INTEGRATED OPERATION OF RESERVOIRS – DAMODAR-BARAKAR SYSTEM

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The Damodar Valley has been ravaged frequently by floods of varying intensities and the first of the major recorded flood dates back to 1730. Thereafter serious floods occurred at regular intervals, but it was the flood of 1943 that left the worst devastation in its wake. As a result, the Governor of Bengal appointed a Board of Inquiry headed by the Maharaja of Burdwan and the noted physicist Dr. MeghnadSaha as member. In their report, the Board suggested creation of an authority similar to the Tennessee Valley Authority (TVA) of United States of America. The Government of India then appointed Mr. W.L. Voorduin, a senior engineer of the TVA to make recommendations for comprehensive development of the valley. Accordingly, in August, 1944, Mr. Voorduin submitted his "Preliminary Memorandum on the Unified Development of the Damodar River".

Mr. W.L. Voorduin of the Tennessee Valley Authority suggested to construct seven storage dams and two barrages across the river Damodar and its tributaries namely Tenughat, Konar, Tilaiya, Panchet, Maithon, Bokaro, Balpahari, Bermo and Durgapur barrage. However, till date only five storages and one barrage could be completed. The projects at Bokaro and Bermo have not been been taken up while that at Balpahari is under investigation. Even the completed projects at Tenughat, Panchet and Maithondo not realize their full potential since land acquisition is not complete. The present Live Storage of about 1400 $Mm^3$is only about 40% of what MrVoorduin had envisaged.TheTenughat project on Damodarriveris not under unified operation, as a result of which Damodar-Barakar river system sometimes faces stress even in meeting the present demands. The present consumptive demandsin the river system are 3368 Mm^3 in 2005 and future demands are estimated to be around 6165 Mm^3 in 2025.

In the above backdrop, simulation study were carried out using the demand scenarios for the year 2005 and year 2025 usingthe 25 years inflow series from 1980 to 2005. Simulating the system as it is now i.e. keeping Tenughat reservoir out of unified operation, shows that the desired reliability levels of meeting various demands are not achieved even under present demand scenario. The simulations for present demand scenario were thus carried out considering Tenughat reservoir under unified operation and then the desired levels of reliability under present demand scenario were achieved. However, with the present storage available in the system, the reliability of meeting the demands in 2025 goes down drastically. The results of the study suggest - the future demands can be met by augmenting the existing storages by acquiring land so that the full storage potential of existing reservoirs can be utilised; new storage schemes in the basin need to be constructed so as to meet future demands in the river system; and Tenughat Dam needs to be in the unified operation for optimal benefits from the system.

INTRODUCTION

The river Damodar is a highly flashy rain-fed river and was once known as 'River of Sorrow' in South West Bengal. It used to bring in devastating floods before the dams were built. The fertile plains in the lower valley located in West Bengal were getting flooded and water logged causing loss of crop, famines and diseases. After the July 1943 flood, which proved disastrous, as road and rail communication to the city of Calcutta were cut-off for a period of about ten weeks, the flood control measures in the valley received top priority.

Damodar - Barakar river basin is a complex integrated multi-purpose water resources system with five dams at Maithon, Panchet, Tilaiya, Konar and Tenughat and a Barrage at Durgapur.

STUDY AREA

The Damodar River rises in the Palamau hills of Chhota Nagpur at an elevation of about 610 m above Mean Sea Level (MSL). It flows in a generally southeasterly direction entering the deltaic plains below Rani Ganj. Before joining the Hooghly, the river bifurcates into two channels viz. Amta&Mundeswari Channels. Amta channel is almost dead since 1959. The river is fed by six streams viz. Bokaro, Konar, Jamunia, Gowai ,Ijri and Barakar of which the principal tributary is Barakar. The area drained by the Damodarriver at its mouth is about 22,015 sq.km. of which 17,818 sq.km. in the catchment of upper Damodar river just above its confluence with the Barakar river. There has been irrigation before the advent of the dams by diverting the water into a canal by a low weir, the Anderson weir, across the Damodar River at Rhondia to the extent of 89,000 hectares.

STREAMFLOW

Stream flows in the river were recorded at Rhondia weir from 1933 to Oct. 1959. Since the completion of the Durgapur barrage and various dams, the discharges are recorded at these sites. The maximum annual flow recorded is of the order of 14,800 Mm^3 at Rhondia and the average annual flow about 7,500 Mm^3 / year. The minimum flow in the river system recorded is NIL. The maximum flood recorded during pre-dam period was from Aug. 6 to Aug. 12 in 1913 with a peak flow of 18,424 m^3/s and total volume of 3,992.60 Mm^3. After the dams were constructed, there was a major flood from Sept. 30 to Oct. 3 in 1959 with a volume of 1,418 Mm^3. The probable peak flow during this period would have been 22,959 m^3/s at Durgapur had there been no moderation by the dams.

CHANNEL CAPACITY

The discharge carrying capacity of the river below its confluence with Barakar River decreases rapidly & at Durgapur, it is only about 7,080 m^3/s. Considerable spilling takes place on the right side where the Damodar River enters the flood plains between Silna and Surekalna. Lower down, the main channel of the Damodar viz. Amta channel has silted up. The other channel leads to the important branch viz. Mundeswari, which receives all the spilled waters as well. Its bankful capacity is of the order of 1,980 m^3/s. Thus, even as low a discharge as 2,830 m^3/s at Durgapur can cause flooding lower down especially when there is heavy rainfall in the area.

CROPS

As per the information furnished by Govt. of West Bengal, ultimate irrigation potential of DVC irrigation system is 515,380 hectares in the districts of Burdwan, Bankura, Hooghly and Howrah. Out of this, 393,930 hectares is for Kharif season and 121,450 hectares for Rabi season.The main crop under cultivation in Kharifseason (June to October) is Aman variety of rice which demands ample and well distributed water supply from middle of July to earlyNovember. In the Rabi season (November to January) normally the vegetables such as potato and tomato are grown.

After the advent of the DVC dams the practice of cultivating High Yielding Variety (HYV) rice during Boro season (February to May) has come up. The maximum area under cultivation in Boro season was 83,610 Ha in the year 1979-80.

STRUCTURES

There are total five dams and one barrage in the DVC system. The operation of Tenughat dam is under the control of Govt of Jharkhand whereas operation of Konar, Tilaiya, Panchet and Maithon are under unified operation of DVC. The capacities of the above dams are as under;

Dam	**MDDL (m)**	**Conservation level (m)**	**Live Storage between MDDL and Conservation level (MCM)**
Tenughat	249.02	263.66	457.22
Konar	410.57	425.81	175.52
Tilaiya	363.32	368.81	140.47
Panchet	119.48	124.97	183.75
Maithon	132.59	146.31	441.64
Balpahari (proposed)	226.00	240.00	666.35

Durgapur barrage is having a capacity of 6.14 MCM between maximum and minimum pool. Its left and right bank canal capacity is 260 cum and 64.3 cum respectively and total cultivable command area is 3, 93,763 Ha.

INFLOWS AND DEMANDS IN THE BASIN

The ten-daily uncontrolled inflows at Tenughat, Konar, Tilaiya, Panchet, Maithon and Durgapur were available for the period 1st June 1980 to 31st May 2005. The inflows were computed by DVC by back calculations taking into account change in reservoir water levels, outflow and evaporation from the reservoirs, release from the upstream reservoir, and channel losses. The trends of inflows at different structures are in the table below;

Dam	**Peak 10daily inflow during monsoon**	**Annual Average Inflow**
Tenughat	150 MCM to about 800 MCM	2231.93 MCM
Konar	20 MCM to about 140 MCM	422.64 MCM
Tilaiya	25 MCM to about 250 MCM	338.84 MCM
Panchet	200 MCM to about 1200 MCM	2826.19 MCM
Maithon	150 MCM to about 1000 MCM	2443.66 MCM
Durgapur barrage	25 MCM to about 900 MCM	2254.15 MCM

The average total annual inflows for the entire basin (10517.41 MCM) is much higher than the Live Capacity (1398.62 MCM) of the all the projects. The demands for consumptive and hydropower generation are as below;

Dam	**Consumptive Annual Demand (2005) in MCM**	**Consumptive Annual Demand (2025)in MCM**	**Annual Hydropower**

	Industrial*	Irrigation	Industrial	Irrigation	Demand in MU
Tenughat	224.64	30.87	616.37	30.87	-
Konar	87.23	38.25	89.22	38.25	-
Tilaiya	5.15	90.03	377.90	90.03	20.66
Panchet	82.1	82.23	412.47	82.23	131.49
Maithon	9.62	-	449.06	-	131.49
Durgapur barrage	266.96	2450.58	588.89	3389.95	-

ORIGINAL PROPOSAL OF DAMODAR VALLEY CORPORATION (DVC)

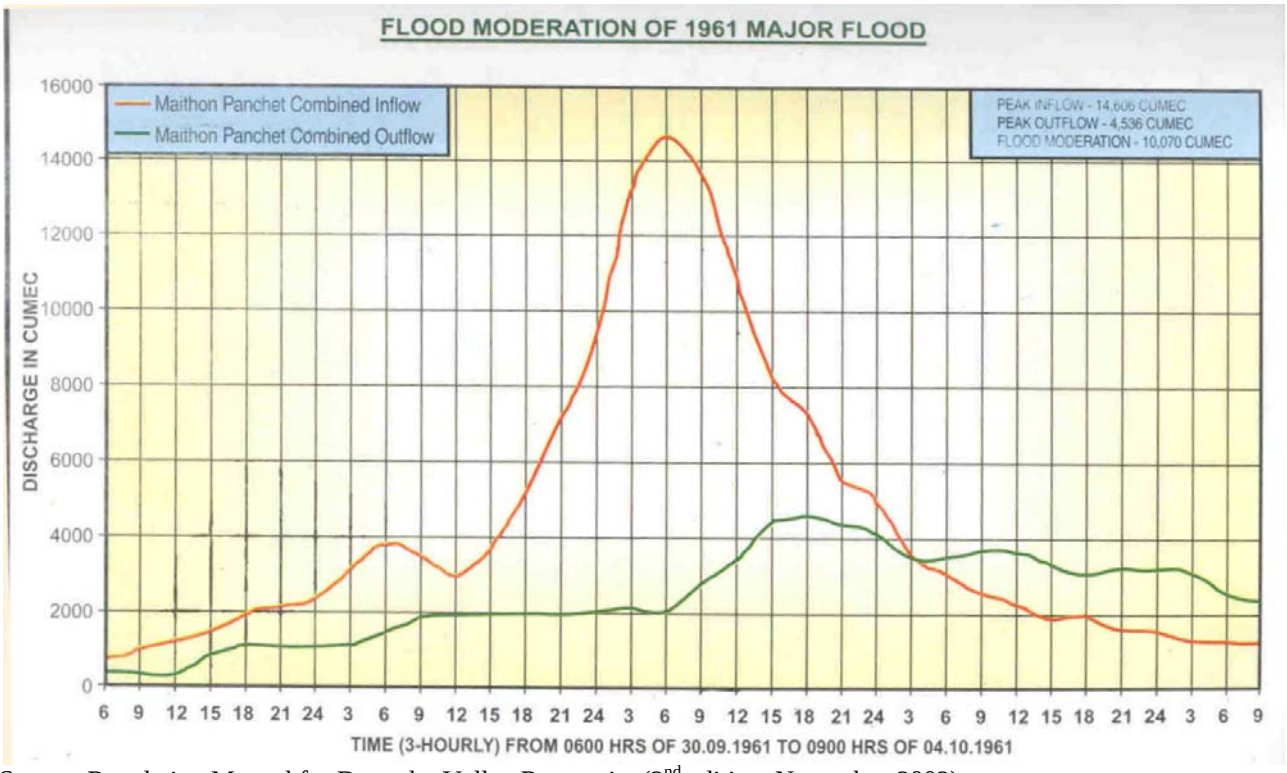
In the original plan, Mr. W.L. Voorduin of the Tennessee Valley Authority, USA suggested to construct seven storage dams across the river Damodar and its tributaries at Tilaiya, Konar, Maithon, Panchet, Bokaro, Balpahari, and Aiyar, a diversion dam at Bermo, and a barrage at Durgapur with an accompanying network of canals. This development was to be carried out in two stages, the first stage to cover the construction of four dams at Tilaiya, Konar, Maithon, and Panchet and a barrage at Durgapur alongwith its Irrigation system, and the second stage to complete the remaining four projects.

PRESENT SITUATION

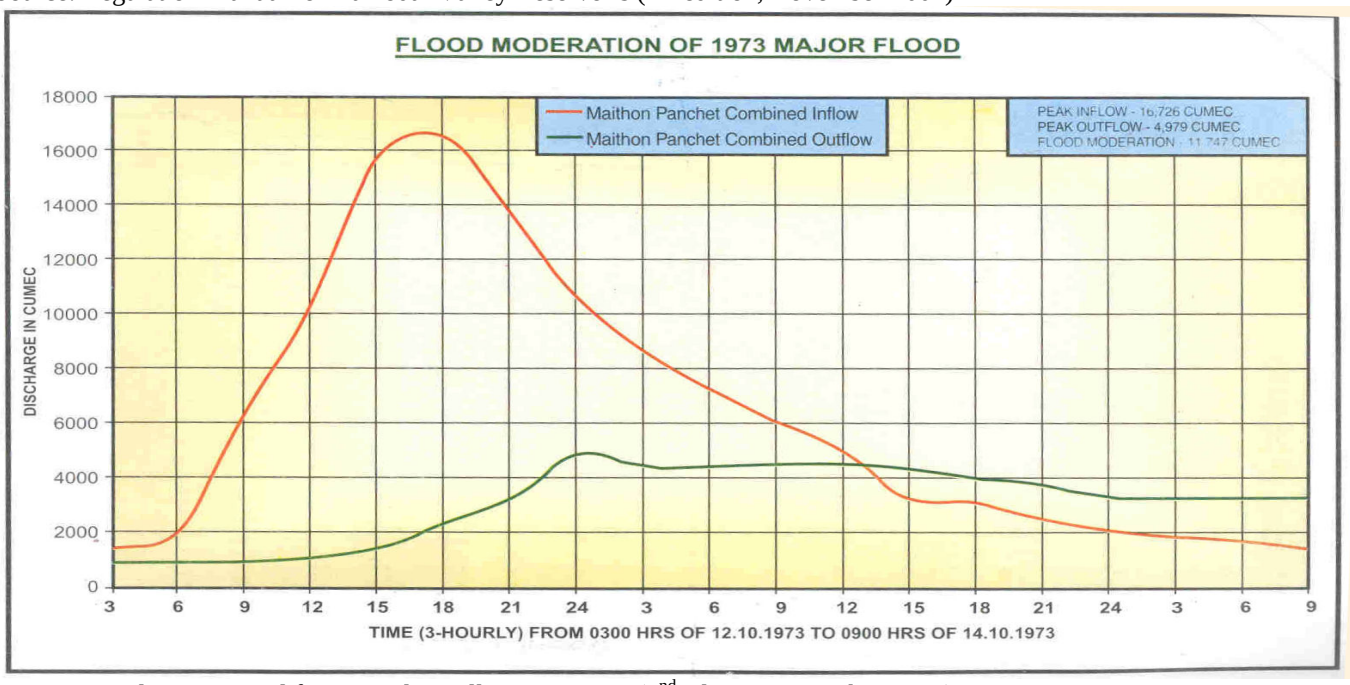
Till date only four dams and a barrage of the original plan (first stage), and one dam in the state of Jharkhand (earlier Bihar), namely Tenughat dam has been constructed of the second stage planning. The desired flood mitigation and conservation benefits have not been achieved to the full extent. Moreover, the land in the upstream of these projects could not be acquired upto the design level so the flood mitigation and conservation benefits suffer further.

Flood moderation

Integrated operation of reservoirs helps in flood moderation in the basin. DVC chain of reservoirs was planned with flood management as one of the objectives. Historical records show that after the construction of Maithon and Panchet dam there has been considerable flood moderation. Some flood moderation hydrographs of various major historical flood events which shows that a flood peak of about 14000-16000 cumec could be moderated to about 4000 cumec i.e. moderation by about 75%. The flood moderation through DVC system can be further increased if the lands around Maithon and Panchet projects are acquired upto the designed level and other envisaged projects are added to the system.



Source: Regulation Manual for Damodar Valley Reservoirs (2nd edition, November-2002)



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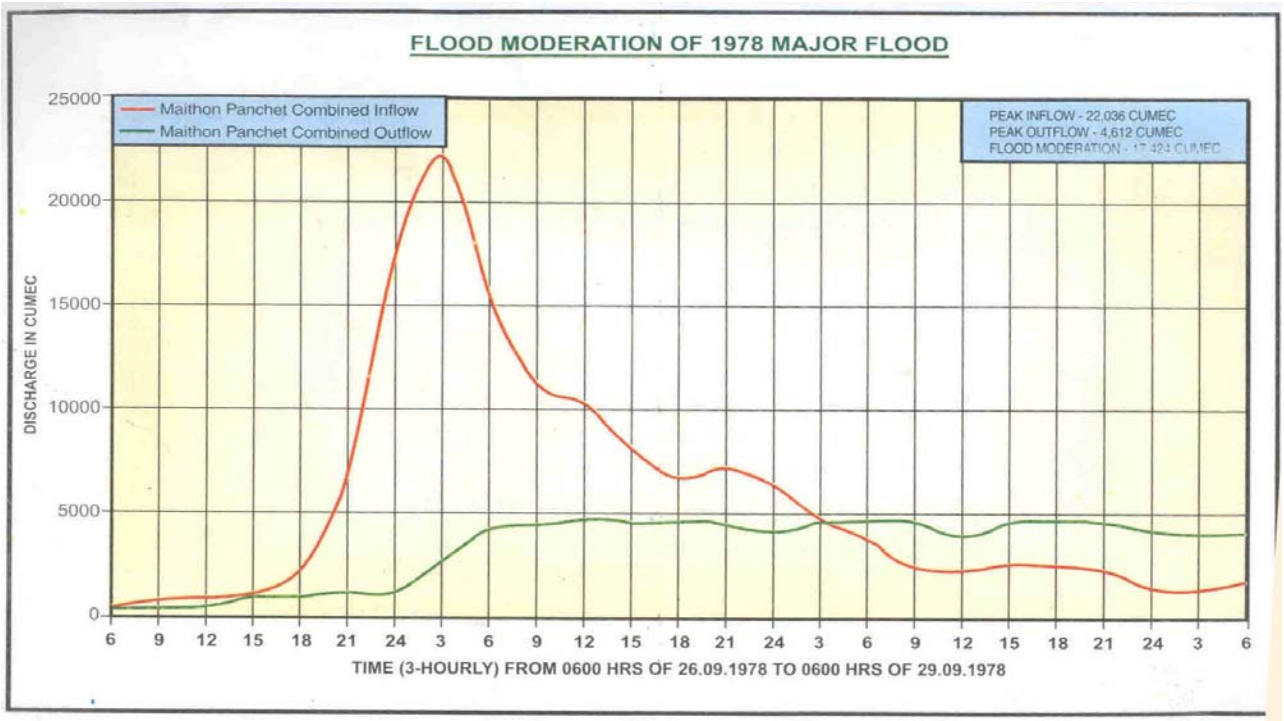

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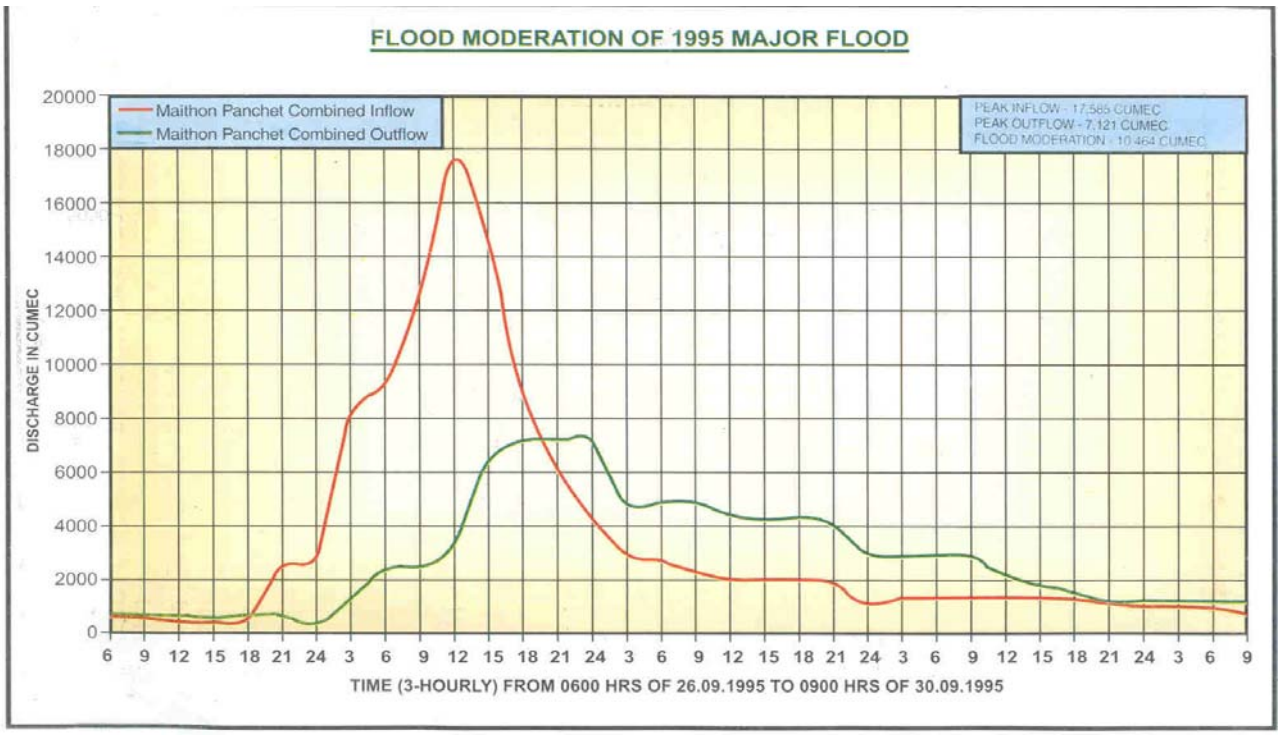

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Conservation

Regarding conservation benefits, the demand for guaranteed supply of water for different purposes has been increasing considerably. The storage capacity of the system being inadequate, water could not be supplied at required reliabilities to various uses. Thus the need for augmentation of storage capacity in the DVC system has been suggested from time to time by different Expert Committees set up to study the problem of water resources management in the Valley. These Committees have predicted strong likelihood of water shortages in future and advised augmentation of storage capacity in the system. The present conservation storage capacity of the system is only about 40% of the storage capacity envisaged

OBJECTIVES OF THE STUDY

In light of the above a Comprehensive System Studies of Damodar-Barakar basin was felt by all the concerned States and Damodar Valley Corporation (DVC). Subsequently a study was taken up jointly by Govt. of Jharkhand, Govt. of West Bengal, and DVC, under the guidance and supervision of CWC / DVRRC by forming a dedicated Core Group for the studies.

The objectives of the study were to get the following information;

- Water balance at each important nodal point in the system;
- Surplus / shortage at each nodal point of interest;
- Summary of system / reservoir performance;
- Incidental power generation; and
- Formulation of various alternatives, developmental / operational measures in tabular and graphical form.

STUDY DETAILS

The ten-daily uncontrolled 25 hydrological years (1980-2005) inflows and consumptive demand for present and future were analysed and 75% dependable inflows and demands for monsoon(1^{st} June to 20^{th} Oct) and post monsoon(21^{st} Oct to 31^{st} May)periods were estimated from the available data. It has been found that in the monsoon season the reservoirs are expected to get filled up after meeting the monsoon water demands as the monsoon inflows are in excess of the sum of monsoon demands + Live Capacity available in the basin. In post monsoon season demands would be met with the available Live Storage only as the Post-monsoon consumptive demands are less than the available Live Storage in the basin.

In case of three reservoirs i.e., Tenughat , Panchet and Maithon it has been found that they will attain their full conservation levels after meeting their own conservational demands as per the monsoon uncontrolled inflow. In Tilaiya and Koner reservoirs there may be the difficulty in attaining the full conservation levels in some years. In case of Durgapur barrage, for about 50% of the years the uncontrolled inflows of this barrage is less than the monsoon irrigation demands whereas post-monsoon demands are more than the post monsoon inflows in 22 out of 25 years.

SIMULATION

The detailed simulations of the Damodar-Barakar river basin were carried out for two demand scenarios: Present demands (Year 2005); and Future demands (Year 2025). The uncontrolled ten-daily inflows of Tenughat, Konar, Tilaiya, Panchet, Maithon and Durgapur for 25 hydrologic years (1^{st} June1980-31^{st} May 2005) were used.

Present demand scenario (Year 2005) results show that when Tenughat is not considered as in unified operation with power incidental the rest of the system fails to achieve desired reliability. However, most of the consumptive use demands are meeting100% reliability except irrigation demand at Durgapur Barrage, Konar and Tillaiya when power demand is incidental and Tenughat is considered in unified operation. But the system performance fails againin meeting the irrigation demand at Durgapur, Tilaiya and Tenughat when power demand is considered with Tenughat in unified operation.

Future demand scenario (Year 2025) shows that the system fails miserably in meeting the future demands with the present storages when power demand is incidental and Tenughat in unified operation. But when the proposed Balpahari dam is considered the system performance improves a bit. It has also been found that total annual consumptive-use shortages in the basin range between 378 MCM to 2620 MCM based upon the 25 years data during 1980-2005 The simulation results for future demand scenario indicate that for meeting the future projected demand, an additional live storage of about 1450 MCM (including that of Balpahari) would be needed.

S. No.	Description of Demands	% Reliability of meeting the demands (2005)		
		Tenughat not in unified operation and power incidental	Tenughat in unified operation and Power Incidental	Tenughat in unified operation with Power Demand
1	Irrigation demand at Durgapur	**52**	**76**	**0**
2	Tenughat Industrial demand	100	100	**52**
3	Konar Industrial demand	**92**	100	**88**

4	Tilaiya Industrial demand	**88**	100	**84**
5	Maithon Industrial demand	**92**	100	100
6	Panchet Industrial demand	**88**	100	100
7	Durgapur Industrial demand	**84**	100	100
8	Tenughat Irrigation demand	100	100	**68**
9	Konar Irrigation demand	**92**	**96**	**72**
10	Tilaiya Irrigation demand	**64**	**76**	**44**
11	Panchet Irrigation demand	**60**	100	**72**

S. No.	Description of Demands	% Reliability of meeting the future(2025) demands (Power incidental)		
		Demands as provided in the 4th meeting of Core-Group	Balpahari dam in system	Additional storage of 1450 MCM including Balpahari
1	Irrigation demand at Durgapur	0	48	76
2	Tenughat Industrial demand	8	64	100
3	Konar Industrial demand	44	84	84
4	Tilaiya Industrial demand	0	80	80
5	Maithon Industrial demand	8	60	76
6	Panchet Industrial demand	68	72	80
7	Durgapur Industrial demand	80	84	92
8	Tenughat Irrigation demand	44	44	76
9	Konar Irrigation demand	52	56	76
10	Tilaiya Irrigation demand	4	76	76
11	Panchet Irrigation demand	52	56	76

DISCUSSION

The simulations in both the present and future demand scenario indicate that theoretically the water availability in Damodar-Barakar system is much more than the consumptive demands. However, the failures in meeting the irrigation demands occur mainly because of poor temporal distribution of water and there is not enough storage available in the basin. So, in addition to increase in storage capacity, there is a need to utilize the full capacity of the existing storages.

The study indicates that about 8154 MCM of water is available annually at 75% dependability in the basin of which 3367.54 MCM is being utilised presently with the existing live storage of 1398.62 MCM. The future demands can be met by augmenting the existing storages by acquiring land so that the full storage potential of existing reservoirs can be utilised. Additionally, new storage schemes in the basin will have to be constructed so as to trap the surplus water which is presently spilling. The total annual consumptive-use shortages in the basin range between 378 MCM to 2620 MCM based upon the 25 years data during 1980-2005. If an additional storage of about 1450 MCM is created, the future irrigation demands can be met at desired 75% dependability level as per the data used in the study for 1980-2005. The storage required to meet the future demand of 6165 MCM in the DamodarBarakar basin shall be 2849 MCM (1399 MCM existing + 1450 MCM additional). With the addition of Balpahari Dam in the system in future having a live storage of about 665 MCM the performance of the river system improves to some extent in meeting the future demands in year 2025. However, to improve the system performance there is a need to i) create more storage and ii) to acquire land so that full potential of Tenughat, Panchet and Maithon reservoirs could be put to beneficial use with increasing demands in future. The additional storage at Balpahari will further moderate the flood peak at the downstream reservoirs namely Panchet and Maithon reservoirs.

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