the matter by dumping even more water into the oceans.
Rising seas threaten to inundate low-lying areas and islands, threaten dense coastal populations, erode shorelines, damage

property and destroy ecosystems like mangroves and wetlands that protect coasts against storms.

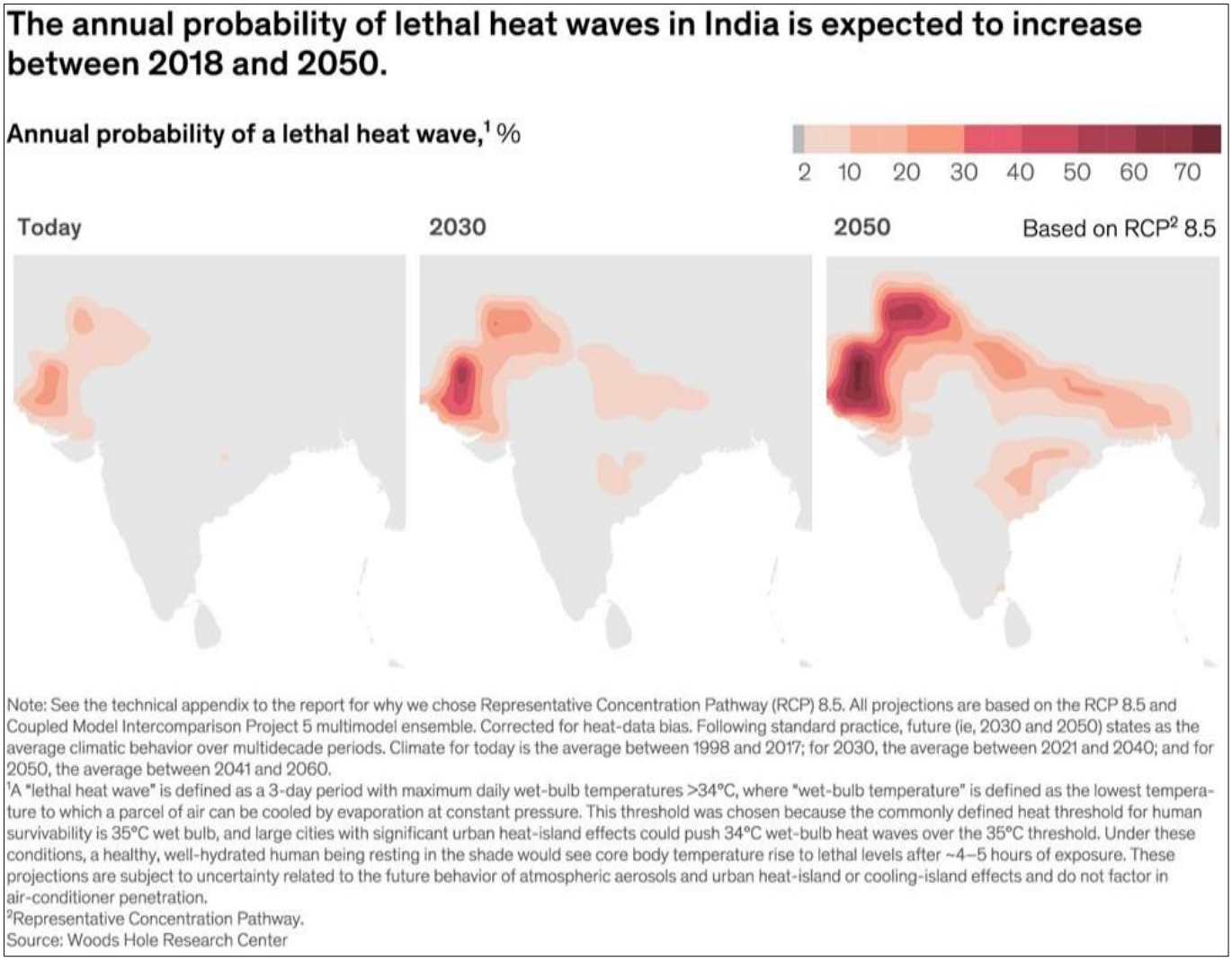
Sea levels have risen between four and eight inches within the past 100 years. Current projections suggest that sea levels could still rise between 4 inches and 36 inches over subsequent 100 years.

A 36-inch increase in sea levels would swamp every city on the East Coast of the us, from Miami to Boston. (ES, 2015) [18].

Worldwide, approximately 100 million people live within three feet of water level. Sea level rise related to global climate change could displace tens of many people in low-lying areas – especially in developing countries. (Env. Eco., CC) Inhabitants of some small island countries that rest barely above the prevailing water level are already abandoning their islands, a number of the world's first global climate change refugees.

The threat of utmost heat and humidity in India

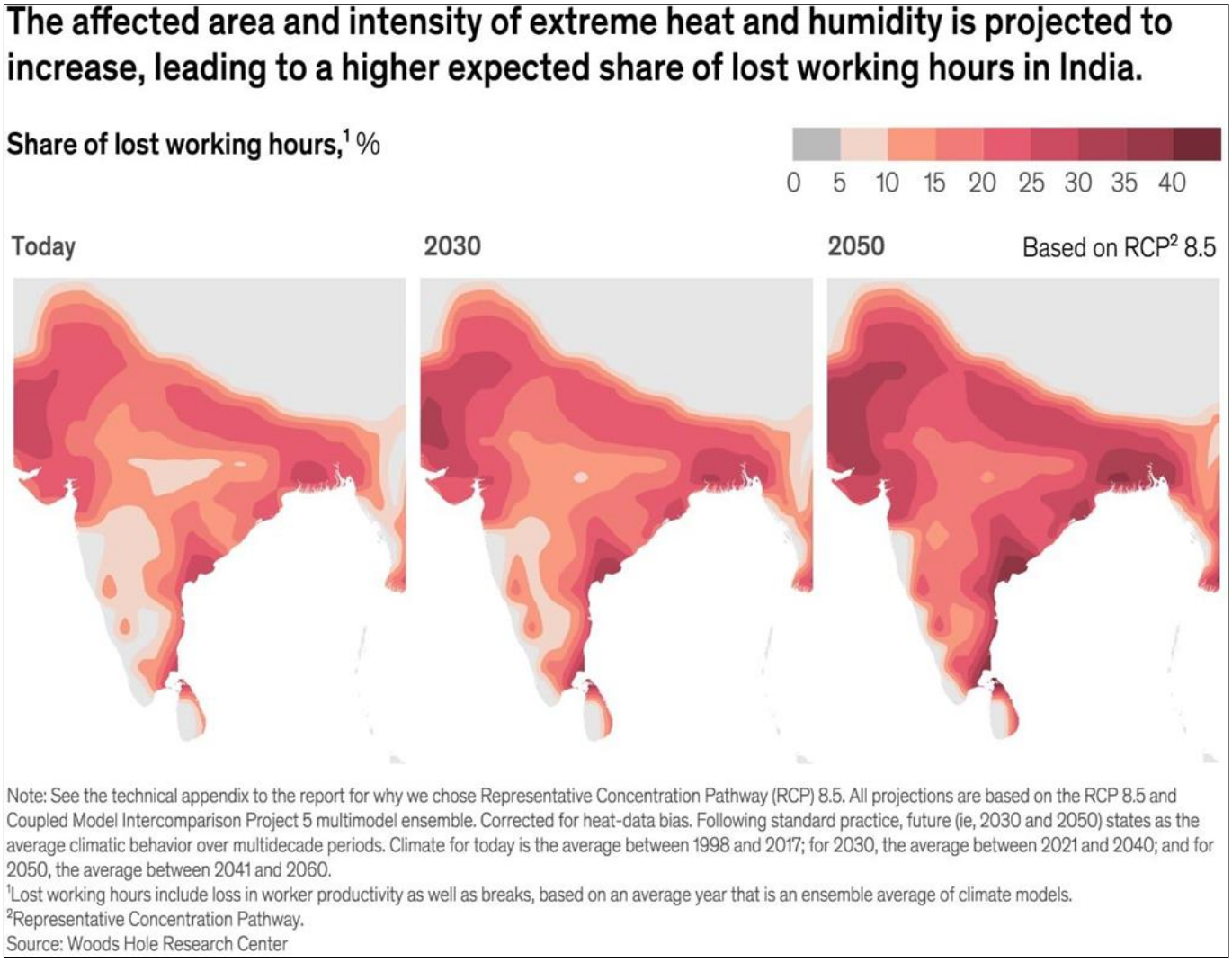
High temperatures are recorded only a few of times on Earth, including a 34.6-degree wet-bulb measurement on the coast of the Persian Gulf in July of 2015, and a later 35.4-degree wet-bulb measurement in the same region. Exposure to 34-degree wet-bulb temperatures will increase mortality risk for the sick and elderly, but more importantly, thanks to the amplifying urban heat- island effect which may raise temperatures in urban areas, for instance, thanks to the presence of concrete buildings and limited green spaces, urban or peri-urban centers exposed to those temperatures may cross the 35-degree survivability threshold for healthy adults.(TOI,2020) By 2050, portions of northern India could begin to experience heat waves that cross the 35-degree wet-bulb survivability with a probability of occurrence a minimum of once within the decade centered on 2050 approaching 80 percent. As heat and humidity increase, this might also affect labor productivity in outdoor work. This phenomenon occurs not only thanks to the necessity to require breaks to avoid dangerous core temperature rise, but also because the body will fatigue to scale back the quantity of work (and therefore heat) that it's ready to produce.



Climate risk and response

By 2050, the amount of individuals living in at-risk regions will increase to 310–480 million. If historical growth rates continue, it's expected that the majority people in India will own an air con unit by 2050, then will have a degree of protection against this risk. It is important that ways to scale back air conditioning carbon footprint are identified within the near term, to stop large-scale air conditioning growth from exacerbating underlying climate risk.

Another consequence of chronic exposure to extreme heat may be a rapid decrease within the capacity for outdoor work. We estimate that the amount of daylight during which outdoor work is unsafe will increase approximately 15 percent by 2030, compared with today's levels



Climate change is making floods, fires and droughts more frequent and severe

Climate change is intensifying the circulation of water on, above and below the surface of the world causing drought and floods to be more frequent, severe and widespread. Higher temperatures increase the quantity of moisture that evaporates from land and water, resulting in drought in many areas. Lands suffering from drought are more susceptible to flooding once rain falls. As temperatures rise globally, droughts will become more frequent and more severe, with potentially devastating consequences for agriculture, water system and human health. This phenomenon has already been observed in some parts of Asia and Africa, where droughts became longer and more intense.

Hot temperatures and dry conditions also increase the likelihood of forest fires. In the conifer forests of the western us, earlier snowmelts, longer summers and an increase in spring and summer temperatures have increased fire frequency by 400 percent and have increased the quantity of land burned by 650 percent since 1970.

Climate change will cause storms, hurricanes and tropical storms to become more intense. Scientific research indicates that global climate change will cause hurricanes and tropical storms to become more intense — lasting longer, unleashing stronger winds, and causing more damage to coastal ecosystems and communities.

Scientists point to higher ocean temperatures because the main culprit, since hurricanes and tropical storms get their energy from warm water. As sea surface temperatures rise, developing storms will contain more energy.

At the same time, other factors like rising sea levels, disappearing wetlands, and increased coastal development threaten to intensify the damage caused by hurricanes and tropical storms.

Climate change brings health risks to the world's most vulnerable communities.

As temperatures rise, so do the risks of heat-related illness and even death for the foremost vulnerable human populations.

In 2003, for instance, extreme heat waves caused quite 20,000 deaths in Europe and quite 1,500 deaths in India. Scientists have linked the deadly heat waves to global climate change and warn of more to return. In addition to heat-related illness, global climate change may increase the spread of infectious diseases, mainly because warmer temperatures allow disease-carrying insects, animals and microbes to survive in areas where they were once thwarted by cold weather.

Diseases and pests that were once limited to the tropics — like mosquitoes that carry malaria — may find hospitable conditions in new areas that were once too cold to support them.

The World Health Organization (WHO) estimates that global climate change may have caused quite 150,000 deaths within the year 2000 alone, with a rise in deaths likely within the future.

Severe impact on the Himalayas

The report highlights that the Hindu Kush Himalayas (HKH) have experienced a temperature rise of about 1.3 degree Centigrade during 1951–2014. "Several areas of HKH have experienced a declining trend in snowfall and also retreat of glaciers in recent decades. In contrast, the high- elevation Karakoram Himalayas have experienced higher winter snowfall that has shielded the region from glacier shrinkage. By the highest of the twenty-first century, the annual mean surface temperature over HKH is projected to increase by about 5.2 degree Centigrade. Human-induced global climate change has led to accelerated warming of the Himalayas and thus the Tibetan Plateau at a rate of 0.2 degree Centigrade per decade during 1951–2014," said the report. (MoES, 2020) [21].

It said that the longer term warming within the HKH region, "which is projected to be within the range of two .6–4.6 degree Celsius" by the top of 2100, "will further exacerbate the snowfall and glacier decline resulting in profound hydrological and agricultural impacts within the region."

Climate change is already affecting economies and lives around the world

Climate change is a major threat to agriculture

The toll that climate change takes on agriculture is nearly incalculable, and as a result, our food security is at risk. All over the world, farmers are struggling to keep up with shifting weather and increasingly unpredictable water supplies. Farmers also must contend with unexpected attacks from weeds, diseases and pests, which affect yield.

India's water, food and energy security to come under stress

The report by the Union Ministry of Earth Sciences observed that the impact of climate change on the availability of freshwater is a critical area of concern for India and the growing propensity for droughts and floods because of changing rainfall patterns caused by climate change would be "detrimental to surface and groundwater recharge, posing threats to the country's water security."(MoES, 2020) [21] "Likewise, the country's food security may be placed under progressively greater pressure due to rising temperatures, heat extremes, floods, droughts and increasing year-to-year rainfall variability that can disrupt rain-fed agricultural food production and adversely impact crop yield," the report warned. It further explained that the rising temperatures are also likely to increase energy demand for space cooling, which if met by thermal power would mean a further increase in greenhouse gas emission.

Changing temperatures are causing vegetation shifts and conservation challenges

Rising temperatures and changing patterns of rain and snow are forcing trees and plants round the world to maneuver toward polar regions and up mountain slopes.

These vegetation shifts will undermine much of the work the conservation community has accomplished so far, with the potential to permanently change the face of Conservancy preserves, local land trusts, and even our national parks.

In the tundra, thawing permafrost will allow shrubs and trees to require root. In the Great Plains of the us, grasslands will likely become forests. And New England's fiery fall foliage will eventually fade as maple and beech forests shift north toward cooler temperatures.

As plant communities attempt to suits the changing climate by moving toward cooler areas, the animals that depend upon them are going to be forced to maneuver. Development and other barriers may block the migration of both plants and animals. Some species and communities like polar bears and alpine meadows could also be left with none remaining viable habitat, putting much of our treasured wildlife in danger

Declining crop yields could put many thousands of individuals in danger for starvation

Climate change affects businesses and economies reception and round the world. If action isn't taken to curb global carbon emissions, global climate change could cost between 5 and 20 percent of the annual global gross domestic product, consistent with a British government report. In comparison, it might take 1 percent of GDP to reduce the foremost damaging effects of global climate change, the report says. These global costs are going to be felt by local communities and businesses:

In southern New England lobster catches have plummeted because of heat stresses and growing parasite threats due to rising sea temperatures. Ski resorts located within the lower altitudes of Swiss Alps have difficulty obtaining bank loans due to declining snow.

In Lake Erie, climate change may significantly lower lake levels, altering shoreline habitats and costing millions for the relocation of ports and shore infrastructure.

Globally, more intense hurricanes and downpours could cause billions of dollars in damage to property and infrastructure. Declining crop yields thanks to prolonged drought and high temperatures, especially in Africa, could put many thousands of individuals in danger for starvation.

High sea temperatures also threaten the survival of coral reefs, which generate an estimated $375 billion per annum in goods and services.

Examples of impacts associated with global average temperature change (Impacts will vary by extent of adaptation, rate of temperature change and socio-economic pathway)

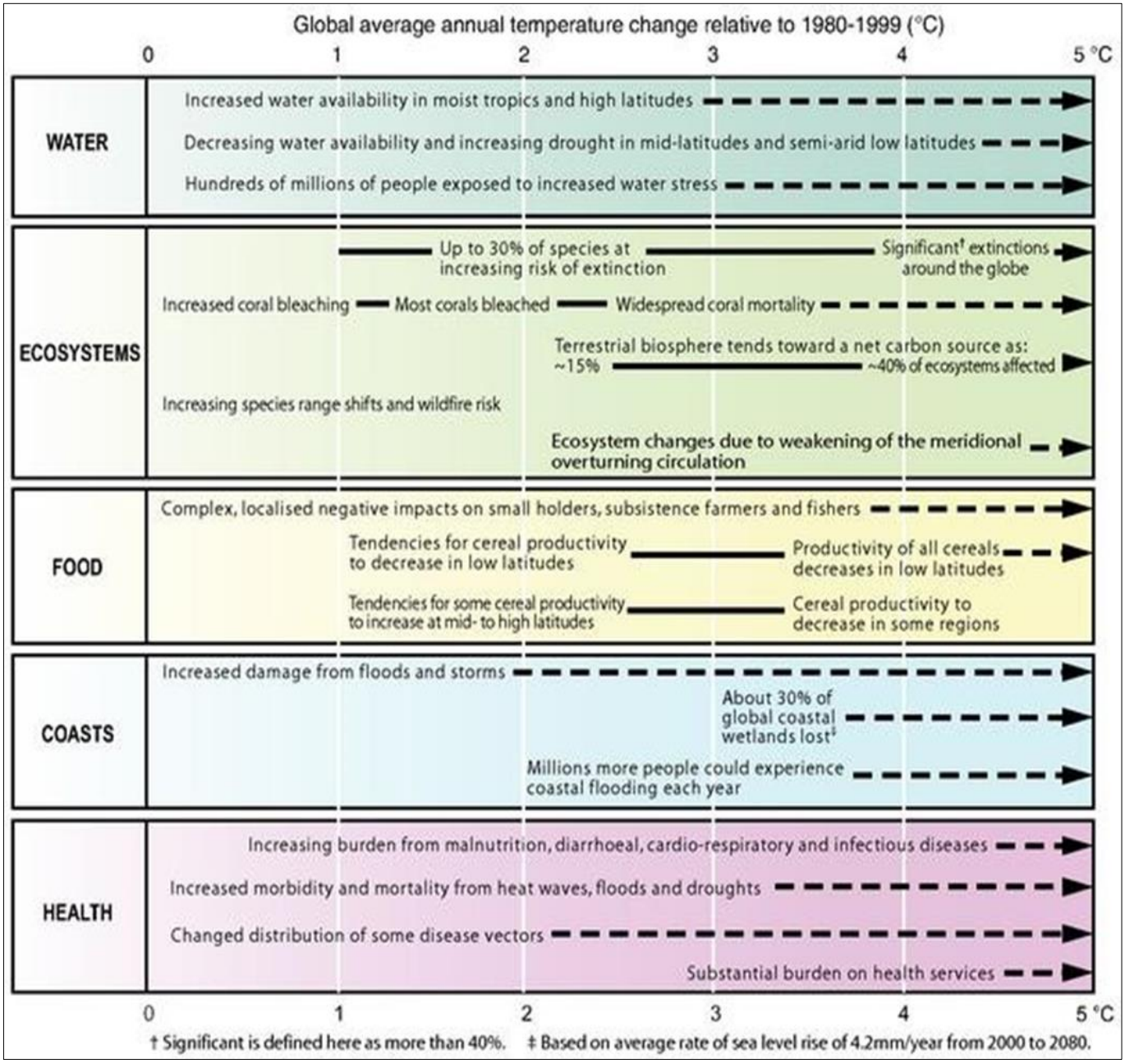


Fig 1: Examples of impacts associated with projected global average surface warming. Upper

Panel: Illustrative examples of global impacts projected for climate changes (and sea level and atmospheric CO_2 where relevant) associated with different amounts of increase in global average surface temperature in the 21st century. The black lines link impacts; broken-line arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left-hand side of text indicates the approximate level of warming that is associated with the onset of a given impact. Quantitative entries for water scarcity and flooding represent the additional impacts of climate change relative to the conditions projected across the range of SRES scenarios A1FI, A2, B1 and B2. Adaptation to climate change is not included in these estimations. Confidence levels for all statements are high.

Because there are so many impacts of climate change, scientists have broadly categorized them into three areas

1. Erratic climate and weather extremes
2. Altered ecosystems and habitats
3. Risks to human health and society
4. The primary impact: Earth's water systems thrown off balance
5. Emissions of heat-trapping gases from human activity—especially the burning of fossil fuels for energy—cause our atmosphere to heat up.
6. This atmospheric heating unleashes a torrent of rapid changes to the way water systems typically function on our planet.
7. For example:

- **The cryosphere—the frozen water on Earth-is melting:** A warmer atmosphere causes the planet's snow pack, glaciers and sea and freshwater ice to melt at an accelerated pace. Melting glaciers and polar ice sheets contribute to sea level rise. As the ice melts, it also exposes more dark ocean waters, which absorbs more sunlight than ice, and thus heats the ocean more, triggering a cycle of melting and heating.
- **Weather of all kinds is getting more extreme:** The increased evaporation of water is like fuel for storms, exacerbating extreme weather events, such as hurricanes. Rising sea levels make coastal flooding events worse. In more naturally arid areas, droughts and wildfires intensify.
- **The oceans are getting hotter, expanding, and becoming more acidic:** The oceans are getting hotter, because they soak up 90% of the extra heat in the atmosphere. This causes the oceans to expand, and this also contributes to higher sea levels. Meanwhile, the increased concentration of carbon dioxide in the ocean triggers a chemistry change that makes the water more acidic. The ocean is almost 40% more acidic than it used to be.

2. This shift in water patterns then alters natural habitats

As climatic patterns rapidly shift, habitats on land and in the sea are changing, making them inhospitable for some species, while letting others move in and take over. In some cases, entire ecosystems are at risk of collapsing.

The changes to the natural world are vast, but here are three notable and well-documented examples.

- **Coral and shellfish are suffering:** Coral reefs are highly sensitive to small changes in ocean temperatures. The heat stresses the algae that nourish the corals and provide their vibrant colors. The algae then leave, and the corals eventually starve, an event known as bleaching. Also, a more acidic ocean affects the normal calcium balance, meaning creatures with calcified shells, such as shellfish and coral, may not have enough calcium to grow.

Forests are more prone to deadly infestations: Milder winters and longer summers allow tree-killing insects to thrive. Meanwhile, trees weakened by prolonged drought have lower defense mechanisms. This cycle of warmer weather, weak trees and thriving insects is likely the culprit behind the massive die-off of 70,000 square miles of Rocky Mountain conifers.

Our Arctic creatures need ice, but it's vanishing

As sea ice disappears, ice-dependent mammals like walruses and polar bears struggle to survive. In 2008, the polar bear became the first animal to be added to the Endangered Species Act list of threatened species because of global warming 3. It also places many added burdens on people and society. Human life is thrown out of balance, too. One of the biggest impacts? Where, how and when we grow food, which is vitally connected to our climate's normal patterns.

More extreme weather also means we face increased pressure on our health, infrastructure, and economy.

- **Warmer, polluted air affects our health:** A warmer atmosphere increases chemical reactions that form ground-level ozone, also known as smog. Smog is a well-known lung irritant and a major trigger of asthma attacks. Smoke from wildfires further degrade the air. Extreme summer heat will mean more deaths during heat waves, and warmer freshwater makes it easier for pathogens to grow and contaminate drinking water.
- **Infrastructure and transportation are at risk, too:** Hot weather, flooding and other extreme weather events damage infrastructure, put heavy burdens on electrical supplies, and disrupt how we travel and commute.

India's climate change report says: Protect India's forests and urban green spaces

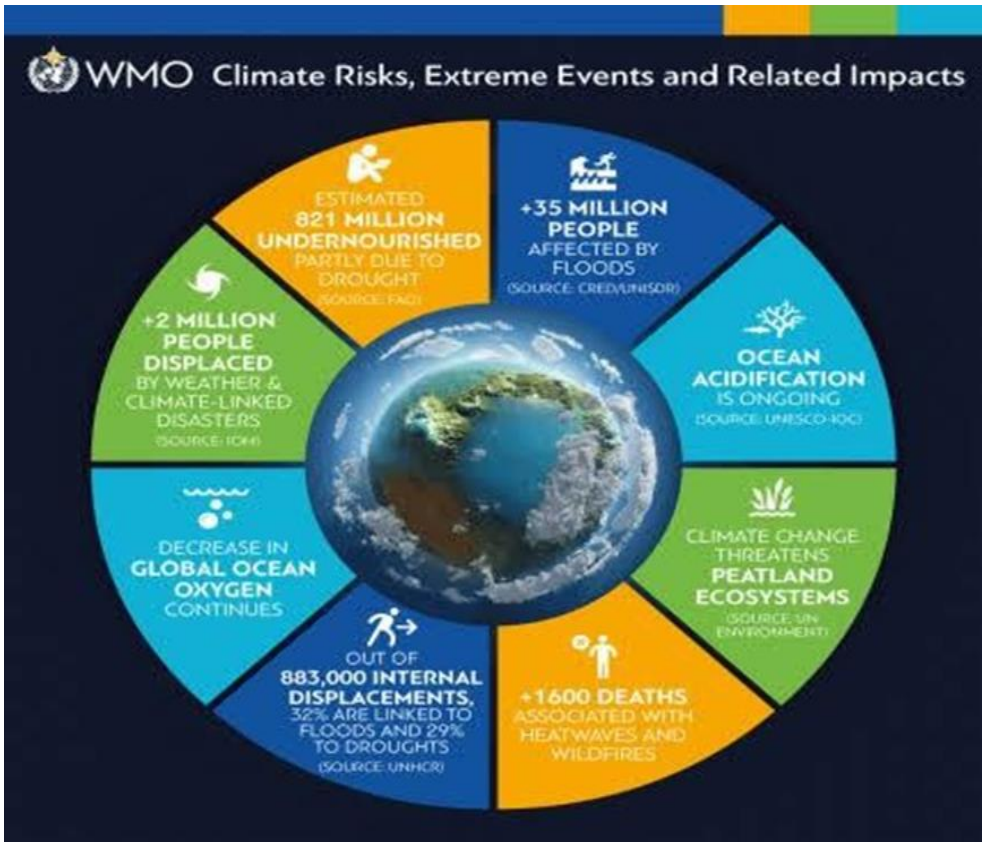
- According to report by Mayank Aggarwal on 19 June 2020, Warning against rapid climate change, India's first-ever climate change assessment report has revealed that the country's average temperature is expected to rise by 4.4 degree Celsius by the end of the year 2100.
- The report warned that the rapid changes in the temperature would mean increasing stress on India's natural ecosystems, agricultural output, and freshwater resources, which means a serious impact on the biodiversity, food, water and energy security, and public health.
- The report called for research and strategies towards improving resilience in Indian cities and advocated for protecting the country's forests and urban green spaces.

The report Assessment of Climate Change over the Indian Region prepared by the Union Ministry of Earth Sciences (MoES) warned that the rapid changes in the temperature would mean increasing stress on India's "natural ecosystems, agricultural output, and freshwater resources, while also causing escalating damage to infrastructure." This ultimately means a serious impact on "country's biodiversity, food, water and energy security, and public health."

The MoES report cautioned that by the end of 2100, the "frequency of summer (April–June) heat waves over India is projected to be 3 to 4 times higher" and the "average duration of heatwave events is also projected to approximately double." The impact of heatwave stress is expected across India but particularly over the densely populated Indo-Gangetic River basin. According to the report, the sea surface temperature (SST) of the tropical Indian Ocean has also risen by one degree Celsius, on average, during 1951–2015, which is higher than the global average warming of 0.7 degree Celsius, over the same period.

The rise in temperature is also playing havoc with India's rainfall which is significant for India's agriculture sector on which millions are dependent. The report noted that the summer monsoon precipitation (June to September) over India has declined by around six percent from 1951 to 2015, with notable decreases over the Indo-Gangetic Plains and the Western Ghats.

"There has been a shift in the recent period toward more frequent dry spells (27 percent higher during 1981–2011 relative to 1951–1980) and more intense wet spells during the summer monsoon season," said the report.



World's meteorological Organization, (2018)

Management

The increased trend of global temperature in the recent decades has focused attention of the scientific community on the specific aspect of global climate and regional monsoon variability in a changing climate.

Addressing this issue involves research and development of an Earth System Model (ESM), together with comprehensive assessment of various interactions among the different Earth System components *viz*., the atmosphere, ocean, biosphere, hydrosphere, cryosphere, It is necessary to strengthen and continue the basic research required for improving the Earth System Model components.

a) Objectives

1. To develop the high-resolution climate models or Earth System Models (ESM) to address scientific questions on attribution and projection of regional climate change.
2. To use regional climate models to produce projections of Indian monsoon under different scenarios and assess the uncertainty in these projections.
3. To study Monsoon Variability and Predictability by identifying regional and global climate drivers for monsoon interannual variability and to identify useful predictors and to understand the dynamics of dry and wet epochs of the Indian summer monsoon rainfall (ISMR) and their relation to the ENSO and other global coupled phenomenon.
4. To document chief features of regional monsoon climate change based on climate reconstructions derived from high resolution proxies and to understand the long-term monsoon climate variability over the Asian region.
5. To build in-house capacity in global and regional climate modeling to address all issues concerning the science of regional climate change with particular emphasis on the South Asian monsoon system.
6. To generate reliable climate inputs for impact assessments.
7. To develop hydrological model for large-scale estimation of run-off and soil moisture using satellite derived data.
8. To understand the role of aerosol loading over the Indian region in monsoon interannual variability and its possible implications on the Indian Monsoon.
9. To study and understand the role of aerosol chemistry (both organic and inorganic ionic species) in radiative forcing and regional climate change.

b) Participating Institutions

Indian Institute of Tropical Meteorology, Pune.

c) Implementation Plan

This is a continuing scheme. Following major activities would be continued to meet the objectives:

1. The existing tree-ring data network will be enhanced by developing tree-ring chronologies from different parts of the country as well as from other South and Southeast Asian countries.
2. To unravel the physical processes responsible for 'internal variation of the monsoon system
3. To improve the understanding of monsoon system by studying various climate model systems and data-model comparison over the Asian monsoon region.
4. To generate high resolution (35 km grid size) simulations of the South Asian monsoon during the 20th century (1890-2005) and future climate (2005 – 2100) based on the AR5 scenario projections. The model outputs will be used for impact assessment studies (eg., impacts on climate, water resources, agriculture, health, etc).
5. To understand the coupling processes and feedbacks among physical, chemical, radiative, dynamical and

biological processes in the Earth's environment and to carry out the comprehensive studies using climate modelling and observational techniques i.e. instruments and in-situ facilities acquired and put in function during the recent years.
6. The Earth System Model (ESM) will be fully developed, tested and implemented. Several long model runs will be performed using the ESM and CCCR will formally participate in the next Coupled Model Inter-comparison Project (CMIP6) and contribute to IPCC AR6 assessment
7. To understand the radiative forcing from the chemical constituents by monitoring tropospheric vertical distribution and seasonal variability in black carbon and air pollutants over India with special reference to Indo-Gangetic plain and mountain regions.
8. To monitor and understand interactions among aerosols, cloud processes and large scale dynamics in organizing large scale cloud systems in the monsoon environment.
9. To upgrade the existing High Performance Computer system of the IITM with storage and necessary infrastructure.
10. Physical mechanism responsible for Indian monsoon variability on each time scale will be will be built up.
11. Monitoring of atmospheric GHG concentration over Indian stations to understand long-term variations in the GHG and understand the anthropogenic and natural processes affecting the GHG variation

India: Climate change impacts

To better understand the risks of global climate change to development, the planet Bank Group commissioned the Potsdam Institute for Climate Impact Research and Climate Analytics to seem at the likely impacts of temperature increases from 2 ºC to 4 ºC in three regions. The scientists used the simplest available evidence and supplemented it with advanced computer simulations to reach likely impacts on agriculture, water resources, cities and coastal ecosystems in South Asia, South East Asia and Sub-Saharan Africa (ICC, 2013). Here is some of their findings for India:

India: Climate change impacts

S. No.	Particulars	What we know	What could happen	What can be done
1	Extreme Heat	India is already experiencing a warming climate.	Unusual and unprecedented spells of hot weather are expected to occur far more frequently and cover much larger areas. Under 4 °C warming, the west coast and southern India are projected to shift to new, high-temperature climatic regimes with significant impacts on agriculture.	With built-up urban areas rapidly becoming "heat-islands", urban planners will need to adopt measures to counteract this effect.
2	Changing Rainfall Patterns	A decline in monsoon rainfall since the 1950s has already been observed. The frequency of heavy rainfall events has also increased	A 2 °C rise in the world's average temperatures will make India's summer monsoon highly unpredictable. At 4 °C warming, an extremely wet monsoon that currently has a chance of occurring only once in 100 years is projected to occur every 10 years by the end of the century. An abrupt change in the monsoon could precipitate a major crisis, triggering more frequent droughts.	Improvements in hydro-meteorological systems for weather forecasting and the installation of flood warning systems can help people move out of harm's way before a weather- related disaster strike. Building codes will need to be enforced to ensure that homes and infrastructure are not at risk.
3	Droughts	Evidence indicates that parts of South Asia have become drier since the 1970s with an increase in the number of droughts. Droughts have major consequences. In 1987 and 2002-2003, droughts affected more than half of India's crop area and led to a huge fall in crop production.	Droughts are expected to be more frequent in some areas, especially in north-western India, Jharkhand, Orissa and Chhattisgarh. Crop yields are expected to fall significantly because of extreme heat by the 2040s.	Investments in R&D for the development of drought-resistant crops can help reduce some of the negative impacts.
4	Groundwater	More than 60% of India's agriculture is rain-fed, making the country highly dependent on groundwater. Even without climate change, 15% of India's groundwater resources are overexploited.	Although it is difficult to predict future ground water levels, falling water tables can be expected to reduce further on account of increasing demand for water from a growing population, more affluent life styles, as well as from the services sector and industry.	The efficient use of ground water resources will need to be incentivized.
5	Sea level rise	Mumbai has the world's largest population exposed to coastal flooding, with large parts of the city built on reclaimed land, below the high-tide mark. Rapid and unplanned urbanization further increases the risks of sea water intrusion.	With India close to the equator, the sub-continent would see much higher rises in sea levels than higher latitudes. Sea-level rise and storm surges would lead to saltwater intrusion in the coastal areas, impacting agriculture, degrading groundwater quality, contaminating drinking water, and possibly causing a rise in diarrhoea cases and cholera outbreaks, as the cholera bacterium survives longer in saline water. Kolkata and Mumbai, both densely populated cities, are particularly vulnerable to the impacts of sea-level rise, tropical cyclones,	Building codes will need to be strictly enforced and urban planning will need to prepare for climate- related disasters. Coastal embankments will need to be built where necessary and Coastal Regulation Zone codes enforced strictly.

			and riverine flooding.	
6	Agriculture and food security.	Even without climate change, world food prices are expected to increase due to growing populations and rising incomes, as well as a greater demand for biofuels. Rice: While overall rice yields have increased, rising temperatures with lower rainfall at the end of the growing season have caused a significant loss in India's rice production. Without climate change, average rice yields could have been almost 6% higher (75 million tons in absolute terms). Wheat: Recent studies shows that wheat yields peaked in India and Bangladesh around 2001 and have not increased since despite increasing fertilizer applications. Observations show that extremely high temperatures in northern India - above 34 °C - have had a substantial negative effect on wheat yields, and rising temperatures can only aggravate the situation.	Seasonal water scarcity, rising temperatures, and intrusion of sea water would threaten crop yields, jeopardizing the country's food security. Should current trends persist, substantial yield reductions in both rice and wheat can be expected in the near and medium term. Under 2 °C warming by the 2050s, the country may need to import more than twice the amount of food-grain than would be required without climate change.	Crop diversification, more efficient water use, and improved soil management practices, together with the development of drought-resistant crops can help reduce some of the negative impacts.
7	Health	Climate change is expected to have major health impacts in India- increasing malnutrition and related health disorders such as child stunting - with the poor likely to be affected most severely. Child stunting is projected to increase by 35% by 2050 compared to a scenario without climate change. Malaria and other vector-borne diseases, along with and diarrheal infections which are a major cause of child mortality, are likely to spread into areas where colder temperatures had previously limited transmission. Heat waves are likely to result in a very substantial rise in mortality and death, and injuries from extreme weather events are likely to increase	Health systems will need to be strengthened in identified hotspots.	Improvements in hydro-meteorological systems for weather forecasting and the installation of flood warning systems can help people move out of harm's way before a weather- related disaster strike. Building codes will need to be enforced to ensure that homes and infrastructure are not at risk.

Conclusion

Human-induced global climate change has contributed to changing patterns of utmost weather across the planet, from longer and warmer heat waves to heavier rains. From a broad perspective, all weather events are now connected to global climate change. While natural variability continues to play a key role in extreme weather, global climate change has shifted the probabilities and altered the natural limits, ensuring kinds of extreme weather more frequent and more intense.

While understanding how global climate change affects extreme weather remains developing, evidence suggests that extreme weather could be affected even quite anticipated. Extreme weather is on the rise, and thus the indications are that it will still increase, in both predictable and unpredictable ways.

References

1. The UN Sustainable Development Goals/ 10 November, 2020.
2. India: The Impact of Climate Change to 2030 A Commissioned Research Report Prepared By Joint Global Change Research Institute and Battelle Memorial Institute, 2009 April. Pacific Northwest Division/ NIC 2009-03D
3. Hafiz Muhammad Anwar Saleem/ Journal of Biodiversity, Bioprospecting and Development/ Extended Abstract /Global Warming and Environmental Science 2020 Aug 10-11, 7. 1 2020 Global Warming -
4. Intergovernmental Panel on Climate Change (IPCC)/special report/Global Warming of 1.5 °C. Essentially, the report analyzes the impacts of a 1.5 °C increase in global average temperature above pre-industrial levels, and details what should be done to limit global warming to 1.5 °C. (October 6, 2018)
5. Hindustan Times / India News / India seventh most affected by climate change in 2019 globally/ Report
6. https://www.hindustantimes.com/india-news/india-seventh-most-affected-by-climate-change-in- 2019-globally-report
7. Climate Change. The Physical Science Basis Contribution of Working Group I to the Fourth Assessment Report of the IPCC. 2007.
8. Climate Change. Impacts, Adaptation and Vulnerability Contribution of Working Group II to the Fourth Assessment Report of the IPCC, 2007.
9. Climate Change. Mitigation of Climate Change Contribution of Working Group III to the Fourth Assessment Report of the IPCC, 2007.
10. Climate Change. Impacts, Adaptation and Vulnerability provides the most comprehensive and up-to-date scientific assessment of the impacts of climate change, the vulnerability of natural and human environments, and the potential for response through adaptation. 2007.
11. 'Global Climate Risk Index 2021' https://www.deccanherald.com/science-and-environment/india-among-top-10-countries-most-

affected-by-climate-change-in-2019-943516.html
12. IPCC. Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E.], 2019.
13. Global Warming, Articles on Global Warming by Ashley Edwards 19 Abrupt Climate Change Scenario: Implications for U.S. National Security.
14. A Guide to the Science, by Willie Soon, Sallie L. Baliunas, Arthur B. Robinson and Zachary W. Robinson, The Fraser Institute, Centre for Studies in Risk and Regulation, Vancouver British Columbia Canada, Risk Controversy Series, 2001, 1.
15. EPA. Global Methane Initiative 2020: Estimated Global Anthropogenic Methane Emissions by Source, 2020.
16. IPCC SRCCL. Since the pre-industrial period, the land surface air temperature has risen nearly twice as much as the global average temperature (high confidence). Climate change... contributed to desertification and land degradation in many regions (high confidence), 2019, 7.
17. IPCC SRCCL. Climate change is playing an increasing role in determining wildfire regimes alongside human activity (medium confidence), with future climate variability expected to enhance the risk and severity wildfires in many biomes such as tropical rainforests (high confidence), 2019.
18. Environmental Science/impact of global warming and climate change environmental sciences essay(2015)
19. http://environment-ecology.com/climate-change/785-climate-change-threats-and-solutions.html
20. https://timesofindia.indiatimes.com/blogs/outlier/heat-hacker hacked/?source=app&frmapp=yes (December 19, 2020)
21. Assessment of climate change over the Indian region: A report of the Ministry of Earth Sciences (MoES), Government of India,17 Jun 2020
22. https://www.worldbank.org/en/news/feature/2013/06/19/india-climate-change-impacts
23. WHO, 2018, 27p; Vandyck *et al*. 2018; IPCC SR15 2018, Hartmann, D. L.; Klein Tank, A. M. G.; Rusticucci, M.; Alexander, L. V.; *et al*. (2013).
24. World Wildlife Fund (WWF), An Overview of Glaciers, Glacier Retreat and Subsequent Impacts in Nepal, India and China, WWF Nepal Programme. 2005 March.
25. Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment. Intergovernmental Panel on Climate Change, eds.
26. Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Keqin Duan LG Thompson, Yao T. A 1000 year history of atmospheric sulfate concentrations in southern Asia as recorded by a Himalayan ice core, 2007. Geophysical Research Letters 34
27. Victor Cruz, Hideo Harasawa, Murari Lal, Shaohong Wu, Asia, in Climate Change. Adaptation and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, eds. M.L. Parry, O.F. Canziani, J.P. Paluti of, P.J. van der Linden, 2007.
28. Hanson CE. (Cambridge: Cambridge University Press; K. Ruosteenoja, T.R. Carter, K. Jylhä and H. Tuomenvirta. "Future climate in world regions: an intercomparison of model-based projections for the new IPCC, 2007.
29. Emissions scenarios," The Finnish Environment 644, (Helsinki: Finnish Environment Institute, 2003.
30. Intergovernmental Panel on Climate Change, eds. M.L. Parry OF, Canziani JP, Palutikof PJ, van der Linden and C.E. Hanson (Cambridge: Cambridge University Press, 2007.
31. Climate Change Science Program (CCSP), "Climate projections based on emissions scenarios for long-lived and short-lived radiatively active gases and aerosols," eds. H. Levy II, D.T. Shindell,
32. Gilliland MD, Schwarzkopf LW. Horowitz (Washington, D.C.: Department of Commerce, NOAA's National Climatic Data Center 2008), http://www.climatescience.gov/Library/sap/sap3- 2/final-report/sap3-2-final-report-all.pdf Central Intelligence Agency: The World Factbook, S.v. India, January 22, 2008.
33. https://www.cia.gov/library/publications/the-world-factbook/geos/in.html; Robert W. Fogel, Capitalism & democracy in 2040, Daedalus Summer. 2007, 87-95.
34. Gannon MJ. Associates, Understanding Global Cultures (Thousand Oaks, CA: Sage 1994).
35. Gurcharan Das. The India model" Foreign Affairs 85 no. 2006;4:2-16.
36. Govindan Parayil. The 'Kerala Model' of development: development and sustainability in the third world, Third World Quarterly. 1996;17(5):941-957.
37. Gopal Kadekodi, Ravi Kanbur, Vijayendra Rao. Governance and the 'Karnataka Model of Development, Economic and Political Weekly 24 February 2007.
38. World Bank. Country Brief: South Asia Region (SAR)–India, 2002. http://www.Worldbank.org; Somini Sengupta, Education push yields little for India's poor, New York Times (17 January 2008). xv Ashutosh Varshney, India's democratic challenge, Foreign Affairs. 2006;86(2):93-106.
39. Ashutosh Varshney, India's democratic challenge, Foreign Affairs. Climate Change Mitigation in Developing Countries: Brazil, China, India, Mexico, South. 2006;86(2):93-106.
40. Africa, and Turkey, (Washington, D.C.: Pew Center on Global Climate Change, 2002.
41. Agarwal, Narain S. Toward a Green World: Should Global Environmental Management Be Built on Legal Conventions or Human Rights? (New Delhi: Centre for Science and Environment, 1992.
42. Ghats are the two coastal mountain ranges that converge in southern India, separated by the Deccan Plateau. xx Intergovernmental Panel on Climate Change (IPCC), Climate Change 2007: the Physical Science Basis, eds. S. Solomon, D. Qin, M. Manning, M. Marquis, K. Averyt,
43. Tignor MMB, Miller HL Jr., Chen Z. (Cambridge: Cambridge University Press, 2007.
44. Ministry of Environment, Forest and Climate Change Government of India. Moef.gov.in. 31 July, 2015.
45. Ministry of environment, forests and climate change demand no. 27:
46. Ministry of Environment, Forests and Climate Change" (web). Indiabudget.gov.in.
47. Following Anil Daves death, Dr Harsh Vardhan gets additional charge of environment". Indiatoday. In today. in 2020.
48. Sanjeev Khagram. Dams and Development", New York, Cornell University Press. "Ministry of environment and forests undergoes a nomenclature change, 2004.

49. "About ENVIS"
50. "Tropical Botanic Garden and Research Institute | Ministry of Environment, Forest and Climate Change Government of India". Envfor.nic.in.
51. "Comments called for on the Draft National Resource Efficiency Policy Released". Press Information Bureau.
52. EU-India joint declaration on resource efficiency and circular economy (PDF). Consilium. europa. eu, 2020, September.
53. National Research Council of the National Academies Committee. America's Climate Choices: Advancing the Change. Washington Science of Climate, DC: National Academy Press, 2010.
54. Min SK, Zhang X, Zwiers FW, Hegerl GC. Human contribution to more-intense precipitation extremes. Nature. 2011;470:378-381.
55. Dai A. Drought under global warming: a review. Wiley Interdisciplinary Reviews: Climate Change. 2011;2:45-65. DOI: 10.1002/wcc.81.
56. Seneviratne SI, Nicholls N, Easterling D, Goodess CM, Kanae S, Kossin J, *et al*. Changes in climate extremes and their impacts on the natural physical environment. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)], 2012.