

Sustainable development of irrigation in Kukadi integrated project by transfer of surplus water from one reservoir to other

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Abstract

An integrated Kukadi irrigation project in western ghat of Maharashtra state in India comprises of five dams built on the Kukadi River and its tributaries receiving seasonal rains. The water from four reservoirs namely Dimbhe, Manikdoh, Wadaj and Pimpalgaon Joge is fed to Yedgaon reservoir through canal and river. The command area of the Kukadi integrated system downstream of Yedgaon dam extends over three districts. The total irrigable command area under the entire Kukadi project is 156278 Ha.

The irrigation requirement of the command area is increasing with completion of the canal system over a period of time. Thus storage in all five reservoirs is to be optimized to its full capacities by the end of monsoon following the approved reservoir operation schedule, to meet irrigation and drinking water requirements of the project for complete water year.

In the Kukadi integrated project the works of five dams namely Yedgaon (1976), Wadaj (1975), Manikdoh (1986) Pimpalgaon Joge (1999) and Dimbhe (2001) are completed. The Reservoir has received a yield of more than 75% dependable yield only twice during the last 25 years since its completion.

An integrated project comprising of five reservoirs is being severely affected due to less rains than estimated in the Manikdoh catchment area. Due to this fact the storage capacity of Manikdoh reservoir is underutilized and adversely affected the performance of the integrated Kukadi project, ultimately resulting in a great stress on the minds of management engineers to fulfill the targets with limited water resources. In contrast, the Dimbhe catchment is drawing increased yield than estimated and excess water spills over. The topographical suitability for linking two reservoirs is met with as Dimbhe reservoir is situated at higher elevation than Manikdoh reservoir.

Keywords: integrated project, optimum water diversion, tunnel.



1 Introduction

Kukadi integrated irrigation project comprises of five dams built on the Kukadi River and its tributaries. Four dams except Yedgaon have to feed their own command area in addition to cater the requirements Kukadi canal of 249 Km. length to irrigate lands of three districts. The integrated project aims for irrigation of 156278 Ha. of land that belongs to seven talukas of three districts namely Pune, Solapur and Ahmandanagar. As per second revised project report of the Kukadi project [1] the storage and water utilizations are as below.

Table 1: Details of the Kukadi integrated project.

Dam	Storage capacity TMC/ mm ³	Dead storage TMC/ mm ³	Live storage TMC/ mm ³	Water requirement for own command TMC/mm ³	Releases to Yedgaon TMC/ mm ³	Losses TMC/ mm ³	Carry over TMC/ mm ³
2	3	4	5	6	7	8	9
Dimbhe	<u>13.50</u> 382.29	<u>1.00</u> 28.31	<u>12.50</u> 353.96	<u>7.01</u> 198.50	<u>6.217</u> 176.05	<u>1.439</u> 40.75	<u>0.761</u> 21.55
Wadaj	<u>1.27</u> 35.96	<u>0.100</u> 2.83	<u>1.17</u> 33.13	<u>2.194</u> 65.13	<u>0.556</u> 15.74	<u>0.362</u> 10.25	<u>0.330</u> 9.34
Manik doh	<u>10.88</u> 308.09	<u>0.700</u> 19.82	<u>10.18</u> 288.27	<u>0.512</u> 14.50	<u>8.556</u> 242.28	<u>1.42</u> 40.21	<u>3.263</u> 92.40
Pimpal gaon Joge	<u>7.695</u> 217.90	<u>4.421</u> 125.10	<u>3.89</u> 110.15	<u>2.995</u> 84.81	<u>0.11</u> 3.11	<u>1.834</u> 51.93	<u>0.200</u> 5.66
Yedgaon	<u>3.30</u> 93.44	<u>0.50</u> 14.15	<u>2.80</u> 79.29	<u>20.379</u> 577.09	—	<u>0.822</u> 23.27	—

With completion of dams, storage as planned is created. Also execution of canal system is nearing completion. The integrated project is planned to utilize 38.20 TMC of water in one year. Dimbhe reservoir is having maximum storage capacity of 13.5 TMC followed by Manikdoh reservoir of 10.88 TMC. The other dams namely Pimpalgaon Joge Dam and Wadaj are having comparatively smaller capacities. Dimbhe and Wadaj reservoirs are planned to feed Yedgaon reservoir through canal while Manikdoh and Pimpalgaon are planned to feed Yedgaon reservoir through river. Kukadi left bank canal of 249 km. length of takes from Yedgaon dam.

2 Study area

The study area consists of Western Ghat of Maharashtra of Sahyadri hill range where five dams of the Kukadi integrated system are situated. Study area also extends up to command area in three districts of Pune, Solapur and Ahamednagar. Figure 1 is a view of the Kukadi complex taken from Google map.





Figure 1: Google map of the Kukadi complex.

3 Data used

- Yield data collected at Dimbhe and Manikdoh Reservoir
- Reservoir operation schedule of Dimbhe

4 Yield study at Manikdoh reservoir

The yield series of Manikdoh reservoir during last 25 years after completion of dam reveals that 75% dependable yield is 5.564 TMC as against planned utilization of 10.986 TMC. The maximum yield received is 11.864 TMC (year 2006) and minimum yield received is 3.82 TMC (year 2009). The 75% dependable yield calculated earlier in year 1990 using 34 years records by Central Design Organization, Nasik is 5.1 TMC [2] Thus the study of yield pattern of about 50 years, i.e. 25 years prior to construction and 25 years after



Figure 2: View of Manikdoh dam.

construction of dam indicates that 75% dependable yield ranges from 5.100 TMC to 5.564 TMC; this yield is less than planned utilization of 10.986 TMC. Thus the planning of the whole Kukadi project is adversely affected. This fact has led the engineers to focus on the subject of augmentation of Manikdoh reservoir for sustainable development of irrigation of the Kukadi project

5 Yield study at Dimbhe reservoir

The yield series of Dimbhe reservoir for last 34 years reveals that the 75% dependable is 15.153 TMC. The maximum yield received is 42.37 TMC (year 1994) and minimum yield received is 7.71 TMC (year 2000). The 75% dependable yield calculated in year 1990 using 34 years records by Central Design Organization, Nasik is 17.565 TMC [2]. Thus over last 50 years the yield pattern indicates that the 75% dependable yield ranges from 17.565 TMC to 15.153 TMC. Also from yield series, it is observed that out of 34 years, during 17 years the inflow at Dimbhe is more than 20 TMC. The yield available at Dimbhe with 50% dependability is 21.30 TMC. These factors are favoring the subject of augmentation of Manikdoh reservoir by linking Dimbhe reservoir for sustainable development of irrigation in the Kukadi project.

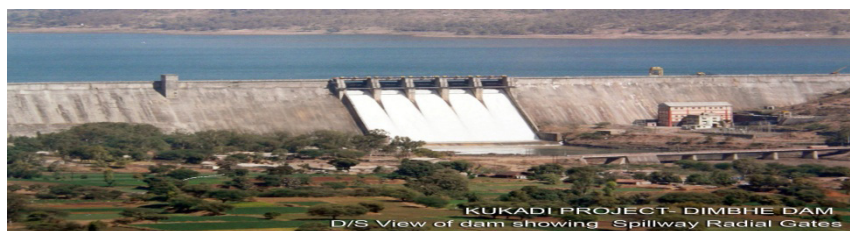


Figure 3: View of Manikdoh dam.

6 Suitability of linking of two reservoirs

Both Dimbhe and Manikdoh dams are situated in western ghat separated by arial distance of about 17.0 km. The length link tunnel is 11.4 km. FRL of Dimbhe reservoir is 719.145m whereas FRL of Manikdoh reservoir is 711.250m. Thus the topography suits linking of two reservoirs.

6.1 Topography

The tract in between two reservoirs is hilly and undulating. The two reservoirs are separated by steep hilly terrain. Soil cover is thin at places with traces of exposed rock on almost vertical steps in hilly regions.

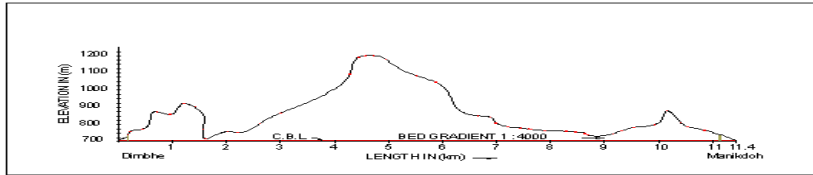


Figure 4: Topography between Dimbhe and Manikdoh.

6.2 Geology

The subsoil exploration done with 18 bore holes result show that Deccan trap lava flows comprising compact basalt, amygdaloidal basalt, volcanic brachia and tachylyte. The flows of amygdaloidal basalt free of joints form a good media for tunneling.

7 Study on optimum diversion of water

So for sustainable development of Kukadi integrated project by transfer of surplus water from Dimbhe reservoir is studied based on actual day inflow and daily water utilization for post construction period i.e. from year 2002 to 2011 to estimate quantity and number of days available for diversion. Topographical suitability followed by geological conformity in conjunction with hydrological feasibility makes a favorable situation to think about linking the two reservoirs. The starting and end level of link tunnel, quantity of excess water available for diversion and period available for diversion are the prime objectives of this study.

The Dimbhe reservoir is situated at marginally higher level than Manikdoh reservoir. Thus decision of starting and exit levels play an important role. Since difference in level is marginal exit level has to be decided even with encroachment in FRL of Manikdoh reservoir to maintain sufficient slope to minimize the cross sectional area of tunnel.

The excess over planned utilization at Dimbhe reservoir (75% dependable yield minus planned utilization of Dimbhe) is $17.56 - 14.66 = 2.9$ TMC which implies only 2.9 TMC of water is available for diversion. Also Manikdoh reservoir has deficiency of planned utilization (75% dependable yield minus planned utilization of Manikdoh) is $10.986 - 5.101 = 5.885$ TMC, say 5.90 TMC.

This study with varied starting level and exit level of link tunnel to calculate period and quantity of water available for diversion is helpful to maximize benefit of diversion of water from 2.9 TMC to 5.9 TMC through the link tunnel connecting the two reservoirs.

7.1 Facts considered in study on optimum diversion of water

a) Dimbhe dam was completed in year 2001. So study is made for the period 2002 to 2011.

- b) Daily data of actual water use from Dimbhe reservoir and releases to Yedgaon reservoir during monsoon period.
- c) The balance storage available in Dimbhe reservoir at start of 1st June is considered as nil though some storage is available above MDDL at the start of the monsoon period.
- d) The levels in Dimbhe reservoir are maintained as per approved reservoir operation schedule as per table 2.
- e) The starting level of the link tunnel is to be decided without adversely affecting the irrigation requirement of Dimbhe command.

Table 2: The reservoir operation levels.

Date	Level (m)	Content (mm ³)
01 June	711.145	229.38
03 August to 15th August	713.145	258.14
16 August to 28th August	715.145	288.06
29 August to 5th September	717.145	320.15
06 September to 15th October	719.145	354.79

7.2 Section of tunnel

Study on optimum diversion is made considering the D shaped tunnel designed as per (IS 4880 Part-1 and Part-II-1976) [3] with lined bed width of 7.00 m and full supply depth of 5.5 m. The tunnel is unlined at sides with bed lined having slope 1:4000. The discharge at FSD is 32.21 m³/sec. and C/S area at FSD is 37.69 sqm velocity of water in tunnel is 0.85 m/s with value of “N” is 0.03 for composite surface [4].

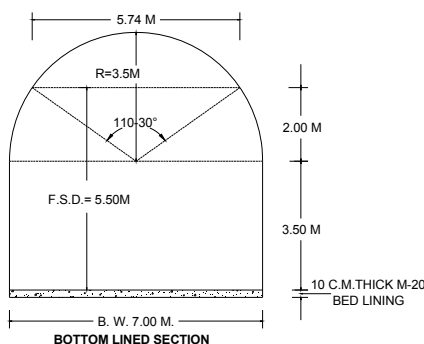


Figure 5: Cross section of link tunnel.

7.3 Abstract of study on optimum diversion

Starting level and exit level of link tunnel are varied and their effects on number of days available for diversion through tunnel, possible spills from spillway,

possible optimum diversion are studied. The overall abstract of this study for period 2002 to 2011 is tabulated in Table 3 and schematic layout of alternatives is shown in figure 6.

Table 3: Abstract of optimum diversion (Average of 7 years).

Sr. No.	Start level (m)	Exit Level (m)	Average No. of days available for diversion	Quantity of water available for diversion without consideration of ROS	Quantity of water available for diversion considering day excess (TMC)	Quantity of water available for diversion with consideration of ROS
1	2	3	4	5	6	7
1	714.10	711.25	42	3.54	0.44	3.11
2	713.10	710.25	49	4.69	0.55	3.79
3	712.10	709.25	66	5.71	1.69	4.24
4	711.10	708.25	73	6.62	0.87	4.72

(Note – The inflow during year 2010, 2009 and 2003 are less than planned utilization of 14.67 TMC hence no water is available for diversion.)

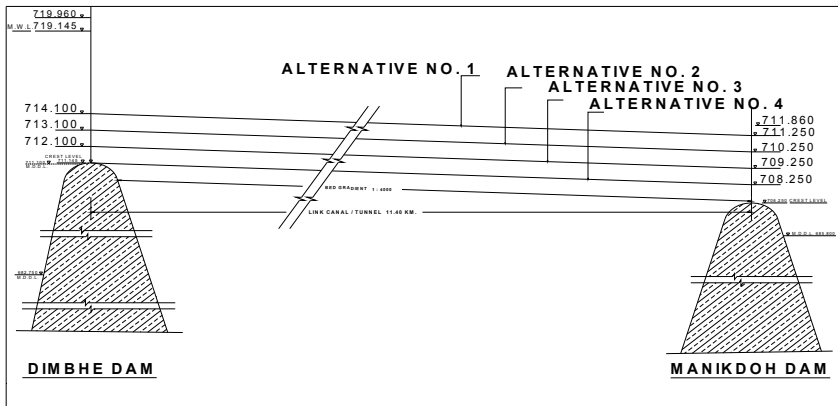


Figure 6: Schematic layout of link tunnel.

7.4 Findings of study on optimum diversion

• Alternative No. 1

With exit level of tunnel as FRL of Manikdoh will not have any submerged flow conditions in tunnel, flow period available is about 42 days with maximum quantity of diversion is 3.54 TMC. This quantity is less than shortfall of 5.90 TMC at Manikdoh reservoir.

- **Alternative No. 2**

At exit level at 1m. below FRL of Manikdoh, the capacity of reservoir available is 94% ($10.88 - 10.22 = 0.66$ TMC short of full storage). The average flow period available is 49 days with maximum capacity of diversion is 4.69 TMC. This quantity is less than shortfall of 5.90 TMC at Manikdoh reservoir.

- **Alternative No. 3**

With exit level at 2m. below FRL of Manikdoh, the capacity of reservoir available is 88.5% ($10.88 - 9.623 = 1.263$ TMC short) The average flow period available is 66 days with maximum capacity of diversion is 5.71 TMC that is marginally less than shortfall of 5.90 TMC.

- **Alternate No. 4**

As per this alternative the quantity of water that can be diverted maximum. However starting level of tunnel is below the level required for self command of Dimbhe dam. Also the exit level is at 83 % of Manikdoh dam capacity, this alternative is not suitable.

7.5 Results of study as per alternative No. 3

As level difference in FRL of two reservoirs is marginal, selection of starting level and exit level of link tunnel plays an important role in deciding quantity of water that can be diverted. Possible diversion of water in to Manikdoh reservoir and percentage of inflow accommodated in storage at Dimbhe reservoir is tabulated in table 4. During very good monsoon year quantity of water available for diversion is 100 % of requirement, however during other good monsoon years it is 60 % to 65 % of requirement.

Table 4: Results of study on optimum diversion of water.

Year	Total inflow (TMC)	Possible Diversion of water (TMC)	Inflow accommodated in Live Storage at Dimbhe (TMC)	% inflow accommodated in Live Storage at Dimbhe (TMC)
2011	20.16	3.65	12.49	100
2010	12.32	0.00	11.49	92
2009	10.53	0.00	10.23	82
2008	17.74	3.00	12.25	98
2007	18.33	3.86	11.38	91
2006	35.35	6.83	12.47	100
2005	32.74	6.12	12.35	99
2004	18.16	3.71	10.30	82
2003	14.45	0.00	10.83	86
2002	16.50	2.52	10.42	83



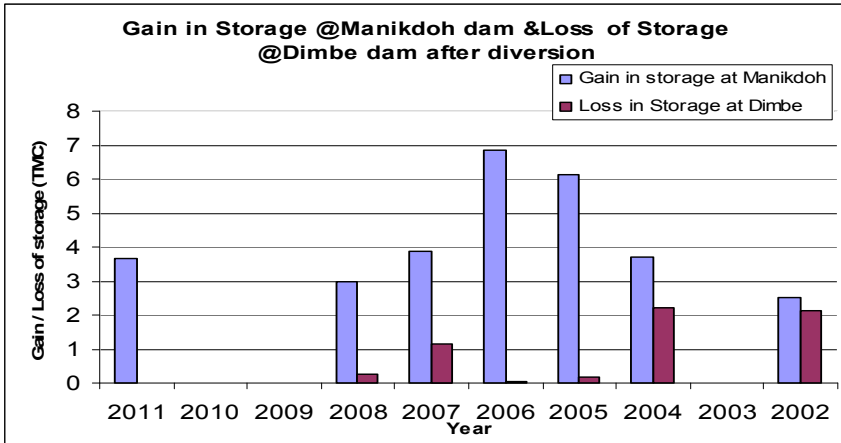


Figure 7: Gain/loss of storage.

8 Conclusion

There is every possibility of diversion of 2.9 TMC with 75% dependability and 6.3 TMC with 50% dependability. The starting level at 712.00m (Gross capacity 10.00 TMC) is so decided that the requirement of 9.5 TMC of Dimbhe reservoir is not affected. Thus study as per alternative No.3 is most suitable for diversion of shortfall of 5.90 TMC at Manikdoh reservoir. The linking of two reservoirs will provide sustainable irrigation to water scarcity areas of Pune, Ahemadnagar, Solapur districts of Maharashtra state. The canal system is ready but in present scenario, sustainable irrigation is not possible due to less storage at Manikdoh reservoir. The augmentation of Manikdoh reservoir from Dimbhe reservoir will not only help in sustainable development of irrigation of 35000 Ha in the Kukadi integrated project which not only increases per capita income of farmers but also contributes towards agricultural benefits of nation. The project also contributes towards power generation of 16.15 million units every through existing dam foot power house of 6 MW. capacity.

References

- [1] *Second revised project report of Kukadi Project Govt. of Maharashtra. (Volume 3)*
- [2] *Simulation study by Central Design Organization Govt of Maharashtra.*
- [3] *Indian Standard, Code of Practice for Design of Tunnels Conveying Water (IS 4880 Part-I and Part-II-1976)*
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