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Location of dam using Analytic Hierarchy Progress

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Abstract. By analyzing the specific case of dam, we can determine the location of the new dam with using the model -- Analytic Hierarchy Progress (AHP), which figures out the result by three main criteria and each criteria is related to two or three sub-criteria. We get the proportion of three main criteria through the AHP model and select the final dam site. In order to obtain the more precise result, we need to make fully investigation and do some comparative programs to determine the location.

1. Introduction

Analytic Hierarchy Progress (AHP) is a model that can express a complex problem as an ordered hierarchical structure, and it can sort the schemes by people's decision. This method can handle the qualitative and quantitative factors in decision-making, and has the advantages of systematization, simplicity, practicability and effectiveness. The project of dam is comprehensive and we can use AHP to simplify the site selection process.

2. Background

Kariba hydropower plant is the fourth-greatest reservoir in the world with the largest reservoir storage. Whereas it has been central to energy security and supporting economic development in both Zambia and Zimbabwe, now the Kariba Dam requires rehabilitation works for its continued safe operation. A failure to invest in the timely rehabilitation of the dam will result in the gradual degradation of key dam safety features to a level below international standards. Therefore, this rehabilitation project, which represents the culmination of a series of in-depth technical studies over the past few years, is absolutely crucial and urgent, and will restore the full safety of the dam.

Under this circumstance, the Zambezi River Authority (ZRA) inclines to remove the existing Kariba Dam and replace it with a series of ten to twenty smaller dams along the Zambezi River. And how to choose the location of the series of dams is vital. We can get the answer by the Analytic Hierarchy Progress Method.

3. Analytic Hierarchy Progress(AHP) Model

3.1 Model Building

In the upstream of Zambezi River, the flow velocity is slow, the terrain slopes gently which make it not worth to exploit hydropower resources, so that we choose to construct dams in middle and upper reaches, middle reaches and lower reaches.We can list a table according to the criteria and sub-criteria that restrict the location of the series of dams.

Then, we build the site-selection APH evaluation system consisting of the target later, the criteria layer, the sub-criteria layer and scheme layer and draw structure chart in Fig. 1.

Table 1: The factor should be considered in AHP

criteria	Environment and Location	Economic Investment	Reservoir Storage
Sub-criteria 1	Human activities	Permanent land investment	Artificial regulation
Sub-criteria 2	Hydrology Resources	Resettlement Investment	precipitation
Sub-criteria 3	Topography	Total static investment	

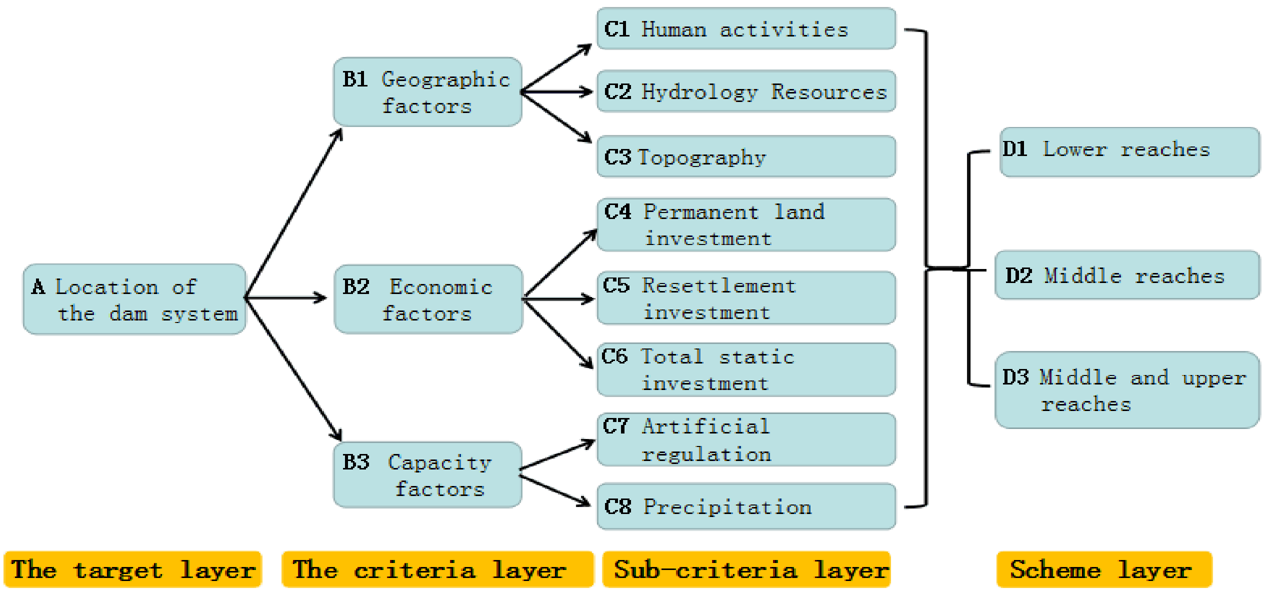

Fig. 1 The structure chart

3.2 Model analyzing

Even though the criteria in this model is not independent, it's not related to all elements neither. The table followed will describe the connection between the factors clearly.

Table 2: The relationship among the criteria and sub-criteria

Sequence	Factors	Relationship between the factors
1	A	determined by B1, B2, B3
2	B1	determined by C1, C2, C3
	B2	determined by C4, C5, C6
	B3	determined by C7, C8
3	C1~C8	All determined by D1, D2, D3

From the above table, we need to sort out the importance degree of each element which is determined by comparing with the other elements.

Table 3: The importance degree among the criteria and sub-criteria

Sequence	Factors	Importance degree
1	A	B2>B1>B3
2	B1	C2>C3>C1
	B2	C4>C5=C6
	B3	C7>C8
3	C1	D1>D2>D3
	C2	D1=D2>D3
	C3	D1>D2>D3
	C4	D2>D1>D3
	C5	D1>D2>D3
	C6	D2>D1>D3
	C7	D3>D2>D1
	C8	D1>D2>D3

(X1>X2 means the factor X1 is more important than the factor X2; X1=X2 means the factor X1 is as important as the factor X2)

According to the importance degree, we can suppose the judgment matrix of each layer as follows.

A	B1	B2	B3
B1	1	1/5	3
B2	5	1	7
B3	1/3	1/7	1

B1	C1	C2	C3
C1	1	1/7	1/3
C2	7	1	5
C3	3	1/5	1

B2	C4	C5	C6
C4	1	7	7
C5	1/7	1	1
C6	1/7	1	1

B3	C7	C8
C7	1	7
C8	1/7	1

C1	D1	D2	D3
D1	1	3	5
D2	1/3	1	3
D3	1/5	1/3	1

C2	D1	D2	D3
D1	1	1	1
D2	1	1	1
D3	1	1	1

C3	D1	D2	D3
D1	1	3	5
D2	1/3	1	3
D3	1/5	1/3	1

C4	D1	D2	D3
D1	1	1/3	1/5
D2	3	1	1/3
D3	5	3	1

C5	D1	D2	D3
D1	1	3	5
D2	1/3	1	3
D3	1/5	1/3	1

C6	D1	D2	D3
D1	1	1/3	3
D2	3	1	5
D3	1/3	1/5	1

C7	D1	D2	D3
D1	1	1/3	1/5
D2	3	1	1/3
D3	5	3	1

C8	D1	D2	D3
D1	1	3	5
D2	1/3	1	3
D3	1/5	1/3	1

Fig. 2: The judgment matrix of each layer

3.3 Result

Based on the judgment matrix, we calculate the proportion of each factor with MATLAB programming language.

Table 4: The proportion of each factor

criteria		Environment and Location	Economic Investment	Reservoir Storage	Total sort weight
Proportion of criteria B		0.6544	0.2289	0.1167	
	C1	0.6370	0.2583	0.1047	0.4882
	C2	0.4737	0.4737	0.0526	0.4246
	C3	0.6370	0.2583	0.1047	0.4882
	C4	0.2583	0.6370	0.1047	0.3271
	C5	0.6370	0.2583	0.1047	0.4882
	C6	0.2583	0.6370	0.1047	0.3271
	C7	0.1047	0.2583	0.6370	0.2020
	C8	0.6370	0.2583	0.1047	0.4882
Proportion of Scheme layer	D1	0.8163	0.6477	0.4992	0.6674
	D2	0.2855	0.2266	0.1746	0.2335
	D3	0.1456	0.1155	0.0890	0.1090

We calculate the relative parameters to test the consistency of each layer with the data in **Table 4** to judge the consistency of the judgment matrix.

There are some formulas to calculate CI and CR.

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{1}$$

Where

$\lambda_{\max}$ is the largest eigenvalue of every factor;

n=3 is the number of the factors in the criteria layer;

CI is the consistency indicators of each layer.

$$CR = \frac{CI}{RI} \tag{2}$$

Where

RI=0.58 is the random consistency index of each layer;

CR is the consistency ratio of each layer.

By analyzing the above result, we can find that the CR of each layer is less than 0.1, which means the judgment matrix meets the consistency demand and we can consider the result we get is right.

Table 5: Proportion of each scheme

Scheme	Proportion
D1	66.74%
D2	23.35%
D3	10.9%

According to the analysis above, the best site selection of the dams is the downstream

4. Conclusion

Generally speaking, in the case of site selection, the proposed criteria should be as comprehensive as possible, and the sub -criteria should be refined, which will greatly improve the objectivity of decision-making. The implementation of the project according to the actual demand, the project construction cost and other factors for further argument on the results of the analysis, according to the needs of decision.

References

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