



**CLIMATE-RESILIENT DAMS AND  
HYDROPOWER INFRASTRUCTURE  
INTEGRATING  
ENVIRONMENTAL SUSTAINABILITY  
IN PLANNING AND DEVELOPMENT**

**CLIMATE CHANGE AND ENVIRONMENTAL  
CONSIDERATIONS IN DAMS HYDROPOWER  
AND RENEWABLE PROJECTS**

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# CLIMATE STRESS AND WATER SCARCITY IN INDIA



- **INDIA HAS 18% OF WORLD POPULATION BUT ONLY 4% OF WATER RESOURCES**
- **INDIA AMONG COUNTRIES FACING EXTREME WATER STRESS**
- **CLIMATE CHANGE CAUSING: AGGRAVATED PEAK FLOODS IN SHORT DURATIONS & PROLONGED DROUGHTS**
- **URGENT NEED FOR ENHANCED STORAGE-BASED PROJECTS IMPLEMENTATIONS TO STORE FLOOD WATER AND RELEASE FOR IRRIGATION DURING DROUGHT**
- **70% OF ALL CROPLAND DEPENDS ON MONSOON & 30 % OF ALL CROPLAND ARE IRRIGATED NEEDING URGENT DEVELOPMENT OF STORAGE DAMS FOR IRRIGATION**
- **TOTAL GROUND WATER 436 BCM WITH 300 BCM WATER USABLE. UTILIZES 91% FOR IRRIGATION AND DRINKING WATER. GROUND WATER STEADILY DEPLETING AND OVER UTILIZED**
- **BY 2025 TOTAL WATER DEMAND PROJECTED 1184 BCM FOR IRRIGATION, INDUSTRY & DOMESTIC NEEDING URGENT WATER RESOURCE PROJECTS TO CATER THE SCARCITY**
- **INDIA IS FOOD SELF-SUFFICIENT/SURPLUS COUNTRY SINCE 1980**
- **INDIA IS 2<sup>ND</sup> LARGEST FOOD PRODUCING COUNTRY IN WORLD .**



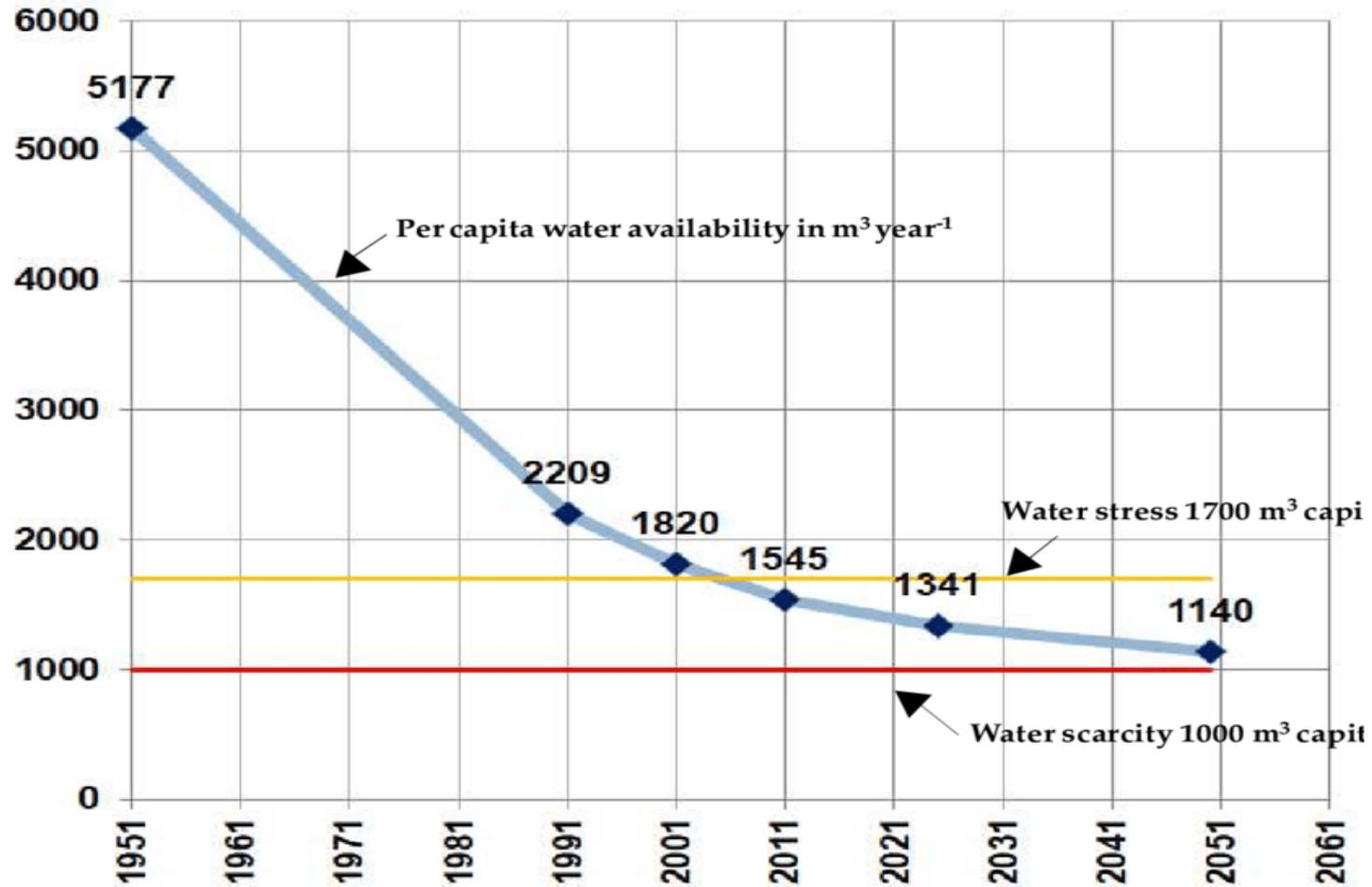
# CHANGING RAINFALL PATTERN & NEED FOR LARGE STORAGE DAMS



- **75–80% RAINFALL OCCURS DURING JUNE–SEPTEMBER**
- **LARGE DAMS SUPPORT FLOOD MODERATION, IRRIGATION, DRINKING WATER, HYDROPOWER GENERATION**
- **FEASIBLE HYDROPOWER POTENTIAL: 145,000 MW**
- **UTILIZED SO FAR: 36%**
- **PUMPED STORAGE POTENTIAL (PSP): 176,280 MW**
- **DEVELOPED PSP CAPACITY: <3%**

# CHALLENGES ON CLIMATE CHANGE IN INDIA

## PER CAPITA WATER AVAILABILITY IN CUBIC METER INCLUDING SURFACE AND GROUND WATER PROJECTION TILL 2051



Source: Report of CWC, Ministry of Jal Shakti March 2020



# NATIONAL PROGRAMMES MITIGATING CLIMATE CHANGE (INTER LINKING OF RIVERS (ILR))



## Interlinking of Rivers (ILR):

- **Interlinking of Rivers** was conceived in 1972 by Dr. K.L. Rao, the then Minister of Irrigation and Power.
- **Additional Storage** of 300 BCM flood water
- **Flood & drought** mitigation
- **Additional** 50,000 MW Hydroelectric (as per later theoretical/planning estimates; not part of the 1972 proposal)
- **Additional Water Transfer Proposed** 33 BCM/year transferred from Himalayan rivers to western states such as Rajasthan, Gujarat, and Haryana & 145 BCM/year transferred from Peninsular rivers to southern and central regions.
- **Additional Drinking Water Supply Proposed** serve 87 million people across water-scarce regions in urban and rural areas
- **Additional irrigation Proposed** to approximately 35 million hectares of agricultural land
- **Additional Food grain Production Proposed** 88.22 million tonnes of food grain production

# LONG TERM BASIN LEVEL PLANNING (ILR)



Himalayan Component	
Sl. No	Name
1	Manas-Sankosh-Tista-Ganga (M-S-T-G) link
2	Kosi-Ghaghara link
3	Gandak-Ganga link
4	Ghaghra-Yamuna link
5	Sarda-Yamuna link
6	Yamuna-Rajasthan link
7	Rajasthan-Sabarmati link
8	Chunar-Sone Barrage link
9	Sone Dam – Southern Tributaries of Ganga link
10	Ganga(Farakka)-Damodar-Subernarekha link
11	Subernarekha-Mahanadi link
12	Kosi-Mechi link
13	Farakka-Sunderbans link
14	Jogighopa-Tista-Farakka link (Alternative to M-S-T-G)
Peninsular Component	
15	Mahanadi (Manibhadra) - Godavari (Dowlaiswaram) link
16	Godavari (Inchampalli) - Krishna (Pulichintala) link
17	Godavari (Inchampalli) - Krishna (Nagarjunasagar) link
18	Godavari (Polavaram) - Krishna (Vijayawada) link
19	Krishna (Almatti) – Pennar link
20	Krishna (Srisailem) – Pennar link
21	Krishna (Nagarjunasagar) - Pennar (Somasila ) link
22	Pennar (Somasila) - Cauvery (Grand Anicut) link
23	Cauvery (Kattalai) - Vaigai -Gundar link
	Ken-Betwa link
24	a) Ken-Betwa Link Phase-I b) Ken-Betwa link Phase-II
25	Parbati -Kalisindh- - Chambal link
26	Par-Tapi-Narmada link
27	Damanganga- Pinjal link
28	Bedti- Varda link
29	Netravati– Hemavati link
30	Pamba- Achankovil- Vaippar link



# REVIEW OF RESERVOIR OPERATION, RULE CURVES & ECOLOGICAL SAFEGUARDS UNDER CLIMATE CHANGE



- EXISTING RESERVOIR RULE CURVES ARE BASED ON ORIGINAL STORAGE CAPACITY AND HISTORICAL INFLOW PATTERNS
- CLIMATE CHANGE HAS RESULTED IN FASTER RESERVOIR FILLING, HIGHER FLOOD PEAKS AND REDUCED FLOOD CUSHION
- PROGRESSIVE SEDIMENTATION HAS FURTHER REDUCED EFFECTIVE LIVE STORAGE
- FIXED AND STATIC RULE CURVES ARE THEREFORE NO LONGER ADEQUATE
- RESERVOIR OPERATION REQUIRES PERIODIC REVIEW AND REVISION BASED ON UPDATED HYDROLOGY AND STORAGE CONDITIONS
- DYNAMIC RULE CURVES SUPPORTED BY REAL-TIME INFLOW FORECASTING ARE ESSENTIAL
- ENVIRONMENTAL FLOW RELEASES ARE MANDATED BY MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE (MOEF&CC) FOR DOWNSTREAM ECOLOGICAL PROTECTION
- FIXED PERCENTAGE-BASED E-FLOW NORMS REQUIRE REVIEW UNDER EXTREME RAINFALL AND PROLONGED LEAN PERIODS



# CASE STUDIES DEMONSTRATING CLIMATE-RESILIENT DESIGN



## Subansiri Lower HE Project

- Subansiri Lower designed as a multipurpose dam
- Orifice-type spillways placed below MDDL
- Enables sediment flushing during monsoon, Reduced live storage loss & Effective flood moderation
- Flood peak reduction: 31–41%

## Dibang HE Project

- Dibang project planned with large storage capacity
- Flood handling integrated into reservoir design
- 25-year & 100-year flood handling
- Demonstrates climate-resilient planning for future dams
- Flood peak reduction: 69–77%

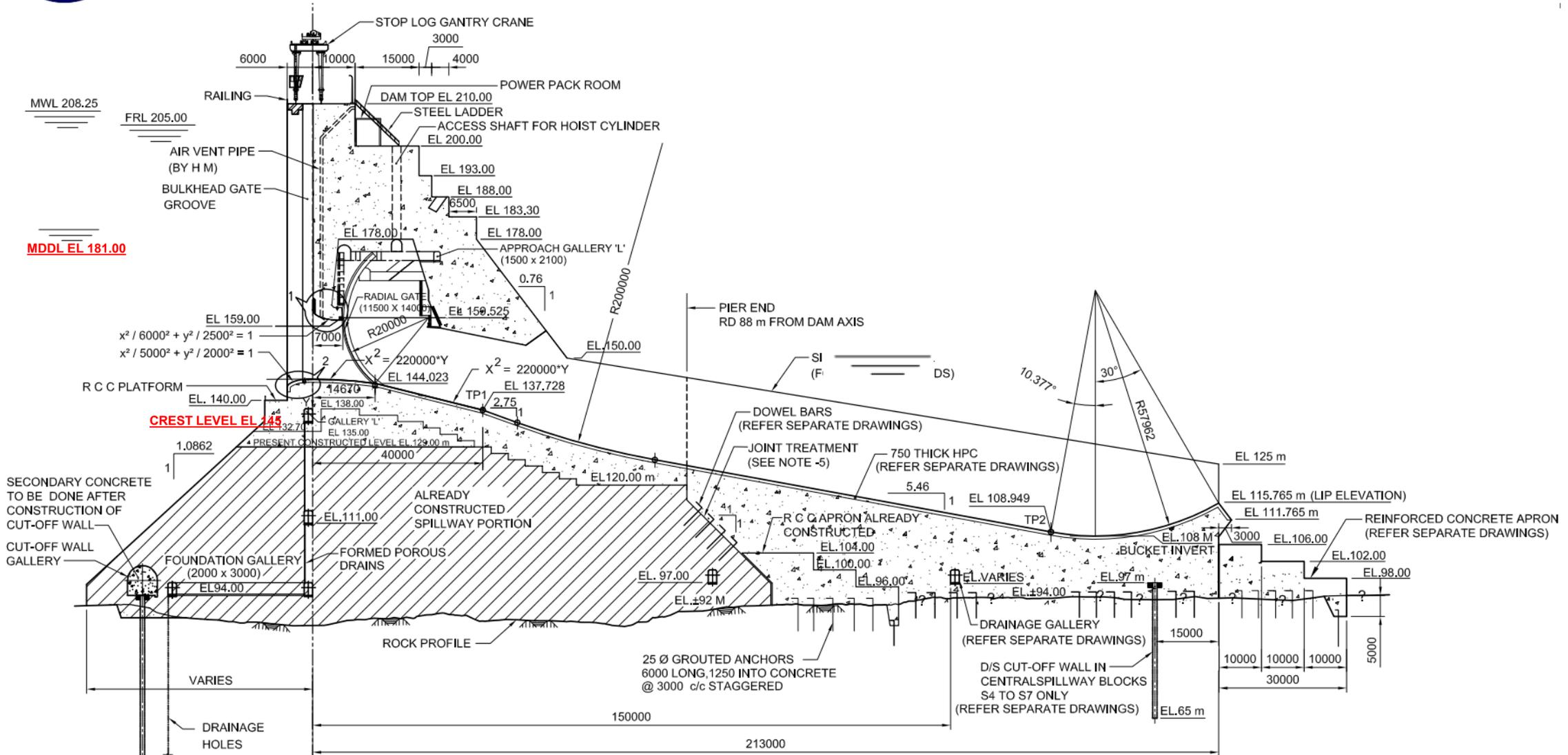
# SUBANSIRI LOWER: SUSTAINABLE SPILLWAY DESIGN AGAINST SILTATION

For Dam sustainability NHPC adopted Orifice type spillway below MDDL to prevent live storage reduction for Multipurpose Dam





# SUBANSIRI DAM CROSS SECTION



# RESERVOIR REGULATION & FLOOD MODERATION - SUBANSIRI DAM

## SUBANSIRI LOWER HYDRO ELECTRIC PROJECT - 2000 MW - MULTIPURPOSE DAM

### PROPOSED RESERVOIR REGULATION

PERIOD	RESERVOIR LEVEL (m)
JUN-I	190
JUN-II	190
JUN-III	190
JUL-I	190
JUL-II	190
JUL-III	190
AUG-I	190
AUG-II	190
AUG-III	195
SEP-I	195
SEP-II	198
SEP-III	205 (FRL)

Note : Oct-I to May-III level varies between 205 m and 190 m depending upon the withdrawal of water for peaking.

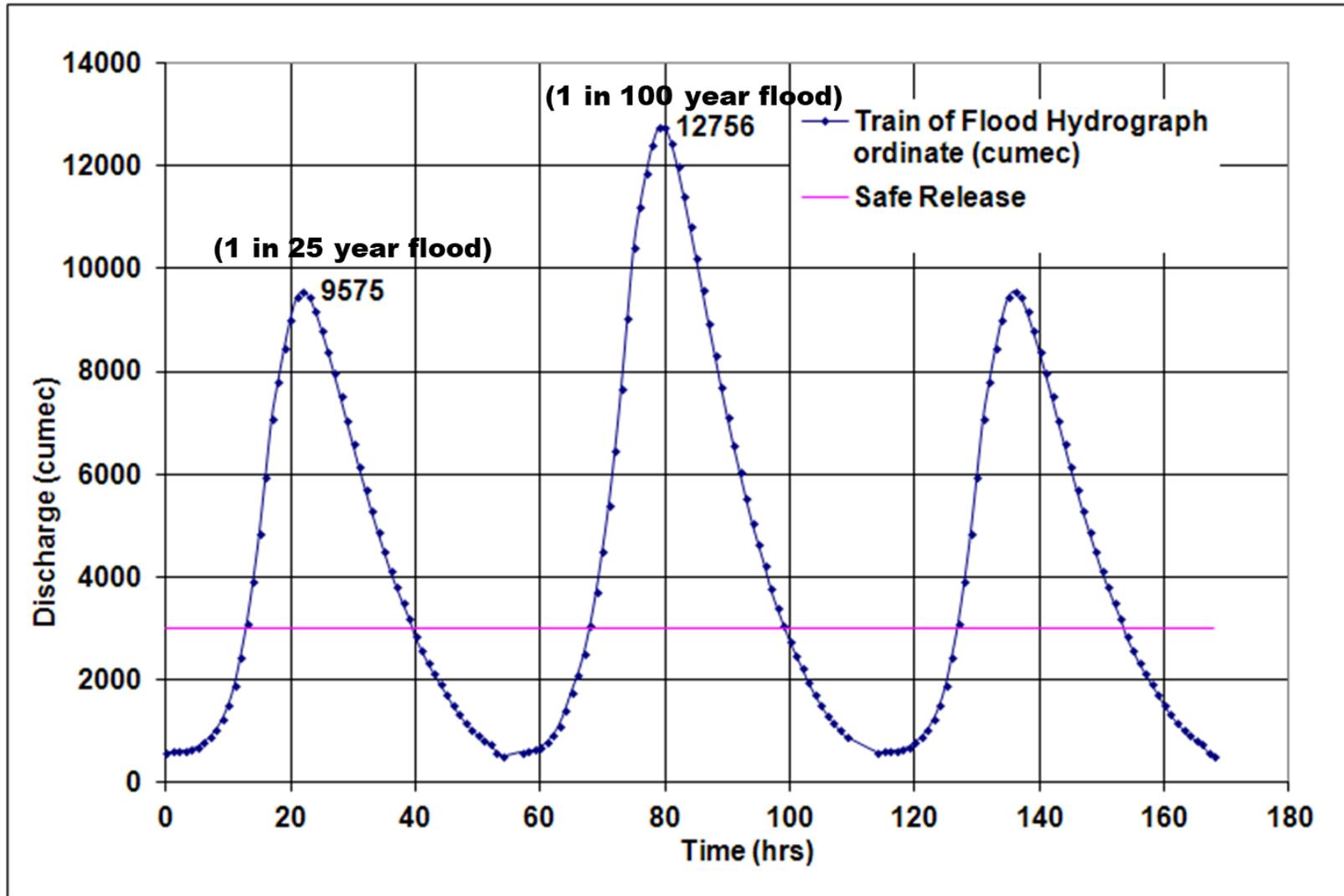
## SUBANSIRI LOWER HYDRO ELECTRIC PROJECT - 2000 MW - MULTIPURPOSE DAM

### ➤ FLOOD MODERATION IN SUBANSIRI LOWER

INFLOW FLOOD (CUMEC)	MODERATED OUTFLOW FLOOD (CUMEC)
	<b>% REDUCTION IN INFLOW PEAK</b>
10 YEAR (12400 CUMEC)	7316 CUMEC (41%)
25 YEAR (14500 CUMEC)	9135 CUMEC (37%)
100 YEAR (19600 CUMEC)	13524 CUMEC (31%)



# TRAIN OF FLOOD - DIBANG DAM



# PROPOSED RESERVOIR RULE CURVE - DIBANG DAM

## DIBANG HYDRO ELECTRIC PROJECT - 2880 MW - MULTIPURPOSE DAM

### ➤ RESERVOIR RULE CURVE

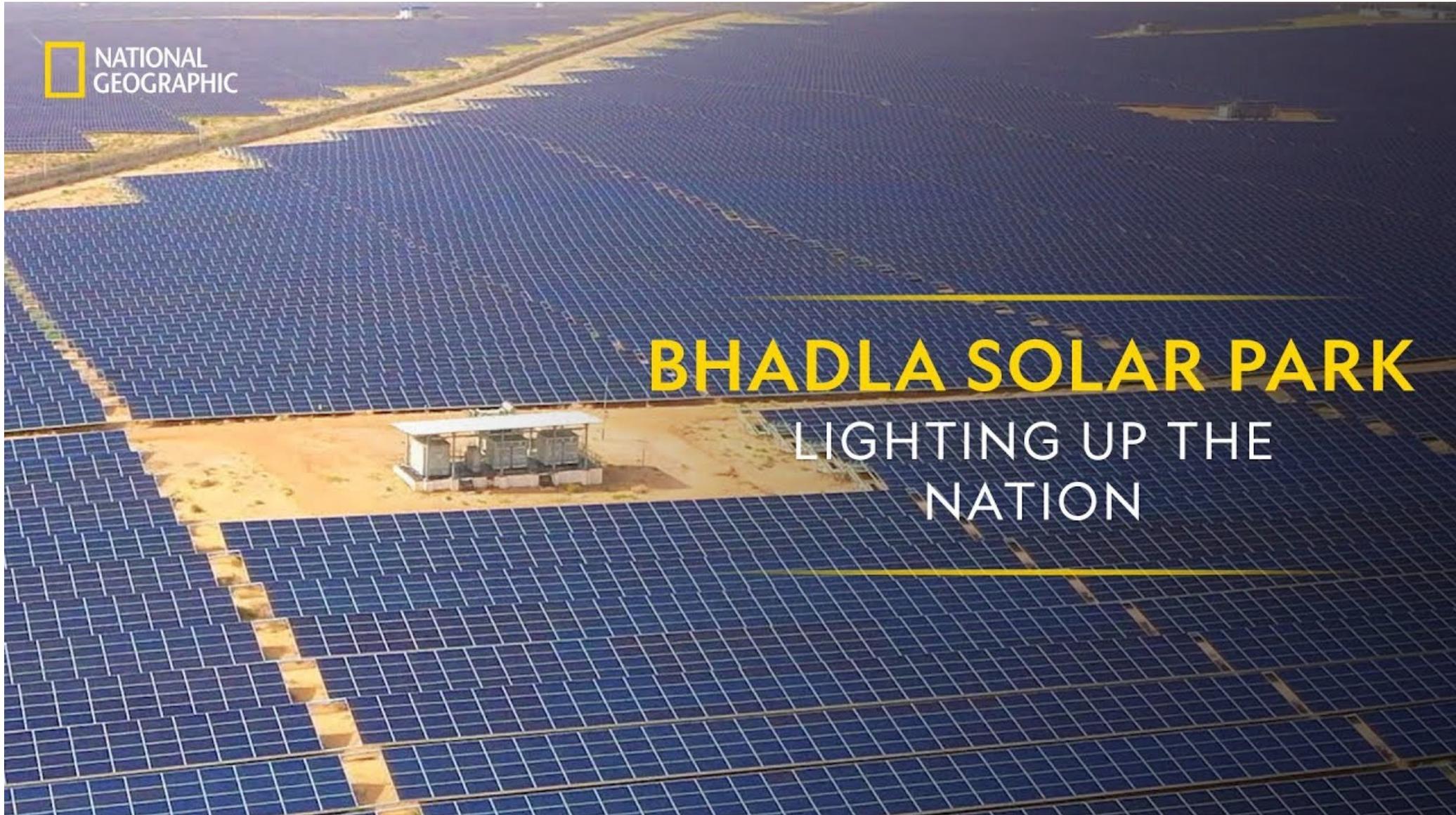
Months (Monsoon)	Reservoir Level at end of period (m)	Remarks	FLOOD INFLOW (CUMEC)	Moderate OUTFLOW FLOOD (CUMEC) % Reduction in inflow peak
May-III to Aug-II	490.2	25+100+25 yr Flood can pass	25 YEAR (9575 Cum)	3000 Cum (69%)
			100 YEAR (12756 Cum)	3000 Cum (77%)
Aug-III to Sept-III	512.6	100 yr Flood can pass	100 YEAR (12756 Cum)	3000 Cum (77%)
Oct-I	530.3	FRL	Normal regulated outflow (post-monsoon condition)	

# PROJECTED INSTALLED CAPACITY OF ELECTRICITY GENERATION TILL 2031-32

<b>CAPACITIES TYPE</b>	<b>Resource Potential (GW)</b>	<b>Installed capacity 2024-2025 (GW)</b>	<b>Projected Installed capacity 2026-27 (GW)</b>	<b>Projected Installed capacity 2031-32 (GW)</b>
<b>Fossil Fuel</b>	-	<b>243</b>	<b>260</b>	<b>284 (31.76%)</b>
<b>Nuclear</b>	-	<b>8</b>	<b>13</b>	<b>19 (2.12%)</b>
<b>Large hydro</b>	<b>133.4</b>	<b>42.1</b>	<b>52.45</b>	<b>62.17 (6.95%)</b>
<b>Pumped storage</b>	<b>176.3</b>	<b>4.74</b>	<b>7.4</b>	<b>26.68 (2.98%)</b>
<b>Solar, wind, biomass, small hydro</b>	<b>1976.3</b>	<b>146.6</b>	<b>276.7</b>	<b>502.42 (56.18%)</b>
<b>Total</b>		<b>444.44</b>	<b>609.5</b>	<b>894.27</b>
<b>Grid stabilizing power i.e. Large Hydro + Pump Storage = 9.94%</b>				



# BHADLA SOLAR POWER PROJECT (2245 MW) – WORLD'S LARGEST





# INNOVATION IN SOLAR POWER

## FLOATING SOLAR - SIMHADRI SOLAR POWER PROJECT (25 MW), ANDHRA PRADESH





# INNOVATION IN SOLAR POWER

**LARGEST FLOATING SOLAR-OMKARESHWAR FLOATING SOLAR POWER PARK (600MW) – MADHYA PRADESH**  
(commissioned 278 MW)





# CONCLUSION



- **NATIONAL ASSESSMENT HIGHLIGHTS ACCELERATE IMPLEMENTATION OF**
  - LARGE STORAGE MULTIPURPOSE HYDRO PROJECTS
  - RENEWABLE POWER
    - SOLAR POWER PROJECT
    - IMPLEMENT FLOATING SOLAR PANEL ON RESERVOIRS
    - WIND POWER AND SMALL HYDRO
  - PUMPED STORAGE PROJECTS
  - INTER LINKING OF RIVERS (ILR) PROJECT
- REVIEW AND IMPLEMENT DAM SAFETY AND RESERVOIR OPERATION OF EXISTING DAM

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**Thank You**