Cost - Benefit Analysis

A water reservoir project is estimated to cost Rs 200 crores and the time required for construction is 5 years. The department budget provides for a phased expenditure on the project as follows:

Year :-	1st	2nd	3rd	4th	5th
Amount :- in crores	20	40	60	40	40

The project is financed at 4% per annum. Surplus funds not required for one year can be invested at 3% per annum along with sinking fund. What amount in excess of Rs 200 crores must be obtained to meet the interest charges on capital during the construction period.

Solution:

construction period = ⟶ 5 years

The percentage breakup of construction cost yearwise for which capital will be available at the beginning of each year is as follows.

1st year	Rs 20 crores	=	10%
2nd "	Rs 40 "	=	20%
3rd "	Rs 60 "	=	30%
4th "	Rs 40 "	=	20%
5th "	Rs 40 "	=	20%
		Total =	100%

Let C_i denote the additional capital percent required to pay interest on the sum $(100+C_i)$ rupees at 4% P.a. we shall calculate the annual expences and returns at the end of each year as follows.

1. End of first year:

Interest paid on $(100+C_i)$ at 4% $= (4.0+0.04C_i)$
interest recieved on $(90+C_i)$ at 3% $= (2.7+0.03C_i)$
Net paid $= \boxed{1.3+0.01C_i}$

Balance capital at end of 1st year $=(90+C_i)-(1.3+0.01C_i)$
$= (88.7+0.99C_i)$

paid for construction installment 2nd year $= 20\%$
Net Balance (for 2nd year) $= (88.7+0.99C_i) - 20$
$= (68.7+0.99C_i)$

2. End of 2nd year:
Interest paid on $(100+C_i)$ at 4% $= (4.0 + 0.04C_i)$
interest recieved on $(68.7+0.99C_i)$ at 3% $= (2.06 + 0.0297C_i)$
Net paid $= \boxed{1.94 + 0.0103\,C_i}$

Balance capital $= (68.7+0.99C_i) - (1.94 + 0.0103C_i)$
$= (66.76 + 0.9797\,C_i)$

Paid for construction instalment of 3rd year = 30

Net balance = $(66.76 + 0.9797 C_i) - 30$

(for 3rd year) $= (36.76 + 0.9797 C_i)$

3\. End of 3rd year:-

Interest paid on $(100 + C_i)$ at 4% $= (4.0 + 0.04 C_i)$

Interest received on $(36.76 + 0.9797 C_i)$ @ 3% $= (1.1028 + 0.0293 C_i)$

Net paid $=$ $\boxed{2.8972 + 0.0107 C_i}$

Balance capital $= (36.76 + 0.9797 C_i) - (2.8972 + 0.0107 C_i)$

$= (33.862 + 0.969 C_i)$

paid for construction instalment of 4th year = 20%

net balance $= (33.862 + 0.969 C_i) - 20$

(for 4th year) $= (13.862 + 0.969 C_i)$

4\. End of 4th year:-

Interest paid on $(100 + C_i)$ at 4% $= (4.0 + 0.04 C_i)$

interest received on $(13.862 + 0.969 C_i)$ at 3% $= (0.415 + 0.0290 C_i)$

Net paid $=$ $\boxed{3.585 + 0.011 C_i}$

Balance capital $= (13.862 + 0.969 C_i) - (3.585 + 0.011 C_i)$

$= (10.277 + 0.958 C_i)$

Paid for construction instalment of 5th year = 20

$\therefore$ Net balance $= (10.277 + 0.958 C_i) - 20$

(for 5th year) $= (-9.723 + 0.958 C_i)$

(5) End of 5th year:

Interest paid on $(100 + c_i)$ at 4% $= 4.0 + 0.04\,c_i$

interest received on $(-9.723 + 0.958\,c_i)$ at 3% $= -0.29 + 0.0287$

net paid $= +4.29 + 0.0113$

$$\text{Balance} = (-9.723 + 0.958c) - (+4.29 + 0.0113)$$

$$= (-14.013 + 0.9467\,c_i).$$

Since the construction period is over and all liabilities have been paid, the value of the above balance must be $= 0$

$$\therefore\ -14.013 + 0.9467\,c_i = 0$$

$$\text{or}\ \boxed{c_i = 14.80}\ \%$$

$\therefore$ additional capital of 14.80 % should be obtained

$$= \frac{14.80}{100} \times 200 = \boxed{29.60\ \text{crores}}$$

Thus Total capital required $= \boxed{229.60\ \text{crores}}$

(P)

MULTIPURPOSE WATER RESOURCES DEVELOPMENT.

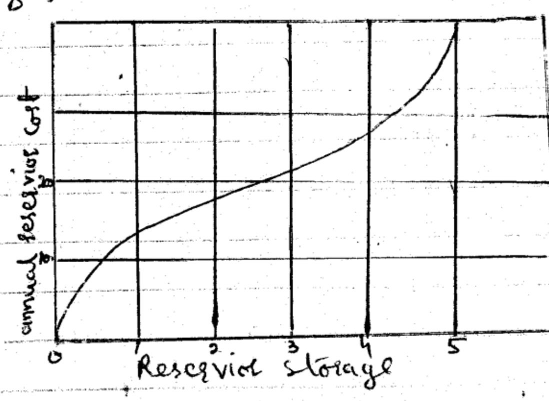
(A) (Graphic Optimization Techniques)

The Graphic optimization techniques are followed to carry out the economic evaluation of multipurpose projects. The procedure adopted is called as marginal analysis. The method of analysis is described below with the help of six graphs. It is not necessary to carry out all the steps indicated below.

(Steps involved in the optimization techniques)

Let us suppose that we have to analyse a multipurpose project and obtain the optimum solution for it. Let the project ~~comprise~~ (i.e. a multipurpose reservior) be used for irrigation, flood control and low flow augmentation for water quality control. We have to optimize the reservior using six graphs.

1 Step (1) → The first step is to design various sizes of the reservior and calculate the total annual cost for a life span of 50 years. We get a curve between reservior storage (i.e. size) Vs the annual reservior cost.



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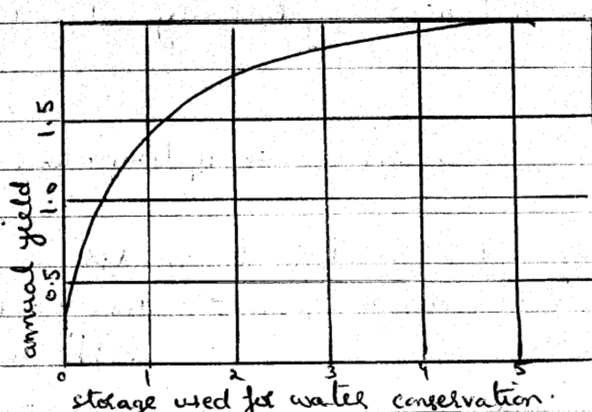
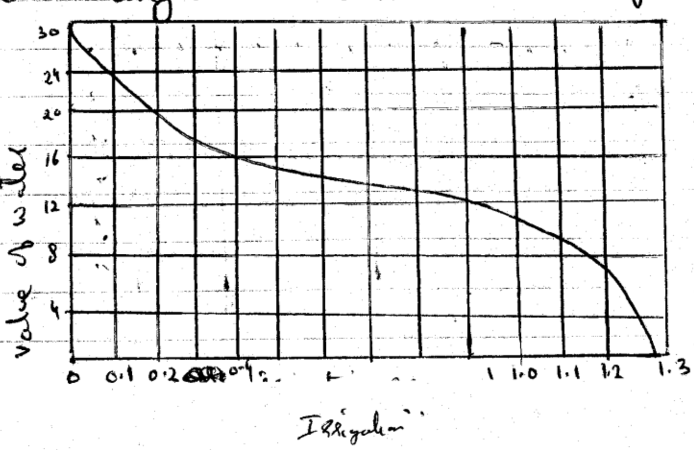
Step 2 → The second step is to study the reservior operation and determine the annual yield developed by a range of storage volume. Here, we have the curve between storage used for water conservation and annual yield.



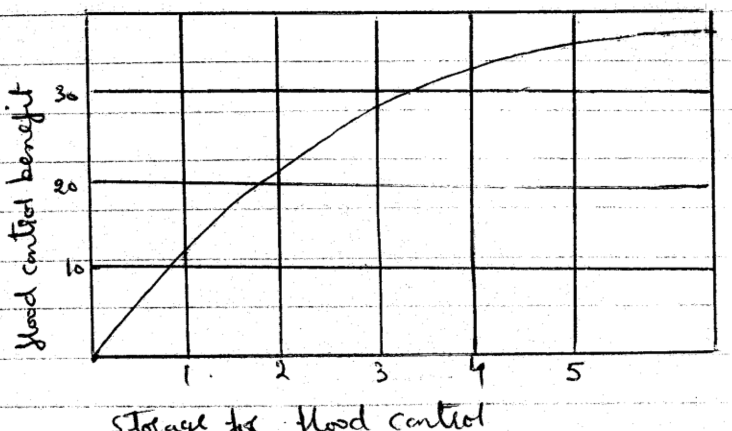
(Reservior yield curve) ↑

Step 3 → The third step is to analyse crop pattern, crop water requirement, distribution loses and develop an irrigation demand curve. The curve expresses the value of water at the reservior site. It does not take into account the cost of water after distribution. We obtain a curve between irrigation demand and value of water.

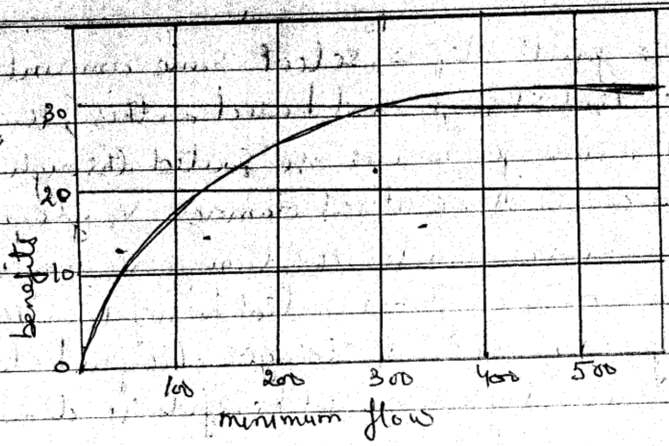


inal irrigation →
and curve.

step 4 → The fourth step is to select some amount of flood control storage and based on this, the floods coverings of various frequencies are routed through the reservoir to develop a curve of residual damage Vs frequency. The reduction in area under the (damage Vs frequency curve) will provide the annual flood control benefits. The procedure is repeated for a number of storages. Graph between 'Storage for flood control' and flood control benefits is drawn.



Step 5 → The fifth step is to develop damage concentration, flow rate concentration and flow duration curves. The three curves are combined to estimate water quality damage without the project. Then a low flow augmentation is done to estimate the residual damages. Subtracting the two damages, we get a curve of minimum flow Vs Benefits



* Step 6 → The flow duration curve is analysed to determine the amount of water required to prevent the flow from falling below a minimum value. The curve gives augmentation required after 15,000 acre-ft/year. Run of the river yield is withdrawn for irrigation, used, and then returned to the stream. It is draw between

augmentation water required Vs minimum flow