Post-Disaster Reconstruction Management using the Analytic Hierarchy Process (AHP) Method

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***Abstract* — Currently world's natural disasters are occurring frequently. The feasibility of reconstruction management programs plays a significant role. From timeliness, planning and design management, project tendering management, quality management, schedule management, capital management and acceptance management, using Analytic Hierarchy Process (AHP) method, the model of evaluating the feasibility of the reconstruction area management program was established. Comparing to Lushan Liming village, Mianzhu Hanwang and Qinghai Yushu, the conclusion was that Lushan Liming village was the best.**

Keywords - reconstruction management; ahp method; feasibility; lushan liming village

I. INTRODUCTION

Due to human living in nature, natural disasters can't be avoided in human life. Reconstruction became the topic of common concern. Reconstruction is process including taking emergency rescue, disaster management, post-disaster assessment, relief, and planning, after the occurrence of the disaster and when it is going. It is the typical system engineering, and can be divided into pre-emergency reconstruction, the medium-term of restoration and the later development of reconstruction [1]. Reconstruction management involves many aspects, for example, planning and design, project bidding, quality management, schedule management, investment management and final acceptance [2]. In the background of social transformation, the oversight role of reconstruction management is very important [3]. With its unique advantages and inherent characteristics, NGO presets a huge space in the field of post-disaster reconstruction, playing an active role. Through investigation and assessment functions, assist the planning function, education function, fund raising function, NGO is recognized by society in the post-disaster reconstruction activities. Combining with policy, economics, management, technology and other factors, based on consideration of its specificity, reconstruction work includes a comprehensive analysis on the reconstruction cost factors. Meanwhile, the construction departments should do the overall planning, make practical construction plans, collect the retained site attestation and image data, and prepare for the completion of the settlement. This paper will begin with the factors of reconstruction management, doing a comprehensive analysis of the feasibility of the reconstruction area management program and providing recommendations for future management of post-disaster reconstruction.

II. THE FACTORS OF RECONSTRUCTION MANAGEMENT PROGRAM

From the time dimension, the whole process of reconstruction is divided into three stages including temporary, preparation and overall reconstruction. In reference to the literature, we summed up the factors at all stages of reconstruction. In the temporary reconstruction phase, after subjecting to the disaster, the victims failed to ease the psychological trauma, the urgent need to provide temporary shelter to appease victims 4-6]. Therefore, the timeliness of reconstruction is the primary factors. In the reconstruction preparation phase, planning and design management and project tendering management are the important factors. In comprehensive reconstruction phase, quality management, schedule management, capital management and acceptance management are the important factors. The following will use the analytic hierarchy process, starting from the various impact factors at the stage, establishing the feasibility evaluation model of reconstruction management programs.

III. AHP PRINCIPLE

AHP can solve complicated, ambiguous decision problems [7]. Use this method to construct the model generally requiring four steps:

Establish a hierarchical structure of the program;

Construct the matrix entirely used to determine each level;

Single-level sorting and the test of consistency;

Total level sorting and the test of consistency;

The following is described in detailing the various steps of process.

A. Hierarchical Structure

The problem solved by AHP is hierarchy, methodical, logical. Only in this way, we can construct a hierarchy scheme. According to their properties, the degree of membership and the partnership, the elements of complicated issue develop a plurality of progressive layers. A layer of elements can play a dominant role. In general, these levels are divided into three categories.

Top layer: This layer contains only one factor. Usually, it is the ultimate goal of the researched questions. You can also call this layer as the target layer.

The intermediate layer: In order to achieve the objectives related to the process, it may be a plurality of layers, considering a plurality of multilayer criteria. You can also call this layer as the guidelines.

Bottom layer: This layer is promising to achieve the target for a variety of methods or means. It can also be called as measures layer or scheme layer.

The hierarchy number of hierarchical structure is related to the tedious degree of researched questions and the detailed requirements. Generally the number of hierarchy is not limited, the respective layers of each element is dominant factors usually no more than 9.

B. Construct Judgment Matrix

The structure of layers can show the relationship between factors, but the proportion of the middle evaluation of the various factors that account for the fundamental objectives are not the same. In the minds of evaluators, various factors have a certain percentage. When we determine the proportion of various factors, the influence of n factors $X=\{x_1,\cdots,x_n\}$ to Z is compared. Saaty suggested to pairwise comparison for factors completing alignment matrix. Selecting two factors x_i x_j at each time, a_{ij} expresses the ratio of the degree of influence x_i and x_j to Z. $A=(a_{ij})_{n\times n}$ expresses all comparison relationships. A has become Judgment matrix between $Z-X$. As can be seen from the matrix, if the ratio of the impact x_i and x_j to Z is a_{ij}, the ratio of the impact x_j and x_i to Z is $a_{ji}=\dfrac{1}{a_{ij}}$. According to the theory of knowledge of linear algebra, If the matrix $A=(a_{ij})_{n\times n}$ is satisfied $a_{ij}>0$ and $a_{ji}=\dfrac{1}{a_{ij}}(i,j=1,2,\cdots,n)$, matrix A is a positive reciprocal matrix. You can determine the value of the scale based on the value of the table, and the content is as shown in Table I:

TABLE I SCALE VALUE TABLE

Scale	Significance
1	It shows the importance of the two compared elements.
3	It indicates that two elements of the comparison, the former is slightly more important than the latter.
5	It indicates that two elements of comparison, the former is much more important than the latter.
7	It indicates that two elements of the comparison, the former is very more important than the latter.
9	It indicates that two elements of comparison,the former is extremely more important than the latter.
2,4,6,8	It shows that they are in the middle level.
Reciprocal	It shows that the ratio of the impact x_i and x_j to Z is a_{ij}, the ratio of the impact x_j and x_i to Z is $a_{ji}=\dfrac{1}{a_{ij}}$

C. Consistency Checking

Eigenvector the matrix corresponding to the maximum value of eigenvalues $\lambda_{\max}$ is W. By normalization which is the same level of the corresponding element on one level for a relatively important factor in ranking weights, this process is called single-level sort. Although this process can reduce the interference of other factors, in a comprehensive comparison, the results are bound to inconsistency. If the comparison results are the same, the factors also need to be met:

$$a_{ij}a_{jk}=a_{ik},\forall i,j,k=1,2,\cdots,n \tag{1}$$

Satisfying the above formula is called Reciprocal matrices consistent matrix. To facilitate determining A can be accepted, you must verify whether the inconsistency A is very serious. If A is consistent matrix so

(1)A must be positive reciprocal matrix.

(2)Transposed matrix A^T is consistent matrix.

(3)A matrix of any two rows is in proportion, and the factor is greater than 0, so $rank(A)=1$, the column is same to this.

(4) $\lambda_{\max}=n$ in A, n is the order of the matrix A. A Other feature roots are 0.

(5) $\lambda_{\max}$ corresponding eigenvectors are $W=(w_1,\cdots,w_n)^T$,so $a_{ij}=\dfrac{w_i}{w_j},\forall i,j=1,2,\cdots,n$

$$A=\begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{bmatrix} \tag{2}$$

A is a positive reciprocal matrix of n order. When it is consistent matrix, $\lambda_{\max} = n$.

When A is inconsistent, $\lambda_{\max} > n$. So, by checking the relationship of $\lambda_{\max}$ and n, test A matrix consistency.

The step of checking A matrix consistency:

(1) Calculate consistency target CI.

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{3}$$

(2) Find the corresponding average random consistency index RI. RI Values in Table II.

TABLE II RI VALUES

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.1	1.2	1.3	1.4	1.4

RI values were obtained by the sample matrix with the institution of methods come. Random from 1-9, their penultimate is picked up, counting digital configured positive reciprocal matrix, averaging maximum characteristic $\lambda'_{\max}$ root. And define

$$RI = \frac{\lambda'_{\max} - n}{n-1} \tag{4}$$

(3) Solve the consistency ratio CR.

$$CR = \frac{CI}{RI} \tag{5}$$

When $CR < 0.10$, A consistency can be passed. On the contrary, it makes adjustments.

This process also includes the total level sorting and consistency check. It's the same method.

IV. EVALUATION MODEL

Establishing model is intended to the theoretical analysis of the reconstruction administration feasibility. Learned from the theoretical analysis, we can provide recommendations for future reconstruction work.

A. Construction of the Target Layer, Criterion Layer and Scheme Level

Target layer is the most feasible reconstruction program. Guidelines layer is timeliness, quality management, schedule management, financial management, inspection management, planning and design management and project tendering management. Scheme layer is Lushan Liming village, Mianzhu Hanwang and Qinghai Yushu. As shown in Figure 1.

B. Construct Judgment Matrix

Judgment matrix need to determine the importance of the seven factors of reconstruction management scheme. In Lushan Liming village, Mianzhu Hanwang and Qinghai Yushu, we conduct questionnaire for these seven factors. By quota sampling[8], extracting respondents(officers and soldiers involved in disaster relief, the public and the personnel of reconstruction). 300 questionnaires were distributed. The number of actual recovery valid questionnaires is 286. Effective recovery rate is 95.33%. After finishing, the survey results are as shown in Table 3.

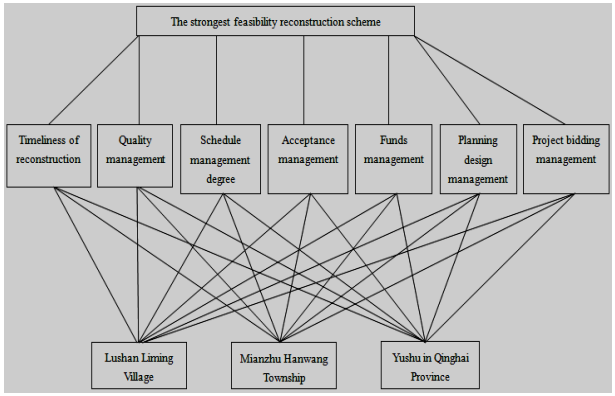

Figure 1. Knees action while shooting

TABLE III THE IMPORTANCE OF MANAGING THE RECONSTRUCTION SCHEME FACTORS

Factors	Quantity	Percentage (%)	Sequence
Timeliness	190	66.43	1
Quality management	161	56.29	2
Schedule Management	133	46.50	3
Funds Management	106	37.06	4
Acceptance Management	74	25.87	5
Planning Design Management	54	18.88	6
Project Bidding Management	39	13.63	7

According to the data in Table III, we construct the comparison matrix of target layer, combining the principle of constructing judgment matrix, as shown in Table IV.

TABLE IV THE PAIRWISE COMPARISON MATRIX OF TARGET LAYER

A	B_1	B_2	B_3	B_4	B_5	B_6	B_7
B_1	1	2	3	4	5	6	7
B_2	1/2	1	2	3	4	5	6
B_3	1/3	1/2	1	2	3	4	5
B_4	1/4	1/3	1/2	1	2	3	4
B_5	1/5	1/4	1/3	1/2	1	2	3
B_6	1/6	1/5	1/4	1/3	1/2	1	2
B_7	1/7	1/6	1/5	1/4	1/3	1/2	1

In one factor, the comparing matrix of scheme layer compares several schemes. Matrix constructor with the same construction method above matrix, portion matrixes are given directly, and others partially are omitted. As shown in Table V to VII.

TABLE V THE PAIR MATRIX OF GUIDELINES LAYER (B_1)

B_1	P_1	P_2	P_3
P_1	1	3	2
P_2	1/3	1	1/2
P_3	1/2	2	1

TABLE VI THE PAIR MATRIX OF GUIDELINES LAYER (B_2)

B_1	P_1	P_2	P_3
P_1	1	5	3
P_2	1/5	1	1/3
P_3	1/3	3	1

TABLE VII THE PAIR MATRIX OF GUIDELINES LAYER (B_3)

B_3	P_1	P_2	P_3
P_1	1	2	1/2
P_2	1/2	1	1/3
P_3	2	3	1

Comparison matrixes of other factors are not mentioned here, directly applied in the calculation.

C. Calculation of Results

Through Matlab software programming computer, the results are shown in Table VIII.

As seen from Table VIII, scheme 1 is the most feasible solution. The feasibility of reconstruction program at Lushan Liming is strongest.

V. CONCLUSION

Combining with the current situation analysis, the development is good at Lushan Liming. This is consistent with the results of the model, indicating the rationality of the model. The feasibility of reconstruction program plays a vital role in the future development for affected areas. The model provides a theoretical basis for the establishment of reconstruction program in future.

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TABLE VIII THE TOTAL LEVEL SORTING

Guidelines		B_1	B_2	B_3	B_4	B_5	B_6	B_7	Total sort weights
Guidelines layer weights		0.3543	0.2389	0.1587	0.1036	0.0676	0.0448	0.0312	
Guidelines layer single sorting	Lushan Liming	0.5396	0.6370	0.2970	0.6370	0.0672	0.6370	0.2970	0.4988
	Mianzhu Hanwang	0.1634	0.1047	0.1634	0.1047	0.0205	0.1047	0.1634	0.1309
	Qinghai Yushu	0.2970	0.2583	0.5396	0.2583	0.9123	0.2583	0.5396	0.3703

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