Role of Dams in Mitigating the Impacts of Climate Change

by

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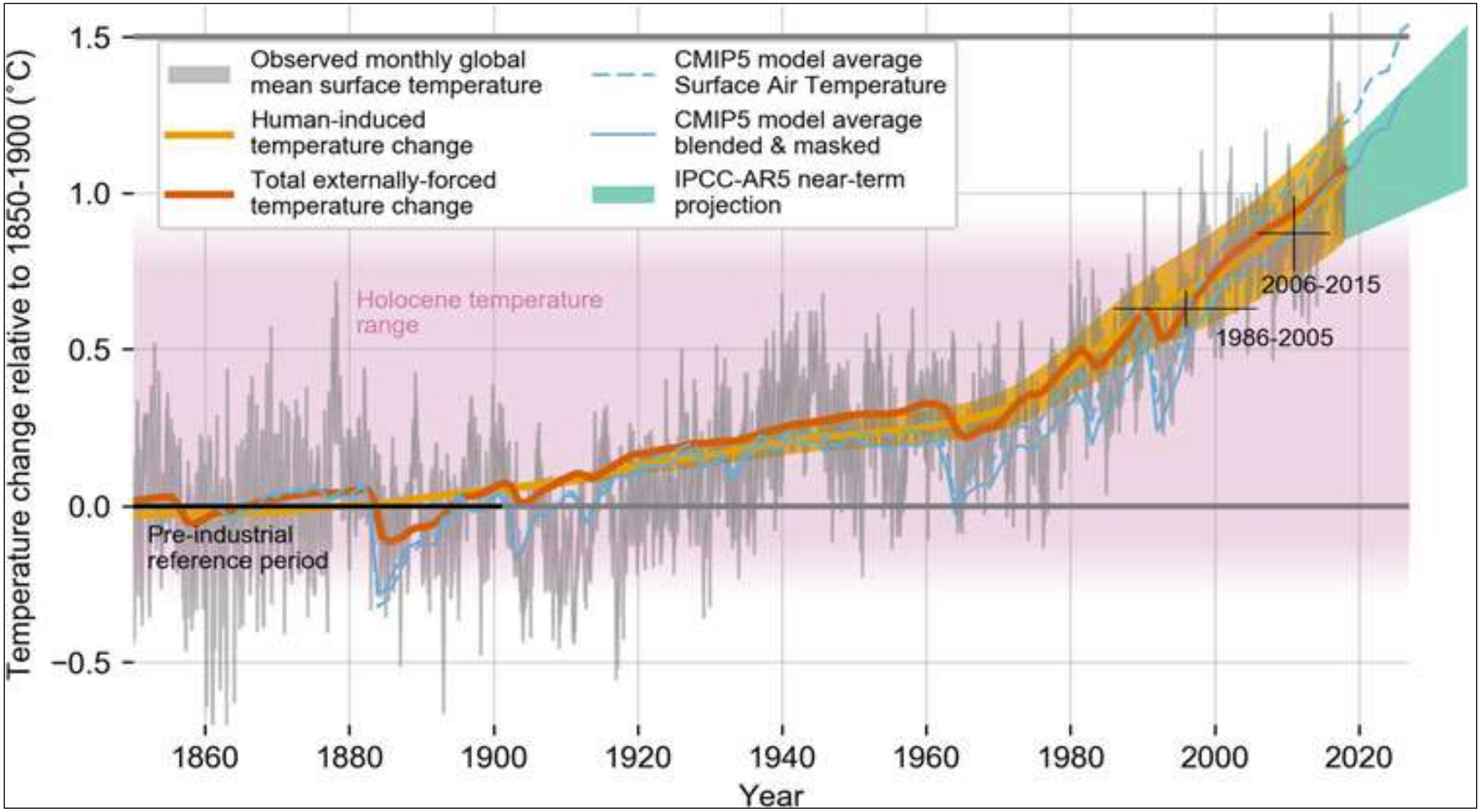
Climate Change

- **Climate change is increasing uncertainty about where cyclones, floods, and other climate crises will occur, when, for how long, and at what level of intensity. Extreme events are likely to increase.**
- **The mean temperature rise over India by the end of the twenty-first century is projected to be in the range of 2.4–4.4 °C**
- **With the resultant increase in temperature and atmospheric moisture, climate models project a considerable rise in the mean, extremes and inter-annual variability of monsoon precipitation by the end of the century**
- **With increase of extremes and inter-annual variability of monsoon precipitation, the role of dams becomes extremely important in mitigating the impacts of climate change.**

Changes Observed in Global; Surface Temperature (Source IPCC – AR5)

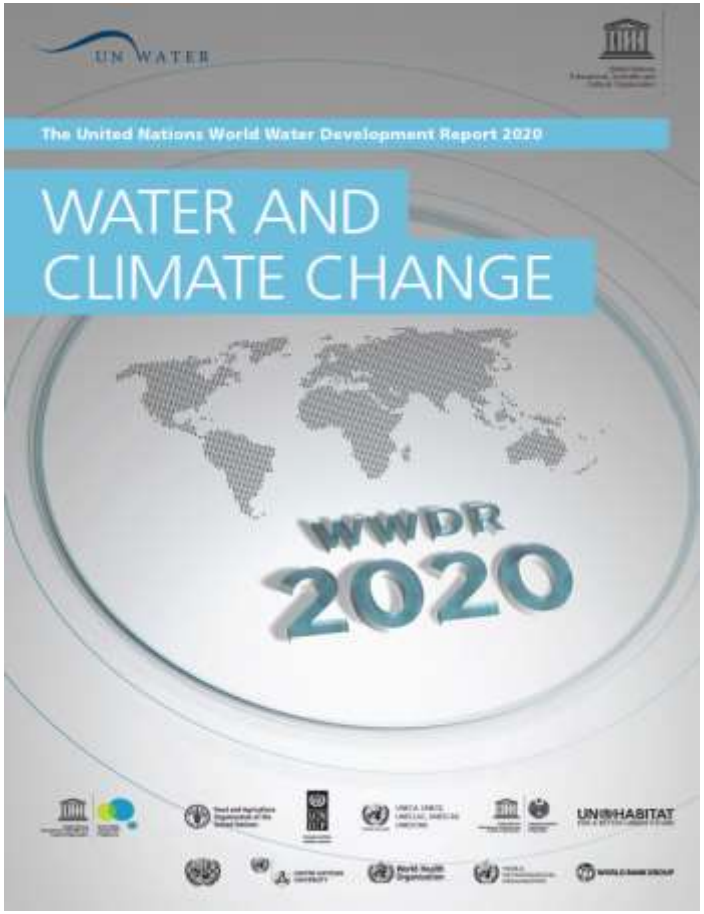


Climate Change – Precipitation Changes Over India

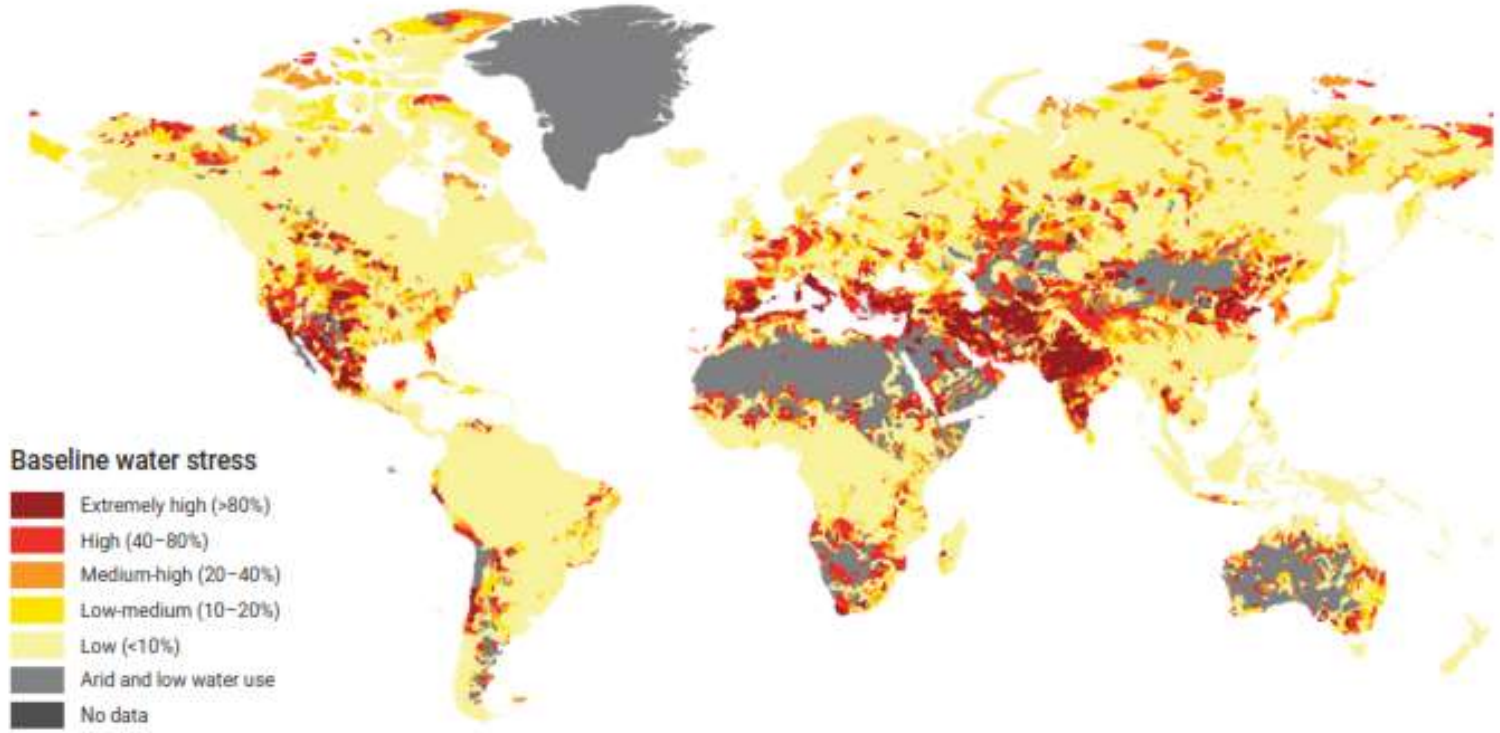
- The water vapour holding capacity of the atmosphere is expected to increase by about 7% per degree of warming
- The enhanced availability of moisture is expected to enhance the Indian summer monsoon precipitation by 5–10%
- There is significant rising trend in the frequency and intensity of extreme heavy rain events.
- Himalayan Mountains cover a surface area of permanent snow and ice in the region which is about 97,020 km2 with 12,930 km3 volume
- Warming is likely to increase the glacial melt more rapidly. At the same time precipitation in the form of snow would also increase.
- This would lead to increased summer flows in some river systems. Distribution of flow would undergo change. Water availability during the lean season would reduce.

Climate Change – Water Crisis

- **As per UN World Water Development Report 2020, Climate change will affect the availability, quality and quantity of water for basic human needs**
- **Climate change will made extreme events more severe by altering the timing, intensity and duration of their occurrences**
- **The alteration of the water cycle will also pose risks for energy production, food security, human health, economic development and poverty reduction**



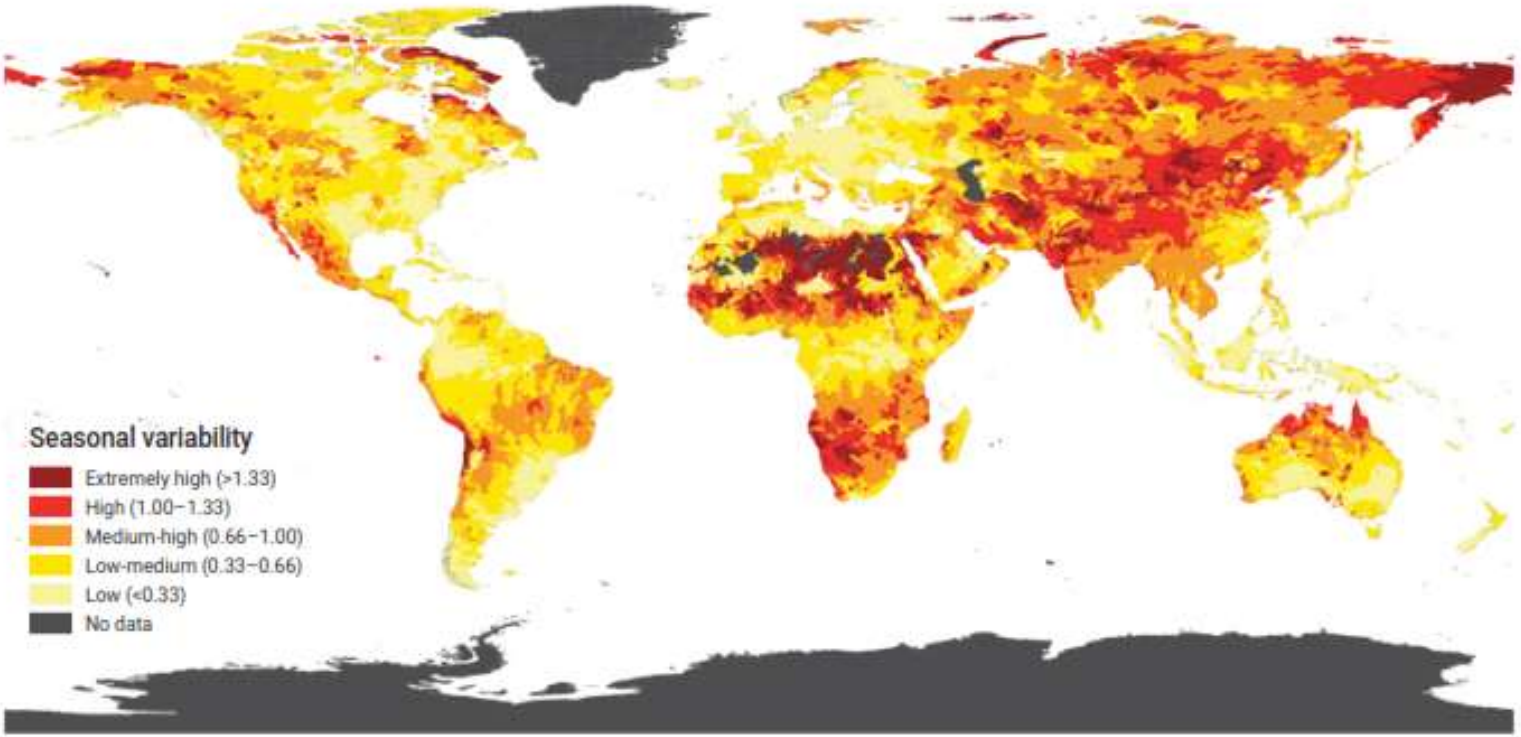
Annual base line water stress-WWRD Report 2020



Note: Baseline water stress measures the ratio of total water withdrawals to available renewable water supplies. Water withdrawals include domestic, industrial, irrigation and livestock consumptive and non-consumptive uses. Available renewable water supplies include surface and groundwater supplies and considers the impact of upstream consumptive water users and large dams on downstream water availability. Higher values indicate more competition among users.

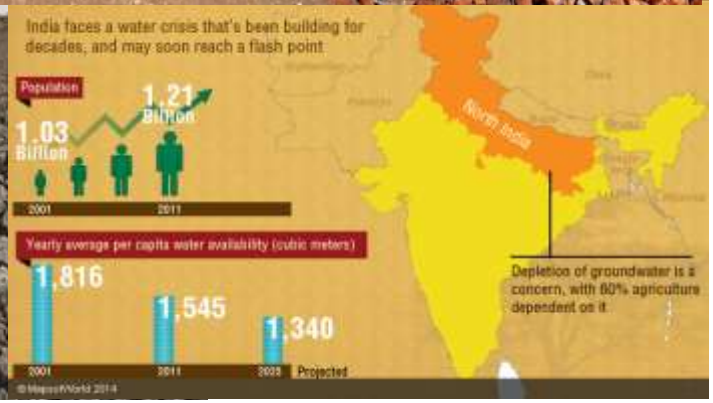
Source: WRI (2019). Attribution 4.0 International (CC BY 4.0).

Seasonal variability of available water-WWRD Report 2020

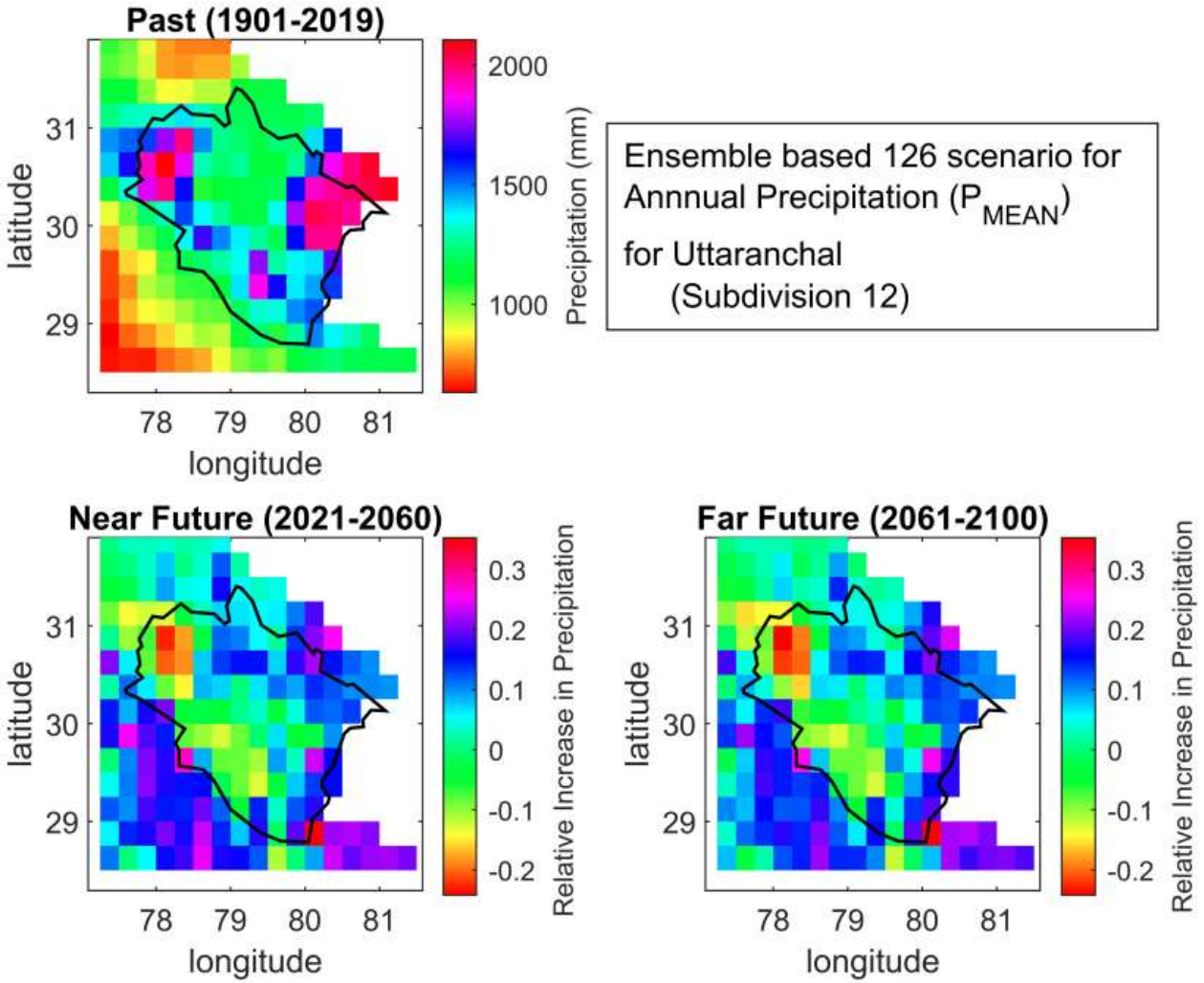


Note: Seasonal variability measures the average within-year variability of available water supply, including both renewable surface and groundwater supplies. Higher values indicate wider variations of available supply within a year.

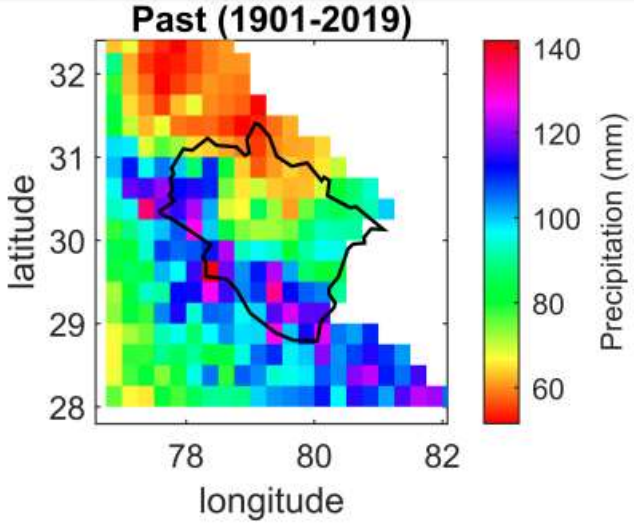
Climate Change – Indian Scenario



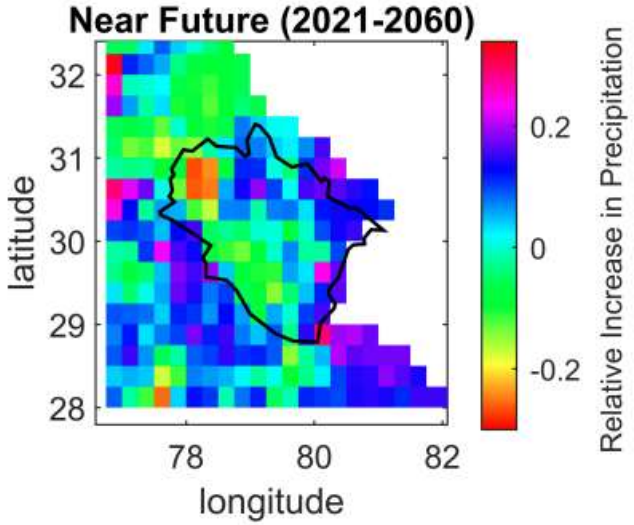
Climate Change- Impact on Annual Mean Precipitation in Uttarakhand

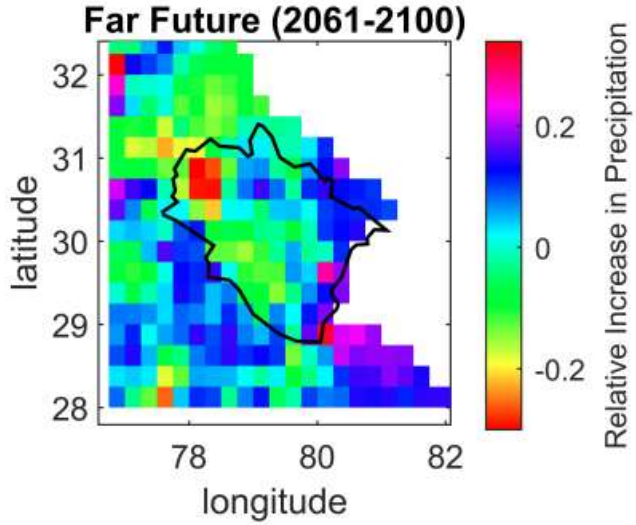


Climate Change- Impact on Annual Maximum Precipitation in Uttarakhand

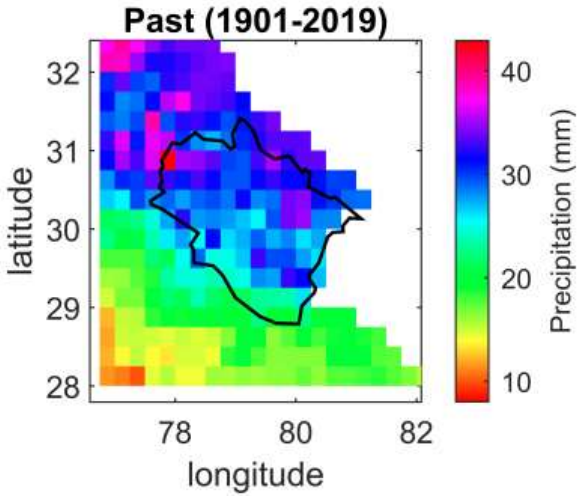


Ensemble based 126 scenario for Annnual Maximum Precipitation (P_{MAX}) for Uttaranchal (Subdivision 12)

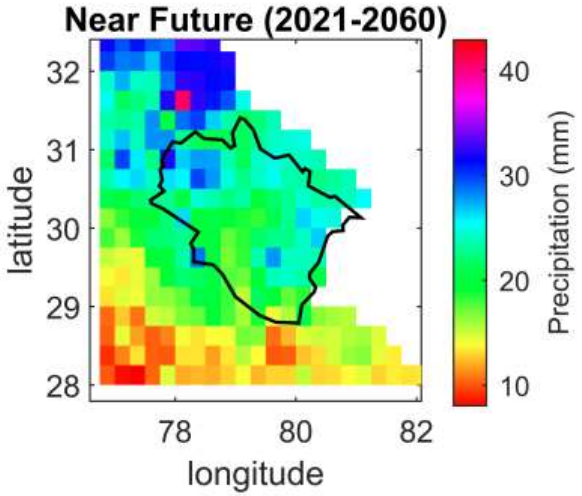


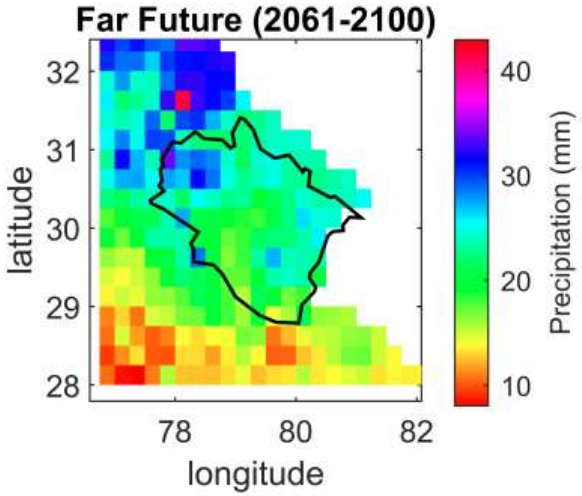


Climate Change- Impact on Winter Season Precipitation in Uttarakhand

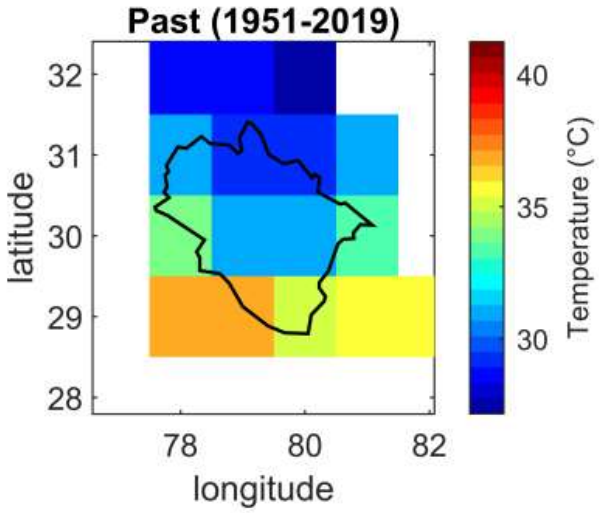


Ensemble based 245 scenario for Winter season P_{MAX} for Uttaranchal (Subdivision 12)

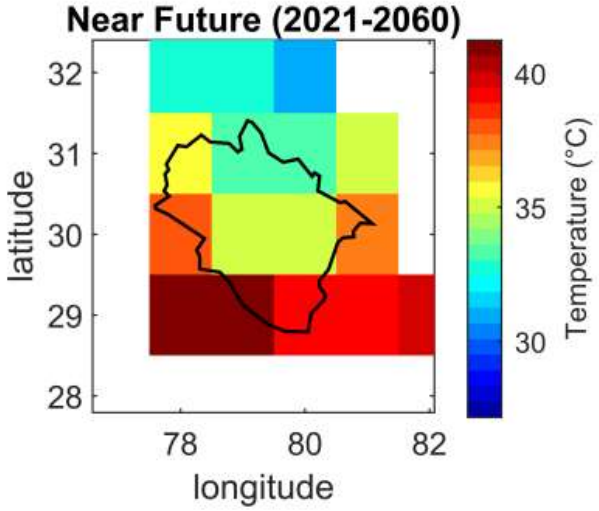


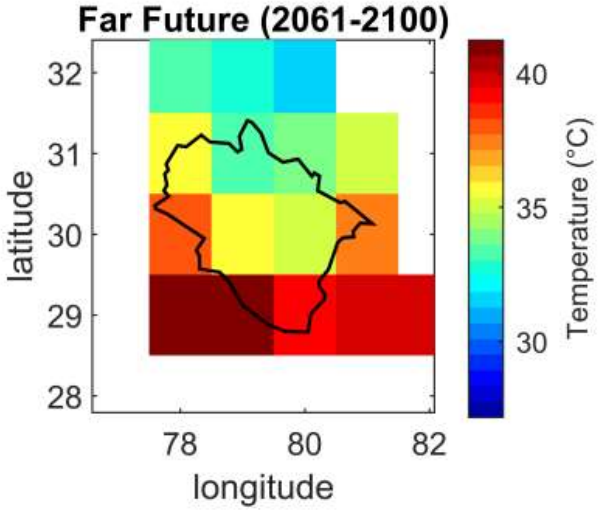


Climate Change- Temperature Change in April Month in Uttarakhand



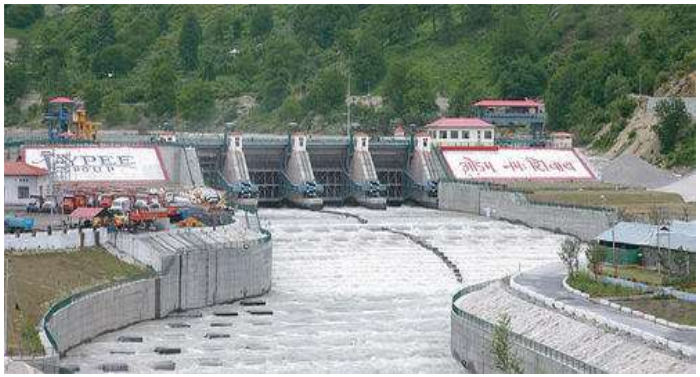
Ensemble based 126 scenario for April Month T_{MAX} for Uttaranchal (Subdivision 12)





Impact of Climate Change on Hydro Power

- **Hydropower is the third largest contributor of energy consumed in the Indian power sector.**
- **India has utilized so far 46,209 large hydropower only of the total 145,000 MW hydropower potential and tremendous opportunities for future expansion exist.**
- **Precipitation and run-off are likely to increase in most parts of India due to climate change**
- **Hydropower projects with storage facility are likely to produce more energy.**
- **Run of the river schemes are likely to be benefitted only marginally due to climate change as increased precipitation mostly during monsoon period cannot be effectively be utilised in these schemes.**



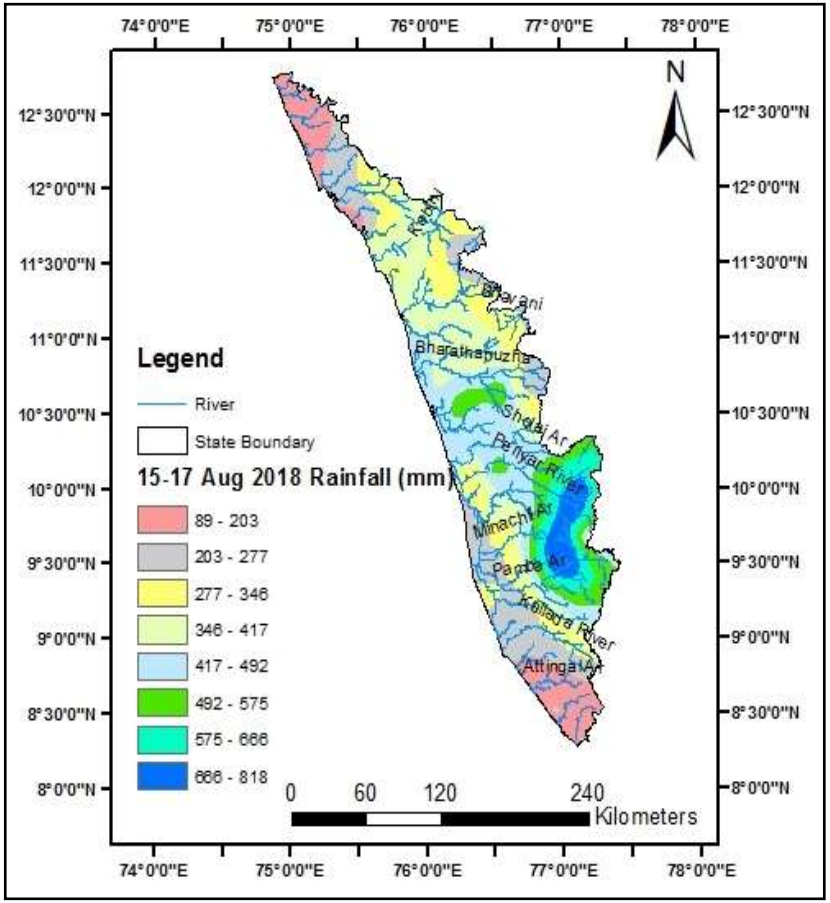
Impact of Climate Change on Water Security

- **As per the NCIWRD estimate, though the water demand in 2050 is high demand scenario (1180 BCM) is approximately matching with the average water availability of the country (1121 BCM), the basin wise water availability has wide variations.**
- **India would face effects of climate change on varied basis where some regions might face High Impacts and some will face low impacts**
- **In such a case, the construction of storage reservoirs and creation of national water grid through river interlinking becomes important for water security**

Sl. No.	Total Water Requirement for Different Uses (in BCM) as per NCIWRD-1999			
	Uses	Year 2010	Year 2025	Year 2050
1.	Irrigation	557	611	807
2.	Domestic	43	62	111
3.	Industries	37	67	81
4.	Power (Energy)	19	33	70
5.	Others	54	70	111
	Total	710	843	1180

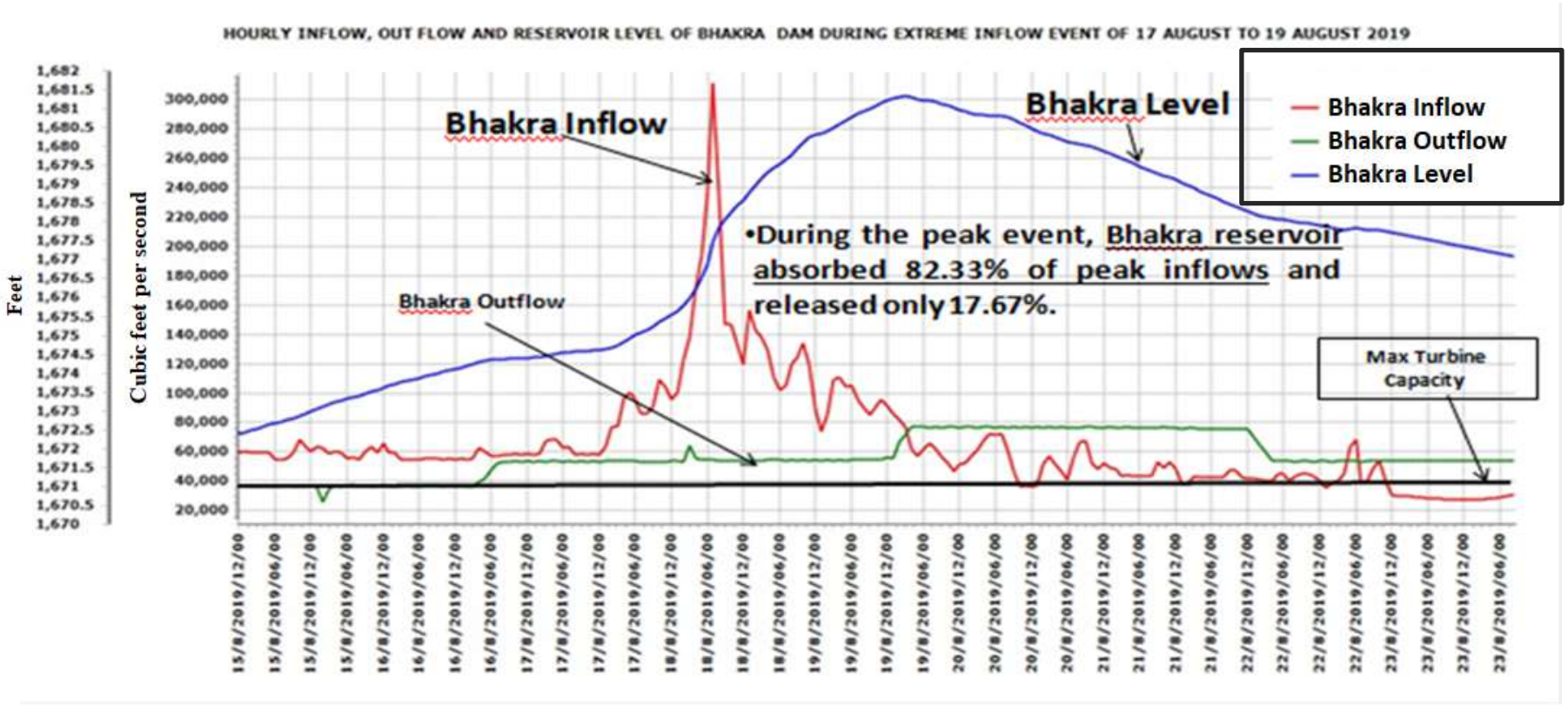
Impact of Climate Change on Floods

- India has seen some major devastating floods in the recent past
- Uttarkhand flood of June 2013, J&K flood of Sep 2014, Kerala flood of Aug 2018, Krishna flood of Oct 2020 indicate the change in rainfall patterns and intensity
- One of the major functions of dams and reservoirs is to mitigate floods
- Even without dedicated flood cushions, almost all reservoirs provide flood mitigation by their dynamic flood cushion



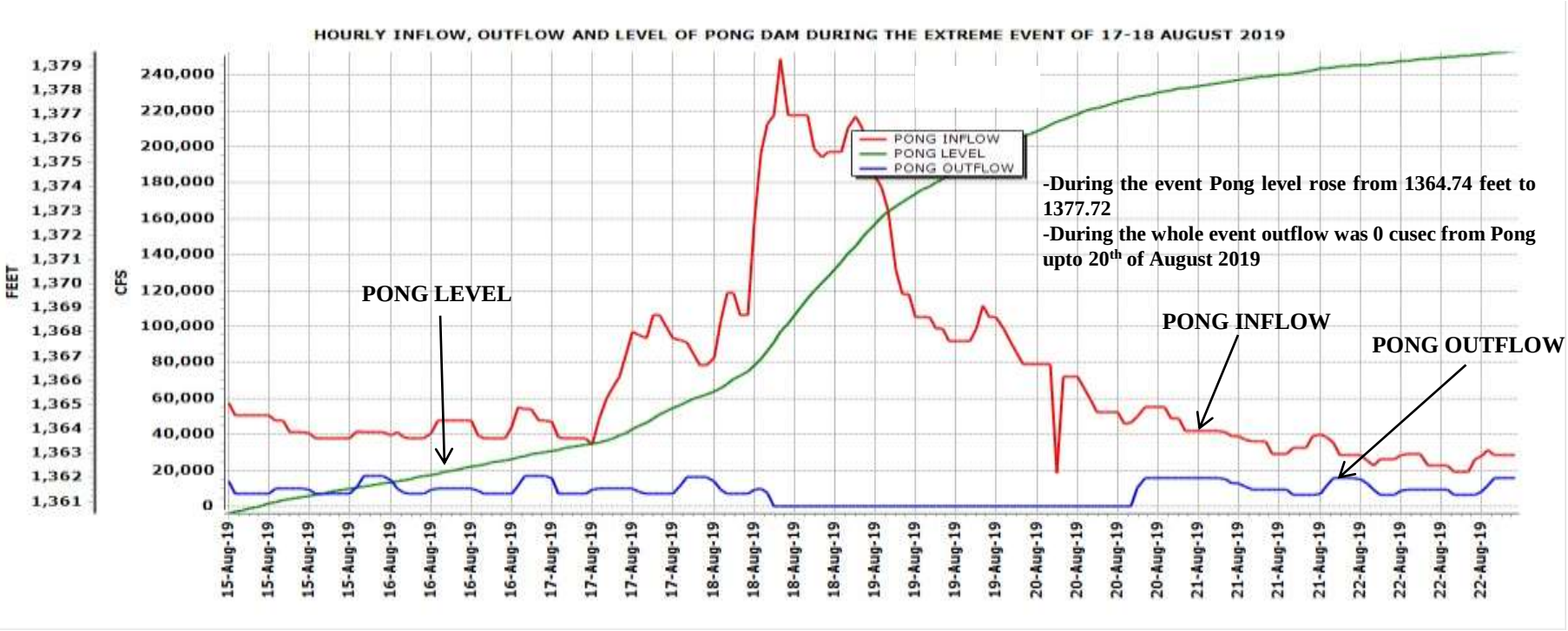
15-17 Aug 2018 rainfall in Kerala

Flood Mitigation by Bhakra Dam During August, 2019 Flood



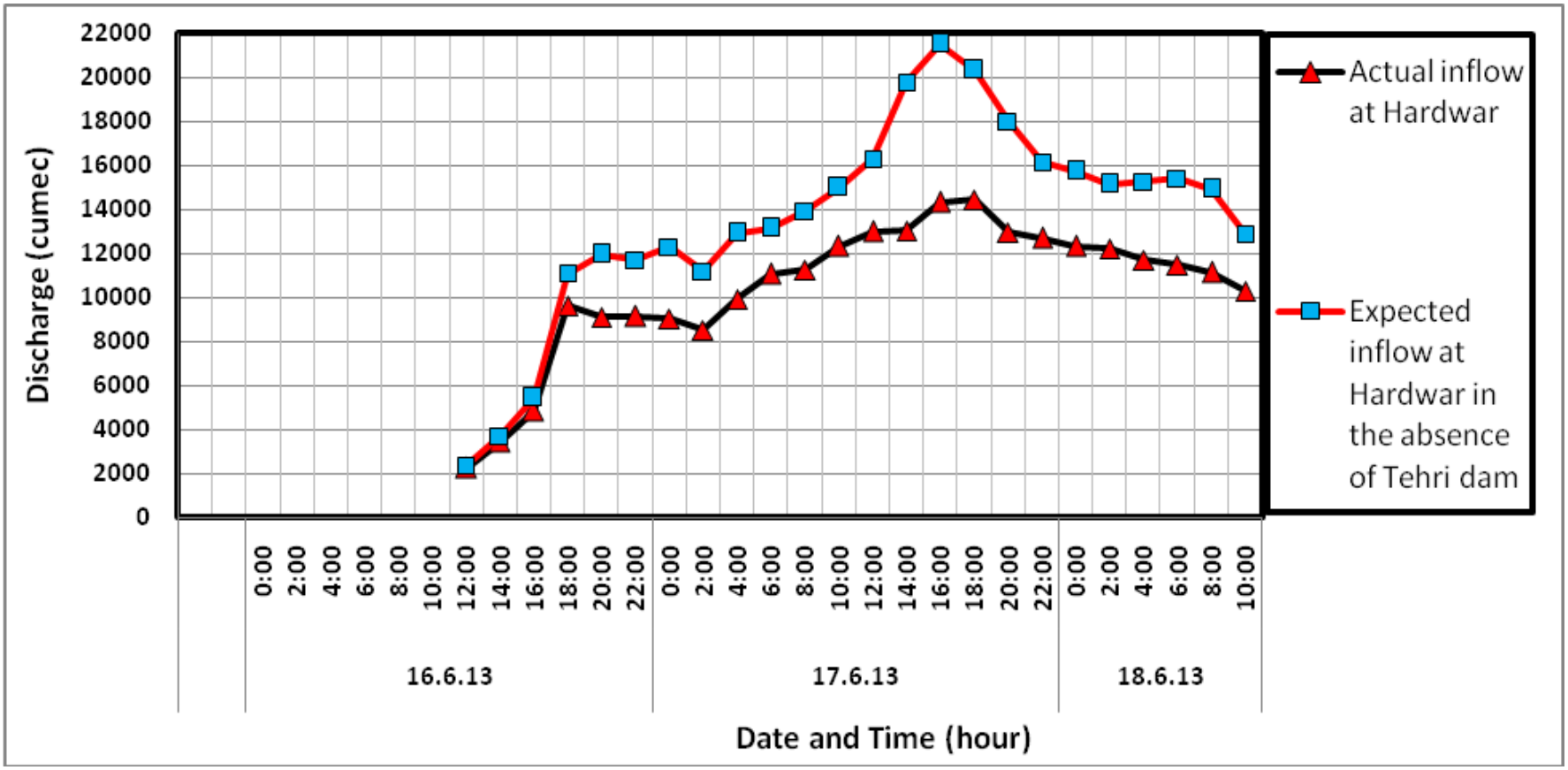
Operation of Govind Sagar Reservoir of Bhakra During Flood the Event of 17th – 18th August 2019

Flood Mitigation by Pong Dam During August, 2019 Flood



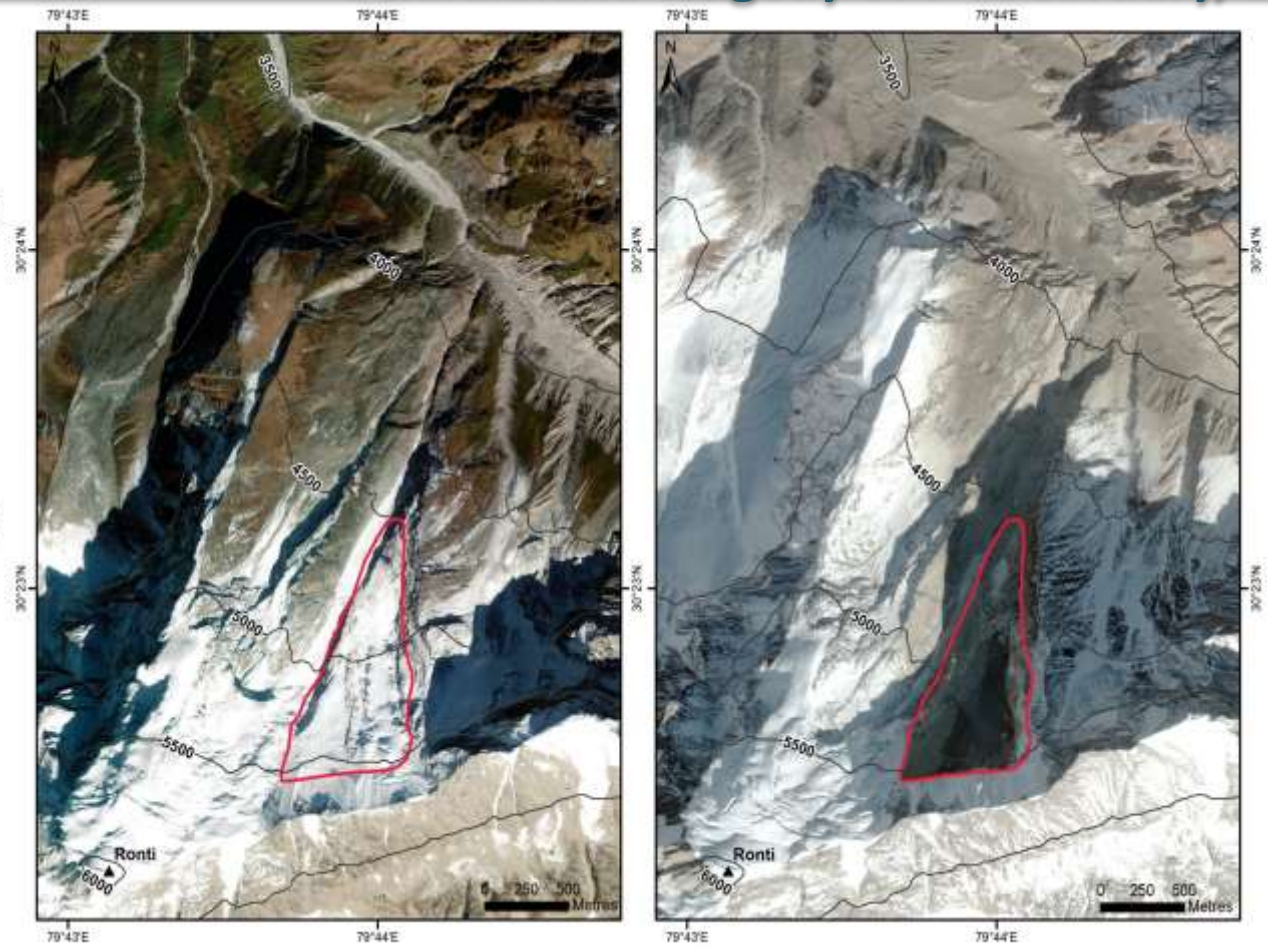
Operation of Maharana Pratap Sagar Reservoir of Pong Dam During Flood the Event of 17th – 18th August 2019

Flood Mitigation by Tehri Dam During June 2013 Flood



Tehri dam mitigated flood peak by 7000 cumec and thus saved Rishikesh and Haridwar from flood devastation

Uttarakhand Tragedy of 7th February, 2021



Pre (left) and post (right) event images showing scarp of the rockslide origin and its sliding surface along the joint plane, including directly impacted and sediment deposited area along the Ronti Gad River valley.

Massive Flood Generated due to Rock Fall from a height of 1600 m Leading to Melting of Ice and Snow

Uttarakhand Tragedy of 7th February, 2021

A massive rockslide of 22 million cubic meter of rock mixed with ice and snow just below Ronti peak triggered the flood. This rock slide happened approximately 22 km upstream of the Rishi Ganga hydropower site, just below Ronti peak in the Nanda Devi glacier. Rockslide 550m wide and 100 to 150m deep triggered from elevation of approximately 5500 m to 3900 m above mean sea level. Kinetic energy of rock slide due to fall of around 1600 m converted into heat energy, melted most of the ice and snow thereby triggering floods. With the force of rock slide and melted snow and ice. Sediments from the slide were carried with water due to high sediment transport force along highly steep slopes of Ronti stream.

Massive Flood Generated due to Rock Fall Leading to Melting of Ice and Snow

Uttarakhand Tragedy of 7th February, 2021

Video showing nature of the devastation.

Massive Flood Generated due to Rock Fall Leading to Melting of Ice and Snow

Uttarakhand Tragedy of 7th February, 2021

Barrage of Tapovan Vishnugad Before and After the Flood Peak on 7.02.2021

Massive Flood Generated due to Rock Fall Leading to Melting of Ice and Snow

Uttarakhand Tragedy of 7th February, 2021

Initial Reports:
Climate change, is the "main factor" for rapid temperature changes leading to freezing and thawing of ice, and glacial fractures over time. “Wadia Institute of Himalayan Geology”.

Final Conclusion: Climate change directly can not be held responsible for the disaster. Though increase of temperature, geological formation and cyclic freezing and thawing of the hill mass are some of the causes contributing to this disaster.

Satellite images depicting probable rockslide in Trishul glacier

Ref: ISRO Brief Note, February 9, 2021

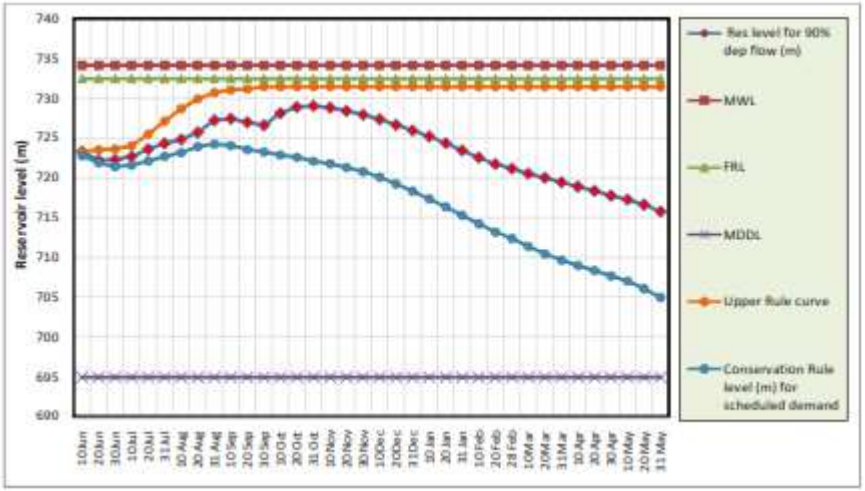
Massive Flood Generated due to Rock Fall from a height of 1600 m Leading to Melting of Ice and Snow

Requirement of Over the Year Storages

- **To mitigate the impacts of climate change, over the year storages shall be required.**
- **Floods in water deficit basins like Krishna and Cauvery, indicates the need to develop some carry over storages in water deficit and other basins with regulatory mechanism in form of RBOs in place**
- **For this the dependability criteria for storages development may require a review**

Impact of Climate Change on Dam Safety Issues

- In climate change scenario changes in 100 year flood and SPF may be expected but little changes in PMF
- This shall require more safety measure for dams
- More robust Inflow forecast, Periodical review of design flood, rule curves etc shall be required
- In some cases provisions of extra spillway bays, fuse plugs etc may be essential



Conclusion

- In spite of uncertainties in climate change prediction scenarios, the hydro-meteorological events in the recent past are giving an indication that deviations in climate from the long term averages are happening. Distribution of percipitation would undergo change. Extreme events would increase leading to devastation. Floods and droughts are likely to be more frequent.
- India has to accept the challenges posed by climate change and to prepare to mitigate its impact by accounting these factors in planning and designing of water resources structures.
- Countries with more population density like India are more vulnerable to climate extremities.
- Considering the water, food and energy security, environmental concerns, there is an urgent need to work on adaptation measures to mitigate the impacts of climate change. Reservoir Rule Curve for storage dams need to be revisited.
- Dams being the important source to provide perennial water supply, energy generation, flood protection, assured irrigation for food security shall play a key role in providing the resilience against climate change.
- For sustainability, design and O&M criteria including Bureau of Indian Standards for dams and connected structures need to be revisited and redefined.

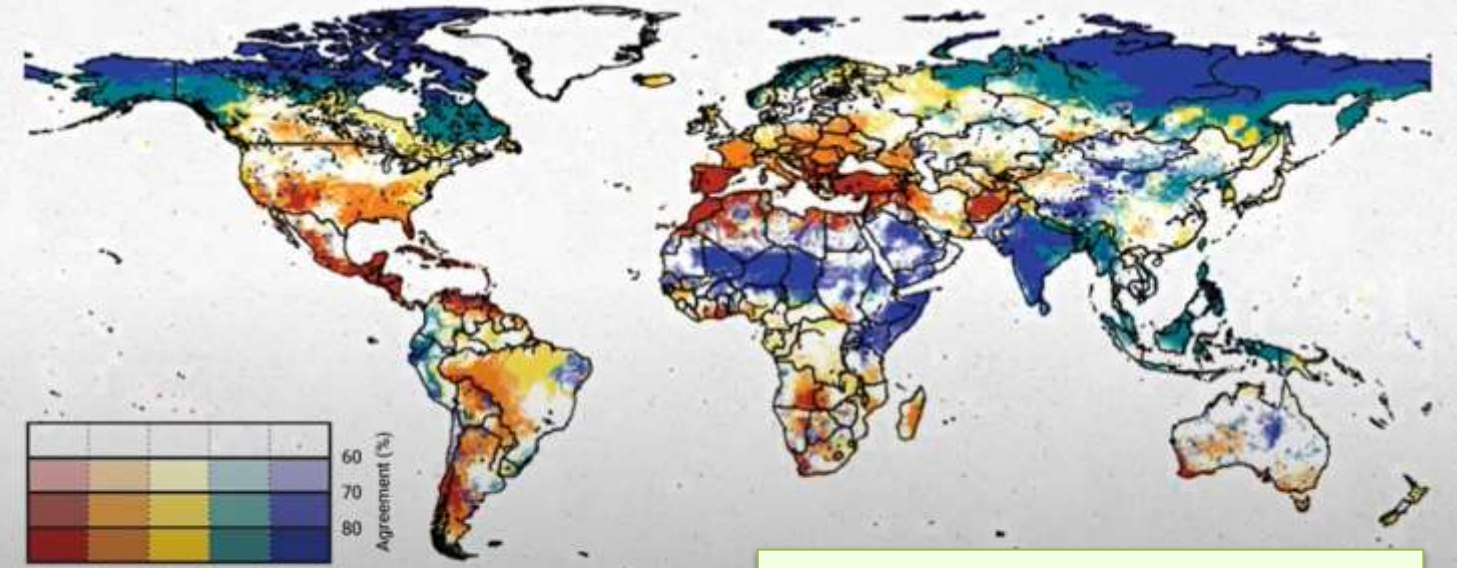
Thank You

Climate Change - Trends in Water Availability

Impacts on Water resources

Figure 8 Climate change scenario trends in water availability

This figure depicts the relative change in annual discharge at 2^0C temperature increased with present day (RCP 8.5)



Note: This figure depicts the relative change in annual discharge at 2°C

Ref: The United Nations World Water Development Report 2020