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CASE STUDY

INDIA: *FLOOD MANAGEMENT – DAMODAR RIVER BASIN*

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INDIA: *FLOOD MANAGEMENT – DAMODAR RIVER BASIN*

Suresh Chandra[1]

1. Introduction

1.1 India is a vast country with a total geographical area of 3.29 million sq. km. It lies between the longitudes 68 ^{0} 0' & 97^{0} 30'East and between latitudes 8^{0}0' & 37^{0} 0'North .Due to its vastness, the different regions of the country have varied climates and rainfall patterns. The rainfall has extremely wide fluctuations ranging from 110 mm in Western Rajasthan to 11,000 mm in North Eastern part of the country with average annual amounting to 1150 mm. Heavy freak rainfall does, however, occur in the driest regions and cloudbursts are not unknown in some particular areas.

1.2 The National Commission on Floods (1980) assessed the flood prone area in India as 40 million ha (12% of geographical area). Out of the total area liable to floods, about 80% (32 million ha) could be provided with reasonable protection and approximately 50% of such area has been provided with a reasonable protection so far through various means of flood management measures. The problem of flood varies from basin to basin, so also the magnitude of damages caused by floods. The most flood prone areas are in the Brahmaputra basin in the North Eastern part of India and the Northern sub-basins of the mighty Ganga basin demanding extensive flood management measures to reduce the damages.

2. Location of flood prone area-Damodar River Basin

2.1 River valleys have remained as cradles of human activities and achievements throughout the course of human history; and the Damodar valley is no exception-nurturing civilisation in different phases through 3,500 years. The Damodar basin is located between 84 ^{0} 45'E longitude and 22^{0} 15' to 24^{0} 30'N latitude, entirely situated in the two states of Jharkhand (earlier Bihar) and West Begal;though Damodar is not the only river flowing through these two states, there are many others. The hilly terrain is almost within the state of Jharkhand and the flatter portion lie within the state of West Bengal. Due to this particular topography of the catchment area, River Damodar used to inundate large tracts of districts of Burdwan, Hoogly and Howrah in the state of West Bengal every year.

The entire left bank area which includes important industrial towns and coal mines was protected by an embankment since long. Vital means of communications like the Grand Trunk Road (NH-2) and main arterial railway line connecting Calcutta, now called Kolkata, with Delhi and other important places in India lie in the vicinity of the river.

Heavy floods in Damodar River often breached the embankment causing breaches in the G.T.Road and the main railway line in the states of Bihar and West Bengal.

2.2 Physical Features

2.2.1 River System (See annexed map)

The Damodar river rises in the Palamu Hills of Chhotanagpur in Jharkhand at about 609.57m above mean sea level. After flowing generally in a south-easterly direction for 540 km (240 km in Jharkhand and the rest in West Bengal) joins the river Hoogly about 50 km below Kolkata. Its principal tributary, the Barakar, joins it just upstream of Jharkhand-West Bengal border. Below Durgapur (West Bengal), it abruptly changes its course and then bifurcates into two channels viz. the Damodar channel(also known as Amta channel) and the Kanka-Mundeshwari channel. The main channel finally meets the Hoogly River, ultimately joining the Bay of Bengal.

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The total population of the affected area from Damodar floods may presently be around 8.9 million.

2.2.2 Catchment

The catchment area of the river is about 22,000 sq. km of which about 19,000 sq. km are in uplands and 3,000 sq. km in plains which are of deltaic nature. The catchment is irregular in shape and somewhat elongated in the lower reach. The river slope is 1.86 m/km for the first 241 km;0.57 m/km in the next 167 km and 0.16 m/km in the last reach. The lower reaches are silt covered and quite fertile. Irrigation facility has been available in the lower Damodar basin before the advent of dams by means of a diversion weir-Anderson weir-at Rhondia on river Damodar and Eden canal to the extent of 89,000 ha in the districts of Burdwan and Hoogly.

2.2.3 Soils

Six sub-types of soils have been identified under the main alluvium, either the Ganga alluvium or the Damodar alluvium in the delta area. Open Sal forests (Shorea robusta) thrive mainly on laterite and dense Sal forest on red and yellow loams in the upper valley.

2.2.4 Climate

The climate of the area is characterised by moderate winters and hot & humid summers. Like the rest of India, the region experiences two principal rainy seasons. In the winters from December to March there is little rain. In the summer months, June to September, the flow of air is from sea to land and the season is characterised by high humidity, clouds and rain. The direction of winds being south-westerly, the season is named South-West Monsoon which is the main season producing rains. Between these two principal seasons are the transition seasons of the hot weather months of April & May and the retreating monsoon months of October & November.

2.2.5 Rainfall

The annual rainfall over the valley ranges between 1,000 mm and 1,800 mm. Distribution of rainfall varies widely owing to differences of terrain and atmospheric conditions in the different parts of the valley. Within the command area, the upper and the middle parts of the Damodar basin receive 1,209 mm rainfall annually and the lower valley 1,329 mm. Above the main plateau escarpment rainfall increases to over 1,500 mm a year. Mean annual rainfall in the basin is of the order of 1,300 mm and about 80% of rain precipitates during the summer monsoon (June to September).

2.2.6 Temperature

The highest maximum temperature exceeding 46^{0}C was recorded over a larger part of the valley. Normal temperature swings between 40 to 42 degrees Celsius in the summers (May & June) to 23 to 26 degrees Celsius in the cold months (Dec. & Jan.).Mean relative humidity varies from 80% during July to September to 40% in March., April & May.

2.2.7 Streamflow

Streamflow in Damodar river was recorded at Rhondia weir from 1933 to 1959.Thereafter,on completion of Durgapur barrage and the Dams, the discharges were recorded at these structures. The year 1966-67 was the poorest on record and the annual inflow into the 4 reservoirs at Maithon, Panchet, Konar and Tilaiya was as low as 0.197 million ha-m. The maximum flood recorded in the pre-dam period was from August 6 to 12 in 1913 with a peak flow of 650,000 cusec[2](18,406 cumec[3]) and with a total volume of 0.3944 million ha-m. The worst flood recorded in the valley, occurred in Sep.1978 with peak flow of 21,900 cumec.

[2] Cubic feet per second
[3] Cubic metre per second

3. Description of Floods in Damodar Valley and Flood Management Measures

3.1 Type of flood

Catchment area of Damodar river experiences seasonal rains due to the South-West Monsoon every year and depending upon the intensity of the storms, floods occur. During the monsoon season, the rainfall in the area is mainly due to either the passage of depressions over and near the area or active monsoon conditions due to accentuation of the seasonal trough. The normal track of the monsoon depression from Bay of Bengal towards Orissa-West Begal coast in west-north-west direction lies to the south of Damodar valley.

The Damodar is a shallow, wide,seasonal and flashy river. During the rains, its flow is torrential; and in the hot weather, barely a trickle. Its destructive propensities have earned the Damodar, the sobriquet of "the river of sorrow". It erodes Jharkhand and floods West Bengal with water and silt and causes much distress and loss in both states.

A heavy storm preceded by another storm normally causes flooding in the West Bengal area which is more or less flat due to silting process going on for times immemorial. The cross section of the lower Damodar in the delta area has become considerably reduced and spreaded, straining its drainage capacity.

3.2 History of Flood Events

The challenge of taming the Damodar seems to have engaged attention for some considerable time even before the British India. Early in the 18th century, embankments were built on both banks from Silna to the mouth of the river to protect the adjoining area from floods. But efforts proving unequal to the fury of the river, a palliative was decided in 1855 that30 km of the river embankment would be removed to allow the river to spill on right bank so that this would relieve pressure on left bank which protected vital interests like the East Indian Railway, the Grand Trunk Road and the Port of Kolkata. Accordingly, between 1856 and 1869,a section of 30 km of the right embankment was removed.

In 1863,the Government of India investigated the possibility of flood control by means of reservoirs in the upper reaches of the river. The engineers recommended construction of controlling reservoirs at four sites of tributaries. A supplementary survey was, later, carried out in 1866 and some more dams were identified on Damodar and Barakar, which,apart from controlling the floods, would also provide irrigation and navigation facilities. The scheme was, however, not accepted by the Government on the ground that the financial investment was disproportionate to the benefits envisaged.

The disastrous flood of 1900 revived deliberations on the issue and a scheme for construction of three masonary dams at a cost of Indian Rs. 6 million (US$ 133,000) was drawn up. The emphasis was on irrigation, but the investment of Rs. 272(US$6) per ha. of reclaimed and benefited land was considered extravagant[investment rate at the end of 9th Five Year Plan(2002) rose to more than Rs.100,000 per ha].It was, therefore, decided to take *ad-hoc* measures from time to time to repair the damage and alleviate the miseries caused by floods. The subsequent high floods of 1907,1909 and 1911 were apparently dealt with in the *ad-hoc* manner.

The flood of 1913 once again brought matters to the head. With a peak discharge of 650,000 cusec (18,406 cumec) the flood caused wide breaches in the embankment and serious damage to the countryside, which roused considerable public outcry and demands for a revision of policy. In 1920,a revised scheme for the construction of detention reservoirs was prepared but was shelved again on financial grounds. In 1932,the Anderson weir was constructed at Rhondia. Seven years later, the Bengal Legislative Assembly approved of the Damodar-Hoogly flushing and irrigation scheme, but it, too, was not pursued.

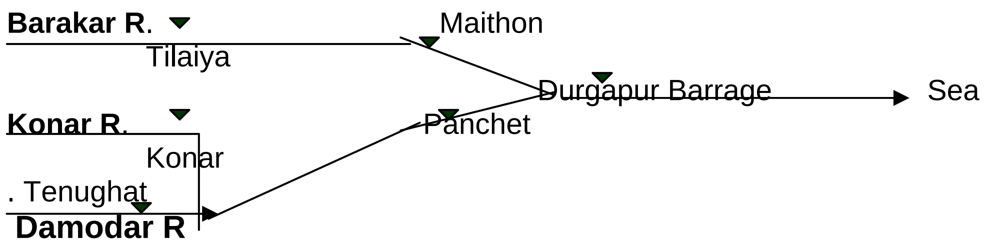
3.3 A moderate flood-about half the size of the 1913 phenomenon-breached the left embankment in July 1943.The consequence this time was the worst disaster, the Damodar region had ever witnessed. The adjoining area was submerged to a depth of six to seven feet (1.8 to 2.1m). Many villages were devastated. The railway lines were dangerously breached, necessitating diversion of traffic. Kolkata was isolated from the rest of India and normal life was helplessly dislocated. All communications, road and rail, were severed between the 14th Army and its General Headquarters for some weeks, throwing out of gear defense arrangements during a critical period of the Second World War in which the British were fighting the Japanese Axis Powers in Burma Theatre (present day Myanmar). The principal strategic lines of communications of the British army were so seriously interrupted that they were almost suspended for a period of three months-at a time so critical to the war effort that adverse consequences might well have been decisive.

With the shock treatment given by Damodar, the Government finally realised that it could not procrastinate further. The Bengal Government appointed a committee, known as Damodar Flood Enquiry Committee in 1944 which recommended inviting an expert from Tennessy Valley Authority (TVA), USA to prepare a project primarily for the control of floods and secondarily for the development of water resources for various other uses e.g. power, irrigation, navigation and water supply for industrial and municipal uses. Mr.W.L.Voorduin of TVA arrived India and after detailed surveys submitted his 'preliminary memorandum on the unified development of the Damodar river' in 1945.The memo was considered by the three Governments of Bihar, Bengal and the Centre in serious earnestness and agreed in 1947 that the scheme be implemented through a TVA type of regional organisation. Accordingly the Damodar Valley Corporation (DVC) came into existence on the 7th July 1948 by an act of the Constituent Assembly. It was independent India's first and last River Basin Organization.

4. Implementation of Damodar Valley Scheme and Institutions Responsible for Flood Management

4.1 The multiple objective of Voorduin's Plan of flood control, irrigation, power, etc. in the valley had been sought to be achieved principally through a set of reservoirs at 8 sites on Damodar and its tributaries viz. at Tilaiya, Maithon and Balpahari on the Barakar river; Bokaro on Bokaro river; Konar on the Konar river and the Panchet, Aiyer and Bermo detention dams on the Damodar itself. Hower, on account of financial and other reasons, the participating governments decided to implement the unified scheme in two phases. In the first, only 4 dams viz. Tilaiya (1953), Konar (1955), Maithon (1957) and Panchet (1959) were constructed by DVC.A pick up structure-Durgapur barrage-was constructed downstream of the 4 dams in 1955 with head regulators for canals on either side for feeding an extensive system of canals and distributaries. The whole system was expected to provide committed annual irrigation of 364,000 ha besides providing water for industrial and domestic uses. Maithon dam lies downstream of Tilaiya on Barakar and Panchet is situated downstream of Konar on Damodar. As such, the Maithon and Panchet act as control reservoirs and are located about 8km above the confluence point of Barakar joining the Damodar.

Only one more reservoir-Tenughat (1978)-came up on Damodar river, constructed by Government of Bihar (Jharkhand) which has remained out of control of DVC due to some reasons.Owing to problem leading to non-acquisition of land upto design level, there is no effective utilisation of its flood moderation capacity. All the 5 dams now fall under the territory of Jharkhand state after reorganisation of states and except for Tenughat which is under control of Jharkhand and Durgapur barrage which is controlled by West Bengal, rest of the dams are operated by DVC.



4.2 The integrated operation of all structures upstream of Durgapur barrage is done by a committee-Damodar Valley Reservoir Regulation Committee (DVRRC) headed by Member (River Management), Central Water Commission (CWC), with representatives each from DVC and the states of Jharkhand and West Bengal. The main functions of Damodar Valley Reservoir Regulation Committee are to discuss and lay down the principles for smooth and effective regulation of the reservoirs including improvement in the carrying capacity of Lower Damodar Channel, creation of additional storage in DVC System and conflict resolution. The Committee directs storing up into and releases from the DVC reservoirs on day to day basis and distributes stored water to DVC and Government of West Bengal for power generation, irrigation, industrial/domestic uses etc. through the member-secretary of the Committee (who is also the Superintending Engineer, Lower Ganga Circle, CWC) stationed at Maithon Dam and by holding its meetings.

The stakeholders/users are involved only indirectly in the work of the Committee, since its composition includes only the government department's representatives who get the brief from the public representatives (Members of Parliament and local politicians) and attend the meetings of the DVRRC. The Government Department's officers also tour the command area, sometimes along with the politicians also, and take feedback from the users to take care of their interests.

The conflicts amongst the states & DVC as well as between the interests of flood control, irrigation and power sectors are resolved by the DVRRC by holding its meeting 3 to 4 times in a year. A reservoir regulation manual prepared by CWC is utilised for integrated regulation of the reservoirs for the principal benefits of flood management, irrigation, industrial and domestic water supply and power generation. Efforts are being made to bring Tenughat reservoir also under the unified control of DVC for integrated operation of Damodar Valley Reservoirs.

4.3 The Committee is assisted by CWC which maintains flood forecasting network for Damodar River Basin comprising 5 stations for which level and inflow forecasts are issued by CWC every year. These stations are Tenughat Dam, Panchet Dam, Durgapur Barrage on Damodar river; Maithon Dam on Barakar River and Harinkhola station on Mundeshwari channel. The Lower Ganga Circle Office of CWC, situated at Maithon, utilises the stage /discharge and other data of 3 reference stations and information of 2 reservoirs viz. Tilaiya and Konar located on Damodar/Barakar rivers on the upstream, for formulation of forecasts.

Under the Danish Hydraulic Institute (DHI)/Central Water Commission collaboration Project, the Damodar Basin as the focus point, computerised mathematical model (NAM S-11) was developed and adopted for Damodar Basin in 1986 which has worked satisfactorily, for example, against the peak level forecast of 2589 cumec on 27.08.1987,the actual level achieved was 2534 cumec.

4.4 In the event of extreme flood events and eventual disaster, the affected states and the central governments apparat swings into action for relocating the people, cattle and limited moveable properties to safe areas and providing them with shelter, food, fodder, water, medicines and other relief items. The army is also deployed under dire circumstances. The District Magistrates from the state administration coordinate all concerned agencies and coordination is total under such conditions. The Crisis Management Group under the Ministry of Home coordinates at central level and monitors the disaster situation and recommends central relief funds to the state governments.

5. Performance of Damodar Valley Reservoirs in Flood Moderation

Examination of actual inflow and outflow data for the two terminal dams at Maithon and Panchet show that tangible flood moderation has been achieved during the past years. Following table shows the performance of these reservoirs in terms of major flood inflows into these reservoirs and the moderation achieved. All flow figures are in cubic metres per second.

Year	Date	Max. Inflow into Maithon & Panchet	Max. Outflow from Maithon & Panchet	Flood Moderation achieved (%)
1958	16-17 Sep	15.7	5.0	68
1959	1-2 Oct	17.6	8.2	53
1960	27-29 Sep	10.0	2.6	74
1961	2-3 Oct	14.6	4.6	68
1963	2-3 Oct	12.8	3.4	73
1963	24-25 Oct	13.2	2.6	80
1971	16-18 Jul	12.0	5.1	58
1973	12-13 Oct	16.7	5.0	70
1975	25-27 Sep	9.7	3.1	68
1978	26-27 Sep	21.9	4.6	79
1984	25 Jun	10.6	4.8	55
1993	14-17 Sep	7.0	2.8	60
1995	27-28 Sep	17.5	7.1	59
2000	19-21 Sep	9.2	2.8	70

It is evident from the above table that a flood moderation to the extent of 53 to 80% had been achieved in the high flood years. Detailed examination of flow data as available at Rhondia, revealed that maximum flow of 650,000 cusec (18406 cumec) had occurred twice in August 1913 and August 1935 before the implementation of Damodar Valley Scheme. Examination of actual inflow for the two terminal reservoirs at Maithon and Panchet show that major floods nearing or exceeding this maximum observed flow of 18406 cumec occurred only in 1959,1978 and 1995.

During 1959, the peak inflow into the reservoirs was 17,641 cumec which was moderated to 8155 cumec.However,the outflow from Durgapur barrage was 9911 cumec due to the contribution from intermediate catchment. It has been estimated by DVC that had there been no dams,a flood of 22,937 cumec would have been experienced below Durgapur which was much higher than the highest recorded i.e.18406 cumec till that date.

The 1978 was an all-time high with a combined inflow peak of 21,900 cumec. If this peak was allowed to pass without any flood moderation, it would have generated a probable peak of 33,414 cumec (1.18 million cusec) at Durgapur barrage, thus surpassing the design flood (1 million cusec) of the structure as is shown in the table below:

Regulation of 1978 Flood

	WITH 4 DVC DAMS		WITHOUT DAMS	
	3 hourly peak inflow	3 hourly peak outflow	3 hourly peak inflow	3 hourly peak outflow
At Maithon & Panchet	21,917	4,615	26,958	26,958
At Durgapur	10,732	10,732	33,414	33,414

It is useful to recall that it was the havoc caused by the 1943 flood which led to the establishment of DVC and the water resources development structures. With the significant industrial development that has taken place below Durgapur, the potential of damage due to floods of the magnitude of 1959 or 1978 or 1995 in the event of a breach in left embankment assumes frightening proportions. In the year 1978,but for the DVC dams the whole of the industrial belt of Asansol, Durgapur, Burdwan, Bankura, Hoogly, Howrah, the Grand Trunk road and the Eastern Railway link would have been devastated.

6. Flood Management Approach in the Lower Valley

The primary consideration of the planners of the Damodar Valley Scheme was to provide adequate protection to the left embankment along the Damodar river which protects the arterial railway line, Grand Trunk Road, industrial establishment etc. by restricting the flows at Durgapur barrage to 250,000 cusec (7079 cumec) which was considered to be the safe maximum carrying capacity of lowe Damodar channel. The carrying capacity of lower reaches of the river below Damodar barrage, later, diminished due to heavy siltation. In some places, it has reduced to even about 50,000 cusec. The lockage of tidal channels at outfalls, further adds to the flood problem of the area.

The state government has now commenced implementation of a scheme, 'Improvement of drainage of lower Damodar' to increase the capacity of the channel. The left bank embankment has also been strenthened to withstand a controlled flow upto 450,000 cusec (12,743 cumec).

The moderated flow from the dams was planned also to prevent excessive flooding of the fertile agricultural land on the right bank of Damodar in this region. However, in the absence of frequent floods of higher intensities and due to low releases of less than 100,000 cusec (2,832 cumec) from the dams during the monsoon period, the lower valley has gained undue value and importance due to false sense of security and there has been extensive encroachment into the flood plains. The Government of West Bengal realised the importance of the productive value of the flood plains of Damodar, given the density of population and high level of investment on flood plains and that such protection can only be imparted at great cost and at the cost of denying the productive use of flood prone land. While there are losses in the high flood years, the flood plains are utilised gainfully by the people living in the area during the low flood years. The approach, therefore, has been to "bear the losses" at the time of flood disaster while enjoying the benefits of the land during the rest of the period/years.

This was a natural approach adopted by the state governments of India from the very beginning itself i.e. after India became independent in 1947. The Policy emerged out of the necessity to safeguard the interest of already densely populated flood plains and the difficulty envisaged in the uprooting and resettlement of the flood plain occupants who were living off the flood plains and also that it was considered more beneficial to accept occasional flood losses against large benefits accruing out of the use of flood plains.

7. Damodar Valley Corporation

As mentioned in para 3.3,DVC came into being in 1948.The DVC was a joint creation of the two states and the central government. The state governments agreed to surrender to the 'Corporation' such of their power as would enable it to discharge its function effectively; 'water' being state subject, fully under the jurisdiction of the states. In brief, the objectives of DVC are, the promotion and operation of schemes for irrigation, water supply, drainage, generation, transmission and distribution of electrical energy (both hydro & thermal); flood control; navigation; aforestation and soil erosion etc. The DVC over the years have developed an integrated network of benefits, a brief picture of their achievement is given below:

DVC control area	24,235 sq. km.
Thermal Power Generation	4 stations (TPS) Capacity 1950 MW
Hydel Power Generation	3 stations Capacity 144 MW
Gas Turbine Station	1 station Capacity 82.5 MW

Major Dams & Barrage	4
Total flood Reserve	1,270 million cubic metres
Total Irrigation Potential Created	364,000 ha
Canals	2,495 km
Check Dams(soil conservation)	1,689 Nos.
Afforestation	121,500 ha

8. Policy

One of the highest flood event in the recent times in India was the flood of 1978 due to which the entire Northern India reeled under its impact for substantial period. The National Commission on Floods which submitted its report in 1980 after the event had had the benefit of the extensive experience of 1978 flood. The Commission put forth 207 recommendations in all as a comprehensive measure of flood management in India. Some of the most important recommendations by the Commission suggested:

- A comprehensive dynamic and flexible approach to the problem of floods as a part of comprehensive approach for the utilisation of land and water resources.
- Priority for measures to modify the susceptibility of life and property to flood damage.

Equally important were the recommendations by the National Commission for Integrated Water Resources Development and Management Plan (1999) regarding flood management.

- Since there are no solutions for protection against floods, the country has to shift its strategy towards efficient management of flood plains, flood proofing, flood forecasting and flood insurance.
- The network of flood forecasting and warning is to be extended to remaining flood prone areas.

The National Water Policy of India formulated in 1987 and then reviewed and revised in 2002 lays down the following policy with regard to water resources development planning and management:

- There should be an integrated and multi-disciplinary approach to the planning, formulation, clearance and implementation of projects, including catchment area treatment, environmental and ecological aspects, the rehabilitation of affected people and command area development.
- While physical flood protection works like embankment and dykes will continue to be necessary, increased emphasis should be laid on non-structural measures for minimization of losses and to reduce the recurring expenditure on flood relief.

9. Lessons Learnt

a) Had all the 8 DVC dams been constructed or were taken up as per design assumptions, the design flood would have been moderated to 250,000 cusec (7,079 cumec). While the 4 dams have served their purpose, the lower channel is not capable of carrying the moderated discharge. There are reaches below Amta, where the Damodar is not even capable of carrying a discharge of 50,000 cusec (1,415 cumec) thus underlining the need for an immediate solution of the problem of drainage congestion of lower reaches in order to derive the maximum benefits of flood moderation. This highlights the need for integrated flood management with coordinated development and management of water, land and related resources in the basin/sub-basin.

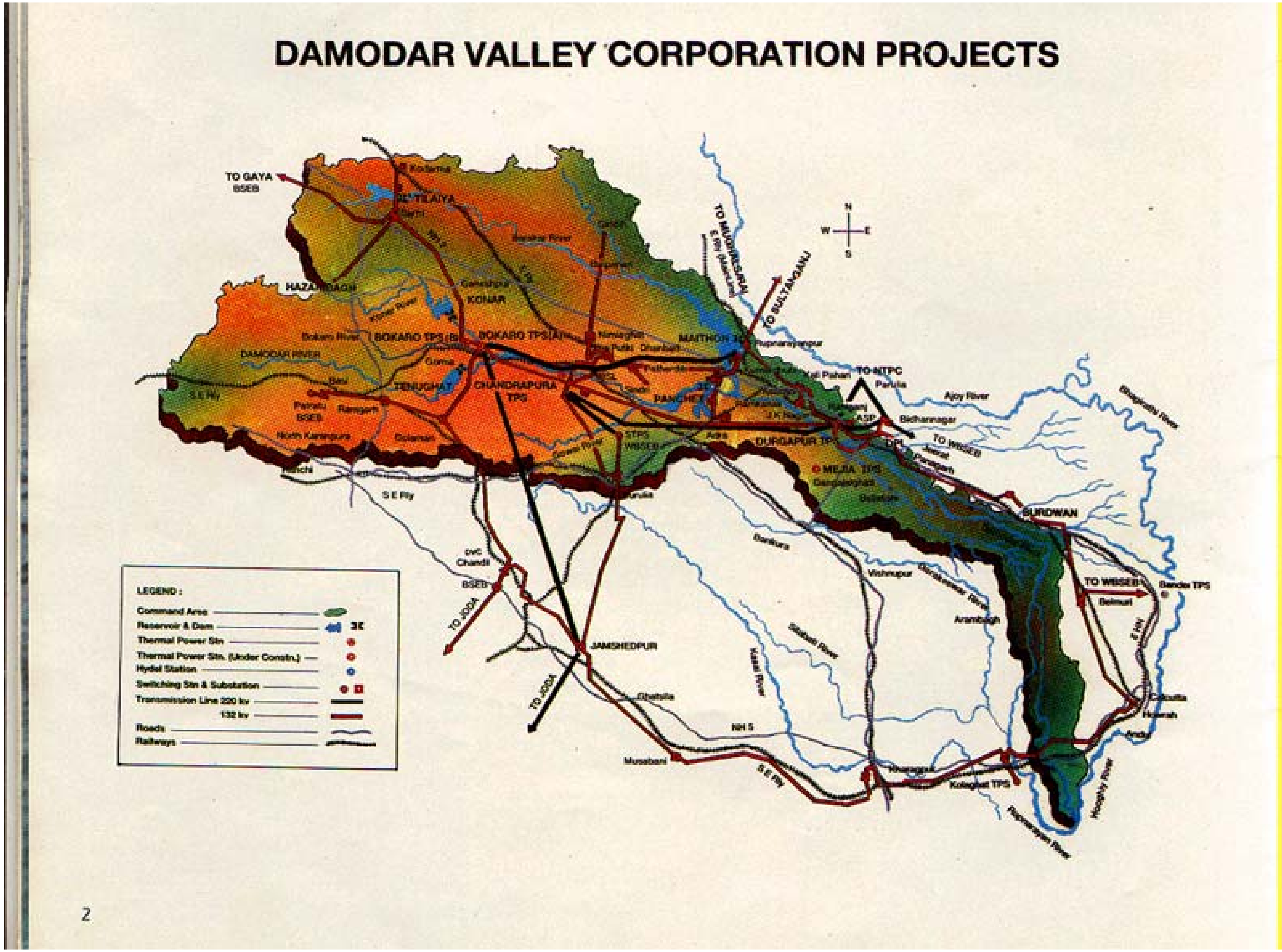
b) Following the example of DVC dams, more than 4,300 large dams were later planned and executed with or without flood cushion in the reservoirs. The entire available storage of Hirakud reservoir during monsoon season, though having no earmarked flood storage, is utilised for flood moderation and subsequently used for irrigation purposes effectively. Taking cue from the success of DVC dams, Ukai multi-purpose project constructed in Gujrat has provided considerable relief from floods by utilising the flood cushion. Rengali and Bhimkund dams in

Orissa, Baigul in Uttar Pradesh, Subernarekha in Jharkhand and Kangsabati dam in West Bengal are other dams in which flood moderation facility has been envisaged.

c) It is evident from the policy changes that the country had realised that structural measures alone should not be the strategy for tackling the problem of floods, rather it should be a mix of structural and non-structural measures, with the primacy of the latter, which should be the back bone of the programme for flood management.

d) The DVC is acting as a River Basin Organization and is successfully implementing the concept of integrated water resources management. It is managing to achieve the development of irrigation, power generation, flood control and water supply facilities while taking up environmental protection measures in an integrated manner. The DVC is self-sufficient and self-sustaining. Models like DVC should be replicated and appropriate River Basin Organizations should be established for the integrated planning, development and management of other river basins taking into account the needs of diverse uses of water with multi-disciplinary approach.

Annex:


DAMODAR VALLEY CORPORATION PROJECTS
TO GAYA
BSEB
HAZARIBAGH
KONAR
BOKARO TPS(B)
BOKARO TPS(A)
DAMODAR RIVER
TENUGHAT
CHANDRAPURA TPS
MAITHON
PANCHET
TO NTPC
DURGAPUR TPS
MEJIA TPS
BURDWAN
TO WBSEB
JAMSHEDPUR
TO JODA
TO SULTANGANJ
NH 5
S E Rly
Ajoy River
LEGEND :
Command Area
Reservoir & Dam
Thermal Power Stn
Thermal Power Stn. (Under Constn.)
Hydel Station
Switching Stn & Substation
Transmission Line 220 kv
132 kv
Roads
Railways
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2