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DEVELOPMENT OF PERFORMANCE EVALUATION FOR SUKHI DAM -CASE STUDY

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ABSTRACT
The construction of large dams is one of the most costly and controversial forms of public infrastructure investment in developing countries, but little is known about their impact. This paper studies the performance evaluation of dams in India. There are so many performance indicators are based on a vehicle to facilitate understanding of the causes of good or poor performance. Performance indicators are measures of inputs, outputs, outcomes and impact of government activities. Performance indicator are comprises of rapid appraisal, rapid evaluation and impact evaluation. To account for endogenous placement of dam previous data is used along with the new methodology for dam's suitability to provide instrumental variable estimates of their impact. We find that, in a district where a dam is built, along with the benefits the OMS (i.e. Operation, Maintenance and Safety) of different types of dams are also equally responsible for the stability and sustainability of dam. For this a new methodology is developed to evaluate the performance of dam. Based upon the data collected there are some performance parameters (i.e. reliability index, sedimentation rate, non-spillway efficiency, conveyance efficiency, water quality, expenditure towards operation & maintenance and irrigation intensity) are decided and based on these parameters result the dam performance is decided whether good or bad.

KEYWORDS: *Performance evaluation, Performance indicator, Dam's suitability, Operations, Maintenance & Safety of dam, Performance parameters*

I. INTRODUCTION

In India the water resources are govern by the government bodies. The performance of water resource project is being evaluated on the basis of the benefits cost ratio at the planning stage. Performance evaluation is a stock taking exercise to assess the achievement of water resources project (2). The degree to which the dam / water resources project could provide services against planned varies substainlly from one to the next. This justifies the need for the regular monitoring and evaluations of the performance of the water resources project. A timely action is required for safety and longevity of the structure and that can be achieved by regular monitoring and evaluation of the performance (1). Before deciding the strategy and measures for further improving the efficiency through modification of the system, it is necessary that diagnostic analysis through performance evaluation of the project is carried out and only the identified items not functioning at desired level are proposed for preservation of modification. This will provide better justification for modernization by qualification of benefits (7).

As the causes for deficiency would differ from project to project, the measures for improving the water use efficiency would also be different. The safety of dams in India is the principal concern of the State agencies that are involved in the various aspects of their Investigation, planning, design, construction, operation and Maintenance. While most of the dams have performed well, there have been a few failures (5). These failures, either partial or complete, highlight the need to review the procedures and the criteria that are being adopted by the various States with the object of establishing the best assurance of dam safety within the limitation of the present state-of-art.

The Study by World Commission on Dams (WCD, 2000) revealed that once dam is constructed the monitoring and evaluation is impeded. It was suggested that continuous monitoring and periodic evaluation of the technical performance of the Water Resources Projects should be carried out in the changing environmental and climatic conditions (7). World Bank directed to adapt continuous monitoring and detailed evaluation of the performance of the public sector entities.

For the development of performance evaluation system of water resources project is taking into consideration Sukhi dam**.** In this study the present condition of Sukhi dam and benefits accrued by the dams such as irrigation, power generation, flood protection etc. are studied and finding the new ways of increasing life of structures, getting more benefits by minimizing the risk and costs. This can be done by regular monitoring and evaluation of the performance, the timely action can be taken up for safety and longevity of the structure.

II. METHODOLOGY

For development of performance evaluation system for water resource project the following steps is follow.

Information on the present system of monitoring the performance was collected and next step was to identify the performance evaluation parameters with respect to operation, maintenance and safety criteria of the Water Resources Projects.

- **Operation** – In this, Parameters for flood control, reliability and timely services towards fulfilling the objectives of the projects, services provided against services planned and their magnitude of importance are come.
- **Maintenance** –In this, Parameters for reduced capacity, sedimentation, routine and preventive maintenance are taken into consideration.
- **Safety** – In this, parameters for indicating the safety of the structure based on the instrumentations records are seen.

The performance indicators or parameters used in this study are:

a) **Reliability Index**: It is defined as the ratio of the total water release to the total demand required.
b) **Sedimentation**: It is defined as the process of deposition of silt on the upstream side of dam.
c) **Operating Efficiency:** It is defined as the efficiency of the gate operation for release of water on the D/S side as per there schedule when there is sufficient inflow is available which is fixed by dam authority.
d) **Conveyance Efficiency:** It is defined as the difference in the water release through the canal for irrigation to the water reached in the field for irrigation.
e) **Expenditure on Operation & Maintenance of Dam:** It is defined as the total expenditure accrued on the repairing and replacement of the different components of dam.
f) **Irrigation Intensity:** It is defined as the ratio of total cultivable Command Area provided for irrigation to the total Area on which actual irrigation is done.
g) **Water Quality:** In this parameter the quality of water sample of dam is check and whether they are in limit or not as per Indian standards (drinking purpose) is check.

After identify the performance evaluation parameters the next step is to evolving the data input system for monitoring the performance of 1) Policy decisions, 2) Inflows, weather details (change in the flood pattern), technical Details of the project, d/s channel capacity, details of the reservoir Capacity and if there any change. After evolving the data input system next step is to evolve the procedure for computing the overall performance of the project. The final step is to evolving the system for interpreting the overall performance and the reasons for poor performance the data which are used to fulfill the criteria of performance indicators for all the 3 dams' i.e.

1. PERFORMANCE EVALUATION OF IRRIGATION SYSTEM which are having data like
   - Performance evaluation of **Reservoir capacity, Headwork's, Conveyance system, Operation& Maintenance, Agricultural Practices.**

2. PERFORMANCE EVALUATION OF DAM in which we take
   - Performa for periodic inspection of dam
   - Checklist for inspection of
     (i) Embankment Dam
     (ii) Masonry Dam

As mention above the type of data used for performance evaluation are briefly explain in the text given below for Sukhi dam and same process for Karjan and Kadana dam.

❖ **Reliability Index (R.I)**

The reliability index for 8 years is shown in the below table 1.

Table - 1 Reliability index of Sukhi Dam

Years	Inflow (Mm^3)	Spillage (Mm^3)	Release (Mm^3)	Release/ Demand= (Mm^3) %
2005-2006	125.17	0	90	76.31
2006-2007	**400.096**	**223.91**	**116.09**	**97.65**
2007-2008	326.036	160.75	87.87	73.91
2008-2009	111.325	4.3091	43.6	36.67
2009-2010	57.05	0	50.94	42.85

2010-2011	116.95	0	89.32	75.12
2011-2012	183.357	4.86	93.78	78.88

Demand =118 Mm^3 (Constant)

Reliability Index = (76.31+97.65+73.91+36.67+42.85+75.12+78.88) / 7 = **68.77 %**

The result shows that the release of water is done properly and as required in demand for irrigation.

❖ **Reservoir Sedimentation**

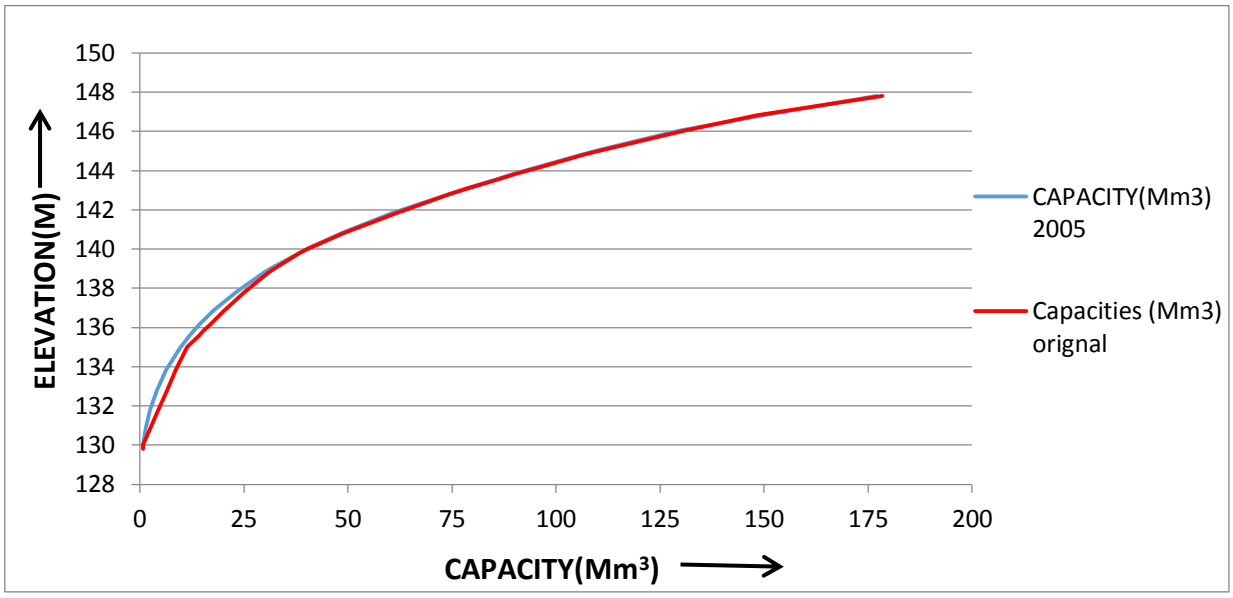

Fig - 1 Elevation v/s Capacity Curve of Sukhi Dam

From the sedimentation survey report of 2005, the annual % loss in the Gross Storage Capacity is 0.05 % and hence the reservoir is classified as **"Insignificant Category"** as per IS 12182-19

❖ **Operating Efficiency**

Operation of gates is working properly when the rue level is maintained. In the below table no.2 the rule level on 15th October is shown from the year 2005-06 to 2011-12.

Table No.2 Operating Efficiency of Gates of Sukhi Dam

Years	Inflow(Mm^3)	Spillage(Mm^3)	Rule Level on 15th Oct.(147.82 m)
2005-2006	125.17	N	145.52
2006-2007	**400.096**	**Y**	**147.82**
2007-2008	**326.036**	**Y**	**147.82**
2008-2009	111.325	Y	145.95
2009-2010	57.05	N	142.65
2010-2011	116.95	N	147.1
2011-2012	183.357	Y	147.32

Operating Efficiency = No. of years having spillover / Total No. of years

= 4 /7 = **57.14 %**

Here, No. of years having spillover= 4 Total no of years count = 7

❖ **Conveyance Efficiency**

When the difference is small the Conveyance efficiency of canal is high or good.

Table No.3 Conveyance Efficiency of Sukhi Dam

Sr. No.	Year	Canal Releases (Mcft)	Releases at Field(Mcft)	Conveyance Losses (Mcft)	% Losses=Col.5/Col.3
Col.1	Col.2	Col.3	Col.4	Col.5	Col.6
1	2002-03	1545.81	1468.84	76.97	4.97
2	2003-04	3967.99	3774.71	193.28	4.87
3	2004-05	4143.65	4071.92	71.73	1.73
4	2005-06	3445.54	3204.36	241.18	6.99
5	2006-07	4556.03	4100.43	455.6	9.99
6	**2007-08**	**3567.13**	**3103.4**	**463.73**	**13**
7	**2008-09**	**1974.07**	**1539.78**	**434.29**	**21.99**
8	**2009-10**	**581.06**	**1743,20**	**581.06**	**24.99**
9	**2010-11**	**4031.66**	**3154.33**	**877.33**	**21.76**
10	**2011-12**	**4139.98**	**3311.99**	**827.99**	**19.99**

From the above analysis we can see that in the initial years i.e. 2002-03 to 2006-07 the conveyance losses are within **10 %** but in later years i.e. 2007-08 to 2011-12 there is sudden increase in conveyance losses which goes more than **20 %**.

Conveyance losses = (4.97+4.87+1.73+6.99+9.99+13+21.99+24.99+21.76+19.99) / 10
= 13.02 % Conveyance Efficiency = **86.08 %**

From this analysis we conclude that Conveyance Efficiency of canal is good and this is a result of proper maintenance of Canal network.

❖ **Water Quality Analysis of Sukhi Dam (Drinking purpose)**

Table No. 6.4 Water Quality Analysis of Sukhi Dam

Parameter	BIS Limit		Sample no.1 (U/S)	Within limit	Sample no.2 (D/S)	Within limit	Sample no.3 (Gallery)	Within limit
	Permissible	Excessive						
pH	6.5-8.5	9.2	8.3	Y	9.13	N	10.3	N
TDS (mg/lit)	500	1000	152	Y	134	Y	112	Y
Total Alkalinity (mg/lit)	200	600	124	Y	104	Y	124	Y
D.O. (mg/lit)	5.0-6.0	>6	6.4	N	6.5	N	---	---
M.P.N. index for E. Coli count / 100 ml	500	1600	>1600/ 100ml	N	>1600/ 100ml	N	---	---
Total Bacterial count /100ml	10000	15000	3.5 x 104	N	3.68 x 104	N	---	---

Sample no. 1 upstream = out of 6 parameter only 3 parameter are within limit.

= 3/6 = **50 %**

Sample no. 2 Downstream = out of 6 parameter only 2 parameter are within limit.

= 2/6 = **33 %**

Sample no. 3 Gallery = out of 3 parameter only 2 parameter are within limit.

= 2/3 = **66 %**

Average of 3 Samples = (50 + 33 +66)/3 = **49.66 %**

From the above result it is conclude that the water quality of Sukhi dam either of upstream or downstream is not suitable for drinking purpose.

❖ **Irrigation Intensity**

It is defined as the ratio of total cultivable Command Area provided for irrigation to the total Area on which actual irrigation is done. The irrigation intensity of Sukhi dam for last 10 years is shown in the below table no.4

Table No.4 Irrigation Intensity of Sukhi Dam

Year	C.C.A (Ha)	Kharif (Ha)	Rabi (Ha)	Hot (Ha)	Total (Ha)	Irrigation Intensity %
2002-03	21209	650	3963.83	0	4613.83	21.75
2003-04	21209	0	5108.99	4250.5	9359.53	44.12
2004-05	**21209**	**568**	**6555.3**	**4122.9**	**22492.6**	**106.05**
2005-06	21209	0	4540.46	3264.8	15610.6	73.6
2006-07	21209	0	4475.03	2491.3	13932.8	65.69
2007-08	21209	0	3151	2486.8	11275.7	53.16
2008-09	21209	0	2998.24	1502	9000.48	42.43
2009-10	21209	63.06	3725.35	68	3586.48	16.91
2010-11	20922	583	4670	3916	9169	43.82
2011-12	**20922**	**174**	**5071**	**2362**	**7607**	**36.35**

The Irrigation intensity which is 106 % in year 2004-05 is decreasing at very fast rate and in year 2011-12 is comes to only 36.35 %.

$$\text{Irrigation Intensity} = \frac{(21.75+44.12+106.05+73.60+65.69+53.16+42.43+16.91+43.82+36.35)}{10}$$

$$= \mathbf{50.30\ \%}$$

The low irrigation intensity can be justified by the poor performance of canal operation or maintenance.

III. RESULT ANALYSIS

Sr. No.	Parameters	Sukhi Dam
1	Reliability index	68.77%
2	Performance parameter for sedimentation rate	100 % (Insignificant category)
3	Performance parameter for Non-spilling efficiency	42.86%
4	Conveyance efficiency	80%
5	Water quality	Not suitable for drinking purpose (49.66 %)
6	Expenditure towards Operation & Maintenance	100% 77.6 rupees/Ha.
7	Irrigation intensity	50.35%

IV. CONCLUSIONS

- The performance evaluation system has been evolved to evaluate the performance of the water resource of the project considering the performance measures such as Reliability index, Reservoir sedimentation rate, Non-spilling efficiency, Conveyance efficiency, Water quality (drinking purpose), Expenditure towards operation and maintenance and Irrigation intensity.
- It is found that Sukhi reservoir is performing well with respect to performance indicators i.e. **(**Out of 7 seven parameters 5 parameter shows good performance)

- The low Performance of sukhi dam for Non-spilling efficiency can be improved by properly maintained rule curve.
- The low Performance of sukhi dam for Irrigation Intensity can be improved by lining of canal

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