

Chapter – 1 Introduction

1.1 General

This report contains results of the feasibility studies of proposed Damanganga-Pinjal Link project carried out by National Water Development Agency. Damanganga-Pinjal Link located in the western part of India envisages to transfer the balance available water at the proposed Bhugad reservoir across Damanganga river and at the proposed Khargihill reservoir across Vagh river, a tributary of Damanganga river, in Damanganga basin for augmentation of water supply to Greater Mumbai to meet its domestic and industrial water requirements in the near future.

The projected water demand for Greater Mumbai by 2021 AD, as per the Municipal Corporation of Greater Mumbai (MCGM), is 1789 Mm³ (4900 MLD) whereas the present water supply from different sources viz. Vaitarna, Tansa, Bhatsa, Vehar and Tulsi is 1075 Mm³ (2945 MLD) only. As such there will be a shortage of 714 Mm³ (1955 MLD) by 2021 AD.

The Bhugad and Khargihill reservoirs (proposed by NWDA) and Pinjal reservoir (proposed by Government of Maharashtra across Pinjal river, a tributary of Vaitarna river) are proposed to be connected through pressure tunnels. The purpose is to make the combined water from Bhugad and Khargihill reservoirs to reach Pinjal reservoir from where further arrangements for transmitting the water to Greater Mumbai will be made by Municipal Corporation of Greater Mumbai (MCGM) and Mumbai Metropolitan Region Development Authority (MMRDA) as per their plans.

1.1.1. Need for planning

The rainfall in the country is mostly confined to monsoon season and is unevenly distributed with respect to both space and time. As a result, some parts of the country are affected by frequent droughts, whereas other parts are affected by floods. Nearly one third of the country is drought prone. Water will become scarce resource in the near future, due to increasing thrust of population and increasing demands of water for various uses. Therefore, it needs no emphasis that water needs to be harnessed in a scientific and efficient manner for its optimum utilisation.

The monsoon flood waters need to be conserved and utilised during the period of its scarcity for drinking & industrial use, irrigation, power generation etc. The water availability and requirements in the various river basins should be assessed realistically and the requirements be met appropriately. The surplus water, if any, should be transferred to the needy areas. The National Water Policy evolved by Govt. of India in 1987 and revised in April 2002 lays emphasis on inter-basin transfer of water.

1.1.2 National Perspective for water resources development

The erstwhile Union Ministry of Irrigation and the Central Water Commission formulated a National Perspective Plan for water resources development in the year 1980, which comprises of two components viz. the Himalayan rivers development and the peninsular rivers development. The distinct feature of the National Perspective proposal is that the transfer of water from surplus basin to deficit basin would essentially be by gravity and only in small reaches it would be by lifts not exceeding 120 metres.

One of the purposes of Peninsular River Development component is to construct storages and to interlink the small rivers flowing along the west coast north of Mumbai and south of the Tapi for transfer of surplus waters to the needy areas of Saurashtra and Kutchh regions. Another scheme provides water supply to the metropolitan areas of Greater Mumbai and also provides irrigation to coastal areas of Maharashtra. Damanganga – Pinjal Link is part of this Peninsular component.

1.2 Present report

1.2.1 Aims of the project

The proposal of Damanganga-Pinjal link envisages diversion of surplus waters of Damanganga and Vaitarna basins to Greater Mumbai city for augmentation of its future domestic and industrial water requirements. The total quantity of water for diversion to Greater Mumbai city through this link has been assessed through water balance studies and simulation studies. The combined surplus waters of Damanganga and Pinjal basins are proposed to be carried to Greater Mumbai from Pinjal reservoir as per the plans of Municipal Corporation of Greater Mumbai (MCGM) and Mumbai Metropolitan Regional Development Authority (MMRDA) for domestic and industrial water needs of Mumbai city. However quantum of water to be transferred for Pinjal reservoir would depend upon Govt. of Maharashtra.

1.2.2 Back ground of the project

Initially toposheet study and pre-feasibility studies for the Damanganga-Tansa link project were done. In these reports, it was envisaged that water would be released from Bhugad and Khargihill reservoirs in the river itself and will be picked up at the existing Madhuban reservoir across river Damanganga for carrying the same through an open link canal upto Tansa river from where the water with proposed to will be pumped to Mumbai city. Commenting on the proposal, the Govt.of Gujarat suggested that the use of Madhuban reservoir as a pickup point may be avoided as it would have certain operational problems. This proposal will also require pumping of water from Tansa River to Mumbai.

On the basis of toposheet studies in NWDA and subsequent discussions with the Municipal Corporation of Greater Mumbai (MCGM) and Mumbai Metropolitan Region Development Authority (MMRDA), it has been found possible to connect Bhugad and Khargihill reservoirs and again Khargihill and Pinjal reservoirs by pressure tunnels. The purpose is to make the combined waters of Bhugad and Khargihill reservoirs to reach Pinjal reservoir from where further arrangements for transmitting the combined waters of these reservoirs to Greater Mumbai will be made by MCGM and MMRDA as per their plans. This arrangement will also minimise environmental problems as the topography suits an underground tunnel between Bhugad and Khargihill reservoirs and between Khargihill and Pinjal reservoirs due to forest cover.

1.3 Description of Damanganga-Pinjal link project

The salient details of Damanganga-Pinjal link project are briefly described below:

- (i) A 826.60 m long composite dam is proposed on Damanganga river near village Bhugad in Peint taluka of Nasik district of Maharashtra State and very near to border of Valsad district of Gujarat. The FRL, of the dam fixed on the basis of detailed Surveys & Investigations is 163.87 m. The gross and live storage capacities of the storages are 426.39 Mm³ and 400.00 M m³ respectively. The

maximum height of dam is 68.63 metres. The Government of Gujarat, Union Territories of Dadra & Nagar Haveli and Daman had constructed Madhuban dam about 40 km downstream of Bhugad dam site. The total catchment area of Damanganga basin upto Bhugad dam site is 729 sqkm, out of which 141 sqkm falls in Gujarat State and 588 sqkm falls in Maharashtra State. 287 Mm³ of water at 100% dependability is proposed to be diverted from Bhugad reservoir to Khargihill reservoir through Bhugad-Khargihill link tunnel during non-monsoon period at the rate of 1181 MLD.

- (ii) A 16.85 km long Bhugad-Khargihill link tunnel with 5.0 m diameter connecting Bhugad and Khargihill reservoirs below their minimum draw down levels (MDDLs) is proposed.
- (iii) A 572.80 m long composite dam across river Vagh at Khargihill site near village Behadpada in Mokhada Taluka of Thane district of Maharashtra State is proposed. The FRL, of the dam fixed on the basis of detailed Surveys & Investigations is 154.52 m. The gross and live storage capacities have been fixed as 460.79 Mm³ & 420.50 Mm³ respectively. The maximum height of dam shall be 75.62m. The total catchment area upto this dam site is 710 sqkm which entirely lies in Maharashtra State. The divertable water yield at Khargihill dam which is proposed to be diverted at 100% dependability is 290 Mm³ during non-monsoon period at the rate of 1193 MLD. Thus, a combined release of 577 Mm³ (287 + 290 Mm³) of water i.e. 2374 MLD will be diverted through Khargihill-Pinjal link tunnel.
- (iv) A 25.70 km long Khargihill-Pinjal link tunnel with 5.25 m diameter connecting Khargihill and Pinjal reservoirs below their MDDLs.
- (v) A 681 m long Pinjal dam on river Pinjal (tributary of Vaitarna river) near village Khidse in Jawhar taluka of Thane district has been proposed by Govt.of Maharashtra. The FRL, have been fixed on the basis of detailed Surveys & Investigations by Government of Maharashtra as 141.00 m. The gross and live storage capacities have been fixed as 413.57 Mm³ and 401.55 Mm³ respectively. The total catchment area of Pinjal sub-basin upto this dam site is 317.00 sqkm which entirely lies in Maharashtra State. The divertable water yield to Mumbai city at Pinjal dam site at 75% dependability (as fixed by Government of Maharashtra) is 332 Mm³. Thus, a combined release of 43.84 cumecs of water i.e. 3741 Million litre per day will be diverted through Pinjal reservoir as per plan of Govt. of Maharashtra.

1.4 Location of project area and approach to various sites

The Damanganga-Pinjal link project lies in Valsad district of Gujarat State and Nasik & Thane districts of Maharashtra State. Whereas Bhugad-Khargihill and Khargihill-Pinjal tunnels are entirely located in Maharashtra State.

The Bhugad dam site across Damanganga River (Damanganga river forms boundary between Gujarat and Maharashtra near Bhugad dam site) can be approached from Valsad town of Gujarat State through Valsad-Dharampur-Nasik State Highway upto Statebari village at 70 km and thereafter through 25 km fair weather road upto Modushi village on right bank of Damanganga river. The Bhugad dam site lies 1 km upstream of Modushi village towards the left bank of the river. The Bhugad dam site on left bank can be approached from Nasik side by Nasik-Harsul-Baphanvahir-Ranapada road (80 km) and then through a foot track of 1.2 km upto the dam site.

The Khargihill dam site is located 1.2 km upstream of the crossing of the Vagh river by Behadpada-Ojarkheda road. The left bank site of dam can be approached from Valsad side through Valsad-Vapi (National Highway No. 8, 25 km), Vapi-Silvassa-Chalatvad-

Behadpada State Highway (83 km) and also from Nasik town through the same State Highway i.e. Nasik-Harsul-Ojarkheda-Behadpada (85km).

The Pinjal dam site is located near the Khidse village in Jawhar taluka of Thane district and can be approached from Valsad side through Valsad-Vapi-Silvassa-Chalatvad-Jawhar-Ene road (125 km) and then a foot track of 4 km along Pinjal river or by Valsad-Vapi-Dahanu-Parsipada-Vikramgad road (180 km) and then by foot track of 1 km length.

The reservoirs to be impounded by these dams are located in deep gorges of the rivers and are in quite inaccessible terrain. The location of proposed Bhugad, Khargihill & Pinjal dam sites and Bhugad-Khargihill & Khargihill-Pinjal link tunnels are shown in the index map.

1.5 Climate

The Damanganga-Pinjal link project falls in the Damanganga and Vaitarna basins. These basins lie in the western ghat region and are bounded on the west by the Arabian sea and on the east by Sahyadri hill ranges. Thus, the climate of this region is moderate and humid. The mean monthly maximum and minimum temperatures are 42.4° C and 10.3°C respectively. These basins receive most of the rainfall from the south-west monsoon during June to September.

The rainfall in the project area varies from a minimum of 1734 mm in Peint taluka of Nasik district to a maximum of 3052 mm in hilly regions of Jawhar taluka of Thane district.

1.6 General description of area

Out of the total geographical area of 5.91 lakh hectares of the Damanganga and Vaitarna basins where the project is located, the forest area, culturable area and the gross sown area are 2.20, 2.81 and 2.56 lakh hectares respectively. Further as per 1991 census, the density of population in the Damanganga and Vaitarna basins is 127 and 542 persons per sq km respectively against the 257 persons per sq km density of population of the country as a whole. The topography of the project area is steep along hills of the Western Ghats and the ground levels reduce as we go westwards towards Arabian Sea.

1.7 Physiography

The project area consists of the main Sahayadri hills on the east, the westernly off-shoots on the north and south, north-south hill ranges on the west, and narrow openings at the end leading to the sea. Physiographically, the entire area can be described as rugged and hilly. Major part of the catchment is covered by basaltic flows commonly referred as deccan traps. The deccan traps in the region are of two prominent types, first the dark grey to bluish black, hard compact and massive type and the second light brown to pink soft type.

The lower reaches of the area are mainly alluvial plains. These flows are interrupted by a large number of dykes of varying thickness. Ground water in the area is restricted to the weathered residual fractured zone having secondary porosity.

1.8 Soils

The soils in the Damanganga basin and Vaitarna basin can be broadly classified into four groups viz. reddish brown soils, coarse shallow soils, deep black soils and coastal alluvial soils and two groups viz. red coarse soils and alluvial soils respectively. However, the predominant soils in Damanganga basin and Vaitarna basin are coarse shallow & deep black soils and alluvial soil respectively.

1.9 Population (a) Affected

Total 24 Villages having a population of 4530 will be affected due to the submergence of the reservoirs out of which 3046 people will be under Bhugad reservoir submergence and remaining 1484 shall be affected by Khargihill reservoir. Details are given under para 7.9 (a) of Chapter-7.

(b) Occupation

(i) Bhugad Reservoir – Majority of the main workers under submergence are cultivators (78.8%). While agricultural labourers are 19.14%. Contribution of other services is little (1.14%). This correlates with the rural nature of the area and the economic is based on the agriculture.

(ii) Khargihill Reservoir - Majority of the main workers under submergence are cultivators (84.7%). While agricultural labourers are 12.74%. Contribution of other services is little (0.93%). This correlates with the rural nature of the area and the economy is based on the agriculture.

1.10 Land use

The land use particulars in Damanganga basin and Vaitarna basin as per the latest circulated preliminary water balance study reports are furnished below.

S.No.	Category	Damanganga basin (Area in ha)	Vaitarna basin (Area in ha)
1	Forest	96,222	1,39,601
2	Barren and unculturable land	7,550	20,370
3	Land put to non-agricultural use	8,620	4,952
4	Permanent pastures and other grazing land	3,130	17,459
5	Land under miscellaneous crops and trees	1,468	8,799
6	Culturable waste	6,473	19,847
7	Other fallows	5,920	17,378
8	Current fallows	5,854	22,974
9	Net area sown	90,907	1,13,320
10	Culturable area (5+6+7+8+9)	1,10,623	1,82,318
11	Area sown more than once	5,734	2,701
12	Gross area sown	96,641	1,16,021
13	Geographical area	2,26,144	3,64,700

1.10.1 Forests

Valsad district of Gujarat and Nasik & Thane districts of Maharashtra in which all the three reservoirs of the link project are located have good forests. The basinwise/statewise submergence of forest in the Damanganga and Vaitarna basins through proposed reservoirs in Damanganga-Pinjal link project are given in Table 1.1.

Table 1.1
Forest submergence in reservoirs

Sr. No	Basin	Basin area (ha)	Forest area in the basin (ha)	Percentage of forest area to total area (%)	Forest area submerged by proposed reservoirs (ha)	Percentage of forest area submerged with respect to forest area of the basin
1	Damanganga basin as a whole	2,26,144	96,222	42.55	3,379	3.51
(a)	Within Gujarat State	43,053	21,472	49.87	820	3.81
(b)	Within Maharashtra State	1,43,835	58,439	40.63	2559	4.38
(c)	Within U.T. of Dadra & Nagar Haveli and Daman	39,256	16,311	41.55	-	-
2	Vaitarna basin Maharashtra	3,64,700	1,39,601	38.28	-	-
		3,64,700	1,39,601	38.28	-	-

1.10.2 Agriculture and socio-economic aspect

The total population of the Damanganga and Vaitarna basins as per 1991 census were 4.96 lakhs and 6.03 lakhs respectively. Agriculture is the main occupation in the basins. Paddy is the predominant crop in the basins. No mineral of any economic significance is found in the basins.

1.11 Water Resources

1.11.1 Surface Water

National Water Development Agency (NWDA) has carried out water balance studies for Damanganga basin as a whole and also upto the proposed Bhugad and Khargihill dam sites and Vaitarna basin. As per these studies, surface water balance at the Bhugad & Khargihill diversion points assessed by NWDA after considering the future in-basin upstream and downstream water requirements upto 2050 AD has been furnished in Table 1.2.

Table 1.2
Surface Water Balance in Damanganga Basin and at the Bhugad and Khargihill Dam sites

Sr. No	Description	Damanganga Basin (Mm ³)	Bhugad dam site (Mm ³)	Khargihill dam site (Mm ³)
1)	a) Gross annual yield			
	At 100% dependability	1104	298	427
	At 95% dependability	1616	471	622

	At 75% dependability	2346	652	870
	At 50% dependability	3134	883	1121
	b) Export	357	-	-
	c) Gross availability			
	At 100% dependability	747	298	427
	At 95% dependability	1259	471	622
	At 75% dependability	1989	652	870
	At 50% dependability	2777	883	1121
2)	Requirement (-ve)			
	Irrigation	354	114	102
	Domestic use	49	11	16
	Industrial use	119	16	21
	Hyropower use	119	34	85
	Enviromental & ecological	23	7	6
	Salinity control	234	-	-
	Sub total	898	182	230
3)	Regeneration from (+ve)			
	Domestic use	39	9	13
	Industrial use	95	13	17
	Irrigation	31	9	9
	Sub total	165	31	39
4)	Surface water balance			
	At 100% dependability	14	147	236
	At 95% dependability	526	320	431
	At 75% dependability	1256	501	679
	At 50% dependability	2044	732	930

Thus, combined balance water available from Bhugad and Khargihill diversion points at 100%, 95%, 75% and 50% dependability works out to be 383 Mm³, 751 Mm³, 1180 Mm³, & 1662 Mm³ respectively. For deciding the capacity of the reservoirs and the corresponding yield of water from reservoir at the specific reliability, simulation studies were carried out to derive yield-capacity relationship of each of the reservoirs and it has been found feasible to divert 287 Mm³ of water from Bhugad reservoir and 290 Mm³ from Khargihill reservoir after considering storage effect of reservoirs in position at 100% dependability.

1.12 Past studies

The National Water Development Agency has prepared pre-feasibility report of Damanganga-Tansa link project and circulated the same during September 1992. The report was discussed and accepted by TAC of NWDA in its 19th meeting held on 26.10.1993. The objective of the link project was to divert the balance water available in the reservoirs of the proposed Bhugad dam and Khargihill dam in Damanganga basin through the existing Madhuban reservoir for water supplies to Greater Mumbai to meet its growing domestic and industrial requirement. In the pre-feasibility report it was envisaged that water would be released from Bhugad and Khargihill reservoirs in the river channel and picked up at the existing Madhuban reservoir for carrying the same through an open channel upto Tansa river from where the water will be pumped to Mumbai city. The salient details of this proposal were:

- (i) A storage reservoir at Bhugad on the Damanganga river with FRL 157.00 m, gross storage 307.69 Mm³ and live storage of 280.96 Mm³.
- (ii) A storage reservoir at Khargihill on the Vagh river, a tributary of Damanganga, with FRL 147.5 m, gross storage capacity of 437.44 Mm³ and live storage of 412.0 Mm³.
- (iii) Existing storage reservoir at Madhuban having FRL at 79.86m, gross storage capacity of 567 Mm³, live storage capacity of 502 Mm³ on river Damanganga, located downstream of the proposed Bhugad and Khargihill reservoirs are proposed to be utilised as a diversion structure. The MDDL of the reservoir is 61.57m. The proposed link canal takes off with FSL 61.57 m from the left bank saddle dam of the Madhuban reservoir.
- (iv) A storage reservoir on Vandri River (tributary of Vaitarna river) has been constructed by Govt. of Maharashtra. The Vandri reservoir has FRL of 43.6 m with gross and live storage capacities of 36.5 Mm³ and of 34.7 Mm³ respectively. The proposed link will utilise this reservoir enroute to cross the Vandri valley.
- (v) A terminal barrage across the Tansa river near village Bhatne with FRL 5 m above MSL for further transfer of water to the Mumbai city.
- (vi) Four small barrages on upstream of terminal barrage with FRLs 11.0m, 16.0m, 21.0 and 25.0 are also proposed. The total water to be stored in all these five small barrages (including terminal barrage) is 15 Mm³ for use at the end of the monsoon before appropriate supply from the Damanganga-Tansa link becomes available.
- (vii) A 129 km long canal off takes from the left bank saddle dam of the Madhuban reservoir with FSL 61.57 m to transfer surplus waters of Damanganga basin to Tansa river.
- (viii) One power house at the end of the link with an installed capacity of 4.5 MW.

Commenting on the proposal, the Govt. of Gujarat suggested that the use of Madhuban reservoir as a pickup point may be avoided as it would have certain operational problems. This proposal will also require pumping of water from Tansa river to Mumbai.

On the basis of toposheet studies by NWDA and subsequent discussions with the Municipal Corporation of Greater Mumbai (MCGM) and Mumbai Metropolitan Region Development Authority (MMRDA), it has been found that it is possible to connect Bhugad and Khargihill reservoirs and again Khargihill and Pinjal reservoirs by pressure tunnels. The purpose is to make the combined water from Bhugad and Khargihill reservoirs to reach to the Pinjal reservoir, which has been planned as an irrigation project by Irrigation Department, Govt. of Maharashtra and is now to be meant for augmentation of water to Greater Mumbai. From Pinjal reservoir, further arrangements for transmission of water to Greater Mumbai shall be made according to the plans of MCGM and MMRDA.

1.13 Stage of development of project

It is proposed that the Damanganga-Pinjal link project will be completed in a period of 9 years. It is expected that pre-constriction survey, investigation, topographical survey of Bhugad – Khargihill and Khargihill-Pinjal tunnels, Bhugad and Khargihill dams would be completed in the 1st and the 2nd year. Simultaneously procurement of T&P and the land acquisition for Bhugad-Khargihill and Khargihill-Pinjal tunnels and construction of temporary buildings will be completed in 1st and 2nd year. The excavation for various purposes approach road and colonies will be taken up in 3rd year and completed in 7th year. Excavation work of spillway for dams will be completed in 4th and 5th year.

The lining of tunnels and construction of Bhugad and Khargihill dams will be started from the 4th year and completed in the 8th and 7th year respectively. Erection of gates on Bhugad and Khargihill dam will be started in the 7th year and will be completed in 9th year. The finishing works of Bhugad-Khargihill and Khargihill-Pinjal tunnels will be started in the 8th year and will be completed by 9th year. Finishing works, erection of spillway gates and adjustment of men, machineries and equipments will be completed in all respect of by the end of the 9th year.

1.14 Cost and benefits of the scheme

The total estimated cost of the whole project is Rs.1277.77 crores, based on March, 2003 prices as given below:

Component	Direct charges Rs in crores	Indirect charges Rs in crores	Total Rs in crores
Unit-I Head works	866.01	9.39	875.40
Unit-II Tunnels	398.77	3.60	402.37
Total	1264.78	12.99	1277.77

The annual cost of the project has been worked out as under:

- i) Rate of interest on capital cost has been taken as 10% of the total cost.
- ii) Depreciation has been worked out @ 1% of the total capital cost.
- iii) Maintenance of head works has been taken as 1% of the cost of headworks.

As the cost of the Pinjal Reservoir Project and the conveyance system for supplying the water from Pinjal reservoir to Greater Mumbai is not available, hence for computation of B-C ratio, the total cost of transferring this water to Greater Mumbai is assumed based on the cost of similar project of the area. In order to ascertain the economic viability of this project, computation of B.C. ratio has been attempted which is worked out to be 1.38. The cost of dropping the combined water of Bhugad and Khargihill reservoir into Pinjal reservoir has also been computed.

The estimated cost of the link project i.e. the cost of the Bhugad & Khargihill dams and the Bhugad-Khargihill & Khargihill1-Pinjal tunnels is Rs.1278 crores. The total transfer of water from Bhugad and Khargihill reservoirs will be 577 Mm³ (287 Mm³ + 290 Mm³) at 100 % dependability.

The cost of dropping the Bhugad and Khargihill waters into Pinjal reservoir works out to Rs.2.21 crores per Mm³ or Rs.22.15 per cubic meter of water.