CHALLENGES IN EFFICIENT WATER MANAGEMENT IN DAMODAR RIVER VALLEY

- ROLE OF DVC

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Abstract

The Damodar River Valley has an extensive history of developmental and planning activities since 1863. DVC was formed in the year 1948 by the act of Parliament to carry out the responsibilities for monitoring and developing this large watershed in an integrated manner. It is well aware that all the projects, planned originally could not be implemented till date by the DVC and the participatory states. Again, silt depositions in the existing reservoirs and channels due to erosions at the upper valley have reduced their respective storage and flowing capacities remarkably. On the other hand, demand of water has been increased many folds within the valley due to growth of industries, population etc. With passing of time, socio-economic and political condition of the valley has also changed a lot. So, considering the different constraints, DVC is trying to manage all its statutory obligations with its limitations. Performances of the operations in the different fields of activities like flood moderation, irrigation, municipal and irrigation water supply, Hydropower etc. have been studied elaborately in this article. Lots of new commendable initiatives to restore the lost-capacities and to increase the storage facilities have also been discussed. A Master Plan of the ecofriendly sustainable developmental activities of the valley in the different projected scenarios has already been prepared by DVC which has also been described in brief. Some scopes have been identified to take up a few new small Hydro schemes at different locations in the upper valley. Some old schemes related to fisheries have also been revived recently. DVC is trying to achieve its goal steadily and it is must to say that DVC has achieved a lot after its inception to restore the activities originally envisaged and to fulfill the gradual increased need of the valley; yet, there is a long path to reach its target within a complex socio-economic and political environment.

1. INTRODUCTION AND DESCRIPTION OF THE BASIN

The Damodar River originates in the Palamau hills of Chotanagpur in Jharkhand state at an elevation of about 610 Mt. above M.S.L. It flows in a south–eastern direction to enter the plains below Raniganj in Burdwan district of West Bengal. The river abruptly changes its course to southern direction near Burdwan and joins the Hooghly at about 48 km. below Kolkata. The slope of the river at first stretch of 241 km. from the source is about 1.89 Mt. per km. During the next 161km., it is about 0.57 Mt. per km., and for remaining length of 145 km., slope is about 0.19 Mt. per km. The river is fed by many major tributaries like Barakar, Konar, Bokaro, Isri, Gowai etc., out of which, the principal tributary is Barakar. The river Barakar originates near Padma in Hazaribagh district of Jharkhand and flows for 225 km. across the northern part of the Chotanagpur plateau mostly in a west to east direction, before joining the river Damodar near Dishergarh in Bardhaman district of West Bengal. It has a catchment area of about 6159 sq. km. Its main tributaries Barsoti and Usri flow from the southern and northern areas respectively to meet with river Barakar. The total catchment area

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of the river Damodar is about 22015 sq. km. (total water shed area under Damodar Valley), out of which 17,818 sq. km. is the catchment of the upper Damodar valley just at above the confluence of Barakar and Damodar.

The upper portion of the catchment is entirely located in the state of Jharkhand and consists of rough hilly terrains where the flatter portion lies within the state of West Bengal. The upper Damodar catchment is fan-shaped and conducive to concentration of floods, while the downstream catchment constitutes a very narrow strip. Due to this particular topography of the catchment area, river Damodar inundates the large area of the districts of Burdwan, Hooghly & Howrah in the state of West Bengal every year. The lower reaches are covered with silt which is quite fertile. Irrigation facility was available in the lower Damodar basin before the advent of dams by means of a diversion weir, popularly known as Anderson weir located at Rhondia on river Damodar to serve the area about 89,000 hectares in the districts of Burdwan and Hooghly.

2. HYDROLOGY

The mean annual rainfalls in different sub-catchments of the Damodar Valley are found as: Barakar 126 cm; Damodar 127.2 cm. and lower valley 132.9 cm. 82 percent of the mean annual rainfall occurs during the four monsoon months from June to September. During the pre and post monsoon seasons, the rainfall in the catchments is about 7 and 8 percent respectively of the mean annual rainfall. The highest annual rainfall is observed about 165 cm. in the southern part of the lower valley. The record annual rain fall was observed at Amta amounting to 169 cm. The rainfall gradually decreases to 105 cm. in the northern part of the Barakar catchments as found from the records. The general distribution of annual and monsoon rainfall indicates that the rainfall over the valley varies from one area to the other. Heavy rainfall in this region is generally caused during the passage of cyclonic depressions which initiates at the head of the Bay of Bengal during the monsoon period and travel in a north-westerly direction. Sometimes, depressions form at overland also and it causes of intense precipitation. The volume of the flow during the monsoon averages to about 90% of the total annual flow which is about 28000 MCM. During the dry period from November to May, there are extended periods of a little or no flow in the main stream and in its tributaries.

The highest maximum recorded temperature was observed as 52^{o} C over the areas in vicinity of Asansol in the lower valley. In the extreme western part of the valley, absolute maximum temperature was found as 42^{o} C where lowest minimum temperature was recorded about 2^{o} C in vicinity of Ramgarh in the upper valley. Over the major portion of the valley area, the lowest recorded temperature was observed between 4^{o} to 7^{o} C only.

Maximum mean relative humidity over the watershed is observed during July to September in the order of 80%. Same is found about 65% in June and 70% in October. The humidity comes down to about 40% in March, April and May. The mean diurnal variation is observed in the order of 10 to 15 percent. The Barakar catchment has the lowest humidity both in the morning and evening, where the mean annual value is observed less than 50%.

3. HISTORY BEHIND DEVELOPMENT OF THE VALLEY

The Damodar River Valley has an extensive history of its developmental and planning activities, usually in response to the need of flood control, as well as for diverse water-need purposes. The records of the Bengal Government for the period 1852 to 1923 show that the river breached its banks frequently. The Government was forced time and again (Case Study, 2060) to take up different plans for flood-control works. For example, notably large floods caused widespread damage in the years 1823, 1840, 1877, 1913, 1935, 1939, 1941, 1943, 1978, 1999 and 2009. Flood control by reservoirs was considered as early as in 1863, survey of which was done in January 1864 by Lt. Garnault to locate dam sites. In 1902, Mr. Horn

Superintending Engineer proposed reservoir site on Barakar above the confluence. Later on after 1913 flood, Mr. Addams Williams, Superintending Engineer suggested large reservoir at the site selected by Mr. Horn. Multi reservoir concept was initiated by Mr. B.W.Glass, Executive Engineer who suggested three dam sites at Parjos on Damodar, Palkia on Barakar and Chetro on Usri in 1919. As none of the above plans was actually implemented, Dr. C.A. Bently suggested in 1925 for re-introduction of flood flows between Damodar and Hooghly rivers to increase soil fertility and decrease mosquitoes. Consequently, construction of Damodar canal was started in 1926. After the severe flood of 1943, the Governor of Bengal set up Damodar Flood inquiry committee. The Committee's report to the Government of India (August 1944) suggested the creation of an Authority similar to that of the Tennessee Valley Authority in United States. The G.O.I then commissioned the Central Technical Power Board to study the proposal. This power board appointed Mr. W.L. Voorduin, Senior Engineer, TVA, who framed a Preliminary Memorandum for unified development of the Damodar Valley. On 7th July 1948, DVC became a corporate entity comprising of one representative each from Central government and participating State Governments, Bengal and the then Bihar, with a far reaching authority for accomplishing the prescribed objectives.

4. DVC PROJECT CONCEPTS

The prime motivating concepts for development of the Damodar River and its valley (Fig. 1) led to projects addressing needs for flood control, hydropower generation, irrigation, navigation, municipal water supply, malaria control, reforestation, and soil conservation. These projects would be undertaken in a valley comprising two distinct landforms, in accordance with the variations in topography, climate, and soil characteristics. Upper valley has a drier climate and more steeply sloping land. The dams subsequently built there have relatively larger watersheds. The lower valley impinges into the lower deltaic region of West Bengal and is largely agricultural, especially in the vicinity of the Durgapur Barrage. Mr. Voorduin's project provided for full control of design flood of 28321 cumec resulting from a rain storm of 50.8 cm. in upper catchment. The controlled flood discharge is to be limited to the assumed channel capacity of 7085 cumec at Rhondia. In the original plan of the Damodar Valley, it was proposed for eight multipurpose reservoirs on Damodar and its tributaries flowing through two states West Bengal and Bihar (presently portion of Damodar valley in the then Bihar lies under Jharkhand state). It was to build reservoirs at Tilaiya, Balpahari, Maithon on Barakar River, at Bokaro on Bokaro River – a tributary of Damodar River, at Konar on Konar River – a tributary of Damodar River, at Aiyer, Bermo, and Panchet on Damodar River itself. However, on account of financial and other reasons, the participating Governments decided to implement the unified scheme in two phases. In the first phase, only four dams at Tilaiya, Konar, Maithon and Panchet were constructed in 1953, 1955, 1957 and 1959 respectively by DVC. A barrage was constructed on river Damodar at Durgapur which is popularly known as Durgapur-Barrage and irrigation canals were constructed at the lower valley just below Durgapur. Afterwards, Government of Bihar constructed other dam at Aiyer presently known as Tenughat Dam on Damodar River which was impounded in 1970.

5. CORPORATE OBJECTIVES

The statutory functions of DVC according to the Act XIV (1948) of Parliament are as follows: (a) Promotion and operation of schemes of flood control; (b) Promotion and operation of schemes for irrigation, water supply and drainage; (c) Promotion of afforestation and control of soil erosion; (d) Promotion and operation of schemes for generation, transmission and distribution of electrical energy both hydro and thermal; and (e) Promotion in public health, agriculture, industrial activities and general well-being in the Damodar Valley and its adjacent area of operation.

Since inception, DVC is functioning steadily keeping in mind the statutory responsibilities to achieve the corporate objectives as stated below.

- To generate more power at lowest possible cost by improving operational efficiencies of the existing plants, rejuvenating old generating units through comprehensive overhauling as well as by installing new generating plants.
- To transmit, distribute and supply reliable and quality power at competitive tariff.
- To improve the financial health of the Corporation by adaptation of efficient industrial, commercial and human resource management practices.
- To ensure optimum utilization of available water resources through effective and efficient management and harness of the remaining potential of Damodar basin to the extent possible.
- To fortify measures for environmental protection at plant levels and to continue with the effectives of eco-conservation activities in the valley area.
- To strengthen socio-economic development for the inhabitants of villages neighboring major projects of DVC.

6. INTEGRATED DEVELOPMENT

The advent of the DVC has brought about extensive construction of road and communication systems, with consequent impacts on health and literacy, and an increase in the standard of living of most people in the Damodar Valley. In the past sixty-five years, towns have grown more than four-fold; literacy rate has increased by a factor of three or more. The local culture has experienced processes of persistence (survival) and invention (adaptation). The DVC is trying to attain its technical goals while also trying to be mindful of the impacts of its activities. The socio economic condition has been changed a lot due to various developmental activities within the river valley. Most of the reservoirs in the valley have silted up rapidly than its expected rate; consequently capacities in different zones of the reservoirs have been reduced remarkably as shown in Table 1. On the other hand, growth of population and industries within the valley has put a tremendous pressure to distribute water from the limited reduced conservation storages. So, need for integrated river basin development and management arises mainly due to the resource crunch, conflicting demands and different political interests. Most developmental decisions today are of multi-disciplinary in nature involving economic, socio and environmental dimensions and values. It involves a coordinated and harmonious development of the various sustainable activities within this basin. This includes (a) the consideration of a large number of factors relating to various disciplines connected with water resources; (b) an in-depth study and understanding of basin's developmental requirements; and (c) the fixation of priorities and limitations. In the task of integrated approach there are various constraints met with, like state boundaries crossing river basins, political barriers within the valley itself, disputes over jurisdiction and ownership etc. Similar experiences as stated above are also faced by the other river basin authorities in India.

7. PERFORMANCE OF THE STATUTORY FUNCTIONS

DVC is very much cautious about its statutory functions and reaching to its goal slowly for which it was formed. Though DVC was modeled on TVA, DVC has attempted to take into account the conditions unique to India since its inception. So, after passing of sixty-five years, it is time to evaluate the performances of its functions. Basically, all the water resources projects taken by DVC are of multipurpose in nature. Out of which, Flood control, irrigation, M&I water supply and hydroelectricity are at top priority. Besides, DVC has promoted fisheries, tourism, social implementation programs and other activities. The performances of the major functions are briefly discussed in the following paragraphs.

7.1 FLOOD MODERATION

It is to mention that the effective moderation depends on the available storage of the flood pool during entering of flood and the flood carrying capacity of the down-stream channel. Obviously, inflow forecast and weather forecast assist to moderate the flood efficiently. Some times, pre-evacuation strategies are also followed while operation. There are well established guidelines stipulated in DVRR Manual approved by the Ministry of Water Resources, Govt. of India which is followed keeping in mind that Structural safety considerations of the Dams are of paramount importance. When the combined flood cushion is occupied by 100%, there is no other option but to match the outflows with the inflows for the safety of the hydraulic structures. The records, since 1958 and onwards reveal that maximum combined peak inflow discharge entered in the reservoirs at Maithon and Panchet was 21917 cumec in the year 1978 and combined peak outflow discharge after moderation was to the extent of 4616 cumec. On the other hand, maximum moderated combined release was observed to the tune of 8580 cumec in the year 2009 which could not be restricted the permitted discharge of 7085 cumec near Durgapur due to combating with the natural inflows entering to the reservoirs. However, it is observed from the Table 2 that in most cases floods could be managed and moderated to a greater extent by successful operation of the reservoirs. It is observed from the table that 33-81% of the peak discharge of the combined inflow could be absorbed or moderated in different occasions by combined operations of the reservoirs at Maithon and Panchet.

7.2 IRRIGATION PROSPECTS

Prior to formation of DVC, earlier irrigation schemes at lower valley through different canals viz. Eden canal (1873-1881) and Damodar canal (1926-1933) did exist with the total command area of 75303 Hectare. In current scenario, after construction of the barrage at Durgapur, the major command area of the valley lies below Durgapur barrage in the state of West Bengal and irrigation water is released from the barrage pond through 8 nos. head regulators and is supplied to the left bank main canal, length of which is about 136.8 km. Most of the irrigation requirements of the Kharif crops during the period July to September are fulfilled from the monsoon releases of the reservoirs at Maithon & Panchet and from the rainfall that occurs in the command area. Rabi and boro irrigation are fulfilled during non-monsoon period from the storage or conserved water available in both the reservoirs. It is also observed a good prospect of irrigation in the Jharkhand state. The prospects of irrigation in both the states are discussed as follows.

7.2.1 IRRIGATION POTENTIAL IN WEST BENGAL

The month of October actually falls in the end-monsoon period and the rainfall in the catchments of the reservoirs and in the command area is scanty. So, sometimes heavy drawl of the stored-water from the reservoirs is observed for irrigation of the kharif crops during this period. In this situation, a total withdrawal of 493 MCM (DVRR Manual 2002) has been allocated for kharif irrigation in the month of October, subject to the condition that water is available in the reservoirs to meet the following committed requirements during the dry season (November - June). Though, usually, indent for kharif drawl is placed for the whole period from middle to end monsoon. Full development of the command area has not yet been attained in any sphere. Kharif irrigation has been extended to 334,274 Hectare against the target of 393,763 Hectare. Rabi irrigation has been extended to 21,044 Hectare against the target of 22,258 Hectare. Besides, in most of the years, water available for the dry period is more than that taken into account while earmarking utilisation. Kharif irrigation requirements have been fully met in all the past years except in 1966 and 1993 when some marginal cuts were imposed. Detail demand and drawl of kharif irrigation water is shown in

Table 3 for the period of 2003-2012 where it is observed that the demand of kharif irrigation could be fulfilled in all the occasions.

The water allocated for Rabi irrigation is about 86 MCM, which is utilized during the period of December - January in every water year. The surplus water, if available, is normally utilised for Boro (summer paddy) cultivation in West Bengal and Emergent hydro-power generation by DVC. The availability of surplus water is mainly dependent on the end or post-monsoon (October–November) inflow in the reservoirs and its quantity varies from year to year. Boro cultivation in West Bengal was picked up in the early Seventies. With the popularity of Boro cultivation due to its high yield, farmers try to bring more and more area under Boro cultivation. Being a summer (February–May) crop, water requirement for boro irrigation is quite high and which is served from surface water as available from the reservoirs and from ground water to some extent. It is observed from the Table 3 that in most of the water years during the period 2003-2012, the drawl of water for combined rabi and boro irrigation is more than the demand or indent, which was placed to DVC. It is further observed from the records that during the water year 2010-2011 there was no surplus water in the system and year was drought. So, water could not be allocated for boro irrigation during that period.

7.2.2 IRRIGATION POTENTIAL IN JHARKHAND

In the original scheme of Mr. W.L. Voorduin, the irrigation potential at the upper reaches was not considered due to the typical undulating topography of the area and that too was surrounded by the coal deposits. Even after construction of the Tilaiya and Konar reservoirs in the upper reaches, the then Government of Bihar did not consider irrigation in the state, perhaps, difficult terrain and involvement of huge cost were the constraints.

In existing scenario, a good potential of irrigation is observed for the state of Jharkhand. About 64,748 Hectare of land is irrigated for kharif crops from 16,882 small ponds created by check Dams (water conservation structures) at upper valley. These check dams were constructed by DVC to reduce soil erosion from the upper valley. It is further observed that the small reservoirs at Jamunia, Charwa and Gonda provide irrigation facilities to the areas of 1458, 405 and 931 Hectare respectively. Konar irrigation project is under implementation stage by the Government of Jharkhand. If the project is completed, irrigation to the areas 47,849 and 14,074 Hectare will be possible for kharif and rabi crops respectively from the reservoir at Konar. Even, 40,468 Hectare of irrigation potential will be created on implementation of Balpahari Dam project in the District of Giridih.

7.3 MUNICIPAL AND INDUSTRIAL SUPPLY

Navigation is still in the experimental stage and presently no water is being used for Navigation purposes. Water Supply for industrial and domestic uses through releases from the reservoirs has reached a figure of 37 cumec against 18 cumec earmarked in the first stage. With the development of the valley as already stated, population and industrial growth occurred many folds. Lot of new industries like steel plants, crockeries, mining machinery plants etc. came in to the picture. Growth of DVC's total power generation capacity to an extent of 5200 MW considering thermal, hydro & gas turbine, facilitated industrial development of this region sharply. It leads to increase in the demand of water for industries and municipalities in the region. DVC supplies about 617 MCM of water annually, to about 150 various industrial & municipal agencies within the valley, during non-monsoon period. A study as shown in Table 4 reveals that the rate of draw of M&I water from DVC system by Jharkhand and West Bengal states has been increased by about 2 and 1.5 times respectively in last ten years.

7.4 HYDROELECTRIC PROJECTS AND NEW SCHEMES

Hydro-power generation is incidental and all the downstream requirements are released through the hydro units. The exclusive utilisation of water by hydro-units is normally done during emergency/peaking power period. The installation capacity of the hydropower plant at Maithon dam is 63.2 MW comprising of 2 units each 20 MW and 1 unit of 23.2 MW capacity. The capacity of the Hydropower plant at Panchet and Tilaiya is 80 MW and 4 MW respectively having 2 units of equal capacity in each project. Besides the flood and irrigation management, several in-house studies in respect of the development of hydro power potential in the upper valley were also considered by DVC. Boro–Konar reversible pump turbine scheme (4 X 75 MW) was envisaged as construction of a dam across Boro-Nala nearly 8.8 Km away from its confluence with Konar River in the District of Hazaribag in Jharkhand. During peak demand period, power will be generated by releasing water from the Konar Reservoir and water will be pumped back during off peak period by reversible pump turbine. Lugu pahar pump storage hydropower project (3000 mw) scheme envisages construction of two dams, one on the Bokaro River near Danea Railway Station and one on the Kairo Jharna Nala on Lugu Pahar. The difference in water level between the two reservoirs created will result in an average gross power potential of nearly 3000 MW electricity from 10 Nos. of 300 MW capacity reversible pump turbine units. Bermo – Chandrapura pump storage scheme (2 x 40 mw) was dropped as same was inferior to the Boro–Konar Hydro Power project and Lugu Pahar Hydro Project. However, DVC is trying utmost to implement following two schemes as stated below.

7.4.1 KONAR HYDROPOWER PLANT (3 - 5 MW)

The structural safety of Konar Dam was studied by NHPC in Sept. 2010 and it was concluded by them that in the light of the observations made in the inspection reports conducted by various experts time to time, the structural safety of the dam remains doubtful. Several cracks have been developed in the concrete walls of the inspection gallery which is continuously monitored by the dial gauges. In such existing circumstances, it shall not be prudent to put a power plant in the Dam. Accordingly, DVC has requested CWC for rehabilitation of Konar Dam under Dam Rehabilitation & improvement Programme (DRIP) undertaken by the Ministry of Water Resources, Govt. of India. Study for installation of 3 - 5 MW hydroelectric units may be considered only after the rehabilitation of the Konar Dam.

7.4.2 BALPAHARI HYDROPOWER PLANT

Location of Balpahari project is at about 16 km. from Giridih, 40 km. away from Govindpur and 52 K.M. away from Dhanbad. The main reservoir, Earthen Dam, Power House & Barrage all will be located in the State of Jharkhand. Affected eight blocks are positioned at Dhanbad, Giridih and Jamtara districts.

Catchment area of the Balpahari reservoir is about 4,400 sq. km. in Barakar-basin. The reservoir will be located at about 50 km. upstream of Maithon Dam on Barakar River. Submergence in the state of Jharkhand will be around 72.66 sq. km. to take up this project. 44 nos. villages, 3000 nos. families, 4079 Hectare cultivable land, 8911 Hectare village land and 2002 Hectare forest land will be affected due to implementation of this project. The gross command area will be available as 39854 Hectare in Dhanbad and Giridih Districts. Irrigation, industrial and drinking water supply will be available from this project as 443.57, 405.20 and 9.61 MCM respectively from the potential live-storage capacity of 715.61 MCM. Hydro Power potential envisaged is 20 MW (2X10MW). The estimated life of the project has been considered as 70 years. The total gross cost to take up the project is estimated as Rs.2127.368 Crore where net cost is Rs.2120.887 Crore; both was calculated at January –

2012 price index. The major benefits (Balpahari-DPR, 2012) that may come from this project are stated below.

- Irrigation to a GCA of about 39,854 Ha in the State of Jharkhand in between Balpahari & Maithon dams. (CCA = 35,478 Ha) with an intensity of irrigation of 156%.
- Municipal and Industrial water supply in the State of Jharkhand in between Balpahari & Maithon dams. The project carries provision for drinking water supply to the projected population of 261,644 in 2032.
- Hydro-power generation (2 X 10 MW installed capacity) will be available as a peaking power. Balpahari Dam project will generate 63.27 MU of annual energy from the power station.
- Prolonged life of Maithon reservoir due to arresting silt at Balpahari reservoir.

8. NEW INITIATIVES

DVC has taken some new initiatives, obviously which are of very useful for effective management in operation of the reservoirs. Among these, thirty-nine automatic rain gauges have been installed recently at various locations of the valley. The work related to modification of the reservoir operational guide curves are on the way of process. DVC has also thought to restore the lost capacities of the reservoirs and barrage pond by the process of de-siltation. Even, some new innovative ideas have also been taken by DVC to create additional storage facilities. The major initiatives are discussed in the following paragraphs.

8.1 INSTALLATION OF 39 AUTOMATIC RAIN GAUGE STATIONS

Quality data acquisition is the basic input behind any hydrological analysis, operation decision or model formulation tasks. DVC took initiative to install thirty-nine automatic rain gauges at various locations of the valley, which would definitely help to develop and to apply the rainfall-runoff empirical models to predict inflows to the reservoirs. DVC is having a very good in-house-built computerized (Chaudhuri,1997) reservoir-data management information-system, which is useful to process, analyze and estimate the reservoir inflows, releases, evaporation losses and other different parameters for different durations like daily, 10-daily, monthly, yearly etc. Different statistical analyses are also performed by this program. Now, this program is being modified for developing on-line data entering and processing system.

8.2 MODIFICATION OF THE EXISTING OPERATIONAL GUIDE CURVES

Original guide curves for the operations of the DVC reservoirs were developed during the period of inception of the projects. As the operational guide curves are very old and operation scenario has been changed due to siltation, increased demand etc., it is felt to revise the same for better flood management and effective utilization of the water resource within the valley. Presently, Tenughat reservoir is not under the unified operational control of the Damodar Valley Reservoir Regulation Committee (DVRRC). As per inter-state agreement between the two states, Government of Jharkhand has agreed to include Tenughat reservoir under unified control, definitely this decision is appreciable for effective efficient and better flood management in the valley area. This also emphasized DVC, to take initiatives to modify all the existing reservoir operational guide curves in an integrated manner taking into consideration the operation of the reservoir at Tenughat.

8.3 CREATION OF STORAGE

DVC has taken initiatives to implement the Balpahari dam project to increase storage facilities as already stated. There will definitely be an impact upon siltation at the Maithon

Reservoir due to construction of the same. Also, this reservoir (Balpahari-DPR, 2012) will serve a great irrigation potential in the state of Jharkhand as well as hydropower generation as already stated. Land at upstream of the reservoir at Maithon could not be acquired between the stages EL-150.88 Mt. to EL-152.44 Mt. (Top of the flood zone). A rim embankment around Maithon Reservoir was also proposed by DVC within the stated elevations of the reservoir to achieve additional flood storage space approximately 160 MCM, on feasibility of the project.

8.4 DESILTATION WORK

In case of the reservoir at Panchet, part of the lost capacity (149 MCM in live & flood zone) may be restored in consequent of de-siltation. Feasibility study followed by preparation of DPR is being explored by DVC for the same. Almost all the major industries are situated in & around Durgapur at the lower valley & entire drinking water requirement of Durgapur Township is met by Water Supply Canal of DVC. Nearly 50% capacity of Water Supply Canal & Harbor Pond at Durgapur has been encroached by siltation. As a result, a higher elevation of RL 64.62 Mt. is to be maintained in the main canal instead of the normal elevation at RL 63.39 Mt. to supply water at different water off take points of industries & municipalities at Durgapur ensuring intake level. DPR has already been prepared by DVC to take up the de-siltation work of this canal. Meanwhile, work for de-siltation in a small stretch of water supply canal has been started on experimental basis.

8.5 FISHERIES

In the recent years, DVC has revived its old fish farms and took lot of initiatives for stocking of fingerlings in DVC reservoirs and to increase its production. In order to stocking of fish seed in different reservoirs, one Indian Major Carp (IMC) hatchery complex has already been established at Maithon fish farm with a capacity of 20 million spawn production capacity per operation since August, 2008. For proper development of reservoir fisheries and for motivation of the stakeholders around the reservoirs, awareness camps are being arranged regularly. A large number of water bodies in the valley will be taken up for promotion of fish culture with a view to increase sustained income generation of the local people. Fishing rights in the reservoirs will be extended through appropriate platform or body to the local villagers and also to the agencies. The fish seed production capacity will be enhanced by formation of new Nursery ponds / Rearing ponds in the different projects. A Model Fish Farm will be constructed at Panchet.

8.6 PREPERATION OF THE MASTER PLAN

DVC took initiatives to prepare a Master Plan for the sustainable ecofriendly developmental activities that may be taken up in coming scenarios considering future growth of the valley. Growths of demand in irrigation, domestic and industrial needs were projected and water availabilities for meeting the needs at different scenarios up to the year 2050 were derived. It (Master Plan, 2011) also projected the food grain requirements for both the states at different intervals. Specially, it elaborately discusses the scope of irrigation in the state of Jharkhand. Lot of potential sites has been identified for mining activities and Thermal Power Stations in the valley. Upper limit of water pollution was also studied for different stretches of the river in addition to the expected air pollution at different scenarios. Areas of high erosion zone were identified separately within the valley. The report also recommended some prospectus projects in hydropower planning. It also emphasized some measures to control the erosion at the upper valley. In overall, it may be said that the Master Plan is a very useful comprehensive planning prepared based on the integrated development approach.

9. ISSUES FACING BY DVC

Inevitably, a variety of issues have evolved for the DVC as the Damodar Valley developed. The issues may be classified (Chaudhuri, 2000) as project related or operation related. Project-related issues typically involve pre-project and post-project concerns. A common pre-project issue entails justification of development. Aspects of environmental impacts, land acquisition, and population rehabilitation must be addressed. Moreover, economic considerations pose on-going problems. Industrialization of the Damodar Valley has resulted in problems of pollution control. Given the limited size of the reservoirs, there is, for instance, little scope for diluting pollutants. Illiteracy, high rate of population growth, and political complexities make the water issues more pressing. Moreover, owing to the fairly complex geography of the Damodar Valley, it is difficult to define or assess accurately the regions that have benefited from the DVC's projects. Some of the critical issues related to project and operation oriented are stated below.

9.1 LAND ACQUISITION

The upper valley has abundant mineral resources (it is, for instance, a major coal mining area for India) and extensive forests. The upper valley's mineral resources complicated land acquisition for the planned reservoirs. The full benefits of many projects within the valley have yet to be achieved. Difficulties exist for acquiring the remaining land for planned reservoirs at Maithon and Panchet. In case of the reservoir at Panchet, Flood zone is designed between the elevation of 125.0 Mt. and 135.7 Mt. However, land could be completely acquired up to an elevation of 129.5 Mt. Above this, Houses is acquired up to an elevation of 132.6 Mt. But the land could not be acquired by DVC till date beyond the elevation of 132.6 Mt. at Panchet. Similarly, for the reservoir at Maithon, land could not be acquired up to its maximum level of EL-152.44 Mt. Besides, DVC is also facing lot of problems to acquire land at its different on-going thermal power projects as well as at new reservoir projects area. In some cases land could be ultimately achieved and in some cases could not be attained.

9.2 REHABILITATION AND RESETTLEMENT

DVC took different plans since its inception of the projects to settle the issues of rehabilitation and resettlement of the families affected due to acquisition of the lands. But, yet; the issues persist and have been aggravated due to political interventions. It is really a tremendous pressure to DVC to tackle these issues satisfying the interests of the political parties, participant states and the Central Government. However, in each case, DVC is trying to resolve these issues sympathetically.

9.3 FLOOD OPERATION

Several significant reservoir operational issues currently exist. Issues have been aggravated more due to non-implementation of the second phase projects that originally planned. Operation of the existing reservoirs in the current scenario is gradually becoming more and more complex due to the various constraints developed. The original planning of moderating a design flood of 28321 cumec to a safe channel capacity of 7085 cumec at downstream with a total flood storage capacity of 3579 MCM went in vain. With the first phase of construction of DVC dams, it was assumed that the capacity of 1851 MCM of flood storage in four reservoirs should be able to moderate a flood 18420 cumec to 7085 cumec at the downstream. Further, due to non-acquisition of lands up to maximum water levels in Maithon & Panchet dams, the total flood storage in the reservoirs was reduced to only 1296 MCM. So it is practically impossible to moderate even a flood-peak discharge near to 17003 cumec to 7085 cumec at downstream of the river. So, in the existing system, flood storage is not at all adequate in moderation of flood discharges of slightly higher magnitude.

9.4 LOWER DAMODAR CHANNEL CAPACITIES

Capacity of the lower Damodar channels in the valley has decreased drastically due to extensive unauthorized encroachment into the flood plain zones; even in some areas encroachment occurred in the regular river course itself. This took place due to absence of frequent flood peak discharges in the river at higher concentration. Soil erosions due to human activities as well as industrial growths boosted the rate of sediment deposition in the channels at lower valley. At present the discharge capacity of lower Damodar channels is only 3684 cumec and that too under favorable conditions of no rain & no tide. Otherwise, combined release to an extent of 2834 cumec (released from both the dams) inundates (Banerjee, Case Study) a lot of areas of the lower valley along the both banks of the river Damodar. Therefore, during medium incoming floods, restriction of releases causes extended occupation of the flood storage zone in the reservoirs, which ultimately increases the risk of releases at higher-magnitude in the event of any comparatively greater incoming flood.

9.5 SILTATION IN THE RESERVOIRS

High rate of silt deposition within the existing reservoirs have reduced the overall dead storage capacity by 49.6%, live storage capacity by 30.5% & flood storage capacity by 16.3%. Due to non-existence of the second phase reservoirs originally planned, silt deposition rate in the existing two large reservoirs at Maithon and Panchet increased many folds than its designed values. As per the recent studies of life of Maithon reservoir (Chaudhuri, 2006), it is observed that by the year 2039, capacity of the flood, live and dead storage zones will be depleted by 11%, 50% and 100% respectively. Obviously, this will induce a great impact in the operation of the reservoirs, as Maithon reservoir alone fulfills about 70% of the total downstream demands. DVC's Reservoir Regulation Act sets operational guidelines for operation of the reservoirs in the Damodar Valley. However, siltation problems in reservoirs and channels located at the lower valley are creating problems to follow such guidelines.

9.6 OPERATION OF THE TENUGHAT RESERVOIR

Tenughat reservoir located at the upstream of Panchet reservoir could not be included in the integrated operation of the DVC reservoirs. Consequently isolated operational-decisions in respect of the reservoir at Tenughat create problems in operating the downstream reservoirs. So, sometimes the decision of releases from this reservoir, especially during monsoon (Banerjee, Case Study) distorts the flood operations of the reservoirs at Maithon & Panchet. Same creates serious problems during flood periods. Even, at any time, it may induce flood at lower valley also. However, it has been observed that silt deposition rate at Panchet was reduced remarkably after construction of the dam at Tenughat.

Several other issues like irregular & un-authorized drawl of water from DVC system by various Govt. & private agencies, construction of small dams in the upper reaches by State Government without intimation to DVC, mining & various other activities within the rivers & submergence areas, contribution of inflows from uncontrolled catchment between Barakar & Damodar catchments etc. also create constraints in overall operation of DVC reservoirs.

10. STRATEGIES TO COMBAT THE ISSUES

From the above discussions, it is felt that the total system conservation and flood storage capacities are must to be increased. To achieve this, flood cushion of Tilaiya and Konar reservoir may be used as a combined storage for controlling flood as well as for conservation purpose. In depth water availability study is required considering all the constraints for keeping provision of water for Jharkhand UMPP from the existing Tilaiya reservoir. Irrigation facilities (Deloitte, 2012) may be extended to Jharkhand state through Konar and Tilaiya reservoirs, if extra water is available and if agreed by Jharkhand. In case of Maithon and Panchet, existing operational conservation level may be increased by 1.52 Mt. in each

reservoir. Certainly balance land in Maithon & Panchet reservoirs up to the level of top of gate will have to be acquired. Precise reservoir survey may be taken up to correctly assess the capacities of all the reservoirs. All M&I water allotments may be reviewed to locate surpluses in the allotted values. To combat the flood at the lower valley, down-stream flood carrying capacities may be reassessed or reviewed. In irrigation and water supply canal system, concrete lining may be provided to reduce the transit and percolation losses. Rich afforestation and soil conservation measures are also required to be taken up at the upper valley to reduce the erosion rates. Besides, it may also be thought, to take lots of small projects related to storing of water by constructing check dams as well as water harvesting structures and simultaneously to take ground water recharging projects which will definitely increase the surface and ground water potential in this valley.

11. CONCLUSION

The original objectives behind the development of the DVC were the creation of more employment, food-grain production, and the overall improvement of socioeconomic conditions within the valley through flood control, irrigation and hydropower production. After the passing of more than sixty-five years, it is appropriate to review the extents to which those objectives have been attained. There has been substantial progress; yet, the severe floods that occurred during September 2009 in West Bengal indicate there are limits to which the DVC can meet all the expectations conceived in 1948.

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Table - 1 Loss of storage in DVC reservoirs due to siltation

Reservoir	Zone	Original Survey Year	Original Survey Capacity MCM	Secondary Survey Year	Secondary Survey Capacity MCM	Sediment Volume MCM	Capacity loss %
Maithon	Dead up to 132.60 Mt.	1955	206	2002	93	113	54.85
	Live 132.60 - 146.30 Mt.		607		441	166	27.35
	Flood 146.30 - 150.90 Mt.		382		334	48	12.57
	Gross		1195		868	327	27.36
Panchet	Dead up to 119.48 Mt.	1956	236	2011	106	130	55.08
	Live 119.48 - 124.97 Mt.		252		169	83	32.94
	Flood 124.97 - 131.10 Mt.		500		434	66	13.20
	Gross		988		709	279	28.24
Tilaiya	Dead up to 363.32 Mt.	1953	141	1987	75	66	46.81
	Live 363.32 - 368.81 Mt.		238		141	97	40.76
	Flood 368.81 - 372.47 Mt.		178		165	13	7.30
	Gross		557		381	176	31.60
Konar	Dead up to 410.57 Mt.	1955	60	1987	35	25	41.67
	Live 410.57 - 425.81 Mt.		221		175	46	20.81
	Flood 425.81 - 427.94 Mt.		56		38	18	32.14
	Gross		337		248	89	26.41

Table – 2 Moderation of major floods since inception of the projects

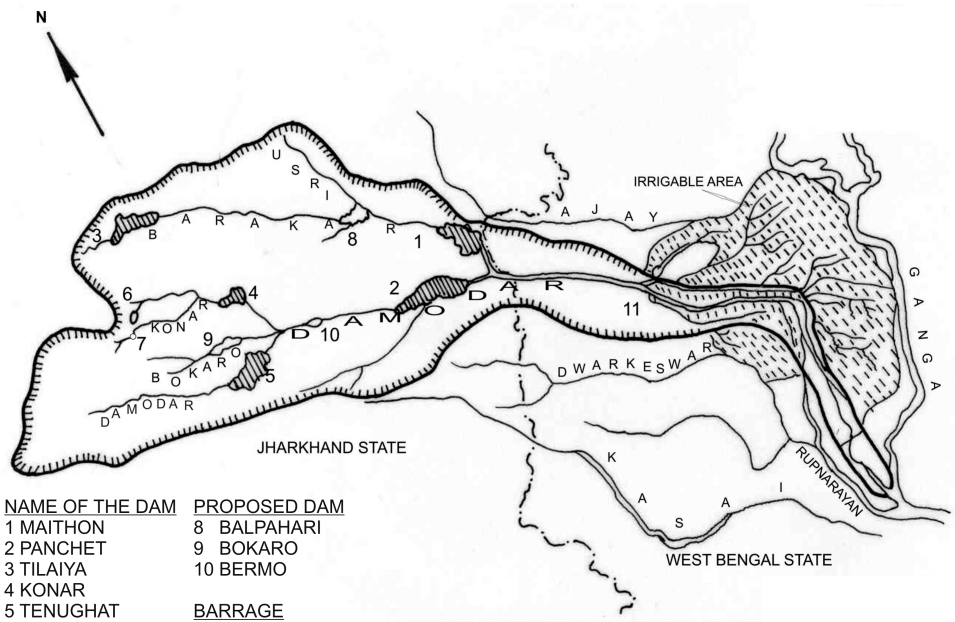
Period of flood peak Month/Year	Combined Peak I/F at Maithon & Panchet Cumec	Combined Peak O/F at Maithon & Panchet Cumec	Moderation Cumec	Moderation in %
Sep, 1958	15716	4955	10760	68
Oct, 1959	17641	8155	9486	54
Oct, 1961	14611	4531	10081	69
Oct, 1963	12771	3426	9345	73
Oct, 1963	13167	2577	10619	81
Jul, 1971	12006	5125	6881	57
Oct, 1973	16650	4955	11695	70
Sep, 1978	21917	4616	17302	79
Aug, 1980	9656	4219	5437	56
Sep, 1980	6796	3398	3398	50
Jun, 1984	6966	2973	3993	57
Jun, 1984	7815	2832	4984	64
Aug, 1987	6060	3398	2662	44
Sep, 1987	6853	4531	2322	34
Sep, 1995	17075	7051	10024	59
Sep, 2000	11185	5805	5380	48
Sep, 2006	20671	6909	13762	67
Sep, 2007	10279	6909	3370	33
Sep, 2009	14838	8580	6258	42
Aug, 2011	5012	2718	2294	46

Table – 3 Performance of Irrigation Supply

	Allocated Water			Kharif Irrigation		Combined Rabi & Boro	
Year	Kharif	Rabi	Boro	Indent	Drawn	Indent	Drawn
	MCM	MCM	MCM	MCM	MCM	MCM	MCM
2003-2004	494	86	489	1578	1639	619	654
2004-2005	494	86	333	1176	1403	448	498
2005-2006	494	86	246	1178	1068	399	369
2006-2007	494	86	404	1147	1179	556	574
2007-2008	494	86	582	39	1214	605	685
2008-2009	494	86	262	350	1098	435	427
2009-2010	494	86	436	236	701	591	579
2010-2011	494	86	Nil	815	875	104	85
2011-2012	494	86	322	764	1275	520	512

Table – 4 Municipal and Industrial Water withdrawal

	M & I Withdrawal	
Year	West Bengal	Jharkhand
	MCM/day	MCM/day
2002	0.68	0.30
2003	0.73	0.31
2004	0.79	0.33
2005	0.79	0.36
2006	0.85	0.41
2007	0.89	0.54
2008	0.91	0.55
2009	0.92	0.56
2010	0.95	0.58
2011	0.97	0.61
2012	1.01	0.63



NAME OF THE DAM	PROPOSED DAM
1 MAITHON	8 BALPAHARI
2 PANCHET	9 BOKARO
3 TILAIYA	10 BERMO
4 KONAR	
5 TENUGHAT	BARRAGE
6 CHHARWA	11 DURGAPUR
7 GONDA	

MAP OF THE DAMODAR VALLEY
FIG. 1