GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
LOK SABHA
UNSTARRED QUESTION NO. 2853
TO BE ANSWERED ON WEDNESDAY, 3RD AUGUST, 2022

HEAVY RAINFALL

2853. SHRI SUBRAT PATHAK:
SHRI RAVINDRA KUSHWAHA:
SHRI RAVI KISHAN:
SHRI RAM KRIPAL YADAV:
SHRI MANOJ TIWARI:
SHRI SHRIRANG APPA BARNE:
SHRI DHAIRYASHEEL SAMBHAJIRAO MANE:
SHRI SANJAY SADASHIVRAO MANDLIK:
SHRI PRATAPRAO JADHAV:
SHRI BIDYUT BARAN MAHATO:
SHRI SUDHEER GUPTA:

Will the Minister of EARTH SCIENCES be pleased to state:

(a) whether the rainfall pattern is changing drastically in different parts of the country, wherein some parts like Assam, Gujarat and parts of Maharashtra are experiencing heavy rainfall and some parts particularly northern planes are facing draught like conditions even in the monsoon time;
(b) if so, the details thereof and the actual rainfall recorded between June and till date in each State;
(c) whether the India Meteorological Department/the Government has conducted any survey through experts to ascertain the reasons for extreme diversity in the rainfall during the monsoon season recently and if so, the outcome therefor;
(d) whether unplanned development leading to obstruction of natural drainage is primarily responsible for this extreme monsoon and if so, the details thereof and the steps taken by the Government to rectify the same; and
(e) the details of other steps taken by the Government to prevent such extreme monsoon conditions?

ANSWER
THE MINISTER OF STATE (INDEPENDENT CHARGE) FOR
MINISTRY OF SCIENCE AND TECHNOLOGY
AND EARTH SCIENCES
(DR. JITENDRA SINGH)

(a) There are changes in monsoon rainfall distribution as seen in district wise trend in rainfall .IMD has carried out an analysis of observed monsoon rainfall variability and changes of 29 States & Union Territory at State and District levels based on the IMD's observational data of recent 30 years (1989- 2018) during the Southwest monsoon season from June to September (JJAS) and issued a report on 30 March 2020. The reports on observed rainfall variability and its trend for each State and Union Territory are available in IMD website (https://mausam.imd.gov.in/) under "PUBLICATIONS" as well as in IMD Pune website;

http://www.imdpune.gov.in/hydrology/rainfall%20variability%20page/rainfall%20trend.html

The **highlights of the report** are given below;

- Five states viz., Uttar Pradesh, Bihar, West Bengal, Meghalaya and Nagaland have shown significant decreasing trends in southwest monsoon rainfall during the recent 30 years period (1989-2018).

- The annual rainfall over these five states along with the states of Arunachal Pradesh and Himachal Pradesh also show significant decreasing trends.

- Other states do not show any significant changes in southwest monsoon rainfall during the same period.

- Considering district-wise rainfall, there are many districts in the country, which show significant changes in southwest monsoon and annual rainfall during the recent 30 years period (1989-2018). With regard to the frequency of heavy rainfall days, significant increasing trend is observed over Saurashtra & Kutch, Southeastern parts of Rajasthan, Northern parts of Tamil Nadu, Northern parts of Andhra Pradesh and adjoining areas of Southwest Odisha, many parts of Chhattisgarh, Southwest Madhya Pradesh, West Bengal, Manipur & Mizoram, Konkan & Goa and Uttarakhand.

(b) Statewise rainfall statistics for the period from 01 June 2022 to 27 July 2022 is given in Annexure-I.

(c) The Ministry of Earth Sciences (MoES), has recently published a Climate Change report entitled "Assessment of Climate Change over the Indian Region" (http://cccr.tropmet.res.in/home/docs/cccr/2020_Book_AssessmentOfClimateChangeOverT.pdf). The report highlights the effects of human-made global warming induced climate change. The summer monsoon precipitation (June to September) over India has declined by around 6% from 1951 to 2015, with notable decrease over the Indo-Gangetic Plains and the Western Ghats. There is an emerging consensus, based on multiple datasets and climate model simulations, that the radiative effects of anthropogenic aerosol forcing over the Northern Hemisphere have considerably offset the expected precipitation increase from Green House Gas (GHG) warming and contributed to the observed decline in summer monsoon precipitation. The Hindu Kush Himalayas (HKH) experienced a temperature rise of about 1.3°C 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.

The main summary of the Report given in ***Annexure-II***

(d) Dissemination of forecasts and warnings for extreme weather events like heavy rainfall are the primary mandates of this ministry. The development related data are being maintained by the respective State Governments. However, IMD forewarn the State Government and the disaster response teams with impact based forecasting and colour coded warnings for timely action.

(e) The extreme rainfall events are induced by the anthropogenic impacts on the weather and climate system. Ministry of Environment, Forest and Climate Change has implemented various action plans such as National Action Plan for Climate Change and State Action Plan for Climate Change towards adapting and mitigating these impacts on the climate system.

Annexure-I

STATE/UT-WISE RAINFALL DISTRIBUTION
Period 01-06-2022 to 27-07-2022

S NO	STATE/UT	ACTUAL (mm)	NORMAL (mm)	% DEP.	CAT.
	REGION : EAST AND NORTH EAST INDIA	**597.3**	**703**	**-15%**	**N**
1	ARUNACHAL PRADESH	880.6	929	-5%	N
2	ASSAM	897.3	814.2	10%	N
3	MEGHALAYA	1770.1	1524.6	16%	N
4	NAGALAND	462.2	524.2	-12%	N
5	MANIPUR	363.2	546.1	-33%	D
6	MIZORAM	667.8	789.3	-15%	N
7	TRIPURA	549.9	752.3	-27%	D
8	SIKKIM	888.8	856	4%	N
9	WEST BENGAL	478.2	652.6	-27%	D
10	JHARKHAND	232.8	467.4	-50%	D
11	BIHAR	269.1	462.9	-42%	D
	REGION : NORTH WEST INDIA	**261.9**	**257.5**	**2%**	**N**
1	UTTAR PRADESH	155.1	322.9	-52%	D
2	UTTARAKHAND	453.9	536.1	-15%	N
3	HARYANA	202.8	184.9	10%	N
4	CHANDIGARH (UT)	499.8	379.7	32%	E
5	DELHI (UT)	207.9	227.7	-9%	N
6	PUNJAB	224.6	193.7	16%	N
7	HIMACHAL PRADESH	282.7	321.2	-12%	N
8	JAMMU & KASHMIR (UT)	281.3	234.1	20%	E
9	LADAKH (UT)	10.7	10.6	1%	N
10	RAJASTHAN	308	194.3	58%	E
	REGION : CENTRAL INDIA	**562.2**	**448.4**	**25%**	**E**
1	ODISHA	497.1	501.6	-1%	N
2	MADHYA PRADESH	496.1	407	22%	E
3	GUJARAT	529.9	331.8	60%	LE
4	DADRA & NAGAR HAVELI AND DAMAN & DIU (UT)	1950.4	1128.6	73%	LE
5	GOA	2023.7	1836.3	10%	N
6	MAHARASHTRA	660.4	490.6	35%	E
7	CHHATTISGARH	564.7	512.7	10%	N
	REGION : SOUTH PENINSULA	**440.2**	**339.6**	**30%**	**E**
1	ANDAMAN & NICOBAR (UT)	797.7	750.5	6%	N
2	ANDHRA PRADESH	250.6	207.7	21%	E
3	TELANGANA	665	321.1	107%	LE
4	TAMIL NADU	196.4	110.8	77%	LE
5	PUDUCHERRY (UT)	182.4	144.7	26%	E
6	KARNATAKA	518.1	421.8	23%	E
7	KERALA	929.4	1224.2	-24%	D
8	LAKSHADWEEP (UT)	632	599.8	5%	N
	COUNTRY : INDIA	**451.5**	**408.9**	**10%**	**N**

LEGENDS:		
LargeExcess: (+60%ormore)	LargeDeficient: (-60%to-99%)	A:ActualRainfall(mm)
Excess: (+20%to+59%)	*Scanty:(-20%to-99%)*	N:NormalRainfall(mm)
Normal: (+19%to-19%)	NoRain(-100%)	D: Departurefromnormal(%)
Deficient: (-20%to-59%)	DataInadequate:**	Rainfallupto0.4mm:*

Annexure-II

Highlights of the Assessment report

The summary on the variability and change of the regional climate system based onthe 12 chapters in this book is as follows.

Observed Changes in Global Climate

The global average temperature has risen by around 1°C since pre-industrial times. This magnitude and rate of warming cannot be explained by natural variations alone and must necessarily take into account changes due to human activities. Emissions of greenhouse gases (GHGs), aerosols and changes in Land Use and Land Cover (LULC) during the industrial period have substantially altered the atmospheric composition, and consequently the planetary energy balance, and are thus primarily responsible for the present-day climate change. Warming since the 1950s has already contributed to a significant increase in weather and climate extremes globally (e.g., heat waves, droughts, heavy precipitation, and severe cyclones), changes in precipitation and wind patterns (including shifts in the global monsoon systems), warming and acidification of the global oceans, melting of sea ice and glaciers, rising sea levels, and changes in marine and terrestrial ecosystems.

Projected Changes in Global Climate

Global climate models project a continuation of human-induced climate change during the twenty-first century and beyond. If the current GHG emission rates are sustained, the global average temperature is likely to rise by nearly 5°C, and possibly more, by the end of the twenty-first century. Even if all the commitments (called the "Nationally Determined Contributions") made under the 2015 Paris agreement are met, it is projected that global warming will exceed 3°C by the end of the century. However, temperature rise will not be uniform across the planet; some parts of the world will experience greater warming than the global average. Such large changes in temperature will greatly accelerate other changes that are already underway in the climate system, such as the changing patterns of rainfall and increasing temperature extremes.

Climate Change in India: Observed and Projected Changes

Temperature Rise Over India

India's average temperature has risen by around 0.7°C during 1901–2018. This rise in temperature is largely on account of GHG-induced warming, partially offset by forcing due to anthropogenic aerosols and changes in LULC. By the end of the twenty-first century, average temperature over India is projected to rise by approximately 4.4°C relative to the recent past (1976–2005 average), under the RCP8.5 scenario. Projections by climate models of the Coupled Model Inter-comparison Project Phase 5(CMIP5) are based on multiple standardized forcing scenarios called Representative Concentration Pathways (RCPs). Each scenario is a time series of emissions and concentrations of the full suite of GHGs, aerosols, and chemically active gases, as well as LULC changes through the twenty-first century, characterized by the resulting Radiative Forcing (A measure of an imbalance in the Earth's energy budget owing to natural (e.g., volcanic eruptions) or human-induced (e.g., GHG from fossil fuel combustion) changes) in the year 2100 (IPCC 2013). The two most commonly analyzed scenarios in this report are "RCP4.5" (an intermediate stabilization pathway that results in a Radiative Forcing of 4.5 W/m2 in 2100) and "RCP8.5" (a high concentration pathway resulting in a Radiative Forcing of 8.5 W/m2 in 2100).

In the recent 30-year period (1986–2015), temperatures of the warmest day and the coldest night of the year have risen by about 0.63°C and 0.4°C, respectively.

By the end of the twenty-first century, these temperatures are projected to rise by approximately 4.7°C and 5.5°C, respectively, relative to the corresponding temperatures in the recent past (1976–2005 average), under the RCP8.5 scenario.

By the end of the twenty-first century, the frequencies of occurrence of warm days and warm nights are projected to increase by 55% and 70%, respectively, relative to the reference period 1976-2005, under the RCP8.5 scenario.

The frequency of summer (April–June) heat waves over India is projected to be 3 to 4 times higher by the end of the twenty-first century under the RCP8.5 scenario, as compared to the 1976–2005 baseline period. The average duration of heat wave events is also projected to approximately double, but with a substantial spread among models.

In response to the combined rise in surface temperature and humidity, amplification of heat stress is expected across India, particularly over the Indo-Gangetic and Indus river basins.

Indian Ocean Warming

Sea surface temperature (SST) of the tropical Indian Ocean has risen by 1°C on average during 1951–2015, markedly higher than the global average SST warming of 0.7°C, over the same period. Ocean heat content in the upper 700 m (OHC700) of the tropical Indian Ocean has also exhibited an increasing trend over the past six decades (1955–2015), with the past two decades (1998–2015) having witnessed a notably abrupt rise.

During the twenty-first century, SST and ocean heat content in the tropical Indian Ocean are projected to continue to rise.

Changes in Rainfall

The summer monsoon precipitation (June to September) over India has declined by around 6% from 1951 to 2015, with notable decreases over the Indo-Gangetic Plains and the Western Ghats. There is an emerging consensus, based on multiple datasets and climate model simulations, that the radiative effects of anthropogenic aerosol forcing over the Northern Hemisphere have considerably offset the expected precipitation increase from GHG warming and contributed to the observed decline in summer monsoon precipitation.

There has been a shift in the recent period toward more frequent dry spells (27% higher during 1981–2011 relative to 1951–1980) and more intense wet spells during the summer monsoon season. The frequency of localized heavy precipitation occurrences has increased worldwide in response to increased atmospheric moisture content. Over central India, the frequency of daily precipitation extremes with rainfall intensities exceeding 150 mm per day increased by about 75% during 1950–2015.

With continued global warming and anticipated reductions in anthropogenic aerosol emissions in the future, CMIP5 models project an increase in the mean and variability of monsoon precipitation by the end of the twenty-first century, together with substantial increases in daily precipitation extremes.

Droughts

The overall decrease of seasonal summer monsoon rainfall during the last 6–7 decades has led to an increased propensity for droughts over India. Both the frequency and spatial extent of droughts have increased significantly during 1951–2016. In particular, areas over central India, southwest coast, southern peninsula and north-eastern India have experienced more than 2 droughts per decade, on average, during this period. The area affected by drought has also increased by 1.3% per decade over the same period.

Climate model projections indicate a high likelihood of increase in the frequency (>2 events per decade), intensity and area under drought conditions in India by the end of the twenty-first century under the RCP8.5 scenario, resulting from the increased variability of monsoon precipitation and increased water vapour demand in a warmer atmosphere.

Sea Level Rise

Sea levels have risen globally because of the continental ice melt and thermal expansion of ocean water in response to global warming. Sea-level rise in the North Indian Ocean (NIO) occurred at a rate of 1.06–1.75 mm per year during 1874–2004 and has accelerated to 3.3 mm per year in the last two and a half decades (1993–2017), which is comparable to the current rate of global mean sea-level rise.

At the end of the twenty-first century, steric sea level in the NIO is projected to rise by approximately 300 mm relative to the average over 1986–2005 under the RCP4.5 scenario, with the corresponding projection for the global mean rise being approximately 180 mm.

Tropical Cyclones

There has been a significant reduction in the annual frequency of tropical cyclones over the NIO basin since the middle of the twentieth century (1951–2018). In contrast, the frequency of very severe cyclonic storms (VSCSs) during the post-monsoon season has increased significantly (+1 event per decade) during the last two decades (2000–2018). However, a clear signal of anthropogenic warming on these trends has not yet emerged.

Climate models project a rise in the intensity of tropical cyclones in the NIO basin during the twenty-first century.

Changes in the Himalayas

The Hindu Kush Himalayas (HKH) experienced a temperature rise of about 1.3°C 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 end of the twenty-first century, the annual mean surface temperature over HKH is projected to increase by about 5.2°C under the RCP8.5 scenario. The CMIP5 projections under the RCP8.5 scenario indicate an increase in annual precipitation, but decrease in snowfall over the HKH region by the end of the twenty-first century, with large spread across models.

Conclusions

Since the middle of the twentieth century, India has witnessed a rise in average temperature; a decrease in monsoon precipitation; a rise in extreme temperature and rainfall events, droughts, and sea levels; and an increase in the intensity of severe cyclones, alongside other changes in the monsoon system. There is compelling scientific evidence that human activities have influenced these changes in regional climate.

Human-induced climate change is expected to continue apace during the twenty-first century. To improve the accuracy of future climate projections, particularly in the context of regional forecasts, it is essential to develop strategic approaches for improving the knowledge of Earth system processes, and to continue enhancing observation systems and climate models.

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