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Suggestions on the problem of the reconstruction of the Kariba Dam

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Abstract: This paper mainly studies how to rebuild the original kariba dam into ten small dams. Based on the geographical position and topography conditions, twenty proper locations are selected. After taking those factors influence to the costs, the first multi-objective programming is established, and ten optimal solutions are chosen Water capacity in each reservoir is confirmed according to the geographical position as well as programming model 2. Water management plan is analyzed in all directions especially under the extreme weather condition, with the advice given. This model helps people to live better through the flood season and dry season.
Keywords: kariba dam, multi-objective programming.

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1. INTRODUCTION

1.1 General Assumptions

Take no account of population migration, transport costs, ecological problems and the spread of disease.

The total normal storage capacity remains the same.

Transportation costs are not included.

Electricity price basically remains unchanged within a certain amount of time.

1.2 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.

1.3 Symbols

Tab 1. Symbolic Descriptions

Symbols	Descriptions
v	Water storage
y	Cost
x	Location
l_1	The distance between the banks
l_2	The distance between main cities and dam point
Q	Water flowage
n	The number of hydropower stastions

2. THE MODEL

2.1 Model 1 the Location Problem

According to the features of geographical hydrology, we choose 20 possible dam addresses. Considering the size of the section of the mouth and transportation cost, we establish the optimizing model.

Tab 2. Information of geographical location to be selected

Number	Latitude and longitude	l_1/m	l_2/m
1	(16°26'06.3"S,28°49'09.2"E)	75	7500
2	(16°17'28.8"S,28°49'48.0"E)	65.625	15000
3	(16°17'28.8"S,28°49'48.0"E)	375	60000
4	(16°02'18.9"S,28°51'05.8"E)	350	0
5	(15°36'38.1"N,29°50'19.6"E)	250	6660
6	(15°36'46.4"S,29°51'43.2"E)	150	37500
7	(15°38'18.8"S,30°01'37.2"E)	156.25	43400
8	(15°37'21.2"S,30°25'47.0"E)	466.67	2000
9	(15°35'07.6"S,32°42'16.4"E)	180	9500
10	(15°35'14.2"S,32°59'36.1"E)	81.82	20000
11	(15°36'46.9"S,33°00'34.2"E)	80	26670
12	(15°59'11.4"S,33°24'06.0"E)	600	28000
13	(17°59'30.7"S,26°52'11.2"E)	300	53300
14	(18°01'07.3"S,26°46'12.7"E)	166.7	50000
15	(18°04'36.1"S,26°41'43.4"E)	250	37500
16	(17°57'56.7"S,26°28'08.8"E)	97.06	4360
17	(17°55'03.1"S,26°14'46.2"E)	41.81	45450
18	(17°55'34.3"S,25°51'27.9"E)	42.31	10000
19	(17°49'53.7"S,25°38'55.9"E)	294	20000
20	(17°47'28.9"S,25°15'46.8"E)	400	2000

The decision variables are $xi = \begin{cases} 1, & xi \text{ is selected.} \\ 0, & xi \text{ isn't selected.} \end{cases}$ $i=1, 2, \dots, 20$

The constraint (The number of dams is ten) $\sum xi = 10$

Optimizing model: According to the impact of the two different costs, respectively, to weight both

Thinking about $y \propto l1$

$y \propto l2$

So we assume that $yi = l1i + 0.01 * l2i$

min $\sum_{1}^{10} y_i$

Based on this, our choice is:

Table 3. Location which we select

Number	Latitude and longitude	l_1/m	l_2/m
1	(16°26'06.3"S,28°49'09.2"E)	75	7500
2	(16°17'28.8"S,28°49'48.0"E)	65.625	15000
4	(16°02'18.9"S,28°51'05.8"E)	350	0
5	(15°36'38.1"N,29°50'19.6"E)	250	6660
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18	(17°55'34.3"S,25°51'27.9"E)	42.31	10000
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2.2 Model 2 Water Storage

From the point of view of safety and cost, a multi-objective programming model is established to determine the storage capacity of each dam. In practical problem, we can simplify the model to a single-objective programming model with minimum cost under the premise of ensuring safety.

Decision variables: water storage capacity of each dam.

Constraints: each dam water equals to the total amount of the original water storage:

$$\sum vi = 1850;$$

Taking into account the safety factors, so that the dam's water storage capacity is gradually reduced:

$$v_i > v_{i+1};$$

Consider the safety factors, as far as possible the reservoir located in the river's original surface area of the larger position:

$$v_i / s \leq 100;$$

Objective function:

$$S(v) = \sum_{1}^{n} (vi - v)^2 / n;$$

(The cost is minimal)

The process of solution is as follows:

$$S(v) = \sum_{1}^{n} (vi - v)^2 / n$$

$$\begin{cases} \sum vi = 1850 \\ v_i > v_{i+1} \\ v_i/s \leq 100 \end{cases}$$

2.3 Model 3 Water Resources Management

Conditions:

In the dry season, the maximum water storage has reached the maximum level of inventory;

In the flood period, the water storage capacity has been reduced to a minimum level;

Model establishment:

In flood season: after the flood is over, the water level is at the normal level, the nearer the better.;

Objective function:

$$\min \ vi\text{-}v$$

Constraints after the end of flood water storage capacity shall not exceed the flood control level:

$$Qi\text{-}1 + 0.5v\text{-}Qi \leq 1.3v$$

In the dry season: to make the water level after the end of the dry season from, the normal closer the better

Objective function: min vi-v

Constraints after the end of the dry season water level is not lower than the lowest water level:

$$Qi\text{-}1 + v\text{-}Qi \geq 0.5v$$

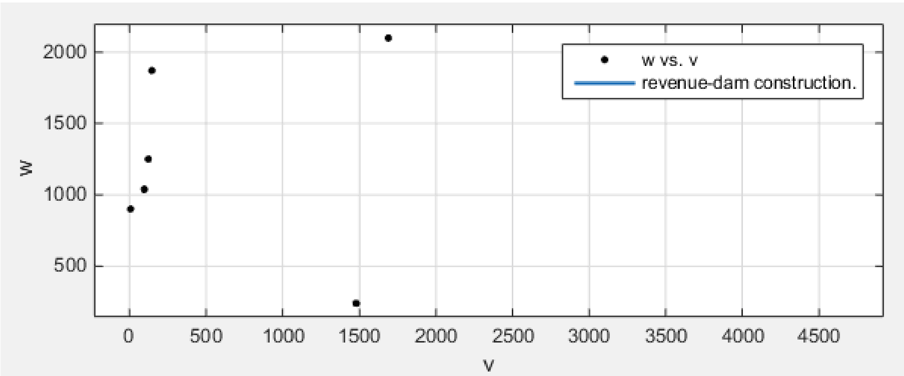
3. SENSITIVITY ANALYSIS

We consider the relationship between revenue and dam construction.

The Kaliba Dam is designed to generate electricity, generating more than 80% of its annual revenue from electricity generation. Here, we consider the relationship between installed capacity of a hydropower station and dam water storage capacity.

Based on the relationship between the storage capacity and installed capacity of several hydropower stations, we get the functional images.

The results show that there is little relationship between water storage capacity and installed capacity .So our assumption about water storage and return is reasonable.



4. CONCLUSION

In this paper, we consider the factors of capital storage and other factors, analyze the problem of the reconstruction of the dam, give the optimal location point in theory, and provide a reasonable operation strategy. After analyzing sensitive questions, we find that our hypothesis is feasible and our result is reasonable.

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