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Conducting an Evaluation Framework for Disaster Management under Adaptive Organization Change in a School System

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Abstract: This long-term study established a sustainable and resilient framework for enhancing organizational capacity and adaptability, based on adaptive thinking, for a school disaster prevention system (SDPS) for academic institutions located in a potential natural disaster area. Due to the movement of continental plates and the effects of tropical depressions, disasters occur frequently in Taiwan. We established a conceptual framework under aspects of organizational resilience for a SDPS for school institutions located in a potential disaster area under a choice experiment (CE) framework. We then evaluated the heterogeneity of staff perspectives on an adaptive disaster-mitigation program, as revealed by their preferences and estimated the marginal effects associated with various potential scenarios for such a program. We found that integrating stakeholder concerns about environmental issues, cooperating with local government drills, providing training to be disaster relief volunteers and cooperating with local government to implement disaster-prevention and protection projects were all valid program characteristics. This study also confirmed the existence of heterogeneity in the preferences of participants for adaptive management in SDPS context, as evidenced by their willing attitudes toward participation in education and training courses, participation in implementing disaster prevention and protection projects and undergoing training to be disaster relief volunteers. Specifically, the potential disaster prevention transformation program embodying these features was associated with the highest marginal willingness to work (MWTW). These outcomes can assist in the development and implementation of evaluation frameworks for organization-based management strategies in the context of SDPS.

Keywords: adaptation and change; organizational capacity; local preferences; policy making

1. Introduction

Natural processes and human activities both carry with them the potential for environmental disasters, although some degree of uncertainty usually surrounds when and where such events will occur. Traditional disaster management emphasizes governance and defense—with a focus on pre-disaster preparation, coping with emergencies and post-disaster recovery [1]. However, community resilience has emerged as a pressing issue in disaster management in recent years. It focuses on the process of improving community capacity and adaptation [2–4]. Community resilience emphasizes stability, recovery and adaptability, as well as learning from previous disaster experiences to prepare for subsequent disaster responses [1–5].

In the face of any disaster, it is imperative that organizations and institutions are able to maintain their functionality and prevent their vital facilities and infrastructure from being damaged. At the same time, organizations must have the capacity to learn from risk and adjust their coping strategies and procedures where necessary. This is known as comprehensive prevention and response [4–6]. Organizational resilience (OR) refers to the ability to cope with disasters immediately, to learn from disaster experiences and to improve the organization's ability to respond [7]. In the face of a crisis, ensuring organization members and stakeholders are well trained in evacuation drills and having sound disaster management plans in place can reduce casualties and losses. OR can thus be seen as a collection of abilities [4]. Resilience education involves cultivating individual resilience and adaptability so that the larger organizations such individuals are part of can respond quickly to crisis and have the ability to cope with and recover from it [1,2,8,9].

Taiwan is affected by the movement of the continental plates and the disturbances caused by tropical cyclones, and disasters often occur there [10]. This is especially true in the central part of Eastern Taiwan, which faces the Pacific Ocean. The terrain is mountainous and crisscrossed with rivers, with two mountain chains bisected by a long, narrow valley. The area is located in an active seismic belt and is regularly affected by tectonic plate collisions. It also bears the brunt of tropical depression disturbances that form over the Pacific Ocean, a number of which predictably develop into typhoons each year. In July 2012, Typhoon Saola hit the central part of Eastern Taiwan, and on February 6, 2018, a magnitude-6.2 earthquake struck there. The impact of disasters like these and the promotion of disaster prevention are the main factors that ensure the safety of schools and communities [11]. Despite the fact that both the aforementioned disasters caused deaths and damage, the passage of time brings with it the risk that disaster awareness will decrease as collective memory of losses fades. Disaster risk-reduction education and regular drills are therefore imperative to maintain a basic level of resilience for any organization or community. This awareness and training must be inculcated in the populace from a young age so that every member of the community can implement appropriate responses when necessary. Therefore, fostering organizational resilience in schools by training faculty to be resilient in their thinking is central to any school's ability to cope with disaster management and educate the next generation in this regard. In practical terms, the key to interoperability in terms of disaster management lies in the integration of communication interfaces, centralized resources and unity of power [12]. We therefore integrate the various organizations, extant topical research and relevant development plans collated from various administrative departments and disaster relief organizations to construct an integrated emergency management system. The vertical integration and horizontal connection are intended to provide continuous support for disaster responses that can be modified according to different disaster situations, as needed, to maintain the effectiveness of response actions [7,9,13].

CE methods are most commonly used for agricultural benefit evaluation, measuring ecotourism preferences and land use planning [14–17]. With CE methods, use and non-use values can be calculated. Moreover, by describing the preference heterogeneity across attributes, it is possible to estimate the changes and effects under various hypothetical states and estimate the differences between them. Understanding the hidden value or marginal value of attributes can allow participants to better understand the tradeoffs between different attributes. If the respondents choose a concentrated set of options and attributes or if the respondents are required to make their choices on multiple occasions, participation in the CE is premised on participants having higher cognitive ability [18]. However, we were unable to find research that has looked at faculty members' heterogeneity with regard to multiple attributes under various aspects of organizational resilience as it relates to disaster management. Ultimately, disaster management must be organized and implemented by members of the organization who are willing to participate in it. Therefore, the preferences of given organization members regarding disaster management determine the amount of time they are willing to work (WTW), the degree of their willingness to change and their coping behavior [7].

This study aimed to establish a conceptual framework under the OR aspects in a SDPS for schools located in a high-disaster-potential area, using CE methodology. Second, we evaluated the heterogeneity of the school faculty members' preferences for various aspects of a disaster-mitigation program. Third, we estimated the welfare values associated with several potential scenarios for such a disaster-mitigation program. We provide a synthesis and discussion of the role of OR in disaster management in Section 2, which includes perspectives on awareness, adaptation, transformation and community capital (CC). In Section 3, we introduce the research sites in our study and explain how we integrated the OR aspects into our CE model. The attribute and CE design of the disaster management program and the resulting hypothetical scenarios of disaster prevention management are also covered therein. Section 4 provides the empirical results of school faculty members' preference estimation under adaptive thinking for SDPS and the evaluation of faculty MWTW associated with various scenarios under a SDPS program. Section 4 summarizes our main research contribution. Finally, we outline management strategies for SDPS based on the evaluation framework of the OR program presented in our research.

2. The Role of OR in Disaster Management

Organizations frequently encounter disasters caused by climate change, making it necessary to develop effective responsiveness to emergencies. Unexpected events may occur inside or outside an organization, and there are different ways of coping with the type, location and duration of the accident [4,9]. Effective OR involves identifying threats and needs quickly, changing direction when required, avoiding conflicts and adapting flexibly to changes in the environment [2,19]. OR should be built around the concept of redundancy, so as to be able to maintain an organization's original functions without disruption [3,4,9]. Robust and agile OR can lay the foundation for effective disaster management.

2.1. Awareness

First and foremost, a resilient organization must have the ability to detect events. Disasters frequently occur at unexpected times and locations, and they cannot always be predicted accurately. Organizations therefore need to demonstrate their resilience not only through early preparations, but by having the ability to perceive changes in the environment, prevent crises from occurring, predict potential dangers and take direct action quickly [10]. The category of what we term "organizational capabilities" immediately enables viable alternatives [1,4]. Therefore, we regard the ability of an organization to detect impending or incipient crisis and prevent it to the fullest degree possible as one of the hallmarks of that organization's resilience. Another key element is the organization's capability to handle crisis events actively and respond to accidents with a strong sense of purpose [4]. Organizations must be able to perceive and interpret early warning signs accurately in order to make timely contributions and extend appropriate responses. To that end, collective or organizational perception is another important element of OR [1,4,10]. Awareness of the local environment is a critical factor in the resilience of school disaster education [20].

There are continuous factors at play in the occurrence of any accident. In the course of the development of one accident, another accident may be occasioned or the result of the previous accident may be continued to produce a new accident factor [21,22]. Therefore, responders use the exclusion method—controlling one of the incident factors—or, alternatively, trace backwards from the known accident to the previous factor to find the root cause closest to the accident at the end of the chain of causality. Such linked situations illustrate what is described often as the domino effect [21,22]. Regularly conducting compound disaster-responder drills, observing and identifying potential factors, participating in project planning, and simulating accident handling procedures can enhance organizational OR and increase the level of understanding among individual members of organizations [4,6]. Disaster management is not merely about action management focusing on large-scale issues, but rather about continually conducting new assessments and learning from small-scale event

experiences to derive pragmatic solutions [6]. Strengthening the resilience and flexibility of the organization calls for anticipating available resources and allocating them effectively [23], as well as having mechanisms in place to assure these resources are exploited as fully as possible in the event of a crisis, despite disruptions.

2.2. Adaptation

Leaders must recognize their control over their organizations' ability to change and must find ways to manage disasters through reflection and learning. The process of coping with disaster is the foundation of organizational learning and change. In addition, disaster response must be informed by professional knowledge encompassing a broad range of disciplines [9,19]. The experience of coping with disasters will enable an organization to make adjustments and the long-term learning resulting from the process should inform subsequent disaster-responser methods [8]. For an organization to be resilient, it must possess adaptability [2]. Adaptive ability can be built up through continuous learning, reflection on results and participation in community disaster prevention organizations (CDPOs). In this way, individuals are able to learn disaster management methods, knowing that the same types of disasters will tend to cause similar damage again [4]. Therefore, knowledge of the losses typically caused by a given type of disaster is an important learning resource for adaptability [2,4]. Disaster is an effective teacher. Even when encountered disasters differ in nature and kind, the extant body of topical knowledge they engender can be queried and used to solve problems. Adaptive management must be able to face cascading hazards or complex emergencies. This makes it necessary to improve forecasting and analysis capabilities, enhance response efficiency and establish and use disaster warning systems and disaster potential maps to implement preventive evacuations [9,11,13,24,25].

It can be said that OR is the ability to provide both confrontation and adaptation, as well as to correct improper management and erroneous understandings in the face of crisis and its mutation [23]. While the occurrence of accidents or events is unavoidable, a resilient organization can predict disasters and respond effectively before damage occurs [4]. Moreover, in the course of coping operations, having a sound understanding of the nature of expected environmental changes means such changes can be anticipated before they occur. This knowledge allows management models and rescue actions to be gradually revised, ensuring response flexibility is maintained [4,24]. Having an organization's members participate in disaster prevention drills and training them to be disaster relief volunteers, are demonstrated ways to enhance OR during operations [7,10]. Not only can exercises provide short-lived results, but they can also bolster self-efficacy and social support in school disaster education [25].

2.3. Transformation

In order to adapt to complex types of disasters, an organization may be required to change its existing management methods to improve its resilience. This entails a transformation of consciousness, whereby the organization must be able to develop a new management model and impart it to every constituent part of the organization, so that the organization can more efficiently perform contingency work. Thus, management of the change process is the foundation of OR [1,4,10]. Organizations can learn from crises and accidents and make appropriate changes to transform their previous knowledge and develop resilience. Transformation through disasters happens when individuals and organizations share their disaster experiences with each other to promote ongoing disaster prevention education. Constant revision and review provide critical reinforcement for a school system's resilience [26]. Organizations must have the ability to perceive crisis in order to cope with future disasters in concert with community-based disaster prevention systems. This means mastering the risks facing a given community is premised on disaster awareness, as is the ability to assist local governments to implement disaster prevention and protection projects. By astutely identifying potential risks and adopting positive contingency actions, an organization can transform its adaptive capacity to face division, change and stress [2,4,27], and, ultimately, to return to a balanced state after the disaster passes.

Organizational transformation requires resilient thinking, awareness of changes and a combination of keen perception and proper action to foster organizational resilience. Organizations must learn from crises, adapt to change, expand their ability to perceive situations and use spare resources flexibly to promote redundancy [2,3]. Social resources are thus the wellspring of OR, and community capital (CC) can lend critical insight to an organization and enhance coordination ability in a crisis [1,4].

2.4. Community Capital

Social capital is a resource that can be used, exchanged or reused [28]. There are 7 types of CC: social, human, natural, financial, physical/build, cultural and political capital [29]. A community's preparations for disaster prevention can be instructional for disaster management. For any geographical environment where people live, the locals' understanding of community vulnerability and possible consequences of disasters (natural capital) has a profound effect on community interactions. It also relates to the level of trust in community organizations (social capital). This is linked to people's willingness to cooperate with local governments to evacuate when necessary and to participate actively in pre-disaster prevention drills (human capital). These activities are closely connected to mastering the critical infrastructure, shelters and vulnerable areas (built capital), and are often contingent on the disaster preparation and prevention funds that can be accessed and how quickly natural and other resources can be restored, rebuilt and continuously utilized (financial capital) [1,29]. Based on the foregoing discussion, we propose an OR program for disaster management and identify the following five attributes: 1) the ability to perceive environmental risk and change; 2) the ability to reorganize and plan for disaster management; 3) the ability to prevent and cope with disaster; 4) level of interest in disaster management; and 5) willingness to work. A more detailed description of these attributes as they are reflected in our results appears in Section 4, and the evaluation framework of this research is contained in the final section.

3. Materials and Methods

The World Bank collected 15 to 25 years of disaster event records (Natural Disaster Hotspots: A Global Risk Analysis) and observed the exposure of regional populations (and associated GDP) to six major natural disasters: cyclones (typhoons), droughts, floods, earthquakes, volcanic eruptions and landslides (including debris flows). Among the results, Taiwan is listed as one of the world's most vulnerable countries to natural disasters because about 73% of the population lives in areas where more than three types of disaster occur, and more than 90% of Taiwan's total land area is affected by at least two types of disaster.

Taiwan is located in the path of subtropical typhoons in the Western Pacific. Due to typhoons, rainy seasons, southwestern airflows and northeast monsoons, the region is prone to frequent extreme heavy rainfall events. At the same time, Taiwan also sits at the collision point between the Eurasian continental plate and the Philippine Sea plate. The Earth's crust bends at the plate boundary and the central part of eastern Taiwan is prone to earthquakes because of this. The tectonic plates pushing against each other affect the rock layer, and the seam between them is obvious. The surface soil and debris atop the rock layer are easily dislodged and washed away by heavy rains, which also cause large-scale slope collapses and debris flows in catchment areas. According to statistics, 17 earth–rock flow disasters occurred in the central area of eastern Taiwan from 1989 to 2019, and there were 306 seismic events with a magnitude of 4.0 or higher. Among the latter, the devastating earthquakes in 1986 and 2018 were the most severe (Figure 1).

In recent years, Taiwan has promoted community disaster prevention mainly through enlisting the participation of residents, raising awareness of potential dangers and taking appropriate actions to establish a safe, secure and peaceful environment. Disaster risk reduction education ideally begins from a young age. Thus, disaster risk-reduction education is taught in schools, with programs in place to promote community residents' awareness of disaster prevention. Campus disaster prevention organizations composed of schoolteachers and staff are predicated on frameworks for community

disaster prevention [4,10,20]. Ideally, campus disaster- prevention organizations should be resilient, in addition to simply reducing accidents to ensure the safety of the students. However, the resilience of such organizations is uneven due to characteristics of the physical environment and financial facts of Taiwan's economy [4]. Insufficient environmental knowledge affects disaster awareness, and lack of funds affects the construction of infrastructure [11,30]. In light of this disparity, our research collected data from elementary and junior high schools located in the central area of eastern Taiwan, where there is a high disaster potential. The chosen locales had all been affected by disasters previously. In our sample, there were a total of 204 faculty members in 12 schools. We focused on the preferences and behaviors of individual members of disaster prevention organizations in schools, as they relate to disaster management, with a view to improving the resilience of those organizations.

Figure 1. Research scope of schools in the central area of Eastern Taiwan.

3.1. The CE Model

The CE methodology is a consumer theory derived from the utility function [31]. The CE captures individuals' preferences regarding the characteristics of goods and services [14,15,18]. By providing respondents with grouped questions, hypotheses can be tested by capturing the respondent's experiences and stated preferences for various attributes and levels, which can provide insight into their marginal willingness to pay (MWTP) for various scenarios [14,18,19]. To date, the CE model is often applied to evaluate the economic value of environmental resources, albeit less frequently in the context of disaster management. In this study, the CE method is applied to the field of OR in order to promote its application in research on disaster management.

Following previous CE research, this study utilized a CE design to understand OR in the context of disaster management. First, we built up the CE attributes and levels based on literature reviews covering the fields of OR. Second, we estimated the heterogeneity of respondents' preferences for disaster management based on the random parameter logit (RPL) [14,16,18]. We also used a *t*-test to characterize the observed individual-specific characteristics (i.e., age, willingness to implement disaster prevention and protection projects and training to be a disaster relief volunteer). The preference function of our study incorporating attributes and levels for OR (Table 1) can be represented with the following Equation:

$$V_j = \beta_1 \times Risk_j + \beta_2 \times Learn_j + \beta_3 \times Cope_j + \beta_4 \times Change_j + \beta_5 \times WTW_j \qquad (1)$$

where V_j is the utility function for OR relative to the alternative j and the other attributes and levels. β_j is the estimated coefficient for alternative i, where if a respondent chooses the option of the status quo this takes the value 1 or 0 otherwise. The other independent variables in this study are described as follows:

- $Risk_j$: the attribute of perceiving the environmental risk and change, where Risk = 1 means respondents had a higher preference for concern about environmental issues, otherwise Risk = 0;

- Learn$_j$: the attribute of having the ability to reorganize and plan for disaster management, where Learn = 1 means the respondents had a higher preference for cooperating with community organizations and drills, otherwise Learn = 0;
- Cope$_j$: the attribute of having the ability to cope with and prevent disasters, where Cope = 1 means the respondents had a higher preference for being disaster relief volunteers, otherwise Cope = 0;
- Change$_j$: the attribute of the level of interest in disaster management, where Change = 1 means the respondents had a higher preference for understanding community risks and cooperating with local government, otherwise Change = 0;
- WTW$_j$: the willingness to work (WTW) for an OR welfare foundation, measured according to levels which were decided based on the results of the on-site survey.

Table 1. Attributes and levels description in choice experiment (CE) model.

Attribute	Levels	Variable
Perceive the environmental risk and change	a. Status quo (participate in earthquake drill on September 21 each year) b. Participate in disaster prevention exercises regularly c. Concern about environmental issues	Risk± Risk 1 Risk 2
The ability to reorganize and plan for disaster management	a. Status quo (fire prevention lecture) b. Participate in disaster prevention organizations in community c. Cooperate with local government drills	Learn± Learn 1 Learn 2
The ability to cope with disaster prevention	a. Status quo (basic knowledge of disaster prevention) b. Training to be disaster relief volunteer	Cope± Cope 1
Level of interest in disaster management	a. Status quo (lack of disaster resilience) b. Integrate community disaster prevention to control community risks c. Cooperate with local government to implement disaster prevention and protection projects	Change± Change 1 Change 2
Willingness to work	a. Status quo (2 h./year/person) b. 4 hr./semester/person c. 8 h./semester/person d. 12 h./semester/person e. 16 h./semester/person	Work

This study calculated the values of WTW by reference to the estimation results of the faculty members' preferences regarding their schools. The MWTW for OR with level change can be measured by the ratios of the attribute parameters and the work attribute, as written in the following Equation:

$$\text{MWTW} = \frac{-\beta_{\text{attribute}}}{\beta_{\text{WTW}}} \tag{2}$$

where $\beta_{\text{attribute}}$ is the attribute's coefficient for the faculty members' preference for disaster management and β_{WTW} is the attribute's coefficient of the WTW [15,32,33]. To sum up, this study measures the welfare values by reference to the empirical results of Equations (1) and (2).

3.2. The Attribute and Level Design for Disaster Management

Following past CE research [14,15], this study utilized a CE design to understand OR in the context of disaster management. We first built up the CE attributes and levels based on a literature review covering the fields of OR and disaster management and also used on-site interviews and focus group discussions conducted with local government officers, community managers and faculty members from the junior high schools and primary schools. Based the literature review related to OR, we chose five attributes related to disaster management on which to focus (Table 1).

As mentioned previously, CC has been associated with seven forms of capital [1,28,29], and it represents the foundation for individuals' resilience and adaptability under any OR structure [2,9]. We used semi-structured interviews to unpack disaster management under adaptive organizational change in a school system under OR and a seven CCs framework, with questions related to the themes "Current situation under your SDPS program", "Any shortcomings of the SDPS program" and "How to improve (or enhance) the community capital(s) for the SDPS program in the school system". These onsite interviews with stakeholders allowed us to glean information to inform and guide our setting of levels for OR in the context of disaster management. Furthermore, we conducted pre-testing from August to October in 2019, during which time we interviewed a total of 50 faculty members in the schools. Based on the pre-test and focus group discussions, the final CE questionnaire was developed in November of 2019. We settled on five attributes of disaster management to examine, basing these choices on the above-mentioned discussions with stakeholders. These attributes were 'perceive environmental risk and change', 'the ability to reorganize and plan for disaster management', 'the ability to cope with disaster prevention', 'level of interest in disaster management' and 'willingness to work' (WTW). The attribute preferences and levels for OR in the context of disaster management are shown in Table 1.

3.2.1. Perceive the Environmental Risk and Change

When caused by the influence of severe weather, natural disasters produce extreme change. The resilience of the organization to such change entails absorbing the interference, rapid response, reducing losses and quickly restoring the original functions of the organization. Mastering community risks is therefore an important part of disaster management [1,4,5]. Regular disaster prevention drills can familiarize members of organizations with various types of disaster situations. Therefore, we set three types of perception of environmental risk and change: current management, regular disaster prevention drills and concern about environmental issues. In other words, we converted different disaster management results into these different preference options.

3.2.2. The Ability to Reorganize and Plan for Disaster Management

In a resilient organization, learning is an important process with direct implications for disaster reduction in the broader context of disaster management [10,24]. Bolstering the resilience of an organization depends on consolidating the learning ability of the organization as well as strengthening its existing abilities. When changes in the environment are detected, the organization can immediately take action to cope with it, continuously learn from the experience and then evolve [4,7]. Therefore, we decided on three options: maintaining the status quo, participating in community disaster prevention organizations (CDPOs) and cooperating with local government to perform disaster prevention drills. This allows us to understand the faculty members' preferences and plan different ways of learning.

3.2.3. The Ability to Cope with Disaster Prevention

Adaptability is the key to the development of organizational capacity building [2,10]. Disaster prevention organizations can make individuals or organizations more resilient by helping them acquire, improve and retain skills and knowledge. In simple terms or is the ability to adapt to changes in the environment [1,2,4]. Therefore, through the disaster prevention training actively promoted by the government, we have set up two possible alternatives: maintaining existing disaster prevention knowledge or training to be disaster relief volunteers.

3.2.4. Level of Interest in Disaster Management

After facing the environment impacts of a disaster, a resilient disaster prevention organization relearns, reorganizes and transitions to a new and more evolved state. The disaster prevention organizations in schools must integrate with CDPOs to grasp the disaster risks in surrounding areas. In the face of environmental impacts, the organizations must gradually transform themselves by

taking the initiative to seek to innovate and change [1,4,34]. Therefore, we have created three levels of interest in disaster management: maintaining existing disaster-responser capabilities, combining community disaster prevention work with mastering community disaster risk and assisting local governments to implement disaster prevention and protection projects. This attribute will reflect how the disaster prevention organizations in schools are transformed and gauge the level of faculty interest in improving disaster management.

3.2.5. Willingness to Work

Their current disaster prevention work involves faculty members conducting 2 h of disaster prevention drills every year. After the pretesting interviews of experts and scholars, we decided to propose five options: maintain the status quo of 2 h per year (equivalent to 1 h per semester), 4 h per semester, 8 h per semester, 12 h per semester and 16 h per semester. This attribute captures the faculty members' preferences via their WTW hours.

3.3. CE Design for Disaster Management

The number of attributes and levels of the disaster management OR gave rise to 270 possible profiles ($3 \times 3 \times 2 \times 3 \times 5 = 270$). To develop the CE questions presented to the respondents in the questionnaire, this study used an orthogonal main effect design, which is one frequently used in empirical studies [17]. We used the procedure to reduce the 270 possible profiles to 35 alternatives (including the current situation). We created three combinations of each alternative and deleted the unreasonable combinations, leaving us with a total number of 35 combinations. We then designed three versions of the questionnaire [14–16].

The first three choice sets were then used in the first version and subsequent versions of the questionnaire, resulting in three versions of the questionnaire. This meant the respondents faced three choice sets, and in each set they were asked to select between three alternatives. We provide an example of the CE questions based on disaster management OR (Figure 2). Each alternative relates to the same attributes of disaster management, but each has different descriptive level conditions for disaster management (i.e., attributes levels). The CE uses the possible combinations of attributes and levels to generate alternative solutions and then organizes these into selection sets. Each respondent is presented with 9 selection sets, and respondents are required to mark the answers they prefer.

Choice set			
Attribute	Alternative 1	Alternative 2	Status Quo
Perceive the environmental risk and change	Perform disaster prevention exercises regularly	Status quo (earthquake drill)	Status quo (earthquake drill)
The ability to reorganize and plan for disaster management	Participate in disaster prevention organization	Participate in disaster prevention organization	Status quo (prevention lecture)
The ability to cope with disaster prevention	Status quo (basic knowledge)	Training to be a disaster relief volunteer	Status quo (basic knowledge)
Level of interest in disaster management	Grasp community risks	Cooperate with local government	Status quo (no level)
Willingness to work	12 hr./semester/person	4 hr./semester/person	Status quo (2 hr./year/person)
Choose one of three options	☐	☐	☐

Figure 2. Example of a CE question for disaster management OR.

3.4. Hypothetical Scenarios of Disaster Prevention Management

This study extends the thread of applying CE methodology established in related studies, including a welfare evaluation of sustainable development in a national park [14], MWTP estimation of community-based ecotourism in an area surrounding a forest park [15], MWTP evaluation under impact reduction management in a reef recreational site [18], MWTP assessment of ecological conservation in a national park [35], assessment of welfare values under climate and land use change in forest parks [32] and revealing MWTW values under multiple land use scenarios close to a forest park [33]. The aforementioned studies all successfully used measurement of individuals' preferences for chosen attributes and levels to draw conclusions and make recommendations for management.

We likewise established a number of hypothetical scenarios for schools in the central area of eastern Taiwan based on the attributes and levels of disaster management. With respect to the empirical results of the RPL model, this study estimated the WTW following the calculation of the coefficients of the attributes based on Equation (2) and derived hypothetical scenarios of disaster management OR, which allowed for a comparison of the different alternative options. The potential scenarios are summarized below. To sum up, the CE model was used to generate a comprehensive framework based on reliable attributes and levels. The following hypothetical scenarios comprising attributes and level changes for disaster management OR were created:

- ScenarioI–Enhancing disaster prevention awareness: This scenario focuses on being aware of environmental vulnerability and community risks. OR means an organization should have the ability to absorb interference and reorganize to maintain its functionality;
- ScenarioII–Adaptive disaster prevention management: The second scenario focuses on combining resources and skills to adapt to new situations and operating environments[1]. OR is a dynamic change that can be seen as an adaptive renewal cycle;
- Scenario III–Transformation of disaster prevention: This scenario integrates all the characteristic aspects of disaster management into one program. Besides enhancing disaster prevention awareness, this scenario also focuses on developing adaptive disaster prevention management ability through integrating these aspects of a SDPS.

3.5. Sample Design and Data

We follow 4.9% estimation bias and 95% confidence level criteria and assume that preference and non-preference are the same for the schools in the central area of east Taiwan. From a total of 251 faculty members, we collected and analyzed 204 valid questionnaires (81.2%). The authors chose the central area of East Taiwan as the research locus since this area has seen disasters occur previously (see Figure 1). Purposive sampling was adopted to select participants for conducting one-on-one interviews, with 204 questionnaires distributed between 1 January and 30 March 2020 in the central area of East Taiwan. We calculated the frequency distribution in our analysis of descriptive statistics to understand the sample distribution status. Most of the participant faculty members were women (65.9%). More than half of all participants were married (69.8%). In terms of age distribution, the largest group of participants were 40 to 49 years old (41%) and the education level of all facility members was university or above. Most participants reported having an income of more than 40,000 NTD (New Taiwan Dollars) per month (77.6%).

Most respondents participated in disaster prevention drills twice per year (50.7%); followed by those that did so once per year (17.6%). Respondent experience of coordinating the implementation of disaster management and response work (including drills) was mostly earthquake drills (38.5%), followed by fire drills (31.3%). Most faculty members agreed that their schools were capable of coping with the requirement to perform disaster work (75.1%) and most were willing to participate in disaster management and response education and training (77.6%). Roughly one-fifth of respondents believed that disaster management in their schools and response work was still lacking in terms of grasping the community risks (21.1%). Just under one-fifth of respondents had participated in CDPOs (19.2%)

and just over ten percent of them had undergone training to be disaster relief volunteers (11.6%). Most of the faculty members were members of disaster prevention organizations in their schools (82.9%) and the majority were willing to cooperate with local governments to carry out community disaster prevention work (60%).

4. Empirical Results

4.1. Estimating Faculty Members' Preferences for Disaster Management OR

The RPL was used to estimate the level of each attribute, reflecting the differences in the preferences of respondents with different characteristics (Table 2). The log likelihood ratio (LLR) was calculated by using the formula LLR = −2(LL1–LL2) = −563.234 (Table 2), which indicated that all the models were statistically significant at the 1% level. We found that the CE method could explain the faculty members' preferences and behaviors in the SDPS context and could thereby provide a new perspective on disaster management.

Table 2. Estimation results of the faculty members' preferences for disaster management organizational resilience (OR).

Attributes and Levels	Original		Interaction with Work	
	Coeff.	*t* Value	Coeff. Intercross	*t* Value
Risk 1	−0.2519	−1.26	−0.2132	−0.96
Risk 2	0.5315	2.66 ***	0.6948	3.09 ***
Learn 1	−0.0400	−0.20	−0.1561	−0.07
Learn 2	0.3739	1.79 *	0.4178	1.74 *
Cope 1	0.1608	1.36	0.2704	2.01 **
Change 1	−0.0351	−0.20	0.0008	0.00
Change 2	0.2299	1.31	0.3363	1.66 *
Work A53	–	–	0.1343	2.41 **
Work A55	–	–	0.1474	2.22 **
Work	−0.0928	−4.02 ***	−0.2260	−5.50 ***

Attributes and Levels	Original		Interaction with Work	
	Coeff.	*t* Value	Coeff. Intercross	*t* Value
NsRisk 1	1.4452	5.78 ***	1.5510	5.16 ***
NsRisk 2	0.4248	1.06	0.1565	0.18
NsLearn 1	1.2241	4.07 ***	1.3720	4.12 ***
NsLearn 2	1.1765	3.44 ***	1.2879	3.49 ***
NsCope 1	0.6896	2.93 ***	0.6827	2.44 **
NsChange 1	0.5805	2.98 ***	0.6187	2.49 **
NsChange 2	0.5805	2.98 ***	0.6187	2.49 **
NsWork A53	–	–	0.2520	4.11 ***
NsWork A55	–	–	0.2520	4.11 ***

Model properties				
Chi-squared	x^2 (14, 0.01) = 29.14		x^2 (17, 0.01) = 33.41	
Log-likelihood	−563.234		−541.216	

***, **, * are significance differences at $p < 0.001$, $p < 0.05$ and $p < 0.1$, respectively. Work A53 means WTW interaction with participation in local disaster organizations and Work A55 means WTW interaction with training to be disaster relief volunteers. Coefficient is a vector of coefficients with respect to the disaster management attributes in preference functions; *t*-value can compare the two regression coefficients and determine the significance for the attributes of the disaster management coefficients.

In addition, the related variables of the impact function were cross-sorted with variables such as "lack of participation in CDPOs" and "lack of disaster relief volunteer training". We found that Risk 2, Work and Learn 2 were positive and significant at the 1% and 10% significance levels. The interviewees expressed that the disaster prevention organizations in their schools were willing to spend more time focusing on environmental issues, willing to spend time to prepare and willing to cooperate

with local governments in disaster prevention drills. Cope 1 was positive and significant at a 5% significance level, indicating faculty members' willingness to participate in disaster relief volunteer training. Change 2 was positive and significant at a 10% significance level, indicating that those faculty members were willing to assist the local government to implement disaster prevention and protection projects. At a significance level of 5%, "lack of participation in CDPOs" and "lack of disaster relief volunteer training" were positive and significant, indicating that faculty members were willing to spend more time to enhance their ability to participate in SDPS and to undergo training to be disaster relief volunteers. Moreover, the consensus revealed by respondents' stated preferences was that there is a need for change in this regard.

Most residents tend to believe in their ability to control things in the area where they live. However, these same residents also had varied understandings and interpretations of environmental disasters, and they may therefore make different decisions when it comes to evacuations. Misestimating the warning signs or lacking awareness of changes in the environment can cause serious casualties [36]. However, surveys have shown that most people do not worry about the impact of hurricanes. They believe their homes will withstand even severe storms, or, in worst-case scenarios, that they will be rescued by the government. Most of the faculty members in high-disaster-potential areas are willing to participate in disaster management and response education and training [24,37]. This reflects their belief that disaster management in schools and related response work is still lacking in terms of understanding the risks facing the communities where these schools are located. They feel they should participate in CDPOs and disaster prevention work, spend more time to cooperate with local governments to implement community disaster prevention programs and are willing to join in disaster prevention training. This shows the potential for capacity building and opens the door to promote OR thinking [10]. The government already promotes strengthening communities' independent disaster prevention resilience, and each community has disaster management capabilities and can assist other communities. The SDPS can function to reduce uncertainty about disaster occurrence and can help communities to avoid erroneous decision making in favor of adopting correct responses, which is key to slowing down the impacts of disasters [10,24,36].

4.2. Welfare Effects under Preference Heterogeneity for OR

Table 3 shows the binary differences between specific cases by using the independent samples *t*-test to compare the difference of the mean WTW between two defined levels of respondents' characteristics, such as marital status, higher and lower age levels and participating in disaster prevention and protection projects organized by local governments. At first glance, we see a large difference in valuation among the respondents who are in favor of participating in education and training courses, cooperating with local governments on disaster prevention and protection projects and training to be disaster relief volunteers. The faculty members having a favorable disposition to these attributes is reflected in a strong positive effect on the environmental issue, participating in drills, participating in projects and being trained as a disaster relief volunteer. Moreover, the faculty members who were over 40 years old and those who held master's degrees were willing to spend more time in assisting local governments in implementing disaster prevention and protection projects, which can make disaster prevention organizations more resilient. This willingness appears to be related to the respondents' age and administrative experience.

It emerged that the faculty members who identified a "lack of disaster prevention training" were willing to spend more time on education about environment issues and disaster drills with local governments. In other words, these respondents were willing to spend more time on disaster management. The faculty members who "lack participation in CDPOs" were also willing to spend more time on disaster management by cooperating with local government on drills. The results of estimating various attributes through the RPL show that in terms of their preferences for disaster management, most of the faculty members were very concerned about environmental issues and were willing to cooperate with local governments on disaster prevention drills. They were willing to spend

more time to carry out disaster management and response work, which would mean making disaster prevention organization in their schools more resilient. This reinforces the assertion that resilience is the ability of the organization to undertake capacity building [4,5]. As mentioned previously or is achieved through long-term learning [1,4,5]. Resilience is not just about training individual faculty members, but requires integrating knowledge, attitudes and skills and connecting scattered professions together to cope with disasters and build the ability to adapt [1,2,4,7,9]. Drills function to simulate the occurrence of disaster accidents. In recent years, extreme weather has resulted in many disasters becoming compound disasters. Every accident simulation is an opportunity for individuals and organizations to adapt their response processes, which means that every experience is transformed into new behavior [2,4,10].

Table 3. Willing to work (WTW) estimation with OR characteristics in school disaster prevention system (SDPS).

Attributes	WTW Risk 2		WTW Learn 2		WTW Cope 1		WTW Change 2	
	WTW	*t* Value	WTW	*t* Value	WTW	*t* Value	WTW	*t* Value
Male	3.073	−0.120	2.200	1.007	1.261	0.951	1.559	0.419
Female	3.074		1.744		1.084		1.507	
Married	3.072	−0.314	1.715	−1.311	1.148	0.067	1.540	0.397
Single	3.075		2.328		1.135		1.489	
Age above forty	3.071	−0.782	1.791	−0.766	1.048	−1.664 *	1.510	−0.402
	3.078		2.150		1.368		1.561	
Masters	3.066	−0.707	2.669	1.498	1.497	1.668 *	1.481	−0.313
Staff	3.074		1.765		1.083		1.533	
Ability to handle in school	3.071	−0.924	1.894	−0.033	1.129	−0.294	1.525	−0.015
	3.080		1.910		1.189		1.527	
Participate in education and training courses	3.078	2.191 **	2.229	2.955 **	1.278	2.901 **	1.599	2.402 **
	3.057		0.730		0.671		1.264	
Lack of participation in local disaster prevention organizations	3.081	1.542	2.576	2.685 **	1.236	0.878	1.537	0.174
	3.068		1.424		1.079		1.516	
Lack of training as disaster relief volunteers	3.091	2.604 **	2.725	2.250 **	1.394	1.647	1.680	1.532
	3.067		1.622		1.060		1.473	
Disaster prevention organization members	3.073	−0.037	1.796	−1.068	1.107	−0.922	1.505	−0.773
	3.074		2.410		1.326		1.626	
To implement disaster prevention and protection project	3.082	2.756 **	2.244	2.000 **	1.469	4.780 ***	1.637	2.399 **
	3.060		1.374		0.650		1.354	
Training to be disaster relief volunteers	3.085	2.142 **	2.775	3.083 **	1.650	4.427 ***	1.680	1.976 **
	3.067		1.420		0.868		1.440	

***, **, * are significant differences at $p < 0.001$, $p < 0.05$, $p < 0.1$, respectively.

We also found that the faculty members were willing to cooperate with local government to implement disaster prevention and protection projects. They were also willing to spend time participating in CDPOs and training to be disaster relief volunteers. The promotion of disaster prevention work is hierarchical, and close cooperation between all levels is required to extend and enhance it [24]. Our research found that the disaster prevention organizations in schools all have basic disaster

prevention knowledge, but there is a lack of professional personnel to promote related matters. Moreover, schools lack funding and resources. Therefore, by participating in CDPOs, faculty members can raise the awareness of crisis and take actions to provide relief and reduce losses [7,24]. Their participating in CDPOs also plants the seeds of community self-disaster prevention and relief work, as they become core participants in the process through training as disaster relief volunteers. It is important for schools and communities to achieve independent disaster prevention and management capabilities and establish sustainable disaster management operation mechanisms [4,7,38,39].

4.3. Evaluation of Hypothetical Disaster Prevention Management Scenarios under Adaptative Behavior

We turn now to looking at the faculty members' preferences regarding OR programs in the RPL model (Table 3). We designed three hypothetical scenarios as guidelines for a future disaster management and OR program, as presented in Table 4. These programs and their constituent attributes were chosen due to the latter having positive and higher levels of preference in the RPL. The results of the average WTW inform us that Scenario III is the one most preferred by faculty members (confidence interval of welfare change at 95% for 7.077 to 8.203 hours/semester/faculty member), followed by Scenario I (confidence interval of welfare change at 95% for 4.551 to 5.389 hours/semester/faculty member). Comparatively, Scenario II (confidence interval of welfare change at 95% for 2.449 to 2.891 h/semester/faculty member) was the least preferred scenario. Scenario III involves the highest number of hours for faculty member participation, with a willingness to work of 8 hours per semester for disaster management OR.

Table 4. Welfare effects under hypothetical scenarios of disaster prevention management.

Attributes	Hypothetical Scenarios		
	Scenario I: Enhancing Disaster Prevention Awareness	Scenario II: Adaptive Disaster Prevention Management	Scenario III: Transformation of Disaster Prevention
Perceive the environmental risk and change	Concern about environmental issues	–	Concern about environmental issues
The ability to reorganize and plan for disaster management	Cooperate with local government to perform disaster prevention drills	–	Cooperate with local government to perform disaster prevention drills
The ability to cope with disaster prevention	–	Training to be disaster relief volunteers	Training to be disaster relief volunteers
Level of interest in disaster management	–	Cooperate with local government to implement disaster prevention and protection projects	Cooperate with local government to implement disaster prevention and protection projects
Average WTW (hr./semester)	4.97	2.67	7.64
95% confidence interval (hr./semester)	4.551–5.389	2.449–2.891	7.077–8.203

Obviously, the most preferred OR attributes for the respondents involved training and participation. These attributes make organizations more resilient and adaptive, thereby promoting sustainable disaster management. Beyond merely maintaining the status quo, it is imperative to pay attention to environmental issues, cooperate with local governments on disaster prevention drills, train to be disaster relief volunteers and assist local governments in implementing disaster prevention and protection projects. OR is the key to successfully responding to uncertain changes or disasters. Adapting to changes in the environment and then revising further in response to changing conditions is critical [2,38]. However, our results revealed that each faculty member should be engaged in working and learning for an additional 8 hours per semester, compared to the status quo, to make their organizations more resilient. These results, derived from the faculty members' preferences, could help to inform future management strategies for the education sector. These hypothetical scenarios could be a guide for better future education operations.

To promote sustainable disaster prevention organizations in schools, we must increase the resilience of these organizations [38,39]. The resilience of the organization is dependent on strengthening the

structure of the organization and ensuring that the organization members have sufficient training and education [9]. We found that the faculty members' disaster management preferences included their willingness to devote an additional 8 hours each semester for learning and working, including gaining environmental knowledge and participating in CDPO training. Faculty members were also willing to cooperate with government disaster prevention strategies and construct common terms and language for disaster management [4,38,39], so that faculty can respond independently. In strengthening disaster management capabilities, a sense of shared identity and having trust in the organization is crucial since building resilience is the shared responsibility of the staff. Therefore, by bolstering the safety-related concepts of adaptation and resilience building [2–7,34,36,40], whether an organization encounters an accident or a disaster, the resultant increased perception of risk and disaster awareness will promote increased resilience [4,10,37]. Crisis awareness makes people pay more attention to the preparation work before a disaster strikes and is linked to individual willingness to participate in disaster risk reduction education and disaster prevention drills organized by local governments [1,3,10]. Since no major disasters have occurred in Taiwan in recent years, residents have gradually forgotten the bitter results of past calamities, despite the fact that the frequency of such disasters is bound to increase with climate change. What is more, residents having a higher awareness of risk may not translate into prudent behavior when it comes to evacuation [36].

The Gukut, Pratan and Dowmung tribes are all located in the central area of eastern Taiwan, where there is a high disaster potential, and all three tribal communities have been affected by disasters previously. They have long been assisted by local governments and have a sufficient understanding of disaster prevention preparations. The interaction between the communities generates trust in each other, and they are more inclined to follow evacuation advisories and orders. However, survey results also show that residents with higher risk awareness may not always be more likely to evacuate their communities [26,36]. In fact, residents may be unwilling to evacuate because they believe their homes will be able to withstand heightened risks, or they may erroneously believe disasters will not recur in their communities.

5. Conclusions

SDPS needs to be cultivated from an early age, making schools the most logical places to promote disaster risk-reduction education. We therefore surveyed primary and junior high schools in the central area of eastern Taiwan—an area well acquainted with disasters in the past—and tried to find out the faculty members' preference for disaster management using the CE method (Figure 3). The results support the validity of using the CE model in an evaluation framework for disaster management. They also provide a new perspective on OR and disaster management. While disasters often bring with them painful losses, memories of these experiences tend to fade over time, gradually leading locals to ignore the ever-present risks. The risk perceptions of residents depend on the severity of the consequences of disasters and their frequency. Whenever a disaster occurs, the judgment of the members of the organization—in this case each school—affects the safety of students. This holds true even in higher educational institutes, in which administrators enjoy a high degree of autonomy, and it is important to include universities when considering the current risk landscape. When it comes to disaster prevention, any organization's resilience includes the ability to cope immediately and respond quickly with limited workforces and resources, as well as educating the next generation about disaster awareness.

There are many cases of schools in Japan that show how decision-making about taking refuge is related to risk perception. For example, when a powerful earthquake occurred on March 11 of 2011, it spawned a devastating tsunami. The so-called "Kamaishi Miracle" refers to a primary and junior high school in Kamaishi city, Iwate-ken, Japan. Over the years preceding the catastrophe, the students and faculty there had undergone repeated tsunami evacuation training. As a result, the Student's took the initiative to move to an evacuation site independently. Then, when they judged that the tsunami could further inundate this evacuation site, they evacuated once again to take shelter on higher

ground. Approximately 3000 students evacuated themselves immediately and their survival rate was 99.8%. This was credited to their standard disaster risk reduction education and having a correctly located refuge place. In contrast, at Japan's Okawa-shi primary school and Riwa kindergarten, all the students were killed due to misjudgment of the threat and improper evacuation. It can be seen that the importance of the resilience of disaster prevention organizations in school is not only a product of disaster risk reduction education but is also the key to effective student evacuation. Disaster perception depends on both environmental awareness and social factors. Individuals having experience with disasters and being willing to work to reduce disaster risks makes it more likely they will cooperate with evacuation orders [24,34].
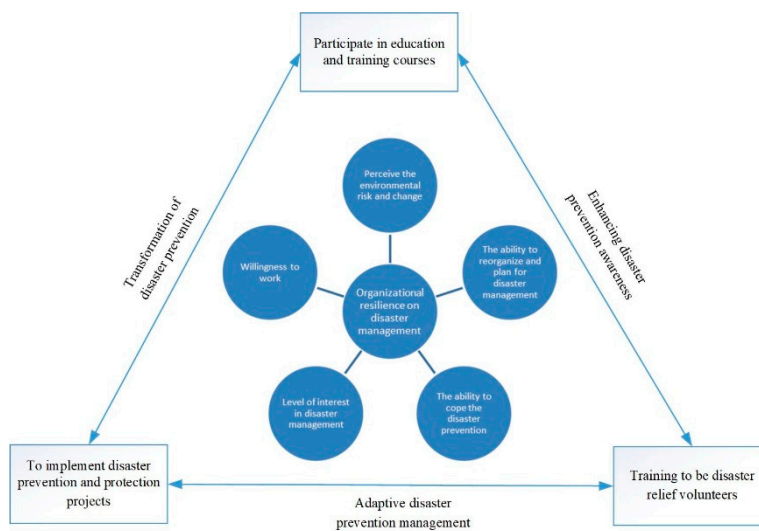
Figure 3. Conceptual framework for an OR program for disaster management.

Awareness of the environment is a precursor to the ability to detect changes in it. Organizations can promote risk awareness, learn to adapt from disaster experience, strive to achieve organizational consensus and take corresponding actions. Even so, the perceptions and judgments that risk awareness can engender are not necessarily positively related to evacuation behaviors when disasters come [41,42]. Although the disaster prevention and education plans formulated by the government can solve many evacuation-related problems, these plans are often not strong enough to offset the intensity of social factors. However, appropriate intervention can capitalize on extant social factors to change the behavior of organizations and achieve the purpose of organizational transformation. Through the continuous interaction of the factors comprising the environment, perception and behavior, the behavior of the organization can become part of the social fabric. Moreover, through observation and imitating the behavior of others, individuals can learn from other organizations. For this to happen, disaster risk-reduction education must start in schools. Organizations must learn to adapt to changes in a crisis. They must also have the ability to anticipate disasters and cultivate awareness of risk. Above all, they must be flexible, use redundant resources and show in resilience in organizational thinking. All of these characteristics improve the organization's ability to perceive danger and behave appropriately in relation to it. By strengthening the sense of organizational identity and formulating proactive disaster avoidance strategies, the losses caused by disasters and accidents can likely be reduced.

From the research results, we know that faculty members' preferences for disaster management can translate directly into organizational resilience. Specifically, if each faculty member spends eight hours per semester learning environmental knowledge and training to become a disaster relief volunteer, in addition to cooperating with community organizations and local government drills to implement disaster prevention and protection projects, the behavioral structure established through implementing these disaster management preferences will ensure the disaster prevention

organizations in the schools we looked are capable of resilience thinking (i.e., awareness, adaptation and transformation) [9,11,13,25,26].

Finally, when it comes to enhancing disaster prevention awareness, bolstering adaptive disaster prevention management and transforming disaster prevention under OR in SDPS programs, local government officials and managers must establish appropriate mechanisms and actions. In doing so, they should take into careful account environmental issues, providing appropriate training for disaster relief volunteers and promoting cooperation between local government and other organizations to perform disaster prevention drills and implement disaster prevention and protection projects (Figure 3). The key is to establish a solid base of individuals who are willing to participation in such endeavors in order to achieve the goals of adaptive organization change in a school system under sustainable development.

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