Disaster Prevention for a Sustainable Community Using Fuzzy Analytic Hierarchy Process in Miaoli, Taiwan

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Abstract: This study attempts to construct a new three hierarchical evaluation model for assessing disaster prevention of a sustainable community in Miaoli country, Taiwan. Fuzzy Analytic Hierarchy Process (FAHP) technique has been applied for multivariable analyses between interacting disaster and its prevention preparation. An empirical in-situ study was conducted to examine the FAHP of disaster management evaluation model. This model effectively promoted the quality of decision making for further related researches. Results show that nine middle level dimensions can be deduced from two upper hierarchical levels that include the establishment of community database in local information and risk, and the preparation of disaster equipment and education training. The first theme and associated benchmarks are: (1) establishing community information database; (2) evaluating vulnerability risk; and (3) analyzing local building condition. The second theme and associated benchmarks are: (1) organizing community's residents; (2) scheming disaster command center; (3) investigating usable resource; (4) arranging disaster saving equipments; (5) educating rescuing skill; (6)training disaster prevention. The nine dimensions expressed by the expert group questionnaire data in the community of Miaoli county were ranked and weighted collectively for 28.5%, 21.3%, 14.3%, 5.6%, 6.8%, 3.6%, 8.3%, 6.1%, and 5.5 % for the nine aforementioned dimensions, respectively. The method may be helpful to decision-maker for disaster prevention of a sustainable community.

Key-words: FAHP, Sustainable Community, Educating rescuing skill, Disaster prevention, Benchmark.

1.

1. Introduction

Many efforts have been made to develop disaster prevention for local residents [5, 6, 9, 13~14]. An application of hazard mitigation technologies to reduce disaster losses was provided by Chen et al. [1] who examined the evolution of the natural disaster management system in Taiwan and found that a very strong relationship with the occurrence of mass disasters. The first fundamental disaster management law - the Disaster Prevention & Response Act (DPRA) was promulgated in 2000. Sebastiaan et al. [2] showed a standardized method of classifying flood deaths and the difficulties associated with comparing, and assessing existing information on flood deaths. A more solid basis for the formulation of prevention strategies and better systematic recording of flood fatalities is suggested. Lu, et al. [5] discussed cumulative effects of past land use changes on Taiwan's mountainous watersheds. Monitoring and studies of mudflows are important for disaster prevention and for the sustainable use of land and water resources particularly in mountain areas threatened by deforestation [6]. Wang, et al. [3] also pointed out a prevention system would provide beneficial reference for the debris flow's monitoring network to be executed on Chengdu-Kunming Railway, China, in order to effectively forecast and alarm the debris flow disasters and reduce the losses.

Regarding environmental disaster study, it is complicated and covers multidisciplinary area. A systemic method of preventing the environmental disaster, by using an integrated and hierarchy way, could be a adequate tool. Among systemic methods, Fuzzy Analytic Hierarchy Process (FAHP) is a more effective way for complicated strategy decision and is able to predict and to enhance managers' ability [8~11]. Moreover, the FAHP method is a more integrated application which breaks down a

complex problem into simple and manageable task. Unfortunately, FAHP has not been applied in disaster prevention of sustainable development study yet. In this work we tried to apply it in a case of Pinglin Community in Miaoli county, Taiwan.

Taiwan has not only the second highest population density in the world but also has 74% mountainous areas with steep slopes and weak geologic formations. It is among few places in the world that was frequently threatened by the environmental disasters as well as watershed management problems. Again, each typhoon season brings torrential rainfall, resulting frequent flooding, debris torrents, and landslides [5, 14]. In addition, dealing with risk and insecurity, it is a central part of how poorer rural people develop their livelihood strategies that has begun to position disaster mitigation and preparedness within many poverty alleviation agendas [4]. Many natural hazards cause major economic losses and resident's fatality, thus risk management in mountainous rural area is becoming a mainstream concern in Taiwan.

In this study we aim to select a case in Maioli county of Taiwan and try to find a systemic method to provide managers a more systematic understanding way of these problems and offer them more effectively disaster prevention management strategy toward sustainability [5, 7, 13]. The purposes of this study are focused on: (1) assessing disaster prevention strategy in rural areas; and (2) using the FAHP by questionnaire survey to achieve important management factor. Eventually disaster prevention could be extended to whole rural areas.

2. Site investigation and method

2.1 Site

Pinglin Community is located at northeast of Zhuolan town of southern Miaoli county (Fig. 1). The Pinglin terrain is mostly hilly, and majority of the community residents built their homes near the mountains. About 30% of Pinglin's eastern area originates from forested hills, and is also the area of the upstream Dage brook. It is well known that after 921 Earthquake, the ground became soft, the Taozi typhoon and 72 Floods brought copious rainfall that attacked Pinglin and Dage mountains' primitive forest region. Due to the steep terrain, large volume of rainfall brought down a large volume of earth, rocks and trees, carried downstream by the Dage brook (Fig. 2).

The event caused the destruction of agricultural areas in seven of Pinglin's neighbors and washed away three residents and compelled the residents of Dage mountain's neighborhood to evacuate, also generated the disruption of the main roads of communication and transportation in Pinglin. Because disasters happened frequently, and Pinglin is only a village quite far from Zhuolan town, therefore this community planned a rescue crew organization under the county government office to manage disaster prevention and relief organizations.

2.2. Research Method

2.2.1 Literature Discussion and FAHP (Fuzzy Analysis Hierarchy Process) application

Local and international related literatures to disasters counter measures and mechanism, were collected to realize the fundamental disaster prevention and rescue work preparation. Both natural system vulnerability and human system vulnerability to cause natural disaster were considered in this study (Fig. 3). By the FAHP questionnaire survey the most important variables can be acquired important management factors. After local government's personnel went through disaster prevention and rescue, the most important disaster prevention factor were selected. At last, we adopted the FAHP induction to achieve important management factors related disaster prevention, rescue's technology and expertise viewpoint in order to enhance the community's disaster prevention ability (Fig. 4).

3. Questionnaire Designing

3.1 Design Method

The goal of questionnaire survey is to examine the appraisal construction and content established by this research, to confirm the appraisal index factors, and to appraise each index factors that correspond importance and less importance, and then to use as reference value for the research's appraisal community. The interviewers of questionnaire were made up of the experts who had most related research

area of expertise, then took the fuzzy strata analysis process integrating these experts' opinion and obtained more objective factor weight. Based on the research goal and design's construction, we planed the questionnaire contents: (1) each factor content and questionnaire fill-up; and (2) appraisal factor's weight.

3.2 Survey Questionnaire

This research chose surveyed experts who are specialized in disaster management, disaster strain, disaster avoidance, community disaster prevention etc. This selection of experts for the questionnaire survey follows: (1) practical experienced persons engaged in disaster prevention and correlated work; (2) experts whose have this related disaster prevention background. Total nine experts were surveyed for the disaster prevention and preparedness level management ability with appraisal measures in Pinglin community. The questionnaire's experts consist of three scholar/researchers, four disaster prevention managers at county, and two disaster prevention managers at local community. Survey results show that nine questionnaires all went through consistency test and effective questionnaire ratio is 100%. Level and bench weights of sustainable Pinglin community FAHB analysis was indicated in Fig. 5 and Fig.6.

4. Results and Discussion

The analyzed questionnaires provide a set of appraisal's system from acquired 36 measures' certified weight. Table 1 listed the measures' importance weight rank, using the measures numbers. The total weight were considered as 1 (100%) in this community disaster prevention and disaster preparation management level ability. We adopt the most important weight value as the disaster prevention management strategy, and the number listed 1 to 19 were accumulated weight which is approximately 76%, and was thought as disaster prevention management's main foundation, number listed 20 to 29 is approximately 93% as the middle degree disaster prevention management ability. Number 30 to 36 listed as advanced disaster prevention management ability due to a relative small value. Evaluating disaster prevention management total ranks in Pinglin community analysis are listed in table 1; W means the abbreviation of weight, R means that of rank.

5. Conclusion

It is urgent to integrate past experiences from different community disaster prevention management experience. This step establishes effective domestic community disaster prevention management measures. Current disaster prevention management has already focused on community disaster prevention rather than traditional administration of community. Over this research, we conclude:

(1) This research used the expert questionnaire analysis to establish a set of slope mountain community disaster prevention management and ability appraisal targets, which can be used as priority consideration for community management leading the future community managers and residents to effectively carry out disaster prevention measures in Miaoli county, Taiwan.

(2) Community disaster management ability appraisal criterion can be effective measured. Domestic community disaster prevention's preparation management stage is insufficient; it only carries out in part of communities at present. Because local resident's in community will face the problem that they had not sufficient expertise and knowledge while comparing with international situation [16], this management was mainly promoted by government and experts.

(3) AHP's appraisal method evaluates the ability in community disaster prevention's preparedness management which is a critical step. For offering community disaster prevention's preparedness and management measures, this research tried to design an appraisal method. First we used this research's design method to appraise community disaster prevention management ability, second pointed out how to improve the weakness, thus would strengthen the community's disaster prevention ability. This research appraisal target accumulated weight is lower than 76% for the low-level management ability of community, 63% ~

93% for the mid-level one, and greater than 93% for the high-level one. By this analysis, it clearly pointed out that this research established targets system and the first step to design appraisal method in evaluating the results which is consistent with the ideas and methods that presently promoted by government towards disaster prevention community in Taiwan.

(4) Using this research method's appraisal, we not only identify the targets but also proposed targets measures according to first rank of weight degree. It is hoped that these research results can provide a method using limited target measures as the first priority to manage community disaster prevention.

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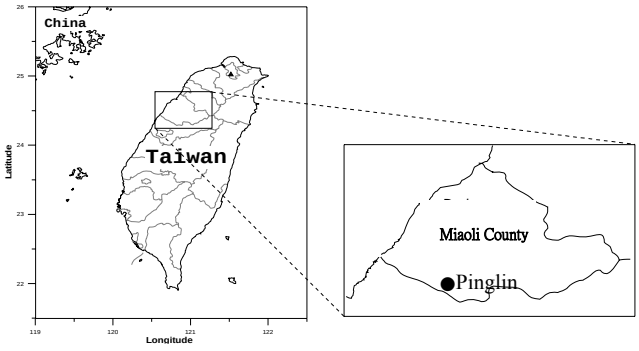

Fig. 1. Location of Pinglin community in Miaoli county, Taiwan.

Fig. 2. Dage brook of Pinglin community in Miaoli county, Taiwan.

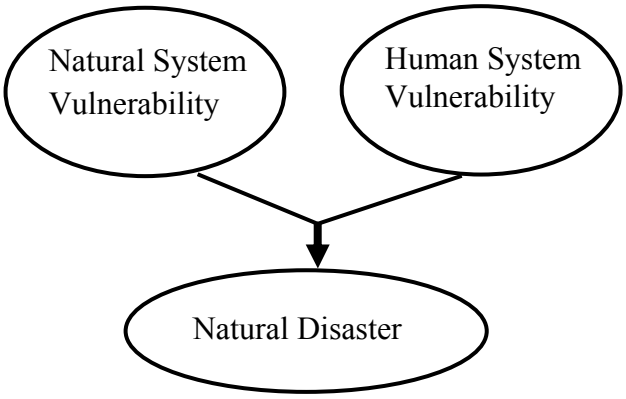

Fig. 3. The structure of natural disaster.

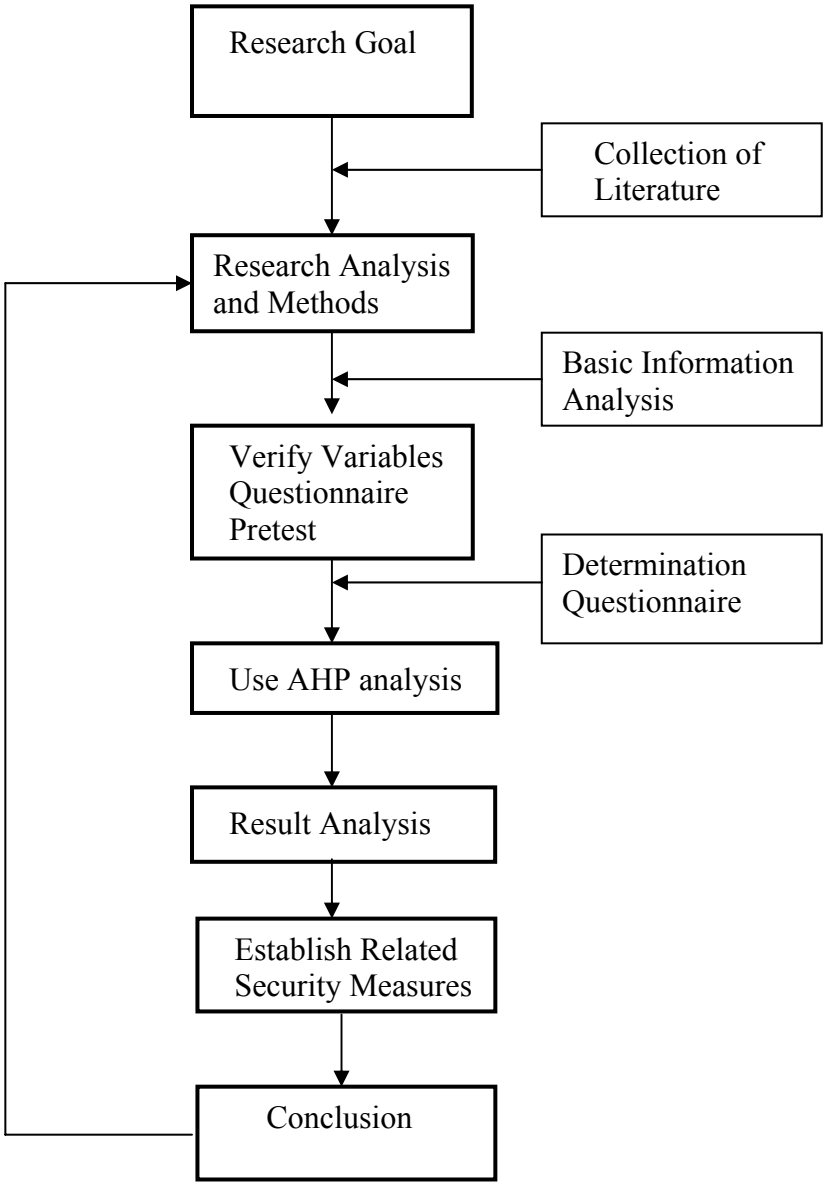

Fig. 4. Research flow chart in Miaoli county of Taiwan.

Table 1 Results of priority of indicator analysis and overall rank in this expert questionnaire.

Benchmark	Relative W.	Relative R.	Absolute W.	Absolute R.
1. Geographical Location	0.113	5	0.032	12
2. Traffic Conditions	0.067	8	0.019	22
3. Communication Situation	0.074	7	0.021	18
4. Geographical Environment	0.142	2	0.04	7
5. Hydrology and Meteorology	0.125	4	0.036	9
6. Land Use and Economic Industry	0.112	6	0.032	13
7. Historical Disaster Records	0.234	1	0.067	3
8. Households Population Surveys	0.134	3	0.038	8
9. Vulnerable Regions	0.296	3	0.061	4
10. Vulnerability Factors	0.379	1	0.081	1
11.Vulnerability Types	0.325	2	0.069	2
12. Planning of Evacuation Routes	0.295	2	0.042	6
13. Emergency Shelter Planning	0.315	1	0.045	5
14. Emergency Shelters	0.247	3	0.035	10
15. Substitute Road Planning	0.143	4	0.02	19
16. Command Center	0.278	2	0.016	26
17. Guard Team in community	0.325	1	0.018	23
18. Rescue Team of Neighborhood	0.269	3	0.0151	28
19.Volunteer in Communities	0.127	4	0.007	36
20. Internal Communication System	0.169	4	0.011	31
21. External Communication System	0.149	4	0.0103	33
22.Emergency Communicator	0.219	2	0.015	29
23. Name List of Communicators	0.176	3	0.012	30
24. Alarm System	0.286	1	0.0194	20
25. Material Management	0.526	1	0.0191	21
26. Material Transportation Planning	0.474	2	0.0173	24
27. Simple Alarming Equipment	0.291	3	0.024	17
28. Simple Life-saving Equipment	0.306	2	0.0254	15
29. Safety Equipment of Rescue's Team	0.402	1	0.033	11
30. Disaster Prevention Propagation	0.463	1	0.028	14
31. Education on Disaster Prevention	0.251	3	0.0153	27
32. Evaluation on Home Safety	0.286	2	0.017	25
33. Use of Communication Equipment	0.460	1	0.0251	16
34. Emergency Medical Service Training	0.174	3	0.0095	34
35. Disaster Evacuation Training	0.167	4	0.0091	35
36. Basic Life-saving Training	0.200	2	0.0109	32

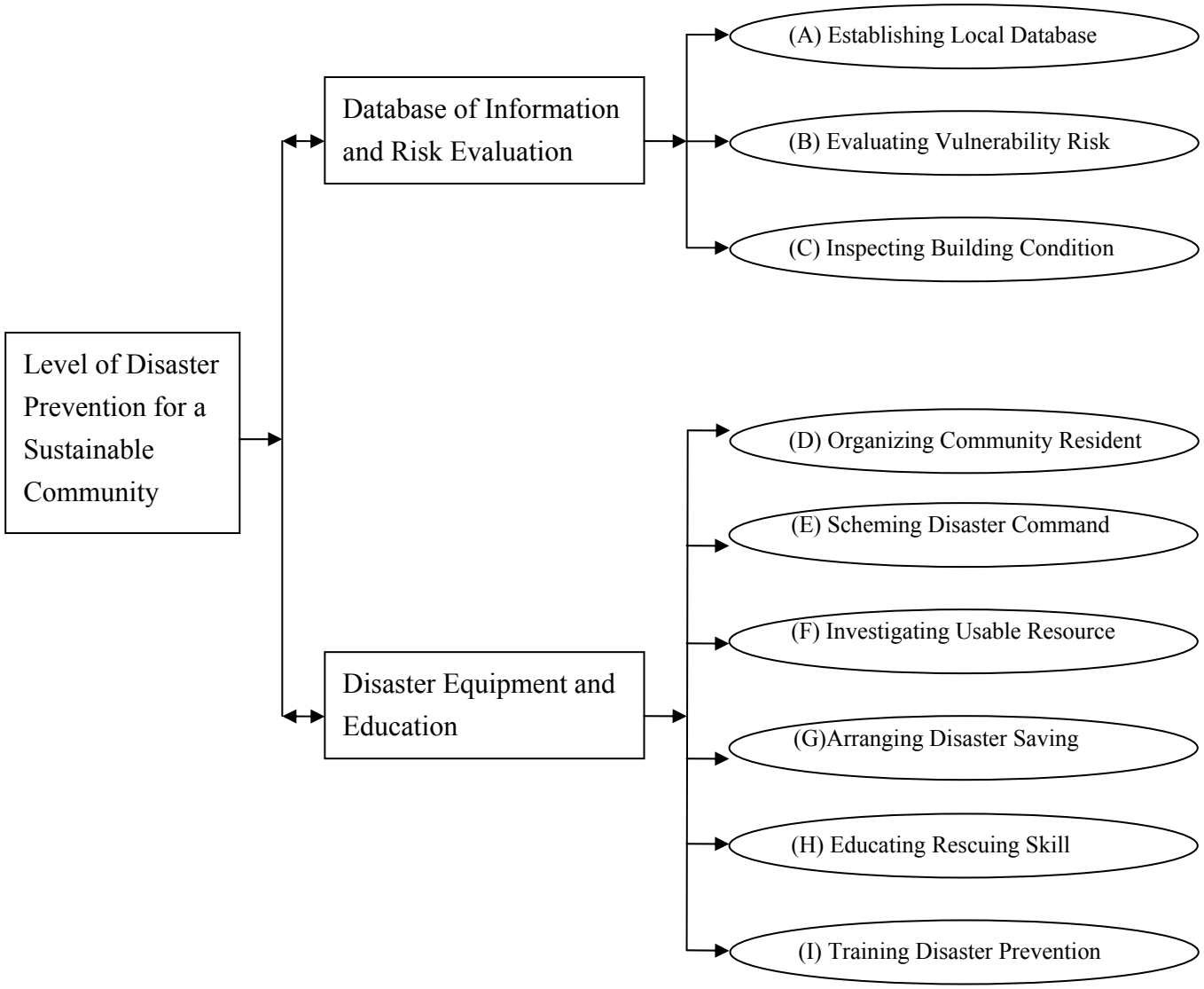

Fig. 5. Level of toward a disaster prevention for a sustainable community study using FAHB method in Miaoli county of Taiwan.

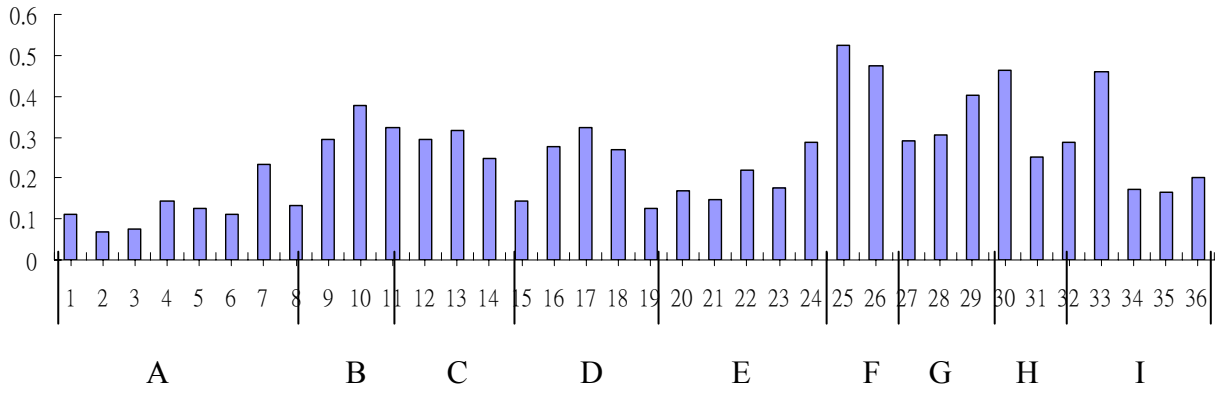

Fig. 6. Level of towards sustainable Pinglin community in Miaoli county, Taiwan. Left column shows relative weight of the 36 benchmarks. Arabic numbers in the bottom of this figure present the benchmark as listed in the left column of Table 1. Characters A~I means level name as Fig.5.