Research Paper Engineering

Determination of Reservoir Operating Rules for A Single Reservoir - A case study (March 2012)

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ABSTRACT

In the present study a LP based is applied to a case study of Bisalpur project, Rajasthan, India. The objective of Linear programming planning model is to determine Maximum water release and suitable cropping pattern which yields maximum net benefits. Ten different strategies (variations) of LP are analyzed with various population sizes, crossover constants and weighting factors. . Minimum and maximum CPU time that was elapsed is also analyzed. It is concluded that LP is the best strategy for the planning problem with maximum net benefits of 95.1903 crores of rupees taking minimum CPU time of 2.844 seconds. The present study can be extended to similar situations with suitable modifications.

This technique is applied to Watrak reservoir project near At-Pahadia, Ta-Malpur, Dist-Sabarkantha, Gujarat. The Watrak reservoir project is a single purpose irrigation project. The major purpose of the scheme is irrigation and water supply. The water from reservoir is being released to meet the irrigation demands. The data for irrigation demands in command area covering cropping pattern with irrigation intensity and its blockwise distribution are available.

Keywords : maximum water release , maximum irrigation benefit, Minimum water loss

I. Introduction

Water is essential basic resource, which is necessary for the existence of human being. It is needed in abundance to meet irrigation, power generation, industrial supplied, low water augmentation and navigation etc. Its availability is restricted in terms of quality, quantity, time and space or combination of all these factors.

Need for efficient integrated management of an irrigation system is keenly felt due to growing demand for agricultural products, the escalating costs of supplying water to farmer's fields and stochastic nature of water resources (Raju and Kumar, 2003). Due to dwindling supply of water the profit conscious irrigators wish to so allocate the water as to maximize the net benefits with competing alternative crops.

· WATER RESOURCES OF GUJARAT STATE

Gujarat state is situated on the west coast of India between Latitude 20°2' and 24°41' N and Longitude 58°8' and 74°23' E. The geographical area of the state is 1, 95,000 km2 (5% of total area of India) on the basis of geographical features. Gujarat State comprises three regions:

1. Gujarat regions, the main land covering the central and eastern area of the state
2. Saurashtra peninsular region
3. Kachh region

The main source of water in the state is predominantly surface water. There are 17 river basins in Gujarat region, 71 river basins in Saurashtra region and 97 river basins in kachh region, considering the actual allocation of water from the interstate rivers, like the Narmada, the tapi, the mahi and the sabarmati the available surface water resources of the state have been estimated at 40,700 Mcum including 11,100 Mcu.m. of the Narmada river. The countries total surface water resources are estimated at 1801000 M cu. m. Therefore, the state's total water resources work out of 2.25 percent of the water resources of India. The lack of the reservoir sites due to flat terrain a no availability of suitable foundations in the state, further restrict the scope of utilizing the entire available surface water Fe-sources. As against the countries utilizable surface water resources are only 314001 Mcu. m. inclusive of Narmada water. This works out to 4.51 percent of the .country's utilizable surface water resources.

· SYSTEM ANALYSIS IN WATER RESOURCES PLANNING

Since it is the role of the planner to select the best of all possible alternatives, the various methods of optimization collectively called systems analysis are obvious tools for this use. Optimization problems are encountered at three levels in water planning. The first level deals with individual features of the project. For example, given the cost diameter and head loss diameter function for a penstock, it is possible to use the methods of engineering economy to accurately determine the optimum solution.

The second level involves the single project. Usually, however there are issues of project scale, which must be separately resolved, the aspects of project scope, which are not quantitatively measurable environmental and ecological consequences value of human life, public preference and other, cannot be included in the solution, despite the constrains, mathematical solutions are valuable in defining one possible optimum point, which provides a point of departure for judging adjustments required to satisfy the non quantifiable factors.

The third level of planning involves systems of projects, multiple reservoirs, canals etc. Solutions based on simplifying assumption may indicate a first approximation to the best configuration of the system, but the only method demonstrated successfully involves simulation. A simulation (Operation study) can be programmed for computer solution and many alternative combinations tested to determine, which alternative offers the maximum net benefits.

Multiple uses of project facilities may increase benefits without a proportional increase in costs and thus enhance the economic justification for the project. A project designed for single purpose that produces incidental benefits for other purpose should not, however, be considered a multiple purpose

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project. Only those projects designed and operated to serve two or more purposes should be described as multiple purposes. The first real multiple-purpose was the Sacandaga reservoir in Hudson River basin, New York in United States, which combined flood mitigation with storage of water for power and industrial use down streams.

Since many major multiple purpose projects have been build in the United States, the basic factor in multipurpose design in compromise. A working plan must be devised which permits reasonably efficient operation for each purpose although maximum efficiency is not necessarily attained for any single purpose. The physical elements of a multiple purpose project (dam, spillway, sluiceways, gates, power plant etc.) do not differ from those for a single purpose project. The unique feature in multiple purpose design is the selection of physical works and an operation plan that is an effective compromise among the various uses.

OBJECTIVES OF THE STUDY

- The aim of the present research study is to determine optimal operation of Watrak dam located on the main stream of the river Watrak using linear programming teqnique. Using the linear programming maximum water release from reservoir and produce maximum net benefit from crops.

SCOPE OF THE STUDY

· LP technique is applied in Watrak reservoir project to determine suitable cropping pattern which yield maximum net benefit in futures..

3 *STUDY AREA*

Watrak Reservoir Project envisaged construction of a gated spillway and earthen dam on both flanks of river Watrak near village BHEMPODA OF MALPUR The gross storage capacity if the reservoir is 183.099 MCM.& live storage is 159.6 MCM. The purpose of the project is to provide irrigation facility in 18376.o Hectare Land of Malpur,Bayad,Kapadvanj taluka of Sabarkantha and Kheda Dist.

· However it is also provided to supply drinking water to Gabat, Sathmba village areas through GWSSB. The Project works were completed in the year 1984. The project cost was Rs. 74.00 Crores The main canal off takes from left bank of the earthen dam. The canal is traversing as ridge canal serving the area lift of Watrak Rivers.

Sr. No.	Name Of Dist	Taluka	CCA_ Ha	Nos. of Village Benefied
1	Sabarkantha	Malpur		9
		Bayad		44
		Kapadvanj		3

The detail of command area is as under

· Network of canals & distribution system as under.

Sr. No.	Canals	Length-KM	Command Area-Ha
1	Main Canal	7.50	514
2	Left Branch Canal	19.05	4832
3	Right Branch Canal	15.82	3018
4	Choila Distributory	7.10	2342
5	Chhobho Distributory	8.03	3646

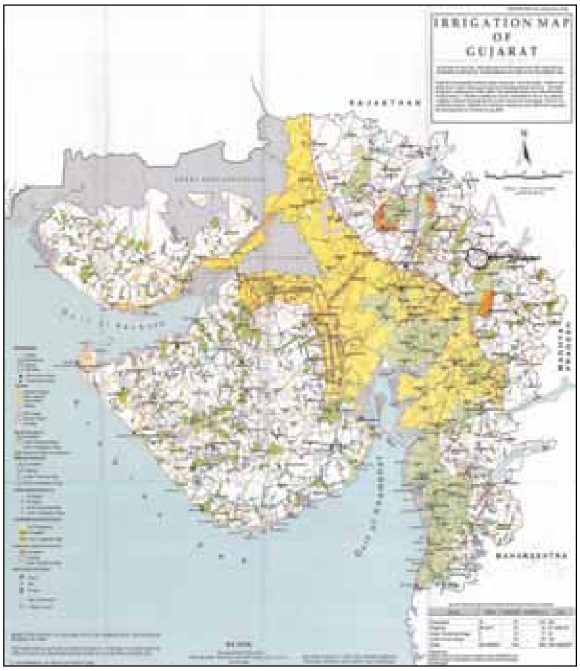

Fig. 1.1- Map of Gujarat State

Fig. 1.2- Map of Watrak Dam Google Map Pho

Reservoir		
Area at full reservoir level	44.75 Km^2	
Gross storage capacity	176.90 Mm^3	
Effective storage capacity	154.30 Mm^3	
Area under submergence		
a) Forest	b) Waste land	c) Culturable
a) 1182 ha	b) 1045 ha	c) 2248 ha
No. of villages under submergence	8 partial, 20 full	

Data Bank of Watrak Reservoir Project

Information about Dam	
Location	Vill: Pahadia, Ta: Malpur, Dist: Sabarkantha
Purpose	Irrigation
River	Watrak
Area of catchment	1114 km^2
Mean annual runoff in the catchment	180.23 Mm^3
Mean annual rainfall	827 mm
Year of commencement of construction work	April ,1971
Year of completion	-

Dam	
Type	Composite
Bed Rock	Quartzite & Phyllite
Maximum height above the lowest point of foundation	43.31 m
Length at the top of the dam	313 m
Total Volume Content:	
Concrete	0.041 Mm^3
Masonry	0.047 Mm^3
Earthwork	2.008 Mm^3

METHODOLOGY:

Mathematical Modelling

Mathematical modelling of the objective function and the corresponding constraints is explained below. The net benefits (BE) from different crops are to be maximized. These are btained by subtracting the cost of surface water from gross benefits of crops. Mathematically it can be expressed as

$$BE = \sum_{i=1}^{9} B_i A_i$$

where i is Crop index [1=Maize (K), 2=Jowar (K) , 3=Ground nut (K) , 4=Soya bean (K),5=Wheat (R), 6=Gram (R), 7=Barley (R), 8= Coriander (R), 9= Mustard (R), K = Kharif , R =Rabi]; t is Time index (1=January, ..., 12=December). BE = Net benefits from the whole planning region (Indian Rupees); Bi = Net benefits from the crop i (excluding cost of surface water, seeds, fertilizers etc) Ai, = Area of crop i grown in the command area (ha); IRt = Irrigation releases from reservoir to command area (Mm3).

Linear programming model

Work planned			
Sr No	Activity or work planned for Phase-II	Amount of work Completed in %	Remark
01	Collection of information of Loop Software and its downloading..etc	95%	
02	Collection of Remaining Data	30 %	
03	Analysis work	100 %	
04	Paper presentation [If possible then I will try to prepare and represent more than two research paper]	100%	

Linear programming is probably the most flexible and most widely used technique for optimizing the planning and operation of water resource systems. Problems such as, determining the system

yield, finding the size of the reservoir, determining optimum operating procedures are being handled frequently through LP application. Here a mixed integer LP model is used for optimal

operation of the irrigation reservoir. The objective function considered is to maximize the irrigation releases. The objective function and constraints of the model can be mathematically presented as follows.

$$\text{Max} \sum_i \sum_j IR_{i,j} \quad i = 1, 2, \ldots n, \; j = 1, 2, \ldots 12.$$

Subjected to

$$S_{i,j+1} = S_{i,j} + I_{i,j} - E_{i,j} - IR_{i,j} - DR_{i,j} - V_{i,j}$$

$$IR_{i,j} \le D_{i,j}$$

$$S_{i,j} \le S_{max}$$

$$S_{i,j} \ge S_{min}$$

where, i represents year with total number of years being 'n', j represents month

$IR_{i,j}$ is the irrigation release, $S_{i,j}$ is the beginning storage in the reservoir, $I_{i,j}$ is the inflow to the reservoir, $E_{i,j}$ is the evaporation from the reservoir, $DR_{i,j}$ is the drinking water supply from the reservoir, $V_{i,j}$ the spill from the reservoir. S_{max} and S_{min} are the maximum and minimum storage volumes of the reservoir. $D_{i,j}$ is the irrigation demand,

To ensure that the reservoir does not spill before reaching its capacity, there must be an explicit constraint in the formulation. Shin and Revelle (1994) attempted to incorporate such a constraint for spill using a zero-one integer variable acting as a spill indicator. They proposed the following constraint, which are also included here.

$$a_{i,j} \le S_{i,j+1} / S_{max} \quad (5)$$

$$V_{i,j} \le a_{i,j} \times B \quad (6)$$

$$a_{i,j} = 0 \text{ or } 1 \quad (7)$$

where, B is a very large number.

It is given in Tabular form as below

Conclusion

Based on the reconnaissance survey, and detailed study of the available data and using on linear programming techniques method are applied to reservoir operation and get maximum water release from the reservoir in watrak dam reservoir at Bhampoda village Taluka Malpur, Dist. Sabarkantha

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