Discussion On The Rehabilitation And Reconstruction Of Kariba Dam

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Abstract

In view of the situation that improvement is urgently needed for the Kariba Dam along the Zambezi river, this paper offers an evaluation about three options that ZARA puts interest in. First of all, simple analysis of potential benefits and costs of three schemes is pointed out combined with the factors like storage capacity, security, management level, the maximum age, etc. The top priority lies on location problem, to solve which multi-objective programming model one is established according to multiple factors such as storage capacity, cost, capacity, cost, benefits and management ability. Then the main problem is proposed and analyzed when secondary cause remains the same by controlling the variables.

Keywords

The Kariba Dam, multi-objective programming model, management.

1. Introduction

1.1 Background

A report by the Institute of Risk Management of South Africa in 2015 pointed out that the Kariba Dam is now in urgent need of maintenance. On October 3, 2014 the BBC reported that "The Kariba Dam is in a dangerous state. Opened in 1959, it was built on a seemingly solid bed of basalt. Nevertheless, in the past 50 years, the torrents from the spillway have eroded that bedrock, carving a vast crater that has undercut the dam's foundations. Engineers are now warning that the entire dam will collapse without urgent repairs[1].In January 2016 it was reported that water levels at the dam had dropped to 12% of capacity. Levels fell by 5.58 meters (18.3 ft), which is just 1.75 meters (5 ft 9 in) above the minimum operating level for hydro power. Low rainfalls and overuse of water by the power plants have left the reservoir nearly empty, raising the prospect that both Zimbabwe and Zambia will face water shortages.[2]

Here are three options which are especially interested to ZRA:

(Option 1) Executing maintenance towards the existing Kariba Dam

(Option 2) Reconstructing the existing Kariba Dam

(Option 3) Removing the Kariba dam, and substituting it with sequential dams from ten to twenty along the Zambezi River.

Our goal is to do some assessment of each Option

2. Terminology

2.1 Terms

Water storage： Water storage refers to the amount of water in a lake at a specific water level. Such as the normal lake water storage capacity, the maximum water storage capacity. In the dame is characterized by capacity, reflecting the different reservoirs under the working conditions of water storage.

3. The report for the Requirement

(Option 1) The restored Kaliba Dam will maintain the same water management capacity as the original, and will guarantee the same level of profits. The cost of repairing the dam is associated with the (damaged (condition of the dam. Since dedicated in 1959, this dam has operated for 58 years. An argreement of $294 million is ratified for maintenance among Zimbabwe, and zambian government and the European Union, the world bank and the African development bank and the Swedish government. The maximum of service life is assumed to be 100 years. Then the dam can be used for 42 years for the most after repairing. According to staff, $ 7.14 million per year will be put in for the average annual cost of the restored Kaliba Dam.

(Option 2) Removal expenses and reconstruction costs of dam are accounted at the mention of rebuilding. It is suggested that 37 million yuan is the approximate value of the blasting cost, calculated on the basis that the market price for blasting is estimated at $3.96 / m3 and 1700 meters long, 8.8 meters wide and 617 meters high, the statistics data of Kariba dam.

The water storage capacity in dam's reservoir, should be of large percentage among the kinds of costs during rebuilding. With the reference to the relationship between the construction prime costs (the $2017 price levels) of several African dams and the storage capacity, it could be fitted between reconstruction cost and the amount of water storage into the function expression as:

$$y=0.5587v^{0.6411}+3.314(\text{billion})$$

when the blasting expense is neglected due to a smaller percentage relatively.

Where:

y is the cost of rebuilding the dam;

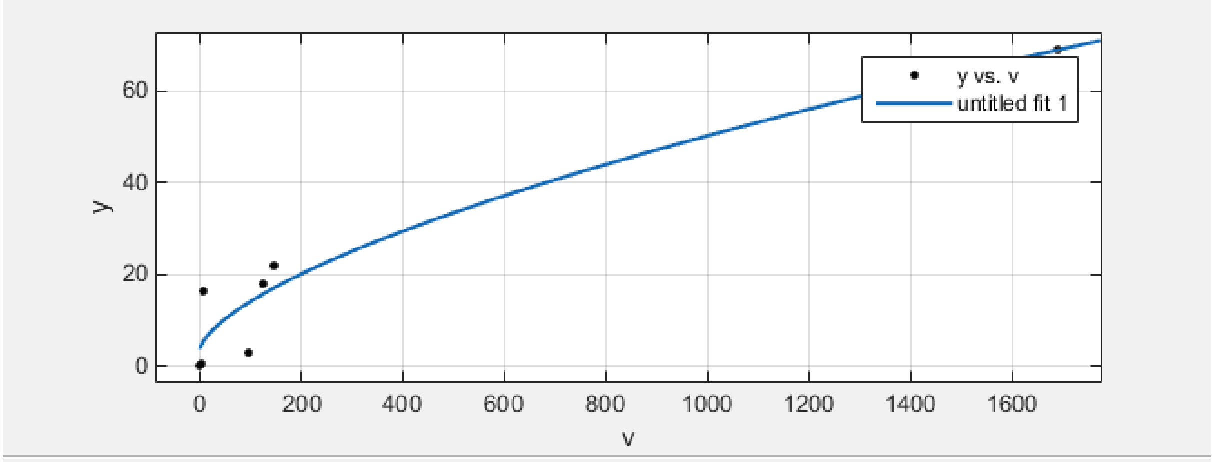
v is water storage.

Here is the historical data we use:

Tab 2 Original Data

Hydropower	Water storage / (10^8m^3)	Cost / (10^8dollar)
Taroudnat	0.45	0.11
El Hachef	2.7	0.34
Aswan	1689	68.84
KdueGorge	7.4	16.46
Melovy	125	18
Becky Ⅲ	147	22
Arvada	97.14	2.92

The result can be shown as:



Besides, it is shown that maximum life of the reservoir is 100 years, and the average annual cost of $27 million 320 thousands. Hence, the new Kariba dam is expected to keep the same water management ability and the same profits gained as the last one indubitability .

(Option 3) Statistics indicates that removing the Kariba dam as well as the substituting program is accounted for the largest proportion of the expenditure. Consequently, the expense of constructing those small dams and dynamite is expected to be the total expenditure.The water management capacity of the new dam will reach a higher level.In addition, it will have an impact on the socio-economic impact of the extension. And we will give a sufficient analysis in the following.

The storage capacity of each dam is 1850/n.

Electricity consumption and price around the reservoir area do not change with time.

Basic model

The number of dams is mainly related to the cost, and the storage capacity has been a function of cost:

$y=0.5587v^{0.6411}+3.314$(billion).

Now we need to consider the relationship between the volume per unit volume and the cost.

Let g(v)= y/v, find the minimum g(v)

What we want to solve: take the derivative of g(v)

$g(x)'=-0.20051743v^{-1.3589}-3.314v^{-2}$

proving g(x) is a monotonically decreasing function, which means the larger the capacity, the smaller the cost of each unit volume. Therefore when n=10,the cost is lowest.

4. Conclusion

Because the fewer dams are built, the more cost - saving, the price of building a new dam on the original site is necessarily lower than that of building ten new small dams, and at the same time, the cost of site selection and material transportation is saved. as we have concluded above, the annual average cost of repairing dams is lower than that of building a new dam, so the most cost-saving method is to repair the old dam.

References

[1] "The marooned baboon: Africa's loneliest monkey". BBC. 3 October 2014. Retrieved 3 October 2014.

[2] "Kariba dam drops to record low 12%, and Zimbabwe, Zambia stare at a nightmare". Mail & Guardian Africa. 2016-01-20. Retrieved 2016-02-18.