23

STANDING COMMITTEE ON WATER RESOURCES

(2022-23)

SEVENTEENTH LOK SABHA

MINISTRY OF JAL SHAKTI
DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

Glacier Management in the Country- Monitoring of Glaciers/Lakes including Glacial Lake Outbursts leading to Flash-floods in the Himalayan Region

TWENTY THIRD REPORT

LOK SABHA SECRETARIAT

NEW DELHI

March, 2023 /Chaitra,1945 (Saka)

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Presented to Lok Sabha on 29.03.2023

Laid on the Table of Rajya Sabha on 29.03.2023

LOK SABHA SECRETARIAT

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INTRODUCTION

I, the Chairperson, Standing Committee on Water Resources (2022-23) having been authorised by the Committee to submit the Report on their behalf, present the Twenty Third Report on “Glacier Management in the Country- Monitoring of Glaciers/Lakes including Glacial Lake Outbursts leading to Flash-floods in the Himalayan Region".

2. The Standing Committee on Water Resources (2020-21) had taken up the subject “Glacier Management in the Country- Monitoring of Glaciers/Lakes including Glacial Lake Outbursts leading to Flash-floods in the Himalayan Region" for examination and report. As the Report could not be finalized during the tenure of the Committee (2020-21), this subject was again selected by the Committee in their successive tenures i.e. 2021-22 and 2022-23 for detailed examination and Report. The Committee took evidence of the representatives of the Ministry of Jal Shakti – Department of Water Resources, River Development & Ganga Rejuvenation; Ministry of Home Affairs - National Disaster Management Authority and National Disaster Response Force; Ministry of Environment, Forest & Climate Change; Ministry of Earth Sciences; Department of Science and Technology - Wadia Institute of Himalayan Geology; Geological Survey of India (GSI); National Institute of Hydrology (NIH); and Defence Research & Development Organisation - Defence Geoinformatics Research Establishment (DGRE) on 23 March, 2021; 08 April, 2021; and 21 June, 2021.

3. The Report was considered and adopted by the Committee at their sitting held on 23.03.2023.

4. The Committee wish to express their thanks to the representatives of the Ministry of Jal Shakti – Department of Water Resources, River Development & Ganga Rejuvenation; Ministry of Home Affairs - National Disaster Management Authority and National Disaster Response Force; Ministry of Environment, Forests & Climate Change; Ministry of Earth Sciences; Department of Science & Technology - Technology - Wadia Institute of Himalayan Geology; Geological Survey of India (GSI); National Institute of Hydrology (NIH); and Defence Research & Development Organisation (DRDO) - Defence Geoinformatics Research Establishment (DGRE) for providing the requisite written information as also for depositions made before the Committee in connection with the detailed examination of the subject.

5. The Committee would also like to place on record their sense of deep appreciation for the assistance rendered to them by the officials of the Lok Sabha Secretariat attached to the Committee.

NEW DELHI;
28 March, 2023
07 Chaitra, 1945 (Saka)

Parbatbhai Savabhai Patel
Chairperson,
Standing Committee on Water Resources

ABBREVIATIONS

AWiFS		Advanced Wide Field Sensor
AWS		Automatic Weather Stations
BIS		Bureau of Indian Standards
CEA		Central Electricity Authority
CGRSM		Centre for Glacial Research, Studies and Management
CGWB		Central Ground Water Board
CMP		Crisis Management Plan
CPCB		Central Pollution Control Board
CWC		Central Water Commission
DGRE		Defence Geoinformatics Research Establishment
DM		Disaster Management
DMP		Disaster Management Plan
DRDO		Defence Research and Development Organisation
DoS		Department of Space
DoWR, RD & GR		Department of Water Resources, River Development & Ganga Rejuvenation
DST		Department of Science and Technology
EAC		Expert Appraisal Committee
EB		Expert Body
EIA		Environmental Impact Assessment
EMP		Environment Management Plan
ENVIS		Environmental Information System
EO		Earth Observation
EPR	:	Extended Producer Responsibility
GBP-NIHE		G.B. Pant National Institute of Himalayan Environment

GIS		Geographical Information System
Gt		Gigatonnes
GLOFs	:	Glacial Lake Outburst Floods
GLs/WBs		Glacial Lakes /Water Bodies
GSI	:	Geological Survey of India
HEP		Hydro Power Projects
HFL		Highest Flood Level
H-K		Himalayan-Karakoram
HKH		Hindu Kush Himalaya
HNBGU		H.N.B Garhwal University
IAF		Indian Air Force
IASH		International Association of Scientific Hydrology
ICIMOD		International Centre for Integrated Mountain Development
IHR	:	Indian Himalayan Region
IMD		India Meteorological Department
IISc		Indian Institute of Science
IITI		Indian Institute Technology Indore
IITR		Indian Institute of Technology Roorkee
IPCC		Intergovernmental Panel on Climate Change
ISRO		Indian Space Research Organization
LIA		Little Ice Age
LLOF		Landslide Lake Outburst Flood
LSD		Lake Shore Drive
MMC		Mountain Metrological Centre
MoEF& CC		Ministry of Environment, Forests and Climate Change
MoES		Ministry of Earth Sciences
MoJS		Ministry of Jal Shakti
MW		Mega Watt
NBC		National Building Code of India
NCAP	:	National Clean Air Programme

NCPOR		National Centre for Polar and Ocean Research
NDMA	:	National Disaster Management Authority
NDMP	:	National Disaster Management Plan
NDRF		National Disaster Response Force
NGOs		Non-Governmental Organizations
NHP		National Hydrology Project
NIH		National Institute of Hydrology
NITI Ayog		National Institution for Transforming India Ayog
NLCs		Nature Learning Centres
NMNH		National Museum of Natural History
NMSHE		National Mission on Sustaining Himalayan Ecosystem
NRSC		National Remote Sensing Centre
NSCS		National Security Council Secretariat
PCCs		Pollution Control Committees
PM-STIAC		Prime Minister's Science, Technology and Innovation Advisory Council
QRTs	:	Quick Response Teams
SDMP		State Disaster Management Plan
SEIAA		State or Union Territory Level Environment Impact Assessment Authority
SERB	:	Science & Engineering Research Board
SFISAR	:	Swiss Federal Institute for Snow and Avalanche Research
SITREP	:	Situation Reports
SPCBs	:	State Pollution Control Boards
SoI	:	Survey of India
SOP	:	Standard Operating Procedure
ULBs	:	Urban Local Bodies
UNFCCC	:	United Nations Framework Convention on Climate Change
USGS	:	United States Geological Survey
WIHG	:	Wadia Institute of Himalayan Geology
WRF	:	Weather Research and Forecasting

Report

Part – I

NARRATION

CHAPTER - I

Introductory

1.1 Glaciers are important components of the hydrological cycles of the Indian Himalayan region as these are the source of three large river systems, i.e. the Indus, Ganges, and Brahmaputra, which provide water for millions of people in the country and accordingly, the Hindu Kush Himalayan Region (HKH) is also known as 'Water Towers of Asia'. Thus, the river systems and associated groundwater forms a significant water resource for the country. The Himalayan glaciers ensure water availability even in post-monsoon period as the base flow of the glacial stream, besides ground water contribution in the river system of perennial rivers. As such, glacier is very important for water security of the country.

1.2 Taking note of the frequent disasters in the Himalayan region viz. Landslides, cloudburst, Landslide Lake Outburst Floods, Glacial Lake Outburst Flood in the recent past and recent flashflood that occurred in Chamoli District of Uttrakhand in February, 2021 due to glacial lake outburs leading to loss of lives and properties, the Committee have taken up the subject "Glacier Management in the Country- Monitoring of Glaciers/Lakes including Glacial Lake Outbursts leading to Flashfloods in the Himalayan Region" for detailed examination and report to understand the impact of glacier melting/retreat and their outburst and the significant risks it has posed not just to the people who live at foothills but also to the stability of water resources in the region. In this Report, the Committee have dwelled on such issues as melting and retreating of Himalayan Glaciers, Black Carbon and its impact on Himalayan Glaciers, Glacier Management and Glacial Lake Outburst Floods (GLOFs). The views of the Ministry and related aspects have been dealt with in succeeding paragraphs in Part – I of this Report. The Observations/Recommendations have been included in Part – II of this Report.

Definition of Glacier

1.3 A glacier is a multi-year accumulation of snowfall in excess of snowmelt on land, resulting in a mass of ice, at least 0.1 Km^2 in area that exhibits some evidence of movement in response to gravity. As per United States Geological Survey (USGS) Climate Change in Mountain Ecosystems Program, minimum size of a glacier should be 0.1 Km^2. There is no specific size to differentiate between major glaciers and minor glaciers. The classification of individual glaciers has been provided in six-digit form as specified in UNESCO / International Association of Scientific Hydrology (IASH) which has been used by Geological Survey of India (GSI) while compiling inventory of the Himalayan glaciers (Published in 2009).

Table-1: Classification of the glaciers (UNESCO / IASH)

	Digit 1	***Digit 2***	***Digit 3***	***Digit 4***	***Digit 5***	***Digit 6***
	Primary Classification	***Form***	***Frontal characteristics***	***Longitudinal profile***	***Major source of nourishment***	***Activity of tongue***
0	*Uncertain or misc.*	*Uncertain or misc.*	*Normal or misc.*	*Uncertain or misc.*	*Uncertain or misc.*	*Uncertain.*
1	*Continental ice sheet*	*Compound basins*	*Piedmont*	*Even; regular*	*Snow and/or drift snow*	*Marked retreat*

2	*Ice-field*	*Compound basin*	*Expanded foot*	*Hanging*	*Avalanche ice and/or avalanche snow*	*Slight retreat.*
3	*Ice cap*	*Simple basin*	*Lobed*	*Cascading*	*Superimposed ice*	*Stationary*
4	*Outlet glacier*	*Cirque*	*Calving*	*Ice-fall*		*Slight advance*
5	*Valley glacier*	*Niche*	*Confluent*	*Interrupted*		*Marked advance*
6	*Mountain glacier*	*Crater*				*Possible surge.*
7	*Glacieret and snow field*	*Ice apron*				*Known surge*
8	*Ice shelf*	*Group*				*Oscillating*
9	*Rock glacier*	*Remnant*				

Glacier vis-a-vis Himalayan Cryosphere

1.4 A glacier is a large mass of ice formed by compaction and re-crystallization of snow and moving slowly by creep down slope due to the stress of its own weight. Whereas, Cryosphere is an all-encompassing term for those portions of Earth's surface where water is in solid form, including sea ice, lake ice, river ice, snow cover, glaciers, ice caps, ice sheets and frozen ground. Himalayan Cryosphere plays an important role as most of the major river system of Asia originate in the Himalayas and is a sensitive indicator of climate change. Melt water from Himalayan snow and glaciers is perennial source for irrigation, hydropower, domestic water requirements and sustainability of bio-diversity & environment in particular. They are vast reservoirs of snow and glaciated ice. The major river systems of North India, namely, the Indus, the Ganges, the Brahmaputra and their tributaries originate in the Himalayas. The contribution of the snow and glacier melt to these snowfed rivers of India is well recognized and most of it is received in the summer months of April to June.

As per the inventory published by the Geological Survey of India (GSI), which is the nodal government agency on survey and monitoring of glaciers in the country, there are as many as 9775 glaciers in the Indian Himalayan Region (IHR). Glaciers are important components of the hydrological cycles and are sensitive to changes in the regional and global climate. Melting glaciers due to any impact of Climate Change will not only severely affect the flow in Himalayan river system but will also give rise to disasters like Glacier Lake Outburst Flood (GLOF), Glacier avalanche, Landslide etc.

Glaciers located in the Indian Himalayan region

1.5 As per Inventory of Himalayan Glaciers maintained by Geological Survey of India (GSI) *(GSI Spl. publication no 34, 2009),* information / data regarding glaciers located in the Indian Himalayan region is as follows:-

Basin Name	***Indus****	***Ganga***	***Brahmaputra***	***Total***
Basin Identification	*5Q*	*5O1*	*5O2*	
No. of glaciers	*7462*	*968*	*610*	*9040*
Glacierised area (sq km)	*14714.48*	*2884.40*	*928.91*	*18527.79*
Total ice volume (cubic km)	*1042.78*	*213.75*	*49.57*	*1306.10*
Largest glacier				
Identification Number	*5O103 02 003*	*5O131 06 029*	*5O103 04 015*	
Length (km)	*73*	*30.20*	*9.8*	
Area (sq km)	*541.78*	*143.58*	*18.08*	
Volume (cubic km)	*108.36*	*28.72*	*1.446*	

** Data on 535 glaciers of Gilgit sector not included as data is based on regional assessment.*

Since inception of Glaciology Division in 1974, GSI has conducted studies on melting of the glaciers by assessment of mass balance studies on nine glaciers and also carried out field observation on recession/ advancement of 76 glaciers. Majority of Himalayan glaciers are observed melting/ retreating at varying rates in different regions as per the details given at ***Annexure-I****.*

1.6 On being asked about the total quantum of glacial water stored in Himalayas and the proportion of ice/snow water therein, the DoWR, RD & GR in its reply stated as follows:-

"As per the inventory of Himalayan Glaciers, a total of 1306.1 cubic km of ice volume (about 1110 cu. km of water) is locked up in glacierised basins of Indus, Ganga and Brahmaputra (Spl. Publication No. 34, GSI, 2009). Specific information about separate volume of ice and snow water is not available".

CHAPTER - II

MELTING AND RETREATING OF HIMALAYAN GLACIERS

2.1 Ground based studies on estimation of mass balance and retreat of glaciers in the Indian Himalayan Region indicate that the glaciers are retreating and losing their mass (negative mass balance), except for some glaciers in the Karakoram, which are gaining mass or advancing. A recent study spreading across India, China, Nepal and Bhutan states that glaciers melted at a rate of 0.25 m per year during 1975 to 2000 and have been melting at ~double the rate (0.5m) since 2000. Therefore, the retreating and melting of Himalayan glaciers poses a significant threat to the water security of the country. There is no comprehensive information about the volume loss of glaciers in the Indian Himalayan Region.

2.2 Explaining the problem of incessant melting and retreating of Himalayan Glaciers and the estimated volume loss of glaciers between the year(s), the Department in its written reply stated as follows:

> *"Geological Survey of India (GSI) has not conducted specific studies on estimated volume loss of glaciers between 1950 and 2020 and also not projected any estimate of loss by the year 2100. Since inception of Glaciology Division in 1974, GSI has conducted studies on melting of the glaciers by assessment of mass balance studies on nine glaciers and also carried out monitoring the recession/ advancement of 76 glaciers. Majority of Himalayan glaciers are observed melting/ retreating at varying rates in different regions."*

2.3 On being asked about the impact of melting of glaciers on the sea-level rise both in short term and long term, the DoWR, RD & GR replied as under:-

> *"According to the IPCC report 2021, the glaciers of Hindu Kush Himalaya (HKH) are shrinking and the snow cover has been reducing since the early 21st century and glaciers have also been thinned, retreated and lost mass since the 1970s. Further the global mean sea level is rising at a rate of around 3.7 mm/yr, according to estimates made between 2006 and 2018. In the long term, the melting of glaciers also contributes to the sea level rising and threatens to submerge some coastal cities in the country. In the short term, the sea level rise may cause the change in rainfall pattern and seasonal flooding in the coastal areas".*

2.4 When asked about the other adverse consequences of melting of glaciers especially on the ecology of the Himalayans, the Departement in their written reply stated as under:-

> *"Melting of glaciers may lead to shift of tree line in the Himalaya and may also cause change in phonological behaviour of plants. It may impact the livelihoods of mountain people and downstream populations. Such changes may lead to negative impact on biodiversity conservation and ecosystem services of the Himalaya".*

Black Carbon and its impact on Himalayan Glaciers

2.5 The Committee desired to know about the impact of black carbon and the threat it poses to Himalayan Glaciers. In response, the DoWR, RD & GR in their written reply stated as under:-

> *"Black carbon particles consist of nearly pure elemental carbon with some oxygen and hydrogen bound into layered, hexagonal structure which corresponds to a*

somewhat disordered graphitic crystal structure.Black carbon is formed by the incomplete combustion of fossil fuels, wood and other fuels.
Formation of atmospheric aerosol layers consisting of black carbon particles up to 5 km elevation near mid and alpine Himalaya results in the so-called 'elevated heat pump effect' inevitably forcing the current state of Himalayan climate dynamical system to substantially change the mean variability.Black carbon absorbs more light and emits infra-red radiation that increases the temperature. Therefore, an increase in black carbon in the high Himalayas contribute to the faster melting of glaciers".

2.6 When asked further, if any study has been conducted by the Government to assess the adverse impact of black carbon on Himalayan Glaciers, the Departement in its written reply stated as follows:-

"Some studies have been conducted by different organizations/ institutes in the country on the effect of pollution in Himalayas. The study conducted by H.N.B Garhwal University at Satopanth Glacier in the Central Himalayas indicates that black carbon is majorly transported through air mass from Indo Gangetic Plains.
The G.B. Pant National Institute of Himalayan Environment and Wadia Institute of Himalayan Geology (WIHG) have also conducted studies on two glaciers i.e., Parbati in Himachal Pradesh and Gangotri in Uttarakhand. The observations showed moderate presence of carbonaceous aerosols viz. organic, elemental and black carbon.

Also, studies conducted by National Centre for Polar and Ocean Research and Space Physics Laboratory under Ministry of Earth Sciences at their Himansh station in Lahaul-Spiti region have revealed that the total suspended particulate matter showed significant variations having dominance of mineral dust components (~67%). The black carbon contributes ~ 4% to near surface composite aerosol mass concentrations.

However, in this regard, detailed research is required for complete understanding of the black carbon emissions in the Himalayas".

2.7 On being further asked about the steps taken to limit the perilous impact of black carbon on Himalayan Glaciers and with what result, the Department in written reply stated as under:-

"Government of India has taken several steps to curb environmental pollution in Himalayan States which, inter alia, includes leapfrogging from BS-IV to BS-VI norms for fuel and vehicles from 1st April, 2020; Introduction of cleaner/alternate fuels like CNG, LPG, ethanol blending in petrol; Faster Adoption and Manufacturing of Electric Vehicles (FAME) -2 scheme; shifting of Brick kilns to zig-zag technology; setting up of waste processing plants; Extended Producer Responsibility (EPR) for plastic and e-waste management, etc.

The Central Government launched National Clean Air Programme (NCAP) as a comprehensive plan to tackle air pollution problem across the country including the States of Himalayan region in a focused manner to achieve 20% to 30% reduction in PM10 and PM2.5 levels by 2024 from 2017 levels. Ambient air quality is being monitored through a network of manual and real time air quality monitoring stations in 394 cities/ towns.

City Specific Clean Air Action Plans have been prepared and rolled out for implementation in 132 non-attainments and million plus population cities, which

include 02 non-attainment cities in Jammu & Kashmir (Jammu, Srinagar), 03 non-attainment cities in Uttarakhand (Kashipur, Rishikesh and Dehradun) and 07 non-attainment cities in Himachal Pradesh (Baddi, Damtal, Kala Amb, Nalagarh, Paonta Sahib, Parwanoo and Sunder Nagar).

Ministry of New and Renewable Energy is giving financial assistance to States for setting up of waste to energy plants. Scheme like 'Pradhan Mantri UjjwalaYojana' is promoting use of cleaner household cooking fuels.

Under Central Sector Scheme of Ministry of Agriculture 'Promotion of Agricultural Mechanization for in-situ management of crop residue practices has been introduced in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi'.

The States and Union Territories of the Indian Himalayan Region have taken several steps to curb environmental pollution which inter-alia includes banning of burning of plastic and garbage, establishment of compactors to compact segregated recyclables (plastic, rubber, cardboard, jute bags etc.). Government of Himachal Pradesh has also regulated the number of vehicles plying to Rohtang pass to 1200 (800 diesels and 400 petrol) in a day".

2.8 When asked about the impact of melting of glaciers which are literally the water towers of the country, on the water security in the country both in terms of water availability and the extreme changes in the flow of rivers thus destabilizing Himalayan rivers, the Department in its written reply stated as under:-

"The presence of the Himalayan glaciers ensures water availability even in post-monsoon period as the base flow of the glacial stream, besides ground water contribution in the river system of perennial rivers.

Presently, hydrological observations are being carried out by CWC at 1543 sites on all major rivers in India including Himayayan river system. Analysis of hydrological data observed at Rishikesh site on Ganga river,Tutingsite on Brahmaputra river and Premnagar site on Chenab river located at foothills of Himalayas for the period from 2010 to 2020, indicates that there are fluctuations in average annual discharge of these rivers. However, there is no specific trend of variations as far as annual discharge is concerned."

2.9 When asked about the average rate of warming of Himalayan glaciers vis-a-vis global parameters as also the impact of their warming on local changes in hydrology and threatening the infrastructure, the Department stated as under:-

"As per information given by DST, it has been indicated that the Himalayan-Karakoram region is warming faster than global mean by 0.5 ^{0}C. This warming will lead to local changes in hydrology by changes in rainfall and snowfall patterns, increased melting from glaciers and threaten the infrastructure by increase in extreme events leading to disasters.

The MoEF&CC has not conducted any study or awarded any project on warming of Himalayan glaciers.

Notwithstanding, it may be noted that the glaciers and their characteristics may exhibit complex changes in specific locations such as various sub-regions in the Himalaya. There are stable, retreating, or even advancing glaciers in the Himalaya, thereby emphasizing the complex geographical and cyclical nature of the glacial dynamics. The impact of an increase in the melting rate of glaciers on the lives of

people in adjoining States is a complex and evolving subject studied through investigations, data collection and analysis of various case studies by scientists in India and all over the world.

Further, as per the World Meteorological Organization, average global temperature for 2015-2019 is estimated to be 1.1 degree Celsius above pre-industrial (1850-1900) level. According to the Ministry of Earth Sciences, in line with rising temperatures across the globe, all India mean temperature has risen by nearly 0.7degree Celsius during 1901 to 2018".

2.10 When asked whether Smaller Himalayan glaciers are more sensitive to climate change and have lost their substantial volume in the last 50 years, the Department furnished in writing the information as under:-

"As informed by MoEF&CC, the smaller Himalayan glaciers are more sensitive to climate change and their shrinkage rate is higher than the larger glaciers.

GSI has conducted studies on melting of the glaciers by assessment of mass balance studies on nine glaciers and also carried out field observation on recession/ advancement of 76 glaciers. The majority of the glaciers irrespective of size are retreating at varying rates across the Himalaya. The advancing and retreating pattern of glaciers in Himalayan region depends upon number of factors viz. type of glacier, orographic disposition, orientation, size, debris cover, ablation/ accumulation, accumulation area ratio and climatic parameters etc.

As such, comprehensive study in this regard needs to be carried out".

2.11 On being asked about the veracity of the fact that over the past 50 years, the Himalayas have become less cold with substantiated decline in number of extreme cold days and cold nights due to global warming and climate change, the DoWR,RD &GR in their written reply stated as under:-

"As per information given by MoEF&CC, the climate change studies exclusively over the Himalayas reported a consistent warming in the present climate. Trend analysis of cold days and cold nights of 16 stations across J&K and Himachal Pradesh has revealed that for most of the stations percentage number of warm days is increasing and number of cold days is decreasing. Also, similar pattern of increase /decrease in percentage number of warm /cold nights is seen. The reduction of cold days is noted to be approximately 2 to 6% within a 30-year period. However, MoEF&CC has not conducted any study or awarded any project on extreme cold days and cold nights attributable to climate change in the Himalaya".

2.12 Further, asked about target date set as per the 2015 Paris Agreement for limiting global warming, the Department in its written reply stated as under:-

"The Paris Agreement does not specify any target date for limiting global warming. It may be noted that the temperature goals of the Paris Agreement are two in number, namely 1.5^{o} C and "well below 2^{o} C". Further in Article 4.1, these temperature goals of Article 2 are described as the "long-term temperature goal". In order to achieve the long-term temperature goal set out in Article 2 "Parties aim .....to achieve balance between anthropogenic emissions by sources and removals by sinks in the second half of the century....". It may be noted here that no specific date is indicated but only a broad period of 50 years. It may also be noted that providing a specific date is not feasible due to many uncertainties including those arising from climate science as well as the inherent variability of climate. Further, the contribution to

mitigation by individual countries are made through their Nationally Determined Contributions. As these are commitments given by individual Parties by their own decision, and their compatibility with the temperature goal was not a requirement under the Agreement, setting a target date to limit global warming to the goals of the Paris Agreement, therefore, is not feasible.

Climate change is a global collective action problem. India's contribution to the problem of climate change is limited but its actions are fair and ambitious. India firmly believes in global cooperation to deal with the challenge through multilateral processes. India is a Party to the United Nations Framework Convention on Climate Change (UNFCCC), and its Kyoto Protocol and the Paris Agreement.

The central aim of the Paris Agreement is to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, by keeping global temperature rise from pre-industrial levels to well below 2 degree Celsius and pursing efforts to limit the temperature increase to 1.5 degrees Celsius. It is well established scientifically that cumulative global emissions have to stay within a global carbon budget from pre-industrial levels, with such budget being determined by the appropriate probability of not exceeding the desired temperature goal. India has always emphasized that the global carbon budget should be equitable and fairly shared, based on the foundational principles of equity and common but differentiated responsibilities and respective capabilities laid down in the UNFCCC and reiterated in the Paris Agreement".

2.13 The Committee's attention was drawn to the 2018 Niti Aayog report (Report of Working Group I Inventory and Revival of Springs in the Himalayas for Water Security) wherein it has been cautioned that almost 60 per cent of water sources in the Indian Himalayan region are on the verge of drying up and recommended launching of National Spring Water Management Programme for the Himalayan Region.

2.14 When asked about the steps taken on the recommendation of Niti Aayog for launching of National Spring Water Management Programme for the Himalayan Region, the DoWR, RD & GR in its written submission stated as under:-

"The NITI Aayog has submitted a 'Report of Working Group I Inventory & Revival of springs in the Himalayas for Water Security' during 2018. The objectives of the report including (i) to take stock of the magnitude of the problem (drying of springs & spring water quality), (ii) to review related policies across Indian Himalayan Region (IHR).

In compliance with the suggestions in the report, an inter-departmental committee was constituted by the Ministry to collect / compile Metadata of all Springs in Hilly States pan- India including Central Ground Water Board (CGWB). Accordingly, a database was created for springs existing in mountainous regions of India, especially in Indian Himalayan region (total 12 states) by compiling all information already available with SoI, CGWB, NRSC, State Governments, NGO's and other organizations. The compiled database was analyzed to create a Spring Geographical Information System(GIS) which is available as web based service in Survey of India G2G portal".

CHAPTER - III
LEGISLATIVE FRAMEWORK FOR GLACIER MANAGEMENT

3.1 The Committee have been informed that details of the Legislative Framework in regard to management of glaciers are not available in CWC. However, National Disaster Management Authority (NDMA), MHA has issued Guidelines titled "Management of Glacial Lake Outburst Floods (GLOFs)" in October 2020. As per the NDMA Guidelines, Ministry of Jal Shakti (MoJS) has been proposed as the nodal Ministry and Central Water Commission (CWC) as the nodal agency for management of Glacial Lake Outburst Flood (GLOF).

3.2 On being asked about the opinion of the Department on the adequacy of the existing Legislative Framework to achieve the intended objectives of conservation of Himalayan Glaciers and whether the Government is contemplating for any new legislation in this regard, the DoWR, RD & GR in its written reply stated that they have no comments to offer.

3.3 During the sitting held on 8.4.2021, Secretary, Ministry of Jal Shakti apprised the Committee that the 'Himalayan Cryosphere' is not specifically mentioned in the Allocation of Business Rules. When asked, whether any proposal has been mooted by the Department of Water, Resources, River Development & Ganga Rejuvenation for allocating the subject “Himalayan cryosphere” to any particular Ministry/Department, the Department stated that they have no comments to offer.

Agencies involved in monitoring and management of the Himalayan Glaciers

3.4 Elaborating the details of various agencies involved in monitoring and managing the Himalayan Glaciers, the DoWR, RD & GR stated as under:-

“The Government of India, has a number of Ministries/ Departments/ Organizations/Agencies which have mandates for handling different hydro-meteorological and hydro-geological hazards.

- *For example, GSI carries out Glacier Mass Balance Studies, Glacier Regimen Studies, Glaciers & Climate Variability Studies for selected glaciers besides Societal & related Studies in Himalayan Belt.*
- *However, scientific research is coordinated and supported by several ministries and departments like the Department of Science and Technology (DST); Ministry of Environment, Forests and Climate Change (MoEF& CC); Ministry of Earth Sciences (MoES); Defence Research and Development Organisation (DRDO), etc.*
- *Department of Space (DoS) has the mandate to monitor glaciers using remote sensing techniques. A large number of researchers belonging to various research and academic institutions in the country carry out research in glaciology and other cryospheric research areas.*
- *As per the NDMA Guidelines on Management of Glacial Lake Outburst Flood (GLOF) - October, 2020, Ministry of Jal Shakti (MoJS) has been proposed as the nodal Ministry and Central Water Commission (CWC) as the nodal agency for management of GLOF. Presently, CWC is monitoring 477 GLs/WBs (above 50 ha size) in Indian Himalayan Region.*

Some other agencies involved in monitoring and studies of the Himalayan Glaciers are given as under:

i. National Centre for Polar and Ocean Research (NCPOR)
ii. Indian Institute of Science (IISc)
iii. National Institute of Hydrology (NIH)
iv. Indian Institute of Technology Roorkee (IITR)
v. G.B. Pant National Institute of Himalayan Environment (GBP-NIHE)
vi. H.N.B Garhwal University (HNBGU)
vii. Indian Institute Technology Indore (IITI)
viii. University of Kashmir".

Studies/findings of some of the Departments/ Agencies/Institutions with regard to the spatial movement and behaviour of the Himalayan glaciers:

(i) *"Important Results from recent Studies supported by Department of Science and Technology on 'Glaciology' :*

- As per inventory prepared by GSI there are as many as 9575 glaciers in IHR.
- Glaciers are retreating as part of natural phenomenon and also due to climate and topography of the region.
- Annual rate of retreat of glaciers in IHR ranges from 5-20 m per year.
- The total glaciated area in the entire Himalayan range (including karakoram) is 40,000 $Km^{2.}$. Out of this, Indian Himalayan Region contributes nearly 23,000$Km^2$and stores 3,651 Gigatonnes (Gt) of glacier water.
- Himalayan glaciers are losing mass at the rate of 6.6±1 Gt per annum (nearly 0.2% per year).
- As per satellite based estimate, Himalaya has lost 13% of glacier area over the period of 40 years (1960-2000) (nearly 0.3% per year).
- 66.4% of total number of glaciers have area less than 1 km^2. They occupy 4% of total area and 12.8% of ice volume
- Just 3% of total number of glaciers have area more than 10 km^2 . They occupy 65% of Ice volume and cover 45% of area.
- Under climate change impact, large glaciers with area more than 10 km^2 are less likely to be impacted appreciably in near future. However, small glaciers of less than 1 km^2 area may show rapid changes

(ii) Results of study carried out by ISRO: ISRO has monitored the glacier advance and retreat of 2018 glaciers across the Indian Himalayan region using satellite data of 2000-01 to 2010-11. The study shows that 87% of glaciers showed no change, 12% of glaciers retreated, and 1% of glaciers have advanced. Further, net change in glaciated area varies from one region to another. In another study by ISRO, 5234 glaciers were monitored between the years 2001 and 2017-18 across Himalayan-Karakoram (H-K) region from Kashmir to Sikkim using satellite data. In Karakoram region (north of Indus river) gain in area (0.056%) has been observed in the area coverage of 17903 Km^2. The loss is obverved in rest of Himalayan region which varies from 0.751% to 2.32%.

3.5 When asked about the opinion of the Department with regard to involvement of multifarious agencies/institutes resulting in overlapping and duplication of efforts as well as lack of coherence in achieving the aims / objectives of different agencies, the Department in its written reply stated as under: -

"Involvement of multiple agencies/institutions results in overlapping of efforts. No demarcation of responsibilities amongst different Ministries/Departments with regard

to Glacier Management in the country has been made till date. As mentioned in reply to LoP-1 above, there are 9575 glaciers in the Indian Himalayan Region. Monitoring of such a large number of glaciers requires a coordinated effort with huge manpower and logistics. Hence, a nodal agency is very much essential for inter-agency coordination to streamline the efforts of different agencies for Glacier Management in the country.

Department of Sceince& Technology (DST) has suggested that Wadia Institute of Himalayan Geology (WIHG), an autonomous institute of DST may be considered to act as a nodal agency.

MoEF has suggested that the responsibility for the co-ordination of all activities on the Himalayan glaciers should rest with National Security Council Secretariat, Govt. of India".

Solutions/Suggestions by various Departments/Agencies/Institutions for effective 'Glacier Management in the country'

3.6 The Committee desired that all the Departments/Agencies/Institutions dealing with the subject may furnish solutions/suggestions for effective 'Glacier Monitioring and Management in the country'. In response, the concerned Departments/Agencies offered following suggestions:-

(a) Suggestions by Department of Science and Technology:

(i) **Need for a single coordinating agency to coordinate with various other agencies having mandates to handle different hydro-meteorological and hydro-geological hazards:** The Government of India, has a number of ministries/departments/ organizations/agencies which have mandates for handling different hydro-meteorological and hydro-geological hazards. For example, the Geological Survey of India under Ministry of Mines is mandated to undertake survey and monitoring of glaciers. However, scientific research is coordinated and supported by several ministries and departments like the Department of Science and Technology (DST); Ministry of Environment, Forests and Climate Change (MoEF&CC); Ministry of Earth Sciences (MoES); Defence Research and Development Organisation (DRDO), etc. Department of Space (DoS) has the mandate to monitor glaciers using remote sensing techniques. A large number of researchers belonging to various research and academic institutions in the country carry out research in glaciology and other cryospheric research areas. While, the agencies and organizations may continue to have their individual mandates for monitoring different hazards, there is a need to have a single agency which can coordinate with various other agencies especially for operational work, such as providing early warnings and alerts, etc.

(ii) **Need for a multi-hazard alert and warning system for the Indian Himalayan Region:** Several of recent hazards such as 2013 Uttarakhand disaster, recent Chamoli floods are found to have characteristics of a combination of more than one hazard. Most of present alert and warning systems that exist today deal with individual disasters. For example, India Meteorological Department has a system of providing alert and warnings for heavy rainfall and cloudbursts but they do not have any warning systems for other disasters such GLOF, Avalanches, Landslides, etc. These disasters are either dealt with by other agencies or there exist no warning systems for them. To deal with these disasters in an integrated manner, a Multi-Hazard Warning System may be put in place through a real-time coordinated mechanism wherein one agency may be entrusted with the responsibility of continuously monitoring and issuing warnings and alerts to authorities, stakeholders and public.

(iii) **Need for State Governments to work in tandem with Central agencies in the monitoring, research and warning system for Hazards:** Many of the State Governments do not participate directly as stakeholders and partners in the monitoring, research and warning system for hazards impacting them, especially in the Indian Himalayan Region. There are good examples of several coastal States in India taking proactive roles in monitoring and warming of Tropical Cyclones. Because of such close partnership with Central Government, there has been considerable saving on lives and property in these states in recent years. There is a need to have States working in tandem with Central agencies in monitoring, predicting and issuing of warnings.

(b) ***Suggestions by Ministry of Environment, Forest and Climate Change***

(i) Glaciers are a strategic national resource; they need to be protected accordingly. Glaciers of the Himalayas are difficult to access due to various obstacles like the rugged terrain, the high snow-covered elevations, and the hostile weather conditions. Hence the support of the military and the para-military forces are necessarily required for accessibility to the glaciers to study and do scientific research. Understandably, the National Security Council Secretariat (NSCS) is coordinating with various Government Agencies in various studies, including impacts of geo-engineering technologies on the glaciers. DGRE of DRDO is also working on the Himalayan glaciers. We in India have a substantial DRDO establishment. It will be of considerable value if our IITs, Indian Institute of Science Education & Research (IISER), Universities, National Institutions etc. urgently collaborate with DRDO on areas of strategic national importance in the true letter and spirit of achieving an 'Aatmanirbhar Bharat'.

(ii) In this context, it may further be mentioned that the 17th meeting of the Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) was convened on 31st March, 2021 under the chairmanship of the Principal Scientific Adviser to the Government of India on 'Trans-Himalayan Research for Informed Decision making to predict and mitigate disasters'. A copy of the minutes of the meeting is attached. The meeting summarized that a nodal agency is required to bring all stakeholders together to communicate the scientific advice effectively to predict and mitigate disasters in the Trans Himalayan region.

(iii) In view of the above, and keeping in mind the scope of the work involved, the responsibility for the co-ordination of all activities on the himalayan glaciers should rest with a single, identified nodal co-ordinating agency within Govt. of India (say, e.g. NSCS). Such an agency would need to be given an appropriate mandate (war-time mandate--because of recurrence glacier breakages, lake-bursts, cloud bursts, landslides etc. which are even happening in unison, compounding the damage to life and property) by allocating the subject through Allocation of Business Rules. However, it may be noted that it will also be the responsibility of this agency to pay particular attention to bring all providers of scientific information together for the said purpose of scientific mitigation of disaster risk due to glaciers in the Trans Himalayan region. The inter-departmental and inter-agency co-ordination may in practice by facilitated by a Inter-Ministerial Permanent Committee for Glacier-related Matters that will assist and guide the nodal co-ordinating agency in its task. The rules of business of this committee should particularly clarify the liberal and unrestricted exchange of data, except where it specifically and directly impinges on national security information.

Apart from above, the representative of the Ministry of Environment, Forest and Climate Change during the course of oral evidence on the subject, apprised the Committee as follows:-

"There is enormity of the issue because we have 34,919 glacials in the Indian Himalayan region. Of that, 87 per cent are in status quo and 12 per cent are receding and one per cent is even increasing. So, we have on one side the enormity of the issue and on the other side, there is complexity. It is because glacials are stable, retreating, advancing and also we have the cyclic nature in a very complex system. So, we have this enormous and complex situation. How are we dealing with it? We are dealing through research project. That is what Sir, you have hit the nail on the head in your first question. Our method of dealing with such an enormous problem, such a complex problem is done by frittered research projects. This does not lead to any actionable points. Sir, the second point which hon. Members made and you seconded it and Secretary also pointed out the same is that there is neither synergy nor linkage nor coordination. So, everybody is doing everything and we are not casting any aspersions on the good research done by the Indian scientists. We may be even world leaders in that research. But it does not lead to any actionable point because you ask that why did the alarm bell did not sound. So, for cyclones, we have very advance warning systems. For this, we have nothing at the moment. Everywhere you touch, you will find gap areas. ....But Sir, after all these discussions, the matter gets precipitated on one point that ISRO does the research from the top, GSI does research on field and DST has research projects. So, MoES has a field station. But this research is not for that kind of management which you people have asked. That is the moot point".

(c) <u>Suggestions given by Ministry of Earth Sciences</u>

(i) Monitoring the Himalayan glaciers and glacier-bound hazards require a network of fully equipped and integrated monitoring systems, supported by a set of field stations in critically important glaciered basins. An excellent role model that could be replicated and/or strengthened is the ongoing activities undertaken at the Himalayan station 'Himansh' by the National Centre for Polar and Ocean Research (NCPOR), under Ministry of Earth Sciences (MoES). The observation systems to be created should be automated, with real time access to data to modelers to create a potential early warning system on glacio-hydrological hazards from to time, based on the hazard potential, coupled with geographical information system tools downstream activities and population vulnerability coupled with. Open access to ground-based meteorological, hydrological, and glaciological data from the entire region is necessary to achieve the target.

(ii) Glacier volume loss will likely cause formation of new glacier lakes and existing ones to expand in area and volume. Some of glacial lakes are critical and highly prone to create a Glacial lake outburst flood (GLOF), flash flood etc. which may cause a disaster in downstream. Development of a reliable data base on the Himalayan glaciers and of glacial lakes require continuous mapping and monitoring of these dynamic system. ISRO can make huge contribution in using high-resolution and near real-time satellite remote sensing to monitor the glacial lake and water bodies.

(iii) It is recommended to initiate a mission-based approach to have a consistent and reliable mechanism for project organization, implementation of uniform techniques and methodology, consistent and complimentary data collection, development and

implementation of coupled atmospheric-cryospheric-hydrological models through networking of the knowledge institutions, linking human resources and creation of institutional capacity. It is important to have a target oriented "Himalayan Cryosphere Mission" modelled on the lines of the highly successful "Monsoon Mission" implemented by MoES. To make the above mission a success, it is crucial to make it a continuing scheme of a Ministry. While the mission could have multiple projects, all of them should be part of a coordinated mission directed to address clear deliverable objectives with multiple institutions contributing to coordinated objectives. This requires not only the technical advancement, but also require skilled human resources dedicated to glacier monitoring and management. Institutionalization of research in glaciers and glacier hazards is a critical need of the hour.

(iv) Fostering meaningful collaborations with international institutions in the major gap areas are also required.

(d) *Suggestion given by Defence Geoinformatics Research Establishment (DGRE) on* Glacial Lake Outburst Flood (*GLOF) Identification, Monitoring and Vulnerability analysis:*

An integrated approach for debris flow and GLOF risk management is the need of the hour. Systematic risk assessment study in the region is imperative to curtail the risks of glacial hazards. An inclusive approach with all the stakeholders is recommended to understand the GLOF phenomenal behavior by creating ground and remote sensing based inventory of benchmark moraine dammed lakes and monitoring the changes on a regular basis. An effective early warning mechanism to monitor GLOF hazrads shall go a long way in minimizing the risk out of such hazards. In order to analyze the adverse effects from the GLOF, DGRE has commenced work in the following areas:

a. Identification of potential glaciers and unstable glacier lakes in J&K and Ladakh UT area using remote sensing and ancillary data in consultation with Armed Forces.
b. Modelling & Simulation of Glacier outburst and movement of debris mass.
c. Vulnerability study as per flow simulation and future development plan in the affected area.

(e) *Suggestions given by Wadia Institute of Himalayan Geology*

The Director, Wadia Institute of Himalayan Geology during the course of oral evidence on the subject held on 21.06.2021 made the following submission:-

"Because glaciology is a very diversified field and it needs data from different aspects and also from different sources/institutes/agencies. All this data need to be collated at one place for effective mitigation of disasters, and sharing to many resarchers to meet their stated objectives of research. Therefore, one common sharing platform is necessary besides putting one nodal agency for proper decision-making".

(f) *Suggestions given by the Ministry of Jal Shakti – Department of Water Resources, River Development & Ganga Rejuvenation:*

The Secretary of the Ministry of Jal Shakti – Department of Water Resources, River Development & Ganga Rejuvenation during the course of oral evidence on the subject held on 8.4.2021, made the following suggestions:-

"The Himalayan cryosphere is something which is not specifically mentioned in the Allocation of Business Rules. It is my opinion that the Himalayan cryosphere should find a mention specifically in the Allocation of Business Rules so that the attention of Ministries and Departments concerned with it, is directed towards it. Now, it has two aspects. One is the effect of Himalayan cryosphere on our water resources, including floods. That is something which the Department of Water Resources should be looking at. We are already looking at it in a substantive manner but we need to get deeper into these issues. On the other hand, the multi-level hazards created by various parameters because of the changes in the glacier system, are something which should be studied more deeply under the overall leadership of the Ministry of Home Affairs under which the National Disaster Management Authority functions. All these institutions should lend their support in such studies to enable us to get a better picture".

3.7 To a specific query as to whether proposal of setting up a separate dedicated institution dealing with mountain hazards and landslides in view of the increasing mountain hazards is under consideration, the Department in its written submission furnished as under:-

"There is no specific information available on setting up of a separate dedicated institution dealing with mountain hazards.
However, as per NDMA Guidelines, "Management of Landslides and Snow Avalanches – 2009"and "National Landslide Risk Management Strategy, September-2019", mapping of landslide Hazard, Landslide Early warning System, monitoring activity and mitigation etc. has be to carried out by Ministry of Mines/GSI in consultation with other related agency/stakeholder including NDMA. The responsibility of dealing with snow avalanches including identification and monitoring lies with SASE (DGRE) and BRO.
As per the NDMA Guidelines on Management of Glacial Lake Outburst Flood (GLOF) - October, 2020, Ministry of Jal Shakti (MoJS) has been proposed as the nodal Ministry and Central Water Commission (CWC) as the nodal agency for management of GLOF. It also proposes that a national level Centre for Glacial Research, Studies and Management (CGRSM) will be established by the MoJS under the umbrella of the National Institute of Hydrology (NIH), Roorkee as a premier centre with state-of-the art facilities, which would eventually grow into a national centre of excellence".

Utilization of funds for Conservation and Management of Glaciers

3.8 On being asked to furnish the details of the funds allocated, expenditure incurred, projects approved and projects completed during the last five years for conservation and management of glaciers, the Department of Water Resources, River Development & Ganga Rejuvenation submitted the following information:-

a) *"ISRO has carried out following projects in the last 5 years for monitoring of Himalayan snow and glaciers:*

Project Title	***Duration***	***Amount***	***Sponsoring Agency***
Monitoring of Himalayan snow and glaciers (Phase-II) (Multiple objective)	*2010-15*	*426 lakh*	*Jointly funded by MoEF&CC and Department of Space*

Integrated studies of Himalayan glaciers (Multiple objective)	*2016-20*	*295 lakh*	*Funded by Department of Space*
Cryosphere Sciences and Applications Program (Multiple objective)	*2002-25*	*40 lakh*	*Funded by Department of Space*

b) *As per information given by DST, the total investment for the research carried out by the Centre for Glaciology at the Wadia Institute of Himalayan Geology, Dehradun was Rs. 20 crore during the last five years. In addition, DST spent another Rs. 20 crore during last 7 years (2014 onwards) for supporting three centres of Excellence on each at Kashmir University, Srinagar; Sikkim University, Gangtok and Divecha Centre for Climate Change, Bangalore, One National Programme on Cryosphere and an InterUniversity consortium on glaciology".*

3.9 When further asked about the details of funds allocated by the Government for management of glaciers in the country including field-based studies on glaciers and for imparting training to budding glaciologists, the DoWR, RD & GR replied as under:-

"DST has funded Rs. 1460.50 lakhs over a period of 12 years to Wadia Institute of Himalayan Geology for Centre for Glaciology with the objective of strengthening field-based studies that created trained manpower (Scientific & Technical staff, Ph.D. Scholars, Post-doctoral Fellows and RAs). In addition, DST has been supporting 3 Centres of Excellence one each at Kashmir University, Srinagar; Sikkim University, Gangtok and Divecha Centre for Climate Change, Bangalore, One National Network Programme on Cryosphere and an Inter-University consortium on glaciology.

GSI has organised seven training courses on Glaciology for field-based studies on glaciers and to impart training to the budding glaciologists. These training courses were sponsored by Department of Science & Technology (DST) and Science & Engineering Research Board (SERB)".

3.10 Explaining the constraints/bottlenecks being faced by the GSI in monitoring the glaciers in the country, the Department stated as follows:-

"GSI carries out Glacier Mass Balance Studies, Glacier Regimen Studies, Glaciers& Climate Variability Studies for selected glaciers besides Societal & related Studies in Himalayan Belt. The major constraints faced by GSI in execution of the glaciological studies mainly inaccessibility and remoteness in the area of operation, challenging work assignment, limited availability of different kinds of capacities and logistics".

CHAPTER – IV

MONITORING OF GLACIAL LAKES AND GLACIAL LAKE OUTBURST FLOODS (GLOFS) IN THE HIMALAYAN REGION

4.1 The Committee have been informed that climate variability has brought a significant impact on the glacier movements in the Indian Himalayan region. In general, the glaciers are shrinking and retreating faster in the recent decade with the proliferation of moraine-dammed lakes, which might impose GLOF danger in future. The new strategies with renewed action is the need of the hour, especially during present times when climate change is adding another dimension to the problems of glacier management especially glacier movement, glacier surge, GLOF, LLOF and cloud burst in mountainous regions. Identification of critical glacial lakes is imperative so that planners, scientists, academicians and community at large can develop and implement appropriate measures such as monitoring, early warning and mitigation measures to reduce the potential risks.

4.2 Glacial lake is a natural water body originated from glacial activity. They are formed when a retreating glacier erodes the land, filling the melt water in the depression created by the glacier. In the event of glacier melting, the melt water accumulates in glacial lakes located behind loose naturally formed glacial/moraine dams made of glacial sediments.

4.3 On being asked about the phenomenon of Glacial Lake Outburst Floods (GLOFs) and the factors triggering them, the DoWR, RD & GR stated as under:-

"A GLOF is a type of flood occurring when water dammed by a glacier or a moraine is released suddenly. When glaciers melt, the water in these glacial lakes accumulates behind loose naturally formed 'glacial/moraine dams' made of boulders, gravels, pebbles, sand, clay and ice residue. Unlike earthen dams, the weak structure of the moraine dam leads to the abrupt failure of moraine dam bounding the glacial lake. The various triggering causes of GLOFs are:

- *High/extreme surface runoff from the upstream catchment resulting from heavy precipitation/cloud burst,*
- *Cascading flood from upstream lakes,*
- *Failure/break open of temporary moraine dam due to water pressure or long-term degradation*
- *Landslide/Earthquake/Geological activity*

With the receding glaciers and rising temperature, the probability of their occurrences has risen in many mountain ranges, particularly on the debris covered glaciers.Since majority of the such lakes in Himalaya are located in remote regions, the people living in the downstream caught unaware of the approaching catastrophe resulting loss of life, besides damages".

Incidents of Glacial lake outburst floods in the Himalayan Region in the recent past

4.4 Elaborating on the incidents of Glacial lake outburst floods that took place in Himalayan Region in the recent past along with advisories issued and remedial measures taken by CWC, the Department in its written submission stated as follows:

"The recent incident of glacial lake outburst flood is the Kedarnath flash flood in June, 2013. Kedarnath area was subjected to two consecutive flood disasters at an interval of about 12 hours. As per the Wadia Institute of Himalayan Geology (*WIHG)*

scientific correspondence published in Current Science Journal, the first flood event occurred on 16th June 2013 at 5:15PM when the torrential rains flooded the Saraswati river and Dudh Ganga catchment area, resulting in excessive flow across all the channels. Due to heavy downpour, the town of Rambara was completely washed away on 16 June evening. The second event occurred on 17th June 2013 at 6:45a.m., after overflow and collapse of the moraine dammed Chorabari Lake which released large volume of water that caused another flash flood in the Kedarnath town leading to heavy devastation downstream viz. Gaurikund, Sonprayag, Phata, etc.

Chorabari lake outburst occurred in early morning of 17th June 2013. The lake was emptied in less than 15 minute resulting devastating flood in Kedarnath temple complex and huge loss of lives. The Chorabari lake was located at an elevation 3960 m, about 2.1 km upstream of Kedarnath temple complex.

The flooding pattern in river Ganga and its tributaries viz. Alaknanda, Mandakini, Bhagirathi etc during 16-18th June 2013 was due to unprecedented early, prolonged and heavy to very heavy wide spread rainfall in the catchments of these river. The continuous heavy rainfall coupled with the Chorabari lake outburst generated the flood wave with very high magnitude and velocity causing erosion of river banks and subsequent slope failure.

The Tehri dam played a very important role in flood mitigation in the downstream area. It attenuated the flood peak at Hardwar by about 7000 cumec, resulting a flood peak of about 14500 cumec, which would otherwise had been about 21500 cumec.

No advisory was issued by CWC in case of above mentioned GLOF event. However, it is informed that during appraisal of Hydro-electric / Multipurpose projects, the project authorities are advised to carry out GLOF studies if any potential Glacial lake falls in the catchment area of the project".

4.5 During the examination of the subject, "Flood Management in the Country including International Water Treaties in the field of Water Resource Management with particular reference to Treaty/Agreement entered into with China, Pakistan And Bhutan", the Committee were apprised by the Ministry of Jal Shakti – Department of Water Resources, River Development and Ganga Rejuvenation that the following incidents occurred during last few years with significantly damaging consequences and/ or potentially damaging consequences:-

(i) Blockade of waterway of river Parechu due to landslide in Chinese territory on 28.6.2004 and 8.7.2004 resulting in creation of artificial lake on upstream and accumulation of huge volumes of water
(ii) Flooding phenomenon of Kedarnath, Uttarakhand during 16 - 18th June 2013
(iii) Blockade of waterway of river Bhote Kosi, a tributary of Sun Kosi in Nepal due to landslide on 2.8.2014 resulting in creation of artificial lake on upstream and accumulation of huge volumes of water
(iv) Flooding phenomenon of Jhelum & Chenab basin in J&K during September 3-7, 2014
(v) Landslide on the Phutkal River in Zanskar Valley in Kargil district in Jammu and Kashmir during December 2014

(vi) Landslide Dam (LSD) on Kanka river, a tributary of Teesta in North Sikkim during August 2016
(vii) Landslide Dam (LSD) in Great Bend Area on river Yarlung Tsangpo in China during 16 - 19 October, 2018
(viii) Recent Chamoli incident on 7th February 2021

Sharing of Data/Information in respect of Glaciers

4.6 The Committee have been informed that for flood management, international treaties have been entered into with neighbouring countries with regard to transboundary rivers.

4.7 To a query as to whether India has any data sharing policy with the Himalayan-Karakoram countries so that large-scale modelling of future glacier and runoff evolution can be done with improved accuracy, the DoWR, RD & GR in its written reply stated as under:-

"The Karakoram is a mountain range spanning the borders of China, India, and Pakistan, with the northwest extremity of the range extending to Afghanistan and Tajikistan. So far as data sharing policy with the Himalayan-Karakoram countries is concerned, no specific information is available in respect of data sharing policy so that large-scale modelling of future glacier and runoff evolution can be done with improved accuracy.
However, presently India is having following treaties with the neighbouring countries:

1. *Indus Water Treaty-1960 for sharing of Indus water between India and Pakistan*
2. *Memorandum of Understanding with China*

a. *Memorandum of Understanding upon provision of Hydrological Information of the River Brahmaputra / Yaluzangbu*
b. *Memorandum of Understanding on Hydrological Data Sharing on River Sutlej / Langqen Zangbo*

Further, as per information received from MoEF&CC, India is a Regional Member Country of the International Centre for Integrated Mountain Development (ICIMOD) which is a learning and knowledge-sharing centre for sustainable and resilient mountain development serving the eight Regional Member Countries (Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan) of the Hindu Kush Himalaya (HKH). From time-to-time ICIMOD come out with reports on the various subjects related to the HKH Region".

4.8 When asked whether any data has been made available to State Governments / local authorities in respect of avalanches / cloudbursts landslides in Himalayan region during the last decade and advisories, if any, issued by CWC in anticipation of the floods, the Department replied in negative.

4.9 With regard to data sharing, the Director, Wadia Institute of Himalayan Geology during the course of oral evidence on the subject held on 21.06.2021 made the following submission:-

"We get some data sometimes and are unable to procure some data due to certain constraints or restrictionson data sharing. Immediately, people cannot utilize some of the high-resolution data because they need some permission before use. However, some data are freely available to a scientist working in this field. Different ministries have different protocols for data collection and their sharing"....

"Effective implementation of early warning system and sensitization of local people can reduce the disaster and loss of lifves in potentially vulnerable areas, especially in catchments that have dams, infrastructure, and large populations downstream.

The early warning system should compose of remote Automatic Water Level Monitoring Stations and Automatic Weather Stations (AWS) with the ability to communicate and transmit the data from remote stations to the control room for operation and monitoring in real-time. It should also have several Sirens to warn vulnerable communities along the river valley downstream. Control station operators should be able to view the latest data from any of the stations using custom-developed software for decision making.The first step to disseminate early warnings to the local people is by sensitizing and generating awareness to the local communities about such disasters and the standard operating procedures to be followed. Further, the information from early warning systems should be directly monitored by the administrative and disaster response agencies like district administration, State disaster relief force for rapid response. Also, the early warning system should be equipped with sirens along the river valleys to alert the vulnerable communities downstream".

Landslide Lake Outburst Flood (LLOF) and Lake Shore Drive (LSD) Breach induced Flash Floods

4.10 When asked in what way the Landslide Lake Outburst Flood (LLOF) are different from Lake Shore Drive (LSD) Breach induced Flash Floods, the DoWR, RD & GR stated as follows:-

"The Landslide Lake Outburst Flood (LLOF) is one type of flood whose water source lies in a temporary lake formed due to the damming of debris from a large landslide or avalanches. When the abutment of a steep and narrow valley fails due to a large landslide/ avalanche, the debris flows rapidly downstream, and accumulates on the river bed, ultimately blocking the river course through temporarily damming by the accumulated debris. Generally, the accumulated landslide debris is highly unconsolidated, non-cohesive, and always has the potential to breach if the upstream water pressure crosses the thresholds. The breaching of dam and outburst of lake may take place under different geo-morphological set up having the rocks with varying geotechnical characteristics.

Lake Shore Drive (LSD) breaching-induced floods are different from the LLOF. Any LSD is generally constructed on top of an artificial levee or dyke constructed at the boundary of a shoreline or lake. If that artificial levee/ dyke breaches, then such a type of flooding suddenly occurs. In the case of LLOF there are a sequence of incidents – mega landslides/ avalanches in a narrow mountainous valley, damming of a river by landslide debris, and then flash flood due to breaching of such artificial landslide dam".

Monitoring of Glacial Lakes

4.11 On being asked about the details of number of glaciers and glacial lakes (States-wise) present in the Indian Himalayan Region and whether all of them are presently being monitored so as to observe any abnormal behaviour in them, the Department in its written reply stated as follows:-

"As per Inventory of Himalayan Glaciers (GSI Spl publication no 34, 2009, updated edition), Indian Territory contains a total of 9575 glaciers. Presently GSI has taken up a project for preparation of an updation of the Inventory of the Himalayan Glaciers based on Remote Sensing Multi-Spectral Data. The work is in progress.
Under National Hydrology Project (NHP) ISRO has taken up GLOF risk assessment of glacial lakes in the Himalayan Region of Indian River Basins. As part of this activity, an updated inventory of glacial lakes of size greater than 0.25ha has been prepared for entire catchment areas of Indian Himalayan rivers using high resolution satellite data. Based on process of lake formation, location, and type of damming material, glacial lakes are grouped into four categories viz., Moraine dammed, Ice-dammed, Glacier Erosion, and Other glacial lakes. A total of 6,921 glacial lakes of size more than 0.25 ha are inventoried within Indian Territory. The State-wise these glacial lakes are as under:

Sl.	***State/UT***	***No. of Glacial Lakes***	***Total Lake Area (ha)***
1	*Jammu & Kashmir (UT)*	*546*	*2550.79*
2	*Ladakh (UT)*	*3219*	*9965.34*
3	*Himachal Pradesh*	*513*	*983.73*
4	*Uttrakhand*	*347*	*560.61*
5	*Sikkim*	*694*	*3153.27*
6	*Arunachal Pradesh*	*1602*	*10735.18*
Total		***6921***	***27948.92***

A total of 26,655 glacial lakes (GT 0.25 ha) have been mapped in the entire catchment area of Indian Himalayan rivers spreading in and outside the Indian trans-boundary".

4.12 When asked about the role of the Ministry of Jal Shakti – Department of Water Resources, River Development and Ganga Rejuvenation in the monitoring and management of glacial lakes in the Himalayan region, the Department in its written reply submitted as follows:-

"Glacier monitoring and management in the country is presently not in the scope of Central Water Commission. However, the work of monitoring of Glacial Lakes /Water Bodies (GLs/WBs) was taken up by Central Water Commission, DoWR,RD&DR, Ministry of Jal Shakti, during XI plan period in the year 2009 under DWRIS Plan scheme. The inventory of GLs/WBs was published in June, 2011 in association with National Remote Sensing Centre (NRSC), Hyderabad based on the satellite imageries data of Advanced Wide Field Sensor (AWiFS) of the Indian Remote Sensing Satellite, Resourcesat-2 collected from May-Nov, 2009. As per this inventory, there are 2028 GLs/WBs having size more than 10 ha including 477 GLs/WBs having size more than 50 ha in Himalayan Region of Indian River Basins.

The monitoring of 477 GLs/WBs having size more than 50 ha is being carried out since 2011 during monsoon season (June to October) every year out of which 95 GLs/WBs are in India. The monitoring had been carried out till 2015 in association with NRSC, Hyderabad using satellite data provided by NRSC. From the year 2016 onward, the above-mentioned work of monitoring of 477 GLs/WBs is being carried out by CWC using Advanced Wide Field Sensor (AWiFS) Satellite imageries procured/ downloaded from NRSC. The study area extends across different countries namely India, Nepal, Bhutan and China.
The monitoring report is being shared with concerned field offices of CWC, concerned Himalayan States and other Stakeholders".

4.13 In this regard, the representative of the DoWR, RD & GR during the course of oral evidence held on 8.4.2021, apprised the Committee as follows:-

"So far, we were monitoring glacial lakes of more than fifty hectares in area. Our assessment was that those big bursts -- which will cause damage or risk downstream -- need to be monitored. This incident has shown that even a smaller mass of ice or water can create problems. So, in this case, they have created problems for all the hydel projects which were being constructed in the upper region. Therefore, the Central Water Commission has reviewed its strategy and it has prepared a proposal where it will start monitoring glacial lakes of ten hectares and above. It will start monitoring even the smaller bodies".

4.14 On being asked as to whether Geological Survey of India (GSI) has any proposal under consideration to prepare an inventory of glacial lakes lying in other regions of Himalayas specifically in the Indian Himalayan Region, the Department of WR, RD & GR in its reply stated as under:-

"Being an attached office of Ministry of Mines (MoM), GSI is primarily mandated to carry out survey and mapping followed by mineral resource assessment. Further,GSI carries out specialized investigation including Glaciological study, and fundamental research in various fields of earth sciences.
Presently, under glaciological studies, GSI carries out assessment of glacier resources and associated studies for selected glaciers in northwest Himalayan Belt. At present, GSI has no proposal for preparation of inventory of glacial lakes lying in other regions of Himalayas".

4.15 To a query as to whether those stretches of the Himalayas where the danger of melting of glaciers and consequent GLOF incidents are most severe have been identified, the DoWR, RD & GR in its written reply submitted as below:-

"There is no specific information on stretches of the Himalayans where the danger of melting of glaciers and consequent GLOF are most severe. However, as mentioned in reply to LoP-47 above, ISRO has taken up GLOF risk assessment of glacial lakes in the Himalayan Region of Indian River Basins under National Hydrology Project (NHP). A total of 26,655 glacial lakes (having size more than 0.25 ha) have been mapped in the entire catchment area of Indian Himalayan rivers spreading in and outside the Indian boundary. Out of total inventoried glacial lakes, the lakes with size more than 1 ha are ranked for GLOF risk considering glaciological, terrain and associated characteristics. The set of parameters used for prioritization of glacial lakes are Lake type, Lake area, Glacier association, Distance between glacier snout and glacial lake inlet, Slope between glacier snout and glacial

lake inlet, Distance between glacial lake outlet and the nearest settlement/infrastructure, Slope between glacial lake outlet and the nearest settlement/infrastructure etc. The details of prioritized ranked Glacial lakes for GLOF Risk are as follows:

a) *Indus basin = 614 lakes*
b) *Ganga basin = 864 lakes*
c) *Brahmaputra basin is under preparation".*

4.16 As regards, identification of potentially dangerous glacial lakes based on field observations, records of past events, geomorphologic and geotechnical characteristics of the lake/dam and surroundings, and other physical conditions, the Department in its written reply stated as under:-

- *"During 2012, a detailed survey was carried out by GSI to assess the GLOF risk on Gepang Gath Glacier lake, Sissu, Lahaul&Spiti, Himachal Pradesh. The GLOF-risk probability was assessed by high precision field surveys and high-resolution Earth Observation data. Other potential triggering factors like earthquakes, cloud bursts, landslides and glacier calving were also taken into account for the overall risk-evaluation. It was concluded that under normal circumstances, there is no threat of GLOF, but unusual natural calamities may lead to devastating flood downstream. During the study, a site has been identified for creation of a "safety breach" to eliminate the GLOF threat to Manali-Leh National Highway and Sissu village downstream. A detailed report of the investigation had been submitted to the Civil Authorities in Himachal Pradesh for further necessary action.*
- *A field based investigation was taken up by GSI during 2016-18 to evaluate the potentiality for GLOF risk and three glacial lakes viz., Vasudhara Tal, Mabang and Pyungru Lakes were identified as potential lake in terms of GLOF vulnerability.Final report of the same has been shared with Wadia Institute of Himalayan Geology, Dehradun for further studies as requested by State Disaster Management Authority, Uttarakhand.*
- *ISRO has taken up GLOF risk assessment of glacial lakes in the Himalayan Region of Indian River Basins under National Hydrology Project (NHP). As part of the study, the inventoried glacial lakes are ranked for GLOF risk considering glaciological, terrain and associated characteristics. The set of parameters used for prioritization of glacial lakes are - Lake type, Lake area, Glacier association, Distance between glacier snout and glacial lake inlet, Slope between glacier snout and glacial lake inlet, Distance between glacial lake outlet and the nearest settlement/infrastructure, Slope between glacial lake outlet and the nearest settlement/infrastructure".*

4.17 When asked to furnish details of those Glacial lakes which are increasing not only in numbers but also in size in the Himalayan region because of retreating glaciers, the Department in its written submission stated that as informed, no such study on temporal changes in glacial lake number and their extent has been carried out by ISRO and GSI.

4.18 To a specific query as to whether the formation and expansion of glacial lakes increase the melting of the glaciers, and in turn cause negative mass balance to the glaciers, the DoWR, RD & GR replied as follows:-

"As informed by GSI, they have not carried out any specific study to establish the relation between expansion of glacial lakes and melting of glacier or negative mass balance. It is to be mentioned that the retreat or the advance of the glacier is the net result of the negative or positive mass balance. In other words, the change

in mass balance is finally reflected in the glacier retreat or advance, though after a significant time lag depending on the response time of the glacier. This response time depends on several factors including the morphometric characteristic of the catchment. ISRO has also informed about no such study by them".

4.19 On being asked whether any study has been conducted to analyse the enlargement and origin of those glacial lakes which are located near human settlements and their potential for causing critically lake outburst, the Department in its written submission stated that no such study has been carried out by GSI, ISRO and DST.

Flood Forecasting/Monitoring Stations in the Indian Himalayan Region

4.20 On being asked to furnish details of number of high altitude meteorological and discharge stations set up by the Government for covering glaciers and watersheds in the Indian Himalayan region and whether these stations are equipped with modern technology, the Department in its written submission stated as under:-

- *"DGRE has three Mountain Metrological Centre (MMC) located at Sasoma in Laddakh, Srinagar in J&K and Auli in Uttarakhand for avalanche study.*
- *As explained in reply to LoP-56, CWC has 46 Nos. existing metrological observations stations in the Himalyan region (1000m above msl). Apart from the above, 16 Nos. metrological observations stations have also been proposed (1000m above msl) in the Himalyan region, which is under various stages of implementation by CWC.*
- *WIHG has five meteorological and discharge stations in the high altitude regions (~3800 m asl).*
- *DGRE is using state-of-art sensors and technologies available word over for mitigating the avalanche hazards. The data received from observatory and weather stations at MMC is used in avalanche and weather forecasting for armed forces. DGRE is working on latest model for forecasting and snowpack model jointly developed with Swiss Federal Institute for Snow and Avalanche Research (SFISAR).*
- *Out of 46 Nos. existing and 16 Nos. proposed metrological observations stations of CWC, 35 Nos. and all 16 Nos respectively are the satellite based telemetry stations.*
- *As informed by DST, most of thestations of WIHG are of conventional type".*

4.21 When asked about the number of flood forecasting stations set up by the CWC in the Indian Himalayan Region (States-wise), the DoWR, RD & GR in its written submission stated as under:-

"CWC is issuing level forecasts at identified locations and inflow forecasts for identified Dams/ Reservoirs/ Barrages for providing advance information about the flow into these structures based on the request from the respective State Government.

In the Himalayan Region including foothills in the States of Uttar Pradesh, Bihar, West Bengal and Assam, State-wise details of flood forecasting stations are as given below:

Sl. No.	Name of State/UT	Number of flood forecasting Stations		
		Level	Inflow	Total
1	Jammu & Kashmir	3	0	3
2	Himachal Pradesh	1	0	1
3	Uttarakhand	4	2	6
4	Sikkim	3	5	8
5	Arunachal Pradesh	3	0	3
6	Uttar Pradesh (along foothills)	4	1	5
7	Bihar (along foothills)	5	2	7
8	West Bengal (along foothills)	7	0	7
9	Assam (along foothills)	5	0	5
	Total	**35**	**10**	**45**

- *As informed by DST, WIHG has five meteorological and discharge stations in the high altitude regions (~3800 m asl). Most of these stations are of conventional type".*

4.22 Elaborating the reasons for meagre number of flood forecasting stations set up in the State of Uttrakhand which is very vulnerable to landslide induced and global lake outburst floods, the Department in its written reply submitted as under:-

"CWC is issuing level forecasts at identified locations and inflow forecasts for identified Dams/ Reservoirs/ Barrages for providing advance information about the flow into these structures based on the request from the respective State Government. Hence, based on request from Govt. of Uttarakhand, at present there are only 6 flood forecasting stations (2 Inflow Forecast Stations + 4 Level Forecast Stations) in the State of Uttarakhand. Depending on the request from Govt. of Uttarakhand, CWC can further expand its flood forecasting network in the State.
The rivers in Uttarakhand are flashy in nature and swell up pretty quickly. The steep slopes of rivers give very less response time to issue a conventional gauge-to-gauge statistical-correlation based (level) forecast for any station and hence, effective level based forecast is very difficult to make. For flood forecasting by rainfall-runoff mathematical modelling, sufficiently representative areal and temporal distribution of real-time rainfall would be required from IMD. Thus in Uttarakhand, constraints of terrain and short time of concentration are a limitation for a worthwhile forecast by conventional system and in case of mathematical model based flood forecasting, the non-availability of real time rainfall data for sufficient number of locations have been major limitations".

4.23 To a query as to whether any protocol has been developed by the Department to predict the ever increasing incidents of disasters due to occurrence of extreme kind of natural events, the Department in its written submission stated as under:-

- *"NDMA has published a "Guidelines on Management of Glacial Lake Outburst Flood (GLOF)" in October, 2020 for management of GLOF, wherein an integrated strategy is elaborated for risk reduction related to GLOF.*
(https://ndma.gov.in/sites/default/files/PDF/Guidelines/Guidelines-onManagement-of-GLOFs.pdf). Section 7.8, page no. 51-54 of the said guidelines indicates the activities needs to be done by the concerned agencies during pre and post phases of disaster.

- *CWC is the nodal organisation for providing information on riverine flooding. The flood forecasting process of CWC has a Standard Operating Procedure (SOP) which is scrupulously followed. This SOP is updated twice every year during April and September. Also, for handling the crisis related to and to forewarn the appropriate administrative authority for responding to a flood emergency due to heavy rainfall, dam break, glacial lake outbursts, landslide dam break, releases from dams etc., Crisis Management Plan (CMP) of the Union Ministry of Jal Shakti (Department of Water Resources, RD&GR) has been formulated. In case of any such crisis, the protocols given in CMP are strictly followed. The CMP is updated annually.*
- *Further, DGRE has a mandate for snow/avalanche forecasting of strategic area. DGRE takes the inputs of Global models from India Meteorological Department (IMD) for Weather Research and Forecasting (WRF) to generate mountain weather forecast for 06 days which further uses it in assessment of avalanche danger. DGRE is sharing the avalanche advisories information to the Armed Forces through a special network provided by the Indian Army. The information is further disseminated through Army channel to Brigade/Units. The communication in this regard is in restricted domain. For civil populated area DGRE is also sharing the avalanche advisory information through National Disaster Management Authority (NMA)/DRDO, which is hosted by them on their website for the benefits of civilian population".*

4.24 Explaining the details of the early warning systems put in place by the CWC, the DoWR, RD & GR replied as under:-

- "*Central Water Commission has developed a network of flood forecasting stations and issues Daily Flood Bulletins including forecasts, if issued, to all designated Authorities/ Agencies of the Central Government and State Governments/ District Administration during the South West and North East Monsoon seasons for all the major river basins in the following categories:*

  a) *Above Normal: Water level between Warning Level and Danger Level*
  b) *Severe: Water level between Danger Level to the Highest Flood Level (HFL) (The highest flood level of the river ever recorded at the place) attained at that location*
  c) *Extreme: Water level equal or higher than the HFL at that location*

Alert Categorization

Category	***Description***	***Stage***	***Alerts to be transmitted to***
Above Normal	*Water level between Warning Level and Danger Level*	***Yellow***	• *JS (DM) & AS (DM).* • *Nodal Officers of NDMA & NDRF.* • *On instruction of JS (DM), be transmitted to HS.*
Severe	*Water level between Danger Level to the HFL* attained at that location*	***Orange***	• *HS / AS (DM) / JS (DM)/PS to HM/PS to MOS.* • *Nodal Officers of NDMA & NDRF.* • *All designated officers in PMO/Cabinet Secretariat.* • *Concerned State/UT Governments*
Extreme	*Water level equal to higher than the*	***Red***	• *HS/AS (DM)/ JS (DM)/PS to HM/PS to MOS.*

	HFL at that location*		• *Nodal officers of NDMA& NDRF.* • *All designated officers in PMO/Cabinet Secretariat.* • *ESF Ministries / Departments & concerned States / UTs.*

** Highest Flood Level: The highest flood level of the river ever recorded at the place.*

- ✓ *Alerts messages will be followed by **Situation Reports (SITREP**).*
- ✓ *Alerts falling in **Orange stage** will be communicated with 06 hourly updates. Alerts falling in **Red stage** will be communicated with 03 hourly updates or at more frequent intervals as warranted by the situation.*

- *Also, DGRE provides avalanche warning for 24 hours in advance, which remains valid from 17:00 Hrs of present day to 17:00 Hs of next day. Sometimes, in extreme bad situations and rapid increase in instability of snowpack, the outlook for next 72 hours is also issued".*

CHAPTER – V
GLACIER DISASTER MANAGEMENT

5.1 Studies/collection of data is basic to glacier management. Monitoring of Himalayan Cryosphere is critical to study of impact of climate change, disaster vulnerability etc. Under climate change scenario resulting in loss of ice cover will lead to large scale environmental changes.

Role of NDMA

5.2 National Disaster Management Authority (NDMA)'s mandate is to lay down the policies, plans and guidelines for disaster management for ensuring timely and effective response to disaster. As per the provision of DM Act 2005, Section (6), (1) & (2) National Authority shall have the responsibility for laying down the policies, plans and guidelines for disaster management for ensuring timely and effective response to disaster; without prejudice to generality of the provisions contained in sub-section (1), the National Authority may —

a. *lay down policies on disaster management;*
b. *approve the National Plan;*
c. *approve plans prepared by the Ministries or Departments of the Government of India inaccordance with the National Plan;*
d. *lay down guidelines to be followed by the State Authorities in drawing up the State Plan;*
e. *lay down guidelines to be followed by the different Ministries or Departments of theGovernment of India for the purpose of integrating the measures for prevention of disaster or the mitigation of its effects in their development plans and projects;*
f. *coordinate the enforcement and implementation of the policy and plan for disastermanagement;*
g. *recommend provision of funds for the purpose of mitigation;*
h. *provide such support to other countries affected by major disasters as may be determined by the Central Government;*
i. *take such other measures for the prevention of disaster, or the mitigation, or preparedness andcapacity building for dealing with the threatening disaster situation or disaster as it may consider necessary;*
j. *lay down broad policies and guidelines for the functioning of the National Institute of Disaster Management".*

5.3 The Committee asked as to whether there is any Disaster Management Plan in place for the Himalayan States in general and in particular for the State of Uttarakhand and if so, how effective that plan was in combating the unprecedented tragedy which occurred on 7thFebruary in Chamoli district of Uttarakhand. In response, the DoWR, RD & GR in its written submission stated as follows:-

> *"As informed by NDMA, there is no specific Disaster Management (DM) Plan for the Himalayan States. NDMA prepared the revised National Disaster Management Plan (NDMP) in November, 2019 which, inter-alia, addresses the disasters likely to happen in Himalayan region like Landslides, Earthquake, Glacial Lake Outburst Flood (GLOF), Cloudburst, Forest Fire etc. for which roles and responsibilities of various stakeholders, including actions to be taken by them for management of these disasters have been mentioned in the NDMP-2019.*

In the NDMP 2019, Himalayan region has been identified as one of the regions involving multiple States requiring special attention. As per the Disaster Management Act, 2005, all States/UTs are mandated to prepare their DM Plan, which should focus on State specific disasters. Accordingly, the States/UTs in the Himalayan region are expected to focus on disasters specific to that region in their DM Plan.

As informed by the State Government, Uttrakhand has developed its own State Disaster Management Plan (SDMP) and the updation of the same is in progress. The SDMP is effective for all disasters and the response, relief and rehabilitation activities were carried out as per the SDMP after the tragedy of 7 February in Chamoli district of Uttrakhand".

5.4 When asked whether any detailed Manual / Standard Operating Procedures have been prepared to deal with the emergent situations arising out of floods including flash floods, Cloudburst, Glacier Outburst and Avalanches, the NDMA in its written submission stated as follows:-

"No manual and Standard Operating Procedure (SOP) has been developed by NDMA to deal with the emergent situations arising out of floods including flash floods Cloudburst, Glacier Outburst and Avalanches. Only guidelines in reference to the subject and disaster management for Management of floods (2008), Urban floods (2008), Glacial Lake Outburst and Floods (GLOFs) (2020) &Landslide & Snow Avalanche (2009) is issued with necessary roles, responsibilities of different Ministries & States. All the SOP & Manual to tackle hazards/ disaster are prepared by their concerned nodal agencies".

5.5 On being asked whether the uniform codes for excavation, construction and grading are in place in India in the even of disasters, as prevalent in other countries, the NDMA in its written submission stated as under:-

"Uniform code for the construction practices is contained in National Building Code of India (NBC 2016) published by the Bureau of Indian Standards (BIS) which comes under the Ministry of Consumer Affairs, Food & Public Distribution. In regards to excavation, a Policy on Sediment Management Ministry of Jal Shakti is in drafting stage".

5.6 When asked whether there are well laid down procedures / regulations for land use planning in the GLOF/ Landslide Lake Outburst Flood (*LLOF*) prone areas, the NDMA replied as under:-

"In the NDMA Guidelines on Management of GLOFs released on 13th October, 2020 it was mentioned that there are no widely accepted procedures or regulation in India for land use planning in the GLOF/LLOF prone areas. It has been recommended in the Guideline to constitute a committee to formulate specific land use zoning, development control and building construction regulations under aegis of MoJS".

5.7 Regarding occurrence of higher casualties due to changes in the architecture of the houses in the hills (the increasing use of brick and concrete instead of the traditional mud and wood), the Department in its written submission stated as follows:-

"State wise damage due to floods/heavy rains are being compiled by CWC. As per data compiled by CWC, loss of human lives in Himachal Pradesh, J&K, Sikkim and Uttrakhand during the year 2001 to 2018 is given at ***Annex-II.*** *The Specific information about higher casualty figure due to changes in the architecture of the*

houses in the hills (i.e. the increasing use of brick and concrete instead of the traditional mud and wood) is not available".

Role of National Disaster Response Force (NDRF)

5.8 Elaborating on the role of National Disaster Response Force (NDRF) in disaster management and in what way it is different from NDMA, the NDMA in its written reply stated as follows:-

"NDRF is a specialised rescue and response force, mandated to respond to Natural & Man-made Disasters. The Role of NDRF is as under:-

i) To provide specialized response for rescue and relief in case of disasters-natural and man-made.
ii) Deployment in case of impending disasters.
iii) Assistance to civil authorities in distribution of relief material during/after disaster.
iv) Co-ordination with other agencies engaged in rescue/relief work.

NDMA is an apex body to lay down Policies, Plans and Guidelines for Disaster Management for ensuring timely and effective response to disasters.

5.9 When asked about deployment/stationing of Quick Response Teams (QRTs) at critical locations in Himalayan States to tackle the eventualities of floods including flash floods, glacier bursts etc, the NDMA replied as under:

"DM Division, MHA undertakes pre-positioning of NDRF teams before Monsoon Season or before any threatening disaster situation or disaster on receipt of Early Warning".

5.10 On being asked as to whether NDRF has in their possession all types of modern equipments and other gadgets as also transportation facilities etc. at its disposal so as to respond and undertake swift rescue operations, the NDMA in their written reply stated as under:-

"NDRF teams are well equipped to undertake the mandated assignments. However, heavy equipment like earthmovers/ heavy drilling machines/ JCBs etc, are not part of equipment profile of NDRF and provided by the local authorities with handlers at the incident site.
Normally NDRF moves in own unit vehicles. However, during emergencies, IAF/state authorities are requisitioned for airlifting of troops".

5.11 When asked whether NDRF has adequate number of modern muck cleaning instruments/equipment so as to deal with emergent situations, the NDMA replied as under:-

"NDRF is not authorised/equipped with such equipment and same is provided by the local authorities at disaster site".

5.12 Enquired whether NDRF has its own aircrafts/choppers for quick transportation as well as rescue purposes, the NDMA replied as under:-

"There is no dedicated air service available with NDRF. For airlifting NDRF is dependent on IAF/ private choppers provided by States".

5.13 In response to a query regarding the delay by NDRF in reaching Reni in Chamoli District Uttarakhand where the disaster struck due to Glacial Outburst, the representative of NDRF during the course of oral evidence on 23.3.2021, stated as follows:-

> *"Sir, unfortunately, this time it took long time for NDRF teams to reach the place of incident. Although, the roads were fine, but the distance was too much, as such there was a delay in reaching there. We will try to improve further".*

Public Awareness to prevent Glacier Disasters

5.14 The Committee asked about the awareness programme initiated by the Government to create awareness among the public on the perilous impact of global warming particularly in Himalayan region. In response, the Department in its written submission stated as under:-

- *"For the purpose of enhanced understanding of the Himalayan ecosystem in context of climate change, the National Mission on Sustaining Himalayan Ecosystem (NMSHE) has taken up several initiatives in partnership with various Himalayan States and institutions. Under NMSHE, State Climate Cells/Centres have been established in 12 out of 13 Himalayan States/UTs for building institution capacity of Himalayan States in the area of climate change adaptation. These centres are working on areas of climate vulnerability assessment, raising public awareness, training and capacity building for climate change adaptation planning. Several tens thousands of people have been trained as part of this mission in the Indian Himalayan region.*
- *The Government of India has launched the National Mission on Himalayan Studies in 2015-16, a Central Sector Scheme, to support the sustenance and enhancement of the ecological, natural, cultural, and socio-economic capital assets and values of the Indian Himalayan Region. Under this Mission, Nature Learning Centres (NLCs) have been set-up with an objective to educate and empower people for environment conservation and sustainable practices through trainings, demonstrations and dissemination material in the Indian Himalayan Region. In first phase of the Mission, NLCs have been set-up in Assam, Manipur, Tripura, Nagaland, Himachal Pradesh and Sikkim.*
- *The G.B. Pant National Institute of Himalayan Environment (GBP-NIHE) through its Integrated Eco-Development Research Programme is also conducting various awareness activities in socio-economic development, forestry and biodiversity conservation, and pollution control, etc.*
- *Further, Environmental Information System (ENVIS) Scheme of MoEF&CC, regularly brings out value-added information products relating to environment, forest, wildlife and climate change which include theme-based newsletters, special publications, thematic bulletins, technical reports, information products developed on parks and sanctuaries, etc.*
- *The National Museum of Natural History (NMNH) of MoEF&CC and its regional centres, are undertaking environmental awareness programmes/ activities like poster, painting, slogan and essay competitions, debates, seminars/ workshops for all sections of the society. Summer vacation programmes and winter nature camps are also organized for school children.*
- *Central Pollution Control Board (CPCB) organize awareness programmes through mass media, on prevention, control or abatement of water, air and noise pollution in different parts of the country including the states of Himalayan region. Further,*

trainings/workshops/skill developments programmes for the stake- holders such as State Pollution Control Boards (SPCBs) / Pollution Control Committees (PCCs) / Urban Local Bodies (ULBs) on prevention, control or abatement pollution are also organized. Stake-holders including States/SPCBs/PCCs are consulted while formulating Environmental Standards, Guidelines etc".

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PART II
OBSERVATIONS/RECOMMENDATIONS

NEED TO MONITOR INDIAN HIMALAYAN REGION

2.1 Glaciers are important components of the hydrological cycles of the Indian Himalayan region as these are the source of three large river systems, i.e. the Indus, the Ganges, and the Brahmaputra, which provide water for millions of people in the country and accordingly, the Hindu Kush Himalayan Region (HKH) is rightly described as 'Water Towers of Asia'. Thus, the river systems and associated groundwater form a significant water resource for the country. The Himalayan glaciers ensure water availability even in post-monsoon period as the base flow of the glacial stream, besides ground water contribution in the river system of perennial rivers. As such, glaciers are very important for water security of the country. The Committee were informed that as per the inventory published by the Geological Survey of India (GSI), there are as many as 9775 glaciers in the Indian Himalayan Region (IHR). Further, a total of 1306.1 cubic km of ice volume (about 1110 cu. km of water) is locked up in glacierised basins of Indus, Ganga and Brahmaputra, although specific information about separate volume of ice and snow water is not available. It has also been informed that the thinning of Himalayan glaciers has been accelerated in the recent years, resulting in a significant rise in glacier melt, including sediment load, in yearly runoff and altered hydrological behaviour in the mountain region and downstream. The Committee observe that close and frequent monitoring of glaciers, glacier discharge, glacial lakes and prospective glacial lake outburst floods in the Himalayan region have become vital and critically important as never before for not only determining the current status as well as future responses of glaciers and glacial lakes, but also for predicting and mitigating the potential hazard disasters that may arise in future.

WARMING OF THE HIMALAYAN-KARAKORAM REGION

2.2 The Committee note that as per the information furnished by the Department of Science and Technology (DST), the Himalayan-Karakoram region is becoming warmer at a faster rate than global mean by 0.5 ^{0}C which will lead to local changes in hydrology in terms of rainfall and snowfall patterns, increased melting from glaciers and threat to the infrastructure due to increase in extreme events leading to disasters. The Committee are further informed by the Ministry of Environment, Forest & Climate Change (MoEF&CC) that smaller glaciers in the Himalayan region are more sensitive to climate change and their shrinkage rate is stated to be higher than those of larger glaciers. Further, as per the World Meteorological Organization, average global temperature for 2015-2019 is estimated to be 1.1 degree Celsius above pre-industrial (1850-1900) level. According to the Ministry of Earth Sciences, in line with rising temperatures across the globe, all India mean temperature has risen by nearly 0.7 degree Celsius during 1901 to 2018.

The Committee further note that as per the IPCC report 2021, the glaciers of Hindu Kush Himalayas (HKH) are shrinking and the snow cover has been getting reduced since the early 21st century and glaciers have also been thinned, retreated and lost mass since the 1970s. According to estimates made between 2006 and 2018, the global mean sea level is rising at a rate of around 3.7 mm/yr. Further in the long term, the melting of glaciers will also contribute to rising of the sea level and threaten to submerge some coastal cities in the country and in the short term, the sea level rise may cause the change in rainfall pattern and seasonal flooding in the coastal areas. The Committee while observing cataclysmic changes that are occurring in the Himalayan region / cryosphere, call for urgent, coherent and coordinated response to the evolving challenges posed by global warming & climate change.

NEED TO CHECK EMISSION OF BLACK CARBON

2.3 The Committee learn that very few studies have been conducted by different organizations/ institutes in the country to assess the adverse effects of atmospheric pollution on the Himalayan glaciers. A study conducted by National Centre for Polar and Ocean Research and Space Physics Laboratory at their Himansh station in Lahaul-Spiti region have revealed that the total Suspended Particulate Matter (SPM) showed significant variations with dominance of mineral dust components therein (~67%). It has also been stated that the black carbon reportedly contributes (~4%) to near surface composite aerosol mass concentrations and also absorbs more light and emits infra-red radiation that increases the temperature. Hence, an increase in Black Carbon in the high Himalayas is stated to contribute to the faster melting of glaciers. The Committee recommend that with a view to assess the extent and scope of adverse impact of atmospheric pollution including black carbon on the fragile and sensitive Himalayan glacier system, the Department of Water Resources, River Development & Ganga Rejuvenation in consultation with the Ministry of Environment, Forest & Climate Change and other concerned Ministries/Departments/Agencies should commission a research work/project for comprehensive examination of this aspect and submit the research findings within a time-bound period.

(Recommendation Sl. No. 1)

NEED FOR OVERARCHING APEX BODY FOR GLACIER MANAGEMENT

2.4 The Committee note that Glaciers are important components of the hydrological cycles of the Indian Himalayan region as they are the source of the three large river systems of India i.e. the Indus, the Ganges, and the Brahmaputra, which provide water for millions of people in the country. However, they note that there are plethora of Ministries/Departments/Institutions with different mandates for dealing with hydro-meteorological and hydro-geological hazards of Himalayan glaciers. While the glaciers are surveyed and their detailed inventory is maintained

by the Geological Survey of India, Ministry of Mines; the Ministry of Environment, Forest and Climate Change looks into all matters related to climate change including its impact on the glaciers. The Department of Science & Technology is involved in conducting research on glaciers and the National Centre for Polar and Ocean Research (NCPOR) under the Ministry of Earth Sciences has done some studies on the Himalayan cryosphere. Besides, the Defence Geo-Informatics Research Establishment under aegis of Defence Research & Development Organisation (DRDO) carries out work on avalanche forecasting, and the Indian Space Research Organization coming under the Department of Space, looks after the National Natural Resources Management System and provides valuable inputs by way of remote sensing. Further, the Department of Water Resources, River Development & Ganga Rejuvenation is tasked with flood-control management and the Central Water Commission has been mandated for monitoring glacial lakes. Apart from different Ministries/Departments/Agencies, glaciological studies and other cryospheric research is carried out by a number of researchers from various research and academic institutes across the country.

The Committee are of the considered view that given the strategic role and importance of glaciers as a vital national resource, there is a critical and imperative need as never before, to formulate new strategies for combating the challenges posed by the climate change and global warming in the glacier management especially glaciers movement, glaciers surge, Glacial Lake Outburst Flood (GLOF), Landslide Lake Outburst Flood (LLOF) and cloud burst in mountainous regions. In this regard, the role of planners, scientists and academicians assumes critical importance in devising, developing and implementing suitable measures for studying, monitoring and providing early warning response to reduce the potential glacier related risks. Fragmented research and studies by various Departments/Institutions/Agencies in this regard will not yield desired results / outcomes and also may not necessarily convert into actionable steps. The Committee, therefore, recommend that there is need to set up a single nodal agency for bringing out synergies among various Government Departments/Ministries involved in glaciological research and monitoring to achieve desirable results. Such an agency should be entrusted with the responsibility of coordinating the activities of all the Departments/Agencies involved in Himalayan Glaciers monitoring and research work. Besides, this agency should be given well-defined and delineated mandate by suitably amending the Allocation of Business Rules. The Committee urge upon the Department of Water Resources, River Development & Ganga Rejuvenation to play a lead role in this regard so as to take the matter to its logical conclusion for setting up of the institution and apprise the Committee about the steps taken by it within three months of presentation of this Report.

(Recommendation Sl. No. 2)

NEED TO SET UP SEPARATE DEDICATED MOUNTAIN HAZARD AND RESEARCH INSTITUTE

2.5 The Committee observe gaps and deficiencies in glaciology research and monitoring of the glacial lakes and water Bodies in the Himalayan region. The Committee note that Geological Survey of India (GSI) has not conducted specific studies on estimated volume loss of glaciers between 1950 and 2020 and also not projected any estimate of loss by the year 2100. Further, there is no comprehensive information about the volume loss of glaciers in the Indian Himalayan Region. The Committee further note that the Ministry of Environment, Forest & Climate Change has not conducted any study or awarded any project on warming of Himalayan glaciers. The Committee were informed by the DoWR, RD & GR that Central Water Commission (CWC) has not issued any advisory to the concerned local Governments regarding the anticipation of floods caused by avalanches/cloudburst landslides in the Himalayan region. Further, there is also no specific information available on stretches of the Himalayans where the danger of melting of glaciers and consequent GLOF are most severe. Moreover, no study on temporal changes in glacial lake number and their extent has been carried out by Indian Space Research Organization (ISRO) and GSI. The Committee also took cognizance of the fact that no study has been carried out by GSI, ISRO and DST to critically analyse the enlargement and origin of glacial lakes near human settlements and their potential cause for a lake outburst.

Taking into consideration the aforestated gaps / deficiencies in the glaciological, hydro-materiological and hydro-geological research relating to Himalayan glacier system, the Committee are of the considered view that there is an need for setting up an over arching organisation at the national level which can coordinate with various Ministries / Departments / Agencies/ Research Institutes engaged in handling different hydro-geological and hydro-materiological hazards including glacier related hazards for having an integrated approach in collecting and collating information / data on Himalayan glaciers and also the research findings at one place and to maintain a reliable database that can be accessed easily by all agencies and also for issuing early warnings and alerts regarding potential multi hazards to the stake holders and public. In this regard, at the behest of the Committee, various Ministries/ Departments/ research agencies have given their suggestions and offered solutions for effective management and monitoring of glaciers in the country in a coordinated manner as under:-

(i) The Department of Science and Technology has suggested that there is a need for single coordinating agency to coordinate with various other agencies having mandates to handle different hydrometerological and hydrogeological hazards. It has also suggested that to deal with the disasters like cloudburst, GLOF, landslides etc. in an integrated manner, a multi hazard warning system may be put in place through a real-time coordinating mechanism wherein one agency may be entrusted with the responsibility of

continuously monitoring and issuing warnings and alerts to authorities, stakeholders and public;

(ii) The MoEF&CC has suggested that the responsibility for coordination of all activities on the Himalayan glaciers should rest with a single identified nodal coordinating agency within Government of India, such as for e.g. National Security Council Secretariat (NSCS), which is already coordinating with various Government agencies in various studies, including impact of engineering technologies on the glaciers. Such an agency would need to be given an appropriate war time mandate because of recurrence of GLOF, Cloudburst, landslides etc. by allocating the subject through allocation of business.

(iii) The Ministry of Earth Sciences has suggested that a network of fully equipped and integrated monitoring systems supported by a set of field stations in critically important glaciered basins is required for monitoring glaciers and glacier bound hazards. The systems should be automated with real-time access to data to modelers to create a potential early warning system on glacio-hydrological hazards from time to time, based on hazard potential coupled with geographical information system tools downstream activities and population vulnerability along with open access to ground-based meteorological, hydrological and glacilogical data from the entire region to achieve the target. ISRO can contribute by using high resolution and near real time satellite remote sensing to monitor glacial lake and water bodies in development of a reliable database.

(iv) Defence Geoinformatics Research Establishment set up under agegis of DRDO has suggested that an integrated approach for debris flow and GLOF risk management coupled with systematic risk assessment study of the region is imperative to curtail risks of glacial hazards. An inclusive approach with all stakeholders is recommended to understand GLOF phenomenal behaviour by creating ground and remote sensing based inventory of benchmark moraine dammed lakes and monitoring changes on a regular basis along with an effective early warning mechanism to monitor GLOF hazards in order to minimize the risk of such hazards.

Apart from above suggestions / solutions offered by various Ministries/Departments/organisations, the NDMA "Guidelines on Management of Glacial Lake Outburst Flood (GLOF)" has proposed that the Ministry of Jal Shakti (MoJS) be designated as the nodal Ministlry and Central Water Commission (CWC) as the nodal agency for management of GLOF. These Guidelines further propose that a national level Centre for Glacial Research, Studies and Management (CGRSM) be established by the MoJS under the umbrella of the National Institute of

Hydrology (NIH), Roorkee as a premier centre with state-of-the art facilities, which would eventually grow into a national centre of excellence. Keeping in view the suggestions / solutions offered by various Ministries / Departments / Agencies, the Committee urge upon the Department of WR, RD&GR to carefully study the same and prepare a comprehensive concept paper / cabinet note subsuming the solutions/suggestions in consultation with all the Ministries / Departments / Agencies, so as to evolve a consensus on the structure mandate and modalities of the proposed national level apex research organisation viz. CGRSM for placing before the Union Cabinet for their consideration. The Committee would like to be apprised of the action taken in this regard within three months of presentation of the Report.

(Recommendation Sl. No. 3)

NEED TO PROVIDE SUFFICIENT BUDGETARY ALLOCATIONS FOR GLACIER RESEARCH

2.6 The Committee learn from the written submission of the Department of Water Resources, River Development & Ganga Rejuvenation that various Ministries/Departments dealing with the subject of glacier management / monitoring have allocated and spent a meagre amount for conducting research/studies in the field in the last 5 years. While on the one hand, the Committee find that studies such as temporal change in glacier origin and enlargement of glacier area are required for proper assessment and management of glaciers, on the other hand, the fund allocation is not sufficient to encourage such studies. The Committee believe that there is an urgent need to conduct various field-based studies on glaciers which may need adequate funding/budgetary support. As the challenges of managing and monitoring the glaciers movement / behaviour and mitigation of hazards arising therefrom are enormous, the Committee recommend the Government to allocate adequate budgetary resources to the concerned Ministries/Departments involved in the research in the field so as to meet their financial requirements and for ensuring that the activities related to research and monitoring of glaciers do not suffer due to shortage of funds.

(Recommendation Sl. No. 4)

NEED FOR REVIVAL OF SPRINGS IN THE HIMALAYAS

2.7 The Committee note that the Niti Aayog Report of 2018 (Report of Working Group-I on Inventory and Revival of Springs in the Himalayas for Water Security) had warned that almost 60 per cent of water sources in the Indian Himalayan region are on the verge of drying up. The Ayog has proposed launching a National Spring Water Management Programme for the Himalayan Region. The Committee are happy to note that in compliance with the suggestions of the NITI Ayog, the Department of Water Resources, River Development & Ganga Rejuvenation has

created a database of springs existing in the mountainous regions of India, especially in Indian Himalayan region (total 12 states) by compiling all information already available with Survey of India (SoI), Central Ground Water Board (CGWB), National Remote Sensing Centre (NRSC), State Governments, Non-Governmental Organizations (NGO's) and other organizations. The database compiled was analyzed to create a Spring Geographical Information System (GIS) which is available as web based service in Survey of India G2G portal. While appreciating the steps taken for creation of database, the Committee urge upon the Department to take necessary steps for the revival of springs in the Himalayan region as millions of people depend only on Springs for their drinking, domestic, and agricultural water needs. The Committee would like to be apprised of the steps taken by the Department in this regard within three months of the presentation of this Report.

(Recommendation Sl. No. 5)

NEED TO HAVE DATA SHARING AGREEMENTS

2.8 The Committee note that though India has entered into treaty / agreement for water sharing / sharing of hydrological information with its neighbouring countries, however, there is no specific Agreement/Treaty with neighbouring countries for sharing of glacier related data for large-scale modeling and runoff evolution. The Committee are of the view that in order to design / devise a comprehensive and coordinated strategy that could effectively address both the risk of glacier related outburst floods and water management challenges, regional cooperation is the need of the hour. Since the threat posed by the melting/retreating of Himalayan glaciers transcends the national boundries of the Himalayan nations, the Committee are of the considered view that in order to formulate / devise an effective and comprehensive response to the threat posed by melting of glaciers and for mitigating potential hazard situations, regional cooperation for seamless sharing of hydrological information / data on glacier movement / behaviour is very much warranted. The Committee, therefore recommend the Department of Water Resources, River Development & Ganga Rejuvenation to take up the matter with the Ministry of External Affairs so as to have some kind of bilateral/multilateral Agreement with neighbouring Himalayan countries for sharing of information / data on the changing state of glaciers and the threats posed by them. The Committee would like to be apprised of the steps taken by the Department in this regard within three months of the presentation of this Report.

(Recommendation Sl. No. 6)

2.9 The Committee observe that there are various constraints / problems even at the national level in data-sharing relating to glaciological research. The Committee understand from the submissions of the Director, Wadia Institute of Himalayan Geology, that there are many obstacles in using the data especially the high-resolution data because they need specific permission from concerned authorities

before their use. Besides, different Ministries have different protocols for data collection and their sharing. The Committee are of the view that since glaciology is a wide ranging and diverse field, research in this area necessitates requirement of data from a wide range of sources, institutions, and authorities. All information pertaining to glaciers need to be gathered at one place so as to enable its easy access and sharing by researchers and other stakeholders so that they accomplish their stated research goals. The Committee, therefore, recommend the Department to take up this issue with concerned Ministries/Department/Agencies/Institutes for setting up a common data sharing platform under the aegis of a single nodal agency so as to enable seamless exchange of data by various researchers / stake holders.

(Recommendation Sl. No. 7)

NEED TO STRENGTHEN NETWORK OF MONITORING STATIONS

2.10 The Committee note that there is a severe shortage of meteorological and monitoring stations in the Indian Himalayan region. Presently the Defence Geoinformatics Research Establishment (DGRE) has set up three Mountain Metrological Centres (MMC) for avalanche study and the Wadia Institute of Himalayan Geology (WIHG) has five meteorological and discharge stations located in the high altitude regions (~3800 m asl), most of them being of conventional type. The Central Water Commission (CWC) has set up 46 meteorological observation stations in the Himalyan region (1000m above msl) and out of these, only 35 are telemetry based stations. Apart from the above, 16 new telemetry based meteorological observation stations are proposed (1000m above msl) to be set up in the Himalyan region, which is under various stages of implementation. As regards Uttarakhand, which is very vulnerable to landslide induced and glacial lake outburst floods, the Committee find that CWC has only 6 (4 Level + 2 Inflow) flood forecasting stations. Explaining the reason for this, DoWR, RD & GR has stated that CWC issues level forecasts at identified locations and inflow forecasts for identified Dams/ Reservoirs/ Barrages for providing advance information based on the request from the respective State Governments. Hence, based on request from Government of Uttarakhand at present there are only 6 flood forecasting stations. While citing the constraints in making accurate and timely forecast by conventional systems due to tough terrain and flashy nature of rivers in Uttarakhand, the Department stated that for flood forecasting by rainfall-runoff mathematical modelling, sufficiently representative and temporal distribution of real-time rainfall would be required from Indian Meteorological Department (IMD).

The Committee further note that Himalayan glaciers and glacial lakes are not being monitored / observed on a scale on which they should have been due to their remote location and difficulty in accessing them. The strategic importance of glaciers in ensuring water security and the frequent occurrence of several extreme hydro-meteorological events in the recent past due to climate change resulting in abnormal flood like situations damaging human lives and infrastructure, has underlined as never before, the urgency of constant monitoring of the glaciers and

glacial lakes. The Committee believe that in order to have effective and seamless monitoring of Himalayan glaciers and glacier-bound risks, a comprehensive network of field stations in highly important glaciered basins supplemented by integrated monitoring systems is the need of the hour. The Committee thus urge upon the Department to make concerted efforts to set up a network of high altitude meteorological and discharge stations covering more glaciers and watersheds in the Himalayan region. Besides, the Committee call upon the Department to work in close liason with the WIHG and explore the technical feasibility of converting their meteorological and discharge stations in the high altitude regions into Automatic Stations which will be of great use in enabling observation at a high time resolution to be received in real time. The Department should also work in close collaboration with the IMD with a view to ensuring real time rainfall forecast systems for a State like Uttarakhand which frequently becomes victim of various mountainous hazard events. Further, the Committee call upon the Department to reconsider its extant policy of setting up flood forecasting station only on the request from the concerned State Governments, and should become proactive and itself identify the vulnerable locations in collaboration with the respective State Governments, where Forecasting Stations are needed to be set up.

(Recommendation Sl. No. 8)

NEED TO BRING SMALLER GLACIERS UNDER THE PURVIEW OF MONITORING

2.11 The Committee note that as per the inventory of GLs/WBs prepared in 2011, there are 2028 GLs/WBs having size more than 10 ha including 477 GLs/WBs having size more than 50 ha in Himalayan Region of Indian River Basins. Presently, Central Water Commission is monitoring 95 GLs/WBs lying in India having size more than 50 Ha on monthly basis during monsoon season (June to October) every year. The Committee are of the view that it is just not enough to cover only large water bodies/glacial lakes as the smaller glaciers are also more vulnerable to climate change which accelerates their melting and thereby pose potent threat, the fact which has been corroborated by the statement of the representative of the DoWR, RD & GR during the course of oral evidence, wherein he has stated that even a smaller mass of ice or water can be troublesome as witnessed in Chamoli incident which occurred in the State of Uttarakhand in early months of the year 2021 which was non monsoon period. The Committee, therefore, recommend the Department of Water Resources, River Development & Ganga Rejuvenation to take necessary steps to bring smaller water bodies/glacial lakes under their purview for monitoring not only during monsoon period but throughout the year. They also urge upon the Department to collaborate with National Remote Sensing Centre (NRSC) for updation of their 2011 inventory of GLs/WBs which was based on the satellite imageries data of Advanced Wide Field Sensor (AWiFS) of the Indian Remote Sensing Satellite, Resourcesat-2 collected during the period May-Nov, 2009.

(Recommendation Sl. No. 9)

NEED TO HAVE ROBUST EARLY WARNING SYSTEM

2.12 The Committee observe that the recent spike in incidents of mountainous hazards / disasters viz. GLOF, LLOF, snow avalanches, cloud bursts and landslides have underlined the paramount importance of having a robust early warning system. The Committee understand that these mountainous hazards should not be viewed in isolation as single and stand alone incidents but should be seen as interconnected to potential multiple disasters having a cascading impact. However, most of the present day warning systems are not capable of dealing with these kinds of disasters as these are designed for making forecasts only for single disaster. The Committee recommend that the Department should take initiative in this regard and in consultation with other Government agencies like NDMA, Indian Meteorological Department and respective State Governments, particularly the State Government of Uttrakhand for evolving a multi-hazard risk assessment approach so that a Multi-Hazard Early Warning System coupled with real-time coordinated mechanism be set up under the aegis of a single nodal agency for regular monitoring and issuing of hazards / disasters warnings to all stakeholders in respect of potential mountainous hazards.

(Recommendation Sl. No. 10)

2.13 Considering the strategic role and paramount importance of Himalayan glaciers which are literally known as "Water Towers of Asia" and owing to the fact that three major Indian river system are glacier fed which provide water security to the country for various uses like drinking water requirements, hydropower, industry, agriculture etc., the Committee are of the considered view that since green cover in the valleys adjacent to the glaciers is critical and acts as a buffer and would help in reducing the impact of climate change, the same should be protected / conserved. For this purpose, the Committee urge upon the Department of Water Resources, River Development & Ganga Rejuvenation to work in close cooperation with the Ministry of Environment, Forest & Climate Change and other concerned Ministries for evolving a comprehensive policy response so as to preserve the sensitive Himalayan glacier system.

(Recommendation Sl. No. 11)

NEED TO EVOLVE LAND USE REGULATIONS

2.14 The Committee are of the considered view that well laid down procedure / regulations for land use planning / zoning in the Himalayan States especially those area which are more prone and susceptible to landslides, LLOFs, GLOFs etc. will go a long way in mitigating the eventualities that arise in the event of disasters. The Committee were informed by NDMA that in their guidelines on management of GLOFs, they have *inter alia* recommended for constitution of a Committee to formulate specific land use zoning and building construction regulations under aegis of Ministry of Jal Shakti (MoJS). Further, the Committee note that while a Uniform Code for the construction practices is contained in National Building Code of India (NBC 2016) published by the Bureau of Indian Standards (BIS) which

comes under the Ministry of Consumer Affairs, Food & Public Distribution, as regards excavation, a policy on Sediment Management is at drafting stage under aegis of the Ministry of Jal Shakti. The Committee are of the view that regulating construction activities in GLOF/LLOF prone areas will go a long way in averting disasters and saving precious human lives. They, therefore, recommend that as suggested by the NDMA, the Department of WR, RD&GR should constitute a Committee to formulate specific land use zoning and building construction regulations expeditiously. They also recommend that the Department of WR, RD&GR should work in close coordination with BIS, so that NBC norms are adhered to strictly by all the people while constructing buildings in the region. The Committee would like to be apprised of the steps taken by the Department in this regard within three months of the presentation of this Report.

(Recommendation Sl. No. 12)

NEED TO STRENGTHEN FUNCTIONING OF NATIONAL DISASTER RESPONSE FORCE (NDRF)

2.15 The Committee note that NDRF is specialized rescue and response force mandated to respond to national and man-made disasters. However, they were apprised of the fact that heavy equipments like earthmovers/ heavy drilling machines/ JCBs etc, do not form part of the equipment profile of NDRF and these equipments are provided by the local authorities with handlers at the incident site. Further, NDRF is also not equipped with modern muck cleaning instruments/equipments to deal with emergent situations such as the one that arose in Chamoli District in the State of Uttarakhand in the month of February 2021. The Committee are surprised to learn from the deposition of the representative of the NDRF that though roads were fine there was considerable delay on the part of rescue team in reaching the site at Reni in Chamoli District Uttarakhand where the disaster took place on 7th February, 2021, because of distance. The Committee note that there is no dedicated air craft service available with NDRF for airlifting NDRF personnel and they are dependent on IAF/ private choppers provided by the States.

The Committee find that notwithstanding the fact that NDRF is a specialized rescue and response force, however, the constraints / problems such as mentioned above are required to be removed as they hamper the rescue efforts of NDRF at critical times. Since the State Governments many a time lack specialized skills and resources required to deal with the different kind of calamities either natural or man-made, so, reliance of NDRF on the State Governments on delivery of various kinds of equipments may not serve the purpose and even may hamper the timely and much needed rescue operations. The Committee are of the view that instead of depending on State Governments, it would be more advisable for NDRF to have its own dedicated inventory of modern search and rescue equipment. Further, for ensuring timely arrival of NDRF rescue teams at disaster struck locations and avert delays as witnessed in Chamoli incident, it should have its own fleet of aircraft and should not be dependent on the IAF/State Governments to

provide choppers. Besides, recognizing the role of local community as a first responder during any calamity, the Committee feel that the NDRF should organize extensive training programmes for local people in all States in general and in particular for the States which are more vulnerable to natural calamities. The Committee are of the view that NDRF should work closely with the States and render them all possible assistance in raising and training their State Disaster Response Teams. The Committee urge upon the Department of Water Resources, River Development & Ganga Rejuvenation to take up the above-mentioned suggestions with the Ministry of Home Affairs/NDMA to streamline the working of NDRF.

(Recommendation Sl. No. 13)

NEED FOR BOTH UNION AND STATES TO WORK IN TANDEM

2.16 The Committee observe that though a revised National Disaster Management Plan has been prepared for addressing the disasters likely to happen in Himalayan region like landslides, cloudburst, GLOF etc., no specific Disaster Management (DM) Plan has been prepared by the NDMA for the Himalayan States, though the State of Uttrakhand has developed its own State Disaster Management Plan (SDMP) and the updation of the same is in progress. Further, the Committee note that no manual and Standard Operating Procedure (SOP) has been developed by NDMA to deal with the emergent situations arising out of floods including flash floods Cloudburst, Glacier Outburst and Avalanches. It has been informed by NDMA that only guidelines in respect of the subjects viz. disaster management for Management of floods (2008), Urban floods (2008), Glacial Lake Outburst and Floods (GLOFs) (2020) & Landslide & Snow Avalanche (2009) have been prepared and issued defining the roles, responsibilities of different Ministries & States, while the SOPs & Manuals to tackle hazards/ disaster are to be prepared by the concerned nodal agencies.The Committee are of the view that preparation of guidelines by NDMA with regard to various calamities is a welcome step, but the need of the hour is that it should be ensured that these guidelines are implemented in true spirit and in the right earnest by all the concerned stakeholders at the ground level. The Committee are of the considered opinion that it is high time that role of State Governments particularly in the Indian Himalayan Region need to be adequately recognized and they should be made active partners and engaged proactively in monitoring and research of glaciers and issuance of warning in the wake of disasters. Thus, the Union Ministries/Department should work in close cooperation and coordination with the State Governments in order to strengthen their efficacy, capacity building and implementation of the SDMP. The Committee also urge upon the Ministry of Home Affairs/NDMA to improve and streamline their functioning and tone up their Disaster Management Apparatus, so as to anticipate and provide quick response to the impending glacier related and other disasters in the Himalayan region.

(Recommendation Sl. No. 14)

PUBLIC AWARENESS PROGRAMME

2.17 The Committee are pleased to note that various Government Departments/Agencies have taken a number of steps to educate and empower people in environment conservation and adoption of sustainable practices through trainings, demonstrations and dissemination of information in the Indian Himalayan Region. The Committee expect that the various training programmes initiated by the Ministry should not be a one time affair but should be sustained and held at regular intervals so that the momentum generated by these Programmes remains intact and do not lose the steam. It is not an exaggeration to mention that the natural calamities caused by climate change will exacerbate the livelihoods of the communities residing in mountains as well as downstream populations. Hence, there is a greater need not only to make people aware about the deleterious impact of global warming particularly in the Himalayan region but also launch programmes to impart knowledge and encourage them in adopting environmentally sustainable practices and support the local participatory planning for the development of this sensitive region. The Committee recommend that the Department should make all out efforts to launch a blitzkreig by involving print, electronic and popular media as well as social media and also the academia on a larger scale in creating public awareness about the consequences of global warming resulting in threat to the ecosystem, communities and infrastructure.

(Recommendation Sl. No. 15)

NEW DELHI;
28 March, 2023
07 Chaitra, 1945 (Saka)

Parbatbhai Savabhai Patel
Chairperson,
Standing Committee on Water Resources

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MINUTES OF THE NINTH SITTING OF THE STANDING COMMITTEE ON WATER RESOURCES HELD ON TUESDAY, 23 MARCH, 2021

The Committee sat from 1500 hours to 1550 hours in Committee Room 'B', Ground Floor, Parliament House Annexe, New Delhi.

PRESENT

Dr. Sanjay Jaiswal – Chairperson

MEMBERS

LOK SABHA

2. Shri Vijay Baghel
3. ShriBhagirathChaudhary
4. ShriNihal Chand Chauhan
5. ShriGuman Singh Damor
6. Dr.HeenaVijaykumarGavit
7. Dr. K. Jayakumar
8. Shri Hasmukhbhai Somabhai Patel
9. Shri Sanjay(Kaka) Ramchandra Patil

RAJYA SABHA

10. SardarBalwinder Singh Bhunder
11. ShriHarshvardhan Singh Dungarpur
12. Dr. Kirodi Lal Meena
13. ShriArun Singh
14. ShriSubhash Chandra Singh
15. Shri Pradeep Tamta

SECRETARIAT

1.	Shri Manoj K. Arora	-	OSD (LSS)
2.	Shri M.K. Madhusudhan	-	Director
3.	Shri R.C. Sharma	-	Additional Director

WITNESSES

Ministry of Jal Shakti - Department of Water Resources, River Development & Ganga Rejuvenation

1.	Shri S. K. Haldar	Chairman, CWC
2.	Shri Atul Jain	Commissioner (FM), DoWR, RD & GR
3.	Shri Reading Shimrey	Chief Engineer, CWC
4.	Shri Sharad Chandra	Director, CWC
5.	Shri Rakesh Toteja	Sr. Joint Commissioner (FM), DoWR, RD GR

Ministry of Home Affairs - National Disaster Management Authority

1.	Lt Gen (Retd) Syed Ata Hasnain	Member, NDMA
2.	Dr V Thiruppugazh	Additional Secretary (Policy & Plan)
3.	Brig Ajay Gangwar	Advisor (Operations)
4.	Shri Vijay Singh Nemiwal	Joint Advisor (Mitigation Projects)
5.	Shri Ravinder Singh	Senior Consultant (Landslides & Avalanches)
6.	Shri Prasoon Singh	Consultant (Flood)

Ministry of Home Affairs - National Disaster Response Force

	Shri Amarendra Kumar Sengar	Inspector General

2. At the outset, the Hon'ble Chairperson welcomed the Members to the sitting of the Committee convened to have briefing by the representatives of the Ministry of Home Affairs - National Disaster Management Authority and Ministry of Jal Shakti –Department of Water Resources, River Development & Ganga Rejuvenation on the topic 'Preparedness to tackle Floods including Flash floods, Cloudburst, Glacier Outburst and Avalanches' in connection with the examination of the subject 'Flood Management in the country including international water treaties in the field of water resource management/flood control with particular reference to treaty / agreement entered into with Nepal, China, Pakistan and Bhutan'.

[The representatives of the Department of Water Resources, River Development & Ganga Rejuvenation and National Disaster Management Authority were, then, ushered in]

3. After welcoming the representatives of the National Disaster Management Authority and Department of Water Resources, River Development & Ganga Rejuvenation, the Chairperson drew their attention to Direction 55(1) of the Directions by the Speaker regarding the confidentiality of the proceedings of the Committee and asked them to express their views on the subject and explain the measures taken in relation to 'Preparedness to tackle Floods including Flash floods, Cloudburst, Glacier Outburst and Avalanches'. Then, the representative of the NDMA briefed the Committee of the various aspects of the disaster management and programmes being undertaken by them in this regard.

4. Thereafter, the Members of the Committee raised queries and sought clarifications on the following issues pertaining to the subject:-

(i) *Organization structure of NDMA.*
(ii) *Approval of disaster plans of various Ministries and Departments by NDMA.*
(iii) *Strength of National Disaster Response Force (NDRF).*
(iv) *Reasons for Glacial Lake Outburst Floods (GLOF) at Chamoli district, Uttrakhand.*
(v) *Lessons learnt by NDMA from Kedarnath tragedy of 2013.*
(vi) *Need to have SoPs to face Chamoli like disasters.*
(vii) *Excessive time taken by NDRF in reaching the affected area.*
(viii) *Issue of lack of necessary equipment like muck cleaning tools at the disposal of NDRF.*
(ix) *Issues of not having Early Warming System at the power projects extensively damaged by GLOF.*
(x) *Criteria of appraisal of power projects by Central Water Commission (CWC) from hydrological and technological point of view.*
(xi) *Issue of small and micro power projects presently not scrutinized by the CWC.*
(xii) *Surveillance of glaciers through satellites and sensors.*

5. The Chairperson then thanked the representatives for the presentation made by them and expressing their views in a free and frank manner. The Chairperson asked the representatives of the National Disaster Management Authority and Department of Water Resources, River Development and Ganga Rejuvenation to furnish written replies to those queries raised by the Members, which could not be readily replied by them within two weeks.

[The witnesses, then, withdrew]

6. A copy of the verbatim record of the proceedings of the sitting of the Committee has been kept.

The Committee, then, adjourned.

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MINUTES OF THE TENTH SITTING OF THE STANDING COMMITTEE ON WATER RESOURCES HELD ON THURSDAY, 8 APRIL, 2021

The Committee sat from 1500 hours to 1640 hours in Committee Room 'D', Ground Floor, Parliament House Annexe, New Delhi.

PRESENT

Dr. Sanjay Jaiswal – Chairperson

MEMBERS

LOK SABHA

2. ShriBhagirathChaudhary
10. ShriNihal Chand Chauhan
11. Dr. K. Jayakumar
12. Shri M. Dhanush Kumar
13. Shri Sanjay(Kaka) RamchandraPatil
14. Shri Sunil Kumar

RAJYA SABHA

8. SardarBalwinder Singh Bhunder
9. Shri N. R. Elango
10. ShriSubhash Chandra Singh

SECRETARIAT

1.	Shri Manoj K. Arora	-	OSD (LSS)
2.	Shri R.C. Sharma	-	Additional Director

WITNESSES

Ministry of Jal Shakti - Department of Water Resources, River Development & Ganga Rejuvenation

1.	ShriPankaj Kumar	Secretary, DoWR, RD & GR
2.	Shri S. K. Haldar	Chairman, CWC
3.	ShriSharad Chandra	Director, CWC
4.	ShriRakeshToteja	Sr. Joint Commissioner-II
5.	Shri N. N. Rai	Director, CWC

DEPARTMENT OF SCIENCE & TECHNOLOGY

1.	Dr. Akhilesh Gupta	Head, Strategic Programs, Large Initiatives and Coordinated Action Enabler (SPLICE)

GEOLOGICAL SURVEY OF INDIA (GSI) KOLKATA

1. ShriSatyaPrakashShukla Deputy Director General

NATIONAL INSTITUTE OF HYDROLOGY (NIH) ROORKEE

1. Dr. Sanjay Kumar Jain Scientist-G

MINISTRY OF EARTH SCIENCE

1. Dr. Vijay Kumar Scientist-G

MINISTRY OF ENVIRONMENT, FORESTS & CLIMATE CHANGE

1. Dr. J. R. Bhatt Advisor

2. At the outset, the Hon'ble Chairperson welcomed the Members to the sitting of the Committee convened to have briefing by the representatives of the Ministry of Jal Shakti - Department of Water Resources, River Development and Ganga Rejuvenation on the subject "Glacier Management in the country – Monitoring of Glaciers/Glacial Lakes including Glacial Lake Outburst leading to flashfloods in the Himalayan region". The Hon'ble Chairperson, then welcomed Shri Sunil Kumar the newly elected Member from Lok Sabha who has been nominated to serve on the Committee. Thereafter, he informed the Members about the sudden demise of Shri A. Mohammedjan, MP (RS) and Member of the Committee. The Committee, then, passed a condolences resolution expressing their heartfelt grief and offered condolence to the bereaved family. The Committee also observed two minutes silence for paying homage to the departed soul.

[The representatives of the Department of Water Resources, River Development & Ganga Rejuvenation Authority were, then, ushered in]

3. After welcoming the representatives of the Ministry of Jal Shakti - Department of Water Resources, River Development and Ganga Rejuvenation, to the sitting the Chairperson drew their attention to Direction 55(1) of the Directions by the Speaker regarding the confidentiality of the proceedings of the Committee. He then asked them to make their submission/presentation on various aspects of the topic "Glacier Management in the country – Monitoring of Glaciers/Glacial Lakes including Glacial Lake Outburst leading to flashfloods in the Himalayan region". Thereafter, the representative of the Department made a power point presentation highlightingthe work done by different Ministries/Departments in the field of monitoring glaciers and glacial lakes and issues faced in undertaking this work, etc.

4. Thereafter, the Members raised queries and sought clarifications on the following issues pertaining to the subject:-

(xiii) *Process of formation of glaciers.*

(xiv) *Role of Hydro Electric Projects (HEPs) in causing flash floods.*

(xv) *Need to monitor smaller glaciers as they are more vulnerable to climate change leading to their melting.*

(xvi) *Lack of coordination among different Ministries/Departments/Agencies involved in glacier monitoring and research work.*

(xvii) *Reason for withdrawal of controversial paragraph of IPCC Report which stated that glaciers would vanish by 2035.*

(xviii) *Effect of Himalayan Cryosphere on water resources, including floods and need to incorporate Himalayan Cryosphere in the Allocation of Business Rules.*

(xix) *Proposal of Central Water Commission (CWC) to monitor glacial lakes of 10 hectare and above in view of recent tragedy at Chamoli district in Uttarakhand.*

(xx) *Need to make efforts to give sufficient warning time to different agencies including State Governments for rescue purpose.*

(xxi) *Effect of black carbon on the health of glaciers.*

5. Thereafter, with the permission of the Hon'ble Chairperson of the Committee, ShriNihal Chand, MP, (LokSabha) and Member of the Committee raised the issue of polluted water released in the canals of the State of Rajasthan.

6. The Chairperson then thanked the representatives for the presentation made by them and expressing their views in a free and frank manner. He then directed the representatives of all the Ministries/Departments who attended the sitting to furnish a brief note separately spelling out the solutions to the various problems discussed during the sitting to the Secretariat within 10 days. He also asked the representatives of the respective Ministries/Departments to furnish their written replies to those queries raised by the Members, which could not be readily replied by them within two weeks.

[The witnesses, then, withdrew]

7. A copy of the verbatim record of the proceedings of the sitting of the Committee has been kept.

The Committee, then adjourned.

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MINUTES OF THE ELEVENTH SITTING OF THE STANDING COMMITTEE ON WATER RESOURCES HELD ON MONDAY, 21 JUNE, 2021

The Committee sat from 1400 hours to 1600 hours in Main Committee Room, Ground Floor, Parliament House Annexe, New Delhi.

PRESENT

Dr. Sanjay Jaiswal – Chairperson

MEMBERS

LOK SABHA

2. Shri Vijay Baghel
15. Shri Bhagirath Chaudhary
16. Shri Chandra Prakash Choudhary
17. Dr. Heena Vijay Kumar Gavit
18. Shri Kaushal Kishore
19. Shri M. Dhanush Kumar
20. Shri Hashmukhbhai Somabhai Patel
21. Shri Sunil Kumar
22. Shri A. Narayana Swamy

RAJYA SABHA

11. Sardar Balwinder Singh Bhunder
12. Dr.Kirodi Lal Meena
13. Shri Subhash Chandra Singh
14. Shri PradeepTamta

SECRETARIAT

1.	Shri Manoj K. Arora	-	OSD (LSS)
2.	Shri M. K. Madhusudhan	-	Director
2.	Shri R.C. Sharma	-	Additional Director

WITNESSES

MINISTRY OF ENVIRONMENT, FORESTS & CLIMATE CHANGE

1.	Shri R. P. Gupta	Secretary
2.	Shri Ravi Agarwal	Additional Secretary
3.	Shri Jigmet Takpa	Joint Secretary
4.	Dr. J. R. Bhatt	Advisor

DEPARTMENT OF SCIENCE & TECHNOLOGY

1.	Dr. Akhilesh Gupta	Scientist & Head, Climate Change Programme
2.	Dr. Kalachand Sain	Director, Wadia Institute of Himalayan Geology, Dehradun

DEFENCE RESEARCH & DEVELOPMENT ORGANISATION (DRDO)

1.	Dr. L.K. Sinha	Director, DGRE & Scientist
2.	Dr. P.K. Satyawali	Scientist
3.	Dr. Amod Kumar	Scientist
4.	Dr. Ravindra Singh	Director, DPARO&M & Scientist

MINISTRY OF JAL SHAKTI (DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION)

1.	Shri R.K. Sinha	Member, CWC
2.	ShriSharad Chandra	Director, CWC

2. At the outset, the Chairperson welcomed the Members to the sitting of the Committee convened to have briefing by the representatives of (i) Ministry of Environment, Forests & Climate Change; (ii) Department of Science & Technology (DST)-Wadia Institute of Himalayan Geology; (iii) Defence Research Development Organization (DRDO)-Defence Geo Informatics Research Establishment (DGRE) in connection with examination of the subject “Glacier Management in the country-Monitoring of Glaciers/Glacial Lakes including Glacieral Lake Outbursts leading to flashfloods in the Himalayan region”.

3. XXX XXX XXX XXX XXX XXX
XXX XXX XXX XXX XXX XXX
XXX XXX XXX XXX XXX XXX
XXX XXX XXX XXX XXX XXX

[The representatives of the Ministries/Departments/Agencies were then, ushered in]

4. Thereafter, Chairperson welcomed the representatives of the Ministries/Department/ agencies concerned and read out Direction 55(1) of the Directions by the Speaker regarding confidentiality of the proceedings of the Committee. The Chairperson then asked the representatives to make a brief presentation on various aspects of the subject “Glacier Management in the country-Monitoring of Glaciers/Glacial

Lakes including Glacial Lake Outbursts leading to flashfloods in the Himalayan region". Thereafter, the representatives of the Ministry of Environment, Forests & Climate Change and Department of Science & Technology (DST) made a power point presentation highlighting the work done by them in the field of monitoring glaciers and glacial lakes and issues faced in undertaking this work, etc. The representatives of DGRE and Department of Water Resource, River Development & Ganga Rejuvenation also explained the work being done by them in the field. Thereafter, the Members raised queries and sought clarifications on issues concerned with the subject matter.

5. The important issues/ topics raised during the discussion on the subject, amongst others, included the following:

(i) Need for a single agency to coordinate with various other agencies having mandates to handle different hydro-meteorological and hydro-geological hazards;

(ii) Setting up of a multi-hazard alert and early warning system to predict GLoFs in the Indian Himalayan Region;

(iii) Need for State Governments to work in tandem with Central Agencies in monitoring, research and warning system for hazards;

(iv) Measures to mitigate impact of global warming on Glaciers;

(v) Identification of critical/sensitive Glacial lakes;

(vi) Need for proper study of solid based water available in upper Himalayan region; and

(vii) Need for coordination among different Ministries/Departments/Agencies for exchange of Data and research findings.

6. The Chairperson, thanked the representatives of the Ministries/Departments/ Agencies for their presentation and for replying to the queries raised by the Members. He asked the representatives to furnish written replies to those queries raised by the Members which could not be readily replied and on which detailed statistical replies are required, to the Secretariat within a fortnight.

[The witnesses, then, withdrew]

7. A copy of the verbatim record of the proceedings of the sitting of the Committee has been kept.

The Committee, then adjourned.

MINUTES OF THE SEVENTH SITTING OF THE STANDING COMMITTEE ON WATER RESOURCES (2022-23) HELD ON THURSDAY, 23 MARCH 2023

The Committee sat from 1500 hours to 1530 hours in Chairperson's Chamber (Room No. 203), Second Floor, Parliament House Annexe Extension, B-Block, New Delhi.

PRESENT

Shri Parbatbhai Savabhai Patel - Chairperson

MEMBERS

LOK SABHA

2. Shri Vijay Baghel
3. Shri Nihal Chand Chauhan
4. Shri Bhagirath Choudhary
5. Shri Guman Singh Damor
6. Dr. K. Jayakumar
7. Dr. Heena Vijaykumar Gavit
8. Shri Dhanush M. Kumar
9. Shri Sunil Kumar
10. Shri Kuruva Gorantla Madhav
11. Shri Hasmukhbhai Somabhai Patel
12. Smt. Agatha K. Sangma
13. Shri Pratap Chandra Sarangi
14. Shri Shivkumar C. Udasi
15. Shri Sanjay Kaka Patil

RAJYA SABHA

16. Shri Aneel Prasad Hegde
17. Shri Arun Singh
18. Sant Balbir Singh
19. Shri Pramod Tiwari

SECRETARIAT

1.	Shri Chander Mohan	-	Joint Secretary
2.	Shri Ajay Kumar Sood	-	Director
3.	Shri R.L. Yadav	-	Additional Director

2. At the outset, the Chairperson welcomed the Members to the sitting of the Committee. Thereafter, the Committee took up for consideration draft Report on the subject "Glacier Management in the Country- Monitoring of Glaciers/Lakes including Glacial Lake Outbursts leading to Flash-floods in the Himalayan Region". After due deliberation, the Committee adopted the aforesaid draft Report, without any modification.

3. The Committee then authorized the Chairperson to present the Report on their behalf to both the Houses of Parliament in the current Budget Session.

4. Thereafter, the Committee decided to undertake an on the spot Study visit in May, 2023.

The Committee then adjourned

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Annexure - I

Details of Glaciers studied by GSI for recession/ advancement

In Geological Survey of India, glacier monitoring has been done both by assessment of glacier mass balance and as well as monitoring the change in glacier length using ground based glaciological techniques in parts of Indus catchment. During 1974-75 to 2020-21 period, the assessment of glacier mass balance, on nine glaciers, viz. Neh Nar, Rulung (Union Territory of Jammu & Kashmir); Gara, GorGarang, ShauneGarang, Hamtah (Himachal Pradesh), Dunagiri, Tipra bank (Uttarakhand) and ChangmeKhangpu (Sikkim) have been undertaken. The studies have revealed overall negative average annual specific balance ranging from 0.11 to 1.47 m of w. eq. indicative of a considerable mass wastage of Himalayan glaciers.

In addition, monitoring of 76 glaciers by GSI has revealed that the majority of Himalayan glaciers are passing through a marked phase of recession, which is a worldwide phenomenon.

List of the Glaciers studied by GSI for recession/ advancement

S.N.	Name of glacier	Basin	Identification No.	Period	Average annual retreat (m/year)
1.	DurungDrung	Indus	IN5Q13205 582	1971-2013	13.1
2.	Hagshu	Indus	IN5Q13205 559	1975-2015	11.4
3.	Pensilungpa	Indus	IN5Q13202 263	1962-2015	7.4
4.	Shafat	Indus	IN5Q13202 080	1975-2015	22.0
5.	Parkhachik	Indus	IN5Q13202 094	1962-2015	3.2
6.	ChhotaShigri	Chenab	IN5Q21212 159	1962-1995	6.8
7.	Bara Shigri	Chenab	IN5Q21212 152	1962-2015	32.4
8.	Hamtah	Chenab	IN5Q21212 180	2000-2010	12.5
9.	Triloknath	Chenab	IN5Q21209 019	1968-1996	17.9
10	YocheLungpa	Chenab	IN5Q21211 179	1963-2006	19.5
11	Mulkila	Chenab	IN5Q21211 170	1963-2006	14.8
12	Panchinala – I	Chenab	IN5Q21211146	1963-2007	10.6
13	Panchinala - II	Chenab	IN5Q21211148	1963-2007	11.9
14	Tingal Goh	Chenab	IN5Q21211 188	1963-2008	16.0
15	Miyar	Chenab	IN5Q21210 045	1961-1996	16.4
				1962-2017	21.90
16	Sonapani	Chenab	IN5Q21212 028	1906-2014	17.6
17	Gangstang	Chenab	IN5Q21211 007	1963-2008	29.7
18	Gepang Gath	Chenab	IN 5Q21212 014	2003-2012	45.0
19	SamundarTapu	Chenab	IN5Q21212 074	1962-2013	24.8
20	Batal	Chenab	IN5Q21212 054	1962-2014	7.2
21	Man Talai (Gl. No. 115)	Beas	IN5Q22109 115	1989-2004	23.3
22	Beas Kund	Beas	IN5Q22108 015	1963-2003	18.8
23	Gl. No. 30	Beas	IN5Q22108 030	1963-2003	13.8
24	Jobri	Beas	IN5Q22108 036	1963-2003	2.5
25	Sara Umga	Beas	IN5Q22109 025	1963-2004	41.5
26	Tal	Ravi	IN5Q21106 047	1963-2005	39.9
27	Manimahesh	Ravi	IN5Q21106 059	1968-2005	29.1
28	Gara-I	Satluj	IN5Q22214 050	1979-2010	25.6
29	ShauneGarang	Satluj	IN5Q22213 084	1963-1984	31.1
30	BilareBange	Satluj	IN 5Q22213 082	1963-2011	65.2
31	NaraduGarang	Satluj	IN 5Q22213 078	1963-2011	34.1

32	Pin	Satluj	IN5Q22219 095	1965-2014	12.7
33	Nisti	Satluj	IN5Q22219 089	1965-2014	14.5
34	Parang	Satluj	IN5Q22219 485	1962-2013	11.0
35	Padma	Satluj	IN5Q22219 478	1962-2013	7.0
36	NagpoTokpo	Satluj	IN 5Q22219 259	1962-1998	6.4
37	Bandarpunch	Yamuna	IN 5O12301 045	1960-1999	25.5
38	JhajjuBamak	Yamuna	IN 5O12301 029	1960-1999	27.6
39	JaundarBamak	Yamuna	IN 5O12301 033	1960-1999	37.3
40	Tilku	Yamuna	IN 5O12301 025	1960-1999	21.9
41	Bhrigupanth	Bhagirathi	IN 5O13106 041	1962-1995	16.7
42	Gangotri	Bhagirathi	IN 5O13106 029	1935-1996	18.8
43	Glacier No. 3	Alaknanda	IN 5O13206 069	1932-1956	8.3
44	Chorabari	Alaknanda	IN5O13202 003	1992-1997	11.0
45	Bhagirathi Kharak	Alaknanda	IN 5O13206 028	1962-2001	14.7
46	Dunagiri	Alaknanda	IN 5O13209 044	1992-1997	3.0
47	Pindari	Alaknanda	IN 5O13203 048	1958-2001	9.4
48	Milam	Ghaghra	IN 5O10303 034	1906-2011	20.6
49	Burphu	Ghaghra	IN 5O10303 063	1963-2011	69.7
50	Jhulang	Ghaghra	IN 5O10304 024	1962-2012	9.4
51	Nikarchu	Ghaghra	IN 5O10305 024	1962-2002	9.1
52	Poting	Ghaghra	IN 5O10303 008	1963-2011	29.0
53	Adikailash	Ghaghra	IN 5O10305 028	1962-2002	13.1
54	Sankalpa	Ghaghra	IN 5O10303 074	1881-1957	6.8
55	Meola	Ghaghra	IN 5O10304 010	1912-2012	18.6
56	Chipa	Ghaghra	IN 5O10304 007	1961-2012	24.9
57	Zemu	Tista	IN5O20105 032	1907-2012	9.0
58	ChangmeKhangpu	Tista	IN5O20104 022	1983-2012	13.4
59	East Rathong	Tista	IN 5O20101006	1966-2015	20.0
60	KedarBamak	Bhagirathi	IN 5O131 06 63	1976-2016	30.8
61	Raykana	Dhauliganga	IN 5O132 08 25	1968-2016	7.19
62	Mabang	Dhauliganga	IN 5O103 04 30	1962-2017	6.96
63	Pyungru	Dhauliganga	IN 5O103 04 73	1962-2017	4.45
64	Takdung	Chenab	IN 5Q21210 051)	1989-2017	9.64
65	Uldhampu	Chenab	IN 5Q21210 075)	1989-2017	4.66
66	Menthosa	Chenab	IN 5Q21210 021)	1965-2018	4.32
67	Gumba	Chenab	IN 5Q21210 078	1971-2018	10.38
68	Gangpu	Chenab	IN 5Q21210 058	1989-2018	2.79
69	Sagtogpa	Rongdo	IN 5Q13106	1973-2018	7.4
70	Sagtogpa East	Rongdo	IN 5Q13106	1973-2018	8.13
71	TharaKangri	Rongdo	IN 5Q13106	1973-2018	+11.13 (Surged)
72	GaramPani	Rongdo	IN 5Q13106	1973-2018	4.96
73	Rassa I	Rangdo	IN 5Q131 06	1973-2019	8.13
74	Rassa II	Rangdo	IN 5Q131 06	1973-2019	2.63
75	Arganglas Glacier	Rangdo	IN 5Q131 06	1973-2019	18.86
76	Phunangma	Rangdo	IN 5Q131 06	1973-2019	11.65

As per the available information in published domain, the predicted effects of climate change include loss of glacier resources, changes in the hydrology of the Himalayan rivers including some water problems in the dry/lean season, enhanced debris production, sea level rise, increased intensity and frequency of extreme weather events, impacts on agriculture, spread of disease etc. Regarding the water-availability in a glacier fed river basin, it is dependent on glacier-melting, seasonal snow-melt, the amount of rainfall and the release of ground water.

Various studies have indicated that under climate change scenario, the continuous recession of glaciers, particularly debris covered glaciers, will lead to formation of glacial lakes.

The further recession of glaciers may lead to increase in size of such lakes which may ultimately lead to Glacial Lake Outburst Floods (GLOF). In view of the above, GSI has undertaken compilation of inventory of glacial lakes in northwest Himalaya. A total of 486, 533 and 925 glacial lakes located in lower reaches of ablation zone have been demarcated in Uttarakhand, Himachal Pradesh, and Jammu & Kashmir (including Ladakh) respectively.Similarly, an updated inventory of the Himalayan glaciers is also in the process of preparation.

The recession of glacier is a natural cyclic process. Throughout the history of the earth there have been number of glacial and inter-glacial periods. The last period of glaciation ceased at about 10,000 years B.P. Since then, a period of de-glaciation has set in with some small fluctuations in between. During this interglacial phase (Holocene period), pulses of minor glacial advancements, commonly referred as 'Little Ice Age' (LIA), have been reported by various workers in different parts of the World, including Indian Himalaya.

Annex – II

LOSS OF HUMAN LIVES DUE TO FLOOD IN HIMACHAL PRADESH, J&K, SIKKIM AND UTTARAKHAND DURING THE YEAR 2002 TO 2018

Sl.	Year	H.P.	J&K	Sikkim	Uttarakhand
1	2001	45	0	0	78
2	2002	0	0	0	0
3	2003	89	0	0	2
4	2004	8	0	0	0
5	2005	8	0	0	0
6	2006	48	0	0	0
7	2007	98	0	0	0
8	2008	148	0	0	0
9	2009	0	0	0	87
10	2010	62	0	0	196
11	2011	51	0	0	54
12	2012	27	0	41	135
13	2013	73	0	16	580
14	2014	45	281	0	66
15	2015	133	3	N.A.	33
16	2016	40	3	N.A.	114
17	2017	75	7	10	59
18	2018	343	6	N.A.	101

Note: N.A. = Not available